Proc. Fla. State Hort. Soc. 109:249-251. 1996.

MEASURING GRAPEFRUIT JUICE ON A PERCENT WEIGHT BASIS FOR MATURITY STANDARDS

W. F. WARDOWSKI
Citrus Research & Education Center
700 Experiment Station Road
Lake Alfred, FL 33850

M. RAINS
Florida Dept. of Agric. & Consumer Services
Division of Fruit & Vegetables
P.O. Box 1072
Winter Haven, FL 33882-1072

V. ZHITELEVA
Citrus Research & Education Center
700 Experiment Station Road
Lake Alfred, FL 33850

P. D. PETRACEK
Florida Department of Citrus
700 Experiment Station Road
Lake Alfred, FL 33850

Additional index words. Citrus juice, FDOC Rules.

Abstract. **Data were collected in August-October 1995 to compare the present minimum grapefruit juice standards (cc juice per fruit) to percent juice by weight.This study was done at the request and financial assistance of the Florida Citrus Packers. Over 1000 ten-fruit samples were measured for juice and other maturity indices. These samples included red and white grapefruit from the three Florida growing districts. The six most commonly packed sizes (27, 32, 36, 40, 48 and 56) represent over 96% of the annual crop. Juice by weight (49% for size 27 and 52%for sizes 32 through 56) has been adopted by the fresh fruit industry as an alternative measurement beginning with the 1996-97 season. These values correspond to the present minimum juice requirement of 275 (size 27) to 170 (size 56) cc juice per fruit. The advantage of using this standard in world markets is that percent juice by weight is easily understood.**

Minimum maturity standards for Florida grapefruit include °Brix, acid, °Brix:acid ratio and amount of juice (Wardowski et al., 1995). The established method for measuring amount of juice of Florida grapefruit is to select 10 fruit of a given ring diameter, extract the juice on a standardized machine, and measure the volume of the juice. The minimum standards are expressed as volume of juice (cm^3 or cc) per fruit (Florida Department of Citrus 1996; Florida Statutes, 1995). However, the cc juice per fruit requirement varies with the size of fruit and time of year. Also other production areas measure grapefruit juice as a percent by weight of the fruit, or like California, have no minimum juice requirement (Soule and Grierson, 1985).

The present juice requirements help to maintain a high minimum juice content in Florida grapefruit. These values, however, are not readily understood by consumers, and can not be compared to standards from other growing areas (Grierson, 1991). Thus, this study was conducted, at the request and with the flnancial support of the Florida Citrus Packers, to equate cc juice per fruit to percent juice by weight for the purpose of assessing alternative minimum standards for juice.

Materials and Methods

In this study, early season grapefruit were sampled because these fruit are less likely to meet the minimum requirement. Red and white grapefruit were harvested from groves in the Gulf, Indian River and Sun Ridge regions from 26 August to 20 October,1995. Four Doran Model 7000XL 30 lb capacity scales (± 0.005) were used among packinghouses packing grapefruit. Normal maturity data and fruit weights were recorded.

For each 10-fruit sample, the sample time and date, fruit type (white or red), size (count per shipping carton), county and production area, cc juice per fruit, °Brix, temperature correction factor, % acid, °Brix/acid ratio, weight of the fruit and weight of the juice were recorded. Also it was noted if the sample was preliminary (before degreening) or final (after degreening).

Samples with missing or inconsistent data were removed from the database. The data were entered into a spreadsheet and statistical analysis was performed by PlotIt (Scientific Programming Enterprises, Haslett, MI). Analyses of the data were by size comparing the cc juice per fruit to the percent juice by weight.

Table 1. Number of 10 fruit samples for each grapefruit size and diameters in inches with minimum juice requirement as cc juice per fruit.[z]

Size	Diameter inches	Minimum cc juice/fruit[y]	Number of samples	Percent juice by weight[x]
18	5-9/32	350	2	—
23	4-25/32	305	34	—
27	4-9/16	275	116	48.5
32	4-1/4	245	209	51.5
36	4-1/8	230	245	51.8
40	3-5/16	210	222	51.8
48	3-3/4	185	201	51.6
56	3-9/16	170	320	53.2
64	3-1/2	165	4	—

[z]Florida Department of Citrus Rules, 1996.
[y]For harvest dates 8/1 through 11/15.
[x]Calculated intercept points, Fig. 1.

Florida Agricultural Experiment Station Journal Series No. R-05465.

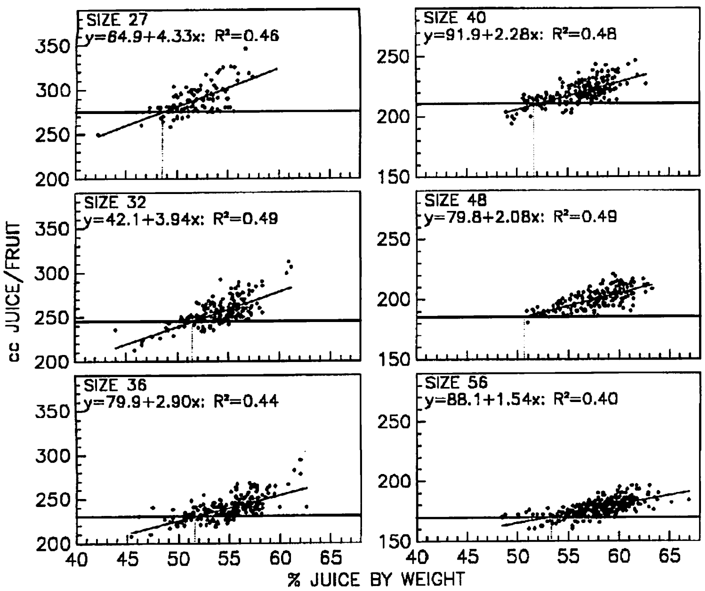

Figure 1. Percent juice by weight and cc juice per fruit for six sizes of grapefruit. Heavy horizontal lines represent the minimum juice requirements for each size.

Results

The number of samples included for each fruit size, the diameters of the sample fruit, and the minimum juice as cc per fruit are listed in Table 1. The fruit diameters and minimum cc juice per fruit are maturity requirements in the Florida Department of Citrus Rules (1996). Data are not presented for sizes 18, 23 and 64 since there were too few samples to consider the results representative. The remaining six sizes (27, 32, 36, 40, 48 and 56) represent over 96% of the 1995-96 season fresh grapefruit crop (Whigham et al., 1996).

A comparison of the cc juice per fruit to percent juice by weight is shown in Fig. 1 for each of six sizes from large (27) to small (56). There was a high correlation (R^2 range: 0.40 to 0.49) between cc juice per fruit to percent juice by weight for each size. The heavy horizontal line in each graph represents the current minimum juice requirement based on cc juice per fruit. The intercept of the line for current minimum requirement and the regression line for percent juice by weight is reported in Table 1. These six intercept points represent the best estimate of percent juice by weight which equals the minimum cc juice requirements.

Mean values, standard deviations, and ranges for cc juice per fruit, fruit weight, % juice, % acid, °Brix, and °Brix:acid ratios of the grapefruit sampled in this study are given in Table 2. None of these parameters were significantly different between fruit sampled before and after degreening ($\alpha = 0.05$, n = 52 paired samples, data not shown).

Table 2. Range of parameters measured for grapefruit of six sizes (27-56), n = 1300 samples of 10 fruit.

Parameter	Mean ± Standard deviation	Range
Juice per fruit (cc)	222 ± 36	160 - 358
Sample weight, (lb)	9.12 ± 1.79	5.73 - 15.22
Juice %	55.9 ± 3.4	42.2 - 66.9
Acid %	1.11 ± 0.11	0.86 - 1.51
°Brix	8.6 ± 0.7	7.0 - 11.2
°Brix:acid ratio	7.8 ± 0.6	6.3 - 10.1

Correlations among parameters are noted in Table 3. As expected, fruit size, juice per fruit, and fruit weight are correlated. Percentage juice was negatively correlated with juice per fruit and fruit weight (r = -0.41 and -0.58) thus indicating that % juice decreases with increasing size. Percent acid was negatively correlated with cc juice per fruit (r = -0.40) and positively correlated with fruit size (r = 0.33). Other correlations among fruit size and juice content parameters and growing area, harvest date, % acid, °Brix or °Brix:acid ratio were weak. Percent acid decreased with sample date (r = -0.40)and °Brix:acid ratio (r = -0.59) and increased with °Brix (r = 0 66). Since °Brix and °Brix:acid ratio were weakly correlated (r = 0.21), the variation in °Brix:acid ratio may be attributed primarily to changes in % acid.

Discussion

The Florida Citrus Packers requested that the Florida Department of Citrus adopt the results of this study into the rules as an alternative measurement method for the 1996-97 season. The rule reads: "This method shall be limited to fruit from 3-9/16 inch to 4-1/4 inch diameter which must have 52% juice by weight and fruit greater than 4-1/4 inch diameter up to 4-9/16 inch diameter which must have 49% juice by weight." This rule allows interested citrus packers to try a new method and still have the old familiar system available.

This alternative method is anticipated to save thc packinghouses down time in that exact diameter fruit within the size ranges do not have to be located for this test. Buyers and consumers will better understand the high minimum juice standards for Florida grapefruit. Early in the 1996-97 season, a limited number of samples are being taken in a manner similar to those in this study to confirm the data with another growing season.This information is not available at this time.

Table 3. Correlation matrix of eight factors for six sizes (27-56) of grapefruit.

	Fruit size	Juice per fruit (cc)	Fruit weight	Juice %	Sample date	Area'	Acid %	°Brix	°Brix:acid ratio
Fruit size	1.00								
Juice per fruit (cc)	-0.94	1.00							
Fruit weight (lb)	-0.94	0.95	1.00						
Juice %	0.58	-0.41	-0.58	1.00					
Sample date	-0.15	0.22	0.16	0.11	1.00				
Area'	-0.04	-0.01	0.04	-0.08	-0.11	1.00			
Acid %	0.33	-0.40	-0.29	-0.14	-0.40	-0.01	1.00		
°Brix	0.23	-0.20	-0.12	-0.10	-0.20	-0.05	0.66	1.00	
°Brix:acid ratio	-0.18	0.30	0.25	0.06	0.32	-0.03	-0.59	0.21	1.00

'Production area: 1 = Sun Ridge, 2 = Indian River, 3 = Gulf.

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Proc. Fla. State Hort. Soc. 109:251-254. 1996.

EFFECTS OF SELECTED PREHARVEST FACTORS ON POSTHARVEST PITTING OF WHITE GRAPEFRUIT

PETER D. PETRACEK AND CRAIG DAVIS
Florida Department of Citrus
Citrus Research and Education Center
Lake Alfred, FL 33850

Additional index words. Citrus peel disorders, chilling injury, *Citrus paradisi.*

Abstract. **The effects of harvest date, canopy position, and fruit size on postharvest pitting of white grapefruit were evaluated. Fruit were harvested every five to seven weeks (7 Dec. 1995, 18 Jan., 5 Mar., 12 Apr., and 20 May 1996) from six trees in a grove near Vero Beach, Fla. Fruit were washed, coated with a shellac-based wax, stored at 21.0°C, and evaluated visually during storage. The incidence of pitting was greater among fruit harvested in Jan. and May (about 40 and 25% incidence, respectively) than for fruit harvested in Dec., Mar., and Apr. (< 15% incidence). Canopy position (interior vs. exterior) did not affect pitting. Fruit orientation to the sun did not affect the distribution of clusters of collapsed oil glands. Pitting increased with fruit size: Pitting incidence (%) = (-0.97 fruit per box) + 51.3; r^2 = 0.70.**

Introduction and Literature Review

Postharvest pitting is a peel disorder characterized by clusters of collapsed oil glands that develop during the early weeks of storage (Petracek et al., 1995). Wax application and high temperature storage trigger pitting while reducing internal O_2 levels and increasing internal CO_2 levels. Fruit stored in low O_2 (4%) develop pits (Petracek, unpublished), and thus pitting may be a symptom of hypoxia.

While the effects of postharvest stress on pitting are becoming apparent, the disorder remains unpredictable. The mercurial nature of pitting is indicated in part by the following observations. First, pitting incidence varies among groves and harvest dates. Packinghouse reports indicate that pitting incidences vary greatly among fruit from adjacent groves that are harvested simultaneously and handled similarly. Reports also suggest that pitting incidences for a grove may vary among harvests within a season and among seasons.

Second, pitting incidence varies among fruit from a harvest. Pitting typically affects < 50% of the fruit. The majority of the fruit show no symptoms of pitting.

Third, distribution of pits on the fruit surface is uneven. The number of pit clusters is greatest at the stylar end (Petracek et al., 1995). Perhaps more important is that about one-quarter of the surface of pitted fruit do not develop pits.

These observations not only indicate that pitting is an erratically occurring event, but also suggest that susceptibility to pitting may be variable and alterable. In order to determine methods for controlling susceptibility, the effects of preharvest as well as postharvest factors must be examined. Many preharvest factors have been suggested as playing a role in pitting including rootstock, tree age, irrigation method, and fertilization strategies. However, no common cultural practice has been found among groves that report pitting (Petracek et al. 1995). In this initial investigation on the effects of preharvest factors on postharvest pitting, we examined the effects of three preharvest factors: harvest date, canopy position, and fruit size.

Materials and Methods

Plant material. Mature 'Marsh' white grapefruit *(Citrus paradisi* Macf.) were harvested from six 30-year-old trees (Swingle rootstock) in a grove near Vero Beach, FL between 1 1:30 A.M. and 2:00 P.M. Fruit were transported to the Citrus Research and Education Center (CREC) in Lake Alfred, FL and stored overnight at 21.0°C and 93% RH. On the morning after harvest, fruit were washed on roller brushes with Fruit Cleaner 395 (FMC Corporation, Lakeland, FL.) and waxed on roller brushes with a commercially-available shellac-based wax (FMC Corporation, Lakeland, FL.). Wax coatings were dried at 60C for about 1 min after wax application, and fruit were stored at 21.0°C and 93% RH. Fruit were not degreened and fungicides were not used.

Morphology. Scanning electron micrographs of pitted fruit were prepared by freeze drying the pitted tissue, freeze fracturing the tissue in liquid N_2, and mounting the tissue on aluminum stubs. Samples were coated with gold-palladium and examined with an S530 Hitachi SEM (Danbury, Conn.) at 20 kV accelerating voltage and photographed with Polaroid P/N 55 film. Stereo pairs were created by tilting the sample 10°.

Effect of canopy position, harvest date, and fruit size. The effect of harvest date and canopy position was determined. Fruit were harvested on 7 Dec. 1995, 18 Jan., 5 Mar., 12 Apr., and