LABOR REQUIREMENTS OF DIFFERENT METHODS OF USING POLYETHYLENE IN PEAR PACKING OPERATIONS

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LABOR REQUIREMENTS OF DIFFERENT METHODS OF USING POLYETHYLENE IN PEAR PACKING OPERATIONS

CHAPTER I

INTRODUCTION

Oregon's pear industry is important to the agricultural economy of the state. Pears are Oregon's leading fresh fruit crop in terms of cash farm income. In 1954, this figure amounted to almost $13.5 million. (18, p.19)

The industry is of particular importance to the agricultural economies of Hood River and Jackson counties. Pears contributed 50 and 70 per cent, respectively, of the total farm incomes of these counties in 1950. (21, p.302) The processing firms associated with this fruit also contribute significantly to the total industrial income of both areas. Packing houses and storage plants furnish seasonal employment for large numbers of workers in addition to their year-around employees.

Oregon, with a production of 150,000 tons in 1955, ranks third among the states in the production of pears. This represented 20 per cent of the national pear output in 1955. (17, p.87) Over 50 per cent of the state's total pear output was made up of winter varieties (Anjous, Boscs, Comice, and Winter Nelis) in 1955. (15, p.2) National output of these varieties is confined almost exclusively to the three Pacific Coast states. Oregon, which leads all states in their production, grows nearly twice as many winter pears as the nearest competing state.

Winter pears are marketed as fresh produce. They make up the bulk of all fresh pears exported to foreign countries. In recent years, however, trade restrictions have caused a loss of much of our foreign market. In 1954, only 460 tons of fresh pears were exported, as compared with over 45,000 tons in 1939. During the same period, Oregon's production of winter pears increased by 20 per cent. (19, p.247 and 20, p.183) These factors have forced the industry to rely more heavily on the domestic market to absorb its product.

Due to this situation and because of the expansion and improvement of merchandising and marketing methods of competing products, the pear industry must continually develop more efficient marketing procedures to maintain or improve its present position in the market place.

Eastern markets are the principal outlets for Oregon's pear crop. The metropolitan areas of New York, Chicago, Boston, Pittsburgh, and Philadelphia received over 60 per cent of the carlots shipped to one hundred major United States cities from the Oregon producing areas in 1954. Seventy five per cent of this state's domestic shipments were destined for the states east of the Mississippi River. (16)

The distant markets and long storage periods - October through May - necessitate the use of expensive packing materials and procedures to insure a quality product for the consumer. These packing and storage costs of pears amount to more per box than the production costs. (10, p.3)

The Oregon pear industry recognizes the problem of delivering high quality, seasonally produced fruit to the consumer at a reasonable price. The industry is interested in developing and adopting methods and procedures which will improve the quality of their product and the efficiency of their operations.

One such method, first introduced in 1953, has received increasing attention in Oregon's pear industry. This method entails the use of a polyethylene liner as an additional packing medium. These liners are made in the form of a bag. They are placed in the standard wood boxes before filling the boxes with fruit. Use of the liners increased threefold from 1953 to 1954. (6, p.26) Although complete figures are not yet available, a further increase in the use of polyethylene was experienced during the 1955 packing season.

In order to market pears several months after they have been harvested, it is necessary to arrest the ripening process of the fruit immediately after it has been picked. This is done by storing the pears at a temperature of 31° Farhenheit. However, all varieties of pears lose their capacity to ripen normally after rather definite periods of storage at this temperature. The pears lose moisture and eventually tend to shrivel, soften, and lose their fresh appearance. The use of the polyethylene liner allows a rate of diffusion of carbon dioxide and oxygen that increases storage life. The liner permits a concentration of carbon dioxide, within the individual box, that approaches ideal storage conditions. It also allows a humid atmospheric condition. This prevents the shriveling caused by dehydration present in unlined boxes. The rate of metabolism of the fruit is further depressed when the liner is used. Soluble pectin formation, loss in weight, and softening of the fruit, recognized guides for the storage condition of pears, are retarded when pears are packed in the polyethylene medium. (6, pp.2-8)

For these reasons, the storage life of good quality pears can be extended from four to six weeks by use of the liner. The retail shelf life of ripened, liner-packed fruit is also prolonged by several days. (6, pp.11-16)

Trade acceptance of the fruit is evidenced by the fact that a premium price is commanded by pears packed in polyethylene when compared with like fruit packed in boxes without the liner.

Methods of handling the polyethylene liner differ among plants for two main reasons. One reason they differ is the lack of knowledge concerning the effects of a tight or loose seal of the liner upon maintenance of fruit quality. This problem is currently being studied by plant physiologists.

Another reason is the limited experience of the industry in the use of polyethylene liners. This has led to the adoption of somewhat hastily improvised methods of handling the liner in the packing houses. Little is known about the relative costs and efficiencies of the different methods. This problem logically falls to the economist to solve, and is the subject with which this study deals.

Representatives of Oregon's pear industry requested information on the efficiency and cost of various methods of handling polyethylene liners. The Oregon Agricultural Experiment Station instituted this study in an effort to obtain such information for the pear industry.

Purposes of the Study

In line with carrying out the request made, the objectives of this study are:

1. To determine the time requirements of different methods of handling polyethylene liners in the packing houses.
2. To recommend methods of handling the polyethylene liners in the packing houses.
3. To appraise economic implications arising from the use of the polyethylene liners.

CHAPTER II

METHODOLOGY

Use of the polyethylene liner in pear packing plants means an increased labor cost per packed box of pears. Except for the liner cost itself, the increased labor requirement is the only source of a significant additional variable cost of using the polyethylene. Therefore, a determination of the labor time requirements of different methods of handling the liner in the packing procedure was made.

Results of a preliminary survey in the two pear producing districts showed that the packing houses were using several variations of two general methods of handling polyethylene. Each plant was classified under one or the other of these two methods, depending upon when the liner was fitted in the box in the overall sequence of handling and packing operations. Figure I illustrates the general layout and sequence of operations performed in a pear packing plant typical of the ones studied.

In Method I, the liner was shaken out and positioned in the box for the packer. The fitting of the liner was done immediately after the box left the boxmaker and before the box was transferred to the packing line by chute or overhead monorail. The only required packer handling of the liner was to adjust it as the actual packing took place.

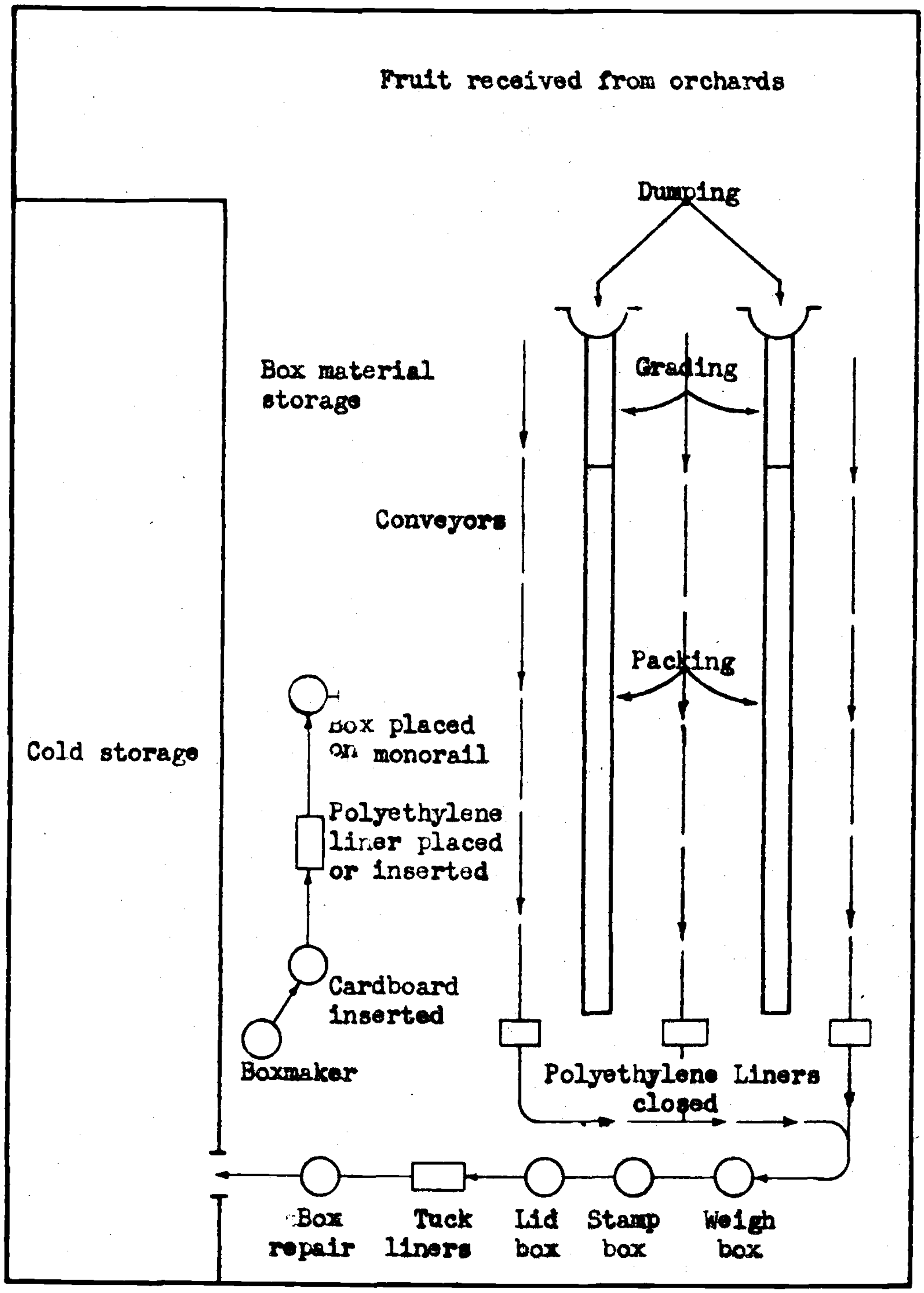

Figure I. Example of a Typical Pear Packing Plant

Method II differed from Method I in that the liner was shaken out and placed, but not positioned, in the box for the packer. The packer then fitted the liner in the box. If necessary she adjusted it during packing. Shaking each liner was necessary in both methods because the liner sides tended to adhere to each other during their storage.

After the packing operation was completed, regardless of the method used to fit the liner, a conveyor belt moved the packed box toward the lidding end of the packing line. Here one or more workers closed the liner before the box was weighed, stamped, lidded, and sent to storage. In some plants the liner was closed by exhausting the air from the fruit-filled liner and sealing it with wire or tape. In other plants the closing operation consisted of merely folding the liner over the top of the fruit and weighting it down with a pear. In these plants, the lidding operation caused portions of the liner to protrude from the box, and it was necessary to tuck them back in. The closing method employed by a particular plant was entirely independent of the method used to position the polyethylene liner in the boxes.

The specific plant variations of the methods of handling the liners are more fully described in Chapter III.

In choosing an area in which to carry out this study it was desirable to pick one that had a large number of packing houses using different methods to handle the polyethylene liners. On this basis, the Medford area in Jackson County, Oregon, was selected for the study. The area contains seventeen pear packing houses.

Only three of the packing houses in this area used Method I of liner fitting. This was partly because the use of polyethylene has increased rapidly. Hence, most plants have not had time to organize their production lines to incorporate the additional operation required by Method I. Method II required no additional facilities to fit the liner. Therefore, it was natural for these plants to solve the immediate problem of where in the operational sequence to fit the liner by resorting to Method II.

The three plants employing Method I and the three largest plants using Method II were selected for the study. Variations within the two general methods employed in these six plants were representative of all seventeen plants in the Medford district.

Method of Obtaining Labor Requirement Data

In order to determine the labor time requirements of different methods of handling the polyethylene liner in the packing houses, it was necessary to measure the time entailed in each operation where polyethylene was used. Two methods, continuous time studies and work sampling studies, were available for making the time measurements. The relative merits of the two techniques are described below.

Regardless of which method is used, a job description of the operation to be studied is made first. One of the best ways to describe an operation is to break it down into definite and measurable elements. Then each one of the job elements may be timed and described separately. This allows a more thorough analysis of the operation than if the entire operation is treated as one element. (1, p.342) Depending upon the operation, one or more workers may be required to carry it out. Each worker may perform one or more elements of the operation.

A continuous time study provides a sequence of individual element times for a given period of observation. The worker's job is first broken down into defined elements. A stop watch is used to measure the length of time spent on each particular job element. Time readings are made on a data sheet for each element every time it occurs during the observation period. The watch is allowed to run continuously for the duration of the study and is read at the breaking point of each element. This point marks the end of one element of the operation and the beginning of another. For example, if the operation consists of fitting polyethylene liners in wood boxes, the elements of one worker's job in that operation may be: (a) pick up and shake liner, (b) fit liner in box, and (c) wait. The sweep hand of the watch starts at zero. At the end of the first element (pick up and shake liner) it may read .05 minutes; at the end of the second element it may read .13 minutes. The times recorded for the two elements then would be .05 and .08 minutes, respectively. The element of "wait" may or may not occur in any given job cycle. When it does occur, it is treated like any other element, and the time is recorded for it in the same manner.

At the end of the observation period the total time required for each element, the proportion of time spent on each element, and the total job cycle time may be determined.

If the operation contains several elements, it is impossible for one observer to study more than one worker during one continuous time study. This is due to the physical and mechanical limitations encountered by the analyst in making the observations and recording the data.

When it is desirable to compare the efficiency of two or more methods of performing an operation, performance rating of the individual worker is necessary if the continuous time study method is used. Performance rating is the process by which the observer compares the speed or tempo of the worker being studied with the observer's own concept of what should be the normal speed or tempo for that job. Later, the rating factors obtained from this procedure are applied to the time values to arrive at the normal time for the job. (1, p.352) It then becomes possible to compensate for individual worker differences in comparing two or more methods of performing an element of an operation. The efficiency of the methods themselves may then be used as the sole criterion for comparison. Performance rating is largely subjective and requires considerable skill and experience on the part of the analyst.

The work sampling, or ratio-delay, method involves taking a comparatively large number of instantaneous observations of several workers simultaneously. The observations are taken in one operation at systematic or random intervals as determined by the nature of the activity. When using the work sampling technique, the observer may break the same total observation period referred to in the discussion on continuous time studies into several short periods of study. Thus, a two-hour observation period under continuous timing may be broken into twelve studies, each of ten minutes duration, for the work sampling method. This enables the observer, using the same amount of time required by the continuous method, to take observations at random intervals throughout the day. By taking into account the effects of the time of the day upon the laborers' rates of work, he can arrive at a more realistic estimate of the labor requirements of the operation.

Just as in the continuous timing technique the operation is first broken down into its component work elements. The number of elements in a work sampling study may be greater than those in a continuous time study because the number of workers and jobs observed may be greater. Each element of the operation is identified on a data sheet. At definite or random intervals an instantaneous observation is taken on all workers in the operation. The observation is then recorded on the data sheet. One observation consists of as many marks as there are workers in the operation. The marks are recorded in the spaces opposite the elements that were being performed by the workers at the time the observation was made.

The example of the operation of fitting polyethylene liners in wood boxes, cited in the discussion of the continuous time method, may be used to illustrate the work sampling technique. This operation may employ five workers performing the same work elements of: (a) pick up and shake liners, (b) fit liner in box, and (c) wait. The observer has decided to take observations four times each minute for the duration of a ten minute study. At approximate 15 second intervals, he glances at the entire operation just long enough to see which of the elements the five workers are performing. Upon his first glance he may see two workers picking up and shaking liners, one worker fitting the liner in the box, and two workers momentarily idle. He then makes two marks on the data sheet opposite the element of "pick up and shake liner", one mark opposite the element "fit liner in box", and two marks opposite the element "wait". This procedure is repeated four times each minute for ten minutes. The element "wait" is again treated like any other element of the operation.

At the end of each study, the individual marks are totaled. Then the amount and proportion of time spent on each element may be determined.

The theory of work sampling is based on the laws of probability. This means that the time spent on the various elements of an operation in a short study will tend to follow the same distribution pattern produced by a long study. (3, p.84)

Performance rating is not required in work sampling if there are enough workers performing the same work elements.

The work sampling method was originally used to find proportions of delay to be used in conventional time study standards. The application of the technique has since been broadened, and it is now employed as an alternative to continuous time and production studies.

Increased use of the technique resulted from time and money saved in collection of data, the flexibility of the method in applying it to various work situations, and less disruption of the workers' routines. Brisley estimates that the work sampling technique obtains reliable data at 1/3 to 1/6 the cost of continuous time observations. (3, p.89)

The characteristics of the packing house operations considered in this study were well suited to the work sampling technique of measuring time requirements. Several workers were used in most operations. This situation may be handled readily by the work sampling method. It also makes performance rating procedures unnecessary. These and the other advantages of the technique mentioned above led to the use of the work sampling method, rather than the continuous time method, to determine the labor requirements of all operations examined in this study.

Application of Work Sampling to Packing House Operations

Three operations in all packing houses studied used a significant amount of labor to handle the polyethylene liners. These operations were studied to determine the polyethylene labor requirements of the different methods used to handle the liner. The operations may be classified as:

1. Pre-packing handling of the liner.
2. Packing handling of the liner.
3. Post-packing handling of the liner.

The amount of labor used to handle the liner in the receiving and storage operations was negligible.

In each plant, the elements of the pre-packing and post-packing operations were first assembled into three groups:

1. Elements attributable to the use of the polyethylene liner.
2. Elements not chargeable to the polyethylene liner.
3. Non-productive elements, in which a worker was idle due to a low supply of work or minor production line breakdowns.

After the sub-division of the pre-packing and post-packing operations had been made, four to eight individual work sampling studies were taken in each packing house for each operation. All studies were ten minutes long.

In all but one plant the pre-packing operation was carried out by one crew of two to five workers. The number of crews carrying out the post-packing operation varied from one to six depending upon the plant studied. In those plants where more than one crew carried out an operation, studies were made of each crew. This was done to further minimize variations in time due to individual worker differences.

Two observers were assigned to each study of the pre-packing and post-packing operations. One observer made the individual worker observations while the second observer counted the production for the period.

The packing operation entailed somewhat longer individual time studies than did the preceding two operations. Physical limitations of the study made it necessary to obtain labor requirement data that would be applicable to the packing industry as a whole. These data replace the packing times for each individual plant and become constants for the study. Since packer fitting of the liner took place in only three of the six plants observed, the time required for the packer to fit and adjust the liner in the box was determined from data taken in those three plants.

Studies of packing without the use of the polyethylene liner were made to obtain data that would determine the additional time required to pack in the polyethylene liner. These studies were taken in four plants, three of which were included among the plants observed for the liner packing operation.

Eight 30 minute studies were made for both types of packing operations in each plant. The breakdown of the operations into job elements followed the same general procedure used for the pre-packing and post-packing operations. However, for the packing operations elements were grouped into only two categories, according to whether they were chargeable to liner jobs or non-liner jobs. No attempt was made to estimate the non-productive time of these operations.

Data for the packing operations were collected in the same manner as for the pre-packing and post-packing operations. One observer made the individual worker marks. The second observer counted the boxes packed by each worker in the study.

A detailed breakdown of the elements measured in the three operations studied at each plant are listed in Appendix I.

Techniques Used to Analyze Time Data

Each study of the pre-packing and post-packing operations was analyzed. The proportion of time and the actual man minutes spent on productive polyethylene elements, productive non-polyethylene elements, and in non-productive work were calculated. A simple average of these data was made to arrive at the man minutes of productive polyethylene time per box for each plant. An average weighted by the production of each study showed essentially the same results as the simple average. However, the simple average was used here because all studies were considered equally representative of the particular operation.

In comparing the efficiency of the two methods productive polyethylene time only was considered since the amount of non-productive time was determined by circumstances and conditions not affected by method. Therefore, this latter time had no bearing upon the actual time requirements of the method itself.

Standard delay allowances were used to estimate the non-productive liner time included in determining the additional labor costs of the different methods of using the polyethylene liner. The standard delay allowance used was 20 per cent of the total liner time. This figure appears reasonable in view of the data obtained for this study. The delay standard is based on an allowance of 5 per cent of the total working time for the mid-morning and mid-afternoon rest periods. The unavoidable delay, caused by machine breakdowns and lack of materials with which to work, varied from 11 to 64 per cent, depending upon the plant and operation studied. If 15 per cent unavoidable delay is taken as a practical minimum, and combined with the allowance for rest, the total non-productive time becomes 20 per cent of the total work time. This procedure for determining delay allowances has been used in similar studies. (13, p.13)

It was necessary to isolate the variations in time to pack different sizes of pears in order to obtain reliable estimates of the polyethylene time for any specified pear size in the packing operation. For example, it takes less time to pack a box of large pears (size 80) than a box of smaller pears (size 120). In order to determine the time difference due to packing in polyethylene, the influence of any difference due to pear size must be eliminated. Enough observations were taken of both polyethylene and non-polyethylene packing with different size fruit so that regression analysis could be used to isolate the effects of polyethylene.

The polyethylene and non-polyethylene packing studies were given the regression analyses separately. Then, to furnish more cases for the non-polyethylene time estimates, the non-polyethylene elements of the liner packing data were included with the original non-polyethylene data for analysis. This gave better estimates of the time required to pack the extreme fruit sizes in the operation not using the liner. Further details of the regression analysis are included in Appendix II.

The time requirements presented in the following chapter for the different methods of handling polyethylene were affected by several variable factors. Purposes of this study did not include isolating the effect of these variables. This does not, however, affect the validity of the results. Observations of time requirements were made during periods of capacity plant operation. This minimized effects of the rate of fruit flow. Physical layout of operation and organization of equipment and personnel are largely inherent in the methods used. Therefore, labor requirements actually include the effects of layout and organization variables. Importance of differences in pace of workers was partly controlled by including large numbers of workers. For example, over 175 different individuals were observed in the study of packing.

The time requirements used are believed to be close estimates, at least, of the actual labor requirements of the different methods studied. Therefore, it is felt that they give a reliable indication of the relative merits of Method I and Method II in the pre-packing and packing operations and of the exhaustion and hand-closing methods used in the post-packing operations.

CHAPTER III

RESULTS OF TIME STUDIES

Results of the time studies will be shown in the general operational sequence followed by pear packing houses in using the polyethylene liner. The results of pre-packing, packing, and post-packing studies will be discussed in that order. These discussions will then be brought together by a presentation of the over-all polyethylene labor requirements for each plant.

Pre-packing Operations

As previously noted, two general methods were observed in the pre-packing operations of handling the polyethylene liner. In Method I the liner was fitted in the box for the packer. The plants using this method are designated as Plants A, B, and C. In Method II the liner was placed in the box for the packer, but the element of fitting was done by the packer. Plants D, E, and F used Method II.

Method I.

Plant A was the only packing house to use more than one team to perform the pre-packing operation. This plant used two teams of two men each for fitting the liner in the box before it reached the packer.

Each team used an inexpensive mandrel, a form constructed to facilitate fitting the liner in the box. One member of the team obtained a liner from a nearby stockpile. He shook the bag to open it and then brought it down over the mandrel. The second member of the team placed a box over the liner-covered mandrel. He then pulled the liner top back over the box sides, thus completing the fit. The same man placed the lined box on a chute carrying the boxes to the packing line. The average polyethylene time requirement for this operation, as shown in Table 1, was .23 man minutes per box.

Table 1. Average Polyethylene Labor Requirements and Outputs of Pear Packing Plants Employing Variations of Method I of the Pre-packing Operation.

Plant	Time requirements per box/1 Average	Range	Average output per man hour	Average non-productive time
	(man minutes)		(boxes)	(per cent)
A	.23	.14-.32	261	15
B	.31	.28-.34	194	14
C	.39	.35-.47	154	11

The pre-packing operation in Plant A was the fastest variation of Method I studied. Expressed in a different manner, Plant A's output of 261 boxes per man hour was the largest of all Method I plants. This operation had the advantage of flexibility. One team could be pulled out and put to work on another job when the packing or boxmaking rate slowed down. Fewer workers per team were needed at this plant than for either Plants B or C.

/1 Includes productive polyethylene time only.

Three workers were involved in the pre-packing operation in Plant B. Boxes were received from the boxmaker on a roller conveyor. Two workers were fully employed placing liners in the boxes. The workers each picked up four or five liners from a table a few feet away and shook each one out. They fitted the liners in the boxes on the conveyors and pulled the tops of the liners down over the box sides. The lined boxes were then pushed down the conveyor to a third worker who placed each box on an overhead monorail leading to the packing line. This worker also adjusted any liners that were out of place when received.

Table 1 shows that this variation of the pre-packing operation required an average of .31 man minutes per box. The average output per man hour was 194 boxes. The time requirement could have been reduced if the liners had been placed closer to the liner positioning station.

Plant C used five operators in the pre-packing operation. Two workers spent full time shaking and inserting liners. Each worker picked up a liner from a stockpile nearby and filled it with air by bringing the liner down suddenly from an overhead position. The air-filled liner was placed in the box, which was moved on a roller conveyor to a team of two who folded the liner top down over the sides of the box. One of these workers then pushed the lined box along the conveyor to the fifth worker who placed the box on the monorail. Frequently, this worker had to adjust a misplaced liner.

This operation functioned smoothly, although the average labor requirement was .39 man minutes per box, and the average output per man hour was only 154 boxes. Too many operators probably caused the comparatively slow time and low output. Better use of each operator employed would have been possible if the liner shaking and inserting jobs had been combined with the job of folding the liner top over the box sides. At least one operator could then have been excluded in this operation. Even so, the time requirement still would have been greater than for Plant A.

Method II.

Plants D, E, and F used Method II of the pre-packing operation. In this method the liner was merely shaken out and placed in the box during the pre-packing operation. The job element of positioning the liner in the box was left for the packer to do in addition to her regular packing duties. She was paid an additional one-half cent per box for this job.

Plant D employed five workers for the pre-packing operation. Three of the workers were assigned to three chutes that transported boxes for number one grade pears to the packing lines. These operators were responsible for taking the boxes off a conveyor belt and either placing them on the chute or in a stockpile. They then shook out and laid a liner in each box on the chute. The two remaining workers were assigned to three chutes handling boxes for number two grade fruit. Their functions were essentially the same as those for the other workers. However, the latter two laborers also were responsible for distributing polyethylene liners to all chutes and for janitorial work.

Table 2 shows that the average time chargeable to the polyethylene elements of the pre-packing operation in Plant D was .13 man minutes per box. The average output was 462 boxes per man hour. This plant used the least time and had the greatest output of any of the three plants using Method II.

Table 2. Average Polyethylene Labor Requirements and Outputs of Pear Packing Plants Employing Variations of Method II of the Pre-packing Operation.

Plant	Time requirements per box: Average (man minutes)	Time requirements per box: Range (man minutes)	Average output per man hour (boxes)	Average non-productive time (per cent)
D	.13	.09-.19	462	20
E	.20	.15-.32	300	64
F	.29	.27-.32	207	34

In Plant E, two operators, stationed in a balcony overlooking the packing lines, kept a monorail filled with boxes for the packers. When the plant packed fruit in the liners, these operators placed a liner in each box as it was hung on an empty monorail hook. The workers also were responsible for shaking out the liners before placing them in the boxes.

The labor requirement attributable to the polyethylene elements of this method, as shown in Table 2, was .20 man minutes per box. The output per man hour was 300 boxes. The slow pace of the workers was a major factor in making the labor requirement as large as it was.

One laborer could undoubtedly handle this operation under many, but not all, conditions. The indivisibility of human inputs, however, would make a curtailment of the labor requirement in Plant E difficult.

Plant F had the highest average polyethylene labor requirement, and, consequently, the lowest average output of all plants using Method II. The time was .29 man minutes per box, and the output was 207 boxes per man hour. This may, in part, be attributed to the method of shaking out the liners. The equivalent of one laborer worked full time shaking the liners out and rolling them into bundles before they were placed in the boxes. The laborer observed worked at an extremely slow pace. Two-thirds of the total polyethylene time in this plant's pre-packing operation was due to these two work elements. In addition to this worker, a team of two workers was employed full time to supply two packing lines with boxes. When the packing house packed in the liners, these workers placed a liner from one of the prepared bundles in each box as it was sent down the chute to the packing line. It was felt that these workers could easily add the liner shaking and rolling elements to their present jobs and, thereby eliminate them as a preliminary job.

Packing Operations

Two job elements were charged to the use of the polyethylene liner in the packing operations. These elements were:

1. Fitting the liner in the box. This job element was performed by the packer in Method II plants only. The packer took the liner from the box, shook it out, positioned it in the box, and folded the top of the liner down over the exterior of the box sides. This completed the fitting, and the packer then proceeded to pack fruit in the box.

2. Adjustments of the liner during packing. This job consisted of rearranging the liner when it became disheveled during the actual packing of the fruit in the box. Packers in both Method I and Method II plants made such adjustments.

The polyethylene labor requirements for the packing operations were derived from time data gathered at the packing plants using Method II. Therefore, the labor requirements given for the liner adjustment element in Method I were actually calculated from data taken in Method II plants. Several studies were made to determine the liner adjustment time in Method I plants. The results of these studies showed no significant difference for this time between Method I and Method II plants.

The packing operation studies were designed to include as many different packers as possible. This was done to avoid introducing a bias caused by individual packer work-rate differences. Over 175 different packers were included in the 48 studies made of the liner and non-liner packing operations.

Polyethylene liner time tended to vary inversely with size of fruit, ranging from .29 man minutes per box for size 80 to .52 man minutes per box for size 180. This relationship may be seen in the second column of Table 3. This relationship was not analyzed further, but it is reasonable to assume that it was due to the liner adjustment element. This may be so because as fruit size decreases, the number of pears packed per box increases. For instance, size 80 indicates that eighty pears will fill a standard wood box; size 180 indicates one hundred eighty pears will fill a standard wood box. Therefore, packing one hundred eighty pears in a box affords a greater opportunity of distrubing the liner than eighty pears. As a result, the number of adjustments increase. Also there is the possibility of the presence of a psychological factor. A packer may automatically fall into a rhythmic time cycle of making liner adjustments. That is, she may unconsciously adjust the liner once every twenty seconds whether or not it is necessary. This, of course, would result in an increased number of adjustments made per box for the smaller fruit sizes.

In order to simplify the analysis the average time requirement for polyethylene liner handling during packing was calculated for the average sized fruit. This amounted to 0.07 man minutes per box for packer adjusting and 0.30 man minutes per box for fitting the liner, or a total of 0.37 man minutes per box for a fruit size averaging slightly larger than 120.

Table 3. Labor Requirements to Pack Fruit and Handle Polyethylene Liners for Different Sizes of Winter Pears./2

Size fruit packed (number fruit per box)	Liner time per box	Packing time per pear	Packing time per box (No liner)	Packing time per box (With liner)
	(man minutes)		(man minutes)	
80	.29	.029	2.29	2.58
90	.30	.028	2.48	2.78
100	.32	.027	2.69	3.01
110	.33	.026	2.90	3.23
120	.35	.026	3.12	3.47
135	.38	.026	3.46	3.84
150	.42	.025	3.82	4.24
165	.47	.025	4.20	4.67
180	.52	.026	4.60	5.12

Packing time per pear, as shown in the third column in Table 3, was essentially a constant, although there was some tendency for this time to decrease as fruit size decreased.

A comparison of the times of liner and non-liner packing operations also is shown in Table 3. The packing times given for the liner operation include the liner fitting and liner adjustment time. Results of this analysis show that the packing times for the non-liner operation increased as size fruit decreased. The increasing time trend, however, is lower than the same trend for the liner packing operation. The trends are presented graphically in Figure II. The heavy black line denotes the time trend for the non-liner packing operation, and the dashed line shows the time trend for the operation when polyethylene is used. The increasing spread between the two lines demonstrates the fact that the liner time, itself,

/2 Includes only productive time.

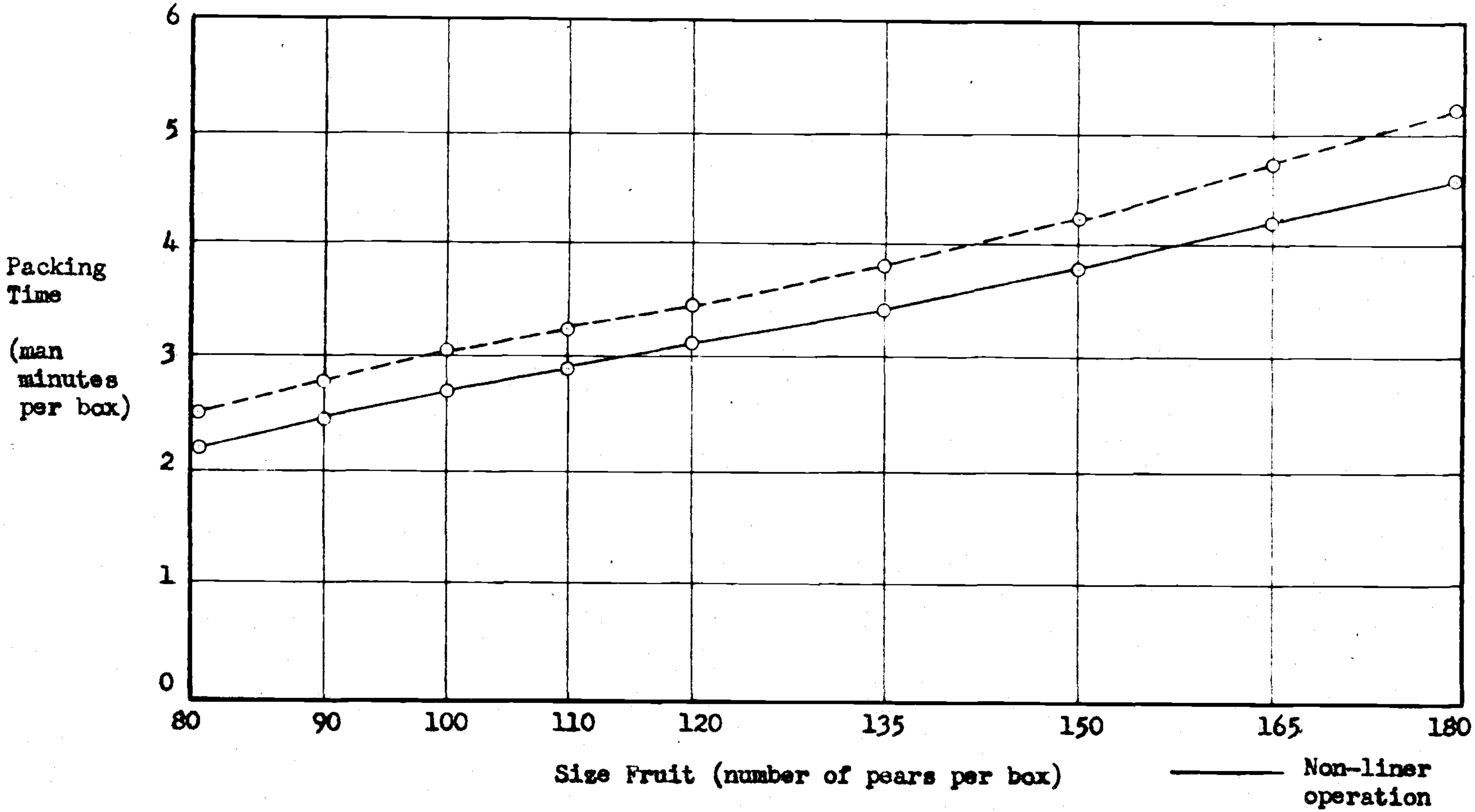

Figure II. Relation of Packing Time and Size of Pears in Packing Plants in Medford, Oregon.

increased as fruit size decreased. The trend for the non-liner operation is substantiated by a similar study made by French in California. (5, p.5)

Packers are paid on a piece-rate basis at the same rate per box regardless of fruit size. In view of the packing study results, showing less time required to pack large fruit sizes, it may appear that those packers who have large pears to work with have an unfair advantage over the other packers. However, all packing plants have a prescribed rotation system that gives the packers an equal opportunity to pack the large fruit sizes. Essentially this system allows each packer a definite period of time to pack any given fruit size. At the end of this period, the worker shifts to the next fruit size station. Another packer rotates to the first packer's original position, and so on, until all packers have packed at each fruit size station. Then the rotation begins again.

The packing times listed in Table 3, however, provide a basis for those packing house operators who wish to change this rate of pay to packers to one based upon fruit size. Also this same information might be used in adjusting the rate of dumping in order to equalize this rate with the packing capacity of the plant.

Post-packing Operations

The post-packing operations consisted of closing the polyethylene liner after the pears had been packed. Two methods of performing this operation were observed. Four plants used vacuuming equipment to exhaust the air from the liner. These machines consisted of tubes connected to pipes leading to a central vacuum container. The exhausted liners were sealed with tape or wire ties. Two plants used a simple procedure of hand-folding the liner over the pears without previously removing any air from the pack. No attempt was made to seal the liners in these plants. The labor requirements and outputs of the post-packing operations of each plant are presented in Table 4.

Table 4. Average Polyethylene Labor Requirements and Outputs of Different Methods Used by Pear Packing Plants in the Post-packing Operation./3

Method of closing used	Plants B	C	A	F	D	E
	(man minutes per box)					
Exhaust liner	.30	.35	.39	.56	-	-
Close liner by hand	-	-	-	-	.35	.18
Tuck liner in box	-	-	-	-	.20	.20
Total time	.30	.35	.39	.56	.55	.38
	(boxes per man hour)					
Output	200	171	154	107	109	158

/3 Times include average productive polyethylene time only. The average per cent non-productive time for each plant was: Plant B, 40%; Plant C, 30%; Plant A, 22%; Plant F, 22%; Plant D, 18%; Plant E, 17%.

The man minutes per box shown in Table 4 varied as follows: Plant B, .27-.31; Plant C, .22-.59; Plant A, .30-.47; Plant F, .52-.61; Plant D, (close liner) .28-.46; Plant E, (close liner) .15-.21. The range for the tucking element for Plants D and E was .15-.22.

Exhaust machines were used by Plants A, B, C, and F. One exhaust unit, operated by two workers, handled the post-packing operation for all lines in Plant B. One worker received the boxes from the packing lines, clasped the liner around the exhaustion tube, and moved the box to the second worker. He then sealed the liner with tape and pushed the box down the conveyor to the weighing station. The labor requirement for the liner elements of this operation was .30 man minutes per box, the least time for all plants using the exhaust machines. The output per man hour was 200 boxes. Since the entire plant output went through one exhaust unit, the rate of boxes received from all packing lines was considerably faster than the rate in the plants using more exhaust units per packing line.

Plant C had six exhaust units, or stations, to handle the entire output of the house. One worker received the packed boxes from the packing line, clasped the liner top around the exhaustion tube, and tied the top of the air-depleted liner with a wire tie. The operator then moved the boxes on a roller conveyor toward the weighing and lidding station. The polyethylene elements of this operation required .35 man minutes per box. The output was 171 boxes per man hour. A comparatively slow rate of boxes from the packing line for each of the machines may have caused this time to be higher than if each machine had been more fully utilized. Undoubtedly fewer exhaust machines could handle the entire plant output. However, it would be necessary to re-locate existing conveyor and receiving facilities before the boxes from all packing lines could be funneled to less than the six exhaust machines used.

In Plant A, three crews of two operators each carried out the post-packing handling of the polyethylene liner. One operator for each crew received the packed boxes from the packing line, pulled up the sides of the liner, and fitted the liner top around the exhaust tube. The second operator wrapped a wire tie around the top of the exhausted liner and moved the box on the conveyor to the weighing station. The labor requirement for this operation was .39 man minutes per box, and the output was 154 boxes per man hour. At this plant the use of two operators per machine and one machine for each packing line reduced the number of packed boxes handled by each worker. This organization of equipment and personnel increased the labor requirement per box.

In Plant F, exhaust machines mounted on portable tables were used for the post-packing handling of polyethylene. Two workers at each of two tables were employed to exhaust the output of one packing line. At each table one worker received the boxes from the packing line, pulled up the liner sides and exhausted the air. He then twisted the liner top to prevent the air escaping. At this point the second worker received the box and taped down the twisted top.

Again it appeared a case of too many workers for the rate of fruit caused a comparatively high time requirement of .56 man minutes per box for this method. It would have been possible to reduce the number of crews, and, thus, reduce the time requirement. Another factor that contributed to the high requirement was the limited vacuuming capacity of the exhaust machines. Output at this plant averaged 107 boxes per man hour.

The tape used to close the liners in Plants B and F proved ineffective as a means of maintaining a tight seal. However, the necessity of a tight seal to increase storage life and preserve fruit quality has yet to be definitely established. This point is further discussed later in this chapter.

In plants D and E operators pulled up and folded the liner over the top of the pears in each box. A pear was placed on top of the fold to keep the liner closed until the box was lidded. One worker then moved the boxes to the weighing station. Four workers performed this operation in Plant D, while only two workers were required in Plant E.

In these plants no air was taken from the boxes before the folding procedure. This caused the liners to bulge out between the side slats of the boxes when lidded. Each plant used a team of two workers to tuck the liner back in the box after it had gone through the lidding machine. The workers used rubber bowl scrapers to perform this job.

Table 4 shows the post-packing time for Plant E was .38 man minutes per box. The time for Plant D was .55 man minutes per box. In both plants .20 man minutes per box was chargeable to the liner tucking element. The difference between the total post-packing operation time requirements of the two plants can be partially explained by the use of four operators in Plant D. Probably the slower rate of boxes from the packing line in Plant D also contributed to the higher labor requirement per box in this plant.

The liner tucking element accounted for the relatively high labor requirements of the post-packing operations of these two plants as compared with the plants using the exhaust machines.

Summary of All Liner Operations

Table 5 indicates that all three plants that fit the liner in the box for the packer (Method I) average less polyethylene time per box in the pre-packing and packing operations than the plants using Method II.

Table 5. Average Polyethylene Labor Requirements of Different Methods Used in the Pre-packing and Packing Operations.

		Operational method used					
		Method I Plants			Method II Plants		
Operation	Polyethylene element	A	B	C	D	E	F
		(man minutes per box)					
Pre-packing operation	Preparation of liners for packer fitting	-	-	-	.13	.20	.29
	Fitting liners for packer	.23	.31	.39	-	-	-
Packing operation (For 120 size fruit)	Fitting liner by packer	-	-	-	.30	.30	.30
	Adjusting liner by packer	.07	.07	.07	.07	.07	.07
Total pre-packing and packing time		.30	.38	.46	.50	.57	.66

This results from the fact that the Method I plants were able to combine the liner preparation and liner fitting elements into one job. This allowed better use of each worker's potential in the pre-packing operation.

A comparison of the labor requirements of the two methods indicates that those plants in which the packers fit the liner in the box would benefit by changing to Method I. However, Method I requires additional floor space for the pre-packing operation. Although the three Method II plants studied could readily adjust their plant layouts to incorporate Method I, some smaller plants in the packing industry not included in this study might encounter difficulties in this respect. Therefore, despite the advantages of Method I, these plants may find Method II more feasible.

Table 6 shows that Plants A, B, and C also had the most efficient post-packing operations. Although these were the plants using Method I of the pre-packing and packing operations, the efficiency of their post-packing operations was not related to the method used in the two previous operations.

Table 6. Average Polyethylene Labor Requirements of Different Methods Used in the Post-packing Operations.

Productive polyethylene elements	Plants					
	A	B	C	D	E	F
	(man minutes per box)					
Exhaust liner	.39	.30	.35	-	-	.56
Hand close liner	-	-	-	.35	.18	-
Tuck liner	-	-	-	.20	.20	-
Pre-packing and packing time/4	.30	.38	.46	.50	.57	.66
Total liner time	.69	.68	.81	1.05	.95	1.22

Although the exhaustion method of liner closing has a definite labor requirement advantage over the hand-folding method, the comparative effect of the two procedures on changes in fruit quality during storage may prove to be a more important determinant of the most efficient closing system to use. The pear industry suffered losses during the 1954-55 marketing season because some pears packed in polyethylene deteriorated in quality as the storage period progressed. Some packing house operators believe that this was caused by the use of a tight exhaustion and sealing method during the packing season. On the other hand, Gerhardt has shown that the hand-folding method affords the fruit only slightly more protection from quality losses than if it were not packed in polyethylene. He indicated that a tight seal seems to be necessary if an effective

/4 Source—Table 5.

concentration of carbon dioxide is to be accumulated. (6, p.25) The presence of a low concentration of carbon dioxide, but higher than present in the non-liner pack, is important in retarding the metabolism of the fruit. Some degree of exhaustion is undoubtedly beneficial in protecting the liner from puncture during the lidding process and storage period.

The total polyethylene times included at the bottom of Table 6 illustrate the accumulative labor requirement advantage Plants A, B, and C had over Plants D, E, and F. As it happened, plants using Method I also used the less time consuming method of closing the liner.

CHAPTER IV

SOME IMPLICATIONS OF TIME STUDY RESULTS

The results presented and discussed in the previous chapter showed a decided advantage for Method I as it related to the labor requirements for inserting polyethylene liners. However, labor used directly on polyethylene is not the only consideration that the pear industry must take into account in management decisions relating to the use of this new container material. Others include:

1. Effect of polyethylene on plant capacity, output, and costs.
2. Price differentials received for the polyethylene pack.
3. Effects of an increased efficiency on producers and consumers.

These considerations will be discussed in this chapter.

Effect of Polyethylene on Plant Capacity, Output, and Costs

The increasing use of polyethylene liners in the pear industry brings with it problems of internal plant adjustment that management must solve. One important problem recognised by management is the limited capacity of the existing plants to handle more packers than presently employed for the non-liner packing operations.

To present this problem clearly, the number of packers required to pack daily volumes of 2500, 5000, and 7500 boxes was determined for the non-liner and the two methods of polyethylene liner packing operations. These volumes were representative of the plants studied. It was assumed that the plants employed the maximum number of packers their facilities would permit. Indications of management were that this assumption was valid. It was further assumed that the estimated daily net working time for each packer was 384 minutes. This figure was based on a total possible working time of 480 minutes (an eight-hour working day). From this was subtracted a normal allowance of 20 per cent for rest periods and unavoidable delay. (13, p.13) The packing times used in this analysis were based on data taken in the study and included all activities of the packer for packing size 120 fruit.

Results of this analysis, presented in Table 7, show that the two liner methods require more packers per plant than the non-liner operation to maintain any given volume. With the number of packers already at a maximum, the use of polyethylene liners will bring about a decrease in the rate of plant output with the existing plant facilities and layout.

Table 7. Estimated Packing Time, Output per Packer, and Packers Required for Three Types of Packing Operations. (Size 120 Fruit)

Packing operation	Packing time per box (man minutes)	Daily output per packer (packed boxes)	Packers required for daily volume of		
			2500 boxes	5000 boxes	7500 boxes
Non-liner	3.48	110.3	22.7	45.3	68
Liner (Method I)	3.55	108.2	23.1	46.2	69.3
Liner (Method II)	3.85	99.7	25.1	50.2	75.2

This, then, points up the problem of the choice of methods management has if the polyethylene liner is to be used, under the condition that the number of packers working in a plant at any one time is limited.

It is now apparent that the use of the liner in the pear industry will increase. Hence, management is interested in the alternatives available to deal with the problem brought on by limited plant capacity. These alternatives include: (a) decreasing plant output, (b) increasing plant size, and (c) lengthening the packing season.

Decreasing present plant output appears to be improbable in both the short and long run. The production of pears is not sufficiently flexible in the short run, and it is not probable that they will be left unpacked once they are produced. The demand for pears is not likely to diminish over the long run, and it would not be in the interests of the pear industry to reduce the volume of pears shipped to market. If individual plants were to cut their outputs, the excess would undoubtedly go to other packing houses for processing. This could only financially weaken the plants that reduced their capacities.

The second alternative - increasing plant capacity - is more acceptable. However, it is doubtful if this could be done for most plants in less than two or three years. Probably it will eventually take place in most plants, at least to some extent.

A lengthened packing season is another possibility of maintaining the annual plant output when polyethylene is used. However, whether this is feasible depends upon the effect of delaying the harvest of the pears on fruit quality. To maintain optimum quality in storage pears must be picked at a certain stage of maturity. Within a few hours after picking they must be placed in cold storage to inhibit further ripening of the fruit.

In view of the alternatives, it is reasonable to expect management to favor Method I as a system for the pre-packing and packing operations. This, as has been previously pointed out, may not be the immediate reaction in plants whose present facilities can not accomodate the Method I operation.

To give a more substantial basis for choosing the best method of handling polyethylene, and to demonstrate the practical significance of the time differences presented in Table 5, labor costs were applied to determine the additional labor cost of each method. A comparison of these costs is given in Table 8.

Table 8. Additional Labor Costs of Different Methods of Using the Polyethylene Liner in the Pre-packing and Packing Operations./5

Plant operation	Method I plants A	B	C	Method II plants D	E	F
	(cents per box)			(cents per box)		
Pre-packing operation	.6	.6	.9	.3	.5	.7
Packing operation/6	-	-	-	.5	.5	.5
Total costs	.6	.6	.9	.8	1.0	1.2

/5 Includes cost of the non-productive time, determined by using the standard delay allowance of 20 per cent of total polyethylene time.

/6 Actual premiums paid to packers by all Method II plants.

The labor cost figures for the pre-packing operations are based on an average hourly wage of $1.20. This wage represents a range of $1.15 to $1.22 paid by all packing houses in the Medford district in 1955 for workers in these operations.

In all plants using Method II, where the liner is fitted by the packer, a one-half cent premium per box was paid for packing. Packers in Method I plants were not paid a premium for their time spent adjusting the liner during the packing operation. However, the one-half cent premium paid by Method II plants did not entirely compensate for the time spent by the packer in handling the liner. Nearly one and one-half cents would have been necessary to compensate for the added time. Packers may recognize this fact and bargain with plant management for an added premium when lining the boxes. If this is realized, the difference between methods in Table 8 will be even greater.

The results of the labor cost application indicate that those plants using the method of fitting the liner for the packer (Method I) have a labor cost advantage over those plants using Method II. The advantage is a substantial one. If this method were adopted on an industry-wide basis, it could effect annual savings of several thousands of dollars in labor expense.

Another point to be considered by management relates to the effect of the lining method on fixed costs. Packing plants hire a considerable amount of hourly-wage labor. Although some of this labor is necessary only when the plants pack in polyethylene, all of the workers must be retained on a full time basis throughout the packing season in order to assure an adequate labor force when needed. The principal reason for this situation may be found in the fact that pears received from the orchards in any one day vary greatly in quality. Plant managers indicated that they attempt to pack only good, sound fruit in the polyethylene liner. Therefore, in order to get all fruit quickly into cold storage, plants are forced to put up both polyethylene and non-liner packs within the same week or, frequently, within the same day. Hence, all of the hourly-wage labor represent short run fixed costs regardless of the type of pack or the resulting output. Other fixed costs would include machinery and building repair and depreciation, management, administration, and other overhead costs.

Total packing plant costs before storage have been estimated at $1.50 per box. (10, p.3) Indications from several industry sources would place the variable portion of this cost at about $1.15, leaving $.35 as the fixed cost per box. Assuming these figures apply to a plant with a daily output of 7500 boxes when the liner is not used, and using the figures in Table 7 as a basis for determining the amount this output is decreased when Method I and Method II of the liner packing operation are used, an inverse relationship between fixed costs per box and plant output can be derived. This relationship is demonstrated in Table 9.

Table 9. Comparison of Fixed Costs per Box and Plant Output for the Non-liner Packing Operation and for Two Methods of the Liner Packing Operation.

Packing operation	Plant output	Fixed costs	
	(packed boxes)	(cents per box)	(per cent increase)
Non-liner	7500	35	-
Liner (Method I)	7358	35.7	2.0
Liner (Method II)	6780	38.7	10.6

Table 9 indicates that fixed costs increase by ten per cent when Method II is used. The absolute fixed cost figures are based on limited available data. They are presented only as a rough approximation of these true costs for a 7500 box plant volume. However, the relationships derived from them are believed to be fairly accurate estimates of the existing differences among the three packing operations.

The foregoing discussion indicates that an immediate solution to the problem of a declining output when polyethylene liners are used is to resort to the Method I variation of the pre-packing and packing operations. This is an especially useful method for those plants whose present facilities will not allow any substantial increase in the number of packers employed. This method, in which the liner fitting element is done for the packers, allows them to pack approximately the same number of boxes per day as they would if polyethylene was not being used. The only added work is the liner adjustment element. This takes relatively little time. Method I not only does not require any significant increase in the number of packers to maintain a given plant output, but also, as shown in Table 8, averages one-half cent less in terms of additional labor costs per box than Method II. In addition to these advantages, the fixed cost-output relationship favors Method I over Method II.

The additional labor costs of using polyethylene in the post-packing operation showed a tendency to favor the plants that exhausted and sealed the liner. The average additional cost of these plants was .9¢ per box, as compared to 1.1¢ per box additional for the plants using the folding method.

From the preceding analysis, it follows that any method that permits total daily output to be maintained or increased is to be desired. This is true as long as the selling price per box is greater than the variable cost per box. Total fixed costs per day remain the same. Therefore, if the selling price per box is greater than the variable costs per box - which is constant - it is to the packing house operator's advantage to increase daily output as much as possible within the limits of a given plant size.

Consideration of Other Costs Involved in Using Polyethylene

In all plants studied the only significant variable cost of using the polyethylene liner for packing, other than the variable labor costs already considered, was the material cost of the liner. This cost amounted to about eight or nine cents each for all plants.

The cost of receiving and storing the liners and the cost of equipment installed to facilitate handling the liners was considered negligible.

Additional Prices Received for Pears Packed in Polyethylene

Trade sources indicate that the labor and material costs of packing pears in polyethylene liners can be estimated to range from ten to fifteen cents higher per box, regardless of the method of using polyethylene, than for non-liner packing.

Management is, of course, interested in the market premium paid for liner packed pears. In order to develop information concerning the differential between prices paid for liner and non-liner packed pears, a comparative analysis was made of the prices paid for these two types of pack shipped from the Medford district to the New York auction market for two marketing seasons. The data for the analysis was taken from daily auction market reports covering the period from January 1, 1954 to October 15, 1955. The analysis was limited to the five most common sizes of the Anjou and Bosc varieties of winter pears. These are the two most important Oregon varieties packed in liners.

Table 10 shows that the average differential for Anjou pears ranged from -$.55 to $2.84 per box in 1954 and from $.22 to $.59 per box in 1955.

Table 10. Average Differentials Paid for Oregon U.S. No. 1 Anjou Pears Packed in Polyethylene Liners on the New York Auction Market in 1954 and 1955.

Month	Size 80	100	120	135	165	Average
1954	(dollars per box)					
February	-.52	-.62	-.73	-.58	-.31	-.55
March	.52	.36	.46	.42	.53	.46
April	1.27	1.30	1.32	1.25	.90	1.21
May	2.40	3.17	3.10	3.11	2.43	2.84
1955						
January	.20	.24	.16	-.03	.52	.22
February	.48	.35	.20	.20	.17	.28
March	.38	.40	.21	.19	.20	.28
April	.33	.59	.42	.72	.48	.51
May	.41	.78	.33	.73	.72	.59

The average price paid for the polyethylene packed pears in the month of February, 1954, was $.55 less per box than for the non-liner pack. This may be ascribed to the fact that the first significant quantity of pears packed in liners arrived on the New York auction market during that month. Auction buyers frequently will discount any innovations in packaging methods until convinced of their merits. (2, p.13) The prices paid for the pears in succeeding months, however, indicates not only their final acceptance of polyethylene as a packing medium, but also their preference for it.

It is significant to note that the differential widens as the marketing season progresses during both years. This trend attests to the superiority of the liner in maintaining fruit quality for a long period of time. This is not necessarily precluded by a possibility of over-estimation of the value of the pears packed in the liner in the months of April and May, 1954.

The differential was considerably less in 1955 than for every corresponding month in 1954. An increasing volume of liner-packed pears in 1955 is possibly the cause of this. Comparative figures for the Medford district alone are not available for the two years, but for the three Pacific Coast states the volume of winter pears commercially packed and shipped in polyethylene increased from 300,000 boxes in 1953-54 to almost one million boxes in the 1954-55 season. (6, p.26) Preliminary figures indicate that the volume packed in polyethylene in the 1955-56 season will double that of the preceding season. (22, p.1) The extent of the effect of future increases in the marketing of liner packed pears on the price differential is a matter of speculation. However, the pear industry feels that the advantages of polyethylene in maintaining fruit quality and in lengthening the marketing season will continue to induce the market to pay a premium at least adequate to cover the additional costs incurred in packing.

A similar analysis for the Bosc variety tends to substantiate the results found for the Anjous. Lack of data, due to insufficient and irregular shipments of this variety, hinders a more thorough analysis. The summary table of differentials paid for Bosc pears packed in polyethylene is included in Appendix III.

Benefits of Increased Efficiency in the Packing House

Any increase in technological efficiency, and the consequent reduction of costs implied, that may result from using different methods of handling polyethylene in the packing house should contribute to improved positions for two affected groups—pear producers and consumers.

The extent to which any benefits of reduced marketing costs of pears are shared by the two groups is determined by the characteristics of the supply and demand functions for that product. If the supply and demand functions have equal elasticities, producers and consumers share equally in the benefits. (4, p.408) However, as in the case of most farm products, the supply function for pears is less elastic than the demand function in the short run. That is, the supply of pears is less responsive to a given price change than is the demand for pears. This is especially significant in the case of pears grown in the Medford district. Horticulturalists estimate eight to twelve years are required for new plantings of the important varieties packed in polyethylene to bear in commercial quantities.

With the supply-demand relationship in mind, it may be reasoned that a firm which has minimized its costs, under the new packing conditions, to gain a competitive advantage in the industry will attempt to increase the volume of pears it receives from producers to maximize its returns. To do this, prices to producers for an existing supply, which cannot be expanded in the short run, will be bid up through a competitive process. Theoretically, firms that have reduced their costs will be able to pay better prices to the producers without raising prices to the market. Producers will, therefore, receive most of the benefits of a marketing cost reduction in the short run.

With particular reference to the Medford pear industry, the pear producers may not immediately receive the benefits derived from a cost reduction because the plants best able to bid for a larger volume of pears are presently handling capacity volumes. However, there is no reason to believe that the analysis still does not apply within the span of the short run. Plants will be able to expand facilities within two or three years.

In the long run, here defined as starting after a sufficient period for new fruit trees to begin bearing marketable fruit in commercial quantities, the supply function may become relatively less inelastic than the demand function, assuming that other variables remain constant. Then, in order to clear the market of an increased production of pears, prices will have to be lowered to the consumer. Hence, the long run beneficiary of a marketing cost reduction may well be the ultimate consumer. (4, p.408)

The interest of the pear industry in the effect increased efficiency has upon the producer should be obvious, especially if the producers are considered an integral part of the industry. Many packing plants, in fact, own and operate their own orchards. In any case, the packing plants work closely with the farmers in production problems such as fertilizer and spray applications, quality development, and timeliness of harvest. They are, to a large extent, dependent upon the producer for the high quality fruit necessary for their success.

The interest of the industry in the ultimate effects of increased efficiency upon the consumer may be more obscure. However, the progressive, top-level management, at least, realizes the importance of consumer reaction to its product. This reaction is conditioned by both price and quality. How the ultimate consumer reacts to these product characteristics will definitely affect the industry's effort to maintain or improve its present position in the market place.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was made at the request of representatives of Oregon's pear industry to provide a basis upon which efficient, low-cost methods of handling polyethylene liners in pear packing houses could be developed. The objectives of the study were (1) to determine the time requirements of different methods of using polyethylene in pear packing houses, (2) to recommend efficient handling methods for the liner, and (3) to appraise the economic implications of this technological development.

To accomplish these objectives, time studies were made of the labor requirements of polyethylene liner handling methods in six plants in the Medford area. The operations studied were the only ones employing a significant amount of labor directly attributable to the polyethylene liner. Two general methods of the pre-packing and packing operations and two methods of the post-packing operations were included in the study. Method I and Method II were used to insert the liner in the former operations. The exhaustion and hand folding methods of closing the liner were observed in the post-packing operation.

The work sampling technique was used to collect the labor time data. This technique enables the taking of a comparatively large number of observations on several workers simultaneously. Packing operation data was subjected to regression analyses to determine the labor requirements of packing different sizes of pears, as well as the labor requirements of the polyethylene elements of this operation.

It was concluded that Method I required the least amount of labor of the two methods studied in the pre-packing and packing operations. The liner fitting and liner preparation elements were combined in the Method I plants. Therefore, better use of each worker's potential in both the pre-packing and packing operations was realized. Also the use of Method I permitted a higher rate of output of packed fruit per plant than did Method II. Plant facility, output, and cost criteria all favored the adoption of Method I over Method II. However, some plants might not be able to adopt Method I immediately because of the physical limitations of their facilities.

The exhaustion method of liner closing showed a labor requirement advantage over the hand closing method. Whether the exhaustion method will gain wide spread adoption by the industry will depend upon the comparative effects of a tight or loose seal upon fruit quality and its storage life.

A price differential analysis was made to determine the premium paid for pears packed in the polyethylene liner. This analysis showed that buyers definitely favored the liner packed pears. The premium paid for these pears amounts to more than the additional costs incurred in packing in polyethylene. The differential widens as the marketing season progresses, attesting to the quality-sustaining characteristics of the liner.

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APPENDIX I

LIST OF JOB ELEMENTS MEASURED

Pre-packing operation:

Plant	Productive liner elements	Productive non-liner elements	Non-productive elements
A	Shake liner and pull on mandril Put box on mandril Put box on belt	Get box Place box on chute	Wait
B	Shake and insert liner Move box Adjust liner	Hang boxes on monorail	Wait
C	Shake and insert liner Fold liner over box Adjust liner Change stations	Hang boxes on monorail	Wait
D	Get liner Shake and place liner in box	Place box on chute Stockpile boxes Line boxes with cardboard Push boxes down chute Move station	Wait
E	Shake and place liner in box	Hand and adjust boxes on hook Get boxes	Wait
F	Shake liner Roll liners Place liner in box Get liner supplies Handle liner Box handling due to liner	Handle boxes Push boxes down chute Move station	Wait

Post-packing operation:

Plant	Productive liner elements	Productive non-liner elements	Non-productive elements
A	Exhaust liner Move box Tie liner	Handle boxes	Wait
B	Exhaust liner Tape liner	(none)	Wait
C	Exhaust liner Tie liner	Move box	Wait
D	Close liner Move box Change stations Tuck liner	(none)	Wait
E	Close liner Move box Change station Tuck liner	(none)	Wait
F	Exhaust liner Move box Tape liner	(none)	Wait

Packing operations:

Operation	Polyethylene elements	Non-polyethylene elements
Non-liner	(none)	Get box Pack box Dispose box Miscellaneous/7
Liner (Method I)	Adjust liner	Get box Pack box Dispose box Miscellaneous/7
Liner (Method II)	Position liner in box Adjust liner	Get box Pack box Dispose box Miscellaneous/7

/7 Miscellaneous elements include stamp box, get wraps, and move station.

APPENDIX II

DETAILS OF THE REGRESSION ANALYSIS

The method of analysis used in this study to determine the time requirements to pack different size pears was an improvement developed by R. A. Fisher in 1924 on the then existing multiple correlation methods used to handle comprehensive analyses involving several variables./8 (7, p.6)

Essentially the method, as used here, consists of setting up an equation of the form,

$$Y=A_1X_1 + A_2X_2 + A_3X_3 + A_4X_4 + A_5X_5 + A_6X_6 + A_7X_7 + A_8X_8 + A_9X_9. \text{---}(1)$$

In this equation:

Y represents the total man minutes of packing time for an individual study,

A_1 to A_9 represent man minutes per box of each of the nine fruit sizes,

X_1 to X_9 represent the number of boxes packed of the fruit size associated with the accompanying A values.

That is, X_1 represents the number of boxes of size 80 fruit packed, X_2 the number of boxes of size 90 fruit packed, and so on to X_9, which represents the number of boxes of size 180 fruit packed. Then each

/8 Fisher developed the improvement in connection with his study of the effect of precipitation in wheat yields at Rothamsted, England. This study was entitled, The Influence of Rainfall on the Yield of Wheat at Rothamsted. It may be found in the following reference: Roy. Soc. (London) Phil. Trans. Ser. B, 213:89-142.

of the corresponding constants, A_1, A_2,----A_9, represent the net effect of a particular fruit size upon the final total man minutes (Y). Then it can be said that any A value is a function of the corresponding fruit size.

It was assumed that this function was a simple relationship, expressable as a second degree polynomial. This being the case, the numerical values of the constants could be represented by an algebraic expression in which the independent variable is the fruit size. (7, pp.6-7) Under the assumption that this relationship was a second degree polynomial, the general equation was written

$$A_i = b_o + b_1w_i + b_2w_i^2 \qquad (2)$$

where A_i equals man minutes per box of a particular fruit size, w_i equals a fruit size, and the b's are constants to be determined. The b_2 value was found non-significant at the five per cent level. This would indicate that A is a linear function of fruit size.

A system of equations was then set up from the general equation (2) by letting w (size fruit) take the values 80, 90, 100, 110, 120, 135, 150, 165, and 180. However, to simplify the calculations these values were coded in the following manner:

Size fruit (w)	Coded values
80	-40
90	-30
100	-20
110	-10
120	0
135	15
150	30
165	45
180	60

The final form of the nine equations used to determine the A values was:

$$A_1 = b_o + b_1w_1 + b_2w_1^2 = 3.117 + .0223(-40) + .000041(-40)^2 = 2.29$$
$$A_2 = b_o + b_1w_2 + b_2w_2^2 = 3.117 + .0223(-30) + .000041(-30)^2 = 2.48$$
$$A_3 = b_o + b_1w_3 + b_2w_3^2 = 3.117 + .0223(-20) + .000041(-20)^2 = 2.69$$
$$A_4 = b_o + b_1w_4 + b_2w_4^2 = 3.117 + .0223(-10) + .000041(-10)^2 = 2.90$$
$$A_5 = b_o + b_1w_5 + b_2w_5^2 = 3.117 + .0223(\ 0\ ) + .000041(\ 0\ )^2 = 3.12$$
$$A_6 = b_o + b_1w_6 + b_2w_6^2 = 3.117 + .0223(15) + .000041(\ 15)^2 = 3.46$$
$$A_7 = b_o + b_1w_7 + b_2w_7^2 = 3.117 + .0223(30) + .000041(\ 30)^2 = 3.82$$
$$A_8 = b_o + b_1w_8 + b_2w_8^2 = 3.117 + .0223(45) + .000041(\ 45)^2 = 4.20$$
$$A_9 = b_o + b_1w_9 + b_2w_9^2 = 3.117 + .0223(60) + .000041(60)^2 = 4.60 \text{---} (3)$$

The final numerical quantities arrived at in this system can be substituted for the constants in equation (1). However, for purposes of this study, this step was not necessary.

The quantities computed in equation (3) were derived from packing data that included data from the non-polyethylene elements of twenty-four liner packing operation studies as well as the data from twenty-four non-liner packing operation studies. These quantities are used as estimates of the packing times of the nine fruit sizes for the non-liner packing operation.

To determine the additional amount of time a packer needed to perform the polyethylene elements of the packing operation, the same multiple correlation method was used on data obtained from the studies taken of the liner packing operations only. The A values were first determined from the data which included the polyethylene elements. Then the A values were determined from the data excluding the polyethylene elements. The difference between any two A values representing the same fruit size are attributed to the polyethylene elements of the packing operation. These differences served as the estimates of the time requirements of the polyethylene liner in the packing operation. The A values and the differences attributed to the polyethylene elements are summarized as follows:

Fruit size	Including polyethylene elements	Excluding polyethylene elements	Difference (attributable to liner elements)
	——man minutes per box——		
80	2.14	1.85	.29
90	2.54	2.23	.31
100	2.91	2.23	.32
110	3.26	2.93	.33
120	3.58	3.23	.35
135	4.02	3.64	.38
150	4.40	3.98	.42
165	4.73	4.26	.47
180	5.00	4.48	.52

The confidence intervals of the packing times for each fruit size in the non-liner packing operation were also determined. The general equation used was,

$$V(A_i) = V(b_o) + w_i^2 V(b_2) + w_i^4 V(b_3) + w_i Cov(b_1 b_2) + w_i^2 Cov(b_1 b_3) \\ w_i^3 Cov(b_2 b_3) \qquad \text{————————} (4)$$

where V and Cov represent, respectively, the variance or covariance of the associated terms in parentheses, A_i represents the packing time (man minutes per box) of a particular fruit size, and w_i

represents the coded value of a particular fruit size.

In equation (4), then,

$V(b_1) = c_{11}s^2$	$Cov(b_1b_2) = c_{12}s^2$
$V(b_2) = c_{21}s^2$	$Cov(b_1b_2) = c_{13}s^2$
$V(b_3) = c_{31}s^2$	$Cov(b_2b_3) = c_{23}s^2$

where the b, c, and s^2 values are constants to be evaluated from the raw study data. From equation (4) the standard deviation of each A was determined and used in the inequality,

$$A - t_{.05}(s_{A_i}) \text{ less than } A_i \text{ less than } A_i + t_{.05}(s_{A_i})$$

where the $t_{.05}$ value with 45 degrees of freedom is 2.014 and, s_{A_i} represents the standard deviation of a particular A value.

This inequality was used to determine the confidence intervals of the packing times (A values) of each of the nine fruit sizes. These intervals are:

size fruit	confidence interval (man minutes per box)
80	1.8172 - 2.7630
90	2.1671 - 2.8019
100	2.4492 - 2.9250
110	2.6713 - 3.1247
120	2.7842 - 3.3600
135	3.1955 - 3.7267
150	3.5077 - 4.1397
165	3.7255 - 4.6841
180	3.8202 - 5.3888

APPENDIX III

RESULTS OF BOSC PRICE DIFFERENTIAL ANALYSIS

Table 11. Average Differentials Paid for Oregon U.S. No. 1 Bosc Pears Packed in Polyethylene Liners on the New York Auction Market in 1954 and 1955.

Month	Size 80	100	120	135	165	Average
	(dollars per box)					
1954						
January	-	.33	.44	.59	.51	.47
February	.81	.52	.53	.52	.30	.54
1955						
January	.21	.29	.10	.04	-.10	.11
February	.18	.19	.09	.15	.13	.15
March	.94	.96	1.18	1.32	1.42	1.16