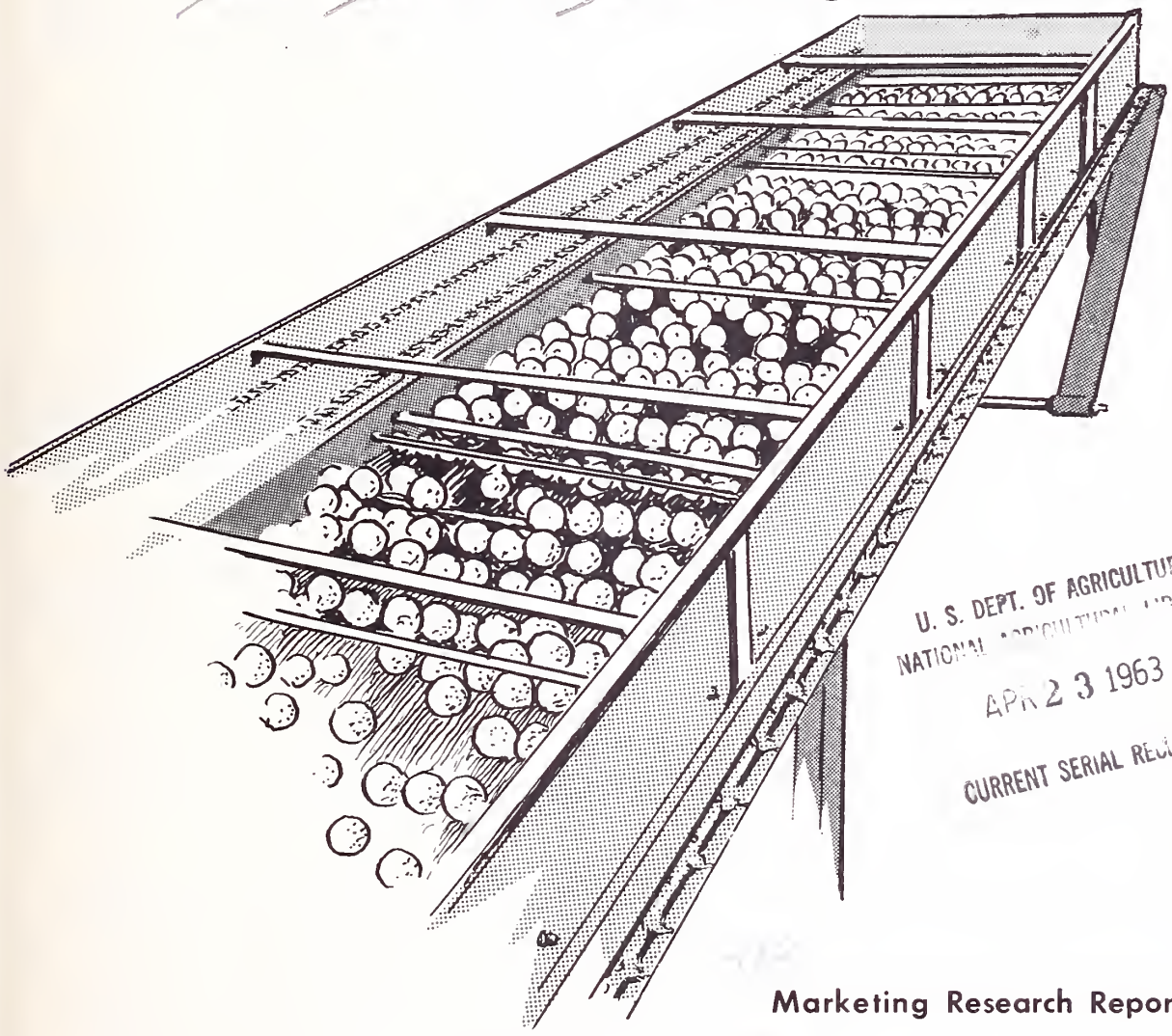
FACTORS AFFECTING RIND BREAKDOWN OF CITRUS FRUITS



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Market Quality Research Division

FACTORS AFFECTING RIND BREAKDOWN OF CITRUS FRUITS

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SUMMARY

Oranges developed rind breakdown after being rotated on the roller brushes of the washing and cleaning equipment for 1, 3, or 5 minutes. The amount of rind breakdown increased with the length of time fruit was brushed and was further increased by 1, 2, or 3 days' delay in brushing the fruit. Pineapple and Murcott Honey oranges were more susceptible to rind breakdown than Valencia oranges when held at 70° F. and 85 percent relative humidity before washing and brushing. The susceptibility of the Valencia orange to rind breakdown increased when the oranges were held at 85° F. and 75 or 50 percent relative humidity. Softness of oranges and their position on brushes contributed to susceptibility to rind breakdown.

Oranges should be washed and brushed as soon as possible after harvest; excessive brushing should be avoided.

In preliminary tests, Marsh and Ruby Red grapefruit did not develop rind breakdown from brushing or from delay in handling.

INTRODUCTION

Physiological disorders of citrus rind tissue that develop during transit and subsequent marketing impair the appearance and degrade the value of the fruit. These unsightly blemishes are known by different terms, such as pitting, aging, stem-end rind breakdown, and rind staining. Collapse of the cells of the rind in certain areas, accompanied by a brown discoloration, is a common symptom.

Eaks and Jones[1] and Hopkins and McCornack[2] reported that rind breakdown was more prevalent in some seasons than in others. Also, it has been reported that certain varieties of citrus fruit were more susceptible to one type of rind breakdown than to other types; for example, Pratt[3] found that Pineapple oranges were most susceptible to stem-end rind breakdown, whereas Eaks and Jones found that navel oranges were seriously affected by rind staining.

These disorders may be caused, at least in part, by loss of moisture. Hopkins and McCornack recommended prevention of excessive moisture loss in degreening rooms by using high humidity and low airflow. They concluded that ethylene was not a factor in the development of rind breakdown.

The detrimental effects of a 2-day delay between harvesting and washing, waxing, and packing have been shown by Hopkins and McCornack.[4] They found that of fruit held 2 days, 34 percent developed stem-end rind breakdown, whereas that processed on the

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[1] Eaks, I. L., and Jones, W. W. Rind Staining and Breakdown of Navels. Calif. Citrog., 44: 390, 400, 402. 1959.

[2] Hopkins, E. F., and McCornack, A. A. Prevention of Rind Breakdown in Oranges. Citrus Mag. 21: 18-23, 25. 1958.

[3] Pratt, R. M. Florida Guide to Citrus Insects, Diseases, and Nutritional Disorders in Color. Univ. Fla. Agr. Expt. Sta. 1958.

[4] Hopkins E. F., and McCornack, A. A. Effect of Delayed Handling and Other Factors on Rind Breakdown and Decay in Oranges. Proc. Fla. State Hort. Soc. 73: 263-269. 1960.

day it was picked had only 2 percent after a comparable storage period. Effects of different delay periods on the same lots of fruit were not reported. Previously, Grierson[5] had found that a combination of ethylene treatment, a period of idling on brushes, and waxing with commercial wax resulted in rind breakdown in Pope Summer oranges after 1 week. Observations of Worden[6] in packinghouses throughout Florida led him to believe that a period of curing before processing the fruit, instead of having beneficial effects, in reality led to an increase in the incidence of rind disorders.

Previous experiments in the Market Quality Research Division's laboratory at Orlando indicated that loss of moisture alone by exposure to high temperature, low humidity, and high airflow did not cause symptoms of rind breakdown.

Rind breakdown is often a serious disorder of oranges on the market. This investigation was undertaken to determine the effects of certain packinghouse procedures that might affect it and to suggest better ways of handling the fruit. During the crop year 1961-62 the effects of delay and brushing were studied. This research was part of a broad program of continuing research designed to maintain high market quality of citrus fruits.

MATERIALS AND METHODS

All lots of fruit were picked from trees in commercial groves. Hamlin, Enterprise, Pineapple, Valencia, and Murcott Honey oranges, and Marsh and Ruby Red grapefruit were used as test fruit. The treatments consisted of controlling the time the fruit rotated on the roller brushes in the citrus washing and cleaning equipment.

Standard equipment with type "S" synthetic fiber brushes with 0.009-inch-diameter bristles was used. Samples of fruit were rotated on the brushes for 1, 3, or 5 minutes on the day they were harvested; comparable samples were similarly treated 1, 2, or 3 days after harvest. The speed of the brushes was 270 revolutions per minute.[7] The temperatures during the delay period, from harvest to brushing, were 70°, 80°, or 85° F., and the relative humidities were 50, 75, or 85 percent. After brushing, all samples were held at 70° F. and 85 percent relative humidity.

Samples were inspected for rind breakdown 1 week after harvest. A fruit was rated as having slight rind breakdown if the total affected area was from 1/4 to 1/2 inch in diameter; such fruit was considered marketable. More extensive rind breakdown was rated as moderate to severe.

For high-temperature, low-humidity studies, a portable cabinet was constructed wherein environmental conditions could be controlled (fig. 1). Temperature was thermostatically controlled by electrical cone heating elements inside the cabinet. Humidity was maintained by dehumidifiers of the silica gel type controlled by a humidistat. Temperature as high as 135° F. and humidity as low as 10 percent were easily maintained. Air movement was supplied by a 12-inch-blade fan inside the cabinet; the fan was operated by a motor mounted on top of the cabinet. Air velocity averaged 2,500 linear feet per minute.

In experiments in which fruit was held at 70° or 85° F. at relative humidities of 75 and 85 percent, holding rooms equipped with thermostatically controlled heating units and with humidifiers were used.

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5 Grierson W. Pretesting Oranges for Susceptibility to Peel Injury. Citrus Mag. 20: 10-11. 1958.

6 Worden, H. C., Florida Citrus Exchange, Tampa, Fla. Personal communication.

7 Checks of packinghouse equipment showed that the speed of the brushes varied widely and sometimes exceeded 300 r.p.m., although the recommended speed is 200 r.p.m.

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Figure 1.--Cabinet for controlling environmental conditions.

RESULTS AND DISCUSSION

Stress conditions of high temperature, relative humidity as low as 10 percent, and high airflow did not produce rind breakdown in oranges. Fruit tolerated temperatures up to 135° F. for 1 hour with only slight immediate effect on rind tissue. After 2 hours at temperatures near 135° F., the rind was invariably injured by burning. Hamlin and Pineapple oranges were injured more than Valencia oranges by these conditions.

A survey of six commercial packinghouses during normal operation showed a wide variation, from less than 1 minute to more than 10 minutes, in total length of time fruit remained on washer and drier brushes. These findings are summarized in table 1. The longer periods were usually due to unintentional lags caused by improper channeling of fruit. The number of fruit involved was usually small; nevertheless, the survey showed that excessive brushing can easily occur. In all the packinghouses stiffer brushes were used in washing than in drying the fruit.

Preliminary tests with Hamlin and Enterprise Seedless oranges indicated that delay before washing the fruit increased rind breakdown. In addition, longer periods on the brushes also increased the amount of rind breakdown.

Table 1.--Time of oranges on washer and drier brushes in commercial packinghouses

Packinghouse No.	Time on washer brushes	Time on drier brushes
1	36 sec. to 42 sec.	1 min. 7 sec. to 3 min.
2	25 sec. to 1 min. 25 sec.	None used
3	23 sec. to 49 sec.	37 sec. to 48 sec.
4	22 sec. to 1 min. 40 sec.	58 sec. to 9 min. 17 sec.
5	30 sec. to 1 min. 17 sec.	44 sec. to 52 sec.
6	18 sec. to 6 min. 30 sec.	1 min. to 3 min. 22 sec.

Pineapple orange. --More extensive tests with Pineapple oranges confirmed the above observations. Results of 76 tests involving over 1,900 fruit are summarized in figure 2. These samples were held at 70° F. and 85 percent relative humidity, both before and after treatment. Samples washed on the day picked had developed little rind breakdown after 1 week; even those fruit subjected to 5 minutes of brushing had an average of only 3 percent rind breakdown that was considered moderate to severe. The incidence of rind breakdown increased with each day of delay before treatment. Even after a 1-day delay, the increase of moderate to severe rind breakdown was of significant importance. After 3 days' delay, which would correspond to fruit picked on Friday and held until Monday before processing, 34 percent of the fruit subjected to only 1 minute on the brushes developed rind breakdown, and 56 percent of the fruit subjected to 5 minutes on the brushes developed rind breakdown.

Pineapple oranges have smooth, thin rinds and are easily damaged by excessive brushing. In addition, in some samples about one-half of the fruit turned end-over-end, exposing the stem-end portion of the fruit to the brushes. These two factors undoubtedly added to the high incidence of stem-end rind breakdown in this variety of orange. Figure 3 shows the type of rind breakdown produced in Pineapple oranges by brushing and delay.

Murcott Honey orange. --The response of the Murcott Honey orange to delay and to brushing was similar to that of the Pineapple orange. Figures 4 and 5 summarize the results of two tests of 550 fruit each. Delay and time on the brushes increased the amount of rind breakdown in the Murcott Honey orange. For example, a 1-minute brushing of fruit held at 70° F. and 85 percent relative humidity before brushing resulted in no moderate to severe rind breakdown in fruit held 1 day, whereas 2 percent of the fruit held 2 days and 10 percent of that held 3 days had moderate to severe rind breakdown. Samples from the same lots were held at 85° and 85 percent relative humidity; 2 percent of the

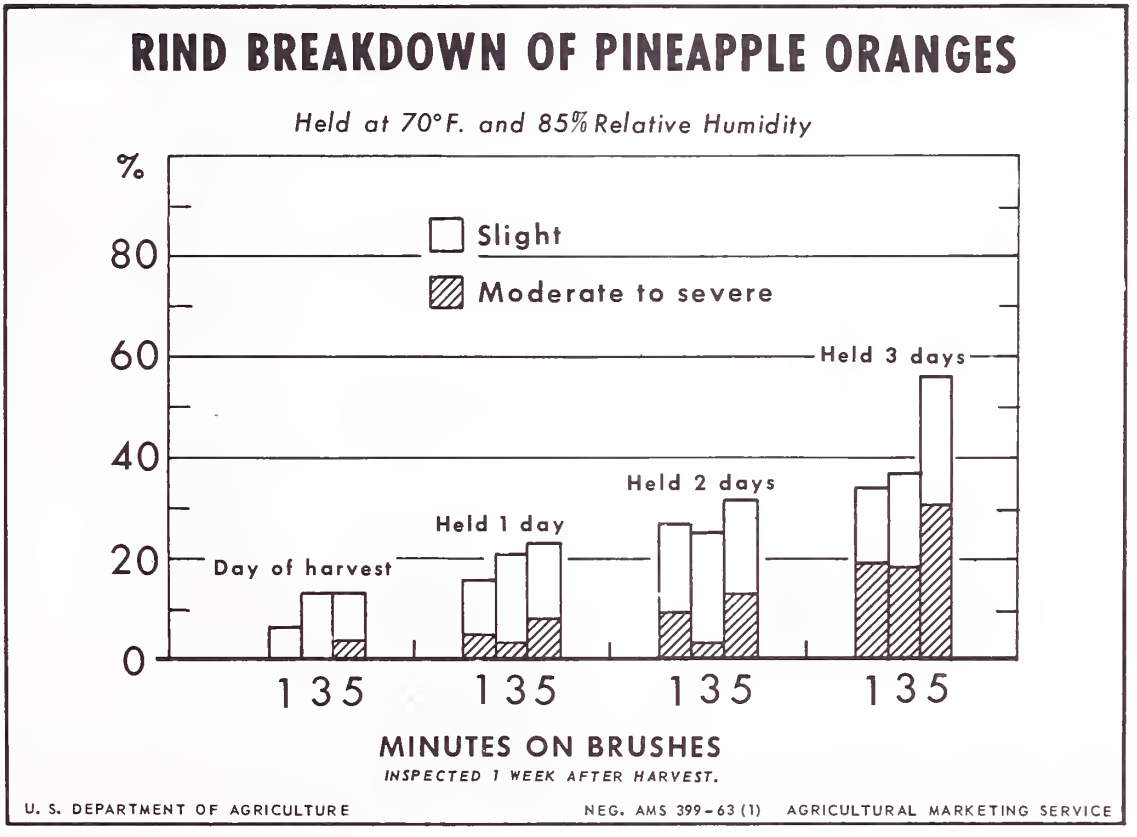

Figure 2.

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Figure 3. --Typical severe rind breakdown of Pineapple orange caused by delay and brushing. Taken 1 week after harvest.

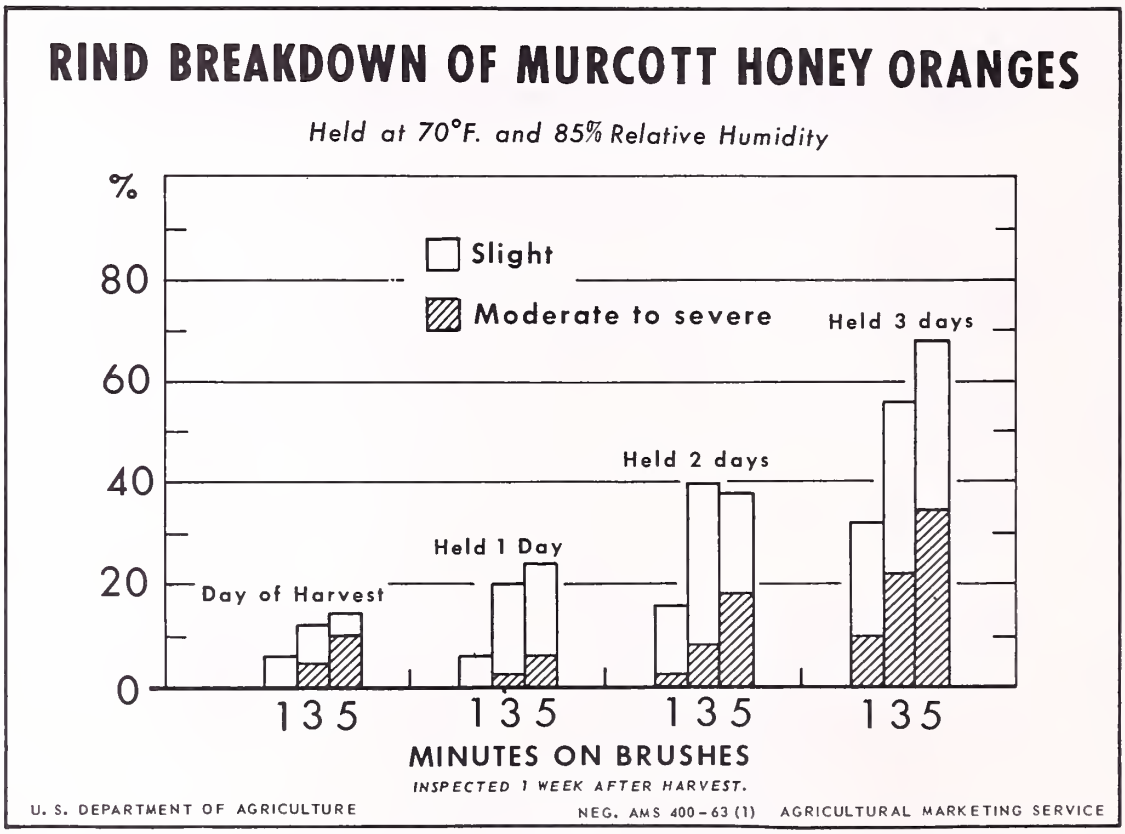

Figure 4.

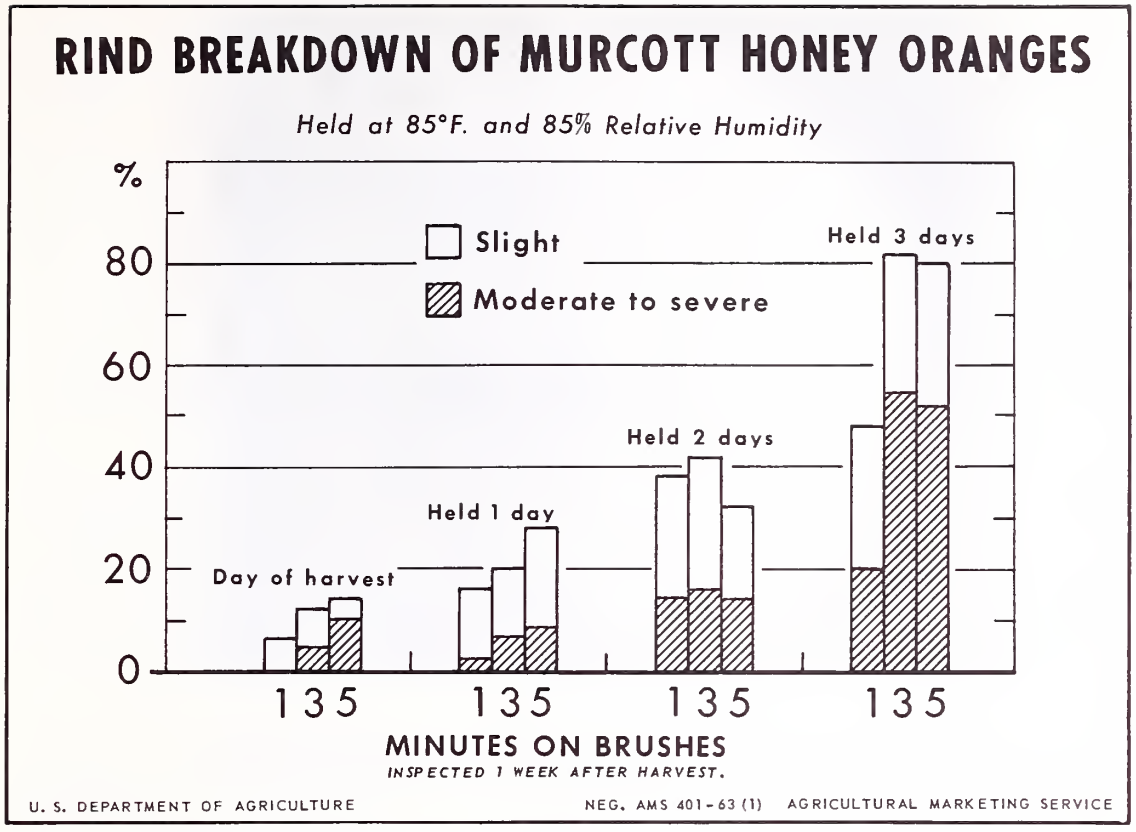

Figure 5.

fruit held 1 day, 14 percent of that held 2 days, and 20 percent of the fruit held 3 days had moderate to severe rind breakdown. Figure 6 shows typical severe rind breakdown of a Murcott Honey orange.

Valencia orange.--The Valencia orange was much less susceptible to rind breakdown than the other varieties of fruit under either 70° or 80° F. at 85 percent relative humidity. In no test, under these holding conditions, was rind breakdown serious until the delay exceeded 2 days.

As a consequence, additional tests at lower relative humidities were made. At holding conditions of 85° F. and 75 percent relative humidity, slightly more rind breakdown occurred. When fruit was held at 85° F. and 50 percent relative humidity, the incidence of rind breakdown increased rapidly. Much of this was injury on the sides of the fruit, the result of brushing, since most of the Valencia oranges turned on their sides on the brushes. However, no injury or rind breakdown occurred when the fruit was treated on the day it was picked.

An average of 1,200 fruit was used at each set of temperature-and-humidity conditions. The effects of brushing for 1, 3, or 5 minutes after a 3-day delay are shown in figure 7. Even after 3 days' delay at 70° or 85° F. at 85 percent relative humidity, little moderate or severe rind breakdown occurred. When fruit was held at 85° F. and 75 percent relative humidity, 28 percent of the fruit subjected to 1 minute on the brushes had slight rind breakdown, and 20 percent of that subjected to 5 minutes on the brushes had moderate to severe rind breakdown. When fruit was held 3 days at 85° F. and 50 percent relative humidity before being brushed, 14 percent of the fruit brushed 1 minute, 34 percent of the fruit brushed 3 minutes, and 54 percent of that brushed 5 minutes had moderate to severe rind breakdown.

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Figure 6. --Rind breakdown of Murcott Honey orange subjected to brushing for 5 minutes after being held for 3 days at 70 F. and 85 percent relative humidity. Taken 1 week after harvest.

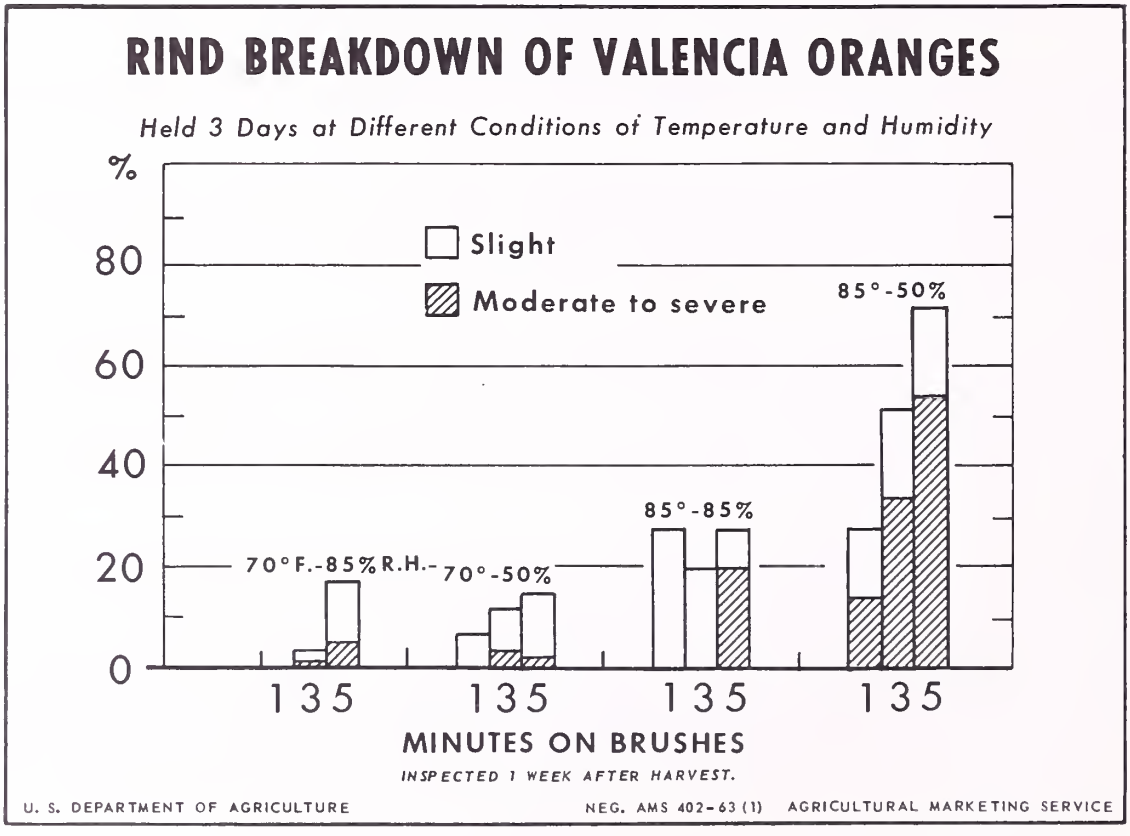

Figure 7.

The effects of brushing for 1, 3, or 5 minutes after 1, 2, or 3 days' delay at 85° F. and 50 percent relative humidity are shown in figure 8. Both the delay before brushing and the length of time the fruit was on the brushes influenced the amount of rind breakdown. For example, after 1 minute on the brushes none of the fruit held 1 day, 10 percent of the fruit held 2 days, and 14 percent of that held 3 days had moderate to severe rind breakdown. After 5 minutes on the brushes, 6 percent of the fruit held 1 day, 40 percent of that held 2 days, and 54 percent of that held 3 days had moderate to severe rind breakdown.

Grapefruit.--Preliminary tests with both Marsh and Ruby Red grapefruit indicated that these varieties were not susceptible to rind breakdown as a result of delay in handling or of time on brushes. Neither a 62-fruit sample of Marsh grapefruit held for 4 days nor a 69-fruit sample of Ruby Red grapefruit held for 5 days, each at 70° F. and 85 percent humidity, then brushed 3 minutes had any moderate or severe rind breakdown after 1 week.

Effect of fruit firmness.--One lot of late-season Valencia oranges was divided into four 50-fruit samples--two of "firm" and two of "soft" fruit. One sample of each group was washed and brushed for 5 minutes on the day picked. After 1 week 12 percent of the firm-fruit sample had slight and 20 percent had moderate to severe rind breakdown; and 4 percent of the soft-fruit sample had slight and 62 percent had moderate to severe rind breakdown. The other two samples were washed and brushed 5 minutes after a 2-day delay at 85° F. and 85 percent relative humidity. Almost all of this fruit, both firm and soft, had moderate or severe rind breakdown after 1 week.

Results were similar with Pineapple oranges picked very late in the season. In this test, even fruit which turned on its side on the brushes developed severe rind breakdown on the stem end after 1 week.

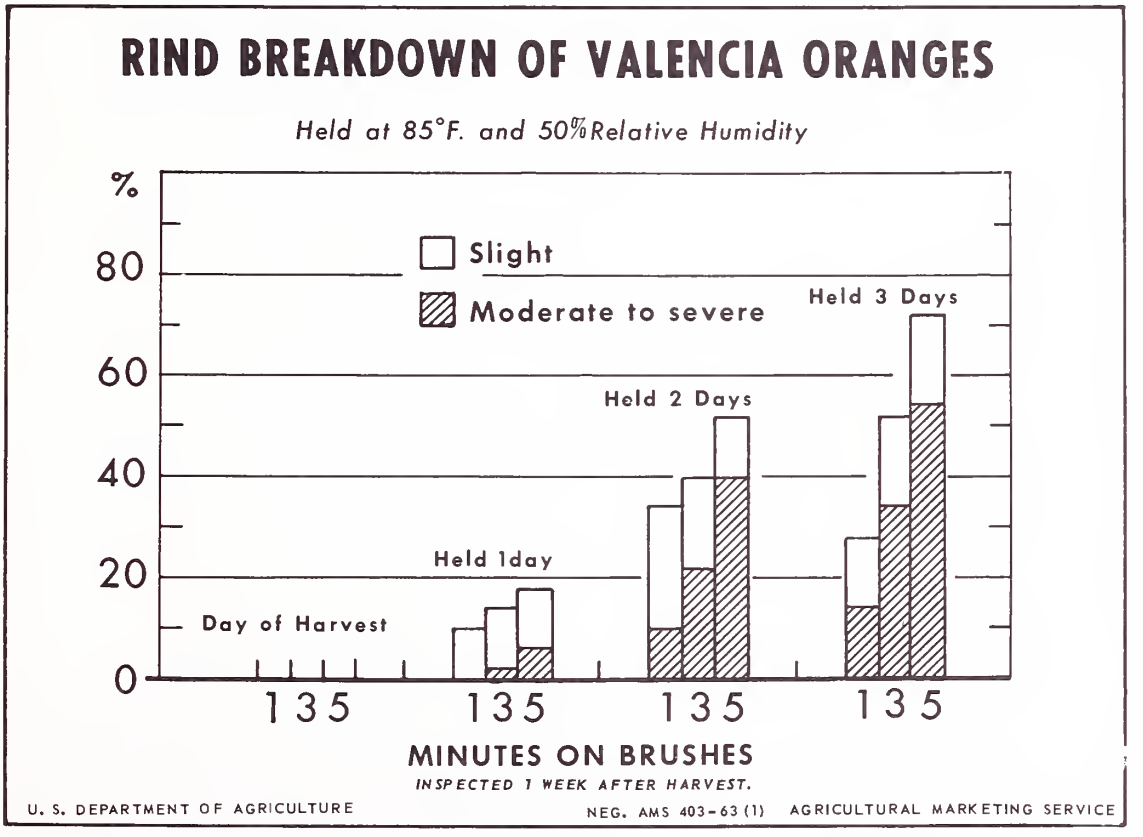

Figure 8.

These results indicate that more quantitative work needs to be done to relate fruit firmness to the amount of injury caused by brushing.

Shape of fruit and position on brushes. --As mentioned before, the shape of the fruits often determined whether they turned end-over-end or on their sides on the brushes. The Murcott Honey oranges were quite flat and turned almost exclusively end-over-end. The Pineapple oranges were very nearly round: Six 10-fruit samples averaged 6.26 centimeters in height and 6.35 cm. in diameter. The Pineapple oranges tended to turn more on their sides, but in some lots more than 50 percent turned end-over-end. The Valencia oranges were more elongated, and more of them turned on their sides than end-over-end.

In a 50-fruit sample of Valencia oranges held at 85° F. and 85 percent relative humidity, the average diameter decreased during a 4-day holding period from 6.61 cm. to 6.49 cm., while the height decreased from 6.78 cm. to 6.52 cm. Another 50-fruit sample of the same lot was held at 85° F. and 60 percent relative humidity. In this sample the diameter decreased from 6.64 cm. to 6.44 cm. during a 4-day holding period and the height from 6.74 to 6.40 cm. Thus, in each case the height decreased at a greater rate than the diameter, causing elongated fruit to become more nearly round. These limited data suggest that a change in the shape of the fruit during delay may increase its susceptibility to rind breakdown at the stem end.

Recommendations. --Oranges for the fresh fruit market should be handled as soon as possible after harvest to reduce rind breakdown. Washing and drying of fruit in the packinghouse are necessary to insure cleanliness, but excessive brushing should be avoided.