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QUALITY OF

RECONSTITUTED CHILLED ORANGE JUICE

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A cooperative study by The Connecticut Agricultural Experiment Station and The Connecticut Department of Consumer Protection

Orange juice is promoted not only as the ideal breakfast drink but also as a thirst quencher throughout the day. Most people drink orange juice because they enjoy its taste. Others drink it because it is a source of natural vitamin C (ascorbic acid), a six ounce glass providing the 60 milligrams (mg) U.S. Daily Recommended Allowance for an adult (4).

The vitamin C content of orange juice varies with the season of the year, the climate where the oranges are grown, and the variety of the oranges. For example, fresh orange juice from California Navel oranges averages 61 mg per 100 grams (g) of juice, and juice from California Valencias averages 49 mg per 100 g. Juice from early season (Hamlins in early autumn) and mid-season (Parson Browns and Pineapples in the winter) varieties of Florida oranges average 51 mg per 100 g of juice; however, a late season variety (Valencias in spring and early summer) averages only 37 mg per 100 g juice (2). No Connecticut or Federal regulations stipulate how much vitamin C pure orange juice must contain.

Consumers purchase orange juice as frozen concentrate, as chilled fresh or reconstituted from concentrate, or canned. In Connecticut, bottlers usually receive orange juice concentrate from Florida. About 90% of the juice produced in the United States comes from Florida. Water is mixed with the concentrate, which is then pasteurized, bottled, and refrigerated. Most distribution is to retail stores in quarts or half-gallons but some juice is packaged in half-pints for vending machines or lunch counters.

In the present survey we examined the microbial content of chilled orange juice for sale in retail stores both before and after the code date had expired. The code date is the date stamped on the container as the last day of sale. We also determined the vitamin C content. We did not rate the taste of the samples.

Methods

Twenty-eight samples of reconstituted chilled orange juice were collected from refrigerated cases in retail stores by inspectors of the Connecticut Department of Consumer Protection from May 1981 to January 1982. Only chilled orange juice was sampled; sterile canned juice and frozen concentrate were not tested. All samples were in plastic-coated cardboard containers except the four noted in the Table. At purchase, samples were placed on ice for delivery to the laboratory. Two containers of the same code date were purchased. One was analyzed for both vitamin C and microbial contaminants when received. A portion of the juice from this carton was removed aseptically to a brown bottle and stored at 40 F (4.4 C) for microbial analysis on the code date. The second carton was stored at 40 F unopened in the dark until the expiration of the code period when it was tested for vitamin C. Some samples were tested at other than at the end of the code

Sample number	Brand	Days to code date	Vitamin C: As purchased, mg/100 ml: L-ascorbic acid	Vitamin C: As purchased, mg/100 ml: Dehydro-ascorbic acid	Vitamin C: As purchased, mg/100 ml: Total effective[d]	Vitamin C: After storage, mg/100 ml: L-ascorbic acid	Vitamin C: After storage, mg/100 ml: Dehydro-ascorbic acid	Vitamin C: After storage, mg/100 ml: Total effective[d]	% loss: Ascorbic acid
1	A & P	27	39.0	1.2	40.0	30.0	0.4	30.3	0.9
2	Cumberland Farms	11	35.5	3.6	38.6	27.0	5.6	31.8	2.4
3	Cumberland Farms[a]	14	35.5	0.2	35.7	31.4	0.0	31.4	0.9
4	Dairy Mart	21	26.5	2.3	28.5	3.0	4.3	6.7	4.0
5	Edward's Finast	10	31.2	2.0	32.9	20.5	1.7	21.9	2.6
6	Florida Citrus	22	39.0	7.0	44.9	16.0	7.3	22.2	2.7
7	Foodland[b]	29	35.9	0.0	35.9	36.2	0.0	36.2	0.0
8	Garelick Farms	11	36.0	2.2	37.9	19.7	7.1	25.7	4.1
9	Grand Union	11	28.0	3.0	30.6	29.0	0.9	29.8	0.0
10	Guida's Dairy	21	45.3	0.0	45.3	34.4	0.0	34.4	1.1
11	Hood	10	31.0	4.9	35.2	17.0	7.9	23.7	3.8
12	Kraft[b]	[e]	42.6	0.0	42.6	42.9	0.0	42.9	0.0
13	Mill Pond Farms	10	36.0	3.5	39.0	30.7	4.0	34.1	1.3
14	Minute Maid	14	33.0	8.8	40.5	15.5	8.6	22.8	3.8
15	Moser Farms	5	25.5	6.1	30.7	—[f]	—	—	—
16	Moser Farms	21	36.7	2.0	38.4	20.5	4.5	24.3	1.8
17	Orange Naturelle (50% juice)	15	13.5	4.2	17.1	0.0	7.1	6.1	6.7
18	Royal Dairy	18	33.5	1.4	34.7	15.0	4.5	18.8	2.6
19	Sealtest	11	26.5	5.2	30.9	13.7	5.6	18.5	4.4
20	Sealtest[c]	1	3.5	8.8	11.0	—	—	—	—
21	Shop Rite	15	30.5	4.6	34.4	19.5	3.6	22.6	2.4
22	Stew Leonard's	9	50.0	2.4	52.0	44.5	3.5	47.5	1.0
23	Stop & Shop	10	40.2	0.0	40.2	33.0	0.8	33.7	1.4
24	Sun Flo	16	32.7	2.1	34.5	14.5	3.6	17.6	3.3
25	Sweetlife	15	33.0	5.5	37.7	14.5	6.4	19.9	3.7
26	Tropicana	6	13.0	7.8	19.6	3.3	10.3	12.0	12.4
27	University of Connecticut	10	35.0	1.1	35.9	30.2	1.8	31.7	1.2
28	Waldbaums[b]	28	39.4	0.0	39.4	36.1	0.0	36.1	0.3

[a] Plastic container. [b] Glass container. [c] Sample obtained one day before expiration date and thus not retested.

[d] Ascorbic acid plus vitamin C activity of dehydroascorbic acid calculated as 85% of that of ascorbic acid.

period. Thus, in the Table some elapsed times may not coincide with the days between purchase and expiration date.

Analysis for ascorbic acid (vitamin C), dehydroascorbic acid, sugars, and acidity was made according to Official Methods (3). Juice contents were estimated by comparisons of ash, potassium, and phosphorus contents with values for authenticated orange juice. High pressure liquid chromatography was used to determine presence of preservatives (5).

For microbial analysis, orange serum agar was used to determine numbers of aerobic bacterial contaminants and violet red bile agar for coliform bacteria (1); incubation at 32 C. Acidified potato dextrose agar was used to test for yeasts and molds (1) and tests were incubated at room temperature (20-22 C).

Results and Discussion

Each processor places a date on the container indicating the date after which the product should be removed from sale (code date). The number of days from time of bottling to the code date (code period) varies among processors. We were not able to obtain the length of the code period for each brand of orange juice collected. Some companies willingly disclosed this information; others did not respond or told us the length of their code period was proprietary information. For

per day Total effective [d]	Elapsed days	Orange juice est. %	Total sugars %	Acidity as citric acid g/100 ml	pH	Microbial counts, no./ml: At purchase Bacteria	At purchase Yeasts	At end of code period Bacteria	At end of code period Yeasts	Sample number
0.9	27	101	9.16	0.83	4.3	6	<1	<1	340	1
1.8	10	107	9.74	0.84	4.5	<1	<1	4	<1	2
0.9	13	108	9.31	0.77	3.9	5	12	720,000	900,000	3
3.5	22	103	8.74	0.78	3.9	28	<1	36	36,000	4
2.6	13	101	9.49	0.80	3.8	1	<1	<1	650	5
2.3	22	105	8.96	0.83	4.3	3	2	<1	350,000	6
0.0	29	107	9.24	0.85	3.8	<1	<1	<1	<1	7
2.9	11	110	8.53	0.80	3.8	<1	<1	<1	710	8
0.3	10	102	8.96	0.83	4.4	1	45	<1	220,000	9
1.1	22	98	9.71	0.83	3.7	2	<1	<1	580,000	10
2.7	12	93	9.06	0.78	4.3	<1	18	<1	160,000	11
0.0	26	95	8.96	0.90	3.7	<1	<1	<1	<1	12
1.1	11	95	9.37	0.80	3.8	4	<1	<1	<1	13
3.1	14	97	8.82	0.86	4.2	<1	<1	<1	<1	14
—	—	93	8.77	0.79	4.3	<1	3,300	<1	120,000	15
1.5	25	103	9.21	0.78	3.9	7	<1	<1	17,000	16
4.3	15	58	11.03	0.94	4.1	<1	<1	<1	39,000	17
2.2	21	107	9.51	0.84	4.4	<1	<1	<1	<1	18
3.6	11	96	8.54	0.85	3.7	9	<1	<1	27,000	19
—	—	87	8.87	0.80	4.2	<1	<1	—[c]	—	20
2.3	15	105	9.44	0.86	4.4	<1	<1	<1	310,000	21
0.8	11	103	10.21	0.83	3.9	<1	<1	<1	<1	22
1.2	13	95	9.14	0.84	3.7	<1	43	<1	110,000	23
2.9	17	103	9.14	0.74	3.9	5	1	<1	370,000	24
3.1	15	106	9.17	0.73	3.9	2	<1	<1	60,000	25
6.5	6	102	8.89	0.86	4.1	14	<1	120	<1	26
1.1	11	92	8.27	0.71	3.8	4,900	560	72,000	700	27
0.3	28	103	9.16	0.80	3.8	1	<1	<1	650	28

[e] This sample was collected on Dec. 1, 1981. Code date was Dec. 26, 1982 but it was retested after 26 days.

[f] This sample was not retested.

those that responded, code periods ranged from 16 days to 49 days; the average was 27 days. For all samples at purchase the number of days left to the code date, i.e., the days remaining to the date stamped on the container, ranged from one to 29. (see Table).

Oxygen in the headspace of the container and that dissolved in the orange juice and the acid nature of the juice favor the gradual decomposition of ascorbic acid. Ascorbic acid alone is the physiologically active form of vitamin C, although dehydroascorbic acid, which is the first compound formed on oxidation of ascorbic acid, can be reconverted to ascorbic acid in the body with an effectiveness variously estimated at 75 to 85%. Further oxidation of the dehydroascorbic acid produces compounds that cannot be changed back to ascorbic acid in the body.

For the data in the Table, dehydroascorbic acid was assumed to have 85% of the effectiveness of ascorbic acid. The average total effective vitamin C (ascorbic acid plus 85% of the dehydroascorbic acid) for the samples as received was 35.8 mg per 100 milliliters (ml) for 27 samples. At this vitamin C concentration, 168 ml or 5.7 fluid ounces supplies the U.S. Recommended Daily Allowance of 60 mg. Orange Naturelle, for which only 50% juice was claimed, is not included in this average.

At the code dates the average total effective vitamin C was 27.1 mg per 100 ml (25

samples) and thus it would take 221 ml or 7.5 ounces to supply the Recommended Daily Allowance. The average loss of effective vitamin C on storage of the juice was 0.68 mg per 100 ml per day or 1.9% per day. The average total loss of effective vitamin C for all samples during storage of 6 to 29 days was 29.3% but the range was from none to 76.5%.

The average loss per day of ascorbic acid alone was 0.73 mg per 100 ml or 2.3%. The losses are nearly the same as reported for ascorbic acid in orange juice in a previous study (6), where the second analysis was of the original sample resealed after the first determination was made.

The average juice content of the 27 samples of claimed 100% juice was 101%. The average sugar content was 9.1% (9 to 10% is considered normal). The acidities as citric acid and the pH of all samples were normal for orange juice. Neither of the preservatives sodium benzoate nor potassium sorbate was found in any samples. The Orange Naturelle sample was claimed to have 50% juice and was found to contain 58% juice. This sample also was claimed to have sugar added, which was confirmed by the test results: 11% sugar found compared to 5% expected.

The orange juice samples were in plastic-coated cardboard containers except where noted in the Table. The four samples in glass or plastic containers appeared to maintain their concentrations of vitamin C on storage better than those in the cardboard containers and showed little or no production of dehydroascorbic acid, because oxygen was practically excluded by the containers.

Few samples contained many bacterial contaminants when tested either at purchase or at the end of the code period (see Table). Only one sample (27) contained many bacteria at purchase. Only two samples (3 and 27) contained excessive bacterial contamination after storage to the code date. This indicated contamination by psychrotrophic bacteria, which can grow at cold temperatures. Sample 27 was the only one that contained coliform bacteria at purchase (75 per ml). Sample 3 was the only one that contained substantial numbers of coliform bacteria after storage (9,700 per ml). Coliform bacteria usually indicate contamination after processing, but these bacteria are usually suppressed or killed under the acidic conditions of orange juice.

Probably the most troublesome contaminants in orange juice are yeasts. They ferment the sugars in the juice and can impart a yeasty or alcoholic smell or taste. Although few samples contained many yeasts when tested at purchase (see Table), 18 of the 28 samples contained a considerable number after storage at 40 F to the code date. No samples, however, appeared unpalatable after storage. Mold contamination was found in only two samples after storage: samples 23 and 27 contained 1,600 and 3,500 per ml respectively.

Conclusions

The effective vitamin C contents of orange juice made from concentrate and sold refrigerated in retail stores decreased at an average rate of about 2% per day during an average period of 16.5 days when stored unopened at 40 F. There was no significant accumulation of dehydroascorbic acid as the ascorbic acid decomposed, and the loss of total vitamin C activity was due predominantly to the decrease in ascorbic acid content. The reconstitution of the orange juice from concentrate was found to be reasonably accurate. Undeclared sugars, acids, or preservatives were not found. Bacterial contamination was found in only a few samples, but yeast growth was considerable in most of the samples after storage.

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