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QUALITY OF COMMERCIAL, CANNED, SINGLE-STRENGTH GRAPEFRUIT JUICE PRODUCED IN FLORIDA DURING THE 1975-76 AND 1976-77 CITRUS SEASONS[1]

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Abstract. **Canned single-strength grapefruit juice samples were collected biweekly from 12 manufacturing plants in Florida during the 1975-76 and 1976-77 citrus seasons. They were analyzed for °Brix, acid, naringin and limonin contents and evaluated for flavor. Flavor, scored on a 9 category hedonic scale, was lower for samples packed early in the season than for those packed late in the season. Naringin and limonin contents were higher and flavor scores lower during the 1976-77 season, than during the 1975-76 season.**

The survey of commercial, canned, single-strength grapefruit was one of the projects emanating from the grapefruit quality improvement program initiated by the Florida Department of Citrus in 1973.

The utilization of the Florida grapefruit crop is generally divided as follows: 1/3 to fresh fruit, 1/3 to canned single-strength juice and 1/3 to other products such as frozen concentrate, canned and frozen sections, citrus salad, chilled juice and juice blends. Thus, 50% of the grapefruit crop that is processed goes into canned single-strength juice. The study of the quality of the single-strength product was, therefore, deemed to be important in determining changes that might be made to improve product quality. The study was inaugurated at the beginning of the 1973-74 citrus season.

Bitterness is a characteristic of grapefruit juice which can influence its quality. When the project started in 1973 the Davis Test (1) was the only chemical method in use for determining bitterness although it is known to be non-specific for the bitter compounds. It measures the total glycosides in a juice regardless of bitterness. During the first two years of this project work was being done to develop specific methods for determining naringin and limonin, the principal bitter compounds in grapefruit. By the beginning of the 1975-76 season, high pressure liquid chromatographic (HPLC) procedures (2, 3) were available and the analyses were included in the program for the last two seasons. Since the complete data on bitter components is only available for the 1975-76 and 1976-77 seasons, only the results for these two years will be presented.

Materials and Methods

Samples were collected from each producing plant on a biweekly basis by the U.S.D.A. supervisory inspectors of the Processed Foods Division, Winter Haven, Florida. Once each week the accumulated samples were delivered to the Agricultural Research and Education Center in Lake Alfred where they were analyzed and evaluated for flavor. By utilizing this procedure, samples were analyzed within a week after production, eliminating any degradation of quality due to storage.

Samples were analyzed for °Brix with a hydrometer (4), % acid by titration (4), naringin by the Davis Test and HPLC and Limonin by the HPLC procedure. Flavor was evaluated by a selected 10-12 member taste panel using a 9 category hedonic scale.

A total of 117 samples of single-strength product were collected and analyzed during the 1975-76 season and 99 during the 1976-77 season. The majority of samples were packed in 46 oz. cans, the others in 6, 7 1/2, 12 and 18 oz. (#2) cans.

Results and Discussion

Table 1 gives the maximum, minimum and average values for the quality characteristics of commercial, canned, single-strength grapefruit juice packed in the 1975-76 and 1976-77 seasons. The maximum and minimum values show that there were large variations in all of the values for both years. The average values for °Brix, % acid and ratio were very close for both seasons. However, all of the naringin and limonin values were higher and all flavor scores lower in 1976-77. The higher naringin and limonin values were believed to be mostly due to a major freeze in mid-January 1977. Freezing causes the peel of the fruit to break down making the naringin and limonin in the peel more available during the juice extraction process. The freeze was not the sole reason for the higher values, however. From the very start of the season in November 1976, indications were that the naringin and limonin values were going to be higher than in the previous year.

Table 1. Maximum, minimum and average values for some quality analyses of commercial, canned, single-strength grapefruit juice packed during the 1975-76 and 1976-77 citrus seasons.

	Maximum		Minimum		Average	
	75-76	76-77	75-76	76-77	75-76	76-77
°Brix (B)	12.75	15.30	8.95	8.75	10.28	10.22
% Acid (A)	1.56	1.55	.84	.93	1.14	1.12
Ratio (B/A)	11.73	11.72	7.25	7.52	9.07	9.06
Naringin (DT)[z]	1377	1505	364	485	658	794
Naringin (HPLC)[z]	711	903	152	240	310	456
Limonin[z]	7.4	12.8	0.3	0.6	3.0	4.7
Flavor Score	7.6	7.3	4.6	2.9	6.1	5.6

[z]Units for naringin and limonin values are ppm.

The frequency by percentage of the flavor values is shown in Table 2. The flavor was evaluated using a 9-category hedonic scale for grading samples where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely. The flavor scores for all samples fell in the six categories shown. The range of average flavor grades that encompass each flavor category is also indicated.

It is evident that flavorwise, the 1975-76 season was the better of the two with over 83% of the average flavor grades falling in the "like slightly" category and above while only somewhat over 60% fell in the same range for the 1976-77 season. Over 9% of the evaluations fell in the "dislike slightly" category and below during the 1976-77 season and none fell in the range during the 1975-76 season.

Fig. 1 and 2 are histograms showing the average monthly values for naringin during both seasons. The few

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Table 2. Frequency by percent of the flavor values for commercial, canned, single-strength grapefruit juice packed during the 1975-76 and 1976-77 seasons.

Flavor	% of samples 1975-76	1976-77
Like Very Much 7.5-8.4	1.7	0.0
Like Moderately 6.5-7.4	35.5	8.1
Like Slightly 5.5-6.4	46.3	52.5
Neither Like nor Dislike 4.5-5.4	16.5	30.3
Dislike Slightly 3.5-4.4	0.0	7.1
Dislike Moderately 2.5-3.4	0.0	2.0

samples collected in November were collected late in the month and the few samples collected in June were collected early in the month so the results were combined with those for December and May respectively for the purpose of this report.

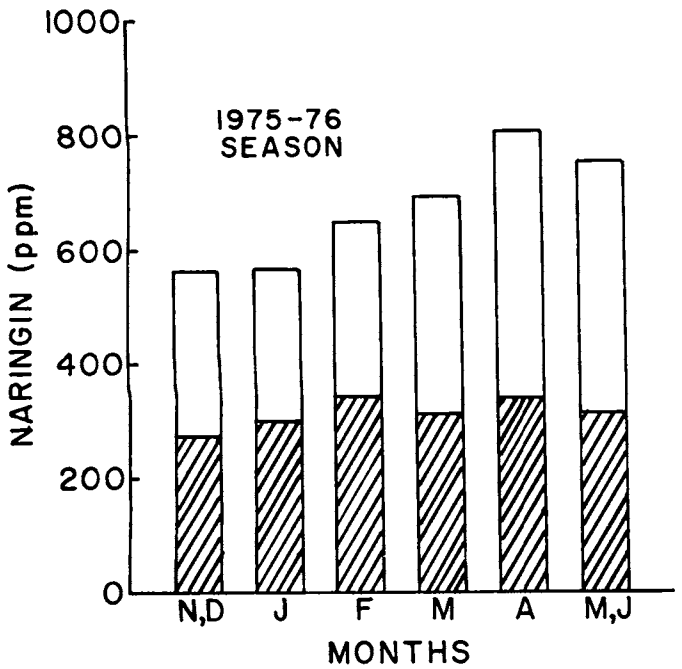

Fig. 1. Average monthly naringin values for canned single-strength grapefruit juice packed during the 1975-76 citrus season. Davis Test values are represented by the total bar for each month; HPLC values by the shaded area for each month.

Fig. 1 represents the naringin values for 1975-76. This can be considered a normal or average season in that no major catastrophe interrupted the growing or processing of the crop. The naringin as measured by the Davis Test gradually increased as the season progressed. However, the true bitter naringin as measured by the HPLC procedure varied only slightly. Throughout the season the variation was less than 75 ppm.

The effect of the freeze in mid-January 1977 is dramatically illustrated in Fig. 2. The Davis Test values started off considerably higher than for the previous season and were starting the normal trend to increase when the freeze occurred. Both the Davis Test and HPLC naringin values

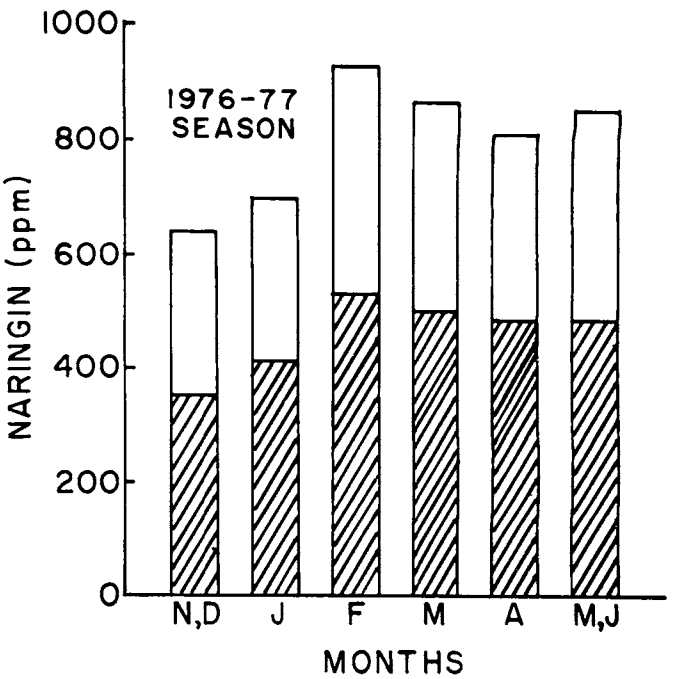

Fig. 2. Average monthly naringin values for canned single-strength grapefruit juice packed during the 1976-77 citrus season. Davis Test values are represented by the total bar for each month; HPLC values by the shaded area for each month.

rose sharply in February and remained high for the rest of the season.

Fig. 3 is a plot of the average monthly limonin values for both seasons. In 1975-76 the limonin content of the juice started out high and then dropped rapidly at the end of the season. However, during the 1976-77 season the limonin content started high, began to drop and then increased rapidly after the freeze and never returned to a normal level.

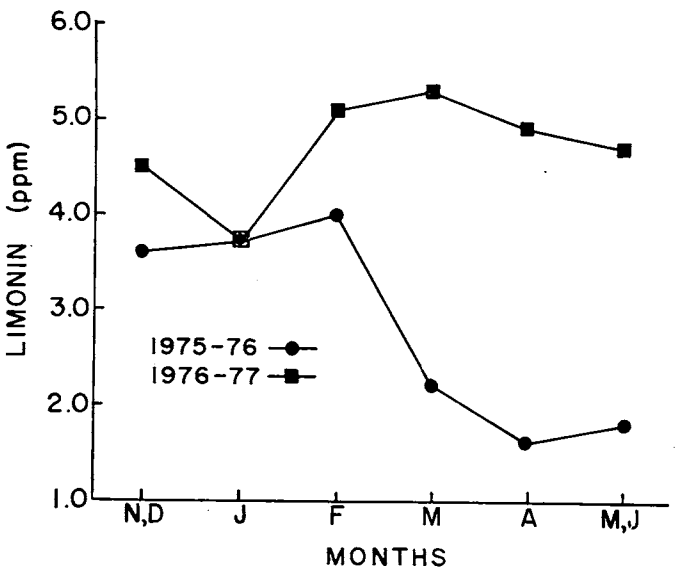

Fig. 3. Average monthly limonin values for canned single-strength grapefruit juice packed during the 1975-76 and 1976-77 citrus seasons.

Fig. 4 is a plot of the average monthly flavor scores for the two seasons. It is interesting in that the flavor for both seasons followed the same trend but throughout the 1976-77 season, the flavor stayed approximately 0.5 flavor score point below that of the 1975-76 season. The high naringin and limonin values brought on by the freeze did not change the upward trend of flavor as the 1976-77 season progressed.

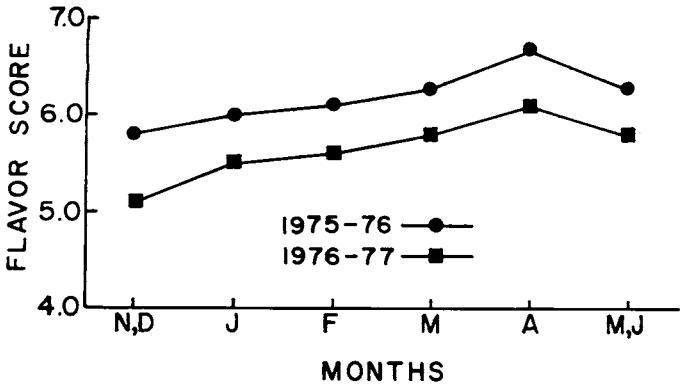

Fig. 4. Average monthly flavor scores for canned single-strength grapefruit juice packed during the 1975-76 and 1976-77 citrus seasons.

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 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.

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.

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QUALITY OF FLORIDA CANNED GRAPEFRUIT JUICE IN SUPERMARKET STORES OF THE UNITED STATES[1]

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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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