Peel Strength Properties of Three Orange Varieties

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ABSTRACT

SEASONAL influence on burst, puncture, and peel strength properties of oranges during the 1976-78 seasons were determined by using the Instron materials testing equipment. The three properties indicate the susceptibility of fruit to the damage that might occur during mechanical harvesting at different times of the day and season.

INTRODUCTION

In 1977, Florida produced 7.63 million tonnes of oranges (Fla. Agri. Statis., 1977), over 95 percent of which went into processed products. Three principal varieties grown for processing are 'Hamlin', 'Pineapple', and 'Valencia'. The first two are early and midseason oranges that are harvested between December and March, and Valencia is a late season orange harvested between April and July.

Although Florida's citrus still is harvested almost entirely by seasonal hand labor, two general mass removal systems have been developed; (a) limb or trunk shakers that drop the fruit to catch frame or ground, and (b) an air shaker that drops the fruit to the ground. An abscission chemical usually is used to loosen the fruit before harvesting.

Fruit that is harvested mechanically is subject to damage from branches and other fruit as it falls from the tree and drops on the ground, and to further damage as it is raked, picked up, loaded and transported to highway trailers. More injury is acceptable for fruit destined for processing than for fresh market fruit.

Research has been conducted for several years to determine the resistance of fruit and vegetables to compression and impact forces. Witz (1954) measured the deformation by using a 0.39 cm diameter plunger to puncture several varieties of potatoes to determine their resistance to bruising. Fridley and Adrian (1966) reported deformation of fruit at rupture was less for impact as compared to slow loading at the bruise and yield points on peaches, pears, apricots, and apples. Wright and Splinter (1968) as well as Fletcher (1971) and Mohsenin and Goehlich (1962) reported similar values for peaches, pears, apples, potatoes, corn, and pea beans on impact and slow loading.

It was reported by Fletcher et al. (1965) that the skin rupture force on apples decreased sharply as impact velocities increased above 25 cm/s. Studies on bruises to apples resulting from dropping and from the application of pressure was reported by Gaston and Levin (1951).

Fluck and Ahmed (1974), reported that Valencia oranges were more resistant to impact damage than Pineapple and 'Temple' oranges or 'Thompson' grapefruit. Ahmed et al. (1973), reported that forces needed to induce stress damage to citrus fruits were greater for Valencia oranges than for 'Dancy' tangerines or 'Navel' and Temple oranges.

This research was conducted to determine the resistance of three varieties of oranges at different times during the season, and of one variety at different times during the day, to burst, puncture, and peel tensile strength forces. Also, a comparison of strength properties of Valencia treated and not treated with an abscission chemical was made. These three properties indicate the susceptibility of fruit to damage from mechanical harvesting and may be useful in establishing machine design parameters.

EQUIPMENT AND METHOD

Tests were conducted to determine the seasonal influence on burst, puncture, and peel strength properties of Hamlin, Pineapple, and Valencia oranges for the 1976 and 1978 harvest seasons. Severe freeze damage in January resulted in abandonment of the 1977 tests for the Hamlin, and Pineapple varieties, but Valencia oranges were tested. Hamlin and Pineapple oranges were sprayed with 20 ppm of Acti-Aid* and the Valencia with 300 ppm of Release. Also, Valencia orange samples treated and not treated with abscission sprays were tested at approximately the same time during the three seasons for comparison. Samples were randomly handpicked around the tree at the 1.8-m height each year from the same test plots. Instron testing equipment was used to determine the force and displacement required to rupture the fruit.

In 1978, the burst test was used on samples of nonsprayed Valencia oranges to determine the influence of time of day on fruit susceptibiltiy to rupture during a mechanical harvesting operation.

Burst Test

The burst test was used to simulate forces that a fruit experiences when it becomes wedged and squeezed between frame members during the rake and pickup operation. Two flat plates, one fixed and the other mounted on the moveable crosshead of the Instron instrument were used for the burst test as shown in Fig. 1. The seasonal

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*Trade names are included for the benefit of the reader and do not imply endorsement by the USDA or the University of Florida.

FIG. 1 Burst test.

tests consisted of 10 randomly handpicked oranges placed one at a time on the flat plate with the stem axis perpendicular to the plate. The crosshead feed rate and chart speed were 200 mm/min. Temperature, relative humidity and force required to rupture fruit were recorded for the 1978 time-of-day test. An average of 50 minutes was required to complete each test. A sample of 20 Valencia oranges was hanpicked every 2 hours 5 times a day at 4 dates (April 5, April 26, May 17, and June 8).

Puncture Test

The puncture test was used to simulate the forces encountered when fruit contacts small branches, sharp objects or rake tines used in gathering fruit. A 0.64-cm-diameter rod attached to the crosshead traveled perpendicular to the flat base plate as shown in Fig. 2 for the puncture test. Fruit was placed in the holder to keep it from rotating, with the stem axis parrallel to the flat plate. Two punctures were made per fruit 90 deg apart on 10 oranges for each test at a crosshead feed rate and chart speed of 200 mm/min.

Peel Tensile Strength Test

The peel tensile strength test was used to evaluate the behavior of the orange peel under applied tensile loads. Clamps were made to hold a section of orange peel for determining peel strength. Peel samples 2.5 cm wide × 5 cm long with an 8-mm-wide section in the center were cut with a cookie-cutter-type die to give uniform sections. Fig. 3 shows a peel sample in position for testing. One clamp was fixed to the base and the other attached to the moveable crosshead of the test machine with a universal joint. The crosshead feed rate was 20 mm/min and the chart speed was 100 mm/min. Ten sample sections were used for each test.

RESULTS

The influence of harvest date on burst, puncture, and peel tensile strength properties for three seasons 1976, 1977, and 1978 is shown in Figs. 4, 5, and 6. Greater forces were required to fracture the Pineapple variety than to fracture Hamlin variety in all three tests (burst, puncture and peel tensile strength). The average burst, puncture and peel tensile strength forces on the Pineapple were 386, 56.4, and 22.5 N, respectively, whereas on Hamlin the forces were 229, 35, and 12 N, respectively. All samples of Pineapple and Hamlin varieties were

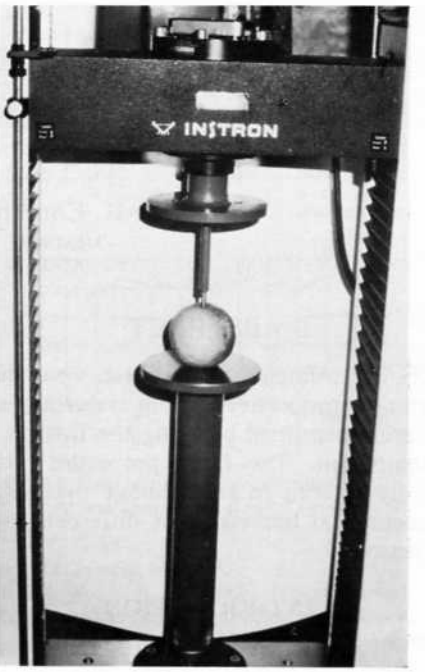


FIG. 2 Puncture test.

sprayed with an abscission chemical. The burst, puncture, and peel tensile strength forces on Pineapple increased during the harvest season. In 1976, the forces on Hamlin increased during the season, but in 1978, they decreased. This may have been due to seasonal differences and greater time lag between tests.

Valencia showed greatest resistance to damage around the middle of May, as indicated by all three properties tested. During 1976 and 1977, the nonsprayed samples required a greater force to rupture in the burst test during April and May than the sprayed samples but less in June. In 1978 the sprayed samples required a greater force to rupture in the burst test.

The 2- and 3-year average burst forces for the sprayed Valencia, Pineapple, and Hamlin were 419, 386, and 229 N, respectively. In 1976 the average displacement for burst, puncture, and peel tensile strength were 9.45, 5.38, and 4.18 mm, respectively, for the Pineapple variety, and 11.1, 5.17, 3.21 mm, respectively, for the Hamlin variety. In 1978 the average displacement for burst, puncture, and peel tensile strength for Pineapple were 22.4, 9.44, 7.39 mm, respectively. Comparable measured displacements in 1978 for Hamlin were 21.5, 10.1, and 7.1 mm. Differences in temperature, relative humidity, and moisture uptake (irrigation or rainfall)

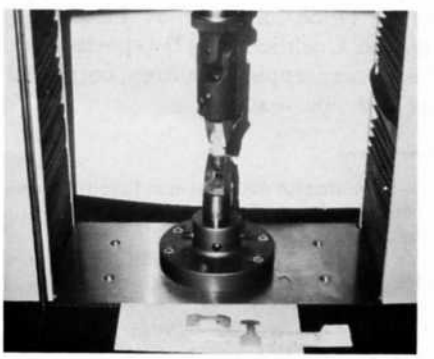


FIG. 3 Peel strength test.

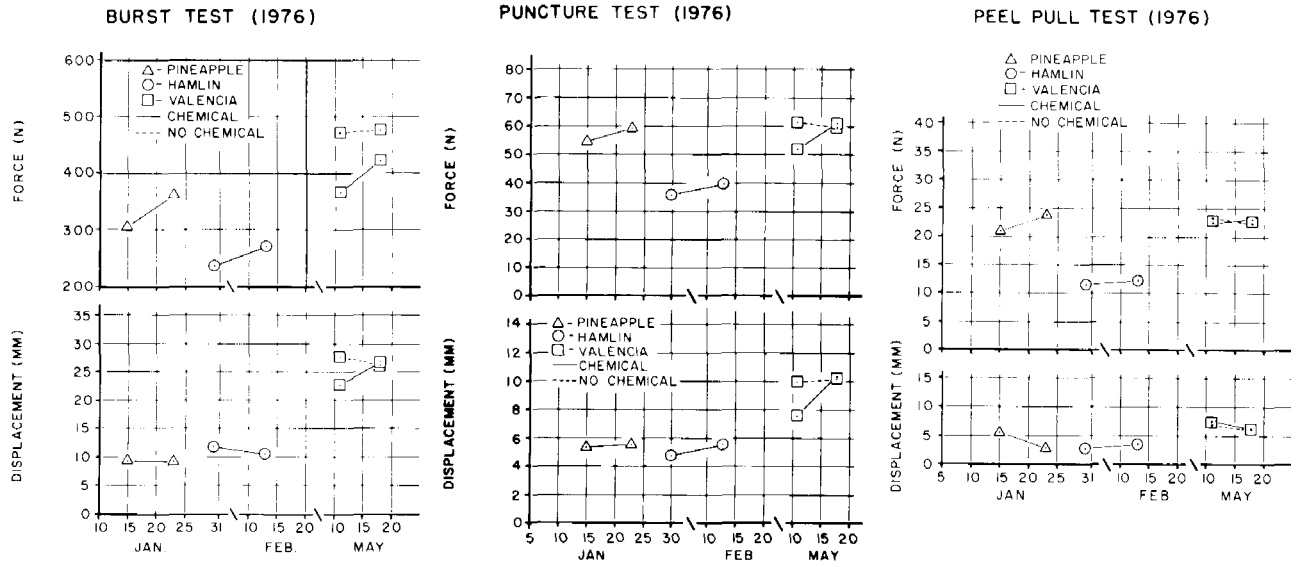


FIG. 4 Results of 1976 seasonal influence test.

may have caused the difference in displacement between years.

The influence of time of day on burst values is shown in Fig. 7 for nonsprayed Valencia oranges. The highest average burst force test reading was at 8:00 a.m. (456 N) and the lowest was at 12:00 noon (347 N). Average forces for all tests varied little for a given time of day on a given date. An analysis of variance indicated that neither the date nor time of day gave significantly different results according to the F test at the 0.05 level.

SUMMARY

Research was conducted for three seasons to determine the influence of harvest date on the physical strength properties (burst, puncture, and peel tensile strength) of three orange varieties. In 1978, research was also conducted to determine the influence of time of day on Valencia by analyzing the burst property at 2-h intervals on four harvest dates.

Average burst, puncture, and peel tensile strength forces increased only slightly during the season. The sprayed Valencia, Pineapple and Hamlin average burst forces were 418.9, 386.3, and 229 N, respectively. The nonsprayed Valencia oranges required a slightly higher average force for all three properties.

Based on these results, neither harvest date nor time of day would influence the damage due to harvesting.

References

1 Ahmed, E. M., F. G. Martin and R. C. Fluck. 1973. Damaging stresses to fresh and irradiated citrus fruits. J. Food Sci. Vol. 38.

2 Coppock, G. E. 1969. Review of citrus harvesting mechanization. In: B. F. Cargill and G. E. Rossmiller (eds.), Fruit and Vegetable Harvest Mechanization: Technological Implications. Rural Manpower Center, Michigan State University, East Lansing. RMC Report No. 16

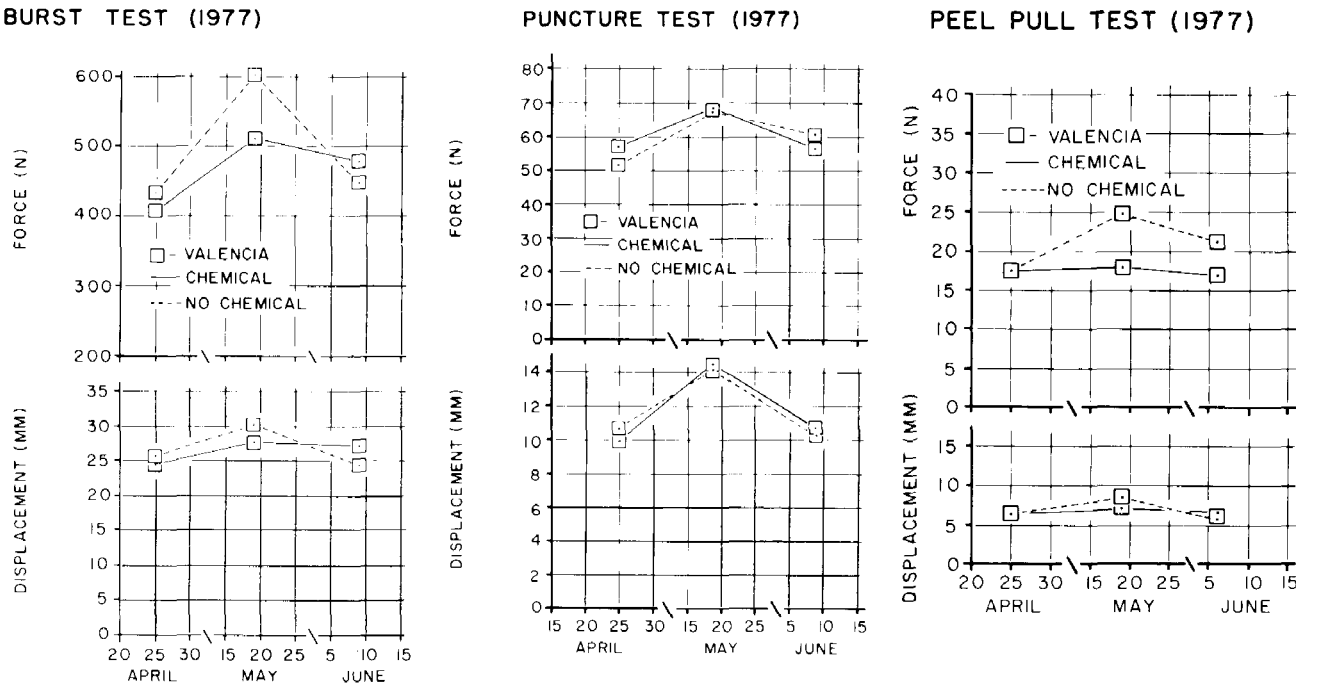
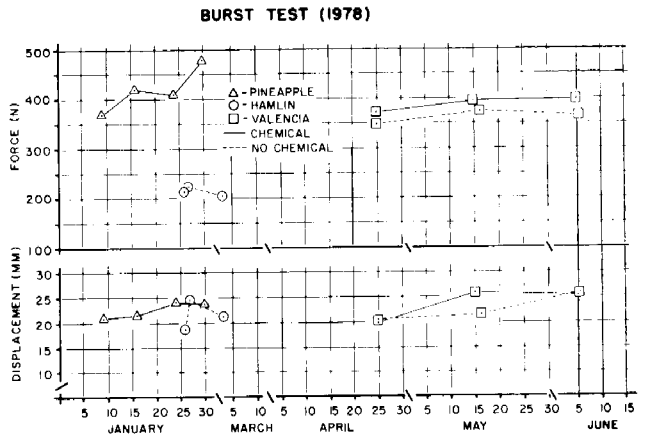
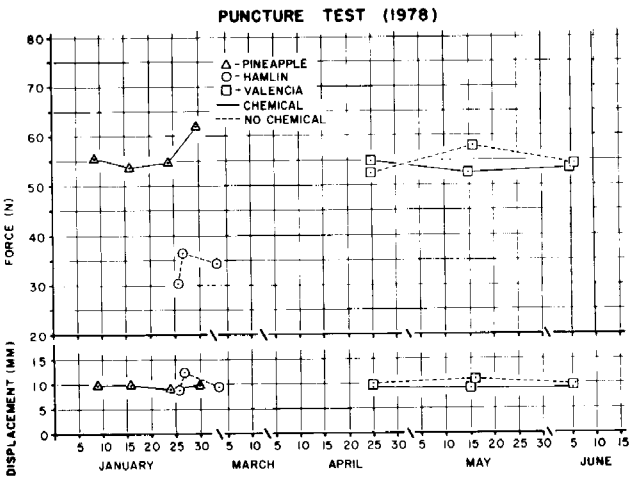


FIG. 5 Results of 1977 seasonal influence test.





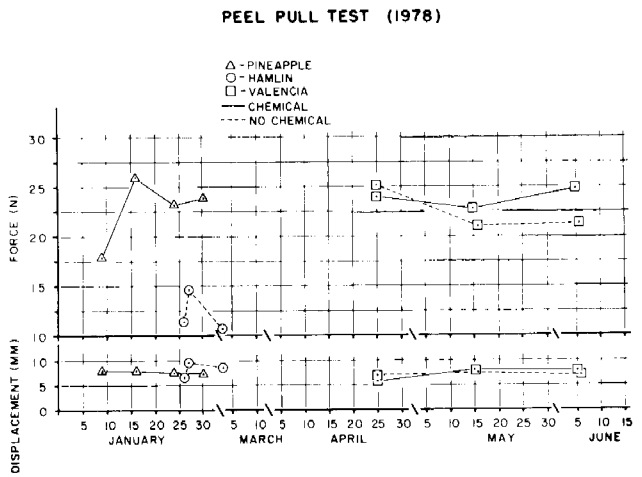


FIG. 6 Results of 1978 seasonal influence test.

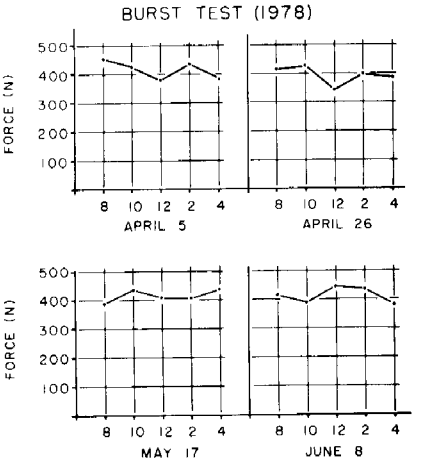


FIG. 7 Results of time of day influence on burst test using non-sprayed 'Valencia' oranges.

777-805. ASAE, St. Joseph, MI 49085.

3 Fletcher, S. W., N. N. Mohsenin, J. R. Hammerle and L. Tukey. 1965. Mechanical behavior of selected fruits and vegetal under fast rates of loading. TRANSACTIONS of the AS 8(3):324-326, 331.

4 Fletcher, S. W. 1971. The mechanical behavior of processed ples. TRANSACTIONS of the ASAE 14(2):234-239.

5 Florida Agricultural Statistics - Citrus Summary 1977.

6 Fluck, R. C. and E. M. Ahmed. 1974. Measurement by c pression test of impact damage to citrus fruits. J. Texture Stu (4):494-500.

7 Fridley, R. B. and P. A. Adrian. 1966. Mechanical propertie peaches, pears, apricots, and apples. TRANSACTIONS of the AS 9(1):135-138, 142.

8 Gaston, H. P. and J. H. Levin. 1951. How to reduce apple br ing. Michigan State College Special Bulletin 374.

9 Mohsenin, N. W. and H. Goehlich. 1962. Techniques for de mination of mechanical properties of fruit and vegetables as relate design and development of harvesting and processing machinery Agr. Engr. Res. 7(4):300-315.

10 Witz, R. L. 1954. Measuring the resistance of potatoes to br ing. Agricultural Engineering 34(4):241-244.

11 Wright, F. S. and W. E. Splinter. 1968. Mechanical behavic sweet potatoes under slow loading and impact loading. TRANS TIONS of the ASAE 11(6):765-770.