Efficiency in Fruit Marketing
accuracy and cost of small-sample grading systems for California fruit packing houses

B. C. French and R. G. Bressler

This article is the second section of Part VIII of a series of reports on the effects of packing-house equipment, plant layout, and work methods on efficiency and costs. These studies have been made co-operatively by the University of California Giannini Foundation of Agricultural Economics and the United States Department of Agriculture under the authority of the Research and Marketing Act of 1946.

Sample grading systems should provide a basis for accurate payments by packing-house management to growers for their fruit—and should limit possible error to within a pre-determined amount.

The more advance information the packing-house management has concerning the expected total season deliveries by each grower, the more efficiently can sampling systems be designed to achieve a desired degree of accuracy.

As every lot of fruit is received at the plant, a sample—usually several full lugs—is taken for examination. The proportions of the sample-fruit which fall into each grade are used to estimate the proportions of the entire lot. With this procedure, fruit of the various growers may be mingled—pooled—in the handling and packaging processes.

The method of selection of a lot-sample and the size of that sample are two important items to be considered when designing a sample grading system.

The practice of taking several full lugs of fruit at random from a lot is a method of sampling which is commonly used and probably does not give bad results. Mechanical sampling devices which provide convenient and unbiased methods of sampling the entire lot at random would be preferred.

The size of the sample taken from a lot affects the accuracy of the estimates of the proportions of fruit in each grade. Because the distribution of grades of fruit in the sample may differ somewhat from the true distribution of grades for all the fruit delivered by the grower, the estimates will be subject to some error. The magnitude of such differences can be reduced by increasing the size of the sample.

The graph on this page indicates how the per cent of fruit to be sampled from each lot changes with the total deliveries per season or per pool period for several designated degrees of accuracy. The curves in this diagram are based on the assumption that representative samples are obtained and that advance estimates are available concerning minimum season deliveries per grower. Nothing is known or assumed about the probable proportions of fruit falling in each grade.

Accuracy of the estimates is expressed as a per cent of the total weight or number of fruit of all grades and is considered in relation to total deliveries per season, rather than for each lot. For example, if the admissible error is to be limited to 1% and the true proportion—for the particular grade to which the error limit refers—is 50% for the season's deliveries, the estimated proportion for this grade may be expected to fall within 49% and 51% in the great majority of the samples.

Basic calculations are made in terms of numbers of individual fruit and are generally applicable to most fruits. Because the quantity of fruit is usually measured in terms of weight, an appropriate ratio must be used to convert to numbers. Gravenstein apples and Bartlett pears, for example, average about three fruits per pound. The lower olive figure appears, for example, average about three fruits per pound of field-run produce, but Sevillano olives average from 40 to 60 fruits per pound. The lower olive figure should be used estimating the number of fruits delivered by a grower to be more certain of limiting the error to the desired range.

The limits of admissible error shown in the graph on this page represent the upper limits of error that rarely will be reached or exceeded. These limits are based on the probability of obtaining an error of estimates once out of 20 times as large as, or

Continued on next page
The costs of sample grading include the costs for workers who collect, sort, weigh, tally, and transport the fruit samples and the costs of sample grading equipment which consists of items such as grading tables for pears and apples, sizing-sorting equipment for olives, and scales for weighing the fruit. Mechanical sampling devices for sample selection, used in some plants, are not included in this report.

The costs given in the table on page 13 represent only the annual costs of equip-

<table>
<thead>
<tr>
<th>Plant</th>
<th>Volume per season</th>
<th>Average volume of deliveries per grower</th>
<th>Estimated 1,000 fruit</th>
<th>Limit of admissible error for the average size grower</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1,000 pounds</td>
<td>per cent</td>
<td></td>
<td>Per cent of the total weight delivered</td>
</tr>
<tr>
<td></td>
<td>1,000 pounds</td>
<td>per cent</td>
<td></td>
<td>3.0%</td>
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<tr>
<td></td>
<td></td>
<td>per cent</td>
<td></td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>per cent</td>
<td></td>
<td>1.0%</td>
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<td></td>
<td></td>
<td>per cent</td>
<td></td>
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</tr>
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<td>210</td>
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<tr>
<td>L</td>
<td>4,524</td>
<td>115</td>
<td>345</td>
<td>0.04</td>
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<tr>
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<td>6,385</td>
<td>320</td>
<td>960</td>
<td>0.03</td>
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<td>240</td>
<td>720</td>
<td>0.03</td>
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<tr>
<td>R</td>
<td>9,000</td>
<td>320</td>
<td>960</td>
<td>0.02</td>
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<tr>
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<td>2,409</td>
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<td>0.09</td>
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</table>

* Costs for pears and apples based on large size sample grading table.

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Costs for a typical pear or apple packing house and a typical olive processing plant are given in the upper table on page 12. The per cent to be sampled from each lot for each size group was determined for several levels of accuracy from the graph on page 11. These figures were applied to the total quantities of fruit to be sampled for each size group. The columns were added for an indication of the necessary total quantities of fruit to be sampled by this plant to obtain various degrees of accuracy. These calculations, indicative of a rapidly increasing quantity of fruit sampled, thus an increasing sampling cost—with increases in accuracy, especially for higher levels of accuracy.

Following similar procedures, costs of sample grading were estimated for a number of plants now using separate-lot systems. These costs, for several degrees of accuracy, are given in the lower table on page 12. Details as to the season deliveries for each grower were not readily available for every plant, so sampling costs were estimated by using the average volume of deliveries per grower to determine the average per cent of fruit to be included in samples.

Sampling costs—per thousand pounds of fruit received—increased with increases in the degree of accuracy. The costs also increased with decreases in the average volume of deliveries per grower and again, because of the fixed costs for equipment, sampling costs decreased as the total plant volume per season increased.

Costs Compared

The cost of a separate-lot system depends on such factors as the length of the break periods between lots, the average size of lot, rates of plant output, and total direct hourly payroll.

Sampling costs are influenced by the desired degree of accuracy, the amount of advance sampling information available, and the distribution of total deliveries among individual growers.

The comparative costs of separate-lot and sample grading systems are illustrated by the bar-graph on page 13. For pear and apple plants studied, the estimated cost of the sampling system with a limit of admissible error of 1% for the average grower was, in all cases, less than the cost of separate-lot systems, even where the break period was as short as two minutes. Where the admissible error was limited to 1½% the cost of sampling was sharply increased. However, even in this case sampling costs were less than separate-lot costs in five of the nine plants.

The case for sample grading was less clear in olive plants. Costs of the separate-lot system per 1,000 pounds of fruit received were generally higher than in pear and apple plants, but so were sampling costs. With 1% accuracy, estimated sampling costs were less than present costs of separate-lot systems in seven of the eight olive plants. Also, they were less than the...
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EFFICIENCY

Continued from page 13

costs of a more efficient separate-lot system with two-minute breaks in five of the eight plants. However, where a limit of admissible error of only 1/2% was desired, sampling costs were greater than present separate-lot costs in all but one plant.

With a limit of admissible error of 1% or more, the sampling system had some cost advantage in the majority of the plants. Where a higher degree of accuracy was desired, both the present and the improved separate-lot systems were generally less costly than the sampling system.

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R. G. Bressler is Director of the Giannini Foundation of Agricultural Economics, University of California, Berkeley.

Other reports in this series compare house operations, methods, equipment, and arrangements. The comparisons may be used to establish standards for efficient and low-cost operation. With minor modifications, the results of these studies can be applied to many of the problems of packing and processing other fruits and vegetables. For detailed reports, address Agricultural Publications, 22 Giannini Hall, University of California, Berkeley 4, California.

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