Proc. Fla. State Hort. Soc. 90:395-397. 1977.

COMPOSITION OF GREENHOUSE TOMATOES AS AFFECTED BY CULTIVAR, PRODUCTION MEDIA AND FERTILIZER[1]

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Additional index words. Vitamin C, soluble solids, fruit firmness, fruit acids, fruit color, fruit solids.

Abstract. **'Floradel' and 'Tropic' tomatoes** (Lycopersicon esculentum **Mill.) were grown in a greenhouse with production media of soil, peat-soil, and peat-vermiculite with a split application of standard fertilizer and with a slow release fertilizer source (Osmocote). At the table-ripe stage, 'Floradel' tomatoes tended to be softer but contained more acids, soluble solids, total solids, and were deeper red than 'Tropic' fruit. Media and fertilizer source interacted in their effects on fruit firmness and color. Softest tomatoes resulted from fertilization with osmocote and the peat-soil media while firmest fruit were produced with osmocote and the peat-vermiculite media. Fruit grown on the peat-vermiculite medium had the best color and application of Osmocote further intensified the color as compared with the standard fertilization. Fruit acidity was highest with the peat-vermiculite and lowest with the peat-soil medium. The standard fertilizer resulted in the highest percentage of total solids while the slow release source produced fruit having the higher vitamin C content.**

During the past 5 years there has been an increase in the production of greenhouse tomatoes in Central, North and West Florida. Production media in these houses has ranged from native soil with standard outdoor production practices to special mixed media incorporating slow release fertilizers. Growers are primarily concerned with fruit yield and appearance. Consumer advocates and discriminating consumers demand high quality fruit. In addition to appearance, the flavor and nutritional composition are important factors that contribute to consumer acceptance.

Normally, greenhouse tomatoes are harvested at a more advanced stage of maturity than field tomatoes, therefore, the ripened greenhouse fruit may be of higher quality (9). Factors other than maturity also affect quality. Nitrates are important in protein synthesis, fruit metabolism, and development of acids. Potassium is also directly correlated with fruit development and acid synthesis. However, optimum fertility rates have minor effects on nutritional composition (1, 13). Climatic conditions also affect fruit composition and quality. Fruit color and Vitamin C content are reduced under conditions of low light. Increased temperatures are conducive to higher soluble solids and acids content. Reduced night temp reduced fruit acidity (4, 7, 12). Vitamin C is affected by many factors. Vitamin C content is generally irregular and inconsistent and is sensitive to minor variations in the environment and duration of ripening (3). Studies reported here were initiated to determine the effects of production media, cultivar, and fertilizer, on the quality and composition of greenhouse tomatoes subsequently ripened to the table-ripe stage. At this stage tomatoes are at optimum consumer quality.

Materials and Methods

Tomatoes were grown in a fiberglass greenhouse in Gainesville in 1976. Cultivars, media, and fertilizers were those reported by Kostewicz and Locascio (6). The greenhouse experiment was a split plot with cultivars as the main plot treatment and a 2 x 3 factorial of two fertilizers and three media forming the subplot treatments. Tomatoes were harvested 3 times weekly (Monday, Wednesday, Friday) for a period of 8 weeks. Composition analyses were conducted only on tomatoes harvested on Friday. Insufficient fruit was produced at the desired harvest to provide the basic 10-fruit sample so replications were pooled. Therefore, for analysis of the compositional data, harvest dates were used as replications.

Fruits were harvested at the turning stage of maturity and ripened to table-ripe (USDA score 6) at 20°C and 85-95% R.H. Fruits reached this ripened stage 4 to 5 days after harvest. Selection was based on visual external color which was dark red. There was no apparent color difference between cultivars. Sample size consisted of the first 10 fruits which simultaneously reached the table-ripe stage. Whole fruits were used for firmness measurements. Thereafter, polar wedges from each of 10 fruits were pooled and blended for chemical analysis. Firmness was measured with the Cornell pressure tester using a 1000g weight, 16mm pressure plate, and 5-second compression time. A macerated and deaerated sample was used for color determination of whole fruit using a digital Hunter Color Difference Meter; a/b values were used for comparison. Whole fruit color was measured to determine whether treatment had any effect on internal color. Titratable acids (TA) were determined by electrometric titration of 10 ml of clarified juice diluted with 150 ml distilled water, with 0.1 N NaOH to an endpoint of pH 8.1. The results were calculated as percent citric acid (TA x 0.064), the dominant acid. Soluble solids (SS), an estimation of sugars, were determined with an Abbe refractometer. The SS/acid ratio (SS/A) was calculated as SS/% citric acid. Determination of Vitamin C was by the Barakat (2) method and total solids (TS) by standard AOAC (5).

Results and Discussion

The main effects of cultivar on quality characteristics of ripened tomatoes are given in Table 1. Although statistical significance is shown, differences are very small. 'Floradel' tomatoes contained both more acids and soluble solids, therefore, would be expected to have a higher taste intensity than 'Tropic'. The SS/acid ratio of 'Tropic' was significantly higher than 'Floradel' but both ratios were unusually high due to low acid content. Flavor of the 2 cultivars would be expected to be quite bland because of the low acid content. Soluble solids concentration of both cultivars was slightly less than normal. Color of 'Floradel' was better than 'Tropic' although color of both was satisfactory. Tomatoes at the table-ripe stage had a good red color. Further ripening to the canning-ripe stage would result in the development of a deeper red color and general softening of the fruit. It is possible some ripeness variation existed because of the subjective method of selecting fruits at the table-ripe stage on the basis of external color. Also, 2 cultivars at the identical ripeness may not have identical color. In this study it was recognized that treatment effects on color were probably related to a ripening phenomenon rather than to pigment intensification. 'Floradel' also contained higher total solids than 'Tropic'. While there was no

[1]Florida Agricultural Experiment Stations Journal Series No. 819.

Table 1. Main effects of cultivar on composition characteristics of tomatoes at the table-ripe stage.

Cultivar	Firmness,[y] units	Soluble solids, %	Acidity, % Citric	SS/A, ratio
	Fruit characteristic			
Tropic	2.80[x]	4.65	0.28	17.03
Floradel	3.22	4.86	0.33	14.85
F value[z]	NS	*	**	*
	Vit. C, mg/100g	Color, a/b	Dry wt. %	
Tropic	12.02	1.94	5.00	
Floradel	11.98	2.08	5.18	
F value	NS	*	*	

[z]F values were not significant (NS) or significant at the 5% (*) or 1% (**) levels.
[y]Cornell pressure tester. Higher numbers represent softer fruit.
[x]Values are average of 48 determinations.

statistical difference in firmness between the 2 cultivars, 'Floradel' tended to yield slightly more to compression than 'Tropic' which also may be indicative of ripeness. Vitamin C content was the same for both cultivars and was slightly less than normal as compared to field-grown tomatoes.

Growing media had a significant effect on the acidity of tomato fruits (Table 2). Tomatoes grown in peat-vermiculite media had a significantly higher acid content than tomatoes grown in soil, or the peat-soil media. This may have been due to the modification of the microclimate and soil moisture level or it could have resulted in a more favorable release of nutrients, possibly K, during development of the fruit. Soluble solids levels were unaffected by plant growth media. Because of the effect on acids, media also had a significant effect on SS/acid ratios. However, these ratios have little significance without consideration of the individual acid and sugar levels. The other quality characteristics were not affected by media.

The main effects of fertilizer on quality characteristics are given in Table 3. The use of standard fertilizer resulted in tomatoes having a very slightly, but significantly higher soluble solids and total solids content. A significantly higher vitamin C content was obtained with the slow release fertilizer as compared to the standard.

Table 2. Main effect of media on composition characteristics of tomatoes at the table-ripe stage.

Production media	Firmness,[y] units	Soluble solids, %	Acidity, % Citric	SS/A, ratio
	Fruit characteristic			
Soil	3.00[x]	4.68	0.29b	16.37b
Peat-Soil	3.17	4.78	0.27c	17.87a
Peat-Verm.	2.87	4.80	0.36a	13.59c
F value[z]	NS	NS	**	**
	Vit. C, mg/100g	Color, a/b	Dry wt. %	
Soil	10.82	1.93b	5.09	
Peat-Soil	12.74	1.92b	5.12	
Peat-Verm.	12.48	2.16a	5.06	
F value	NS	**	NS	

[z]F values were not significant (NS) or significant at the 5% (*) or 1% (**) levels. Mean separation within columns by Duncan's multiple range test.
[y]Cornell pressure tester. Higher numbers represent softer fruit.
[x]Values are average of 32 determinations.

Table 3. Main effect of fertilizer on composition characteristics of tomatoes at the table-ripe stage.

Fertilizer	Firmness,[y] units	Soluble solids, %	Acidity, % Citric	SS/A, ratio
	Fruit characteristic			
Standard	2.99[x]	4.81	0.31	15.81
Slow release	3.03	4.70	0.31	16.08
F value[z]	NS	*	NS	NS
	Vit. C, mg/100g	Color, a/b	Dry wt. %	
Standard	11.31	2.00	5.18	
Slow release	12.73	2.02	5.00	
F value	*	NS	**	

[z]F values were not significant (NS) or significant at the 5% (*) or 1% (**) levels.
[y]Cornell pressure tester. Higher numbers represent softer fruit.
[x]Fruit are average of 8 determinations.

Fertilizer source significantly interacted with media in their effect upon firmness and color (Table 4). With the peat-soil media the slow release fertilizer resulted in slightly softer fruit as compared to other combinations of fertilizer and media.

Table 4. The interaction of fertilizer and media on composition characteristics of tomatoes at the table-ripe stage.

Fertilizer	Production media[y]: Soil	Peat-Soil	Peat-Verm
		Firmness, unit	
Standard	2.94[z]	2.99	3.04
Slow release	3.07ab	3.34a	2.69b
		Color, a/b	
Standard	1.95b	1.93b	2.11a
Slow release	1.91b	1.91b	2.22a[x]

[z]Values are average of 16 determinations.
[y]Mean separation between media by the Duncan's multiple range test, 5% level.
[x]Difference between fertilizer for a media significant at the 5% (*) level.

With both fertilizers, the use of the peat-vermiculite medium resulted in tomatoes with the most red color. The difference in fruit color as a result of soil and peat-soil media was not significant. Tomatoes with the most red color were produced with the slow release fertilizer in the peat-vermiculite media. It may be postulated that this combination of fertilizer and medium, resulting in a darker red fruit, was due only to an advanced ripening stage. If this were the case then these fruits should also be softer. However, these more red fruits were actually the most firm.

The overall compositional qualities of these tomatoes was somewhat less than optimum. Even though the Vitamin C content was slightly low, it was well within limits for normal acceptability (11). Actually, for greenhouse tomatoes grown during this season of the year the Vitamin C content may be higher than normal as the reported range is from 10 (winter production) to 26 mg/100g (summer production) for all tomatoes (USDA Agr. Hdb. 8). Fruits were softer than desired for distant shipping but the softness was attributable to the advanced stage of maturity at which they were harvested.

Records were also kept on external and internal appearance of the fruits. Frequency of abnormalities observed was not unusual, although not statistically analyzed, and could not be associated with cultivar, media, or fertilizer. Frequency of abnormal fruit increased slightly during the seventh and eighth harvests because of the declining condition of the plants. Tomatoes were harvested during the last half of the greenhouse production season during late March, April and May. This was a period of increasing temperatures with highs over 95°F not uncommon.

Due to the small differences in composition as a result of the various treatments, the selection of fertilizer or media to be used could be on the basis of economics and availability. No particular treatment was outstanding enough to warrant recommendation.

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Proc. Fla. State Hort. Soc. 90:397-399. 1977.

EFFECT OF TEMPERATURE AND SHORT DAY ON DEVELOPMENT OF VERTICILLIUM WILT OF SUSCEPTIBLE, TOLERANT, AND RESISTANT TOMATO CULTIVARS[1]

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Abstract. **Elevated temps and short day conditions favored development of Verticillium wilt of susceptible, tolerant, and resistant tomato cultivars. The percentage of wilted plants and symptom severity of root-dip inoculated 'Tropic' (a cultivar that possesses the Ve gene for resistance) seedlings increased as the incubation temp increased from 20 to 32 C. Additionally the percentage of inoculated 'Tropic' plants from which** V. albo-atrum **race 1 was isolated increased wth increasing incubation temperature. At 20 C the pathogen was isolated from 40% of the inoculated plants but only 10% of the plants exhibited symptoms. Resistance conferred by the Ve gene in 'Tropic' appeared to be reduced under conditions favoring maximum development of Verticillium wilt.**

For the past few years we have been involved in developing techniques for evaluating tomato (*Lycopersicon esculentum*) cultivars and breeding lines for resistance to Verticillium wilt incited by *Verticillium albo-atrum* Reinke and Berth race 1. The occurrence of Verticillium wilt was discovered to dramatically increase as the daily light duration was decreased from 16 to 4 hours. A 4 hour daily photoperiod was then incorporated into our experiments on the interaction of *V. albo-atrum* and nematodes and for the routine evaluation of breeding lines. In a nematode-*Verticillium* interaction experiment, wilt development was much greater at 27 C than at 21 C and in a breeding line evaluation experiment, seedlings of the 'Tropic' cultivar developed wilt symptoms when root-dip inoculated and incubated in growth rooms of 4 hour light duration and 27 C. 'Tropic' contains the Ve gene for resistance to race 1 (4), and with one exception (1), indicates that the Ve gene results in less than perfect control of *V. albo-atrum* race 1. These observations prompted us to design and carry out 2 experiments to determine the effect of increasing temperature (coupled with a 4 hour daily photoperiod) on the development of Verticillium wilt of tomato. The results of these 2 experiments and the 2 preliminary *Verticillium*-nematode and cultivar evaluation experiments are presented herein.

[1]Florida Agricultural Experiment Stations Journal Series No. 9058.

Materials and Methods

General Methods: Two-week-old seedlings of diverse cultivars were root-dip inoculated (6) with *V. albo-atrum* race 1, transplanted into a sterile commercial peat:vermiculite mix contained in styrofoam trays, and incubated in temperature controlled growth rooms. A 4 hour daily photoperiod was used in all experiments and was provided by cool-white fluorescent tubes. A light intensity of 7,535 lux was used in experiments 1 and 2 and of 6,458 lux in experiments 3 and 4. Noninoculated plants of each cultivar were used as controls in each experiment.

The *V. albo-atrum* race 1 used for inoculum in all experiments was cultured 2 weeks at 21 C under 81 lux continuous illumination on potato-dextrose agar in petri dishes. The cultures were comminuted in sterile, deionized water and the resulting dense mycelial-conidial suspensions were used as inocula.

All plants were examined weekly or twice weekly for external symptoms of Verticillium wilt. No reisolation of the pathogen was attempted except in experiment 4.

Experiment 1: This experiment was designed to delve into the interaction of *V. albo-atrum* and various phyto-