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EVALUATION OF FLORIDA TOMATOES FOR JUICE PROCESSING[1]

R. F. MATTHEWS AND P. E. PHILLIPS
University of Florida, IFAS,
Food Science and Human Nutrition Department,
Gainesville, Florida 32611

J. J. AUGUSTINE[2]
University of Florida, IFAS,
Agricultural Research and Education Center,
5007 160th St., E., Bradenton, Florida 33508

Abstract. **Tomato breeding lines and/or cultivars grown at AREC Bradenton were evaluated for their potential use for juice processing. Ripe fruit were harvested at Bradenton and transported to Gainesville for processing. The raw fruit were analyzed for pH, titratable acidity, Brix, and color. The following values were obtained; pH, 4.25-4.56, titratable acidity, 0.34-0.45, Brix, 3.8-4.6, and color values, 2.1-2.4. For juice processing, fruit were chopped in a blendor system which resulted in rapid inactivation of enzymes to retain the inherent viscosity of the raw fruit. Viscosities of the processed juice ranged from 50 to 290 seconds. Selected processed juices were evaluated by a sensory panel.**

Current information on Florida-grown tomatoes is limited to data from fresh and canned fruit, with little data regarding the possibility of Florida tomatoes as a juice stock.

The U.S. Federal Standard of Identity (21 CFR 156) for Tomato Juice (1) defines it as "the unconcentrated liquid extracted from mature tomatoes of red or reddish varieties, with or without scalding followed by draining. In the extraction of such liquid, heat may be applied by any method which does not add water thereto. Such liquid is strained free from skins, seeds, and other coarse or hard substances, but carries finely divided insoluble solids from the flesh of the tomato. Such liquid may be seasoned with salt . . ." In determining the U.S.D.A. grade of a juice, quality measurements are based on a point system with categories in color, consistency, defects and flavor. All categories except color are relatively non-specific in their requirements to meet "Grade A", "Grade C", or "Substandard" classification. There are no specific standards or guidelines for pH, titratable acidity, °Brix, or viscosity. All of these contribute significantly to the quality of a particular juice, and viscosity or consistency is regarded by industry as a very important attribute in the product. Other factors which may affect the quality of a juice include Brix/Acid ratio, ripeness, variety, and sodium chloride level.

In the following work, 15 breeding lines and/or cultivars (Table 1) developed by the University of Florida (except Campbell 28) and grown in Florida were evaluated for pH, titratable acidity, °Brix, Brix/Acid Ratio, color, and viscosity. In addition, 6 of these entries were evaluated by a sensory panel for flavor, consistency, and overall acceptability as a canned juice product. Consistency or viscosity is stressed as a major factor in the evaluation of the juice (3, 4) and extraction procedures were chosen to optimize this.

Materials and Methods

Tomato breeding lines and/or cultivars were grown in the spring and fall, 1979, season at AREC Bradenton. Seed of each entry was sown in Speedling® flats. Five to 6 week old seedlings were transplanted and grown on 25.4cm high by 76.2cm wide flat-topped beds of Myakka sand using the full bed mulch system with seepage irrigation (9). Standard fertilizer and pesticide applications were used. Plots in spring 1979, were single row/beds with 10 plants spaced 46cm apart replicated 4 times in a randomized complete block design. Fall 1979, plots were single row/beds with 15 plants spaced 46cm apart. Ripe fruit (50 lbs.) of each entry were harvested and transported to Gainesville for evaluation.

Table 1. List of tomato entries analyzed in the fall and spring 1979 season.

Entry	1979 Season Analyzed
Walter	fall
MH-1	fall
Flora-Dade	fall
Campbell 28	fall, spring
UF A251	fall
UF A2525	fall
UF A1192	fall
UF A1182	fall, spring
UF A1184	fall, spring
UF A1191	fall
UF A1197	fall, spring
UF A2049	fall
UF A2050	fall
UF 71050-1	fall, spring
UF 71050-2	fall, spring

Each entry was analyzed in the fresh state for pH, titratable acidity, soluble solids by refractometer (7), ascorbic acid content (2), Brix/Acid ratio, and color. All tests were performed on a composite sample from 10 tomatoes.

For juice processing, 8.5 pounds of ripe fruit from each entry were macerated and blended for 2 minutes in a large Waring Blendor equipped with a 1 gallon stainless steel bowl. A steam heated coil was inserted in the bowl to surround the blade assembly and heat the blend to the enzyme deactivation temperature of 185°F or higher. This temperature inactivates enzymes responsible for degradation of the pectin in the juice, and subsequent loss in consistency. The hot juice was then passed through a Chisholm-Ryder screw-finisher to remove seed, pulp, and peel particles. The finisher was equipped with a .020 inch diameter screen.

Juice samples from each entry were retained for determinations on viscosity. All viscosities were evaluated with a Calab-capillary viscometer and readings recorded at 30°C for all samples. The remaining juice was salted (.65%) and hot filled into #303 cans. After sealing, the canned juice was stored at 35°F until further evaluation by a sensory panel.

Six entries were selected for sensory panel evaluation with a commercial juice for flavor, consistency, and overall acceptability. Two entries from each viscosity range of low, (20-50 seconds), medium, (100-150 seconds), and high, (200-300 seconds) were selected.

Sensory panel evaluations for the canned juice used the 9 point Hedonic Scale where the numerical value of "9" represented an evaluation of "extremely better than reference". A score of "1" represented "extremely poorer than reference". A score of "5" indicated the sample was the same as the reference. Random code numbers were

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[2]Present address: BHN-Research, Rt. 8, Box 700 E. Naples, FL 33940.

assigned to the samples and the reference juice was coded "R". A sample of the reference juice was also coded and included among the other samples, to insure against any great sensitivity differences within a particular panelist.

Statistical analysis was performed according to the methods described in *Methods for Sensory Evaluation of Food* (5).

Results and Discussion

pH. Mean pH values of the raw fruit ranged from 4.25 to 4.56 (Table 2) and pH values for the 6 entries of processed juice ranged from 4.36 to 4.51 with the reference juice having a pH of 4.40 (Table 3). The pH of the processed tomato juice increased slightly over the pH of the raw fruit. Differences in pH are most probably due to variety and ripeness level in the raw fruit.

Titratable Acidity. Mean values in the raw fruit ranged from .34% to .48% (Table 2). Processed juice values ranged from .33% to .49%, and the reference juice had a value of .39% citric acid (Table 3). The Walter sample had the highest acidity reading at the raw level, and second to highest reading in the processed juice. This sample also ranked the lowest in all three categories for flavor, consistency and overall acceptability. Leonard (6) noted that higher acidity levels accounted for lower sensory ranking among given juice samples with added citric acid.

Brix. Values ranged from 3.8 to 4.6% in the raw fruit (Table 2). The 6 processed juice samples evaluated by a sensory panel had a range of 5.0 to 5.8% (Table 3). Mean Brix values increased .2% in the processed juices after the addition of .65% salt. The reference juice had a 6.7% Brix reading. In Padua's study (8), this reference was ranked highest in Overall Quality Scores among 4 commercial brands, and also had the highest soluble solids mean among the samples. The lower soluble solids value was the major analytical difference between the Florida entries and the commercially canned juice. The lower solids of these juices could be contributing to their lower sensory panel flavor scores. In previous work Padua (8) found a positive correlation between soluble solids and flavor. The mean Brix value for the juice from the Florida varieties was 5.35°. This is a difference of 1.35° Brix and would require a 25 percent soluble solids increase in the Florida juice to equal that of the commercial juice.

Brix/Acid Ratio. Values ranged from 9.32 to 14.87 in the raw fruit (Table 2) and 11.55 to 17.42 in the processed juice (Table 3). The reference juice had a value of 17.14. Scott (10) reported that high sugar-acid ratios were in close agreement with bland and "flat" juices. His high ratios ranged from 7-8 and lows of 4-5. There was no evidence that the higher ratios in this study correlated with lower sensory panel scores.

Table 2. Quality factors of raw fruit of 15 tomato entries.

Entry	pH	°Brix[z]	Titratable Acidity (% Citric Acid)	Brix/Acid	Ascorbic Acid (mg/100g)	Color (a/b)
Walter	4.36	4.5	.483	9.32	7.89	2.13
MH-1	4.56	4.4	.370	11.89	9.58	2.09
Flora-Dade	4.31	4.3	.436	9.86	11.12	2.26
Campbell 28	4.38	4.3	.361	11.91	12.05	2.39
UF A251	4.35	4.2	.418	10.05	10.56	2.37
UF A2525	4.26	4.3	.445	9.66	12.81	2.21
UF A1192	4.25	4.5	.389	11.57	13.61	2.18
UF A1182	4.41	4.0	.269	14.87	11.76	2.05
UF A1184	4.31	4.6	.386	11.92	10.86	2.34
UF A1191	4.23	4.0	.342	11.70	11.58	2.01
UF A1197	4.32	3.8	.337	11.28	10.92	2.14
UF A2049	4.36	4.0	.344	11.63	9.54	2.23
UF A2050	4.43	4.3	.346	12.43	11.58	2.28
UF 71050-1	4.35	4.0	.342	11.70	9.48	2.45
UF 71050-2	4.43	4.4	.363	12.12	11.34	2.35

[z]Values corrected to sugar scale readings at 20°C.

Table 3. Processed tomato juice analysis of 6 tomato entries and a standard.

Entry	pH	°Brix[z] (before salt)	°Brix (after salt)	Titratable Acidity (%Citric Acid)	Brix/Acid	Color[y] (a/b)
Walter	4.46	5.6	5.7	.485	11.55	1.60
Flora-Dade	4.36	5.8	5.9	.493	11.75	1.78
UF A2049	4.48	5.2	5.4	.329	15.81	1.80
UF A2050	4.49	5.4	5.5	.310	17.42	1.75
UF 71050-1	4.51	5.1	5.3	.329	15.50	1.84
UF 71050-2	4.43	5.0	5.3	.327	15.29	1.84
Reference	4.40		6.7	.391	17.14	1.89

[z]Values corrected to sugar scale readings at 20°C.
[y]Color values standardized against a Gardner Tomato Red Plate where L = 24.5, a = 27.6, b = 13.2, a/b = 2.09.

Color. The range of means for color ratio was 2.01 to 2.45 in the raw, deaerated samples (Table 2). Mean values in the panel evaluated juices ranged from 1.60 to 1.84 (Table 3). The reference juice had a color ratio of 1.89. The Walter variety processed juice had the lowest color values of any entry.

Viscosity. Values at 30°C ranged from 42 seconds to 297 seconds for the processed tomato juice (Table 4). The reference value was 54 seconds. Factors affecting viscosity include ripeness and variety. The extraction procedure was designed to maximize yield and also viscosity of the product. Overall, the panelists preferred the Florida juices which had higher viscosities. However, the commercial juice, which had a low viscosity, received the highest rating for consistency.

Table 4. Processing yields and viscosity of extracted juices of 15 tomato entries.

Entry	Yield (%)	Viscosity (seconds)
Walter	86.1	41.7
MH-1	91.2	110.4
Flora-Dade	89.0	45.1
Campbell 28	87.4	233.8
UF A251	92.9	132.0
UF A2525	89.4	187.5
UF A1192	92.9	187.2
UF A1182	92.9	225.8
UF A1184	88.2	75.9
UF A1191	86.3	141.3
UF A1197	90.6	246.8
UF A2049	88.6	114.3
UF A2050	78.8[z]	136.7
UF 71050-1	89.4	229.0
UF 71050-2	92.9	296.5

[z]Low yield due to leak in blendor.

Sensory Panel Evaluation. (Table 5). Fifteen panelists evaluated the following entries for flavor, consistency and overall acceptability against a reference commercial juice; Walter, Flora-Dade, UF A2049, UF A2050, UF 71050-1, and UF 71050-2. Results for flavor indicate a significantly lower preference for the Walter sample than for the other 5 samples which had no significant differences from the reference juice. Consistency scores indicate samples Walter, Flora-Dade, and UF A2050 to be significantly lower than the other samples and reference. Overall acceptability means showed samples UF A2049, UF 71050-1, Flora-Dade, and UF 71050-2 to be significantly higher than Walter and UF A2050.

Table 5. Sensory panel evaluation of juice from selected tomato cultivars.[z,y]

Cultivar	Flavor	Consistency	Overall
UF A2049	4.0a	4.77a	4.23a
UF 71050-2	3.14a	4.67a	3.60a
Walter	2.27b	3.60b	2.57b
Flora-Dade	3.74a	3.77b	3.77a
UF 71050-1	4.0a	4.84a	4.07a
UF A2050	2.8a	4.10b	2.87b
Reference	4.9a	4.9a	5.1a

[z]Mean separation by Duncan's multiple range test at 5% level of significance.
[y]Means within vertical groups followed by the same letter are not different at the 5% level of significance.

Of the samples evaluated, panelists preferred the higher viscosity samples and described the lower ones as "watery" and "diluted." Flavor from the juice obtained for the entries was scored consistently lower than the reference, however, only the Walter variety was statistically different. Comments on flavor included "tangy", "sour", "green", "rubbery", "bitter", and "chalky". Overall, panelists gave higher scores based on the consistency attributes of a particular sample than for its flavor.

In conclusion, the consistency of juice from these entries grown in Florida compared favorably with commercial juice brands, however, the soluble solids of the cultivars were significantly lower than the commercial juice and the flavor scores of the juices were lower.

Literature Cited

1. Anon. 1978. Code of Federal Regulations, Section 21 Part 100-199.
2. Association of Official Anal. Chemists. 1975. Official Methods of Analysis. 12th Edition, p. 829. Washington, D. C.
3. Gould, Wilbur A., 1974. Tomato Production, Processing and Quality Evaluation. p. 150-154. AVI Publishing Company, Inc.
4. Kattan, A. A., W. L. Ogle and A. Kramer. 1956. Effect of process variables on quality of canned tomato juice. *Proc. Am. Soc. Hort. Sci.* 68:470.
5. Larmond, Elizabeth. 1970. *Methods for Sensory Evaluation of Food.* Publication 1284. p. 20-24. Canada Department of Agriculture.
6. Leonard, S., B. S. Luh and R. M. Pangborn. 1960. Effect of sodium chloride, citric acid, and sucrose on pH and palatability of canned tomatoes. Food Technology. 14:433.
7. National Canners Assoc. 1968. Laboratory Manual for Canners and Processors. Volume 2. p. 444. AVI Publishing Company, Inc.
8. Padua, H. 1978. Chemical and Physical Factors Affecting the Sensory Quality of Tomato Juice. M.S. Thesis, University of Florida.
9. Poe, S. L., J. P. Jones, D. S. Burgis and J. P. Crill. 1977. Tomato Yields Affected by Cultural Management. *Proc. Fla. Hort. Soc.* 90:376-379.
10. Scott, L. E. and E. P. Walls. 1947. Ascorbic acid content and sugar-acid ratios of fresh fruit and processed juice of tomato varieties. *Proc. Amer. Soc. Hort. Sci.* 50:269-72.

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POTENTIAL WATER POLLUTION FROM CITRUS UNIT PROCESSING OPERATIONS, A REVIEW[1]

P. G. Crandall
University of Florida, IFAS,
Agricultural Research and Education Center,
P. O. Box 1088, Lake Alfred, FL 33850

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Abstract. **During the 1978-79 season, the Florida citrus industry processed more than 8.5 million tons of citrus. Several estimates on the amount of water pollution generated during a processing season are reviewed. One estimate of the lost products is equivalent to 40 million pounds of biochemical oxygen demand (BOD) and an estimated loss of 26 to 56 million pounds of juice solids. Then pilot plant studies were conducted to check these estimates under carefully controlled conditions. Four tests were conducted. Volume and pollution measurements were kept on the waste loads generated from the unit processing operations.**

For the pilot plant studies, approximately 1,660 lb. of water was required to wash a ton of oranges and the water contained 0.04 lb. of BOD. Clean-up required approximately 1,580 lb. of water and generated 1.28 lb. of BOD per ton of fruit processed. The oil mill operation used 1,022 lb. of water per ton of fruit and had a potential oxygen demand of 28.6 lb/ton. The oxygen demand, for products which potentially reach the waste stream, ranged from 102 lb. of BOD per ton of grapefruit juice lost to more than 1,100 lb. of BOD for dry grapefruit peel. The pilot plant data support the generalized calculations on the potential water pollution loads.

How close are Florida's citrus processors to totally utilizing all of the fruit that is taken into their plants? The easiest way to answer this question is to estimate how much waste is generated per ton of fruit processed. For example, during the 1978-79 season, Florida processed 8.5 million tons of citrus (3). During the same season, Federal and State water pollution guidelines stipulated that no more than 0.8 lb. of biochemical oxygen demand (BOD) (as a maximum 30-day average) could be discharged per ton of fruit processed (4, 6). Calculating from the tons of citrus processed, the BOD discharged would amount to a maximum of 6.8 million lb. for a whole season. After July 1, 1983, the wastewater guidelines will become 6 times more restrictive, limiting the discharge to 0.14 lb. of BOD per ton of fruit processed or 1.2 million pounds for the season. The average of these 2 levels, 4 million lb., can be used to estimate the amount of discharge because processing plants are at varying stages of compliance (9).

This 4 million pounds of BOD is NOT the amount of waste load leaving citrus processing plants but rather it is an estimate of the waste load discharged from their waste treatment facilities. The efficiency of most waste treatment is approximately 90% as shown in a 3-year study where un-

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