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EFFECTS OF ROOTSTOCK ON FRUIT QUALITY AND POSTHARVEST BEHAVIOR OF 'MARSH' GRAPEFRUIT

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Abstract. **Our objective was to determine the effects of rootstock on fruit quality and postharvest behavior of 'Marsh' grapefruit. We sampled grapefruit grown on sour orange, Carrizo citrange, Smooth Flat Seville, Swingle citrumelo, US-812 and Cleopatra mandarin rootstocks grown in replicated plots in a commercial grove in Martin Co., Fla. Fruit sampled from trees on each rootstock were analyzed at the time of harvest for standard fruit quality attributes (fruit size, % juice, Brix, and acidity). Fruit were stored at 5 °C for 5 weeks and then transferred to 20 °C, at which time they were rated for chilling injury (CI). Samples of fruit were again analyzed for the fruit quality parameters following storage. Rootstock had significant effects on all attributes measured with the exception of juice content. Fruit grown on sour orange rootstock developed significantly more CI than did fruit grown on the other five rootstocks. Fruit grown on Carrizo developed the least amount of CI. The results confirm that rootstock has significant effects on grapefruit quality, and it may be important to consider rootstock when making decisions regarding postharvest handling of the fruit.**

Approximately 40% of the grapefruit grown in Florida is marketed fresh; of that, approximately 60% is exported (Florida Ag. Stat. Services, 2002). Grapefruit for the fresh fruit market must not only be high quality at the time of packing, but must also be free of postharvest disorders at the destination. Numerous postharvest disorders may affect citrus fruit (Grierson 1986) resulting in economic losses. One postharvest disorder particular to grapefruit is chilling injury (CI), which is induced by holding the fruit at temperatures below 8-10 °C (Chalutz et al., 1985; Paul, 1990). Symptoms of CI include pitting and increased susceptibility to decay (Grierson, 1986; Chalutz et al., 1981).

Grierson (2002) has stressed the importance of identifying the "grove origins" or preharvest factors related to postharvest disorders, including chilling injury, on citrus fruit. One preharvest factor that may affect postharvest behavior is rootstock. The use of rootstocks is essential to citrus production in Florida (Castle et al., 1993). In addition to the effects on tree vigor, pest resistance and yield, rootstocks have significant effects on fruit quality (Castle et al., 1993; Wutscher, 1979), however, little information is available on the effects of rootstock on fruit postharvest behavior (McDonald and Wutscher 1974).

Although sour orange was once the predominant citrus rootstock used in the Indian River district, susceptibility to citrus tisteza virus has led to it's abandonment. A recent survey of rootstock usage in the Indian River district (Stover and Castle, 2002) indicated that 96.9% of the grapefruit trees were on five rootstocks: sour orange (*Citrus aurantium* L.), Swingle citrumelo (*C. paradisi* [Macf.] × *Poncirus trifoliata* [L.] Raf.), Carrizo citrange (*C. sinensis* [L.] Osbeck × *P. trifoliata* [L.] Raf.), Cleopatra mandarin (*C. reticulata* Blanco), and Smooth Flat Seville (*Citrus* hybrid) which represented 54.7, 27.3, 3.7, 8.5, and 2.7%, respectively of the grapefruit acreage. US-812 (*C. reticulata* × *Poncirus trifoliata*) is a recently released citrus rootstock (Anonymous, 2001). Our objective was to determine the effects of rootstock on fruit quality and postharvest behavior of 'Marsh' grapefruit.

Materials and Methods

'Marsh' grapefruit (*C. paradisi* Macf.) on a variety of rootstocks were planted in June or October 1995 in a cooperative field trial near Hobe Sound, Martin County, involving Becker Groves, University of Florida, and USDA. The 'Marsh' budline used was F57-X-E. The trees were spaced 15 ft. × 22.5 ft., and planted in Wabasso fine sand, with irrigation by microsprinkler. The experimental design was a randomized complete block with 12 replications of single-tree plots. Trees chosen to collect samples were scattered in a random fashion across about a three-acre area of the experimental block.

Samples of 40 fruit from each of 4 replications of sour orange, Swingle citrumelo, Carrizo citrange, Cleopatra mandarin, and Smooth Flat Seville and US812 rootstocks were harvested on Dec. 12, 2001 and taken to the USDA laboratory

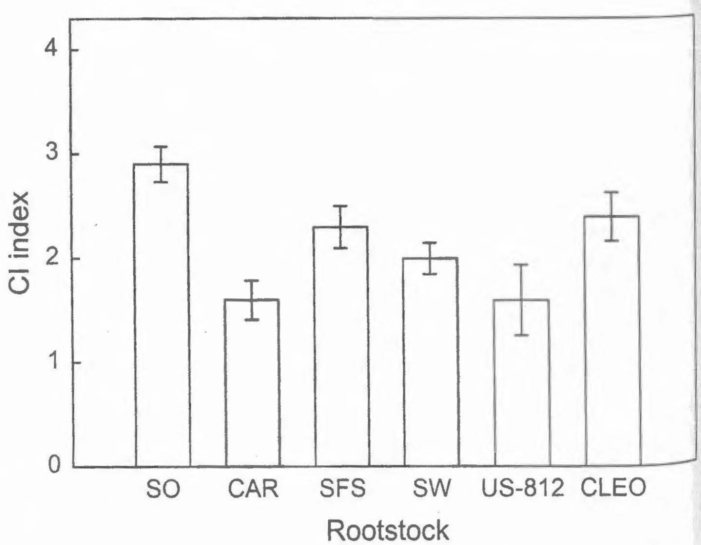

Fig. 1. Effects of rootstock on chilling injury of 'Marsh' grapefruit following 5 weeks of storage at 5 °C. SO, sour orange; CAR, Carrizo; SFS, Smooth Flat Seville; SW Swingle; US-812, CLEO, Cleopatra mandarin.

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ble 1. Analysis of variance for the effects of rootstock on quality of Marsh grapefruit at the time of harvest.

		Means				
Rootstock		Fruit wt. (g)	% juice	Brix	Acidity (% citric acid)	Brix/acid
Sour orange		383 c	54.6	8.9 a	1.03 a	8.6 b
Carrizo		446 a	53.3	8.3 b	0.89 c	9.3 a
Smooth Flat Seville		420 b	53.4	7.9 c	0.96 b	8.2 b
Swingle		430 ab	53.1	8.5 b	1.02 ab	8.3 b
812		460 a	54.6	8.2 bc	1.01 ab	8.2 b
Cleo		377 c	55.g	8.1 bc	0.99 ab	8.2 b
Source	df	Analysis of variance mean squares				
Rootstock	5	3.125	3.058	0.3397	0.0008	0.5867
Error	12	0.2101	3.497	0.001	0.00005	0.004
Total	17					
F		14.88***	0.8745ns	21.84***	18.47***	16.5***

[z]Means within columns followed by the same letter are not significantly different at 5% level as determined by Duncan's multiple range test.
[y]F values significant at the 0.001 level (***) or not significant (ns).

in Ft. Pierce. The fruit were inspected and those with defects were discarded. The remaining fruit were washed in 0.05% detergent rinsed with water and air dried overnight. The following day the fruit were divided into four lots of 30 fruit each. Three of the four lots were placed into storage at 5 °C. The fourth lot of 30 fruit was divided into three lots of 10 fruit and used for quality analysis.

Juice was extracted with uniform pressure using a Sunkist type 7 juice extractor. The weight of the juice was determined. Dividing the weight of the juice by the total weight of the fruit and multiplying by 100 calculated percent juice. Total soluble solids (°Brix) were determined using a Bausch and Lomb refractometer. Titratable acid was determined by titration of a 25 mL juice sample with 0.3125N NaOH and data expressed as % citric acid.

Following storage at 5 °C for five weeks, samples were removed from storage and rated for chilling injury on a scale of 0 to 4 where 0 represents no chilling injury and 4 represents severe chilling injury. After the fruit were rated their juice quality was determined as described above.

All data were subjected to analysis of variance using the Statistical Analysis System. The experimental design was completely randomized with three replications.

Results and Discussion

Rootstock had significant effects on fruit quality at the time of harvest (Table 1). Carrizo, US 812, and Swingle rootstocks produced the largest fruit while sour orange and Cleopatra produced the smallest fruit. Percent juice averaged 54% and did not differ among the rootstocks. Soluble solids of fruit grown on sour orange rootstock averaged 8.9 °Brix and were significantly higher than fruit grown on all other rootstocks. Smooth Flat Seville rootstock produced fruit with the lowest soluble solids (7.9 °Brix). Fruit grown on sour orange had the highest acidity (1.03% citric acid) while that on Carrizo rootstock had significantly lower acidity (0.89% citric acid) than fruit grown on all other rootstocks. In addition to the low acidity of fruit grown on Carrizo, the Brix/acid ratios were higher in fruit from Carrizo (9.3) than from all other rootstocks.

Table 2. Effects of rootstock on fruit quality following storage for 5 weeks at 5 °C.

		Means				
Rootstock		Fruit wt. (g)	% juice	Brix	Acidity (% citric acid)	Brix/acid
Sour orange		377 d[z]	53.6	9.3 a	1.06 a	8.7 ab
Carrizo		440 ab	52.5	8.5 b	0.92 d	9.2 a
Smooth flat Seville		413 c	54.8	8.2 c	0.95 cd	8.6 ab
Swingle		423 bc	55.1	8.7 b	0.97 bcd	9.0 ab
812		457 a	53.9	8.6 b	1.03 ab	8.3 b
Cleo		370 d	56.7	8.6 b	1.00 abc	8.7 ab
Source	df	Analysis of variance mean squares				
Rootstock	5	3.3	6.1	0.364	0.0087	0.286
Error	12	0.2	7.3	0.01	0.001	0.144
Total	17					
F		19.3***[y]	0.8 ns	36.49***	5.99***	ns

[z]Means within columns followed by the same letter are not significantly different at 5% level as determined by Duncan's multiple range test.
[y]F values significant at the 0.001 level (***) or not significant (ns).

Following storage, fruit quality parameters were similar to those measured at the time of harvest (Table 2). Total soluble solids increased slightly in fruit from each rootstock, as did total acidity. In contrast to the initial samples, following storage there were no significant differences among the rootstocks in Brix/acid ratios.

Rootstock had significant effects on the amount of chilling injury on 'Marsh' grapefruit following 5 weeks at 5 °C (Fig. 1). Fruit grown on sour orange rootstock had the greatest amount of CI (CI index 2.9) whereas fruit grown on Carrizo and US812 rootstocks had the least amount of CI (CI index 1.6 for each). This effect of rootstock on CI should be a factor to consider when making postharvest management decisions. To our knowledge, this is the first report of the effects of rootstock on CI. Future studies should be conducted to evaluate the effects of rootstock on other postharvest disorders including decay, pitting (Petracek et al., 1998), and stem end rind breakdown. Although it is unlikely that rootstock effects on postharvest behavior would have an important role in the selection of a rootstock, information regarding how rootstock affects postharvest disorders could be utilized in developing an expert system for growers, packers and shippers. Such a system would be useful for making management decisions regarding postharvest handling.

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THE COMPARISON OF A METAL OXIDE BASED ELECTRONIC NOSE, GAS CHROMATOGRAPH, AND A MASS SPECTROMETER BASED CHEMICAL SENSOR

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Abstract. **A mass spectrometer based chemical sensor system is compared to a metal oxide semiconductor (MOS) system and a gas chromatograph for differentiating not from concentrate orange juices. Five not from concentrate and one from concentrate juices were analyzed. The separation of the different classes were similar for the MOS and gas chromatograph systems. The mass spectrometer based unit appears to have superior class separation based on preliminary results. Each system has advantages and disadvantages and these will be discussed along with the multivariate statistics used to achieve the separation.**

Electronic noses are an important QA/QC tool used in many industries. These instruments utilize advanced multivariate statistics coupled with a chemical sensor array in order to differentiate samples. Any type of sensor that responds to chemicals can be used for an electronic nose. For example, a flame ionization detector (FID) for a gas chromatograph can be used for a chemical sensor. As each compound elutes from the GC, the FID produces a response. The individual peaks of the chromatogram become the 'sensors'. This has some advantages in that the peaks are likely to be single compounds and thus the model can be related to specific chemicals and could provide additional information. This method, however, is different from a traditional electronic nose since there is chemical separation of the individual constituents. Additionally, there are currently no commercially available GC-FID electronic nose instruments. In a similar manner, a mass spectrometer can also be used as a chemical sensor.

A slightly different approach is to utilize a mass spectrometer (MS) as an electronic nose/chemical sensor. In the case of the MS, each mass to charge (m/z) is used as a 'sensor'. There is no chemical separation of the sample prior to analysis which means that the mass spectra collected are of the entire product. This is slightly different from the traditional use of a MS–where chemically pure compounds are introduced as

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