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FRUIT QUALITY SAMPLING OF 'VALENCIA' ORANGE TREES

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Abstract. **Fruit samples that are in the same size range (sized samples) are often used to estimate juice content, soluble solids content (SSC), titratable acidity (TA) and ratio of SSC: TA. Typically fruit samples are taken around the tree at a 3-6 ft height. We compared fruit quality of a 20-fruit sized sample of 'Valencia' oranges [*Citrus sinensis* (L.) Osb.] on Carrizo citrange [*C. sinensis* (L.) Osb. × *Poncirus trifoliata* (L.) Raf.] or rough lemon (*C. jambhiri* Lush.) rootstocks with whole tree harvests at seven commercial groves in Florida. Ten trees were sampled and harvested at each location. Juice content samples averaged 6.8% higher than the whole tree measurements and SSC and TA means were 4.7 and 7.2% lower, respectively. SSC content of the sized sample and actual whole tree values were poorly correlated, probably because SSC is generally much higher in the top vs the lower portions of the canopy and SSC is quite variable within the tree. Sample and whole tree juice content levels were moderately correlated and TA content sample levels were highly correlated with whole tree measurements. Within tree variation for these quality factors is lower than for SSC. Therefore, sized samples provide a relative measure for estimating whole tree juice quality for juice content and TA but are less reliable for estimating SSC.**

Citrus juice quality is determined primarily by juice content, soluble solids content (SSC), titratable acidity (TA) and the ratio of SSC: TA. Juice quality varies within and between growing regions (Reuther and Rios-Castano, 1969), and within seasons (Barry et al., 2003; Harding et al., 1940; Harding et al., 1959; Harding and Sunday, 1949). There is also large variation in juice quality within the tree (Appleman and Richards, 1939; Bartholomew and Sinclair, 1943; Denny, 1922; Wallace et al., 1955). A classic study in Florida by Reitz and Sites (1948) clearly showed within tree variation for several fruit quality factors. They suggested that a 20-fruit, uniformly sized sample could be used to estimate fruit quality of the entire tree for oranges. This sampling method has become standard for determining when to harvest fruit in Florida (Wardowski et al., 1995).

Recently, Barry et al. (2003) showed that fruit sample number for determining treatment differences varied with juice quality factor and degree of precision required For example, a 35 fruit sample is necessary to determine a 0.3 SSC and 0.06% TA difference among treatments, whereas, a 0.4% SSC and 0.08% acidity difference can be determined with only a 20 fruit sample. They also found that SSC varied considerably within a tree as observed by others (Morales et al., 2000; Syvertsen and Albrigo, 1980).

As part of a larger study, we routinely collected uniformly sized fruit samples of 'Valencia' oranges and compared juice quality with whole tree harvests. Our objective was to compare juice content, SSC, TA and ratio of SSC: TA among samples at seven commercial locations in Florida.

Materials and Methods

Commercial groves of mature, bearing 'Valencia' orange trees on Carrizo citrange or rough lemon rootstocks were used in the study. Groves were located in Fellsmere, Bartow, DeSoto county and at four locations owned by Consolidated Citrus. A 20-fruit sized sample was collected at a 3-6 ft height from each of 10 trees per location. The entire tree was then harvested and fruit were transported to Gainesville, Fla. for juice analysis. Fruit was harvested on the following dates: Fellsmere (18 Apr.); Consolidated 1 (25 Apr.); Consolidated 2 (2 May); Consolidated 3 (8 May); Consolidated 4 (31 May); Bartow (16 May); DeSoto (24 May) 2001.

Fruit quality of the 20-fruit sample was determined by weighing and juicing the fruit, and then weighing the juice. Fruit were juiced using an FMC Fresh and Squeeze juicer (FMC, Inc., Lakeland, Fla.). A 2000 mL aliquot of juice was used to determine juice Brix using an RFM 100 series refractometer (Bellingham and Stanley, Tunbridge Wells, UK). Three subsamples of the juice were randomly taken with a disposable pipette and values were averaged for each sample. Titratable acidity was determined using standard methods and a Denver Instruments automatic titrator (Denver Instruments, Denver, Colo.) (Wardowski et al., 1995). Soluble solids content was determined by using standard correction values related to the amount of TA to adjust uncorrected Brix values.

For whole tree juice quality measurements, fruit from the entire tree were weighed and fruit were juiced using an FMC Fresh and Squeeze juicer. The juice was then weighed and a subsample was collected for Brix, TA and SSC:TA ratio measurements. These analyses were done as described for the 20-fruit samples.

Results and Discussion

Juice content was always greater for the sized sample than for the whole tree sample (Table 1). Average juice content for the sized sample for all locations averaged 6.8% higher than for the whole tree. In contrast, SSC and TA were lower for the sized than the whole tree samples for six of seven locations averaging 4.7% lower for SSC and 7.2% lower for TA. Ratio of

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Table 1. Fruit quality of whole tree and sized fruit samples for 'Valencia' oranges at various locations in Florida, 2001.

Location	Juice (%)		SSC (%)		TA (%)		Ratio	
	Tree[z]	Sample[y]	Tree	Sample	Tree	Sample	Tree	Sample
Fellsmere	55.2	55.5	12.74	12.42	1.15	1.00	11.09	12.42
Consol. 1	54.5	—	12.79	10.78	—	—	—	—
Consol. 2	55.6	60.1	12.54	12.18	1.05	1.07	12.00	11.38
Consol. 3	54.8	60.5	12.25	11.41	1.24	1.12	9.87	10.18
Consol. 4	50.7	55.5	11.66	11.66	0.75	0.74	15.68	15.75
Bartow	56.6	60.1	12.45	12.24	0.78	0.73	16.14	16.76
DeSoto	59.3	63.9	12.81	12.38	0.84	0.75	15.34	16.50
$\bar{x}$	55.5	59.3	12.46	11.87	0.97	0.90	13.35	13.83
ΔS vs T	6.8%		-4.7%		-7.2%		3.6%	

[z]Means of 10 individual tree samples for each location. The entire tree was harvested.
[y]Means of a single 20-fruit sized sample from each of 10 trees for each location.

SSC: TA was 3.6% higher for the sized vs whole tree sample. Fruit quality factors within each location were quite variable in some cases but not others. For example, juice content for the sized and whole tree sample were very similar at Fellsmere (55.2 vs 55.5%) but considerably different at Consolidated 3 (54.8 vs 60.5%). The same was true for SSC, with differences of 0 at Consolidated 4 to nearly 2.0 at Consolidated 1. TA measurements varied between the two methods by 0.01 (Consolidated 4) to 0.15% (Fellsmere). Not surprisingly, differences between the sized sample and whole tree for SSC: TA ratio also varied from 0.07 (Consolidated 4) to 1.33 units (Fellsmere).

We also determined r^2 values for the sized sample and whole tree values for juice content, SSC and TA. Juice content samples were fairly well positively correlated with whole tree samples, $r^2 = 0.68$ (Fig. 1), but SSC samples and whole tree values were poorly correlated ($r^2 = 0.029$) (Fig. 2). However, two data points varied considerably from the others, viz. Consolidated 1, 12.79 vs 10.78, and Consolidated 4, 11.66 vs 11.66. These extremes certainly affected the position of the best fit line. In contrast, r^2 for TA was 0.91 and sized sample values were highly positively correlated with whole tree samples (Fig. 3).

The differences in juice content between sized and whole tree measurements were larger than expected based on previous studies. Reitz and Sites (1948) found that juice content varied the least of the quality factors measured for 'Valencia' trees. Similarly, Morales et al. (2000) observed small differences in juice content for 'Orlando' tangelo fruit within a tree with top outside fruit having the lowest juice content. Syvertsen and Albrigo (1980) measured relatively large differences in juice content of 'Ruby' grapefruit with juice content being greatest in the south vs north part of the canopy. Juice content was similar for inside and outside fruit. Thus, the relatively large variation in the sized sample vs whole tree measurement is difficult to explain. However, we did observe that fruit size was much larger in the top vs lower canopy in several locations. Large fruit often have proportionately lower juice content than small fruit. Fruit from Fellsmere were the smallest in the study (data not shown), had the most uniform size, and showed the highest correlation between the sized sample and the whole tree harvest.

It is well-known that SSC varies considerably within a tree. Reitz and Sites (1948) observed that fruit from the lower canopy had much lower SSC than fruit from the top outside can-

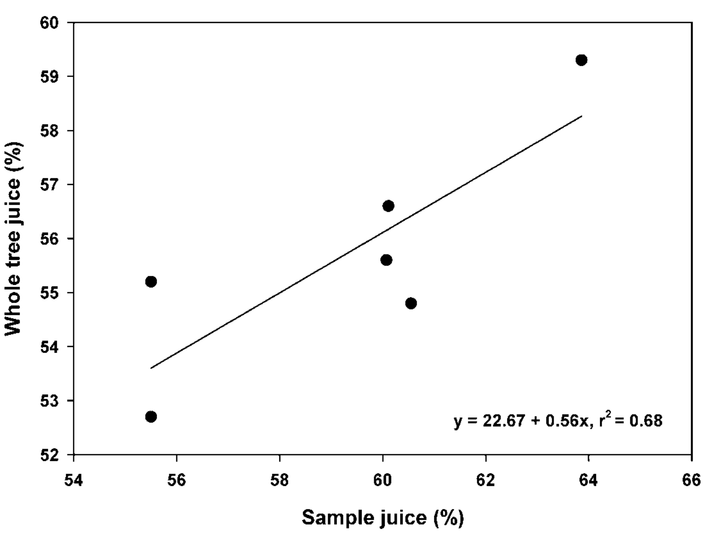

Fig. 1. Relationship between sized fruit and whole tree juice content samples for 'Valencia' orange trees from six commercial groves in Florida, 2001. Each data point represents the mean of 10 individual tree samples for each location.

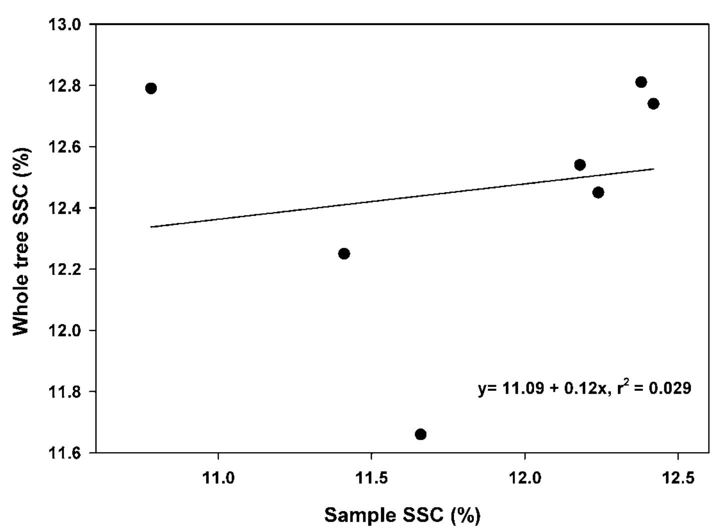

Fig. 2. Relationship between sized fruit and whole tree SSC samples for 'Valencia' orange trees from seven commercial groves in Florida, 2001. Each data point represents the mean of 10 individual tree samples for each location.

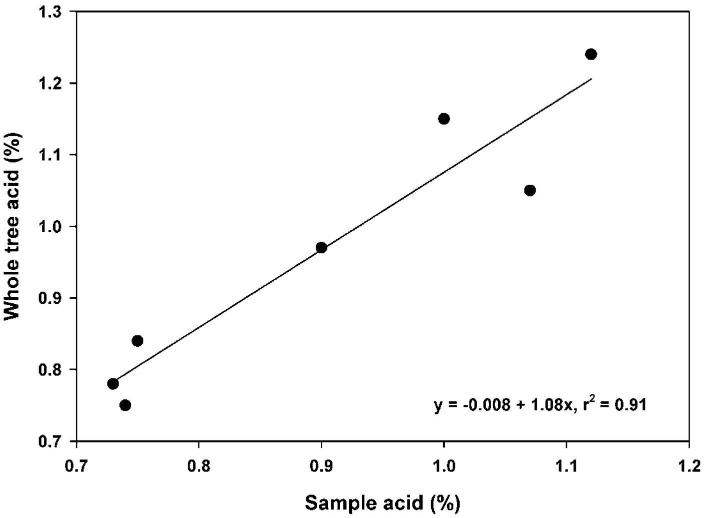

Fig. 3. Relationship between sized fruit and whole tree TA samples for 'Valencia' orange trees from seven commercial groves in Florida, 2001. Each data point represents the mean of 10 individual tree samples for each location.

opy position. Similarly, Syvertsen and Albrigo (1980) found higher Brix in the outside vs inside canopy positions, but the magnitude of the differences was much less. Morales et al. (2000) also found much higher Brix in fruit from the top vs lower part of the canopy. Moreover, Barry et al. (2003) found greater variation in SSC from the bottom to top of the tree than within trees. Therefore, a sized sample from mid-canopy may not represent SSC for the entire tree, especially for tall trees with a large portion of the fruit located in the upper canopy as occurred in several locations in this study.

Titratable acidity levels also were found to vary widely within the canopy but were not as highly correlated with location in the canopy as SSC (Reitz and Sites, 1948). Similarly, Syvertsen and Albrigo (1980) and Morales et al. (2000) observed less variation in TA than for SSC. Therefore we expected and found a better correlation between the sized and whole tree TA values than for SSC and juice content. Logically, the ratio of SSC: TA also varied considerably based on whether TA and SSC varied independently. Reitz and Sites (1948) also found considerable variation in SSC:TA ratio within the canopy.

Our findings differ from those of Reitz and Sites (1948), and represent a much larger sample size (70 trees) than used in their study (1 tree), although we did not measure every individual fruit on the tree. Therefore, it appears that fruit quality values from a 20 fruit, sized sample should be viewed with caution in making inferences about whole tree fruit quality unless great care is taken to obtain a representative fruit size. This is particularly true when estimating SSC for large trees with a disproportionately large amount of fruit in the top of the canopy.

Literature Cited

Appleman, D. and A. V. Richards. 1939. Variability of sugar: acid ratio and total nitrogen in 'Valencia' oranges. Proc. Amer. Soc. Hort. Sci. 37:539-542.

Barry, G., W. C. Castle, and F. S. Davies. 2003. Predicting juice quality of Valencia sweet orange in Florida using a temperature-dependent model. Proc. Intern. Soc. Citricult. 1:308-314.

Bartholomew, E. T. and W. B. Sinclair. 1943. Soluble constituents and buffer properties of orange juice. Plant Physiol. 18:185-206.

Denny, F. E. 1922. Formulas for calculating number of fruits required for adequate sample for analysis. Bot. Gaz. 73:44-57.

Harding, P. L. and M. B. Sunday. 1949. Seasonal changes in Florida tangerines. U.S. Dept. Agr. Tech. Bul. No. 988.

Harding, P. L., J. R. Winston, and D. F. Fisher. 1940. Seasonal changes in Florida oranges. U.S. Dept. Agr. Tech. Bul. No. 753.

Harding, P. L., M. B. Sunday, and P L. Davis. 1959. Seasonal changes in Florida tangelos. U.S. Dept. Agr. Tech. Bul. No. 886.

Morales, P., F. S. Davies, and R. C. Littell. 2000. Pruning and skirting affect canopy microclimate, yields, and fruit quality of 'Orlando' tangelo. HortScience 35:30-35.

Reitz, H. J. and J. W. Sites. 1948. Relation between positions on the tree and analysis of citrus fruit with special reference to sampling and meeting internal grades. Proc. Fla. State. Hort. Soc. 54:80-90.

Reuther, W. and P. Rios-Castano. 1969. Comparison of growth, maturation and composition of citrus fruits in subtropical California and tropical Colombia. Proc. First Intern. Citrus Symp. 1:277-300.

Syvertsen, J. P. and L. G. Albrigo. 1980. Some effects of grapefruit tree canopy position on microclimate, water relations, fruit yield, and juice quality. J. Amer. Soc. Hort. Sci. 105:454-459.

Wallace, A., S. H. Cameron, and P. A. T. Wieland. 1955. Variability in citrus fruit characteristics including the influences of position on the tree and nitrogen fertilization. Proc. Amer. Soc. Hort. Sci. 65:99-108.

Wardowski, W., J. Whigham, W. Grierson, and J. Soule. 1995. Quality tests for Florida citrus. Inst. Food and Agr. Sci., Univ. of Fla., Gainesville. SP99.