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SUGAR DEVELOPMENT IN 'SUGARLEE' AND 'DIXIELEE,' TWO RECENTLY-RELEASED WATERMELON CULTIVARS COMPARED WITH 'CHARLESTON GRAY'[1,2,3]

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Abstract. **Sugars in watermelon** [Citrullus lanatus **(Thunb.) Matsum. & Nakai] cultivars grown at Leesburg, Florida, were determined by liquid chromatography. Flesh samples from developing fruit were obtained at 7 intervals from 12 to 36 days after anthesis. Initial development of sugar was more rapid in two recently-released cultivars, 'Sugarlee' and 'Dixielee', than in 'Charleston Gray', the most widely grown cultivar in Florida. Early development of sugars is especially important for production of high quality fruit when melons are harvested at less than full maturity for shipping. The predominant sugar in fully matured fruit of 'Charleston Gray' was sucrose whereas fructose was the predominant sugar in 'Sugarlee' and 'Dixielee'. Since the relative sweetness of fructose is greater than that of glucose and sucrose, cultivars with high fructose content in the edible flesh might be preferred by consumers over those high in sucrose.**

Quality in watermelons is determined by color and texture of the edible flesh and by sweetness. Dark-red flesh is preferred over pink or medium red (1) and flavor ratings have been found to be highly correlated with soluble solids content (8). Total soluble solids content is dependent on cultivar, maturity, and location within the fruit (6, 10, 11, 13, 14, 15).

Glucose was found in fruits 1 day after anthesis; fructose was found a few days later. Sucrose was not detected before the 20th day after anthesis (4, 6). Rate of sugar development and type of sugar present varied among 8 watermelon cultivars grown in Florida (4). Since the 3 sugars found in watermelon fruits vary in relative sweetness, total soluble-solids content may not be the sole factor involved in sweetness of mature watermelons. Although many tests have demonstrated that fructose is the sweetest of the common sugars, having a relative value as high as 180 when compared to sucrose as 100, the relationship can vary with concentration (7, 16), the presence of acids and salts (9), and cooking (5).

Even though Florida watermelon production has increased markedly in recent years, the potential market for Florida watermelons has not been fully realized because of a 25% decrease in per capita consumption of watermelon in the U.S. over the last 30 years (12). The consumption of commercially produced watermelons in the U.S. has fallen from an average 17.8 lb. per capita during the 3-year period 1947-1949 to approximately 13.1 lb. for the 1977-1979 period. Increased fruit quality may help reverse this trend. The objective of this study was to compare qualitative and quantitative differences in sugar content and pattern of development in the leading watermelon cultivar in Florida, 'Charleston Gray', with 2 recently-released cultivars 'Sugarlee' and 'Dixielee' (1, 2).

Materials and Methods

Watermelon cultivars were grown in the spring of 1979, at Leesburg, Florida. Fertilization included 800 lb/acre of 5N-6.5P-6.6K in a preplant application and 650 lb/acre of 14N-11.6K in 3 other applications prior to flowering. Plants of 'Charleston Gray', 'Sugarlee' (2) and 'Dixielee' (1) were grown in 2-plant hills spaced 5 ft apart in rows 10 ft apart. Pistillate blossoms were tagged at anthesis and fruit were harvested at 4-day intervals between 12 and 30 days after anthesis.

A 1-inch-thick slice was obtained from individual melons mid-way between the blossom and stem ends. After the outer rind was removed, juice was pressed from the flesh with a potato ricer. Each sample contained juice from 3 melons and each final determination was the average of 3 composite samples. Juice was frozen within 2 hr for later analysis. To determine whether or not there was a change in sugar content in the samples prior to freezing, expressed juice from single fruits of 'Sugarlee', 'Dixielee', and 'Charleston Gray' was frozen immediately or after intervals of 1, 2, 4, and 8 hr. Prior to freezing, these samples were stored at 37°C.

The juice of each sample was thawed and passed through a 0.6 μm Millipore filter. Fructose, glucose, and sucrose were determined in 10 μl of juice analyzed with a Waters 202/401 liquid chromatograph equipped with a refractive index detector and Waters carbohydrate column, 4 mm x 30 cm. The solvent was acetronitrile/water (85/15) at a flow rate of 1 ml/minute; analysis time was 10 minutes.

In the absence of values for the various sugars specifically for watermelon, relative sweetness was calculated using the midpoints of the ranges suggested by Eisenberg (3), with sucrose assigned a value of 100, fructose 140-175, and glucose 60-75.

Results and Discussion

Since the juice samples were obtained in the field and remained unfrozen for up to 2 hr, some conversion or loss of sugar might have occurred. However, there were only minor changes in either total sugar or the relative content of fructose, glucose, and sucrose even after being held at 37°C for up to 8 hr (Table 1). In previous work, with samples of higher sucrose concentration, there was an indication of a slight decrease of sucrose and slight increase in reducing sugars when held for 8 hr before freezing (unpublished data). This point warrants further evaluation.

Watermelon fruit maturity may be defined in many ways, including development of pigment in the flesh, maturation of seed, or sugar development. Rate of maturation is dependent upon, among other factors, cultivar and temperature. Initial seed coloration in this experiment occurred 24 days after anthesis for all 3 cultivars, and

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Table 1. Fructose (F), glucose (G), and sucrose (S) in watermelon juice samples frozen immediately and after 1, 2, 4, or 8 hr.

Cultivar[z]	Hours	Sugar (g/100 ml) F	G	S	F+G+S
Charleston Gray	0	3.2	2.4	0.6	6.2
	1	3.3	2.5	0.6	6.4
	2	3.3	2.5	0.6	6.4
	4	3.2	2.5	0.3	6.0
	8	3.4	2.6	0.4	6.4
Sugarlee	0	3.6	2.6	0.9	7.1
	1	3.6	2.7	0.9	7.2
	2	3.5	2.6	0.9	7.0
	4	3.6	2.7	0.8	7.1
	8	3.7	2.7	0.8	7.2
Dixielee	0	3.2	3.0	—	6.2
	1	3.2	2.9	—	6.1
	2	3.2	3.0	—	6.2
	4	3.3	3.0	—	6.3
	8	3.3	3.0	—	6.3

[z]The 'Charleston Gray' and 'Sugarlee' fruits were harvested 22 days after anthesis and the 'Dixielee' was harvested 18 days after anthesis.

by day 32 essentially all seeds showed mature coloration. Flesh coloration was begun 12 to 16 days after anthesis and gradually increased thereafter. However, sugar content is a better indication of maturity than either of the aforementioned criteria for commercial melons, because seed and flesh coloration continues to intensify following harvest but sugar concentration does not.

The pattern of sugar development for the 3 cultivars is shown in Fig. 1 and Table 2. Fructose and glucose are the predominant sugars in immature fruit of all cultivars. Fructose and glucose levels peaked in 'Charleston Gray' fruit 24 days after anthesis. Sucrose was not evident until 24 days after anthesis. Subsequent sucrose formation was rapid, and sucrose was the predominant sugar in fully mature (36-day-old) melons.

In 'Sugarlee' the overall pattern of fructose and glucose development was similar to that in 'Charleston Gray' except that at each sampling date sugars were 14% to 44% higher in 'Sugarlee' than in 'Charleston Gray'. Sucrose appeared at about the same time after anthesis but increased at a slower rate in 'Sugarlee' than in 'Charleston Gray'.

The pattern of fructose development in 'Dixielee' was similar to that of 'Sugarlee'. However, fructose level in 'Dixielee' peaked 32 days after anthesis, 8 days later than in the other 2 cultivars, at 4.1 g/100 ml juice, 27% higher than the peak level for 'Charleston Gray'. Sucrose was not evident until 28 days after anthesis and subsequently increased rather slowly. Total sugar content peaked 32 days after anthesis in all 3 cultivars. Fructose was the predominant sugar in mature fruit of both 'Sugarlee' and 'Dixielee'.

Early development of sugar or sweetness is important because commercial melons are generally harvested before full maturity, especially early in the season. In Florida, commercial melons probably are harvested 24 to 32 days after anthesis. The 24-day-old fruit of 'Sugarlee' and 'Dixielee' had 11.1% to 18% more total sugar than 'Charleston Gray' and similar differences in calculated sweetness (Table 2). 'Sugarlee' and 'Dixielee' melons harvested at early stages of maturity should be of higher quality, judged by sweetness, than fruit of 'Charleston Gray' harvested at similar maturity.

Since the relative sweetness of fructose is greater than that of sucrose, melons with a higher proportion of fructose than sucrose will have a higher calculated sweetness. For example, 32-day-old fruit of 'Charleston Gray' and 'Dixielee' had the same total sugar content but the calculated sweetness of 'Dixielee' was 5% higher than that of 'Charleston Gray'.

In a watermelon breeding program for improving quality, sugar determinations with a refractometer at early stages of maturity are helpful in selecting lines in which early formation of sugar is rapid. However, since there apparently are genetically based differences in the content of the 3 major sugars and the relative sweetness of the sugars varies, a second criteria in the selection process is also important. Selection should be for lines with high, stable levels of fructose, for these lines will have a sweeter taste than cultivars with low or unstable levels of fructose, even if total sugar content might be equal. The calculated

Table 2. Fructose (F), glucose (G), and sucrose (S) and calculated sweetness in juice from melons harvested at 7 stages of maturity.

Cultivar	Age (days after anthesis)	Sugar[z] (g/100 ml) F	G	S	F+G+S	Avg calculated sweetness[y]
Charleston Gray	12	1.8d	1.8d	0.0c	3.6	405
	16	2.0d	1.9cd	0.0c	3.9	440
	20	2.9c	2.6b	0.0c	5.5	630
	24	3.7a	3.1a	0.4c	7.2	830
	28	3.5a	2.6b	2.2b	8.3	950
	32	3.3ab	2.2bc	3.3a	8.8	995
	36	3.0bc	1.8d	4.0a	8.8	995
Sugarlee	12	2.6c	2.4cd	0.0c	5.0	575
	16	2.6c	2.4cd	0.0c	5.0	575
	20	3.5b	3.2ab	0.0c	6.7	765
	24	4.2a	3.6a	0.7b	8.5	975
	28	4.1a	3.3ab	1.1b	8.5	980
	32	4.0ab	3.0bc	2.6a	9.6	1090
	36	3.5b	2.2d	2.5a	8.2	950
Dixielee	12	1.6d	1.5c	0.0b	3.1	350
	16	2.9c	3.0b	0.0b	5.9	660
	20	3.8b	3.6a	0.0b	7.4	845
	24	4.3ab	3.7a	0.0b	8.0	925
	28	4.5a	3.6a	0.1b	8.2	965
	32	4.7a	3.3ab	0.8a	8.8	1045
	36	4.2ab	2.8b	1.3a	8.3	985

[z]Mean separation within columns for each cultivar by Duncan's multiple range test, 5% level.
[y]Values calculated using mid-point of relative sweetness range suggested by Eisenberg (3), S = 100, F = 140-175, G = 60-75.

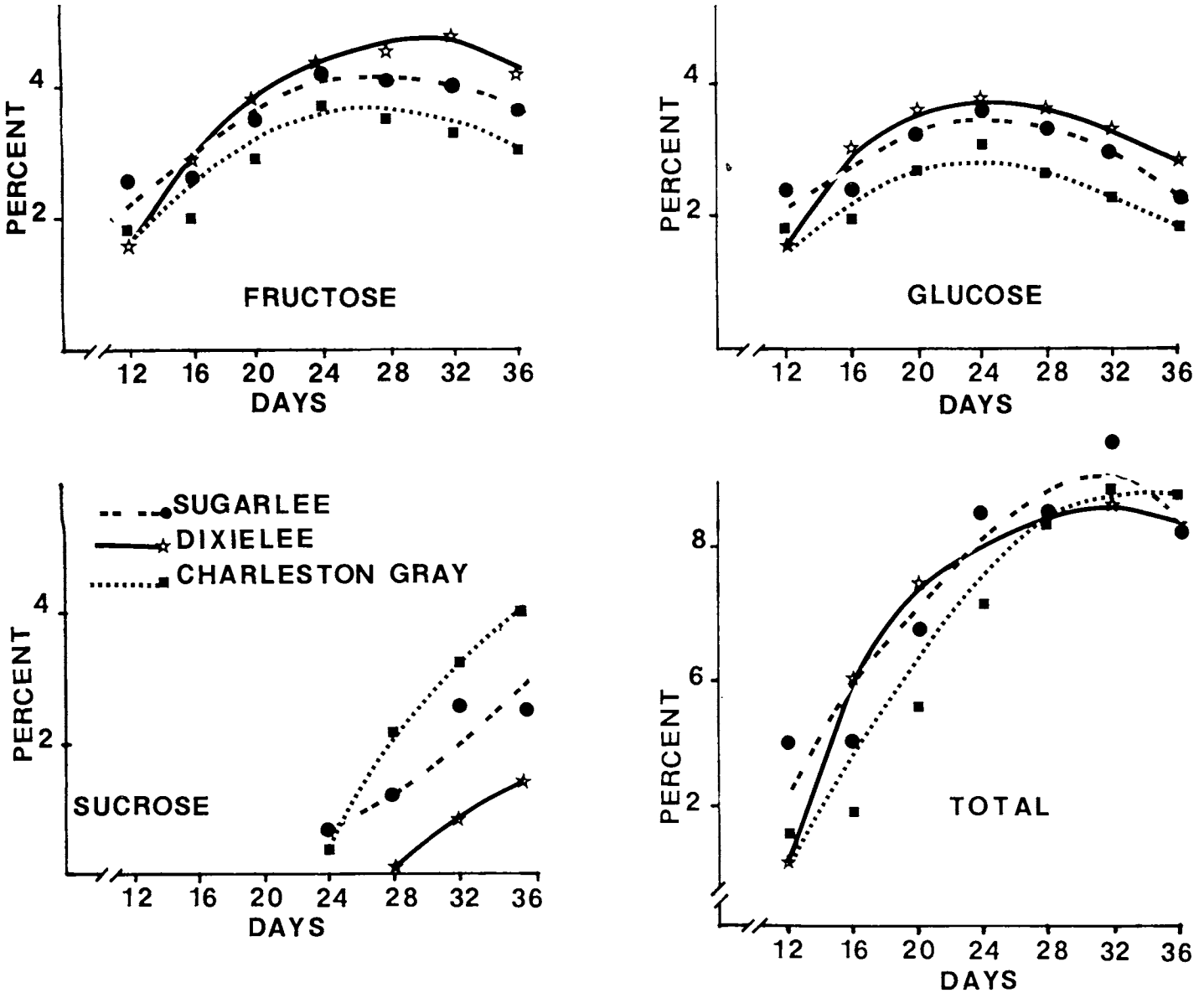

Fig. 1. Fructose, glucose, sucrose, and total sugar content in maturing fruit of 3 watermelon cultivars. Samples taken 12-36 days after anthesis at 4-day intervals.

sweetness values need to be substantiated by actual taste panel evaluation.

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