Vitamin C Contents in Processed Florida Citrus Juice Products from 1986–1995 Survey

Hyoung S. Lee* and Gary A. Coates

Florida Department of Citrus, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, Florida 33850

Vitamin C content in citrus juices processed in Florida was studied. A total of 2299 samples from February 1986 through October 1995 (908 frozen concentrated orange juices, 401 orange juices from concentrate, 319 pasteurized orange juices, 213 pasteurized grapefruit juices, and 458 grapefruit juices from concentrate) were obtained from 21 Florida processors for analysis of vitamin C. Means, standard deviations of the means, and maximum and minimum values are presented for each product on the basis of milligrams of vitamin C per 100 mL of product. Variations are reported for month, year, and manufacturing plant for each type of juice.

Keywords: *Vitamin C; citrus juice; orange juice; grapefruit juice; Florida*

INTRODUCTION

Since vitamin C (L-ascorbic acid) is one of the principal nutrients in citrus and highly related to quality changes during processing and storage, its content and stability are subjects of active study. Several reviews have been published that give discussions of many factors on variability in vitamin C contents of citrus fruits and their products (Nagy, 1980), analytical methods for the determination of vitamin C (Pachla et al., 1985), and the chemistry of ascorbic acid related to foods (Liao and Seib, 1988). Seasonal variabilities of nutrients included in Florida oranges (Harding et al., 1940) and in frozen concentrated orange juice product (Huggart et al., 1960; Ting et al., 1974) were investigated. However, many of these data were collected over 25 years ago before major changes occurred in cultural practices, types of juices, processing techniques, and packaging materials. Devastating freezes in Florida in the 1980s also contributed greatly to the varieties of oranges available for processing. Furthermore, blending with juices of non-Florida-grown oranges was not as prevalent as it is today. The Florida citrus industry, which accounts for nearly three-fourths of the U.S. citrus production, expects its citrus production to grow significantly over the next decade. Much of the Florida citrus crop is processed into juice products. In citrus juice products, frozen concentrated orange juice (FCOJ) is orange juice concentrated in a high vacuum evaporator and frozen until needed. Orange juice from concentrate (OJFC) refers to the juice prepared by reconstituting either frozen concentrate orange juice or concentrated orange juice for manufacturing. Pasteurized orange juice (POJ) and orange (or grapefruit) juice from concentrate, major types of chilled juice in Florida, are single-strength, ready-to-serve juice which are kept refrigerated during distribution and sale to the consumer. This study was initiated to provide a guide for values and ranges of vitamin C in commercially processed juices from Florida processing plants. This will be used for nutritional value and to respond to the concern regarding the validity of data in nutrient composition. An early part of this study including minerals and other nutrients has been reported by our own group (Fellers et al., 1990, 1991). This paper presents a comprehensive, up-to-date study on the variation of vitamin C content in five major citrus juice products manufactured in Florida from 1986 to 1995.

* Author to whom correspondence should be addressed [fax (941) 295-5920; e-mail HSL@icon.lal.ufl.edu].

MATERIALS AND METHODS

From February 1986 through October 1995, samples of orange juice products were obtained on a monthly basis from Florida processors and grapefruit juice products were obtained twice per month from November through June. Samples were randomly selected by USDA personnel and delivered in the retail package to the Citrus Research and Education Center (CREC), Lake Alfred, FL, by Florida Department of Citrus employees. Juice samples were subjected to different treatments upon arrival at the CREC. Single-strength products were poured into polyethylene bottles and frozen for analysis at a later date. (FCOJ) was reconstituted with 3 volumes of water using a precision pipet and water purified by a Milli-Q purification system (Millipore Corp., Bedford, MA) prior to placing in bottles on the day of analysis. Vitamin C was analyzed using the HPLC method developed by Lee and Coates (1987) and expressed as milligrams per 100 mL. The HPLC procedure was based on using a C_{18} column, a phosphate-buffered, aqueous mobile phase, and UV 245 nm detection. For this study, the °Brix values for orange juice and grapefruit juice products were normalized on the basis of U.S. grade standards (U.S. Department of Agriculture, 1982, 1983) and Florida standards (State of Florida, Department of Citrus, 1996) as follows: OJFC and reconstituted FCOJ, 11.8; grapefruit juice (GJ), 9.0; grapefruit juice from concentrate (GJFC), 10.0; and POJ, 11.0. Statistical analyses including means, standard deviations of the means, and analysis of variance (ANOVA) were performed using SigmaStat PC software from Jandel Scientific Software (San Rafael, CA). Differences between mean were evaluated using Duncan's multiple range test.

RESULTS AND DISCUSSION

Data in Table 1 summarize the mean, standard deviations, maximum, and minimum values expressed as milligrams per 100 mL. A total of 2299 juice samples from five different citrus products were analyzed over a 10-year period from February 1986 through October 1995. Results in Table 1 include samples from all types of retail packages. A majority of POJ samples are packaged in cartons, whereas OJFC is more often

Table 1. Ascorbic Acid Data for Commercial Florida Processed Citrus Juice Products from February 1986 through October 1995[a]

	FCOJ	POJ	OJFC	PGJ	GJFC
no. of samples	908	319	401	213	458
mean[b] (% DV)[c]	43.9 (173.0)	35.1 (138.4)	40.9 (161.2)	28.3 (111.5)	34.1 (134.4)
SD	5.5	7.0	7.1	5.5	5.1
maximum (% DV)[c]	66.8 (263.3)	58.7 (231.4)	63.1 (248.7)	41.5 (163.6)	64.8 (255.4)
minimum (% DV)[c]	27.9 (110.0)	18.6 (73.3)	21.5 (84.7)	13.8 (54.4)	20.5 (80.8)

[a] Abbreviations: FCOJ, frozen concentrated orange juice; OJFC, orange juice from concentrate; POJ, pasteurized orange juice; GJFC, grapefruit juice from concentrate; GJ, grapefruit juice. [b] Ascorbic acid values (mg/100 mL) are based on normalization of °Brix to 11.8 for OJFC and FCOJ, to 11.0 for POJ, to 10.0 for GJFC, and to 9.0 for GJ. [c] Percent daily value in 8 oz serving.

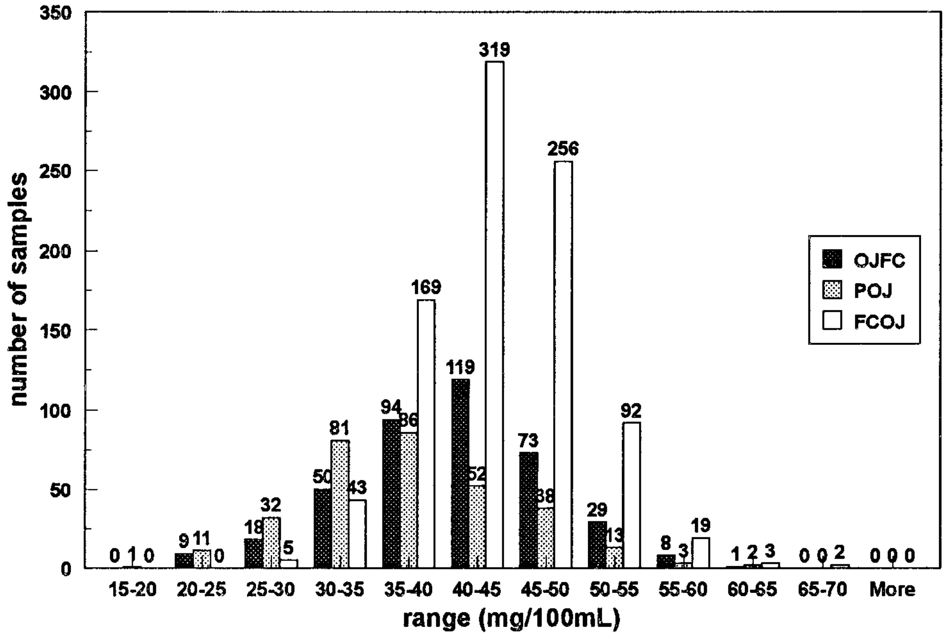

Figure 1. Distribution of vitamin C in OJFC, POJ, and FCOJ from 1986 to 1995.

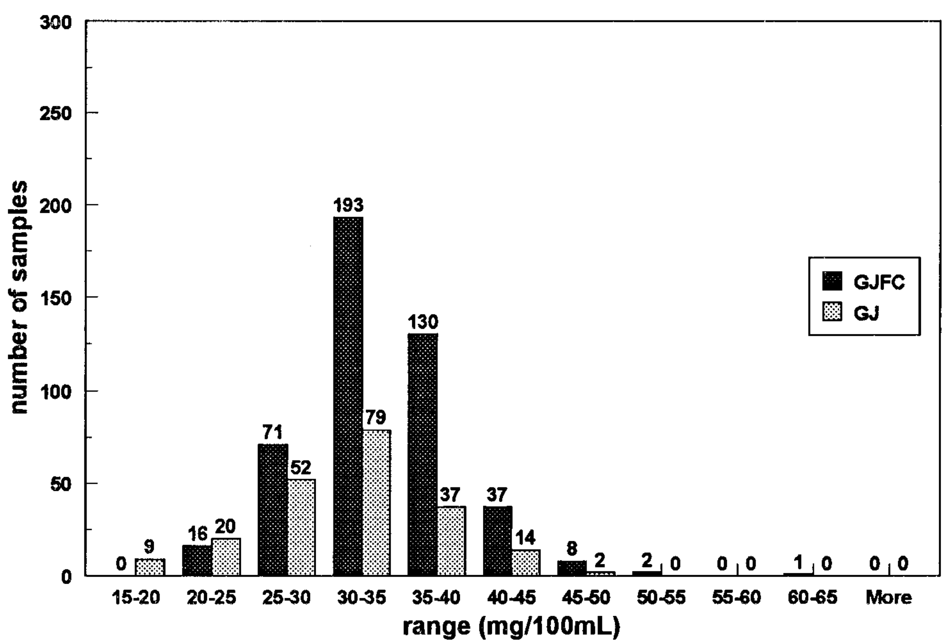

Figure 2. Distribution of vitamin C in GJFC and GJ from1986 to 1995.

packaged in cans or in bottles. Also, almost all POJ is sold as a chilled product in the market, but some OJFC is retailed at room temperature. In average vitamin C content in orange products, FCOJ was the highest followed by OJFC and POJ. Grapefruit is generally lower in vitamin C than orange fruits, which reflects the lower content in GJ products compared to vitamin C in orange juice products in Table 1. The POJ values do not necessarily represent the actual values as they were adjusted to 11.0 °Brix. The lower °Brix of GJ would account partly for some of the lower vitamin C values.

The data shown in parentheses in Table 1 represent values for the percent of daily value (DV) per 8 fl oz serving in the citrus juice products. Vitamin C was calculated as percentage of the reference daily intake (RDI) and expressed as percent of DV based on the Nutrition Labeling and Education Act of 1990. Percent

Table 2. Monthly Variation of Ascorbic Acid Values (Milligrams per 100 mL) from Processed Florida Citrus Juice Products for a 10-Year Period[a]

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
FCOJ												
no. of samples	84	86	78	78	73	72	64	75	79	72	72	75
mean	$45.3^{a,b}$	45.4^{a}	44.3^{a-e}	44.0^{a-f}	42.7^{c-k}	42.2^{e-k}	42.7^{c-j}	44.6^{a-d}	42.7^{c-i}	43.6^{a-h}	43.8^{a-g}	44.7^{a-c}
SD	5.6	5.6	6.1	4.5	4.6	4.8	5.9	5.7	4.5	5.2	6.0	5.3
maximum	61.4	65.9	61.2	56.8	51.5	53.2	54.0	66.8	57.2	59.4	60.6	57.9
minimum	32.7	32.5	34.2	34.2	30.7	33.1	27.9	32.6	28.5	33.8	34.6	29.0
POJ												
no. of samples	29	28	27	22	29	33	20	31	26	26	24	24
mean	44.1^{a}	43.2^{a}	38.4^{b}	34.3^{c}	30.9^{c-i}	29.8^{c-i}	32.9^{c-f}	$33.7^{c,d}$	31.8^{c-g}	33.2^{c-e}	31.6^{c-g}	37.6^{b}
SD	6.3	6.8	5.1	5.0	5.6	4.3	5.0	5.2	4.8	4.3	4.7	5.5
maximum	58.7	57.9	48.3	42.5	41.3	38.6	41.9	50.4	42.9	40.6	39.2	47.9
minimum	28.2	25.6	28.0	26.2	18.6	19.9	22.4	22.4	23.4	24.9	21.8	26.9
OJFC												
no. of samples	28	36	29	31	31	31	36	34	41	35	31	38
mean	41.5^{a-e}	42.9^{a}	41.5^{a-f}	40.3^{a-h}	38.7^{b-j}	40.7^{a-g}	38.1^{b-k}	$42.8^{a,c}$	38.5^{b-k}	41.9^{a-d}	39.6^{b-i}	44.6^{a}
SD	9.0	6.7	7.9	6.2	6.6	5.9	5.8	6.4	7.3	6.7	6.5	7.2
maximum	63.1	54.7	58.6	52.8	54.4	51.1	48.5	58.5	53.1	55.5	55.4	58.1
minimum	23.5	24.9	26.4	27.3	21.8	28.0	24.8	23.5	24.3	21.5	27.4	24.9
GJ												
no. of samples	34	36	33	27	25	21	3				11	23
mean	29.9^{a-c}	30.4^{a}	28.1^{a-e}	28.5^{a-d}	24.8^{d-f}	24.8^{d-f}	25.3				28.2^{a-c}	30.5^{a}
SD	4.3	5.2	5.2	2.9	4.8	5.5	6.3				8.5	5.8
maximum	40.9	41.5	39.1	33.8	31.1	34.0	31.9				38.1	38.9
minimum	18.2	21.1	15.7	23.8	14.0	14.2	19.3				13.8	15.7
GJFC												
no. of samples	53	63	57	69	64	67	2				34	49
mean	35.5^{a-c}	$36.5^{a,b}$	35.0^{a-d}	$31.7^{e,f}$	$32.0^{e,f}$	32.3^{e}	30.4				35.2^{a-d}	36.6^{a}
SD	3.9	7.0	5.4	3.5	4.7	3.2	0.4				4.5	4.7
maximum	43.3	64.8	52.3	39.9	41.5	38.2	30.7				43.5	45.0
minimum	26.4	20.5	24.8	21.2	22.3	22.4	30.1				25.4	22.3

[a] Means in the same row with the same letter are not significantly different ($p > 0.05$).

Table 3. Yearly Variations of Ascorbic Acid Values (Milligrams per 100 mL) from Processed Florida Citrus Juice Products for a 10-Year Period[a]

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
FCOJ										
no. of samples	104	105	118	113	88	77	75	77	84	67
mean	42.1^{e}	43.5^{d}	$41.9^{e,f}$	40.9^{e-g}	43.5^{d}	47.8^{a}	$47.4^{a,b}$	46.9^{a-c}	$46.1^{b,c}$	41.7^{e-g}
SD	7.9	5.0	4.8	5.0	3.2	4.6	4.1	4.0	3.9	3.6
maximum	65.9	59.4	57.9	66.8	60.6	61.4	56.3	55.0	55.0	50.2
minimum	27.9	32.9	33.1	29.8	34.4	36.8	38.2	36.6	34.8	33.0
POJ										
no. of samples	11	16	18	23	24	30	55	44	49	49
mean	32.2^{b-i}	41.6^{a}	36.6^{b}	36.0^{a-e}	36.0^{b-d}	34.3^{b-h}	$36.1^{b,c}$	35.3^{b-f}	35.2^{b-g}	$31.7^{b,d-i}$
SD	12.0	8.6	6.4	8.2	5.1	4.4	5.9	6.6	7.3	5.9
maximum	57.9	58.7	47.6	52.9	46.6	45.3	51.1	49.9	51.5	44.6
minimum	18.6	26.6	28.0	21.8	25.7	24.9	25.6	24.3	22.0	20.7
OJFC										
no. of samples	36	62	56	43	54	31	48	35	22	14
mean	$36.2^{i,j,l,m}$	$43.8^{a,b}$	$38.8^{i,k,l}$	$39.7^{b,d,f,h-k}$	$39.9^{b,d,f,h,i}$	$43.5^{a,b}$	$42.1^{a,b,d,f-h}$	43.4^{a-d}	$43.2^{a,b,d,f}$	$37.3^{b,c,e,g,i,j,l,m}$
SD	9.1	7.3	7.4	6.0	5.7	5.6	5.0	5.8	7.5	6.9
maximum	58.6	58.5	54.7	50.6	55.4	63.1	56.2	55.2	54.4	45.9
minimum	21.8	30.2	21.5	24.9	26.4	33.0	31.3	26.5	24.9	26.0
GJ										
no. of samples	17	15	20	28	13	17	30	27	17	29
mean	32.1^{a}	30.5^{a-d}	$30.7^{a,b}$	29.7^{a-e}	30.6^{a-c}	28.0^{b-g}	24.1^{i}	27.5^{b-h}	28.5^{a-f}	26.3^{c-i}
SD	4.4	4.0	4.3	3.8	4.6	7.1	6.5	4.8	4.5	4.6
maximum	39.5	39.0	41.5	37.2	38.9	40.9	35.8	35.9	34.1	35.4
minimum	25.7	23.7	24.8	21.8	22.1	15.7	14.0	13.8	18.5	15.7
GJFC										
no. of samples	52	57	66	38	67	49	46	42	26	15
mean	35.9^{a-c}	30.7^{g-i}	32.2^{e-i}	32.4^{e-h}	34.9^{b-d}	34.4^{b-f}	37.4^{a}	$36.0^{a,b}$	34.7^{a-e}	33.4^{b-g}
SD	8.4	5.5	4.8	3.3	3.5	4.0	3.4	3.1	2.2	3.2
maximum	64.8	47.7	45.8	40.1	43.1	43.3	46.3	42.3	38.2	40.1
minimum	22.3	20.5	21.2	26.5	24.9	27.3	31.8	27.4	30.7	29.4

[a] Means in the same row with the same letter are not significantly different ($p > 0.05$).

of DV was introduced as a reference value to replace the term "U.S. RDA", which was introduced in 1973 as a label reference value for nutrients in voluntary nutritional labeling. Mean values for the percent of DV for vitamin C in Florida processed citrus products are high enough, ranging from 111.5% to 173% of DV per 8 fl oz serving, to easily qualify as supplying 100% of the DV of vitamin C as determined by the U.S. FDA (1992). For the entire 10-year study, 98 samples of 2299 total juice samples (about 4.3% of total sample size) were below the 100% DV. By type, GJ had the largest number of samples below 100% DV, with 56 samples (26.3%) falling below 100% DV, 17 (5.3%) for POJ, 16 (3.5%) for GJFC, and 9 (2.2%) for OJFC; no samples fell below 100% DV for FCOJ.

In the sample size for this study, FCOJ populated the largest proportion (39.5%) in our samples, which could reflect the share in total citrus production from Florida citrus processors. On the basis of the Florida Citrus Processors Association statistical summary of the 1994–1995 season, FCOJ occupied 59.6% of the total production. By form, ready-to-serve juices displayed the greatest market growth, but FCOJ was still a major citrus product from Florida. Mean value for vitamin C in FCOJ for the 10-year period was 43.9 mg/100 mL and ranged from a maximum of 66.8 mg/100 mL to a

Table 4. Variations in Ascorbic Acid (Milligrams per 100 mL) by Processing Plant in Processed Florida Citrus Juice Products for February 1986 through October 1995[a]

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
FCOJ																					
no. of samples	52	7	32	86	51	64	102	22		4	99	86	5		83	2	2	33	104	60	14
mean	45.0^{a,c,e,f}	47.7^{a}	40.8$^{g,n-r}$	44.2$^{a,b,e-g,i,k-m}$	43.4$^{a,e-g,i,k-n}$	45.6$^{a,c-e}$	44.2$^{a,c,e-g,i,k,l}$	39.7$^{g,p-s}$		39.5	45.7^{a-c}	43.0$^{a,f,g,m-o}$	45.0$^{a,c,e-g}$		45.0$^{a,c,e-i}$	42.5	45.8	42.0$^{g,i-q}$	44.8$^{a,c,e-g,i-k}$	40.1$^{g,p-s}$	42.8$^{a,b,d,f-h,j,l-n,p}$
SD	5.7	6.8	6.2	5.0	4.2	6.6	5.3	5.2		4.6	5.1	3.9	13.9		5.8	1.7	13.2	5.1	5.3	4.4	4.5
maximum	57.9	57.0	65.9	56.0	53.4	66.8	58.3	51.1		45.8	59.4	51.5	59.2		56.5	43.7	55.1	53.7	59.1	49.2	53.2
minimum	33.0	39.4	29.8	33.1	36.6	33.6	33.0	30.3		35.0	33.4	32.6	27.9		29.0	41.3	36.4	30.7	28.5	31.6	37.6
POJ																					
no. of samples	2	3	46		37	46				3	38	1		17	126						
mean	31.7	43.9	30.9		36.7^{a,b}	33.7^{a-d}				33.4	35.8^{a-d}	24.9		37.2^{a}	36.3^{a-c}						
SD	6.6	8.2	5.7		4.3	7.2				11.4	7.0	0.0		10.4	6.6						
maximum	36.4	49.5	44.1		47.9	51.8				46.6	51.5	24.9		58.7	57.9						
minimum	27.0	34.5	20.7		29.0	23.1				26.2	21.8	24.9		21.2	18.6						
OJFC																					
no. of samples	1	15				36		4	17	70	66	81		85	2	1		23			
mean	39.8	43.1^{a-c}				42.2^{a,b,f}		39.4	42.1^{a-c}	40.2^{b-e}	40.8^{b-e}	36.3		45.1^{a}	40.6	52.5		40.3^{b-f}			
SD	0.0	7.4				6.1		9.4	8.2	7.1	7.4	5.8		5.7	2.7	0.0		4.7			
maximum	39.8	53.4				54.7		53.1	55.2	58.6	55.5	53.6		63.1	42.5	52.5		50.4			
minimum	39.8	27.6				26.8		31.8	24.8	21.5	24.3	21.8		30.2	38.7	52.5		32.1			
GJ																					
no. of samples		17	38			38	2	1	1		30		3	36	47						
mean		31.0^{a}	23.4			28.2^{a-d}	26.3	23.9	32.0		28.2^{a-d}		30.9	30.7^{a-c}	29.6^{a,b}						
SD		3.1	6.2			5.5	4.8	0.0	0.0		5.7		7.5	3.9	3.6						
maximum		39.0	35.9			37.7	29.7	23.9	32.0		39.0		39.5	41.5	35.4						
minimum		26.7	13.8			14.0	23.0	23.9	32.0		18.5		25.7	25.7	19.0						
GJFC																					
no. of samples	1	19				62		3	23	53	44	60	5	100	85	3					
mean	36.2	29.9^{b}				34.6^{a-e}		28.7	33.3^{a-f}	34.6^{a-d}	35.3^{a-c}	32.3^{b,d,f,g}	35.5^{a,b}	36.0^{a,c}	33.3$^{b,d-g}$	30.4					
SD	0.0	5.5				3.9		7.2	6.2	5.4	4.6	3.8	5.6	5.5	4.5	8.0					
maximum	36.2	43.7				45.0		33.7	52.0	52.3	49.5	39.0	41.0	64.8	45.8	38.2					
minimum	36.2	22.4				24.9		20.5	26.3	27.0	27.3	22.5	28.4	23.3	21.2	22.3					

[a] Means in the same row with the same letter are not significantly different ($p > 0.05$).

minimum of 27.9 mg/100 mL, but most samples (>35% of FCOJ) fell within the range of 40−45 mg/100 mL, as can be seen in Figure 1.

Figure 1 shows the sampling distribution of vitamin C content based on 1628 orange juice products. OJFC had a maximum of 63.1 mg/100 mL and a minimum of 21.5 mg/100 mL, with most samples (29.7% of the total sample) falling in the ranges of 40−45 and 35−40 mg/100 mL (23.4%), whereas POJ had a maximum of 58.7 mg/100 mL and a minimum of 18.6 mg/100 mL, with the majority appearing in the ranges of 30−35 (30.7%) and 35−40 mg/100 mL (24.1%). The distribution of vitamin C contents is not symmetrical about its mean values but showed a somewhat bell-shaped distribution for FCOJ and OJFC as we draw a smooth curve that might appear in Figure 1. Its spread can be estimated by the value of its standard deviation, and POJ, which showed a nearly equal standard deviation compared to OJFC, showed a large magnitude and somewhat different shape of distribution as we can draw from Figure 1. An explanation could be that FCOJ and reconstitutes (OJFC) can be blended to produce more uniform products throughout the season but POJ is processed on the basis of fruit availability, which could reflect the natural variability of vitamin C in fruits throughout the season.

Figure 2 shows the distribution of vitamin C content based on 671 GJ products for the 10-year period. GJFC had a maximum of 64.8 mg/100 mL and a minimum of 20.5 mg/100 mL, with a majority of the samples (42.1%) falling into the range of 30−35 mg/100 mL. A maximum of 41.5 mg/100 mL and a minimum of 13.8 mg/100 mL were noted in PGJ, with the highest number of samples (35.2%) appearing in the range of 25−30 mg/100 mL.

Table 2 presents monthly variations for each type of processed Florida citrus juice over the 10-year period. A significant ($p < 0.05$) amount of month-to-month variation in vitamin C content was found in all types of product. Vitamin C data in POJ and GJ in Table 2 could be an exact representation of oranges and grapefruit grown in Florida. Since considerable amounts of Brazilian and other non-Florida orange juices are currently used for blending in Florida, the vitamin C data in Table 2 could also represent values found in current blended juice products such as FCOJ and OJFC in Florida processing. As an early study indicated (Ting et al., 1974), the variation of vitamin C in FCOJ was not of large magnitude. Trends of month-to-month variation in blended samples (FCOJ, OJFC, GJFC) were not very discernible, which is probably due to the common blending practices in the citrus industry. In POJ, there was a noticeable difference from month to month. POJ showed a higher level of vitamin C during the months of December through March, when vitamin C-rich Hamlin oranges were a major contributor to the orange juice market. Generally, the low values of vitamin C were found in POJ samples collected between May and July and probably reflected the use of large amounts of Valencia oranges, which possess lower amounts of vitamin C of the three major Florida sweet orange cultivars. A seasonal change was also noted in GJ with a decrease in vitamin C concentration as the season progressed. This observation is in agreement with that of an early study which indicated a seasonal decline of vitamin C content with maturity in some varieties of grapefruit (Harding, 1944). During the off-season from August to October, GJ samples were not available.

Data in Table 3 show variation in vitamin C by year for the 10-year period from February 1986 through October 1995. Significant differences ($p < 0.05$) in vitamin C content were noted between production years for each type of juice. The variation by year between the highest and lowest amount was about 14.4% for FCOJ, 17.4% for OJFC, and 23.8% for POJ. Florida experienced three freezes with damage to citrus trees during the course of this investigation. One indirect effect of the freezes has been the loss of mature Pineapple orange trees, which is one of three major orange varieties, from northern citrus-producing counties of Florida and the planting of young Ambersweet trees in more southern counties. Such varietal changes, regional changes, and age of the tree, as well as variations in the weather during the growing season, could probably affect year-to-year variation of vitamin C content in POJ but are less likely to affect blended products such as FCOJ or OJFC.

Manufacturing plants can also contribute to the variation of vitamin C as is noted in Table 4. Initially, 17 different plants contributed FCOJ to the study. This number diminished to 10 plants as the study continued due to mergers, closing of plants, market trends, etc. This same market force change also decreased the number of OJFC samples. For POJ, however, this trend was reversed, initially involving only 2 plants in 1986 and culminating in the participation of 7 plants in 1995. This is presumably due to the large change in market trend for the sale of POJ because of consumers' perceptions of improved convenience and "fresher" quality than concentrate. Consumers began to purchase more of the single-strength not from concentrate, which was reflected in the number of processors participating in the study over time. A similar trend in GJFC and GJ was also observed, although GJ showed a decrease in the number of plants participating, dropping from 6 to 5.

The magnitude of differences in vitamin C contents between plants was significant. When the highest vitamin C level in FCOJ from plant B was compared to the lowest level at plant H, there was a 16% difference. Only plants with five or more samples were considered for statistical evaluation. There are perhaps several factors responsible for plant-to-plant variation; major contributors to this variation could be the variety of fruit used in juice preparation and seasonal differences as pointed out by Fellers et al. (1991). The Hamlin orange, as previously noted, has a higher level of vitamin C, whereas the Valencia fruit possesses less vitamin C. Thus, a plant that utilizes more vitamin C-rich Hamlin fruit than average could produce higher vitamin C products. Grapefruit juices could be affected by the amount of early (higher vitamin C) or late season (lower vitamin C) fruit that is used by each plant. Also, geographic location of plants, types of cultivars, and the quality of fruits delivered for processing may also be reflected in these values.

In summary, the present study provides a considerable amount of information on vitamin C of citrus juices produced for 10 processing seasons in Florida. The data can also be used to estimate the vitamin C content in current blended products in Florida processing operations. The samples used in this study represent products collected at the point of manufacture and do not take into account any changes in vitamin C levels that might occur during marketing. Vitamin C retention can vary considerably depending on types of container in addition to market conditions. This survey indicates that about 95.7% of the total samples of citrus juice products processed in Florida could provide >100% of DV for vitamin C per 8 fl oz serving at time of packing.

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