more—is necessary during this procedure to assure settling of the fruit.

Vibration settling is one of the most critical parts of the tight-fill operation. An automatic vibrator, under development by the University of California, was used in the 1963 tests. This incorporates positive timing and positive seating of the cover. It appeared to improve fruit settling over anything which could be done by hand.

### Padding

Both top and bottom pads are necessary. Half-inch envelope pads of either excelsior or redwood bark are suitable. The bottom pad reduced injury due to impact bruising; the top pad reduced injury due to vibration. Where the fruit was uneven across the top of the container, loose excelsior was better than excelsior or redwood bark pads. However, loose packing material was objectionable to both the packer and the receiver. Acceptable results in these tests were obtained with an envelope top pad.

### Closing

The lid must be closed under pressure to assure tightness within the container during transit. Both depth of fill and closing pressures should be such that the fruit is held as firmly as possible without crushing. This requires careful attention to all steps in the packing operation.

### Fruit firmness

Tests were made with fruit of normal commercial maturity for both local and eastern shipment, rather than with so-called "tree ripe" fruit, of which only a small volume is marketed. The very early soft tipped varieties were also not tested. Such varieties are often shipped in single-layer flats to protect the tips from compression bruising. Such soft fruit requires special handling. Thus, fruit for tight-fill packing should be of comparable firmness and maturity to that shipped commercially either to local or eastern markets.

For a complete detailed report of this program, the reader is referred to University of California Information Series in Agricultural Economics No. 64–1, "Technical and Economic Evaluation of New and Conventional Methods of Packing Fresh Peaches and Nectarines."

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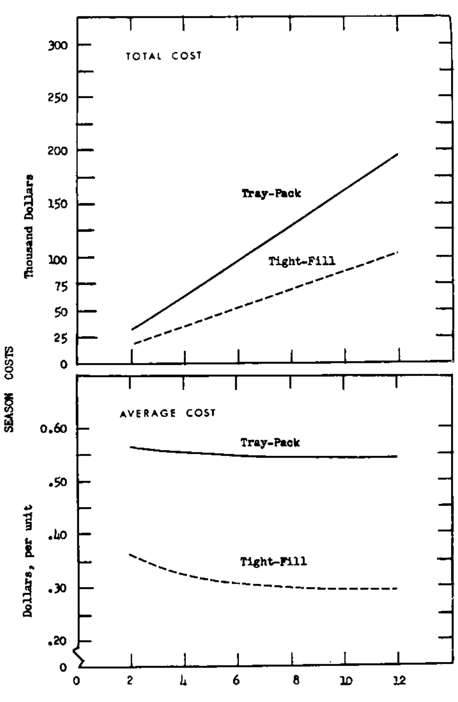
# ECONOMIC-ENGINEERING COST STUDIES PROVE VALUE OF TIGHT-FILL PEACH PACKING

R. H. REED • R. H. DAWSON

Studies were made of place-packing and tight-fill procedures with fresh peaches and nectarines in relation to the amounts of labor and equipment required at various rates of packout and lengths of season (for sizing and packing operations only). In commercial operations, as analyzed in this study, two types of equipment are most commonly used in place-packing operations: belt equipment and bin equipment. Belt packing requires the selection of unsized fruit from a conveyor. In bin-packing operations, the fruit is passed over a mechanical sizer and delivered, by size, to bins from which it is place-packed. For each type of equipment, one or both of two styles of pack are used: the cup-pack and the tray-pack. With the cup-pack, each fruit is placed in thin paper cups and then pattern-placed in the container. In tray packing, sized fruit is placed in the cells or depressions of preformed trays. Place-packing methods, representing specific combinations of type of equipment and style of pack, are given specific consideration.




**Peaches and Nectarines: Total and Unit Season Costs of Tray-Pack Operations with Bin Equipment and Automatic Tight-Fill Operations in Relation to Selected Rates of Output and 300 Hours of Operation per Season, California, 1964.**

Analyses of operations and costs with the tight-fill packing procedure are based on data obtained from three plants in the same general area, supplemented by a synthesis based on data obtained from pomologists, engineers, and equipment manufacturers. Data were also used from previous studies of operations in pear and plum packinghouses. The tight-fill pack, as described in the accompanying article, consists of filling a container with fruit, settling it by vibration, and closing the lid under pressure. Packing labor with the tight-fill method is partly or wholly replaced by semi-mechanical or automatic gravity-fed bulk fillers.

### Automatic filling

With automatic filling, quality graded fruit flows to the packing area over a weight or dimension sizing assembly. When a weight sizer is used, the fruit fed to the sizer is received by a patented plastic belt system that aligns the fruit in single file from which it is deposited into parallel rows of individual plastic cups which pass over a series of scales preset to the desired weight. Sized fruit is then deposited on a foam plastic ramp that leads to a side-delivery belt, which conveys it to bulk fillers where the cartons are automatically filled to a predetermined weight, as governed by the scale on the filler. The full boxes are automatically ejected from the filler onto powered conveyors which lead to the main fruit conveyor. Empty boxes are supplied to the packing area by an overhead monorail conveyor. A scale is installed in the packed fruit line for checking fill weight. With dimension sizing, the sizing unit most commonly used is the diverging slat-sizer, whereby the fruit is conveyed by a series of metal flights that gradually widen to allow successively larger fruit to drop onto cross collection belts. Other operations are essentially the same as described above.

With semi-mechanical filling, the quality graded and sized fruit is delivered by size to a series of holding bins. The fruit may be sized either by weight or dimension sizing equipment. In the filling operation, a worker places an empty container beneath the fill-chute, and releases the fruit by means of a lever-operated gate. When the container is filled, the operator releases the lever to close the gate, and pushes the full box along a roller conveyor to the check-weigh scales. He then adds or removes fruit to make the desired weight, and asides the box to the conveyor leading to the vibrator. At higher output rates, the filler operator is provided with a helper who handles the check-weigh and set-off jobs. A conventional three-deck conveyor assembly is used for packed fruit removal and for supplying the empty cartons.

Production standards for each method and size of operation were developed from studies of actual packing operations, plant record data, interviews with equipment manufacturers, and from data obtained from other studies.

Variable costs for each method were calculated by applying appropriate cost rates to the quantities of labor, materials, power, and other inputs directly related to the volume of output. Replacement costs for equipment were estimated at current installed prices quoted by equipment manufacturers. An annual fixed charge, expressed as a percentage of replacement cost, was used to reduce investment cost to an annual or per season basis. These charges included allowances for depreciation, taxes, insurance, interest on investment, and fixed repairs and maintenance.

Comparisons of packing costs with different methods and types of equipment must take into account both fixed and variable costs. This is conveniently done in terms of total costs per season. Total season costs, related to hourly rates of packout, methods used, and length of season, are calculated by adding total variable costs per season to the annual fixed charge for equipment.

**Place-packing costs**

Comparative cost analyses of place-packing methods were based on two different types of piece-rate wage plans: the typical wage plan in which packers are paid a constant 10 cent rate per container irrespective of fruit size distribution, style of pack, or type of equipment used; and an "adjusted" wage plan in which the typical piece-rate is adjusted so as to equalize average hourly packer earnings among the methods involved.

The comparisons made on the basis of the "adjusted" wage plan, showed that the use of bin equipment, coupled with a tray-pack, results in cost savings that range from 2 to 3 cents per lug. The tray-pack, bin equipment method was also the least costly when calculated on the basis of the typical 10-cent wage plan.

**Tight-fill costs**

Irrespective of the method of size-grading, the total hourly variable costs of the automatic tight-fill pack were less than with the semi-mechanical method. Total season costs (including both fixed and variable cost components) were also less for the automatic tight-fill pack than for the semi-mechanical method.

**Cost comparisons**

The cost relationships shown in the graphs are for the tray-pack, bin equipment method of place-packing size no. 80 fruit and tight-fill packing of weight-sized fruit with automatic filling equipment. Packaging costs are shown to be much less with the tight-fill procedure than with place-packing for all rates of packout and lengths of season shown. For an output rate of 600 Los Angeles lug equivalents per hour, and an operating season of 300 hours, the total season costs were about $98,000 with place-packing and nearly $56,000 with the automatic tight-fill method. The corresponding unit costs—also shown in the graphs—are about 55 and 31 cents per Los Angeles lug equivalent, respectively. Cost savings with tight-fill packing in this example amount to about $42,000 per season or approximately 24 cents per Los Angeles lug equivalent. These savings are attributed to reduced costs of package materials and labor.

Cost savings with the tight-fill pack were smaller, but still appreciable for small plants operating short seasons. With a season of 100 hours, unit cost savings with the tight-fill pack (for an hourly packout rate of 200 Los Angeles lug equivalents) would amount to approximately 18 cents more per lug equivalent than that obtained with the tray-pack, bin equipment method. Large cost savings would also result if comparisons were made between place-packing and semi-mechanical tight-fill procedures.

Packaging cost components were compared (see table) for plants with an hourly capacity packout rate of 400 Los Angeles lug equivalents and operating 300 hours per season. Package materials costs are shown to be the most important component, amounting to about 75% of the total unit costs of place-packing, and about 82% of the total unit costs of the tight-fill methods. Labor costs in place-packing operations range from 19% of total unit costs with the tray-pack, bin equipment method to about 25% with the cup-pack, belt equipment method. Labor costs with tight-fill methods are much lower, representing about 9% of the total unit costs of semi-mechanical filling and nearly 5% with automatic filling. The unit cost comparisons given in the table again demonstrate the large cost savings in labor and package materials that are possible with the tight-fill pack. The analyses indicate that the total investment required for tight-fill pack could be recovered in a relatively short time.

COSTS PER CONTAINER FOR PACKAGING SIZE 80 PEACHES AND NECTARINES IN RELATION TO METHOD OF FILL, CALIFORNIA, 1964[a]

| Cost component | Place packing | | | | Tight-fill packing[b] | |
|---|---|---|---|---|---|---|
| | Belt equipment | | Bin equipment | | Semi-mechanical | Automatic |
| | Cup pack | Tray pack | Cup pack | Tray pack | | |
| | Cents per Los Angeles lug equivalent[c] | | | | | |
| Labor[d] | 15.03 | 13.63 | 13.77 | 10.47 | 2.84 | 1.59 |
| Power and repairs | .13 | .13 | .12 | .10 | .35 | .37 |
| Building and equipment | 1.41 | 1.40 | 1.81 | 1.63 | 3.05 | 3.12 |
| Packaging materials | 43.36 | 42.65 | 43.36 | 42.65 | 26.80 | 26.80 |
| Total | 59.93 | 57.81 | 59.06 | 54.85 | 33.04 | 31.88 |

[a] Packinghouse capacity: 400 Los Angeles lug equivalent per hour, operating 300 hours per season.
[b] Costs apply to weight-sized fruit.
[c] On an equal-weight basis, 100 Los Angeles lugs are equivalent to 60 tight-fill cartons.
[d] Place-packing labor costs based on "adjusted" price-rates to equalize average hourly packer earnings among methods compared.

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## ALMOND ROOTSTOCK COMPATIBILITY ERROR

AN ERROR has been noted in the key to symbols for the table on page 10, *California Agriculture*, September, 1964. It should read, "X = least *in*compatible," and "XXXX = most *in*compatible."