HANDLING MECHANICALLY HARVESTED FRUIT AT THE PROCESSING PLANT[1]

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Several promising mechanical harvesting systems have been developed to a prototype stage and operated under commercial, or near commercial, conditions. Until now, their acceptance has been limited but is expected to increase if harvesting costs continue to rise. Thus, in the future, it is expected that processing plants will receive an increasing amount of mechanically harvested fruit. Just how this will affect in-plant handling of the fruit is being studied at the Citrus Experiment Station. Already, with only limited experience and research, several problems have been encountered which will need attention. This paper describes the condition of the fruit which might be expected from present mechanical harvesting systems and discusses some of the expected problems and their possible solutions.

Harvest Systems and Condition of Fruit

The limb shaker and catching frame system has reached a prototype stage of development (2). The fruit is detached by shaking limbs

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with a mechanical shaker. Catching frames collect the fruit which is automatically accumulated in a bin. A high-lift grove truck transports the fruit from the bin to a roadside semitrailer for hauling to the processing plant. A system developed at the Citrus Experiment Station has been tested over a 3-year period in cooperation with Libby, McNeill, and Libby, Southern Fruit Distributors, and Coca Cola Company, Foods Division.

A second harvesting system, of which a version is being used commercially, employs a tractor-mounted mechanical limb shaker to detach the fruit, which is then raked into a windrow for pick up either by hand or by a pick-up machine (5). The fruit is then hauled to the roadside semitrailer in a high-lift grove truck. This system, using a tractor-mounted shaker and a pick-up machine, was tested in cooperation with Lykes-Pasco Packing Company, Plymouth Growers Association, and Southern Fruit Distributors.

A third harvest system that has been operated under near commercial conditions shakes the limbs with oscillating air to detach the fruit, and collects it on catching frames for delivery into a high-lift grove truck. As in the other systems, the fruit is hauled to the roadside and dumped into a semitrailer for transport to the processing plant.

Samples from trailer loads of mechanically harvested oranges were inspected for visible damage. Also, a count was made of fruit with stems attached (Table 1). Replicated samples of the fruit from all harvesting systems were stored at 70° F to determine decay after 3, 5, and 7 days (Table 2).

Most of the damage occurred as splits, plugs, punctures, and bruises (oleocellosis). The percentage of "plugged" fruit is less in mechanically harvested than in hand harvested fruit. On the other hand, the percentage of fruit with stems over 1/2-inch long was higher in the mechanically harvested fruit. The percentage of fruit with stems attached decreased in 'Hamlin' and 'Pineapple' oranges as the fruit loosened near the end of the harvest season. Fruit samples stored at 70° F indicated that there was a considerable amount of concealed damage done during the mechanical harvesting process as indicated by accelerating decay after a 3-day period. This may not be a severe problem if the fruit is processed within 36 hours after harvest.

In-Plant Handling

Three semitrailer loads of fruit harvested with the Citrus Experiment Station's limb shaker and catching frame system were followed through Libby, McNeill, and Libby's processing plant at Leesburg. Fruit with attached stems was the biggest problem. Samples were taken: 1) at the tailgate of the truck; 2) after passing over the first grading table; 3) after passing through the storage bins, but before the second grading table; and 4) after the second grading table, before going to the extractors. The percentage of fruit with stems at each of these positions is given in Table 3.

An average of 8% of the fruit still has stems attached when the fruit entered the In-line extractors. They cause some problems in delivering the fruit into the extractors. In the extractor, the stems collected and packed in the upper extractor cups. If they are not constantly removed, a reduction in juice yield will occur. To remove these stems, the extractor has to be shut down and the stems picked out with a probe. The graders spent about 80% of their time on stem removal, thus reducing their efficiency in picking out cull fruit. Unless some type of stem removal system is devised, it is estimated the size of grading tables will have to be increased by 200 to 300% and the number of graders increased accordingly.

Libby, McNeill, and Libby's Agricultural Research Department suggested that ethylene gas injected into a closed trailer loaded with mechanically harvested fruit might loosen the stems enough to cause them to come off during the in-plant handling. One trailer load was exposed to ethylene gas for 12 hours prior to taking it to the processing plant. The trailer was covered with a tarpaulin and the gas injected (15 ml per minute for the first 10 minutes and then 2 ml per minute for the remaining time) through a perforated pipe placed in the bottom of the trailer. Fruit from the treated trailer and from an untreated trailer were sampled at several locations along the handling system. The percentages of fruit with stems still attached are given in Table 4.

Ethylene treatment loosened the stem sufficiently and many of them were shed along the conveyors between the tailgate of the truck and the first grading table. The percentage of fruit with stems getting through to the extractor was reduced by 43%. Another trailer of mechanically harvested fruit was treated with ethylene gas; but the outside temperature dropped to 32° F during the 12-hour treatment period, resulting in no noticeable loosening of the stems. This, of course, reflects the known time-temperature relationship of the physiological action of the ethylene.

Fruit condition of these first few mechanically harvested loads was such that prompt handling was necessary. One load that was held 24 hours had many injured fruit that were starting to break down. However, detailed studies over several years (3) have indicated that with reasonable care decay potential of most varieties should be within levels with which the industry has managed to live successfully in the past. In a summary of 3 years of holding test, it was noted that decay in mechanically harvested 'Hamlin' oranges was on the average no more than in handpicked 'Pineapples.' Decay in mechanically harvested 'Valencia' oranges and 'Marsh' grapefruit seldom exceeded that in handpicked 'Hamlins.' This surprising result is in part due to the fact that there are far fewer "plugs" in the mechanically harvested fruit than with the handpicked loads.

In a single experiment, good grapefruit sections were prepared with mechanically harvested 'Duncan' grapefruit. This is encouraging in view of the high percentage of 'Duncan' going to the sectionizing plants where the stem problem does not present nearly as much of a hazard as in juice plants using In-line extractors.

Experience in handling mechanically harvested fruit has drawn attention to several problems which will need attention. No doubt, some of them will become insignificant as the harvesting equipment is improved. Trash and sticks can be more easily removed in the grove than at the plant, thus reducing the associated problem of cleanup and disposal. Better machine design to reduce fruit damage will aid in reducing decay, thus inceasing the permissible hold period before processing.

The problems of adhering stems and increased decay potential cannot be overcome completely in the mechanical harvesting systems, but several possible solutions are available. One solution to the stem problem is postharvest treatment of the fruit with an abscission-inducing chemical such as ethylene. The possibility of this has been demonstrated. Another possible solution is to develop a machine to mechanically remove these stems as part of the in-plant handling system. The most attractive solution is the use of a preharvest abscission chemical to loosen the fruit. It has been shown with experimental abscission chemicals that the number of fruit with attached stems can be reduced, resulting in increased mechanical harvesting efficiency (6). An extensive effort is being made by research agencies and several chemical companies to develop a controllable, legal, and economical chemical for this purpose.

Although prompt processing is obviously preferable, preharvest and postharvest fungicides may provide a solution to the decay problem. A preharvest fungicide being studied by researchers at the Citrus Experiment Station has demonstrated remarkable decay control (1). A postharvest fungicidal fumigation treatment, that could be applied to bulk loads in semitrailers, is in prospect if legal approval can be obtained (4). Effective fungicides could extend the potential postharvest life of the fruit thus opening up a whole new area for potential economic gains in fruit harvesting. Operations could be determined by efficient coordination of labor and equipment, rather than by the frailty of the fruit. With dependable harvesting equipment, fruit handling could be programed into the plant directly from the tree. A proposal by industry leaders of a system whereby the fruit might be windrowed in the middles has encouraged the development of a high-capacity fruit pick-up machine. Although experimental fungicides have controlled decay well, field trials encountered some trouble from sunburned fruit (3). The economic possibilities of such systems will continue to be of interest to the researchers in view of developments in better decay control measures although protective measures against sunburn are still lacking.

CONCLUSION

The best information we have today suggested that there will be problems at the processing plant in handling fruit from the prototype harvest systems in their present stage of development. However, these are not considered severe enough as to hinder the acceptance of mechanical harvesting. Possible solutions to these problems look very promising, particularly if F.D.A. approval can be obtained for successful abscission agents and fungicides.

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Table 1.--Condition of oranges harvested by different systems sampled at the roadside trailer.[1]

Harvest systems	Visible fruit damage % split	% punctures	% plug	% bruised	% sound	Stems % stems	Avg. length of stems
Mechanical shaker							
Catching frame (H)[2]	2.3	6.5	1.3	2.5	87.4	40.9	2.0"
Mechanical shaker							
Windrow and pickup (P)	4.9	0.6	0.4	0.4	93.7	16.9	--
Conventional							
Handpicked (H)	0	0.6	12.8	0	86.6	9.5	2.1"

[1]Harvest systems were operated under different harvest conditions.

[2](H)- 'Hamlin (P)- 'Pineapple'

Table 2.--Decay in oranges harvested by mechanical systems and stored at 70° F.

Harvest systems	% decay from all causes, but mainly mold		
	3 days	5 days	7 days
Mechanical shaker			
Catching frame (H)[1]	3.1	17.4	33.5
Mechanical shaker			
Windrow-pickup (PB)	4.7	24.7	56.0
Air shaker			
Catching frame (P)	6.1	31.7	59.8
Conventional			
Handpicked (H)	0	7:7	15.1
Conventional			
Handpicked (PB)	0	2.6	2.6

[1](H)-'Hamlin' (PB)-'Parson Brown' (P)-'Pineapple'

Table 3.--Percentage of total fruit with stems at various locations in the handling system.[1]

Locations	% stems
1. Tailgate of truck	32
2. After 1st grading table	22
3. After storage and before 2nd grading table	11
4. After 2nd grading table and before extractor	8

[1]Average of 3 semitrailer loads of 'Hamlin' oranges harvested with tree shaker and catching frames.

Table 4.--The effect of ethylene treatment on the percentage of 'Hamlin' oranges with stems at various in-plant locations.[1]

Locations	Ethylene treatment	No treatment
1. Tailgate of truck	20	24
2. After 1st grading table	9	16
3. After storage and before 2nd grading table	10	11
4. After 2nd grading table and before extractor	4	7

[1]Determinations were made by personnel at Libby, McNeill, and Libby's processing plant.