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INTERNAL QUALITY OF INDIAN RIVER DISTRICT GRAPEFRUIT OVER THE PAST 36 YEARS

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Abstract. **In recent years, growers in the Indian River District have expressed concern about low soluble solids concentration (SSC), pound solids per box (PS/B) and poor grapefruit quality in general. Internal fruit quality data from the Florida Agricultural Statistics Service (FASS) for red and white grapefruit from 1968 to 2003 for the Indian River Citrus District were evaluated to see if changes had occurred that supported this concern. The historical data did not support the belief that a large decrease in SSC nor PS/B has occurred in recent years. Acidity levels in December did appear to be lower in the short term if February-March and October-November mean temperatures were higher, but large difference occurred in 2 to 3 year cycles that were not accounted for. Generally, SSC and PS/B were higher and acidity values were lower for red than white cultivars, and the difference was very consistent and pronounced the last 4 to 5 years. Recent trials with relatively new red cultivars and rootstocks were evaluated to see if their adoption in the River District might have resulted in significant changes in quality. Except for 'Star Ruby', the new darker red cultivars appeared to be more like 'Ruby Red' and not as low in SSC or PS/B as 'Marsh' (seedless white) in one trial. None of the scion cultivars were different in another trial. The use of the 'Smooth Flat Seville' rootstock clearly resulted in lower SSC and PS/B in grapefruit compared to trees on sour orange, but neither 'Carrizo' nor 'Swingle' were different from sour. For new plantings, growers should select moderately vigorous rootstocks, which have been shown to produce good internal grapefruit quality. Growers can partially overcome low solids early in the season by avoiding over irrigation, which dilutes soluble solids, and by selectively harvesting from the top and south side of the tree, where soluble solids concentration is higher, rather than selecting only for size.**

Growers in the Indian River District have expressed concern about a general decline in grapefruit quality in recent years and specifically, low soluble solids. Current costs of production and fruit returns, particularly processed juice values, make it very important to maximize internal quality. The Florida Agricultural Statistics Service (FASS) has data from 1968 for the Florida citrus producing districts that includes internal quality values for red and white grapefruit (FASS, 1968-2003), which could verify or dispel this concern. Furthermore, scion cultivars and rootstocks have changed over the past 10 to 20 years and these scion changes could have resulted in poorer grapefruit quality. Also, weather variables can affect fruit quality, particularly soluble solids and acidity levels (Reuther, 1973; Reuther and Castano-Dios, 1969). Therefore, we examined historical records to determine what, if any, changes in quality occurred in the Indian River District, and the role of various factors, such as climate, cultivar, rootstock, irrigation, and fruit canopy position.

Materials and Methods

White and red grapefruit quality measurements were obtained from the Florida Agricultural Statistics Service for the years 1968 through 2003 (FASS, 1968-2003). The data for samples taken each 1 Dec. were used since these represent a legally mature grapefruit and the effects of cultivar, rootstock, and weather on fruit development. Data later in the harvest season may be less reflective of seasonal differences as fruit senescence becomes a factor. Data obtained include concentrations of soluble solids (SSC), acidity, their ratio, juice content as percentage by weight, and pounds solids per box. The data each year represented the average of 33 to 35 individual grove samples for whites cultivars (primarily 'Marsh') and from 22 to 29 separate groves for samples of red cultivars (primarily 'Ruby Red' in early years and included newer red selections in the last 10 years).

Weather data was accumulated from four U.S. Weather Service Stations in the Indian River District (NOAA, 1968-2003). Mean monthly temperatures in 2 month increments were averaged for the four weather stations.

Fruit internal quality was obtained from 'Marsh' trees grown in a Ft. Pierce rootstock trial. Fruit were sampled in Feb. 2003 and Jan. 2004 when the trees were 8 and 9 years old (data provided by Dr. W. S. Castle).

The juice quality data of 'Marsh', 'Ruby Red', 'Flame' 'Ray Ruby' and 'Star Ruby' trees on 'Swingle' rootstock was determined in Mar. 2004 samples of 30 fruit collected from each of three trees of each cultivar. These trees were 12 years old and planted at Lake Alfred, Fla. Juice analysis was performed with an official automated citrus juice test sampling system with an FMC extractor as were other samples reported here. The data were statistically analyzed as a one-way ANOVA test.

Juice quality was measured during the 1995-1996 season of 'Marsh', 'Ruby Red', 'Flame' 'Ray Ruby', 'Rio Red' and 'Star Ruby' fruit from trees on 'Swingle', 'Carrizo' or sour rootstocks. These trees planted at Immokalee, Fla. were 6 years old in 1995.

Results and Discussion

The 36-yr trend in SSC on 1 Dec. for white and red grapefruit cultivars in the Indian River District showed considerable year-to-year variation (Fig. 1A). The values in some years

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were 9.5 or lower, and in high Brix years, the values were close to 11. Most values were between 10.2 and 10.7 with red cultivars having slightly higher values than white cultivars in 29 of the 36 years. This trend for reds to have slightly higher SSC was true for juice content in only 18 of the years (Fig. 1B), but pound solids per box (PS/B) was higher for red than white cultivars in 29 years also (Fig. 1C). There is little indication that the difference between red and white cultivars has changed in the past 10 years as compared to the previous 26 even though the red cultivars used in the industry have changed in recent years. The FASS test records do not support that any consistent decrease in SSC has occurred over the past few years. Cancalon (2003) did not report any difference in SSC of processed juice over the past 50 years either. A strong alternating pattern of high and low values for SSC has occurred over the past 8 years and large swings in internal quality occurred during earlier periods also, with red cultivars continuing to be slightly higher than whites. In a previous study of soluble solids production in 'Valencia' orange in Florida (Albrigo, 1993), winter mean temperature was found to have a significant effect on PS/B with higher mean temperatures for December-January corresponding to higher soluble solids, perhaps due to higher photosynthetic rates. These winter weather patterns did not appear to be related to grapefruit PS/B (Fig. 1D vs 1C).

Seasonal grapefruit juice acid levels in December each year varied considerably and often were negatively related to short term changes in February-March and October-November mean temperatures when adjacent years were compared (Fig. 2A and B, respectively). Higher mean maximum temperatures in the October-November periods were related to lower acidity values (Albrigo, 2004). Further there were several 2 to 3 year sequences after 1984 of increasing acidity levels that do not appear to relate to temperatures in either of these time periods. These periods should be evaluated further to determine what factor(s) may account for the elevating acidity levels.

There appears to be a gradual elevation in February-March mean temperatures over the 1968 to 2003 time period. This could partially account for the apparent earlier bloom dates observed the last 10 years compared to the 1960-1970 time period (Simanton, 1969; Valiente and Albrigo, 2002) and to the slightly lower acidity observed in the last 3 years. But the general declining trend in acidity of processed grapefruit over the past 50 years as reported by Cancalon (2003) is not supported by the annual December FASS grapefruit juice quality data for the Indian River District. Cancalon (2003) used processed sample data where there has been a trend to harvest later in the season to improve ratio and quality, and he also considered that the shift from Central Florida to primarily South Florida and Indian River production of grapefruit was important. Neither of those factors are involved in the data presented here.

The juice quality among the fruit of three new red cultivars growing on 'Swingle' citrumelo growing at Lake Alfred was similar to and not different from 'Ruby Red' but had higher SSC than 'Marsh' fruit SSC (Table 1). The one exception was 'Star Ruby', which was similar to 'Marsh' with lower SSC and PS/B. On the other hand, a scion cultivar comparison (1995-1996 and 1996-1997 seasons) in Immokalee, Florida did not indicate that fruit of 'Marsh' nor 'Star Ruby' were particularly lower in SSC or PS/B than several other red cultivars (Fig. 3).

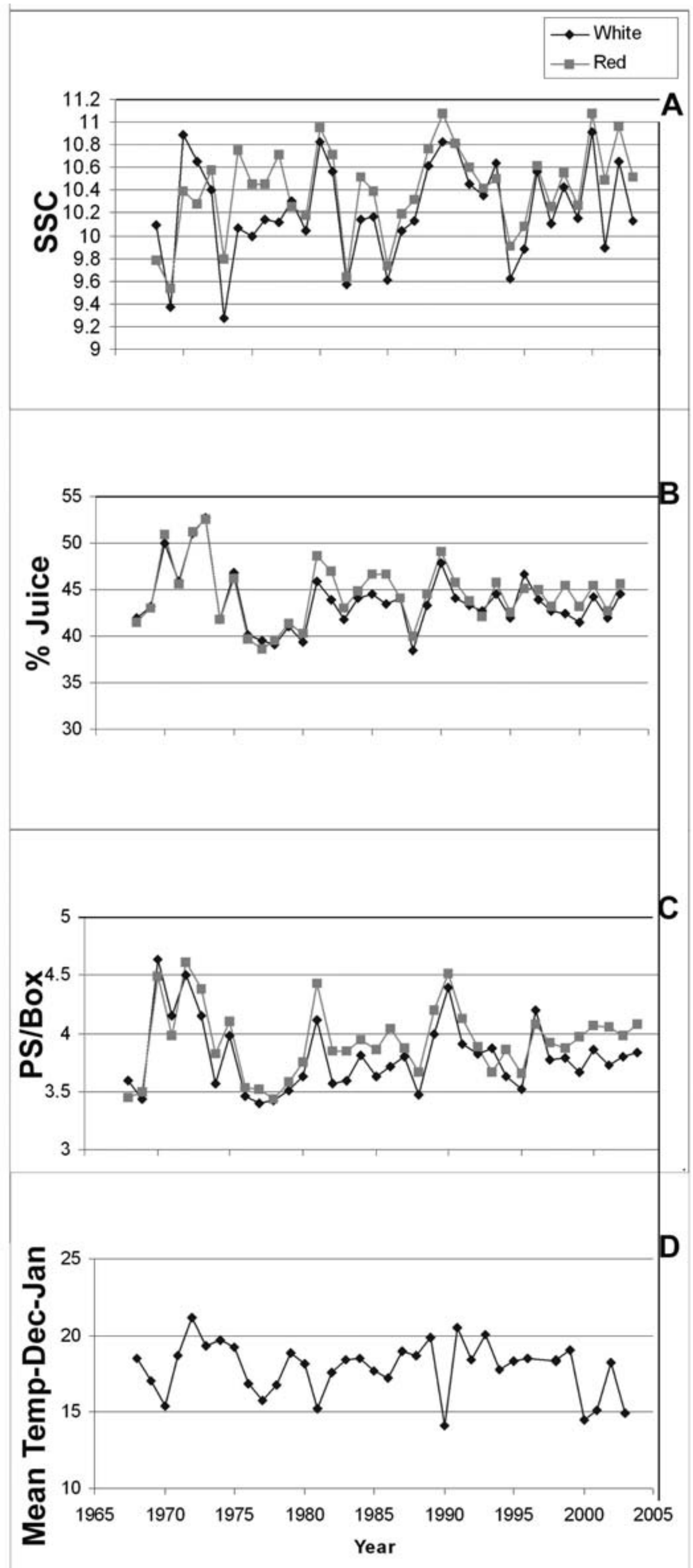

Fig. 1. Soluble solids concentration (SSC) (A), percentage juice (B), pounds solids/box (PS/Box) (C) for red and white grapefruit on 1 Dec. from 1968 to 2003 and December-January mean temperatures (D) for these same years for the Indian River District of Florida (FASS and NOAA data).

Based on these comparisons and the shift to newer red cultivars in the Indian River District, the SSC and PS/B values should have improved slightly or not changed in recent years.

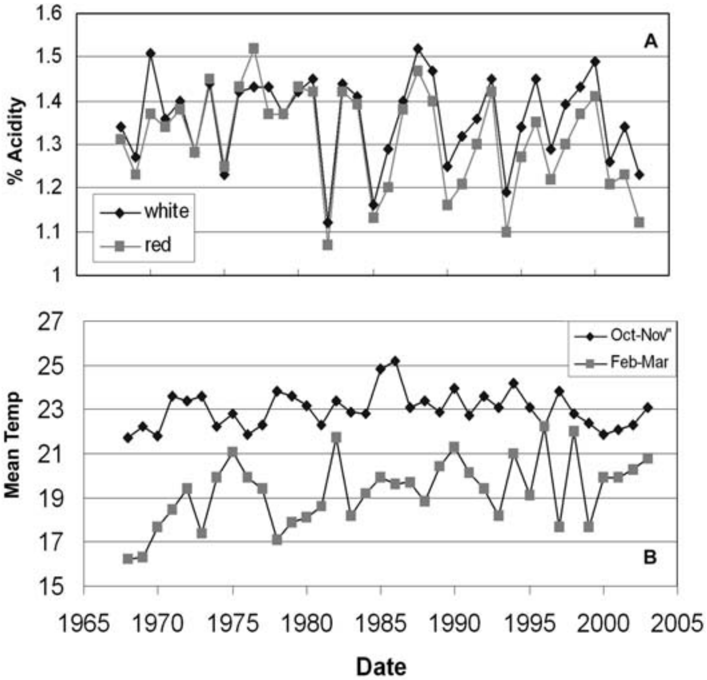

Fig. 2. Acidity (%) of red and white grapefruit (A) and mean February-March and October-November temperatures (B) for the Indian River District of Florida from 1968 to 2003 (FASS and NOAA data).

An improvement may be reflected in the consistently higher values for red compared to white cultivars reported by FASS (1968-2003) the last 4 to 5 years although a similar difference did occurred in the past, PS/B in the early eighties (Fig. 1A and 1C).

The cultivar changes over recent years did not appear to have had a major effect on grapefruit juice SSC, however, the shift in the Indian River District from sour orange, which is highly susceptibility to tristeza, to 'Smooth Flat Seville' is apparently a considerable source of grower complaint. Trees on 'Smooth Flat Seville' clearly produce fruit inferior to those grown on sour orange in respect to SSC (Fig. 4A). Trees on this rootstock also produce fruit with lower juice content (Fig. 4B) which coupled with SSC translates into far less SS/B compared to fruit on sour orange rooted trees (Fig. 4C). However, a comparison across six cultivars on 'Carrizo', 'Swingle' and sour rootstocks in the Immokalee area in the 1995-1996 harvest season did not show any large difference in SSC, percentage juice nor in PS/B for these rootstocks (Fig. 5). However, there did appear to be a small but consistent difference in fruit acidity levels when these rootstocks were used (Table 2).

Although rootstock use in the River District has changed over time (Stover and Castle, 2002) the historical data in Fig. 1 do not suggest that any discernible effect on juice quality from any rootstock changes has occurred in the Indian River District either. However, blocks on 'Smooth Flat Seville' are clearly inferior for internal fruit quality.

Table 1. Soluble solids concentration (SSC), acidity, Brix to acid ratio, juice content and pound solids per box (PS/B) for grapefruit cultivars growing on 'Swingle' citrumelo rootstock at Lake Alfred, Fla. and sampled in March 2004.

Cultivar	SSC %	Acid %	SSC/A Ratio	Juice %	PS/B
Marsh	9.9 b	1.21 a	8.3 c	59 ab	2.26 b
Ruby	10.4 ab	1.14 a	9.1 b	60 ab	2.40 ab
Ray Ruby	10.5 a	1.16 a	9.3 b	64 a	2.58 a
Flame	10.6 a	1.06 b	10.0 a	62 a	2.53 ab
Star Ruby	9.3 c	1.03 b	9.0 b	56 b	1.91 c

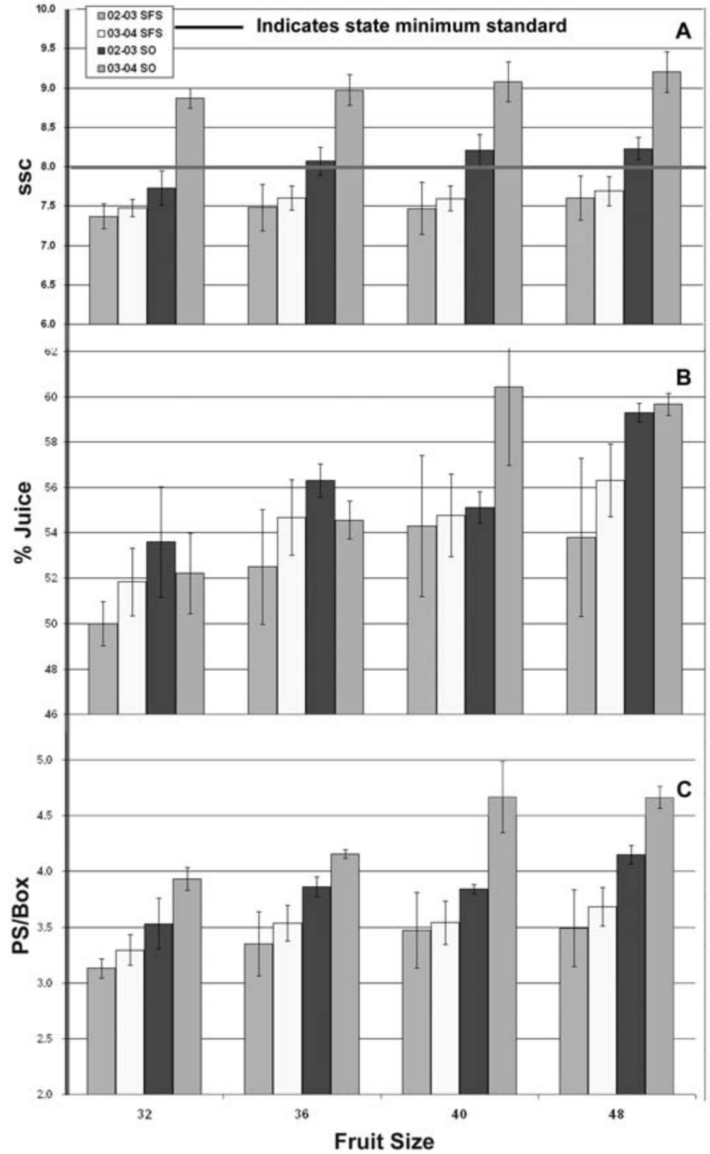

Fig. 3. SSC, SSC/Acidity ratio and SS/B for 6 grapefruit cultivars grown in Immokalee, Florida and sampled 3 times during the 1995-1996 harvest season (not significantly different).

Trees on vigorous rootstocks tend to produce fruit with lower SSC than those on less vigorous rootstocks (Albrigo, 1977; Reitz and Embleton, 1986). Trees on 'Smooth Flat Seville' are of moderate vigor, similar to sour orange (Stover and Castle, 2002), but produce poorer quality fruit than those on sour orange. 'Smooth Flat Seville' seems particularly unsuited for grapefruit in the Indian River District. Obviously, a good decision, with long-term consequences, is to select rootstocks that produce good quality fruit early in the harvest season. Unfortunately, new rootstocks with reliable experimental data concerning suitable fruit quality, good horticulture and disease resistance characteristics are not available yet.

Another factor that may be responsible for some growers observing poorer fruit quality is better irrigation manage-

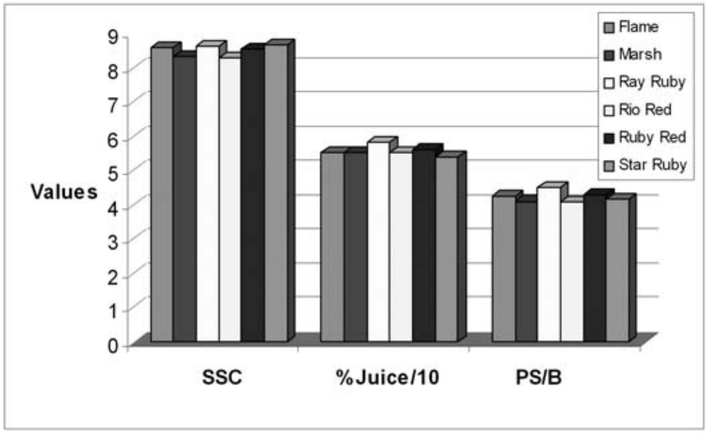

Fig. 4. SSC (A), percent juice (B), and PS/B (C) for 'Marsh' grapefruit on sour orange or 'Smooth Flat Seville' rootstock during the 2003 and 2004 seasons in Ft. Pierce, Florida (data provided by Dr. W. S. Castle).

Table 2. Average acidity of 6 grapefruit cultivars on 'Swingle', 'Carrizo' or sour orange rootstocks. Average from 3 harvest dates (Immokalee, Fla. 1995-96).

Rootstock	Acidity
Carrizo	0.98 a
Sour	1.00 b
Swingle	1.03 c

Table 3. SSC, acidity, SSC/acid ratio, % juice, and PS/B for 'Marsh' grapefruit trees as influenced by irrigation level in the Indian River District (2003-2004).

Irrigation treatment	Brix	Acid	B:A ratio	Juice (%)	Solids/box (kg)
No IRR 0X	11.0 a	1.2 a	9.0 b	60.8 a	2.57 a
Normal 1X	10.8 a	1.1 b	9.7 a	57.4 b	2.38 b
Extra 2X IRR	10.4 b	1.1 b	9.3 b	60.7 a	2.43 b

ment than in year's past. The improved double row bedding procedure and implementation of microjet irrigation for flood irrigation in the Indian River District probably has decreased drought stress and increased size and dilution of soluble solids and acid levels (Sites et al., 1951). A recent comparison under such conditions demonstrated that SSC and PS/B were decreased by increased irrigation (Table 3). Many growers may be over irrigating in the spring and particularly the fall, which acerbates the low soluble solids problem.

If cultivar, rootstock, weather and other conditions do result in low soluble solids, improved harvest quality early in the season may be achieved by selectively removing fruit from areas of the canopy known to have higher SSC. Early season spot picking for size is common in grapefruit, but this practice selects fruit with the lowest SSC (Long et al., 1959). Harvesting from the top and south outside of the tree will select fruit with higher SSC levels in order to meet juice quality standards at the earliest possible date (Reitz and Sites, 1948; Syvertsen and Albrigo, 1980). The down side of this procedure is that fruit in these positions may be smaller than in other canopy areas, particularly inside the tree.

Overall, the grower concerns in the Indian River District about a recent downturn in grapefruit quality are not supported by the long-term FASS data. The recent decline in acidity levels may be related partially to warmer spring and fall temperatures. The recent years of low acidity may have resulted in acceptable SSC/Acid ratios for maturity standard earlier and therefore harvests may have started earlier. This would have led to lower SSC at these earlier harvest dates and caused growers to perceive that SSC and PS/B were unusually low. On the other hand, neither scion or rootstock cultivar changes in recent years appear to have changed the general trends in SSC nor PS/B as presented in the December FASS data.

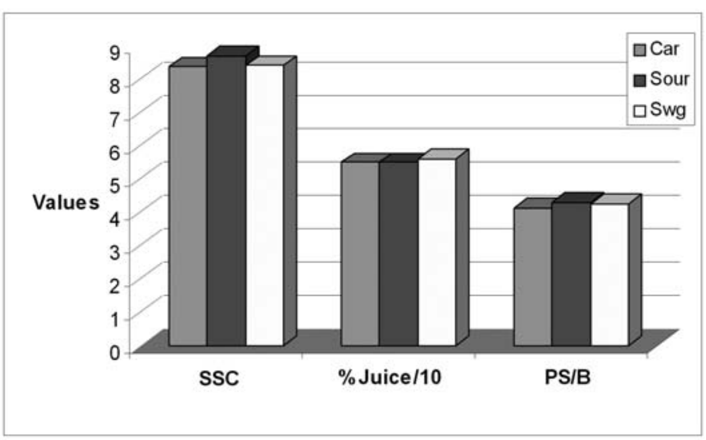

Fig. 5. SSC, percent juice and PS/B averaged for six grapefruit cultivars on 'Swingle', 'Carrizo', or sour orange rootstocks when grown in Immokalee, Florida (1995-1996 season).

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