wide variations in grove conditions and harvesting procedures. The tests indicated that a 40 percent increase in the pickers' picking rate could be expected in the orange grove described in this paper, provided the ground fruit was picked by a separate crew. The increase in terms of manpower eliminated per machine would be 1.01 man. In this grove the number of ground pickers needed to keep up with the platform pickers was 54 percent of one picker, thus giving the equivalent of 2.54 men per machine crew.

Assuming that an average picker receives approximately $2000 per season, then the gross savings due to the platform would be about $2000 if only the increase in picker's productivity is considered. The amount that the platform is used per season, the skill of the picker, and the grove conditions would greatly influence the gross savings. In order to apply these savings against the machine cost, pay rate per box would have to be adjusted so that the picker would still receive the same dollar return per day as when picking by the conventional method. This would be a difficult problem to solve.

The fatigue of the picker caused by the accelerated picking rate was not considered in this study. A prototype machine operated over an extended period would be needed before this factor could be evaluated.

SUMMARY

A study of the design requirements of a proposed picker's platform for use under current grove conditions revealed that it would have to transport two pickers to and from the grove, place them individually in picking position with a minimum of lost time, collect and store the picked fruit in bulk containers and discharge these containers when full.

An experimental picker's platform was built for use in studying some of the factors affecting the performance of the proposed picker's platform.

Tests conducted in an orange grove showed that the proposed machine could be expected to increase the pickers' picking rate 40 percent over the conventional method. This increase in terms of man-power eliminated would be approximately one man per machine.

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EFFECT OF DELAYED HANDLING AND OTHER FACTORS ON RIND BREAKDOWN AND DECAY IN ORANGES[1]

E. F. HOPKINS AND A. A. MCCORNACK[2]

Florida Citrus Experiment Station

Lake Alfred

Delay in handling of oranges from the time they are picked until packed can allow the development of rind breakdown about the stem end of the fruit, designated "stem-end rind breakdown," and can increase spoilage.

Stem-end rind breakdown occurs in fruits of Hamlin, Parson Brown, Pineapple, and Valencia varieties of oranges, especially when held for two or more days and subjected to low relative humidities and high rates of air flow before being washed, waxed and packed. This condition is characterized by a collapse of the rind tissue in the stem-end portion of the orange and often extends several centimeters from the fruit button (Figure 1). In general, stem-end rind breakdown is not evident in oranges within two or three days after picking when held under adverse post har-

[1]Cooperative research by the Citrus Experiment Station and the Florida Citrus Commission.

[2]Plant Physiologist and Assistant Horticulturist, respectively.

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vest conditions but shows up about six or seven days from the picking date.

The authors have previously shown (1, 2) that during the ethylene degreening of oranges, which may be considered an unavoidable delay in handling, if a high relative humidity of at least 85 percent and a low rate of air flow are maintained in the degreening room rind breakdown can be held to a minimum. Delayed handling under conditions of low relative humidity was also shown to increase the incidence of decay caused by stem-end rot and *Penicillium* mold. Other references to literature on rind breakdown are cited in the above papers.

While some attention was given to the effect of delayed handling on non-degreened oranges in our previous work, a more exten-

Table 1. Effect of Adverse Conditions in the Degreening Room on Stem-end Rind Breakdown and Decay in Valencia Oranges. Average of Four Experiments.

Degreened at:	Avg.* Temp. °F.	Avg.* R. H. %	% SERB 1 week	% TOTAL DECAY 2 weeks	% TOTAL DECAY 3 weeks
High humidity	85	94	0.6	9.7	20.4
Low humidity	83	74	77.5	27.2	41.9

*During degreening

R. H. = Relative humidity
SERB = Stem-end rind breakdown

Table 2. Effect of Delayed Handling of Ungassed Hamlin Oranges on Rind Breakdown and Decay. Average of Five Experiments.

Treatment	Avg. Temp. °F.	Avg. R. H. %	% SERB 1 week	% TOTAL DECAY 2 weeks	% TOTAL DECAY 3 weeks
Processed at once	70	**	0.4	12.0	23.0
Delayed handling	69*	77*	22.2	35.4	56.0

*During a 2 day standing period
**Packed in a closed carton after processing

R. H. = Relative humidity
SERB = Stem-end rind breakdown

sive study of this phase of the problem was deemed important and was undertaken in this investigation.

Experimental Methods

When degreening was required, the fruit was distributed at random into the desired number of lots of 80 to 100, depending on the average size of the fruits, as soon as received from the grove. Half of the lots were degreened at a relative humidity of 85 percent or above and the other half at a lower relative humidity. Degreening was started the same morning the fruit was picked. At the end of the degreening period it was washed, waxed, packed in closed cartons, and stored at 70° F. Inspections for rind breakdown and decay were made one week from picking date. Further inspections for decay were made after two and three weeks from the time of picking. At each inspection only decayed fruits were removed from the cartons. Oranges to be processed and packed without degreening were also distributed at random into a number of lots the same morning they were picked. Some of these lots were left unwashed and allowed to stand in open field crates on the packinghouse floor for two days before they were processed. Other lots were washed, waxed, packed at once and stored at 70° F. in closed cartons. Inspections for stem-rind breakdown and decay were made as described above for degreened fruit.

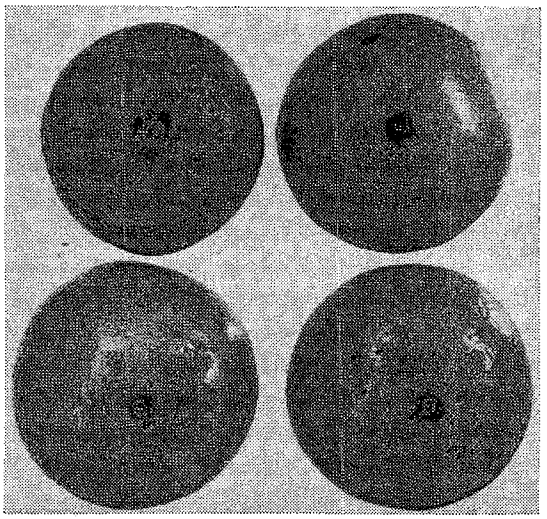

Fig. 1. Stem-end rind breakdown on Valencia oranges due to delayed handling.

Results

Degreened Oranges. — While most of the data to be given are concerned with non-degreened fruit, the results of a series of four experiments with Valencia oranges degreened for 48 hours at high and at low humidities are presented here to show the effect of adverse conditions in the degreening room on fruit of this variety in the 1959-60 season. The results (Table 1) show a very high incidence of rind breakdown in fruit degreened at an average relative humidity of 74 percent compared with practically none in that degreened at 94 percent. In addition to a high incidence of rind breakdown, fruit degreened at the lower humidity developed almost three times as much decay at two weeks and twice as much after three weeks. This is in agreement with our more extensive published work (1, 2) and again emphasizes the importance of careful attention to the relative humidity in the degreening process.

Non-degreened Oranges. — The effect of delayed handling of four varieties of ungassed oranges on rind breakdown and decay is shown in Tables 2 to 5. Comparison in each case is made with identical lots of fruit washed, waxed, packed in closed fiberboard cartons and stored at 70° F. the same morning the fruit was picked. It will be noted that a delay of two days in processing resulted in high percentages of stem-rind breakdown contrasted with very little in fruit handled promptly. Fruit of the Pineapple variety was especially susceptible to this type of peel injury. The average amount of rind breakdown recorded one week from picking for all varieties was 2.0 percent in promptly handled fruit and 33.9 percent for fruit processed after a delay of two days when held under prevailing conditions of temperature, humidity and air movement in the packinghouse. In addition to the effect on rind breakdown, delayed handling caused a very marked increase in the amount of decay recorded at two weeks. Decay in Hamlin and Valencia oranges was increased 3.0 times, in Parson Brown oranges 1.5 times, and Pineapple oranges 2.1 times as compared with promptly handled fruit.

A striking example of the effect of delayed handling shown in one experiment is given in Table 6. Valencia oranges, both pulled and clipped, were allowed to stand two days in

the packinghouse, at an average temperature of 76° F. and a relative humidity of 66 percent, before processing. They showed high amounts of rind breakdown at the one week inspection in both pulled and clipped lots compared with none in fruit processed at once. There were also high amounts of decay recorded at the second week inspection compared with practically none in promptly handled fruit. In a few experiments delayed handling increased the amount of decay without causing visible rind breakdown. For example, in one experiment no rind breakdown was recorded seven days from the picking

Table 3. Effect of Delayed Handling of Ungassed Parson Brown Oranges on Rind Breakdown and Decay. Average of Five Experiments.

Treatment	Avg. Temp. °F.	Avg. R. H. %	% SERB 1 week	% TOTAL DECAY 2 weeks	% TOTAL DECAY 3 weeks
Processed at once	70	**	0.9	26.0	43.8
Delayed handling	73*	76*	13.3	39.8	59.0

*During a 2 day standing period.
**Packed in a closed carton after processing.

R. H. = Relative humidity
SERB = Stem-end rind breakdown

Table 4. Effect of Delayed Handling of Ungassed Pineapple Oranges on Rind Breakdown and Decay. Average of Four Experiments.

Treatment	Avg. Temp. °F.	Avg. R. H. %	% SERB 1 week	% TOTAL DECAY 2 weeks	% TOTAL DECAY 3 weeks
Processed at once	70	**	5.1	23.5	41.8
Delayed handling	73*	73*	83.7	50.3	70.5

*During a 2 day standing period.
**Packed in a closed carton after processing.

R. H. = Relative humidity
SERB = Stem-end rind breakdown

date, but decay at the two week inspection increased from 3.8 percent in promptly handled fruit to 20.0 percent in that subjected to delayed handling.

An interesting relationship between stem-end rind breakdown and decay is shown by Pineapple oranges. Fruit which was allowed to stand for two days on the packinghouse floor before washing and waxing showed considerable variation between experiments in respect to the incidence of stem-end rind breakdown. This was due to variation in humidity and air movement during the standing period. Variation in fruit samples may also have been a factor. Statistical analysis of the data from 14 experiments showed a highly significant correlation of rind breakdown at one week with total decay at two weeks ($r = +0.866$). The relationship is shown in Figure 2.

Table 5. Effect of Delayed Handling of Ungassed Valencia Oranges on Rind Breakdown and Decay. Average of Four Experiments.

Treatment	Avg. Temp. °F.	Avg. R. H. %	% SERB 1 week	% TOTAL DECAY 2 weeks	% TOTAL DECAY 3 weeks
Processed at once	70	**	1.6	7.2	17.5
Delayed handling	77*	69*	16.6	21.3	30.7

*During a 2 day standing period.
**Packed in a closed carton after processing.

R. H. = Relative humidity
SERB = Stem-end rind breakdown

Table 6. Effect of a Two Day Delay in Handling Valencia Oranges. Average Temperature 76° F., Average Humidity 66% in the Packinghouse. One Experiment.

No.	Treatment	% SERB 1 week	% DECAY 2 weeks
1	Pulled fruit, processed at once	0	1.3
2	Pulled fruit, delayed handling	28.8	26.3
3	Clipped fruit, processed at once	0	0
4	Clipped fruit, delayed handling	37.5	22.5

SERB = Stem-end rind breakdown

An example of what might happen to oranges left outdoors is shown by Valencia fruits taken from a semi-trailer. These fruits were in the trailer for 22 hours at a low humidity and part of the time were exposed to direct sunlight. A sample was then placed in the shade of a tree. Average humidity in the shade was 54 percent; average temperature was 86° F. The total time from picking was about 44 hours. Comparison was made with

Table 7. Effect of Exposure Outdoors Before Processing on Rind Breakdown and Decay in Valencia Oranges. One Experiment.

No.	Treatment	Avg. Temp. °F.	Avg. R.H. %	% Sunburn 1 week	% SERB 1 week	% DECAY 2 weeks
1	Processed at once	70	**	0	1.3	3.8
2	Stood in Packinghouse 48 hours	81*	66*	0	8.8	12.5
3	Exposed outdoors, 44 hours	86*	54*	32.5	48.8	47.5

*During the standing period
**Packed in a closed carton after processing

R. H. = Relative humidity
SERB = Stem-end rind breakdown

Table 8. Effect of Delayed Handling on Rind Breakdown and Decay in Pulled and Clipped Oranges.

No.	Treatment	Pineapple Oranges % SERB 1 week	Pineapple Oranges % DECAY 2 weeks	Valencia Oranges % SERB 1 week	Valencia Oranges % DECAY 2 weeks
1	Pulled fruit, processed at once	3.3	22.8	0.3	3.4
2	Pulled fruit, delayed handling	49.6	39.5	16.3	21.3
3	Clipped fruit, processed at once	1.3	14.9	0	3.4
4	Clipped fruit, delayed handling	33.9	35.9	14.7	19.1

SERB = Stem-end rind breakdown

Pineapple Oranges
Average of 8 experiments
Average temperature 73° F.
Average relative humidity 73%

Valencia Oranges
Average of 4 experiments
Average temperature 78° F.
Average relative humidity 72%

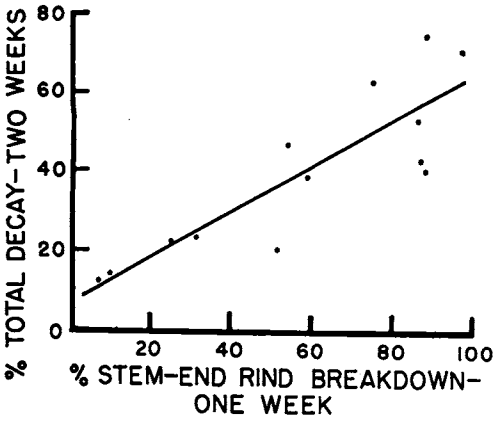

Fig. 2. Correlation of stem-end rind breakdown with decay in Pineapple oranges subjected to delayed handling. Regression equation, E = 0.584X + 6.12.

other fruit of the same variety picked the same day and: 1. processed and packed without delay; 2. allowed to stand 48 hours in the packinghouse. The results of this test are given in Table 7. In addition to heavy rind breakdown and decay in oranges left outdoors, there was also considerable sunburn.

Experiments were carried out to determine whether pulled fruits were more susceptible to stem-end rind breakdown than clipped fruits. The theory was that pulling, even when the fruit was not plugged, might injure tissue about the stem-end and make it more liable to breakdown. In eight experiments (Table 8) with Pineapple oranges the average amount of rind breakdown due to delayed handling in pulled fruits was 49.6 percent; in clipped fruit it was 33.9 percent. Statistical analysis of the data showed the difference to be on the borderline of significance. There was no significant difference in total decay between pulled and clipped lots after two weeks storage. Results of five experiments with Valencia oranges (Tables 6 and 8) showed very little difference between pulled and clipped fruits in respect to rind breakdown or to decay. In these experiments, however, there were marked differences in rind breakdown and decay for both methods of picking between oranges processed at once and those allowed to stand two days before processing.

Curing non-degreened Valencia oranges was investigated as a means of controlling rind breakdown when a delay in processing is unavoidable. Curing was done in degreening rooms at a high relative humidity for two days. No ethylene was used. In one room the temperature was controlled at 85° F. and in the other room, without temperature control, the average was 76° F. Comparison was made with fruit which stood on the packinghouse floor for the same period. Curing at 85° F. reduced rind breakdown from 16.6 percent to 3.8 percent, but increased decay from 15.0 percent to 17.5 percent. Curing at room temperature reduced rind breakdown from 16.6 percent to 3.3 percent and reduced decay from 15.0 percent to 10.7 percent.

Discussion and Summary

Data presented in this paper bring out very forcefully the importance of prompt handling of oranges for the fresh fruit market, when the degreening season is over, in order to reduce losses from stem-end rind breakdown and decay resulting from delayed handling. This was shown to be true for four of the common commercial varieties. Fruit subjected to delayed handling developed, on the average, 34.0 percent stem-end rind breakdown compared with only 2.0 percent for fruit processed the same morning it was picked. Delayed handling also caused a marked increase in decay from 17.2 precent in promptly handled fruit to 36.7 percent in that subjected to a delay in processing, or over twice as much. The total loss in marketable fruit from rind breakdown combined with excessive decay was found to be very great due to delayed handling.

Oranges exposed outdoors also developed high amounts of rind breakdown, sunburn and decay. When ungassed oranges cannot be handled without delay, the results showed that rind breakdown can be controlled by holding them at a high relative humidity in degreening rooms (without ethylene) either at 85° F. or at prevailing temperature until they can be processed. No marked difference in respect to rind breakdown and decay was found between pulled and clipped fruit due to delayed handling. A highly significant correlation was found between stem-end rind breakdown and decay, indicating a deterioration in the rind tissue which facilitates the invasion of stem-end rot and mold fungi into the fruit.

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