Proc. Fla. State Hort. Soc. 97: 138-140. 1984.

DEFORMATION OF 'MARSH' GRAPEFRUIT AS AFFECTED BY FRUIT ORIENTATION AT PACKING

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Additional index words. fruit rheology, postharvest handling, *Citrus paradisi.*

Abstract. **Resistance of Florida 'Marsh' grapefruit to compression applied on the longitudinal or lateral axis was measured by quasi-static and static load creep tests using the Tensilon Tensile Tester and the Grierson Creep Tester, respectively. The fruit were more stiff and elastic thus more resistant to deformation when compression force was applied longitudinally rather than laterally. Deformation of grapefruit during actual export shipments was reduced significantly by packing the fruit in the shipping boxes with longitudinal orientation.**

Severe fruit deformation has been one of the most costly problems in exporting Florida grapefruit to Japan (7, 11). The deformation was attributed to bulge packing (3, 7), and was reduced significantly by packing the fruit flat in shipping boxes 1.3 cm deeper than the standard 4/5-bu boxes (14). The constant demand for "a good full pack", however, results in forcing too much fruit into the boxes. It was recommended that shippers negotiate with buyers to avoid overfilling and to avoid packing fruit too tightly in the boxes (10). Tray-pack containers (4) and honeycomb cell-pack boxes (5, 8) have been field tested as means of providing protection to large fruit during extended overseas shipments.

Harvesting and handling conditions sharply influenced subsequent resistance of grapefruit to deformation (12). Gently handled grapefruit kept in humid and shaded conditions until packing were far more resistant to deformation than were those roughly handled and exposed to sun and wind as too commonly occurs under commercial conditions. Loss of fruit elasticity, and hence susceptibility to permanent deformation, increased with advancing season. Individual film wrapping, referred to as "Unipack", in a low-density polyethylene bag was very effective in minimizing weight loss, maintaining fruit firmness, and hence reducing deformation (1, 9).

The mechanical properties of citrus fruits have been studied (2, 12, 13), but there is no clear-cut data on the resistance of grapefruit to deformation as affected by compression direction relating to the fruit orientation at packing and deformation in transport. This study was conducted: 1) to determine whether resistance of grapefruit to compression differ when the force is applied on the longitudinal and lateral axis; and 2) to evaluate the effects of fruit orientation at packing in actual export shipments.

Materials and Methods

Florida grapefruit stored for a few weeks at 10°C after unloading were obtained for the creep tests from the Sakai Seika Center, south of Osaka, Japan.

Quasi-static load creep test. A Tensilon Tensile Tester UTM LH SS-7D, an Instron-type devise, was used to draw force-deformation curves (Fig. 1). Grapefruit was placed longitudinally or laterally between a 10 kgf (98.07 N) load-cell and an iron plate, and compressed by loading to 8 kgf and then unloaded to 0 kgf at a speed of 5 mm/min. The deformation as a function of time was recorded on a strip-chart recorder. Fruit stiffness, initial deformation and percentage of permanent deformation were calculated based on the curve as shown in Fig. 1. A 50 kgf load-cell was used when the fruit was compressed to rupture at a loading speed of 50 mm/min.

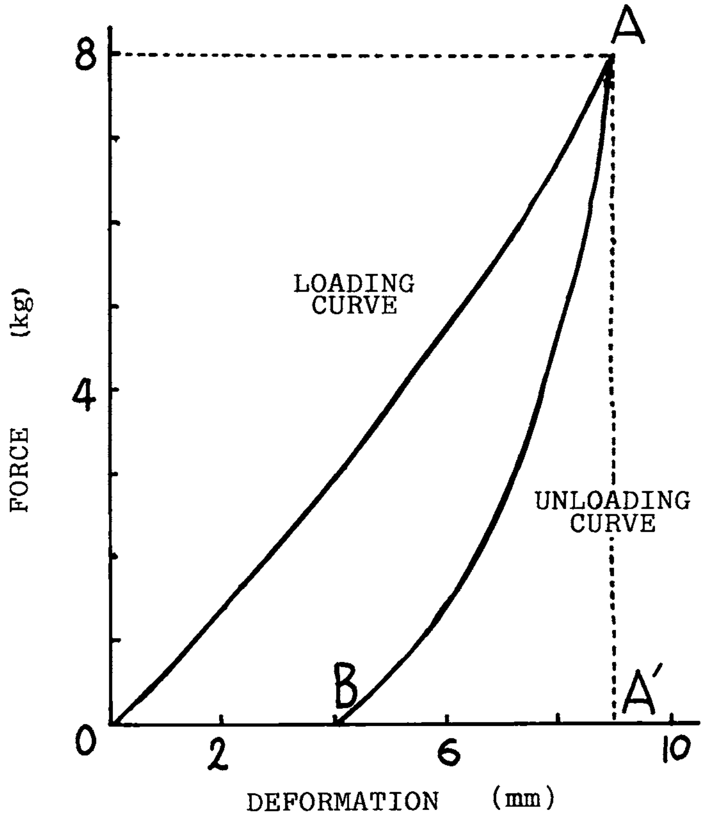

Fig. 1. Force-deformation curve of 'Marsh' grapefruit to compression by loading to 8 kgf (78.5 N) and then unloading to 0 kgf as a speed of 5mm/min. Stiffness:AA'/OA'. Initial deformation: OA'. Percentage of permanent deformation: OB/OA' x 100.

Static load creep test. Fruit deformation was obtained with the Grierson Creep Tester (Fig. 2) as described by Rivero, et al. (12). The compression strength, however, was 2 kg for 10 min and remaining deformation was recorded 10 min after removal of the weight. Five fruit were ranged in a column, oriented end-to-end or side-to-side.

Shipping tests. Conducted by investigating commercial shipments of Indian River fruit which were packed in flat orientation in the box so that the fruit were compressed by the overhead pressure longitudinally. Other boxes of the same lots were packed so that the fruit were compressed by the overhead pressure laterally. Thus we were able to evaluate the effect of the packing orientation on deformation of Florida 'Marsh' grapefruit during actual export shipments within a single lot. We made 3 observations after unloading and storage at 10°C for a few weeks at the Sakai Seika Center in the 1982-83 season.

Results and Discussion

The force-deformation curve of grapefruit obtained

[1]The authors are indebted to Dr. P. W. Hale, USDA Horticultural Lab., Orlando, Fl., for his advice editing the manuscript.

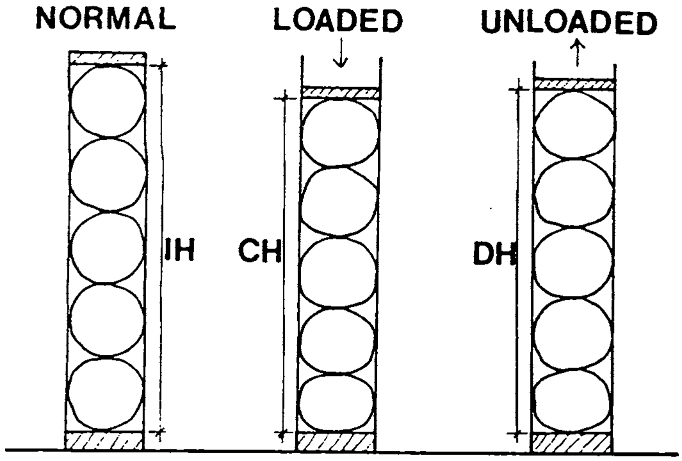

Fig. 2. Grierson CreepTester methodology. IH = initial height; CH = compressed height; DH = decompressed height. Permanent deformation = (IH − DH) x 100/IH. Percentage elasticity = ((DH − CH)/ (IH − CH)) x 100. After Rivero, et al. (12).

with the Tensilon was similar to that of apples (15), but there was no yield point (Fig. 1). When compression was continued to the point of rupture, the fruit oil glands started to burst at about 16 kgf. A broad yield point appeared at around 30 kgf and the fruit then ruptured by 38 to 40 kgf regardless of the fruit orientation. The yield point coincided with rupture of endocarp (pulp segment) and juice sacs. Grapefruit was more stiff and resistant to deformation when compressed in a longitudinal direction than when compressed in a lateral direction (Table 1).

Table 1. Resistance of 'Marsh' grapefruit to deformation as affected by compressing direction, measured with the Tensilon Tensile Tester.

Direction	Stiffness (kg/mm)	Initial deformation (mm)	Permanent deformation (%)
Longitudinal	0.73	11.1	40.8
Lateral	0.54	14.9	51.6
t test	**z	*	*

zSignificant at 1% level (**) or 5% level (*). Data based on the individual measurement of 20 fruit each.

These results were confirmed by the static creep test. Grapefruit were more elastic and resistant to deformation when they were compressed longitudinally than laterally (Table 2). Both tests rheologically measure the same properties, but as Rivero, et al. (12) claimed the Grierson Creep Tester seemed to more accurately measure susceptibility to distortion, especially under fruit-on fruit conditions.

Results of the 3 observations made on commercial grapefruit shipments were similar; thus only the data of the second observation made on May 17 is presented in Table 3. There were 10% less serious deformations in the boxes packed with longitudinal orientation than with lateral orientation. Seriously deformed fruit cannot be sold even at a discount and thus this treatment effect is commercially very meaningful. Slight deformation results not only from overhead pressure but also from overfilling (10). This would be a reason for the ineffectiveness of the treatment in reducing the slight deformation (Table 3). This speculation is supported by the fact that most of the slight deformation occurred on the side of fruit. It is, therefore, strongly recommended that the container packing rules include a provision to avoid excessively tight place packing of fruit in the shipping boxes (10).

Table 2. Resistance of 'Marsh' grapefruit to deformation as affected by compressing direction, measured with the Grierson Creep Tester.

Direction	Permanent deformation	Elasticity
	(%)	
Longitudinal	1.21	69.9
Lateral	3.71	39.8
t test	**z	**

zSignificant at 1% level. Data based on 5 measurements, fruit per measurement.

Table 3. Percentage of Florida 'Marsh' grapefruit deformed in an export shipment to Japan as affected by packing orientation of fruit.

Packing orientation	Deformationz		
	Sound	Slight	Serious
Longitudinal	30.0	33.9	36.1
Control (Not oriented)	17.7	36.3	46.0
t test	*y	ns	*

zSlight deformation = total aggregate flattened or indented surface area 2.5 to 5.1 cm in diam, serious deformation = total aggregated flattened or indented surface area more than 5 cm in diam. Fruit with deformed area totaling less than 2.5 cm in diam were classified as sound (5).
ySignificant at 5% level (*) or nonsignificant (ns). Data base on 15 boxes, 36 fruit per box each.

As the Japanese consider grapefruit a quality fruit, seriously deformed fruit are graded out and slightly deformed fruit can be sold but only at a discount (11). From these results it might be suggested that the striking effect of tray-pack (4) and cell-pack (8) boxes in minimizing fruit deformation were achieved not only by protecting the fruit from compression but also by fully utilizing the fruit's inherent resistance to deformation by packing fruit longitudinally. The extra cost to pack and transport grapefruit in tray- and cell-packs appears justifiable and should increase final returns to the shippers. Bulk bins would be another alternative for exporting grapefruit to Japan (6). Repacking lines have been built in Sakai and Tokyo to grade out decays and repack after washing and waxing with wax containing thiabendazole (TBZ). It is certainly important, however, to ship only top quality fruit, particularly to this market (11), otherwise above mentioned efforts are meaningless.

Literature Cited

1. Albrigo, L. G., K. Kawada, P. W. Hale, J. J. Smoot, and T. T. Hatton, Jr. 1980. Effect of harvest date and preharvest and postharvest treatments on Florida grapefruit condition in export to Japan. Proc. Fla. State Hort. Soc. 93:323-327.
2. Chuma, Y., M. Iwamoto, and T. Shiga. 1971. Studies on the techniques during the distribution process of *Citrus unshiu (Part 3)*: Mechanical properties as related to the design of a container for bulk transportation. J. Soc. Agr. Machinery, Japan 33:304-311.
3. Hale P. W. 1973. Which grapefruit pack: bulge, flat, or slack? Citrus and Veg. Mag. 36(12):8, 11.
4. Hale, P. W. 1976. New tray-pack containers for exporting Florida grapefruit. Citrus and Veg. Mag. 40(2):12, 13, 16, 30.
5. Hale, P. W. 1980. Exporting large grapefruit in honeycomb cell-pack boxes. Citrus and Veg. Mag. 43(5):8, 28, 29, 32.
6. Hale, P. W., W. R. Miller, and R. Egan. 1980. Bulk bins for exporting Florida grapefruit. Citrus and Veg. Mag. 44(3):62-66.
7. Hale, P. W. and J. J. Smoot. 1973. Exporting Florida grapefruit to Japan. Citrus and Veg. Mag. 37(3):20-23, 45.
8. Hale, P. W., J. J. Smoot, and T. T. Hatton. 1980. Cell-pack boxes for exporting large grapefruit. Proc. Fla. State Hort. Soc. 93:316-319.

9. Kawada, K. and L. G. Albrigo. 1979. Effects of film packing, in-carton air filters, and storage temperatures on the keeping quality of Florida grapefruit. Proc. Fla. State Hort. Soc. 92:209-212.
10. Kawada, K. and P. W. Hale. 1980. Effect of individual film wrapping and relative humidity on quality of Florida grapefruit and condition of fiberboard boxes in simulated export tests. Proc. Fla. State Hort. Soc. 93:319-323.
11. Kitagawa, H. and K. Kawada. 1979. Marketing of Florida grapefruit in Japan. Proc. Fla. State Hort. Soc. 92:241-245.
12. Rivero, L. G., W. Grierson, and J. Soule. 1979. Resistance of 'Marsh' grapefruit to deformation as affected by picking and handling methods. J. Amer. Soc. Hort. Sci. 104:551-554.
13. Sarig, Y. and D. Nahir. 1973. Deformation characteristics of 'Valencia' oranges as an indicator of firmness. HortScience 8:391-392.
14. Smoot, J. J. and P. W. Hale. 1977. Evaluation of decay control treatments and shipping cartons for export of grapefruit to Japan. Proc. Fla. State Hort. Soc. 90:152-154.
15. Tsukamoto, M. 1981. Studies on the mechanical injury of fruit. II. Susceptibility to impact and compression in apple fruit as related to storage periods and fruit portion. J. Japn. Soc. Hort. Sci. 49: 571-575 (in Japanese, abstr. in English).

Proc. Fla. State Hort. Soc. 97: 140-142. 1984.

QUALITY OF FLORIDA FRESH MARKET TOMATO GENOTYPES AS AFFECTED BY PRODUCTION ENVIRONMENT[1]

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Additional index words. tomato, composition, color, flavor.

Abstract. **Ten tomato (**Lycopersicon esculentum **Mill.) genotypes were grown at 9 production environments in Florida. Quality components measured at the table ripe stage were firmness, acidity, soluble solids, sugar/acid ratio, a/b color, vitamins A and C, and total solids. Data obtained from these analyses were pooled to establish a consumer quality index (appearance, texture, flavor, nutrition). There were differences in consumer quality among genotypes. Best quality fruit was produced at Ft. Pierce (Spring 1982) and Immokalee (Spring 1983). Tomatoes produced during the spring (Ft. Pierce and Bradenton) had a higher quality index than those grown in the fall, primarily because of firmness, soluble solids and total solids. These data do not support the assertion that consumer quality of newer tomato cultivars produced in Florida are inferior to cultivars previously grown.**

Increased consumption of fresh fruits and vegetables could be a vital link in alleviating some of the dietary problems of consumers. A reduction in obesity, a major health problem, and lower cancer risk are both associated with increased intake of fresh fruits and vegetables (1). Consumers have become more knowledgeable concerning the nutritional content of fresh vegetables and purchases are thus influenced. Fresh tomatoes are a major contributor of essential nutritional components to the human diet, providing a substantial amount of ascorbic acid, β-carotene, minerals and dietary fiber accompanied with a very minimal intake of calories (10). Consumers widely believe that newer tomato cultivars are inferior to older cultivars that have been available previously.

Variations in tomato quality (color, texture, flavor) have resulted from production factors involving fertilization, water management, and soil composition (2, 6, 7, 8). General consensus from these and numerous other reports is that quality differences are small or inconsistent and are frequently associated with environmental stress conditions. Quality differences are negligible where production provides for optimum growth of the plant.

It is generally recognized that tomato flavor is mainly attributable to the sugars and acid content and there is difference in flavor intensity between cultivars, harvest maturities and production environments (2, 4, 9, 12); there are also differences in firmness, color and total solids (2, 5).

Commercial cultivars of tomatoes in Florida have been evaluated by the senior author as to specific quality attributes or nutritional components. Fruit quality characteristics have also been studied in relation to stability among tomato genotypes grown under various environments within Florida and are being reported elsewhere. Genetic material having desirable characteristics has been identified and is being incorporated into developing cultivars. However, terminology such as "good quality" is non-definitive. From the standpoint of the consumer a tomato should have acceptable appearance, good flavor, texture and contain the desirable components for nutrition. Hence, further considerations of tomato quality in this paper will be determined based on the collective contribution of firmness, color, acidity, sweetness, vitamins A & C, and total solids (dry weight).

[1]Florida Agricultural Experiment Stations Journal Series No. 6055.