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Differences in Temple Orange Color and Quality Associated with Stylar-End Greening

THE CALYX or stem-end half of a citrus fruit differs from the blossom or stylar-end half in several aspects. Bartholomew and Sinclair (1) found that the stylar half of Valencia and Navel oranges and unnamed grapefruit had higher soluble solids in 95 to 99 per cent of the segments, higher acid in 91 per cent, and higher reducing sugars (glucose) in 100 per cent. Haas and Klotz (6) found that specific gravity, sugars, osmotic pressure, ash, amino acids, and inorganic nitrogen were higher in juice from the stylar half than from the calyx half. They found the carotenoid content of juice from stylar halves to be one and one-half times that of the calyx halves.

The stylar half of the rind of citrus fruit usually turns yellow, due mainly to loss of chlorophyll (8), earlier than the rind of the calyx half of the same fruit, although the calyx end eventually may become more highly colored.

This is a report of analyses of Temple oranges in which the normal order of color change in the rind was reversed; the calyx end turned yellow while the stylar end remained green. The greenness persisted for 3 to 5 weeks at the stylar end, and the rind at the stylar end was considerably roughened, in reverse of the usual pattern. Because this atypical pattern of ripening has been associated with stubborn disease of citrus (3, 4), fruits with stylar-end greening were analyzed to determine whether the concentration gradients of the soluble solids and acid were different from those of normally colored fruits.

Methods

Fruits with stylar-end greening and normally colored fruits of approximately the same age were collected from an 11-year-old grove of Temple orange trees on rough lemon rootstock on February 1 and 15, 1960. Samples of 10 fruits from each lot were analyzed individually. Since the fruits exhibiting greening were from a delayed bloom, the controls were normally colored fruits from the same bloom on the same or adjacent trees. Color determinations were made on each fruit; the fruit was then cut in half (at right angles to the axis), and the juice from the calyx half and that from the stylar half were analyzed separately.

The difference in light transmittance due to absorption by chlorophyll was determined with the "Hortispect" (Horticultural Spectrophotometer) (2), which transmits a beam of light varying in wave length from 435 to 718 millimicrons through the fruit; the transmittance of various wave lengths is recorded by a strip-chart recorder. Relative chlorophyll absorption was the difference in transmittance of light at 700 millimicrons, the reference wave length, and light of 677 millimicrons, the wave length of the peak absorption by chlorophyll. In these tests, the stylar end of the fruit was presented to the light source.

Rind color was determined by reflected light with a Hunter Color and Color Difference Meter (7); readings were taken on the calyx end and the stylar end of each fruit. Reflectance (Rd) values are a measure of rind smoothness and other factors such as color intensity and hue. The "a" value is a measure of redness (+) or greenness (−), and the "b" value is a measure of blueness (−) or yellowness (+) of the object from which the light is reflected.

Total soluble solids of the juice of calyx halves and stylar halves of the fruits was determined refractometrically. Total acid was determined by titration with standard sodium hydroxide solution, using phenolphthalein as the indicator. For these determinations, the juice from the calyx half and the stylar half was extracted with a hand press.

Results

Temple fruits with stylar-end greening differed significantly from normally colored fruits with respect to light absorption due to chlorophyll as well as with respect to the wave lengths of maximum light transmittance (Table 1).

TABLE 1. DIFFERENCES BETWEEN THE COLOR OF TEMPLE ORANGES WITH AND WITHOUT STYLAR-END GREENING

Color of fruit	Relative chlorophyll absorption	Wave length of peak transmittance in millimicrons	Part of fruit	Hunter values		
				Rd	a	b
Stylar-end green	24.3	590	Calyx	38.5	12.4	34.9
			Stylar	16.8	-10.1	20.2
Control	-10.9	601	Calyx	34.6	31.2	33.3
			Stylar	29.1	29.8	31.4
F Test[a]	**	**		**	**	**

[a]**Significant at the 1 per cent level.

The "a" value of a −10 indicates that the stylar end of a fruit with stylar-end greening is a strong green while the calyx end was a yellow-orange (+12). Normally colored Temples were dark orange (+30 to +31). The "b" value of +20 indicates that yellow is below the level, +31, expected in normally ripened fruit.

The total soluble solids are normally greater in the juice from the stylar halves of oranges, mandarins, or grapefruit. The solids from normally colored Temple fruits followed that pattern (Table 2). On

TABLE 2. TOTAL SOLUBLE SOLIDS AND TOTAL ACIDITY OF TEMPLE ORANGES WITH AND WITHOUT STYLAR-END GREENING

Color of fruit	Part of fruit	Total soluble solids	Total acidity	Solids-to-acid
		per cent	*per cent*	*ratio*
Stylar-end green	Calyx	10.71	1.30	8.33
	Stylar	10.84	1.26	8.61
Control	Calyx	12.62	1.15	11.07
	Stylar	13.26	1.22	10.90
F Test[a]		**	**	**

[a]**Significant at the 1 per cent level.

the other hand, the solids content of Temple fruits with stylar-end greening was much lower in both halves than in normal fruits, and it was depressed significantly more in the stylar half (Table 2). The acid concentration was higher in juice from the calyx half of normal fruits, but the concentration was higher in juice from the stylar half of fruit with green stylar ends (Table 2). Thus the solids-to-acid ratio of the stylar half and the calyx half of fruits with stylar-end greening was significantly lower than in the corresponding halves of control fruits, and the gradients were reversed.

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