Table 4. Simple correlation coefficients (r) between color rank and month packed, CR, CY, L, a, b or flavor.

	Color Rank -vs-						
		Citrus	Citrus	Hunter			
Samples	Month	Red	Yellow	L	a	b	Flavor
White	0.544	0.786	0.688	0.570	0.008	0.743	0.316
Pink	–0.093	0.957	0.810	–0.165	0.892	0.677	–0.197
All season	0.162	0.948	0.898	–0.142	0.851	0.819	–0.113

and pink juices. The L value was related to color rank in white juices at r = 0.570. Changes in a and b values were associated with visual evaluation of pink juices. The a value apparently was not related to visual evaluation of white juices at an r = 0.008.

Summary

Visual color changes in white and pink grapefruit juices were closely associated with Hunter Citrus Colorimeter measurements. Changes in both hue and saturation were associated with visual appearance. Visual changes in color were slightly but significantly related to flavor differences. Visual color in white juices were associated with maturity date. Many grapefruit visual colors *could be predicted* from hue or chroma measurements, but the use of both hue and chroma improved the correlation.

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SPECTRAL CHARACTERISTICS OF COMMERCIALLY PREPARED GRAPEFRUIT JUICES[1]

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Abstract. **Commercially prepared Florida grapefruit juices obtained during the 1976-77 season, were investigated for their characteristic visible and ultraviolet absorption obtained from alcoholic solutions of the juices. The samples were also analyzed for naringin by both the Davis Test and high pressure liquid chromatography (HPLC), and for color and flavor. Visible absorbance appeared to be related to the degree of whiteness, chamois yellowness and pinkness of the product. Ultraviolet absorbance at 284 nm correlated well with naringin as determined by either the Davis Test or HPLC. Flavor did not correlate with chemical or instrumental characteristics.**

With increasing grapefruit production in Florida the quality of processed grapefruit juice has become a growing concern of the grower, processor and consumer. The Florida Department of Citrus has responded by initiating a grapefruit quality improvement program. This investigation is one of several that make up this program.

Product color has a great influence on consumer preferences and purchases. A consumer survey (2) revealed that the color of orange juices or orange drinks directly affected the consumer opinion concerning flavor, body, sweetness and other characteristics associated with the quality of these products. Importance of color as a quality factor is evident in that it is included in the U.S. Standards for Grades of Grapefruit Juice (8). The grading system allows up to 20 quality points for juice color out of a total of 100 points used in determining product grade. However, instrumental methods or visual color standards for determining color quality points have been lacking.

Huggart and Petrus (5) investigated the color of Florida canned commercial grapefruit juices. Liquid standards were prepared using FD&C dyes and clouding agents. The grapefruit juices were then compared with the standards by a trained panel. It was found that the sum of visible absorbance at 504, 470 and 445 nm appeared to be associated with the degree of whiteness, yellowness or pinkness of the juices.

Naringin is known to be one of the principal bitter components of grapefruit juice. Its bitterness is claimed to be so pronounced that it can be detected when 1 part is dissolved in 50,000 parts of water (1).

Analyses presented in this paper include visible and ultraviolet absorption, naringin by the Davis Test and high pressure liquid chromatography (HPLC), visual color ranking and flavor.

The object of the investigation was to determine the relationship of various spectral characteristics with other analyses and flavor of grapefruit juice.

Florida experienced a major freeze during January, 1977 and the results reported may not be typical of those obtained during a normal season.

Materials and Methods

Samples were collected biweekly from the processing plants by USDA supervisory inspectors and delivered to the Agricultural Research and Education Center, Lake Alfred, Florida.

The samples were analyzed for naringin by the Davis Test (3) and HPLC (4), visual color score by a trained panel using prepared synthetic liquid standards (6) and flavor by an experienced taste panel using a 9-category hedonic scale (where 1 = dislike extremely and 9 = like extremely). Alcoholic solutions of the samples were investigated for their characteristic visible and ultraviolet absorption (7). A Coleman Model 124 recording spectrophotometer employing an R-136 photomultiplier detector

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and 1.000 cm cells was used. The solutions were scanned from 600 to 200 nm.

A Tektronix 4051 Graphic Computing System was used for data evaluation.

Results and Discussion

Typical visible absorption spectra are presented in Fig. 1. Absorbance maxima were observed at 504, 470, and 445 nm. It was found that visual color scoring of whiteness, chamois yellowness of pinkness appeared to be associated with visible absorbance. If the sum of absorbance was less than 0.06 absorbance units and the curve was smooth, the juice appeared white visually (Fig. 1-a). The juice appeared chamois yellowish when the absorption curve became irregular and indicated definite shoulders (Fig. 1-b) with the sum of absorbances greater than 0.06 absorbance units. Products that appeared pink produced absorption spectra with well defined wavelength maxima and sum of absorbances greater than 0.130 absorbance units (Fig. 1-c). The results are similar to those of the 1975-76 season (5). Statistical analyses revealed absorbance sum correlated with observed visual color ranking with r = 0.8832. There appeared to be little correlation between absorbance sum and flavor with r = 0.0935.

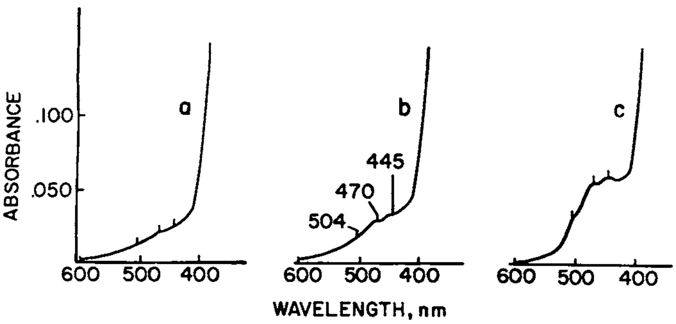

Fig. 1. Visible absorption spectra obtained from alcoholic solutions of (a) white, (b) chamois yellow and (c) pink grapefruit juices.

Average and maximum ultraviolet absorbance spectra are presented in Fig. 2. Absorbance maxima were recorded at 322, 284, 245, and 230 nm. The solid curve represents an average ultraviolet absorbance spectrum. The strong ultraviolet spectrum represented by the dashed curve is usually associated with hard extraction procedures (7).

Absorbance values at 284 nm revealed high coefficients of correlation with naringin determined by the Davis Test (Fig. 3) and HPLC method (Fig. 4) with r = 0.9205 and 0.9178 respectively. Naringin, determined by the HPLC method and that by the Davis Test had a high correlation with r = 0.9346 (Fig. 5). It appears then that absorbance at 284 nm, Davis Test and HPLC methods are essentially determining similar constituents of the juice.

Histograms were obtained for absorbance at 284 nm and the two naringin methods. Absorbance at 284 nm (Fig. 6) indicated three samples fell outside two positive standard deviations. Similar histograms were obtained for naringin. The Davis Test indicated three samples and the HPLC method two samples outside of three standard deviations. In each case the samples with the high values were from the same processor. However, only one of the samples ranked in the dislike slightly flavor classification.

Regression analyses of results were conducted to investigate any correlations with flavor of grapefruit juices. Fig. 7 represents a scatter pattern showing a very low correlation of absorbance at 284 nm with flavor with r = 0.0818. Similar trends were obtained for absorbances at 322 and 245 nm. Naringin as determined by either Davis Test

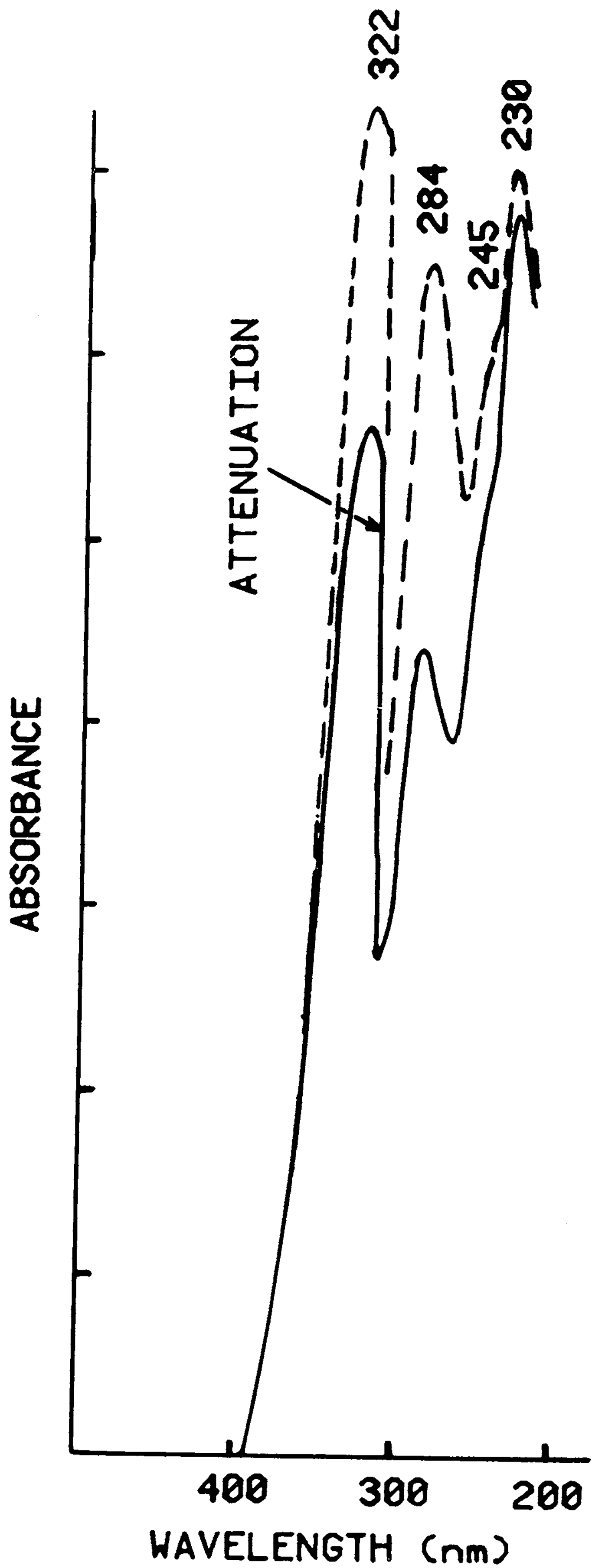

Fig. 2. Ultraviolet absorption spectra, obtained from alcoholic solutions, of grapefruit juices exhibiting average (————) and maximum (— — —) absorbance.

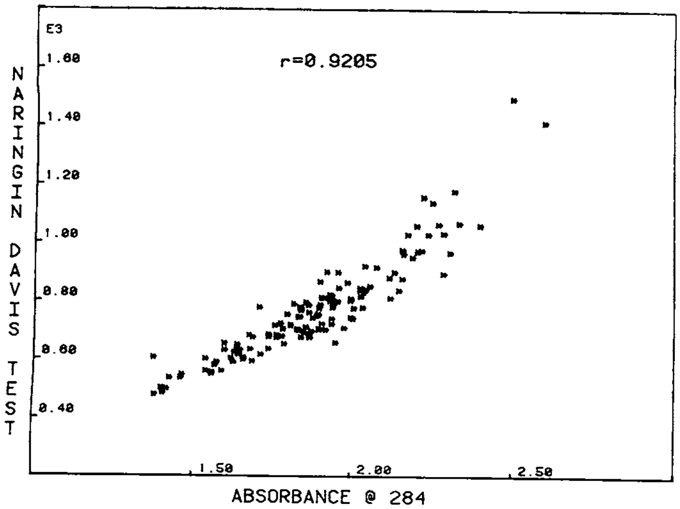

Fig. 3. Statistical correlation of absorbance at 284 nm with ppm naringin by Davis Test. Note: E3 = ppm X 1000.

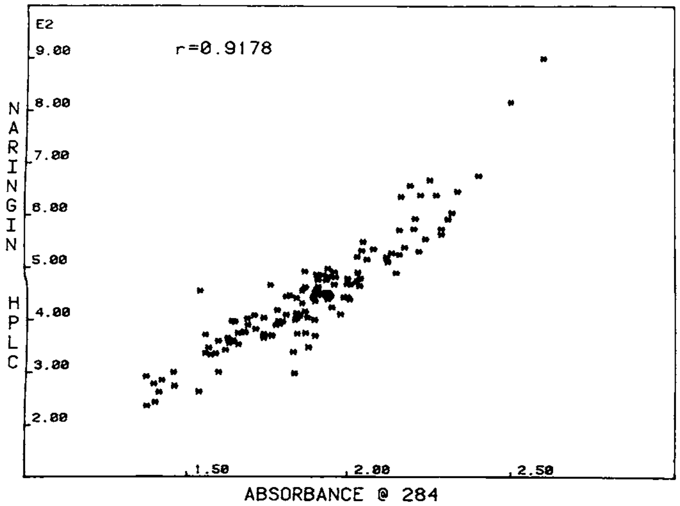

Fig. 4. Statistical correlation of absorbance at 284 nm with ppm naringin by high pressure liquid chromatography (HPLC). Note: E2 = ppm X 100.

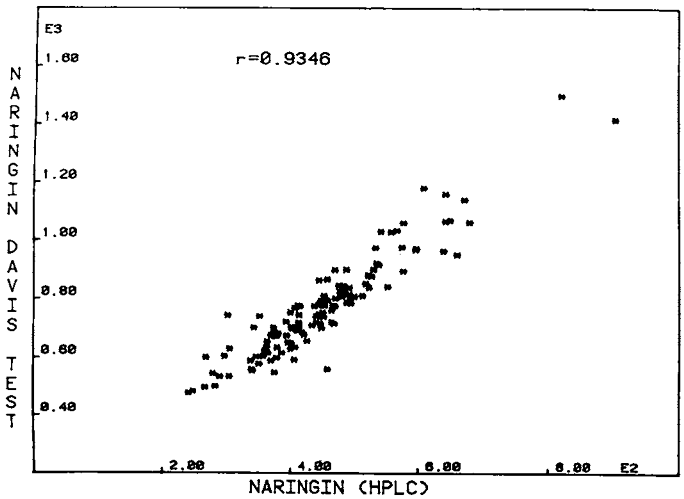

Fig. 5. Statistical correlation of ppm naringin by HPLC with Davis Test. Note: E2 = ppm X 100; E3 = ppm X 1000.

or HPLC method produced similar patterns and indicated very low correlations with flavor with r = 0.0730 and 0.0853 respectively.

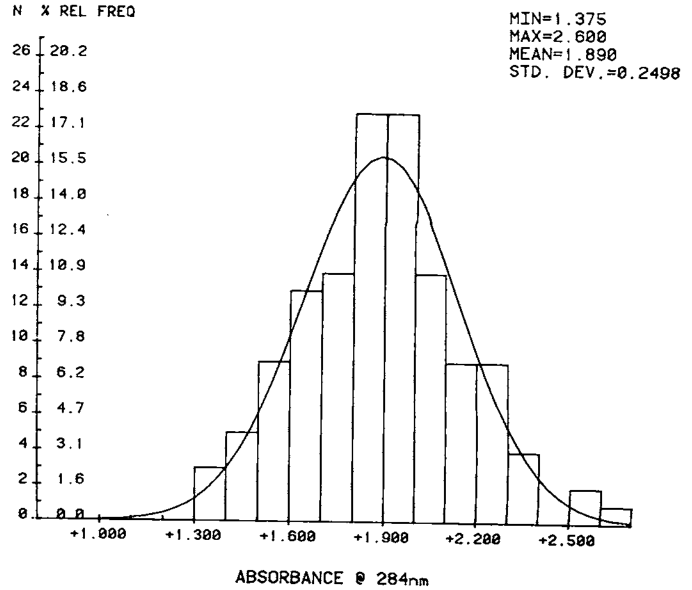

Fig. 6. Histogram (with normal curve fitted) representing absorbance at 284 nm of 130 samples of grapefruit juices.

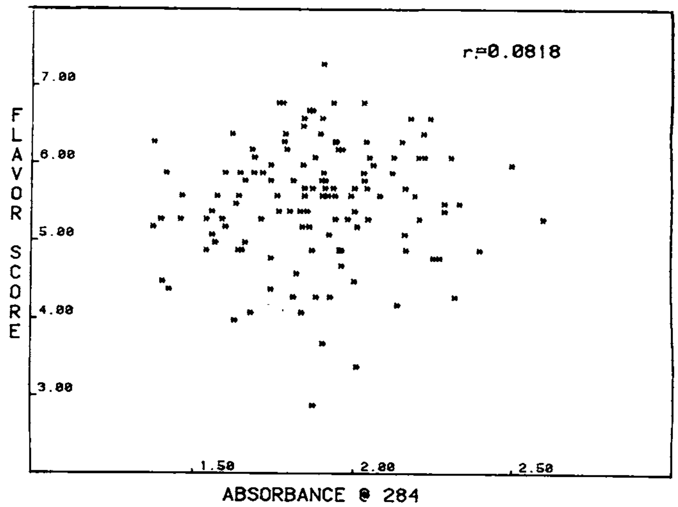

Fig. 7. Statistical correlation of absorbance at 284 nm with flavor score of grapefruit juices.

Conclusions

It was found that the sum of the visible absorbances at 504, 470 and 445 nm correlated well with observed visual color ranking of processed single strength grapefruit juices.

Absorbance at 284 nm revealed high correlations with naringin as determined by either the Davis Test and HPLC method. It appeared that the three methods are essentially determining the same or related components present in the samples.

Flavor did not correlate with visible or ultraviolet absorbance, or naringin as measured by either the Davis Test or HPLC method.

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MINERAL CONTENT OF CANNED GRAPEFRUIT JUICE[1]

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Additional index words. grapefruit, nutrition, Ca, Cu, Fe, P, Ca, Mg, K, Na.

Abstract. **The mineral elements, Zn, Cu, Fe, P, Ca, Mg, K, and Na which are essential in human nutrition, of more than 200 samples of canned grapefruit juice were determined by atomic absorption spectroscopy, flame emission spectroscopy, or colorimetric analysis. Zn and Cu were found to be less than 1 ppm, and the range for Fe was between 1 and 7 ppm. The average P content was about 110 ppm. Ca and Mg generally varied between 50 to 180 ppm. The range for values of K in these grapefruit juice samples was about 1000 to 2000 ppm with the average around 1500 ppm, while those for Na had a much wider variation. Occasionally samples had abnormally high values of Na, nearly 10 times that of the mean of the majority of the samples.**

Canned grapefruit juice is one of the main grapefruit products of the Florida citrus industry. With increased use of this product by the consumers during the past few years (2), with the current interest in human nutrition and with the recently promulgated Nutrition Labeling regulations (11) by the US FDA (U.F. Food and Drug Administration), there is a need to accumulate more information on its mineral nutrient content. There have been relatively few references on the mineral constituents of grapefruit juice in the literature. Harding (4) compared the mineral compositions of the flesh of grapefruit on various rootstocks at different stages of maturity. Roberts and Gaddum (7) and McCance and Widdowson (5) showed representative values of inorganic constituents of citrus fruits including grapefruit flesh. Dawes (3) reported the mineral values of 17 grapefruit juice samples of New Zealand.

This paper reports the values of several nutritionally important elements in canned Florida grapefruit juice from a survey of over 200 samples. Included in the list of elements analyzed in addition to those of the USFDA nutrition labeling regulations (11) were K and Na.

Material and Methods

Sample Collection and Preparation

Canned grapefruit juice samples [all in 46 oz (1360 ml) cans] used in this study were collected from the supermarket grocery shelves in connection with a quality survey (10). Also included in these samples were canned grapefruit juice collected from several manufacturing plants and stored at ambient temperature. All together 206 samples, all ascertained to be produced in Florida, during the past 2 years (10) were analyzed for the various elements.

Sample preparations for the analysis was similar to that used for frozen concentrated orange juice (9) except that 50 ml of single strength juice was first evaporated to dryness on a water bath before ashing procedure began.

Atomic Absorption (AA) Spectroscopic and Photospectrometric Analysis

The analyses were carried out by the Soil Analytical Laboratory at the University of Florida, Gainesville on a Perkin Elmer Model 503 AA spectrophotometer using the parameters recommended by the instrument manufacturer for the various elements. K and Na were determined on the emission mode, while P was determined by a colorimetric procedure (1). Elements determined on the absorption mode were Fe, Cu, Zn, Ca, and Mg. For Ca, a dilution of 1 to 25 was found to be satisfactory. Lanthanum was added at 0.5% of the diluted sample to prevent interference to Ca determinations by P. For K and Mg, a dilution of 1 to 50 was used.

Appropriate standards for each element were made within the concentration range of the element in the samples. Occasionally in a few samples it was found necessary to further dilute the samples in order to fall within the range of the standards.

Results and Discussion

The mean, range, and standard deviation of the various elements analyzed in these samples are shown in Table 1. K is by far the most abundant inorganic constituent in grapefruit juice. The mean value of 1550 ppm is considerably lower than that reported by McCance and

Table 1. Inorganic constituents of canned Florida grapefruit juice.

Element	Range	Mean	Standard deviation
		Parts per million	
Element	Range	Mean	Standard deviation
Potassium	850-2100	1550	174
Sodium	2-56	6.7	7.8
	(2-9.7)*	(4.2)*	(1.5)*
Calcium	50-182	76.4	17.7
Magnesium	51-129	93.0	9.2
Phosphorus	68-176	110	15.9
Iron	0.7-7.6	2.3	1.7
Copper	0.2-1.2	0.37	0.11
Zinc	0.33-0.92	0.51	0.10

*Sodium values in parentheses were calculated by not considering any values greater than 10 ppm.

[1]Florida Agricultural Experiment Stations Journal Series No. 857.