



Fig. 4. Average monthly flavor scores for canned single-strength grapefruit juice packed during the 1975-76 and 1976-77 citrus seasons.

The data for the two years was analyzed statistically for correlation of flavor with the other analytical values for quality. The correlation coefficients obtained are shown in Table 3. In the 1975-76 season, flavor correlated positively with °Brix and negatively with limonin content. Significant correlation was not found with any of the other characteristics. In 1976-77 no significant correlation was found with any of the characteristics.

Summary

Flavorwise, the 1975-76 pack of canned single-strength grapefruit juice in Florida was slightly better than that of 1976-77. The naringin and limonin levels in the juice

Table 3. Correlation coefficients of flavor scores to various characteristics of commercial, canned, single-strength grapefruit juice packed during the 1975-76 and 1976-77 seasons.

	1975-76	1976-77
°Brix	0.261**	0.098
% Acid	0.028	-0.177
Ratio (B/A)	0.152	0.317
Naringin (DT)	-0.039	-0.063
Naringin (HPLC)	-0.129	-0.007
Limonin	-0.469**	-0.200

**Significant at the 1% level.

in 1976-77 were considerably higher than in the previous year but there was no statistical correlation indicating that these higher levels were the reason for the lower flavor values. However, since the values for all other characteristics for both seasons were similar and there was correlation of flavor with limonin in 1975-76, one might rationalize that the higher naringin and limonin values were responsible for the lower flavor grades.

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QUALITY OF FLORIDA CANNED GRAPEFRUIT JUICE IN SUPERMARKET STORES OF THE UNITED STATES¹

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Abstract. About 50% of the samples of canned grapefruit juice produced in Florida and collected regularly from the supermarket stores in various parts of the United States were found to be below a flavor score of 5 (neither like nor dislike) on a 9-point hedonic scale. Correlation studies of the various quality factors with flavor scores were made. Significant, although low, correlation coefficients were found between bitterness and limonin. Furfural was found to be related to the time period between packing and analysis. Similar relationships were found between this time period and the tinny flavor of the product.

Canned grapefruit juice is currently the most important processed grapefruit product from Florida utilizing about 30% of the annual grapefruit production of more than 50 million boxes (7). There have been few systematic studies made on the quality of this product until the last few years when the Florida Department of Citrus launched a more intensive study to determine the various factors affecting the quality of the many processed grapefruit products with special emphasis on the canned juice.

Dougherty and Fisher (3) conducted a survey on the flavor and some of the chemical constituents of canned grapefruit juice received from the manufacturing plants immediately after the processing. They found the average flavor of these samples to be in the like-slightly to the like-moderately category on a 9-category-hedonic scale. The flavor score also showed a low, but statistically significant, correlation with limonin content analyzed by the method of Fisher (3). This paper reports the quality of Florida canned grapefruit juices as they appear after they have been displayed on the grocery shelves of supermarkets in different areas of the United States.

Materials and Methods

Samples

Canned grapefruit juice samples were collected by the field staff of the Florida Department of Citrus at several

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locations on the West Coast of the United States, in and around the St. Louis, Mo. area, and at Eastern markets in Boston, Mass. and in Lakeland, Fla. areas. Two 46 oz cans of the same can code of each 2 brands of grapefruit juice were taken from the grocery shelves twice a month at each location and sent to the U.S.D.A. Processed Foods Inspection Service Laboratory in Winter Haven, Fla. The date of packing of each sample was ascertained by the can code which also identified its being produced in Florida.

Sampling began in November, 1975 and continued through May, 1977. Because of occasional lack of personnel at some locations, the samples were not received as regularly as planned. However, sufficient samples were obtained to fulfill the purpose of this investigation.

Analytical Procedures

Flavor. The flavor of each sample was evaluated by a panel of at least 12 to 14 members selected from local residents of Winter Haven. Selection was based on the ability of each member to separate correctly two grapefruit juice samples of different quality with triangular tests.

Chemical analysis. The soluble solids of the juice were determined with a Brix hydrometer and the total acidity by titration with standardized sodium hydroxide solution to a phenolphthalein end point. The ratios of °Brix to acidity were calculated. Furfural (2), Davis values (1), naringin by HPLC (5), and limonin (6) were all analyzed by the appropriate procedures.

Statistical Calculations

Using the can code, the age of the samples was determined by the number of months elapsed between the time the sample was packed and the month in which the sample was analyzed. The data were introduced into a General Automation Model SPC-16-65 computer. The mean, max, and min of flavor scores, flavor comments made by the panelist, and each of the quality measurements were ascertained. Simple linear correlation coefficients and multiple regression analysis with flavor as the dependent variable were calculated.

Results

The mean, min, and max values of the quality factors, flavor scores, and number of flavor comments of each category of 156 samples of the canned grapefruit juice received in this survey are shown in Table 1. There were no significant differences due to the geographical area where the sample was collected. The average number of months that a juice was on the shelves was 8, although products as old as 22 months were found on the shelf. The soluble solids content (°Brix) of these juices averaged 10.3 and varied from 9.1 to 12.6. Some samples had flavor scores as low as 3 or in a dislike moderately category, and the average flavor scores of these samples was only 4.6. The percentage distribution of the flavor scores on the hedonic scale is shown in Table 2. The ratio between number of samples in the dislike part of the scale is more than twice that in the like categories.

The number of unfavorable comments on these 156 samples totaled 1,074 with comments on bitterness averaging 2.2 per sample (Table 3). The "nondescript" off-flavor comments usually accompanied samples with low flavor scores and indicated that the panel member could not definitely identify or did not specify the types of off-flavor.

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Table 1. Characteristics of grapefruit juice from supermarkets.

	Min.	Max.	Mean
°Brix	9.1	12.6	10.3
Acid	.25	1.37	1.14
B/A Ratio	7.6	12.4	9.17
Davis value (as ppm naringin)	440	980	614
Naringin (HPLC)	123	442	285
Limonin (ppm)	1.5	10.9	5.6
Furfural (ppm)	.15	5.58	1.94
Age (month)	1	22	7.9
Flavor score	3.0	6.7	4.64

Table 2. Percentage distribution of flavor scores of grapefruit juices from supermarkets.

Range of flavor	% Distribution
Like moderately	2.5
Like slightly	17.8
Neither like nor dislike	33.8
Dislike slightly	37.7
Dislike moderately	8.3

Table 3. Average number of unfavorable comments per sample.

Comments	Number/sample
Bitter	2.19
"Nondescript"	1.73
Tinny	1.25
Sour	1.17
Watery	.54
Medicinal	.08

Total number of samples 156
Total number of comments 1,074

Significant although relatively low correlation coefficients were found between flavor score and some of the juice quality measurements (Table 4). Highly significant correlations were found between flavor and the soluble solids content (°Brix). Significant negative correlations were found between flavor scores and the HPLC naringin and limonin contents of the samples.

Table 4. Correlations of flavor scores to juice characteristics (156 samples from supermarkets).

Flavor to:	
°Brix	.352**
Acid	.054
B/A ratio	.246*
Davis values	-.097
HPLC naringin	-.187*
Limonin	-.166*
Furfural	.100
Storage	-.075

**Significant at 1% level

*Significant at 5% level

Flavor score was found to be significantly correlated with 4 of the 6 classifications of unfavorable comments (Table 5) with highest correlation to the "nondescript" off-flavor comment and to bitterness and only slightly lower correlation to sour and tinny off-flavor. No significant correlations were found between flavor score and the "watery" and "medicinal" comments.

Using the measured juice characteristics and the unfavorable comments as the independent variables and flavor score as the dependent variable, a multiple correlation coefficient (R) between flavor and 5 of the 14 independent variables was found to be 0.785.

Table 5. Correlation of some unfavorable comments to analytical measurements.

Unfavorable comments	Analytical Measurements								
	Time ^z	°Brix	Acid	B/A ratio	Furfural	Limonin	Davis value	HPLC Naringin	Flavor score
Bitter	.000	-.070	.055	-.130	-.033	.233**	.222**	.131	-.434**
Sour	.011	.086	.262**	-.245**	.105	.136	.035	-.020	-.301**
Tinny	.225**	-.045	.109	-.203**	.250**	.026	.089	-.027	-.332**
"Nondescript"	-.090	-.077	-.166	.128	-.245**	.055	.034	.333**	-.465**
Watery	.181	-.304**	-.323**	.108	.098	-.103	-.216**	-.317**	-.125
Medicinal	-.107	-.139	-.146	.042	-.047	.007	-.146	.004	-.078

^zTime is calculated as the period between the date of packing and the date of analysis.

**Significant at 1% level

*Significant at 5% level

The correlations of unfavorable comments to some of the chemical measurements are also shown in Table 5. Generally the comments reflect the factors that may bear a relationship. For instance, bitterness is significantly correlated with limonin and Davis values, and sourness is correlated with titratable acidity and the Brix/Acid ratio.

The number of months that a product was on the market was highly correlated with furfural content of the juice. There were negative correlations between the age of the sample and the limonin and acid content (Table 6).

Table 6. Correlation of some juice characteristics to age of samples.

Age of samples to:	
°Brix	.120
Acid	-.198*
B/A ratio	.302**
Furfural	.731**
Limonin	-.223**
Davis value	-.052
HPLC naringin	-.136
Flavor	-.075

**Significant at 1% level

*Significant at 5% level

Discussion

Canned grapefruit juice from Florida may remain on the market for as long as 22 months, but the average number of months was found to be 8. The average canned grapefruit juice had a soluble solids content of 10.3 °Brix, a value slightly higher than that required for grapefruit juice from concentrate, and higher than that for chilled grapefruit juice (9). All samples examined had a Brix/Acid ratio above the values required by the rules of the Florida Department of Citrus (8).

While the flavor of grapefruit juice can be satisfactory at the time of production (3), the rate of flavor deterioration in storage has been reported (4) to accelerate with temperature above 70°F. The correlation between flavor and time period between packing and analysis was not significant. This was probably due to the fact that the time relationship with flavor is greatly affected by the temperature factor and that many other factors such as bitterness and sourness or off-flavor also contribute to form the judgment of the taste panel members.

Among the correlations between flavor scores and the unfavorable comments, the highest correlation was with

the "nondescript" off-flavor. This unfavorable comment is generally given to a sample of low flavor score by the panel members. The age of the sample has a significant positive correlation with furfural content. Its significant negative correlation with limonin and acid is interesting. Possible reaction with the metal could reduce the titratable acidity (Table 6).

The coefficient of determination (R^2) indicates that about 62% of the flavor score variations may be explained by 4 of the 6 unfavorable comments (Table 5) and by °Brix (Table 4).

Summary

The average length of time of Florida grapefruit juice on the market was about 8 months. Some samples were on the shelves as long as 22 months. About 50% of the samples examined had flavor scores below 5 on a 9-hedonic scale. Panelists' comments on bitter, sour, and tinny were correlated with limonin, total acidity, and the age of the product, respectively. A multiple regression coefficient of 0.785 was found between flavor and 5 of the independent variables.

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