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FLAVOR AND COLOR PROFILES OF FROZEN CONCENTRATED ORANGE JUICE AND ORANGE JUICE FROM CONCENTRATE SAMPLES SUBMITTED FOR FLORIDA'S SEAL OF APPROVAL OR SUNSHINE TREE PROGRAMS, 1986 THROUGH 1989

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Abstract. Florida's Seal of Approval and Sunshine Tree programs guarantee purity and quality when the certification marks appear on citrus products. Flavor and color are two of the major quality factors that are determined on each sample. Together, flavor and color constitute 80% of the 100 total score points possible when product is graded using the United States and Florida Standards for Grades for orange juice products. Only the products frozen concentrated orange juice and orange juice from concentrate are considered here, numbering 797 and 2,741 samples, respectively. Mean values and comparison of the means for hedonic flavor scores and color numbers are presented for each product by year, product type, and by Florida and non-Florida product. Correlation analysis between flavor scores and color numbers revealed some significance for each product by year and by origin of fruit (Florida and non-Florida).

Since 1985, the Florida Department of Citrus has been actively engaged in a rebate program for the citrus industry and retailer to build consumer confidence in quality of citrus juice products (1). Florida's Seal of Approval and Sunshine Tree programs are designed to guarantee purity and quality when their certification marks appear on citrus juice products. The "Seal" guarantees 100% pure juice that meets or exceeds Florida Grade A standards and meets or exceeds U.S. Grade A standards regardless of origin of the

juice or where the juice was packed. The "Tree" guarantees the same as the "Seal" except that the product must have been produced from 100% Florida-grown citrus. Two of the several subjective and analytical quality factors determined on each juice submitted for "Seal" or "Tree" certification are flavor and color. When taken together, these two key quality attributes constitute 80% of the 100 total score points possible when orange juice product is graded using either United States or Florida Standards for Grades. The other quality factors which are determined in the certification process include: °Brix, percent acid and the °Brix to percent acid ratio; testing for possible adulteration such as addition of sugar or pulp wash, dilution with water, use of preservatives such as sodium benzoate or potassium sorbate, use of color additives, especially turmeric or annatto, addition of juices from other cultivars such as grapefruit juice to orange juice, and use of natural juices from other commodities, especially that from apples or pears.

Fellers (2) reported results on analyses of 234 frozen concentrated orange juices (FCOJs) and 52 orange juice from concentrates (OJFCs) produced in Florida over three years' time for flavor (as determined by 15-member panels) and color in addition to several other quality characteristics. Mean values and comparison of means for flavor scores and color numbers by product type, year, month of production and processing plant were presented. Correlation analysis between flavor and color was also made. In another study, Fellers et al. (3) utilized 72 Florida-packed FCOJs drawn from the retail market outside Florida. Large consumer panels evaluated samples for flavor and other quality attributes. The relationship between flavor and color was explored showing a complex situation, including a significant ($P < 0.05$) negative correlation between the two factors.

Several types or forms of citrus juices are involved in the "Seal" and the "Tree" programs, but for purposes of this study, only FCOJ and OJFC which constituted the bulk of the samples will be discussed.

Analysis of the great number of samples coming into the "Seal" and "Tree" programs have given the opportunity to compile and analyze a large amount of data on

Florida Agricultural Experiment Station Journal Series No. N-00322. The authors wish to thank Mary Ahnger for performing much of the statistical analysis of the data.

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certain quality characteristics of the various types of citrus juices. It is the intent of this study to: (1) present large current data bases for flavor and color on the two major forms of processed orange juice, FCOJ and OJFC; (2) compare flavor and color quality in FCOJ and OJFC for 100% Florida juice versus juices having less than 100% Florida juice; (3) determine variation in FCOJ and OJFC flavor and color quality from year-to-year; (4) compare FCOJ flavor and color quality with that of OJFC; (5) determine the correlation between flavor and color.

Materials and Methods

Sample collection and distribution. Juices packed both in Florida and outside of Florida were obtained from United States retail outlets by Florida Department of Citrus and Alert Marketing, Incorporated (Waterbury, CT) field personnel. All but single-strength canned products were frozen, shipped generally by Federal Express under dry ice to Lake Alfred, logged, thawed (if necessary), samples drawn for the various analyses, opened containers resealed and refrozen. Very few samples were certified to use the "Seal" or "Tree" for 1985 while the program was being started up, so the data presented here begin in 1986.

Evaluation of Samples. Samples were analyzed in the laboratory for flavor and color generally the same day as received or the following day. Since very large numbers of samples were tested each year (about 1,600), full taste panel evaluations were deemed to be unfeasible. Thus, flavor was determined individually by an expert taste panelist, author Fellers, who rated samples at room temperature (approx. 24°C or 75°F) on a 9-point hedonic scale where 9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely. Liberal commenting was made on aroma and taste of all samples. About 1.5 fl oz of juice identified by type was served in 3 fl oz waxed, cold-drink

paper cups labeled only with the program code number. Therefore, brand name or manufacturer was always unknown to the sensory evaluator. A score of 5 or less was considered unacceptable whereas a score of 6 (like slightly) or more was considered acceptable. Generally, not more than 20 samples were evaluated in a day. Not more than five samples were evaluated at a single session during a day.

Color number was determined on the OJFCs and properly reconstituted FCOJs (11.8°Brix) using a HunterLab D45-2 citrus colorimeter (Hunter Associates Laboratory, Fairfax, VA).

Means, standard deviations of the means, analysis of variance and correlation analysis were determined using SAS Institute's Statistical Analysis System software (SAS Institute, Inc., Cary, NC) on a VAX 11/750 (Digital Equipment Corp., Maynard, MA) minicomputer.

Results and Discussion

Data in Table 1 present means and standard deviations from the means for FCOJ and OJFC by year for flavor and color number from 1986 through 1989 and by origin of juice (100% Florida from brands having the "Sunshine Tree" mark and hereinafter called "Florida FCOJ" or "Florida OJFC") and juices containing less than 100% Florida juice (as represented by brands having the "Seal" and hereinafter called "non-Florida FCOJ" or "non-Florida OJFC"). All significance for this table was at $P < 0.05$ while nonsignificance was at $P > 0.05$. No significance was noted between flavor means by year for Florida FCOJs. Flavor of 1988 non-Florida FCOJs was significantly better than 1986 and 1987 juices. When Florida and non-Florida FCOJs were combined, again the 1988 juices had better flavor than the 1986 and 1987 juices with the 1987 juices being in the middle. No significant difference was

Table 1. Comparison of means^z for hedonic flavor score and color number of frozen concentrated orange juice (FCOJ) and orange juice from concentrate (OJFC) by year and by origin.

Year	FCOJ					OJFC				
	Number samples	Flavor score ^y (mean)	SD ^x	Color number ^w (mean)	SD	Number samples	Flavor score (mean)	SD	Color number (mean)	SD
Florida										
1986	18	6.33 ^a	0.84	36.18 ^a	0.46	100	6.08 ^a	0.98	36.06 ^a	0.57
1987	26	6.19 ^a	0.90	36.48 ^{ab}	0.60	240	6.20 ^a	0.84	35.99 ^a	0.52
1988	26	6.65 ^a	1.02	36.77 ^b	0.69	354	6.19 ^a	1.06	36.53 ^b	0.68
1989	51	6.35 ^a	1.11	36.51 ^{ab}	0.61	413	6.24 ^a	0.95	35.99 ^a	0.60
Non-Florida^y										
1986	125	6.00 ^a	0.95	36.19 ^a	0.55	305	5.76 ^a	0.93	36.10 ^a	0.54
1987	169	6.09 ^a	1.05	36.15 ^a	0.56	380	5.83 ^a	0.97	36.14 ^{ab}	0.61
1988	185	6.37 ^b	0.94	36.33 ^b	0.62	386	5.87 ^a	1.08	36.39 ^c	0.73
1989	197	6.18 ^{ab}	1.03	36.43 ^b	0.68	563	5.89 ^a	1.06	36.20 ^b	0.63
Florida and non-Florida										
1986	143	6.04 ^a	0.94	36.19 ^a	0.54	405	5.84 ^a	0.96	36.09 ^a	0.55
1987	195	6.11 ^a	1.03	36.19 ^a	0.57	620	5.97 ^b	0.94	36.08 ^a	0.58
1988	211	6.41 ^b	0.95	36.38 ^b	0.64	740	6.02 ^b	1.08	36.46 ^b	0.71
1989	248	6.22 ^{ab}	1.05	36.45 ^b	0.66	976	6.04 ^b	1.03	36.11 ^a	0.63

^zMean values having the same superscripts in columns for sets of 4-year data are not significantly different at the 95% confidence level.

^yAs determined by an expert taste panelist using a 9-point hedonic scale where 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely.

^xStandard deviation.

^wAs determined using a HunterLab D45-2 citrus colorimeter.

^vJuice derived from less than 100% Florida-grown fruit.

found between flavor means for Florida or non-Florida OJFCs for any particular year. However, when Florida and non-Florida OJFCs were combined, 1987, 1988 and 1989 juices were significantly better than 1986 juices.

The main reasons for grading down flavor in FCOJs in the approximate order of most to least frequent were: harsh/bitter taste, strong/heavy taste, heated/processed/cooked/storage aroma and taste, spoiled (mainly with diacetyl) aroma and taste, nondescript off-aroma/off-taste, excessive peel oily aroma and taste (especially taste), excessive aqueous essence/essence oil aroma and taste, excessive tartness, and excessive blandness/lack of orange juice flavor. The main reasons for grading down flavor in OJFCs in the approximate order of most to least frequent were: excessive heated/processed/cooked aroma and taste (especially in canned product but also in chilled product in carton or plastic), spoiled (mainly with diacetyl) aroma and taste, nondescript off-aroma/off-taste, harsh/bitter taste, excessive tartness, strong/heavy taste, excessive peel oily aroma and taste (especially taste), thin/watery consistency, and bland/weak aroma and taste.

Averages for color of all juices regardless of type or origin easily made minimum U.S. or Florida Grade A specification of 36 color score (Table 1); a minimum of 35.0 and 35.5 color number, which rounds off to 36 color score, is required for minimum Grade A for OJFC and FCOJ, respectively. Juice color was especially outstanding for both types of Florida juice obtained during 1988.

When the flavor of Florida FCOJ was compared with non-Florida FCOJ (Table 2), means for each year from 1986-1989 for the Florida juices were higher than for the non-Florida juices, but were found nonsignificantly so ($P>0.05$). However, when the juices for all four years were combined totaling 121 Florida FCOJ samples, the 6.38 mean was found significantly ($P<0.05$) higher (better) than the 6.18 recorded for 676 non-Florida samples. For the much larger number of OJFC samples, flavor was found superior for the Florida juices for each year and for the four years combined at the 99% confidence level.

Color of Florida FCOJ was significantly ($P<0.01$) better than non-Florida FCOJ during 1987, 1988 and for all four years combined (Table 2). No significant difference ($P>0.05$) was noted for the 1986 and 1989 years. For color of OJFC, there were mixed results. For the 1987 and 1989 years, color was better ($P<0.01$) in the non-Florida OJFCs than in the Florida OJFCs, however, the reverse was true for 1988. No significant differences ($P>0.05$) were noted for the 1986 year nor, as would be expected, for data for all years combined.

When flavor was compared between FCOJ and OJFC (Table 3), the FCOJs for 1986 and 1989 were found significantly better than the OJFCs at the 95% confidence level, while FCOJs produced during 1988 and FCOJs for all years combined were significantly better than OJFCs at the 99% level. No significant difference ($P>0.05$) was noted between flavor of FCOJ and OJFC in 1987. These results are in general agreement with taste panel results reported by Fellers (4) for FCOJs and OJFCs surveyed from Florida production from the 1970-1971 through 1981-1982 citrus seasons. One reason why flavor of FCOJ may be rated better than that of OJFC may be directly related to the heated/processed/storage type of flavor sometimes associated with OJFC, but not generally with FCOJ. This

Table 2. Comparison of means for both hedonic flavor score and color number of frozen concentrated orange juice (FCOJ) and orange juice from concentrate (OJFC) by origin and by year.

Year	Florida		Non-Florida ^y		Significance between row means ^x
	Number samples	Flavor score ^z (mean)	Number samples	Flavor score (mean)	
FCOJ-Flavor					
1986	18	6.33	125	6.00	NS
1987	26	6.19	169	6.09	NS
1988	26	6.65	185	6.37	NS
1989	51	6.35	197	6.18	NS
86-89	121	6.38	676	6.18	*
OJFC-Flavor					
1986	100	6.08	305	5.76	**
1987	240	6.20	380	5.83	**
1988	354	6.19	386	5.87	**
1989	413	6.24	563	5.89	**
86-89	1107	6.20	1634	5.85	**

Year	Florida		Non-Florida ^y		Significance between row means
	Number samples	Color number ^w (mean)	Number samples	Color number (mean)	
FCOJ-Color					
1986	18	36.18	125	36.19	NS
1987	26	36.48	169	36.15	**
1988	26	36.77	185	36.33	**
1989	51	36.51	197	36.43	NS
86-89	121	36.51	676	36.29	**
OJFC-Color					
1986	100	36.06	305	36.10	NS
1987	240	35.99	380	36.14	**
1988	354	36.53	386	36.39	**
1989	413	35.99	563	36.20	**
86-89	1107	36.17	1634	36.21	NS

^zAs determined by an expert taste panelist using a 9-point hedonic scale where 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely.

^yJuice derived from less than 100% Florida-grown fruit.

^x* = $p < 0.05$; ** = $p < 0.01$; NS = not significant at $p > 0.05$.

^wAs determined using a HunterLab D45-2 citrus colorimeter.

flavor in OJFC may be due to: (1) too severe heat processing of the reconstituted juice in the manufacture of OJFC; or (2) marketing/storage of OJFC at temperatures perhaps in excess of about 40°F (4.4°C).

Color numbers of FCOJs produced in 1987 were significantly higher ($P<0.05$) than OJFCs produced that same year (Table 3). Color numbers of FCOJs for 1989 and FCOJs for all four years combined were significantly higher ($P<0.01$) than corresponding color numbers for OJFCs. No significant differences ($P>0.05$) in color numbers between FCOJ and OJFC were noted for the 1986 and 1988 years.

Correlation analysis between juice flavor and color of FCOJ and also between juice flavor and color of OJFC revealed negative correlation seven of the eight times significance either at the 95% or 99% confidence level was achieved. Only for 354 Florida OJFC samples for 1988 was there a significant positive correlation ($r=0.108$; $P<0.05$). In cases of significance, the degree of significance was rather small explaining a maximum of only 8% of the vari-

Table 3. Comparison of means by year of hedonic flavor scores and color numbers of frozen concentrated orange juice (FCOJ) and orange juice from concentrate (OJFC).

Year	Flavor				
	FCOJ		OJFC		Significance between row means ^y
	Number samples	Flavor score ^z (mean)	Number samples	Flavor score (mean)	
1986	143	6.04	405	5.84	*
1987	195	6.11	620	5.97	NS
1988	211	6.41	740	6.02	**
1989	248	6.22	976	6.04	*
86-89	797	6.21	2741	5.99	**

Year	Color				
	FCOJ		OJFC		Significance between row means
	Number samples	Color number ^x (mean)	Number samples	Color number (mean)	
1986	143	36.19	405	36.09	NS
1987	195	36.19	620	36.08	*
1988	211	36.38	740	36.46	NS
1989	248	36.45	976	36.11	**
86-89	797	36.32	2741	36.19	**

^zAs determined by an expert taste panelist using a 9-point hedonic scale where 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely.

^y* = $p < 0.05$; ** = $p < 0.01$; NS = not significant at $p > 0.05$.

^xAs determined using a HunterLab D45-2 citrus colorimeter.

ation in flavor (125 samples of non-Florida FCOJ where $r = 0.289$; $P < 0.01$) as being due to color. The other incidences of significant correlation were: all 676 non-Florida FCOJ samples; all 797 Florida and non-Florida FCOJ samples; 305 OJFC 1986 non-Florida samples; 563 OJFC 1989 non-Florida samples; 240 OJFC 1987 Florida samples; and 413 OJFC 1989 Florida samples. For the seven incidences of an inverse relationship between flavor and color, the following explanations may apply: (1) Up to 10% juice of highly-colored *Citrus reticulata* or hybrids thereof, may be utilized in FCOJ or OJFC; however, tangerines, Murcotts and allied hybrids often produce poorly-flavored processed juice. Thus, the addition of these juices to *Citrus sinensis* (sweet) orange juice could have adversely affected overall flavor; (2) Use of certain highly-colored orange juice produced outside the state of Florida possessing a strong/heavy overall flavor (Fellers, personal observation), whether blended in quantity with Florida juice or used as 100% product, would act to affect flavor adversely. The above explanations were also enumerated by Fellers et al.

(3) in a large consumer study of Florida-produced FCOJs when data showed "flavor score means for consumers generally declining with increasing amount of color as rated by the colorimeter".

In summary, data bases utilizing 797 FCOJs and 2741 OJFCs have been established including means and standard deviations of the means for flavor (as recorded by an expert taste panelist using a 9-category hedonic scale) and color (using a HunterLab D45-2 colorimeter) by year (1986-1989), and by origin (juice from 100% Florida-grown fruit and juice from less than 100% Florida-grown fruit). Significant findings were as follows: (1) there was no yearly variation from 1986-1989 in flavor means for Florida FCOJs; (2) for non-Florida FCOJs, flavor of 1988 juices was better than that of 1986 and 1987 juices; (3) when Florida and non-Florida FCOJs were combined, the flavor of 1988 juices was also better than that of 1986 and 1987 juices; (4) no yearly variation for either Florida or non-Florida OJFCs was noted between 1986 and 1989; (5) when Florida and non-Florida OJFCs were combined, the 1986 juices were worse than those of every other year; (6) in general, flavor of either FCOJ or OJFC produced from 100% Florida-grown fruit was better than the respective products produced from less than 100% Florida-grown fruit; (7) on average, FCOJs rated better in flavor than OJFCs for three of the four study years and overall; (8) on average, FCOJs (reconstituted basis) rated better in color than OJFCs for two of the four study years and overall, while for two other years no difference was noted. Correlation analysis between flavor and color revealed eight significant correlations (seven negative) out of the 22 various correlations which were determined showing a small but measurable amount of adverse effect of highly colored fruit on flavor in several instances.

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