THE EFFECT OF REFRIGERATOR STORAGE UPON THE PALATABILITY AND ASCORBIC ACID RETENTION OF FRESH AND FROZEN ORANGE JUICE CONCENTRATE

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1952

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1957

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INTRODUCTION

Many homemakers believe that ascorbic acid in citrus fruits is an extremely unstable vitamin and that there is little ascorbic acid in fresh or reconstituted frozen juice that has been stored in a home refrigerator. Although the preparation for the serving of frozen orange concentrate is not as time-consuming as the preparation of fresh orange juice, it would be convenient and time-saving to prepare a quantity of either type of orange juice sufficient for several days. This applies not only to the home, but also to institution food services such as those in schools, hospitals and restaurants. In addition, if the homemaker purchased the frozen concentrate in the large size can the cost of ascorbic acid in the diet might be reduced. Therefore, it was considered worthwhile to determine the palatability and the ascorbic acid retention of reconstituted frozen orange juice and fresh orange juice during refrigerator storage.

Specifically, the present study was undertaken to: (1) determine the palatability and ascorbic acid content of fresh orange juice and of two brands of reconstituted frozen orange juice stored in a home refrigerator for 0, 24, 48, and 72 hours; and (2) the average cost of a serving of each of these orange juices during a given season of the year.

REVIEW OF LITERATURE

Factors Influencing the Ascorbic Acid Content of Orange Juice

A survey made by the United States Department of Agriculture (1956) indicated that the present per capita consumption of reconstituted frozen orange juice averaged six quarts per year. With the increasing popularity of frozen concentrated citrus juices, consumers are interested in the ascorbic acid content of the juice.

Several studies have been made concerning the factors that influence the vitamin C content of fresh oranges, and which in turn has a bearing on the nutritive value of the frozen concentrated juice. Harding et al. (1940) reported that the highest amounts of ascorbic acid are usually found in immature oranges. As the fruit ripens the quantity of ascorbic acid gradually decreases and the lowest values often are found late in the season, particularly in Valencia oranges. The Council on Foods and Nutrition (1951) also ascribed, in part, the variation in the ascorbic acid content of oranges to seasonal influences. They stated that, in general, fruit picked in midseason tends to be higher in vitamin C than the fruit picked early or late in the season.

Harding et al. (1940) also reported that oranges exposed to sunlight had significantly higher ascorbic acid values than shaded ones. The difference in the ascorbic acid content of exposed fruit and that of shaded fruit ranged from 14.3 to 47.8 percent. Nevertheless, the early and midseason varieties of

oranges had as high an ascorbic acid content as Valencia oranges, which have a much longer growing season, and therefore are exposed to sunlight for a correspondingly longer time. Valencias require from 12 to 16 months from bloom to harvest as compared with seven to 12 months for the earlier varieties. Burrell and Ebright (1940) studied the vitamin C content of fruits and vegetables. They gave the vitamin C content of Florida Valencia oranges as 0.360 milligrams of ascorbic acid per gram of fresh fruit as compared to 0.480 milligrams per gram for the Navel orange.

According to Harding et al. (1940) rootstocks have some influence on the ascorbic acid content of the fruit. Fruit from sour-orange rootstock had a consistently higher ascorbic acid content than fruit from rough-lemon rootstock. They found no significant differences in the ascorbic acid content of oranges that could be attributed to differences in the soil.

Factors which affect the amount of ascorbic acid in fresh or processed juice were listed by Roy and Russell (1948). They included variety, rootstock, growing conditions, the nature of the commercial processes, and the conditions and length of storage before analysis. In their study it was shown that the ascorbic acid content of reconstituted frozen concentrates varied directly with that of the fresh oranges which were processed from December to June.

Factors Affecting the Flavor of Orange Juice

It was pointed out by Harding et al. (1940) that the flavor

of orange juice is influenced by several factors such as the presence of aromatic constituents, the acidity, the concentration of sugar, the proportion of acid to sugar, and the presence of peel oil. They stated that the age of the fruit also influences flavor. Immature oranges usually are very acid, with a raw, immature taste; whereas overmature fruit held on the tree, stored under refrigerator conditions for long periods, or held at high temperatures usually develops stale, aged, or disagreeable "off" flavors. Harding et al. (1940) found that there was a disagreeable flavor in orange juice which resulted from the peel oil. Thus, the oranges that they used in flavor tests were carefully squeezed by hand to prevent the flavor from being affected by oil from the peel.

Charles and Van Duyne (1952) reported that freshly prepared juices from California and Florida oranges were scored between excellent and good in flavor and that the frozen concentrate juices were scored slightly above to slightly below good. The Council on Foods and Nutrition (1951) stated that color of frozen concentrates varied appreciably from batch to batch, but this had no effect upon the flavor or vitamin C content.

Palatability and Ascorbic Acid Retention During Refrigerator Storage of Orange Juice

Results of experiments reported in the literature indicate that ascorbic acid as it exists naturally in citrus fruit juices may be stable for several days at refrigerator temperatures. Moore et al. (1945) conducted a study using Florida oranges.

These investigators reported that after three days in a cold room (40° F.) both covered and uncovered fresh juices were considered good in flavor and retained 98 percent of the original ascorbic acid. After a week in the cold room the juices had retained 96 percent of the ascorbic acid and the flavor was still considered good.

Huggart et al. (1954) reported 94 percent retention of ascorbic acid in reconstituted citrus juices after storage for two days at 50° F. in a household electric refrigerator. When analyses were extended beyond the two-day period, there was a high retention of ascorbic acid, but the juices had begun to ferment. These authors concluded that reconstituted citrus juices do not undergo appreciable ascorbic acid losses up to the time the juices ferment or otherwise become unpalatable and that the length of storage is limited more by loss of palatability than by loss of ascorbic acid.

Another factor which might influence the retention of ascorbic acid includes the type of water used to reconstitute the concentrate, such as distilled or tap water. According to Miller and Marsteller (1952) some oxidizing agent might be present in tap water which is capable of causing oxidation of ascorbic acid. Their work showed that when distilled water was employed for reconstituting the concentrate a higher percentage of ascorbic acid was retained during refrigerator storage than when tap water was used.

Cost Per Serving of Orange Juice

In the study completed by Charles and Van Duyne (1952) at Urbana, Illinois the composition and cost of orange juice was compared at monthly intervals throughout a year. They reported that the mean cost of a 100-milliliter (3.5 ounces) serving of fresh California orange juice was 7.8 cents, whereas a serving of fresh Florida orange juice was the same as that of canned orange juice or 4.4 cents for 100 milliliters. The mean cost of a serving of frozen orange juice was 3.8 cents, which was lower than that of either the fresh or canned juices. Comparative costs were affected to some extent by the place where the juices were purchased as well as by the size of the container.

Requirement of Ascorbic Acid

The daily dietary allowance of ascorbic acid as recommended by the Food and Nutrition Board, National Research Council (1953) is as follows:

Group	Milligrams	Group	Milligrams
Children		Men	75
1-3 years	35	Women	70
4-6	50	Pregnancy	110
7-9	60	Lactation	150
Boys		Infants	30
10-12	75	Girls	
13-15	90	10-12 years	75
16-20	100	13-20	80

Harris (1953) stated there is no universal agreement about the amount of vitamin C required for maintaining health. It has been established that as small a quantity of ascorbic acid as ten

milligrams a day is sufficient to prevent scurvy and that there is a wide gap between the minimum and the optimum requirements, i.e. the amount needed to promote good health.

van Eekelen (1953) stated that it is difficult to give a specific value for the amount of ascorbic acid in a given foodstuff because many factors determine this value. For example, the amount of ascorbic acid in different parts of the plant or fruit may vary considerably. It has been shown that orange peel contains from three to six times more ascorbic acid per gram than the juice.

Properties of Ascorbic Acid

It was pointed out by King (1953) that ascorbic acid is closely related to the hexoses, and that the reactions by which this vitamin is formed in plants and animals have not been established in detail. However, it is clear that in animals there is a direct conversion from glucose to ascorbic acid.

Jackel et al. (1950) have shown that Carbon^{14} d-glucose, labelled uniformly in all positions, and given to rats by subcutaneous injection, caused the excretion in the urine of l-ascorbic acid, which also was labelled uniformly in all positions. Harowitz and King (1953) reported that in the rat, d-glucose, labelled with Carbon^{14} at position one, produced l-ascorbic acid labelled mainly at position six. The similarity of radioactive l-ascorbic acid in the urine gave further support to the view that the sixth carbon of glucose entered into ascorbic acid via the same

molecular pathway that was followed by carbon one. Thus, evidence was furnished for direct conversion of d-glucose to l-ascorbic acid in rats.

Ray (1934) reported on the synthesis of vitamin C during germination of pea seeds. He found that in plants there was an overall conversion of sugars (d-glucose, d-fructose and d-mannose) into l-ascorbic acid in cotyledonless pea seedlings. In a similar study Isherwood (1953) postulated that a compound such as glucose was developed as an intermediate to germinating cress seedlings. The increase in the amount of l-ascorbic acid that was present in the treated seedlings as compared to those grown in water indicated that the compound used could act as a precursor to ascorbic acid. Either indirect conversion or direct conversion of glucose to ascorbic acid resulted.

Fenton (1940) stated that ascorbic acid is the most easily destroyed of all the vitamins, and that it dissolves in water more readily than any vitamin or mineral. She also pointed out that the destruction of ascorbic acid is catalyzed by copper and that an ascorbic acid-oxidizing enzyme is found in nearly all fruits and vegetables. A sufficiently low pH decreases the activity of the oxidizing enzyme, therefore Loeffler and Ponting (1942) recommended that for analysis of ascorbic acid in fruits and vegetables an acid medium be used for the extraction process.

Fenton (1940) further reported that ascorbic acid is present in the reduced form in growing plants but is readily oxidized to dehydroascorbic acid and then to biologically inactive products.

Rosenberg (1951) stated that ascorbic acid occurs predominantly in nature in the free, or reduced form. Both authors attributed the biological activity of ascorbic acid to the reduced and dehydro-forms.

Methods of Determining Ascorbic Acid

Quantitative determinations of the vitamin C content of foods could not be done until after 1932 when this vitamin was isolated in the crystalline state. Loeffler and Ponting (1942) devised a chemical means for analysis of ascorbic acid that is adaptable to many varieties of fruits and vegetables, either fresh, frozen, or dehydrated. In their method, ascorbic acid is extracted in the presence of a strong acid to inhibit enzymic and autoxidation. The ascorbic acid extract is then reacted with 2, 6-dichlorophenolindophenol dye, and the decolorizing effect of the extract on this dye is measured in a photoelectric colorimeter. A large proportion of one percent metaphosphoric acid yields a pH sufficiently low to prevent loss of ascorbic acid during blending of the vegetable or fruit tissue, and yet a sufficiently high pH to prevent the fading of color during the reaction with the dye. The advantages of this method include non-interference caused by pigment or moderate turbidities and negligible loss of ascorbic acid in the preliminary blending of the sample in acid.

In determining the vitamin C content of foods it must be remembered that besides ascorbic acid the reversibly oxidized form of the vitamin, dehydroascorbic acid, may be present. This

biologically active but nontitratable substance may already occur in the food or may be formed during analysis. In fresh vegetables and fruits almost no dehydroascorbic acid occurs. It may, however, arise during extraction, when the process is unduly prolonged, especially if oxidases are present, van Eekelen (1953) stated.

Noble and Hanig (1948) compared the indophenol method, which measures the reduced form of ascorbic acid, with the phenylhydrazine method which measures both the oxidized and reduced forms. They found that the average amount of dehydroascorbic acid present in raw and cooked vegetables was ten percent or less of the total ascorbic acid present.

Hewston et al. (1951) stated that bioassay is the only specific method for measuring vitamin C in the presence of interfering reducing substances. These authors were of the opinion that no existing chemical procedure is entirely adequate for this purpose. However, they concluded that the indophenol method is justified as a routine procedure in the analysis of fruits and vegetables for biologically active ascorbic acid.

PROCEDURE

Preliminary Studies

No previous studies on orange juice had been done in this laboratory. Hence, preliminary work was necessary to become acquainted with the problems involved in performing palatability and ascorbic acid tests on this product and to standardize the

methods to be used in the main experiment. Five brands of frozen orange juice concentrate were tested for palatability and ascorbic acid content shortly after reconstituting and after 24, 48, and 72 hours of storage in a home refrigerator. Similar plastic refrigerator containers with tight lids were used for storage.

Two brands of concentrate were tested at one period and each brand was reconstituted with both distilled and tap water. This provided four samples for the palatability committee to judge at one time. The scores for the orange juice tested in the preliminary work indicated that the judges had no preference for juice reconstituted with either distilled or tap water.

The ascorbic acid values for orange juice reconstituted with distilled and with tap water agreed with the data cited in the literature. Orange concentrate mixed with distilled water had consistently higher ascorbic acid values (approximately 1.5 to 2.0 mg/100 g) than that mixed with tap water. Even though the homemaker would use tap water for the reconstitution of frozen concentrates, it was considered advisable to use distilled water for the proper operation of the Klett-Summerson photo-electric colorimeter and for uniformity of results.

During the preliminary period it was noted that the palatability committee rated the orange juice of less intense color lower than that with a more intense color. Because of these data, it was decided to add small amounts of food coloring when necessary to give the samples a uniform color.

The Main Experiment

Two brands of frozen orange concentrate were chosen from those tested during the preliminary work. One brand selected was a nationally advertised brand in the medium price range. The other brand of frozen orange concentrate was offered for sale by a large chain store and it was one of the least expensive brands on the market. California Navel oranges and California Valencia oranges were selected as the source of fresh juice. The former variety was available for the greater part of the experiment (nine weeks). The California Valencia oranges were used for a three-week period at the end of the experiment.

The fresh juice oranges were purchased at a local market each week, whereas a case of each brand of frozen concentrate was purchased at the beginning of the experiment. Two cans of each brand of concentrate were made up at the beginning of every week for 12 weeks. Each can contained six fluid ounces and was reconstituted with 18 ounces of cold distilled water. One can of concentrate and the water was adequately mixed at a time, then the two cans of reconstituted juice were mixed together. An equal amount of juice was extracted from fresh oranges by means of an aluminum fruit juicer. This provided a sufficient amount of each sample for palatability tests and ascorbic acid determinations within two to four hours after mixing, and after 24, 48, and 72 hours of storage in a home refrigerator (34° F.).

The fresh orange juice obtained for this experiment was always brighter in color than the reconstituted juices. Therefore,

a small amount of yellow food coloring was added to the reconstituted juices to provide a uniform color in all samples.

Four samples of orange juice, approximately 40 milliliters each, were presented to a palatability committee at each testing period. Two samples of reconstituted juice, Brands A and B, and one sample of fresh orange juice, C, were presented along with a fourth sample which was a duplicate of either the fresh orange juice or one of the reconstituted frozen concentrates. The randomized block design given in Table 1 is the pattern that was followed in presenting the samples to the palatability committee.

Table 1. Design used to present the orange juice to the palatability committee.

Week	Sample numbers on the score card.			
	1	2	3	4
1	B	B	A	C
2	C	A	C	B
3	A	C	A	B
4	C	B	A	A
5	C	B	A	B
6	B	C	C	A
7	C	B	A	C
8	B	A	C	A
9	B	A	B	C
10	A	A	B	C
11	C	B	A	C
12	A	B	C	B

A - Nationally advertised brand of frozen orange juice concentrate.
B - Chain store brand of frozen orange juice concentrate.
C - Fresh juice.

The orange juice was served in clear juice glasses, and it was scored on Form I (Appendix).

Determination of Ascorbic Acid

A modification of the method developed by Loeffler and Ponting (1942) was used to obtain values for the ascorbic acid content of the orange juice. The changes from their method that were made for the present study were: (1) an increase in the size of the sample from 25 or 50 grams to 100 grams, (2) the addition of five milliliters of diluted filtrate to five milliliters of dye instead of adding nine milliliters of dye to one milliliter of filtrate, (3) the use of sodium 2, 6-dichlorobenzenone indophenol rather than 2, 6-dichlorophenolindophenol, and (4) the substitution of a Klett-Summerson photoelectric colorimeter for the Evelyn photoelectric colorimeter.

All of the aliquots of the juice tested for ascorbic acid were weighed and then measured in a graduated cylinder to determine the number of milliliters in 100 grams of orange juice. A 100-gram portion of orange juice was placed in a Waring blendor jar and a few drops of butyl stearate were added to prevent foaming during blending. A solution of one percent metaphosphoric acid was added until the jar was one-fourth to one-third full and the sample was blended for one minute. The blended material was then rinsed with the metaphosphoric acid solution into a 1000-milliliter volumetric flask, made up to volume with one percent metaphosphoric acid, and mixed by inverting ten times.

A clear filtrate for analysis was obtained by filtering the blended sample through fluted filter paper, (#1 Whatman), into a 125-milliliter Erlemeyer flask. The clear filtrate was analyzed

using the procedure described for standardizing the dye, sodium 2, 6-dichlorobenzenone indophenol, (Appendix). Unless the dye had been prepared the same day, the reading the dye gave in the colorimeter was checked by running a blank reading before starting the ascorbic acid analysis. If the blank reading for the current day did not coincide with the one obtained the previous day, the dye was restandardized.

Correction for turbidity was accomplished by mixing five milliliters of the diluted filtrate with five milliliters of distilled water and adjusting the colorimeter to zero. Dilution of the filtrate was necessary to bring the colorimeter readings within the range observed when standardizing the dye. The milligrams of ascorbic acid present in 100 grams of the sample of orange juice were calculated by the following formula:

$$\frac{\text{Ascorbic acid factor} \times \text{unknown reading} \times \text{dilution}}{5 \text{ milliliters}} = \text{milligrams of ascorbic acid per 100-gram sample}$$

Statistical Analyses

Analyses of variances were run on data for the following factors: color, aroma, flavor, degree of dispersion, general acceptability, milliliters of juice per 100 grams, ascorbic acid content and percent retention of ascorbic acid. The sources of variation and degrees of freedom were: blocks (weeks of the experiment), 11; juices, 2; storage, 3; juice x storage, 6; duplicates, 48; and remainder, 121. If there were interactions or significant differences among the juices, two-way tables of means were analyzed by least significant differences.

RESULTS AND DISCUSSION

Palatability Factors

The average of the mean palatability scores are presented in Table 2, and the detailed data are given in Tables 14 through 25 (Appendix). In general, with storage, the mean scores reflected a gradual deterioration in all the palatability factors. There were exceptions in the fresh orange juice; the average score for color was slightly higher at the end of 72 hours of storage than after 48 hours. Also, there was an increase between 0 and 24 hours in the average score for the dispersion of fresh orange juice followed by a decline to approximately the original figure.

During the first nine weeks of the experiment, Navel oranges were used to provide the fresh juice, and the last three weeks Valencia oranges were used. When the data for the unstored juice from Navel and from Valencia oranges were analyzed, there were no significant differences between the two varieties of juice in aroma, degree of dispersion, flavor, general acceptability, and percent retention of ascorbic acid. However, the juice from the Navel oranges had a significantly higher concentration of ascorbic acid than that from the Valencia oranges (Tables 30 through 33, Appendix), and the color scores for juice from Navel oranges were significantly higher than those for juice from Valencia oranges (Tables 22 through 25, Appendix). Regardless of these differences, the data for all factors from the two varieties of oranges were pooled for statistical analyses because Valencia oranges were used for only three weeks of the experiment.

Table 2. Average of mean palatability scores for fresh orange juice and two brands of reconstituted frozen orange juice. (Possible range, 7-1).

Juice	Refrigerator storage in hours	Palatability factors: Aroma	Color	Dispersion	Flavor	General acceptability
A	0	4.69	4.98	4.61	4.58	4.63
	24	4.41	4.96	4.48	4.32	4.55
	48	4.26	4.67	4.31	4.24	4.29
	72	4.05	4.70	4.14	3.95	4.08
B	0	4.62	4.94	5.07	4.73	4.77
	24	4.44	4.82	5.10	4.58	4.74
	48	4.21	4.62	5.05	4.57	4.72
	72	4.03	4.58	4.79	4.06	4.20
C	0	5.48	5.22	4.61	5.59	5.50
	24	5.16	4.96	4.96	4.74	4.89
	48	4.68	4.67	4.81	4.13	4.52
	72	4.46	4.75	4.64	3.44	3.92

A - Nationally advertised brand of frozen orange juice concentrate.
B - Chain store brand of frozen orange juice concentrate.
C - Fresh orange juice.

Flavor. The average of the mean flavor score, given in Table 3, was significantly ($P<.05$) higher for the fresh orange juice than scores for the reconstituted frozen juices before storage, but the average score for the fresh juice decreased more rapidly than those for the reconstituted juices. After 72 hours of refrigerator storage, the fresh juice was significantly ($P<.05$) poorer in flavor than the reconstituted juices, regardless of variety of orange. Brand B was the most resistant to change in flavor.

Three judges commented that the freshly extracted orange juice had an objectionable peel oil flavor, and after 24 hours

they remarked that it was bitter. Therefore, the highest possible score, seven, generally was not used for flavor.

Table 3. Least significant differences among the average of mean flavor scores.

Juice	Refrigerator Storage in Hours							
	0		24		48		72	
Fresh-C	5.59	*	4.74	*	4.13	*	3.44	
	*		near*		ns		*	
Brand-A	4.58	ns	4.32	ns	4.24	ns	3.95	*
	ns		ns		ns		ns	
Brand-B	4.73	ns	4.58	ns	4.57	*	4.06	

lsd. * = 0.48 ($P < .05$)
A = Nationally advertised brand of frozen orange juice concentrate.
B = Chain store brand of frozen orange juice concentrate.
C = Fresh orange juice.

Aroma. There was a consistent, but slight, decrease in the average aroma scores as the orange juice was stored (Table 2). The fresh orange juice was scored slightly higher in aroma than the frozen reconstituted juices at all storage periods, regardless of the variety of orange. The scores for fresh juice decreased 1.02 points during 72 hours of storage as compared to 0.64 and 0.59 of a point for Brands A and B, respectively (Table 2).

Least significant differences among the aroma and color scores (all storage periods combined) for the juices A, B, and C were calculated. Also, least significant differences in aroma

and color scores among storage periods were calculated by pooling the data for the three juices at each storage period, and are presented in Tables 4 and 5. The aroma score for fresh orange juice was significantly higher than that for either Brand A or B. (Table 4). When the aroma scores for all orange juice were combined there were significant decreases in these scores from every storage period to the next (Table 5).

Table 4. Least significant differences among the average of mean aroma and color scores for the three juices, (all storage periods combined).

Juice	Aroma	Color	
Fresh-C	4.94	4.90	
	*	ns	
Brand-A	4.35	4.83	*
	ns	ns	
Brand-B	4.32	4.74	

Aroma lsd.* - 0.13 ($P \leq .05$)
Color lsd.* - 0.11 ($P < .05$)

Table 5. Least significant differences among the average aroma and color scores for storage. (All three juices combined).

Storage periods	Aroma	Color
0	4.93	5.05
	*	*
24	4.67	4.91
	*	*
48	4.38	4.65
	*	ns
72	4.18	4.67

Aroma lsd. * - 0.15
Color lsd. * - 0.13

Color. A small amount of yellow food coloring was added to the reconstituted juices to attempt to provide a uniform color in all samples. Apparently this attempt was not completely successful. One judge, in sampling fresh Valencia orange juice, commented that the color was "too dark". Also when the color scores for each juice were calculated by pooling the data for all storage periods, Brand B averaged significantly lower than the fresh juice (Table 4).

Degree of Dispersion. The greater the degree to which the solids were dispersed in the solution, the higher the dispersion score. The average of mean scores presented in Table 2 point out that the judges made no real distinction in the degree of dispersion from one storage period to the next, regardless of the juice

A, B or C. Also, least significant differences (Table 6) indicated that the degree of dispersion did not change rapidly with refrigerator storage, but that the average dispersion score for Brand B decreased significantly ($P<.05$) between 48 and 72 hours. Moreover, at every storage period the average dispersion score was significantly ($P<.05$) better for Brand B than for Brand A or fresh juice (Table 6).

Table 6. Least significant differences among the average of mean dispersion scores.

Juice	Refrigerator Storage in Hours						
	0		24		48		72
Fresh-C	4.61	*	4.96	ns	4.81	ns	4.64
	ns		*		*		*
Brand-A	4.61	ns	4.48	ns	4.31	ns	4.14
	*		*		*		*
Brand-B	5.07	ns	5.10	ns	5.05	*	4.79

lsd. * - 0.21

General Acceptability. The palatability scores in Table 2 indicated that the judges gave aroma and flavor priority in determining general acceptability. The fresh juice was significantly ($P<.05$) more acceptable than the frozen reconstituted orange juice before storage, but lost this advantage after 24 hours of storage (Table 7). Brands A and B were probably about the same in general acceptability, but it appeared that Brand B held up a little longer under storage than Brand A.

The average of mean scores for general acceptability, as given in Table 7, declined gradually during storage for Brand A and for Brand B through 48 hours of storage, but for the fresh orange juice the decline was more pronounced. The average score for the general acceptability of the fresh juice decreased significantly ($P < .05$) after every storage period, regardless of the type of orange.

Table 7. Least significant differences among the average of mean general acceptability scores.

Juice	Refrigerator Storage in Hours						
	0	:	24	:	48	:	72
Fresh-C	5.50	*	4.89	*	4.52	*	3.92
	*		near*		ns		ns
Brand-A	4.63	ns	4.55	ns	4.29	ns	4.08
	ns		near*		*		ns
Brand-B	4.77	ns	4.74	ns	4.72	*	4.20

lsd. * = 0.37

Ascorbic Acid Determinations

Ascorbic Acid Content. Fresh orange juice had more ascorbic acid than either brand of frozen reconstituted orange juice (Table 8). The juice from the Navel oranges had a significantly higher concentration of ascorbic acid than that from the Valencia oranges. Brand B had more ascorbic acid than Brand A (Table 9). On a percentage basis, the fresh juice had about six percent more

ascorbic acid than Brand B and 17 percent more than Brand A. Average of mean values for the ascorbic acid content of the three juices showed that there was a decline in the ascorbic acid as storage time progressed (Tables 8 and 10).

Table 8. Average of mean ascorbic acid content, percent retention of ascorbic acid and the number of milliliters per hundred grams in orange juice.

Juice	Refrigerator storage in hours	Ascorbic acid mg/100 g.	Percent retention	Orange juice ml/100 g.
A	0	48.55	-----	96.4
	24	47.43	97.75	96.3
	48	45.99	95.75	96.5
	72	44.58	91.90	96.2
B	0	52.74	-----	96.3
	24	51.86	98.37	95.9
	48	50.92	96.89	96.3
	72	50.60	96.07	96.1
C	0	56.20	-----	95.3
	24	55.19	98.27	95.3
	48	54.10	96.81	95.6
	72	52.98	94.50	95.3

A - Nationally advertised brand of frozen orange juice concentrate.
B - Chain store brand of frozen orange juice concentrate.
C - Fresh orange juice.

Table 9. Least significant differences among the average of mean values for the ascorbic acid content of each juice. (All storage periods combined).

Juice	Mg./100 grams
Fresh-C	54.62
	*
Brand-B	51.54
	*
Brand-A	46.64

lsd. * - 0.98

Percent Retention of Ascorbic Acid. During storage there was a slight decline in the percent retention of the ascorbic acid in all juices (Tables 10 and 11). In terms of absolute (rather than percentage) decrease, storage beyond 24 hours significantly ($P < .05$) reduced the ascorbic acid concentration approximately an equal amount in all juices (Table 11). Brand B had the highest percentage ascorbic acid retention after 72 hours of storage.

Table 10. Least significant differences among the average of mean values for the ascorbic acid content during storage. (All three juices combined).

Storage Periods	:	Mg./100 grams
0		52.50
		ns
24		51.49
		*
48		50.33
		ns
72		49.40

lsd. * - 1.13

Table 11. Least significant differences among the average of mean values for the percent retention of ascorbic acid in orange juice.

Juice	Refrigerator Storage in Hours				
	24	:	48	:	72
Fresh-C	98.27	*	96.81	*	94.50
	ns		ns		*
Brand-A	97.75	*	95.75	*	91.90
	ns		ns		*
Brand-B	98.37	ns	96.89	ns	96.07
			*		

lsd. * = 1.59

Milliliters Per 100 Grams of Orange Juice

The ascorbic acid analyses were carried out on 100-gram samples of juice. However, it was considered worth while to determine the volume of 100 grams of each of the juices studied, because of the interest in the cost per serving. The 100-gram samples were weighed, and then measured in milliliters. From the data in Table 12, it may be noted that each orange juice varied only slightly from the others as to the number of milliliters per 100 grams of juice. However, as shown in Table 12, the mean value for the volume per 100 grams of fresh orange juice (95.39 ml./100 g.) and the average value for Brand B was significantly ($P < .05$) lower than that for Brand A (96.33 ml./100 g.).

Table 12. Least significant differences of mean values for milliliters per 100 grams of orange juice.

Juice :	Mean values-milliliters/100 gram
Brand-A	96.33
	*
Brand-B	96.14
	*
Fresh-C	95.39

lsd. * - 0.18

Duplicate Samples

Analyses of variance in which duplicate samples was one source of variation were run on the data for the following factors: color, aroma, flavor, degree of dispersion, general acceptability, milliliters of juice per 100 grams, ascorbic acid content and percent retention of ascorbic acid. These analyses showed that there were no significant differences between duplicate samples of orange juice for any of the factors tested. This indicated that the palatability panel was consistent in the scoring of duplicate samples, and that the techniques for measuring the volume of 100 grams of orange juice and for determining the ascorbic acid content were precise.

Cost of the Orange Juice

Six cups of fresh Navel orange juice cost, on the average, $1.31 as compared to $1.51 for six cups of Valencia orange juice.

Brand A, the nationally advertised brand of frozen orange juice concentrate, cost $0.33 for six cups of reconstituted juice as compared to $0.28 for a like amount of Brand B, the chain store brand. As a general rule, 100 grams of fresh orange juice contained more ascorbic acid than the reconstituted frozen orange juice. However, there were instances when the reconstituted juice provided more ascorbic acid than the fresh. This was particularly true with the last lot of fresh Navel orange juice. This agrees with the data of Harding et al. (1940) who found that the ascorbic acid content of orange juice at the end of the growing season was low.

With the juices used in this study the homemaker could provide the daily requirement of ascorbic acid (70 mg.) recommended for adults by serving approximately one-half cup of juice at a cost ranging from 2.5 to 15 cents.

Table 13. Cost per serving of orange juice.

Juice	Amount*	Cost
Fresh Valencia	145 ml. or 9.4 T	$0.15
Fresh Navel	119 ml. or 7.6 T	0.10
Brand A	144 ml. or 9.4 T	0.03
Brand B	133 ml. or 8.6 T	0.025

* Determined using values for no refrigerator storage.

These data agree with those of Charles and Van Duyne (1952) who reported that California orange juice was a less economical source of ascorbic acid than the reconstituted frozen concentrate.

SUMMARY

The purposes of this study were: (1) to determine the palatability and ascorbic acid content of fresh orange juice and of two brands of reconstituted frozen orange juice stored in a home refrigerator at 34° F. for 0, 24, 48, and 72 hours; and (2) to determine the average cost of a serving of these three types of orange juice during a given season.

California Navel oranges, available for nine weeks, and California Valencia oranges, available for three weeks, were the source of the fresh juice (C). In addition, a nationally advertised brand (A) of frozen orange concentrate in the medium price range, and a frozen orange concentrate sold by a large chain store (B), which was one of the least expensive on the market, were used in this study.

The fresh orange juice, reconstituted juice prepared from each of the frozen concentrates, and a duplicate of one of these three were presented to a taste panel and analyzed for ascorbic acid content at each testing period. The panel scored the samples for aroma, flavor, color, degree of dispersion, and general acceptability. The method used for the ascorbic acid analyses was a modification of that given by Loeffler and Ponting (1942).

In general, with storage, the mean scores for all three juices reflected a gradual deterioration in all the palatability factors. The general acceptability of the fresh juice was significantly higher than that of the frozen reconstituted orange juice before storage, but the fresh juice lost this advantage

after 24 hours of storage. It appeared that Brand B held up a little longer under storage than Brand A. Also, the flavor of fresh juice, regardless of the type of orange, was significantly higher before storage than that of the reconstituted frozen juices. However, the average flavor score for the fresh juice decreased more rapidly than that for the reconstituted juices, and after 72 hours of storage it was significantly poorer in flavor.

Fresh orange juice contained slightly more ascorbic acid than either brand of the frozen reconstituted juice. The Navel oranges had a significantly higher concentration of ascorbic acid than the Valencia oranges, and of the reconstituted frozen juices, Brand B had more ascorbic acid than Brand A. There was a decline in the ascorbic acid content as storage time progressed. During 72 hours of refrigerator storage Brand B had the highest percent (96.07) retention of ascorbic acid, whereas Brand A lost the most ascorbic acid (91.90 percent retention). The fresh juice averaged 94.50 percent retention of ascorbic acid.

In this study the cost of 70 milligrams of ascorbic acid (the recommended daily allowance for adults) averaged 15, 10, 3, and 2.5 cents for California Valencia, Navel, Brand A reconstituted and Brand B reconstituted juices, respectively. Approximately one-half cup of each type of orange juice furnished 70 milligrams of ascorbic acid.

ACKNOWLEDGMENT

The author wishes to express her appreciation to Dr. Dorothy L. Harrison, Head of the Department of Foods and Nutrition, for her guidance and aid in the preparation of the manuscript; to Dr. H. C. Fryer, Professor of Mathematics, in charge of the Statistical Laboratory, for the statistical analysis of the data; and to the members of the tasting panel of the Department of Foods and Nutrition for their evaluations.

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APPENDIX

SCORE CARD

ORANGE JUICE

Date_____

Sample No._____

_____

Name_____

			1	2	3	4
1. Aroma	Use the following numbers as a guide					
2. Color	Superior	7				
	Moderately Sup.	6				
	Slightly Sup.	5				
	Standard	4				
	Sl. inferior	3				
	Moderately inf.	2				
	Inferior	1				
3. Degree of dispersion (solids are well distributed or precipitated out)						
4. Flavor						
5. General acceptability						

Comments:

Preparation of Solutions

Metaphosphoric acid. A ten percent solution of metaphosphoric acid was prepared fresh on the day it was used. One hundred grams of metaphosphoric acid pellets were weighed and dissolved in distilled water. This solution was made up to volume in a 1000-milliliter volumetric flask and mixed by inverting 15 times. The resulting ten percent solution of metaphosphoric acid was used to prepare a fresh solution of one percent metaphosphoric acid, which was used to protect the ascorbic acid during the extraction and analysis procedure. The one percent acid solution was prepared by mixing 900 milliliters of distilled water with 100 milliliters of ten percent metaphosphoric acid in a 1000-milliliter stoppered graduated cylinder.

Dye. The solution referred to as dye was an aqueous solution of sodium 2, 6-dichlorobenzenone indophenol dye. It was prepared by weighing out approximately ten milligrams of dye on a chainomatic balance. The dye was brushed into a funnel containing #1 Whatman filter paper. Hot distilled water was poured over the dye, and the solution filtered into a 500-milliliter volumetric flask. When all of the dye was dissolved in the hot water, the solution was cooled to room temperature and made up to volume with distilled water.

Ascorbic acid. A standard solution of ascorbic acid was prepared to use in standardizing the freshly prepared dye. Exactly 25 milligrams of ascorbic acid (Cebione-Merck) were weighed, then brushed into a 250-milliliter flask containing a

small amount of freshly prepared one percent metaphosphoric acid. The flask was then made up to volume with one percent metaphosphoric acid and mixed by inverting ten times. Portions of three, four, and five milliliters were pipetted into 100-milliliter volumetric flasks, made up to volume, and used to standardize the dye. The three dilutions represented concentrations of three, four, and five milligrams respectively, per 100 milliliters of solution.

Standardization of the Dye

Five milliliter portions of dye were pipetted into matched test tubes. One five milliliter portion of distilled water was also pipetted into a similar test tube. The Klett-Summerson photoelectric colorimeter was used for standardizing the dye as well as for the ascorbic acid analysis. The first adjustment necessary before beginning the actual reading was made by placing the test tube containing the water in the colorimeter, and adjusting the colorimeter to zero. This procedure corrected for the turbidity of the water and the test tube.

Next, the blank reading was obtained. This was done by quickly injecting five milliliters of one percent metaphosphoric acid into a test tube containing dye. The contents of the tube were quickly inverted and shaken, and a reading was taken within 15 seconds. This procedure was continued until two identical readings had been obtained from duplicate samples of acid. Those readings represented the blank reading. Duplicate readings were

obtained for each of the three dilutions of ascorbic acid in the same manner, except that five milliliter portions of the ascorbic acid dilution were used instead of the one percent metaphosphoric acid. The purpose of using three dilutions was to establish the range in which the dye was most sensitive to the ascorbic acid. The detailed reaction of the ascorbic acid was explained by Huguenard (1953).

The two constants obtained from standardization of the dye that were necessary for further calculations in connection with the ascorbic acid analysis included the blank reading and the ascorbic acid factor. The blank reading was obtained directly from the colorimeter. The ascorbic acid factor was obtained from an average of calculations using duplicate readings from the three dilutions of the ascorbic acid solution, as follows:

$$\text{ascorbic acid factor} = \frac{\text{concentration of ascorbic acid in dilution}}{\text{blank reading minus ascorbic acid reading}}$$

Table 14. Mean palatability scores for brand A[1] - frozen orange juice concentrate, zero storage.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.80	5.20	3.80	4.20	4.00
2	4.67	5.17	4.50	3.83	3.83
3	5.00	4.85	4.57	4.43	4.57
3 Dup.	4.57	4.85	5.00	4.43	4.71
4	4.80	4.50	4.30	4.80	4.75
4 Dup.	4.80	4.50	4.20	5.00	4.60
5	4.83	5.16	5.00	5.00	5.16
6	4.83	5.17	5.17	4.83	4.83
7	5.00	5.67	4.67	4.50	4.57
8	4.50	5.33	4.50	4.50	4.58
8 Dup.	4.00	5.50	4.50	4.33	4.33
9	4.50	5.00	4.83	4.17	4.50
10	5.00	5.00	5.00	4.40	4.90
10 Dup.	4.80	5.00	4.60	5.20	5.20
11	4.20	4.60	4.40	4.60	4.40
12	4.75	4.25	4.75	5.00	5.12
Av.	4.69	4.98	4.61	4.58	4.63

[1]Nationally advertised brand - medium priced.
Dup. - duplicate sample.

Table 15. Mean palatability scores for brand A[1] - frozen orange juice concentrate, 24 hours refrigerator storage.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.34	5.34	3.50	4.00	4.17
2	4.80	5.00	4.00	4.40	4.40
3	4.33	5.16	4.50	4.25	4.50
3 Dup.	4.42	4.67	4.50	4.50	4.75
4	4.40	4.40	4.80	4.60	5.20
4 Dup.	4.40	4.60	4.60	4.60	5.20
5	4.83	5.16	5.00	5.00	5.16
6	4.80	5.00	4.40	4.20	4.60
7	4.29	5.43	4.29	4.57	4.43
8	4.00	5.62	4.75	3.75	4.00
8 Dup.	4.50	5.62	4.50	4.00	4.75
9	4.28	5.14	4.71	4.50	4.50
10	4.33	4.58	4.33	4.25	4.25
10 Dup.	4.33	4.58	4.50	4.08	4.08
11	4.00	4.50	4.33	3.83	4.00
12	4.50	4.50	5.00	4.50	4.88
Av.	4.41	4.96	4.48	4.32	4.55

[1]Nationally advertised brand - medium priced.
Dup. - duplicate sample.

Table 16. Average palatability scores for brand A[1] - frozen orange juice concentrate, 48 hours refrigerator storage.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.24	4.83	4.16	4.34	4.24
2	4.00	4.34	3.67	5.00	4.67
3	4.50	5.00	4.50	4.50	4.67
3 Dup.	4.33	4.33	4.33	4.17	4.25
4	4.43	4.30	4.57	4.57	4.40
4 Dup.	4.30	4.30	4.57	4.10	4.10
5	4.80	5.00	5.20	4.80	5.00
6	4.33	4.83	4.33	3.90	4.17
7	4.20	5.50	4.00	4.20	4.30
8	4.75	5.00	4.87	4.25	4.57
8 Dup.	4.00	5.25	4.37	4.00	4.25
9	3.80	4.80	4.20	4.00	3.80
10	3.80	4.00	3.80	3.80	3.60
10 Dup.	4.00	4.40	4.00	3.80	3.80
11	3.80	4.40	3.80	3.80	3.90
12	4.80	4.40	4.60	4.60	4.80
Av.	4.26	4.67	4.31	4.24	4.29

[1]Nationally advertised brand - medium priced.
Dup. - duplicate sample.

Table 17. Average palatability scores for brand A[1] - frozen orange juice concentrate, 72 hours refrigerator storage.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.16	5.00	3.83	4.25	4.34
2	4.00	5.00	3.67	5.00	5.00
3	4.34	4.83	4.00	3.50	4.16
3 Dup.	3.83	4.50	4.00	3.66	3.93
4	4.33	4.50	4.00	4.33	4.17
4 Dup.	4.50	4.50	4.17	4.50	4.17
5	4.50	4.83	4.33	4.67	4.67
6	4.33	5.00	4.17	3.75	4.10
7	3.60	4.80	4.40	3.90	4.30
8	3.80	4.60	4.40	3.80	3.80
8 Dup.	3.80	5.00	4.20	3.60	3.70
9	3.91	5.00	4.33	3.83	4.16
10	3.67	4.50	4.33	3.17	3.50
10 Dup.	3.83	4.50	4.33	3.67	3.91
11	4.00	4.33	4.33	3.50	3.50
12	4.25	4.25	3.75	4.00	3.88
Av.	4.05	4.70	4.14	3.95	4.08

[1]Nationally advertised brand - medium priced.
Dup. - duplicate sample

Table 18. Mean palatability scores for brand B[1] - frozen orange juice concentrate, zero storage.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.80	5.20	4.40	4.60	4.60
1 Dup.	4.40	5.20	4.40	4.60	4.40
2	4.67	5.17	5.17	4.67	4.50
3	4.85	4.71	5.00	4.29	4.57
4	4.33	4.50	5.00	4.67	4.33
5	4.50	4.67	5.33	4.40	4.60
5 Dup.	5.00	5.33	5.33	5.33	5.33
6	4.83	5.67	5.67	5.50	5.50
7	4.33	5.67	5.67	5.16	5.16
8	5.00	5.67	5.00	5.00	5.17
9	4.83	5.00	5.00	4.67	4.67
9 Dup.	4.83	5.00	5.33	4.58	4.83
10	4.60	5.00	5.00	4.80	4.80
11	4.40	4.20	4.80	4.20	4.60
12	4.25	4.00	5.25	4.50	4.50
12 Dup.	4.25	4.00	4.75	4.75	4.75
Av.	4.62	4.94	5.07	4.73	4.77

[1]Chain store brand - low priced.
Dup. - duplicate sample.

Table 19. Mean palatability scores for brand B[1] - frozen orange juice concentrate, 24 hours storage period.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.67	5.17	4.67	4.67	4.67
1 Dup.	4.50	5.17	4.83	4.67	4.83
2	4.60	4.80	5.20	5.20	5.40
3	4.33	4.50	5.17	4.42	4.75
4	3.80	4.00	5.20	4.50	4.50
5	4.33	4.17	5.33	4.67	4.33
5 Dup.	4.50	5.17	5.33	5.00	4.75
6	5.20	5.80	5.20	5.40	5.30
7	4.14	5.43	4.86	4.14	4.57
8	5.25	5.75	4.75	4.25	4.87
9	4.43	5.14	5.28	4.57	4.64
9 Dup.	4.36	5.00	5.28	4.00	4.36
10	4.00	4.50	5.00	4.33	4.41
11	4.00	4.50	5.00	4.00	4.42
12	4.50	4.00	5.25	4.75	5.00
12 Dup.	4.50	4.00	5.25	4.75	5.00
Av.	4.44	4.82	5.10	4.58	4.74

[1]Chain store brand - low priced.
Dup. - duplicate sample

Table 20. Mean palatability scores for brand B[1] - frozen orange juice concentrate, 48 hours storage period.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.34	4.83	4.83	4.34	4.50
1 Dup.	4.50	4.83	5.00	4.83	4.83
2	4.00	4.67	4.34	4.67	5.00
3	4.17	4.33	5.00	4.90	4.90
4	4.00	4.10	4.80	4.00	4.30
5	4.00	4.40	5.80	4.80	5.00
5 Dup.	4.80	5.00	5.60	5.20	5.40
6	5.17	5.50	5.00	5.33	5.40
7	3.80	5.50	5.20	3.60	4.40
8	4.50	5.00	5.00	4.75	4.70
9	4.20	4.60	5.20	4.10	4.10
9 Dup.	4.00	4.60	5.20	4.40	4.30
10	3.60	4.20	4.60	4.10	4.10
11	3.80	4.20	5.00	3.80	4.10
12	4.20	4.00	5.00	5.62	5.62
12 Dup.	4.20	4.20	5.20	4.60	4.80
Av.	4.21	4.62	5.05	4.57	4.72

[1]Chain store brand - low priced.
Dup. - duplicate sample.

Table 21. Mean palatability scores for brand B[1] - frozen orange juice concentrate, 72 hours storage period.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	4.50	5.00	5.17	4.67	4.67
1 Dup.	4.67	5.00	4.83	4.83	4.83
2	4.00	4.67	4.34	4.67	5.00
3	3.67	4.33	4.33	3.83	4.16
4	4.17	4.00	5.00	3.83	4.60
5	3.83	4.17	4.83	4.00	4.00
5 Dup.	4.50	4.83	5.00	4.67	4.75
6	4.50	5.33	5.17	4.67	4.75
7	3.60	4.80	5.00	3.80	4.20
8	4.40	5.00	4.60	4.00	4.10
9	3.67	4.83	4.67	3.50	3.67
9 Dup.	3.83	5.00	4.67	3.67	4.00
10	4.00	4.50	4.83	3.83	4.16
11	3.83	4.33	4.50	3.50	3.58
12	3.75	3.75	4.75	3.75	3.50
12 Dup.	3.50	3.75	5.00	3.75	3.25
Av.	4.03	4.58	4.79	4.06	4.20

[1]Chain store brand - low priced.
Dup. - duplicate sample.

Table 22. Mean palatability scores for fresh orange juice, zero storage.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	5.40	5.40	4.00	5.40	5.20
2	5.34	5.00	4.00	4.67	4.67
2 Dup.	5.17	5.00	4.34	4.67	5.00
3	5.30	4.85	3.86	5.00	4.86
4	5.30	5.80	5.20	5.20	5.30
5	5.33	5.33	5.50	6.00	5.83
6	5.67	5.42	4.67	6.00	5.83
6 Dup.	5.83	5.42	4.83	6.17	5.91
7	5.67	5.67	5.00	5.83	5.91
7 Dup.	5.67	5.67	5.17	6.17	6.00
8	5.67	5.50	4.33	6.17	5.90
9	5.50	5.33	5.33	5.83	5.75
10	5.60	4.80	5.00	5.60	5.40
11	5.20	4.80	4.00	5.40	5.20
11 Dup.	5.60	4.80	4.00	5.80	5.60
12	5.50	4.75	4.50	5.50	5.62
Av.	5.48	5.22	4.61	5.59	5.50
Navel Av.	5.49	5.37 *	4.69	5.59	5.51
Valencia Av.	5.48	4.79	4.38	5.58	5.46

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - duplicate sample.
* ($P < .05$).

Table 23. Mean palatability scores for fresh orange juice, 24 hours storage in refrigerator.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	5.17	4.50	4.67	4.83	4.83
2	5.00	4.60	4.80	3.20	4.00
2 Dup.	5.00	4.20	4.60	2.80	3.40
3	4.83	4.67	4.67	2.92	3.83
4	4.40	5.40	5.00	4.10	4.20
5	5.33	5.33	5.50	6.00	5.83
6	5.20	5.20	4.80	4.80	4.90
6 Dup.	5.40	5.20	5.20	5.00	4.90
7	5.57	5.43	4.86	5.71	5.71
7 Dup.	5.29	5.29	5.00	5.71	5.64
8	5.75	5.50	5.00	5.37	5.62
9	5.14	5.21	5.28	5.71	5.43
10	4.67	4.67	4.83	4.50	4.58
11	5.17	4.67	4.83	5.17	5.08
11 Dup.	5.33	4.67	4.83	5.17	5.17
12	5.25	4.75	5.50	4.88	5.12
Av.	5.16	4.96	4.96	4.74	4.89
Navel Av.	5.17	5.04 *	4.95	4.68	4.86
Valencia Av.	5.11	4.69	5.00	4.93	4.99

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - duplicate sample.
* ($P < .05$).

Table 24. Mean palatability scores for fresh orange juice, 48 hours storage in refrigerator.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	5.34	4.25	3.83	4.50	4.67
2	4.00	4.00	4.34	3.00	4.00
2 Dup.	4.00	4.00	4.67	2.67	3.34
3	4.33	4.50	4.33	2.00	3.33
4	4.57	5.30	4.57	3.40	4.30
5	4.60	4.60	5.40	3.60	4.20
6	4.50	5.00	4.67	4.17	4.40
6 Dup.	4.67	5.00	5.17	4.67	4.75
7	5.00	5.20	5.40	5.00	5.40
7 Dup.	5.20	5.20	5.40	5.10	5.50
8	5.75	5.00	5.00	5.50	5.37
9	4.60	4.70	5.00	5.30	5.20
10	4.00	4.40	4.80	4.10	4.30
11	4.60	4.40	4.80	4.40	4.70
11 Dup.	4.90	4.60	4.60	4.60	4.60
12	4.80	4.60	5.00	4.00	4.20
Av.	4.68	4.67	4.81	4.13	4.52
Navel Av.	4.71	4.73	4.82	4.08	4.54
Valencia Av.	4.58	4.50*	4.80	4.28	4.45

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - duplicate sample.
* ($P < .05$).

Table 25. Mean palatability scores for fresh orange juice, 72 hours storage in refrigerator.

Week	Palatability factors				
	Aroma	Color	Dispersion	Flavor	General acceptability
1	5.16	4.67	4.34	3.50	3.83
2	4.67	4.34	4.67	2.34	3.67
2 Dup.	4.34	4.00	4.67	2.34	3.67
3	2.58	4.58	4.16	1.00	2.33
4	4.50	5.33	4.67	2.67	3.50
5	4.33	4.67	4.83	2.33	3.17
6	4.50	5.00	4.67	3.50	3.67
6 Dup.	4.67	5.00	4.67	3.83	4.10
7	4.80	5.00	4.80	5.20	5.30
7 Dup.	4.60	5.00	5.00	5.00	5.10
8	5.00	5.00	4.40	4.60	4.80
9	5.00	4.83	4.33	4.50	4.75
10	4.17	4.67	4.83	3.83	4.25
11	4.17	4.67	4.67	3.50	3.25
11 Dup.	4.83	4.67	4.83	3.67	4.10
12	4.00	4.50	4.75	3.25	3.25
Av.	4.46	4.75	4.64	3.44	3.92
Navel Av.	4.51	4.79 *	4.60	3.40	3.99
Valencia Av.	4.29	4.63	4.77	3.56	3.71

Weeks 1 through 9 - Navel oranges.
Weeks 9 through 12 - Valencia oranges.
Dup. - duplicate sample.
* ($P < .05$).

Table 26. Mean ascorbic acid content, and milliliters per 100 grams in brands A and B frozen orange juice concentrate, zero storage.

Week	Brand	Ascorbic Acid content	Milliliters orange juice = 100 grams
1	A	52.80	96
2		46.91	97
3		51.01	96
3 Dup.		49.16	96
4		48.19	96
4 Dup.		48.19	96
5		52.49	96
6		46.41	97
7		45.01	97
8		48.76	97
8 Dup.		48.76	97
9		50.96	96
10		48.16	96
10 Dup.		47.30	96
11		47.92	97
12		44.72	96
Av.		48.55	96.4
1	B	56.32	97
1 Dup.		55.15	97
2		54.84	97
3		51.94	96
4		50.87	96
5		57.92	97
5 Dup.		57.92	96
6		51.87	96
7		49.42	97
8		51.52	96
9		55.51	96
9 Dup.		54.60	95
10		49.88	96
11		51.47	97
12		48.16	96
12 Dup.		46.44	96
Av.		52.74	96.3

Brand A - Nationally advertised brand of frozen orange juice concentrate.
Brand B - Chain store brand of frozen orange juice concentrate.
Dup. - Duplicate sample.

Table 27. Mean ascorbic acid content, percent retention of ascorbic acid, and milliliters per 100 grams in brands A and B frozen orange juice concentrate, 24 hours refrigerator storage.

Week	Brand	Ascorbic Acid content	Percent retention	Milliliters orange juice x 100 grams
1	A	50.45	95.55	96
2		48.68	103.77	96
3		48.23	94.55	96
3 Dup.		46.38	94.34	96
4		47.30	98.15	97
4 Dup.		46.41	96.31	97
5		51.59	98.29	96
6		44.59	96.08	97
7		44.13	98.04	96
8		47.84	98.11	96
8 Dup.		46.92	96.23	96
9		50.96	100.00	97
10		47.30	98.21	96
10 Dup.		47.30	100.00	96
11		46.15	96.31	96
12		44.72	100.00	96
Av.		47.43	97.75	96.3
1	B	55.15	97.92	96
1 Dup.		53.97	97.86	96
2		53.10	96.77	96
3		48.23	92.86	96
4		50.84	100.00	96
5		57.02	98.45	96
5 Dup.		56.11	96.88	96
6		50.96	98.25	96
7		49.42	100.00	96
8		51.52	100.00	96
9		54.60	98.36	96
9 Dup.		54.60	100.00	95
10		49.88	100.00	96
11		50.59	98.29	96
12		47.30	98.21	96
12 Dup.		46.44	100.00	96
Av.		51.86	98.37	95.9

Brand A - Nationally advertised brand of frozen orange juice concentrate.
Brand B - Chain store brand of frozen orange juice concentrate.
Dup. - Duplicate sample.

Table 28. Mean ascorbic acid content, percent retention of ascorbic acid, and milliliters per 100 grams in brands A and B frozen orange juice concentrate, 48 hours storage.

Week	Brand	Ascorbic acid content	Percent retention	Milliliters orange juice = 100 grams
1	A	49.40	93.56	96
2		45.26	96.48	97
3		44.06	86.38	96
3 Dup.		46.94	93.45	96
4		49.09	101.87	96
4 Dup.		45.52	94.46	96
5		49.78	94.84	96
6		45.50	98.04	97
7		45.01	100.00	97
8		45.14	100.11	97
8 Dup.		45.14	100.11	97
9		49.14	96.43	97
10		43.86	91.07	96
10 Dup.		44.72	94.55	97
11		44.38	92.61	96
12		43.86	98.08	97
Av.		45.99	95.75	96.5
1	B	55.73	98.95	96
1 Dup.		50.67	91.88	97
2		52.36	95.43	97
3		48.75	93.86	96
4		49.09	96.50	96
5		54.30	93.73	97
5 Dup.		56.11	96.88	96
6		50.05	96.49	96
7		48.54	98.22	97
8		50.03	102.21	96
9		54.60	98.36	96
9 Dup.		53.69	98.33	97
10		49.02	98.28	95
11		49.70	96.56	96
12		46.44	96.43	96
12 Dup.		45.58	98.15	96
Av.		50.92	96.89	96.3

Brand A - Nationally advertised brand of frozen orange juice concentrate.
Brand B - Chain store brand of frozen orange juice concentrate.
Dup. - Duplicate sample.

Table 29. Mean ascorbic acid content, percent retention of ascorbic acid, and milliliters per 100 grams in brands A and B frozen orange juice concentrate, 72 hours storage.

Week	Brand	Ascorbic acid content	Percent retention	Milliliters orange Juice = 100 grams
1	A	48.13	91.16	96
2		44.38	94.61	97
3		43.13	84.55	96
3 Dup.		43.13	87.73	96
4		44.62	92.59	96
4 Dup.		41.95	87.05	96
5		49.78	94.84	97
6		44.59	96.08	96
7		42.36	94.11	96
8		46.00	94.34	96
8 Dup.		45.30	92.90	96
9		47.32	92.62	96
10		43.86	91.07	96
10 Dup.		43.86	92.73	97
11		44.38	92.61	96
12		40.42	90.38	96
Av.		44.58	91.90	96.2
1	B	53.20	94.46	96
1 Dup.		51.93	94.16	96
2		52.36	95.43	96
3		48.75	93.86	96
4		48.19	94.73	96
5		56.11	96.88	96
5 Dup.		54.30	93.75	96
6		50.05	96.49	95
7		48.54	98.22	97
8		49.68	96.43	96
9		53.69	96.72	96
9 Dup.		53.69	98.33	97
10		48.16	96.55	96
11		49.70	96.56	96
12		47.30	98.21	96
12 Dup.		44.22	96.30	96
Av.		50.60	96.07	96.1

Brand A - Nationally advertised brand of frozen orange juice concentrate.
Brand B - Chain store brand of frozen orange juice concentrate.
Dup. - Duplicate sample.

Table 30. Mean ascorbic acid content, and milliliters of fresh orange juice per 100 grams, zero storage.

Week	Ascorbic acid mg/100 g.	Orange juice ml/100 g.
1	65.71	95
2	61.95	95
2 Dup.	62.84	96
3	61.22	95
4	61.58	95
5	61.54	95
6	60.06	95
6 Dup.	60.97	95
7	52.07	95
7 Dup.	51.19	96
8	56.12	96
9	50.96	95
10	52.46	95
11	47.04	95
11 Dup.	46.15	96
12	47.30	96
Av.	56.20	95.3
Navel Av.	58.90 *	95.3
Valencia Av.	48.20	95.5

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - Duplicate sample.
* ($P < .05$).

Table 31. Mean ascorbic acid content, percent retention of ascorbic acid, and milliliters of fresh orange juice per 100 grams, 24 hours storage.

Week	Ascorbic acid mg./100 g.	Percent retention	Orange juice ml./100 g.
1	62.19	94.64	95
2	61.95	100.00	95
2 Dup.	63.72	101.40	96
3	60.29	98.48	95
4	58.91	95.66	95
5	61.54	100.00	95
6	58.24	96.97	96
6 Dup.	57.33	94.03	96
7	51.19	98.31	95
7 Dup.	52.07	101.72	95
8	55.20	98.36	95
9	50.95	98.21	96
10	51.60	98.36	95
11	45.26	96.22	95
11 Dup.	45.26	98.07	95
12	48.16	101.82	96
Av.	55.19	98.27	95.3
Navel Av.	57.72	98.15	95.3
Valencia Av.	47.57*	98.62	95.3

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - Duplicate sample.
* ($P < .05$).

Table 32. Mean ascorbic acid content, percent retention of ascorbic acid, and milliliters of fresh orange juice per 100 grams, 48 hours storage.

Week	Ascorbic acid mg./100 g.	Percent retention	Orange juice ml./100 g.
1	64.60	98.31	95
2	58.58	94.56	96
2 Dup.	58.58	93.22	96
3	60.00	98.01	96
4	58.91	95.66	95
5	60.64	98.54	96
6	55.51	92.42	96
6 Dup.	56.42	92.54	95
7	51.19	98.31	95
7 Dup.	50.30	98.26	96
8	53.10	101.62	96
9	49.14	96.43	96
10	50.74	96.72	95
11	45.26	96.22	95
11 Dup.	45.26	98.07	96
12	47.30	100.00	96
Av.	54.10	96.81	95.6
Navel Av.	56.72 *	96.02	95.6
Valencia Av.	47.14	97.75	95.5

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - duplicate sample.
* ($P < .05$).

Table 33. Mean ascorbic acid content, percent retention of ascorbic acid, and milliliters of fresh orange juice per 100 grams, 72 hours storage.

Week	Ascorbic acid mg./100 g.	Percent retention	Orange juice ml./100 g.
1	58.27	88.68	95
2	57.29	93.12	96
2 Dup.	58.58	93.22	96
3	56.25	91.88	96
4	58.01	94.20	95
5	59.73	97.06	95
6	56.42	93.94	95
6 Dup.	56.12	92.54	95
7	51.19	98.31	95
7 Dup.	50.30	98.26	95
8	51.52	91.80	95
9	49.14	96.43	96
10	49.02	93.44	95
11	44.30	94.34	95
11 Dup.	44.38	96.16	95
12	46.44	98.18	96
Av.	52.98	94.50	95.3
Navel Av.	55.29	94.12	95.3
Valencia Av.	46.06*	95.50	95.3

Weeks 1 through 9 - Navel oranges.
Weeks 10 through 12 - Valencia oranges.
Dup. - duplicate sample.
* ($P < .05$).

Table 34. Mean squares and significance for aroma, color, dispersion, flavor and general acceptability.

Source of variation	D/F	Factors analyzed				
		Aroma	Color	Dispersion	Flavor	General acceptability
Weeks	11	0.4989 ***	1.831 ***	0.9554 ***	1.441 **	0.8597 **
Juices	2	7.846 ***	0.4050 *	6.160	0.9385	1.698
Storage	3	5.198 ***	1.740 ***	0.8938	11.05	6.997
Juice storage	6	0.2346 ns	0.0644 ns	0.2618 **	2.369 ***	1.098 ***
Duplicates	48	0.0476 ns	0.0407 ns	0.0253 ns	0.0640	0.0662 ns
Remainder	121	0.1351	0.0950	0.0863	0.4523	0.2807
Total	191					

* - Significant at the 5 percent level.
** - Significant at the 1 percent level.
*** - Significant at the 0.1 percent level.
ns - Non-significant.

Table 35. Mean squares and significance for ascorbic acid content, percent retention of ascorbic acid and milliliters of orange juice per 100 grams.

Source of variation	D/F	Factors analyzed		
		Ascorbic acid mg./100 grams	Percent retention of ascorbic acid	Ascorbic acid ml./100 grams
Weeks	11	182.2 ***	32.40 ***	0.3273 ns
Juices	2	1037.0 ***	50.21	15.80 ***
Storage	3	87.30 ***	193.6	0.8667 *
Juice storage	6	2.866 ns	15.27 *	0.0667 ns
Duplicates	48	2.954 ns	4.114 ns	0.1667 ns
Remainder	121	7.708	5.045	0.2512
Total	191			

* - Significant at the 5 percent level.
** - Significant at the 1 percent level.
*** - Significant at the 0.1 percent level.
ns - Non-significant.

THE EFFECT OF REFRIGERATOR STORAGE UPON THE PALATABILITY AND ASCORBIC ACID RETENTION OF FRESH AND FROZEN ORANGE JUICE CONCENTRATE

by

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1957

Many homemakers believe that ascorbic acid in citrus fruits is an extremely unstable vitamin and that there is little ascorbic acid in fresh or reconstituted frozen juice that has been stored in a home refrigerator. Therefore, it was considered worthwhile to determine the palatability and the ascorbic acid retention of reconstituted frozen orange juice and fresh orange juice during refrigerator storage.

Specifically this study was undertaken: (1) to determine the palatability and ascorbic acid content of fresh orange juice and of two brands of reconstituted frozen orange juice stored in a home refrigerator at 34° F. for 0, 24, 48, and 72 hours; and (2) to determine the average cost of a serving of these three types of orange juice during a given season.

The study was carried on for a 12-week period beginning in February and continuing to the middle of May. California Navel oranges, available for nine weeks, and California Valencia oranges, available for three weeks, were the source of the fresh juice (C). In addition, a nationally advertised brand (A) of frozen orange juice concentrate in the medium price range, and a frozen orange juice concentrate sold by a large chain store (B), which was one of the least expensive on the market, were used in this study.

The fresh orange juice, reconstituted juice prepared from each of the frozen concentrates, and a duplicate of one of these three were presented to a taste panel and analyzed for ascorbic acid content at each testing period. The panel scored the

samples for aroma, flavor, color, degree of dispersion, and general acceptability. The method used for the ascorbic acid analyses was a modification of that given by Loeffler and Ponting (1942).

In general, with storage, the mean scores for all three juices reflected a gradual deterioration in all the palatability factors. The general acceptability of the fresh juice was significantly higher than that of the reconstituted orange juice before storage. Also, the flavor of fresh juice, regardless of the type of orange, was significantly higher before storage than that of the reconstituted frozen juices. However, the average flavor score for the fresh juice decreased more rapidly than that for the reconstituted juices, and after 72 hours of storage was significantly poorer in flavor. It appeared that Brand B held up a little longer under storage than Brand A.

Fresh orange juice contained more ascorbic acid than either brand of the reconstituted frozen juice. The Navel oranges had a significantly higher concentration of ascorbic acid than the Valencia oranges, and of the reconstituted frozen juices, Brand B had more ascorbic acid than Brand A. There was a decline in ascorbic acid content as storage time progressed. During 72 hours of refrigerator storage Brand B had the highest percent (96.07) retention of ascorbic acid, whereas Brand A lost the most ascorbic acid (91.90 percent retention). The fresh juice averaged 94.50 percent retention of ascorbic acid.

In this study the cost of 70 milligrams of ascorbic acid (the recommended daily allowance for adults) averaged 15, 10, 3, and 2.5 cents for California Valencia, Navel, Brand A reconstituted, and Brand B reconstituted juices, respectively. Approximately one-half cup of each type of orange juice furnished 70 milligrams of ascorbic acid.