ASCORBIC ACID CONTENT OF FROZEN AND CANNED FRUITS BEFORE AND AFTER PREPARATION FOR QUANTITY SERVING

APPROVED:

Florence I. Scoular
Major Professor

Price Truitt
Minor Professor

Florence I. Scoular
Dean, School of Home Economics

Jack Johnson
Dean of the Graduate Division

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Presented to the Graduate Council of the North
Texas State Teachers College in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Lila Marette Boney, B. S.
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INTRODUCTION

Many factors must be considered in comparing the ascorbic acid values of canned and frozen fruits. The basic factors that have been shown to influence the ascorbic acid content of fruit in quantity preparation are, however, the variety of the fruit, the size, and the degree of ripeness. Schroder, Satterfield, and Holmes ('43)[1] considered all of these factors in assaying peaches. No correlation was found between the size of the peach and the ascorbic acid content, but the degree of ripeness did affect the content, the ripest being the highest in ascorbic acid. The variety influences the content, varying from 3.84 to 12.86 mg./100 gm. in different varieties.

The influence of the duration and of the temperature of storage upon the ascorbic acid content of a variety of apples was determined by animal feeding and by dye-titration, Todhunter ('36).[2] The results showed that some varieties

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[1] G. M. Schroder, G. H. Satterfield, and A. D. Holmes, "Influence of Variety, Size, and Degree of Ripeness on the Ascorbic Acid Content of Peaches." Journal of Nutrition, 25: 503-509, 1943.

[2] E. N. Todhunter, "Some Factors Influencing the Ascorbic Acid Content of Apples." Food Research, 1: 435-442, 1936.

have twice the ascorbic acid content of others, with longer storage time and the higher storage temperatures giving an increased loss of ascorbic acid. The ascorbic acid content has also been shown to vary with the climate, weather, and conditions of harvesting, Antonov and Sverena ('42).[3]

Kaski, Webster, and Kirch ('44)[4] found that the same variety of tomato grown in the same location was influenced by rainfall and sunshine; the greatest amount of ascorbic acid being found when sunshine preceded collection. No significant difference in ascorbic acid was noted in green and ripe tomatoes collected at the same time; however, variations did occur in green and ripe tomatoes.

Other environmental factors, such as the effects of light intensity, day length, temperature, and fertilizer have been shown by Hamner, Bernstein, and Maynard ('45)[5] to influence the ascorbic acid content of tomatoes. The production of ripe fruit under shade gave lower ascorbic acid values than that grown in the sunshine, but the greatest

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[3] M. V. Antonov and T. A. Sverena, "Vitamin C in Fresh and Frozen Berries." (Chem. Zentr.) Chemical Abstract, 36: 7167, 1942.

[4] I. J. Kaski, G. L. Webster, and E. R. Kirch, "The Ascorbic Acid Content of Tomatoes." Food Research, 9: 386-391, 1944.

[5] K. C. Hamner, L. Bernstein, and L. A. Maynard, "Effects of Light Intensity, Day Length, Temperature, and Other Environmental Factors on Ascorbic Acid Content of Tomatoes." Journal of Nutrition, 29: 85-97, 1945.

influence upon content was the light intensity previous to harvest. Fruit grown in a greenhouse gave an ascorbic acid value of 22.0 mg./100 gm., while fruit grown under natural illumination eight and sixteen hours each day showed an ascorbic acid content of 16.7 mg./100 gm., and 19.5 mg./100 gm. respectively.

These factors which affect the ascorbic acid content of fresh fruits are of importance when considering the variations found in the canned and frozen fruits. Losses may also occur after picking and before processing Somers, Hamner, and Nelson ('45)[6] while extraction and processing, according to Kirk and Tressler ('41),[7] cause additional losses. In comparing fresh fruit with that frozen commercially Fitzgerald and Fellers ('38)[8] concluded that if the product is adequately blanched it will contain no dehydro ascorbic acid when stored at a low temperature. Half of the ascorbic acid in their frozen pineapple was found to

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[6] G. F. Somers, K. C. Hamner, and W. L. Nelson, "Field Illumination and Commercial Handling as Factors in Determining Ascorbic Acid Content of Tomatoes Received at the Cannery." Journal of Nutrition, 30: 425-433, 1945.

[7] M. M. Kirk and D. K. Tressler, "Ascorbic Acid Content of Pigmented Fruits, Vegetables, and Their Juices." Food Research, 6: 395-411, 1941.

[8] G. A. Fitzgerald and C. R. Fellers, "Carotene and Ascorbic Acid Content of Fresh Market and Commercially Frozen Fruits and Vegetables." Food Research, 3: 109-120, 1938.

be in the extracted juice when sugar was added. The effect of freezing and storage on the ascorbic acid content of orange and grapefruit juice was determined by Conn and Johnson ('33)[9] using feeding tests with guinea pigs. The results showed that the antiscorbutic value of the frozen juices equaled that of the fresh juices. Storage of the frozen juice for five months did not greatly reduce these values, although little difference was found in the ascorbic acid content of the pulp-included juices and the pulp-free juices.

Different methods of quick-freezing orange juice were compared for their ascorbic acid content by Nelson and Mottern ('33).[10] Both feeding tests and the chemical dye methods were used; the results showed no great loss of the vitamin due to freezing by any method, although the frozen did not have as great antiscorbutic properties as the fresh fruit.

The ascorbic acid and carotene content of canned fruits

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[9] Lillian Conn and A. H. Johnson, "Vitamin C Content of Frozen Orange and Grapefruit Juice." <u>Industrial and Engineering Chemistry</u>, 25: 218-221, 1933.

[10] E. M. Nelson and H. H. Mottern, "Vitamin C Content of Frozen Orange Juice." <u>Industrial and Engineering Chemistry</u>, 25: 216-218, 1933.

was determined by Pressley, et al ('44).[11] The values reported for apricots, unpeeled halves, gave a range of 1.1 to 5.7 mg./100 gm. with an average of 3.9 mg./100 gm. Clingstone peaches ranged in ascorbic acid content from 2.0 to 5.7 mg./100 gm. and averaged 3.9 mg./100 gm. Freestone peaches showed lower values, ranging from 1.4 to 3.7 mg./100 gm. and an average of 2.3 mg./100 gm. The distribution of water soluble vitamins between the solid and liquid portions of canned fruits and vegetables was found to be about the same for all fruits analyzed by Brush, Hinman, and Halliday ('44).[12] The content of the solid portion of canned pears was 20 per cent higher than the liquid, which was the only exception reported in this study.

Newman and Fellers ('40)[13] analyzed commercially canned foods in glass and tin containers obtained from various markets. They found that the ascorbic acid was not significantly different in the two types of containers, and the losses were small in both.

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[11] A. Pressley, C. Ridder, M. C. Smith, and E. Caldwell, "Nutritive Value of Canned Foods, Ascorbic Acid and Carotene or Vitamin A Content." Journal of Nutrition, 28: 107-116, 1944.

[12] M. K. Brush, W. F. Hinman, and E. G. Halliday, Nutritive Value of Canned Foods, and Distribution of Water Soluble Vitamins Between the Solid and Liquid Portions of Canned Vegetables and Fruits." Journal of Nutrition, 28: 131-140,1944.

[13] K. R. Newman and C. R. Fellers, "Vitamin C In Packaged Foods Purchased in Retail Markets." Journal American Dietetic Association, 16: 695-696, 1940.

Preparation of foods in quantity has been shown to have a destructive effect upon the ascorbic acid content of the foods analyzed. Nagel and Harris ('43)[14] estimated these losses of ascorbic acid to be 45 per cent, while a large portion was discarded in the water. Additional losses occured by allowing the food to stand on the steam table.

The present study was undertaken to compare the ascorbic acid content of canned and frozen fruits before and after preparation for quantity use.

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14 A. H. Nagel and R. S. Harris, "Effect of Restaurant Cooking and Service on the Vitamin Content of Foods." Journal American Dietetic Association, 19: 23-25, 1943.

PROCEDURE

The fruits analyzed in this study were both canned and frozen apples, apricots, blackberries, cherries, peaches, and pineapple. Since canned strawberries were not available in institutional quantity only the frozen strawberries were studied. The fruits were obtained from local wholesale distributors and were packed in institutional size containers, that is, number ten cans for the canned fruits and five, ten, and thirty pound packages of frozen fruits, depending upon the type of fruit and the size of container available. The same size container of each fruit was used throughout the study.

Three different lots of each fruit, both canned and frozen, were studied. An average size serving was considered to be a number 16 dipper of apples, blackberries, cherries, crushed pineapple, and strawberries, or three slices of peach, or three apricot halves. An average size serving was used as a sample and three samples of each lot of canned and frozen fruits were taken for analysis. The frozen fruits were thawed according to directions on the package and several packages were mixed before taking samples. Several cans of a lot were opened and the contents were mixed before samples were taken. Each sample was collected in a one-half pint jar containing 50 ml. of one per cent meta-phosphoric acid. The samples were mixed individually in the Waring Blendor, returned to the collection jars and refrigerated until determinations for total and reduced ascorbic acid could be made. Three samples, consisting of one serving each, of each lot of fruit after preparation for serving were also taken, preserved, and analyzed in the same manner. Two aliquots of each sample were analyzed as soon as possible after collection. When two aliquots failed to give a close check three were analyzed and the results were averaged for calculations.

These fruits were prepared and served in Bruce Hall, a residence hall cafeteria at North Texas State College, Denton, Texas, during March and April, 1948.

TOTAL ASCORBIC ACID

Determination of total ascorbic acid was made according to the method of Roe and Kuether ('43)[15] with modifications by Roe and Oesterling ('44)[16] for plant tissues. Later

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[15] J. H. Roe and C. A. Kuether, "Determination of Ascorbic Acid in Whole Blood and Urine Through the 2,4-dinitrophenyl-hydrazine Derivative of Dehydro-ascorbic Acid." Journal Biological Chemistry, 147: 399-407, 1943.

[16] J. H. Roe and Jane Oesterling, "Determination of De-hydro-ascorbic Acid in Plant Tissue by 2,4-dinitrophenlhydra-zine Method." Journal Biological Chemistry, 152: 511-517, 1944.

modifications by Balomey and Kremmerer ('46)[17] eliminated the need for an ice bath by use of glacial acetic acid instead of 85 per cent sulfuric acid. The former solvent does not char or heat the solution on standing.

Reagents and Solutions:

5% metaphosphoric acid and 10% acetic acid. (50 gms. metaphosphoric acid sticks, 100 gms. acetic acid, 850 ml. distilled water).

2,4-dinitrophenlhydrazine reagent. (Dissolve 2 gms. 2,4-dinitrophenlhydrazine in 100 cc. approximately 9N sulfuric acid.)

Norit.

Thiourea solution. (Dissolve 10 gms. thiourea in 100 ml. 50% by volume aqueous alcohol.)

Bromine water.

Standard Curve:

25 mg. of pure ascorbic acid were dissolved in 25 ml. 5 per cent metaphosphoric acid and 10 per cent acetic acid. Bromine water was added drop by drop until yellow and the solution was shaken until the color disappeared. Solutions were then made with 5 per cent metaphosphoric acid and 10 per cent acetic acid containing 0.001 to 0.04 mg. per ml. Fifty ml. of this were added to 1 gram acid washed norit and filtered. Then 4 ml. of the filtrate were added to each of seven test tubes. One tube

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[17] R. H. Balomey and A. R. Kremmerer, "Determination of Ascorbic Acid, A Simplication of the Roe Method." Journal Biological Chemistry, 165: 377-378, 1946.

was held for a blank. To each tube one drop of thiourea solution was added, followed by 1 ml. of 2,7-dinitrophenylhydrazine reagent to all the tubes except the blank. The tubes were held in a water bath at 37° C. for three hours. Finally to each tube, including the blank, 5 ml. of glacial acetic acid were added. 1 ml. of the 2,4-nitrophenylhydrazine reagent was added to the blank. Contents of the tubes were removed to the photolometer[18] cells and read against the blank, using a 550 milimicron filter. Results were plotted on semi-logarithmic paper.

For the determination of total ascorbic acid in food, a known portion, 5 grams, was mixed with 20 times the volume of 5 per cent metaphosphoric acid and 10 per cent acetic acid. An aliquot portion, 25 ml., was mixed with approximately 1 gram acid washed norit and filtered. 4 ml. of the filtrate was added to three test tubes, one of which was kept for a blank. To each was added one drop thiourea solution; one ml. 2,4-dinitrophenylhydrazine reagent was added only to the test solutions. These tubes were held in the water bath at 37° C. for three hours. 5 ml. glacial acetic acid were then added to each. one ml. 2,4-dinitrophenylhydrazine reagent was finally added to the blank. Solutions were then read in the photolometer and the concentration determined from the standard curve.

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[18] Cenco Sheard Sanford Photolometer used in this laboratory.

For recoveries, 125 mg. ascorbic acid were dissolved in 25 ml. 5 per cent metaphosphoric acid and 10 per cent acetic acid. Bromine water was added until yellow and the solution shaken until colorless. One ml. of this was dissolved in 250 ml. 5 per cent metaphosphoric acid and 10 per cent acetic acid, giving a proportion of 0.02 mg. per ml. Two 5 gm. portions of food were weighed; to one portion 101 ml. 5 per cent metaphosphoric acid and 10 per cent acetic acid were added, the solution filtered. To the other 100 ml. 5 per cent metaphosphoric acid and 10 per cent acetic acid was added 1 ml. of the original ascorbic acid solution (125 mg./25 ml.). Five test tubes were prepared as follows: (1) 4 ml. of 5 per cent metaphosphoric acid and 10 per cent acetic acid, used as a blank; (2) 4 ml. ascorbic acid solution containing 0.02 mg./ml., 1 drop thiourea solution and 1 ml. 2,4-dinitrophenylhydrazine reagent; (3) 4 ml. food filtrate in 5 per cent metaphosphoric acid and 10 per cent acetic acid and one drop thiourea solution; (4) 4 ml. food filtrate, one drop thiourea solution and 1 ml. 2,4-dinitrophenylhydrazine; (5) 4 ml. food filtrate to which the ascorbic acid was added, one drop thiourea and 1 ml. 2,4-dinitrophenylhydrazine reagent. These tubes were held in the water bath for three hours and read in the photolometer.

REDUCED ASCORBIC ACID

The method of Loeffler and Ponting ('42),[19] which omits a buffer and uses one per cent metaphosphoric, was followed for determination of reduced ascorbic acid. Scrudi and Ratish ('38)[20] using the colorimetric method made determinations on fruit juices and found that cystine, histidine, creatinine, ammonia, phenol and uric acid did not interfere with this method, whereas hydroquinone and glucoreductones did. This interference was reduced by an acid media. Hochberg, Melnick and Losner ('42)[21] found that photometric procedure has greater accuracy than the titration method, and small amounts of ascorbic acid, even in the presence of other substances which reduce sodium 2,6-dichlorobenzenonlindophenol, may be determined in extracts.

Reagents and Solutions:

Solution of pure ascorbic acid. (100 mg. dissolved in 500 ml. 1% metaphosphoric acid).

Solution of 1% metaphosphoric acid. (10 gms. metaphosphoric acid stick dissolved in 990 ml. distilled water).

Dye solution. (80 mg. Sodium dichlorobenzenonidophenol dissolved in 1 liter distilled water).

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[19] H. H. Loeffler and J. D. Ponting, "Rapid Determination in Fresh, Frozen and Dehydrated Fruits and Vegetables." Industrial and Engineering Chemistry, 14: 846-849, 1942.

[20] J. V. Scrudi and H. D. Ratish, "A Colorimetric Method of Determination of Ascorbic Acid." Industrial and Engineering Chemistry, Anal. Edition, 420-423, 1938.

[21] M. Hochberg, D. Melnick and B. Losner, "Photometric Determination of Reduced and Total Ascorbic Acid." Industrial and Engineering Chemistry, 15: 182-188, 1942.

Standard Curve:

Solutions of ascorbic acid containing from 0.001 to 0.04 mg./ml. were made. The photolometer was set for 100 using 10 ml. distilled water in a flat cell. The dye was then standardized by adding a few crystals of the dye until the solution gave a reading of 18 with 1.8 ml. of 1 per cent metaphosphoric acid. Five ml. of the dye were added from a calibrated pipet to 1.8 ml. of the ascorbic acid solution in a cylindrical cell. Readings were taken fifteen seconds after addition of the dye, using a 515 millimicron filter. Results were then plotted on semi-logarithmic paper.

The food was mixed with seven times the volume of 1 per cent metaphosphoric acid, and an aliquot portion, 10 ml., of this mixture was filtered. The photolometer was set for 100 with 1.8 ml. of the test solution and 5.0 ml. distilled water in a cylindrical cell. To another cell was added 1.8 ml. of the test solution and 5.0 ml. of the dye solution (previously standardized). The reading was taken and the concentrations read from the calibrations plotted on the standard curve. Each sample was analyzed in duplicate. When checks did not occur three analyses were made, and the results were averaged for calculation.

For recoveries, a known portion of ascorbic acid, 25 mg., was dissolved in 25 ml. 1 per cent metaphosphoric acid. One ml. of this solution was diluted to 100 with 1 per cent metaphosphoric acid and read in the photolometer to check with the standard. Five ml. of the original solution were added to 10 ml. of the food mixture diluted up to 80 ml., the solution was then filtered and read in the photolometer.

DISCUSSION OF RESULTS

The comparative cost of serving frozen, fresh, and canned fruits as salads and desserts in a residence hall cafeteria was studied by Welch and Boney ('48).[22] While the fresh fruits in season were found to be lower in cost, the canned fruits were higher than the frozen with the exception of cherries and pineapple. These results suggested that the determination of the ascorbic acid content of both the frozen and the canned fruits would be of value in considering an economical source of ascorbic acid.

In the present study seven fruits, apples, apricots, blackberries, cherries, peaches, pineapple, and strawberries, were analyzed for total and reduced ascorbic acid content before and after preparation for quantity serving. The method of Roe and Oesterling ('44)[23] was followed for the determination of total ascorbic acid, and recoveries ranged from 96 per cent to 106 per cent. For the determination of reduced ascorbic acid the method of Loeffler and Ponting ('42)[24] was used: recoveries ranged from 95 per cent to 105 per cent.

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[22] Frances Welch and Marette Boney, "The Comparative Cost of Serving Frozen, Fresh, and Canned Fruits as Salads and Desserts." Accepted for publication, Practical Home Economics.

[23] Roe and Oesterling, op. cit.

[24] Loeffler and Ponting, op. cit.

The standard size portion described under procedure was used in calculating the ascorbic acid content before preparation for serving, but when fruits were used in pies and cobblers the weight of the pastry was deducted from the total weight of the sample so that only the weight of the fruit was compared in calculations. Each value reported represents the amount of ascorbic acid in a standard size serving.

In analyzing for total ascorbic acid all of the ascorbic acid present in the sample is converted to dehydroascorbic acid and determined. Reduced ascorbic acid was determined as a basis for comparing the results with values reported by others. Reduced ascorbic acid was more difficult to determine in pigmented fruits since some of the color persisted even after the solution had been filtered with norit, thereby interfering somewhat with the color obtained when the dye was added to the solution. In spite of this Kirk and Tressler ('41)[25] found that an electrometric titrimeter method was satisfactory in analyzing pigmented fruits, vegetables, and their juices for ascorbic acid. They reported values of 0.40-1.04 milligrams per kilogram for strawberries,

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[25] Kirk and Tressler, op. cit.

0.07-0.13 milligram per kilogram for peaches, and "very little" for blackberries and cherries. The amount reduced ascorbic acid obtained on analyzing these fruits in the present study gave similar results.*

In analyzing the total ascorbic acid content in the samples from each of the three lots of frozen and of canned fruits it was found that the frozen fruits contained more total ascorbic acid before preparation for serving than did the canned fruits, Table 1. Of the frozen fruits apricots gave the highest total ascorbic acid value (17.96 mg.), and the apples the lowest (4.24 mg.) for an average serving. Of the canned fruits the highest was pineapple (5.6 mg.), and the lowest was peaches (1.22 mg). Some of the frozen fruits showed a wide variation in their average total ascorbic acid content, namely 7.42-33.52 mg. for an average serving of blackberries and 9.44-14.37 mg. for peaches. Some, however, showed little variation, for example, 3.81-4.43 mg. for apples and 7.07-9.24 mg. for pineapple. In all of the canned fruits the ranges for total ascorbic acid were much less. The greatest was 0.93-2.11 mg. for an average serving of cherries, and the least was 1.13-1.32 mg. for peaches.

*Appendix, Tables 4, 5, 6, and 7.

TABLE 1

A COMPARISON OF THE TOTAL AND REDUCED ASCORBIC ACID OF FROZEN AND CANNED FRUITS BEFORE AND AFTER PREPARATION

Average Total Ascorbic Acid

Fruit		Before Preparation				After Preparation			
Kind	Lot	Frozen	Canned	Difference		Frozen	Canned	Difference	
		Mg.	Mg.	Mg.	%	Mg.	Mg.	Mg.	%
Apples (Cobbler)	I	3.9	1.4	2.5	64	5.0	2.3	2.6	53
	II	4.4	2.5	1.9	43	4.5	1.9	1.9	57
	III	4.4	1.2	3.2	73	5.5	1.2	4.4	79
	Ave.	4.2	1.7	2.6	60	5.0	1.8	3.0	63
Apricots (Salad)	I	19.7	1.6	18.2	92	17.6	1.4	16.2	92
	II	17.8	2.5	15.3	86	15.2	1.5	13.8	90
	III	16.3	1.4	14.9	91	17.9	1.4	16.5	93
	Ave.	17.9	1.8	16.1	89	16.9	1.4	15.5	92
Black-berries (Cobbler)	I	8.1	1.8	6.3	77	2.6	1.2	1.4	54
	II	7.4	1.1	6.4	85	1.6	1.6	0.0	0
	III	33.5	2.0	31.5	94	3.7	1.9	1.7	49
	Ave.	16.3	1.6	14.7	85	2.0	1.6	1.5	51
Cherries (Pie)	I	13.2	0.9	12.3	92	4.5	0.7	3.8	84
	II	10.0	1.1	8.9	81	5.6	0.9	4.7	84
	III	11.6	2.1	9.5	81	4.1	0.9	3.2	78
	Ave.	11.6	1.4	10.2	85	4.8	0.8	3.9	82
Peaches (Salad)	I	14.4	1.3	13.1	90	11.3	1.1	10.2	90
	II	9.4	1.1	8.3	88	7.5	1.1	6.4	85
	III	9.6	1.2	8.3	87	5.0	1.2	3.7	75
	Ave.	11.1	1.2	9.9	88	7.9	1.1	6.8	83
Pine-apple (Pie)	I	7.1	5.3	1.8	25	5.7	8.9	3.2*	36*
	II	9.2	5.3	3.9	42	4.9	6.6	1.7*	26*
	III	7.9	6.2	1.8	22	5.0	6.9	1.9*	27*
	Ave.	8.1	5.6	2.5	29	5.2	7.5	2.3	29
Straw-berries (Fruit Cup)	I	14.9				11.1			
	II	10.0				6.1			
	III	12.5				8.9			
	Ave.	12.5				8.1			68.6

*Canned more ascorbic acid than frozen.

TABLE 1--Continued

Average Reduced Ascorbic Acid							
Before Preparation				After Preparation			
Frozen	Canned	Difference		Frozen	Canned	Difference	
Mg.	Mg.	Mg.	&	Mg.	Mg.	Mg.	%
0.5	0.5	0.0	0	0.0	0.0	0.0	0
0.2	0.5	0.4*	68*	0.0	0.5	0.0	48
0.0	0.5	0.0	0	0.0	0.5	0.0	48
0.3	1.5	0.4	68	0.0	0.5	0.0	48
0.0	0.0	0.0	0	0.0	0.0	0.0	0
0.0	0.0	0.0	0	0.0	0.0	0.0	0
0.0	0.0	0.0	0	0.0	0.6	0.0	0
0.0	0.0	0.0	0	0.0	0.0	0.0	0
0.0	2.0	0.0	0	0.0	0.0	0.0	0
0.0	1.4	0.0	0	0.0	0.5	0.0	0
0.0	1.3	0.0	0	0.0	0.5	0.0	0
0.0	1.5	0.0	0	0.0	0.5	0.0	0
0.6	0.3	0.3	58	0.6	0.4	0.2	36
0.7	0.3	0.4	55	0.8	0.4	0.4	53
0.7	0.0	0.7	100	0.7	0.3	0.4	55
0.6	0.3	0.0	71	0.7	0.4	0.0	48
4.0	0.4	3.6	89	4.6	0.4	4.2	90
0.0	1.2	0.0	0	0.0	0.0	0.0	0
0.0	0.5	0.0	0	0.0	0.5	0.0	0
4.0	0.7	3.6	88	4.6	0.5	4.2	90
0.5	0.8	0.3	36	0.6	0.5	0.1	1.3
0.0	0.5	0.0	0	0.6	0.5	0.1	1.1
0.0	0.6	0.0	0	0.5	0.6	0.1	1.0*
0.5	0.6	0.3	36	0.6	0.5	0.1	1.1
1.3				0.6			
1.0				0.6			
1.1				0.6			
1.1				0.6			51.8

*Canned more ascorbic acid than frozen.

The superiority of the frozen packs of fruit over the canned as a source of ascorbic acid is shown by the higher per cent of ascorbic acid present in the frozen fruit, Table 2.

TABLE 2

THE PER CENT[1] OF TOTAL AND REDUCED ASCORBIC ACID AVAILABLE FROM FROZEN FRUITS WITH THE CANNED FRUIT USED AS A CONTROL

	TOTAL		REDUCED	
Fruit	Before	After	Before	After
	%	%	%	%
Apples	60	63	68*	48*
Apricots	89	92		
Blackberries	85	51		
Cherries	85	82	71	48
Peaches	88	83	89	90
Pineapple	29	29*	36*	1.1

[1] To obtain this per cent the average amount of ascorbic acid in the canned fruit was subtracted from the average ascorbic acid value of the frozen fruit and the difference was divided by the average ascorbic acid value of the frozen fruit and multiplied by 100. For example, apples:

$$\begin{array}{r} 4.24 \\ -1.69 \\ \hline 2.55 \end{array} \div 4.24 \times 100 = 60$$

*Average per cent greater for canned fruit.

The total ascorbic acid of frozen fruit varied from 29 to 89 per cent before preparation for serving. After preparation the difference between the frozen and the canned fruit remained about the same, varying from 51 per cent to 92 per cent, with the exception of pineapple, which showed a greater per cent of total ascorbic acid in the canned fruit. Both pineapple and apples gave higher percentages of reduced ascorbic acid (36 per cent and 68 per cent respectively), but after preparation only the apples still showed a higher per cent of reduced ascorbic acid for the canned fruit.

All of the frozen fruits except apples gave lower values of total ascorbic acid after preparation for serving. The percentage of retention ranged from 18.3 per cent for blackberries, to 117.6 per cent for apples. The retention values obtained for canned fruits were higher on the whole, though the initial ascorbic acid content was lower than the frozen fruit. Consequently, the amount of ascorbic acid found in a serving of frozen fruit was greater than for the canned fruit. Pineapple with a percentage of 134 and apples with 114 gave the highest retentions for the canned fruit, while the other fruits ranged from 83 per cent to 99 per cent.

When only the reduced ascorbic acid retention of these frozen fruits is considered the values ranged from zero per cent for apples, blackberries, and apricots, to 115 per cent for peaches. The lowest value reported for the canned fruits was zero per cent for apricots, and the highest was 123 per cent for apples and 130 per cent for cherries, Table 3.

TABLE 3

ASCORBIC ACID CONTENT AND RETENTION OF FROZEN AND CANNED FRUITS AFTER PREPARATION FOR QUANTITY SERVING

Fruit and Method	Total Ascorbic Acid						Reduced Ascorbic Acid					
	Frozen			Canned			Frozen			Canned		
	Before	After	Retention	Before	After	Retention	Before	After	Retention	Before	After	Retention
	Mg.	Mg.	%	Mg.	Mg.	%	Mg.	Mg.	%	Mg.	Mg.	%
Cobbler												
Apples	4.2	5.0	118	1.7	1.8	114	0.3	0.0	0	0.4	0.5	123
Blackberries	16.3	2.0	18	1.6	1.6	99	0.0	0.0	0	1.5	0.5	24
Pie												
Cherries	11.6	4.8	42	1.4	0.8	67	0.6	0.7	107	0.3	0.4	130
Pineapple	8.1	5.2	66	5.6	7.5	134	0.5	0.6	108	0.6	0.5	89
Salad												
Apricots	18.0	16.9	94	1.8	1.4	83	0.0	0.0	0	0.0	0.6	0
Peaches	11.1	7.9	69	1.2	1.1	94	4.0	4.6	115	0.7	0.5	64
Fruit Cup												
Strawberries	12.5	8.1	69				1.1	0.6	52			

In Table 3 it may be noted that the low values of total ascorbic acid obtained for the average serving of canned and frozen apples prior to preparation resulted in the highest retentions. The same was true of other fruits also when the initial content of ascorbic acid was low. These higher retentions may be partially accounted for by technical errors due to the difficulty experienced in analyzing for very small amounts of ascorbic acid, although a micro technique was used.

Fruits were grouped according to the manner in which they were prepared for quantity service, Table 3, in order to determine if the method of preparation had a significant effect upon the ascorbic acid content. The fruits gave wide variations in the percent of ascorbic acid retained for each method of preparation whether frozen or canned fruits were considered. The widest variation occured in determing the total ascorbic acid of frozen fruits in the cobblers. The apples gave the highest percentage of retention, 117.6 per cent, while the blackberries gave the lowest, 18.3 per cent. The canned fruits followed the same trend for both total and reduced, but the range was not as great, Table 3.

Similarly no general trend was noted for total ascorbic acid retentions in the fruits prepared as pies. Pineapple gave higher retentions than cherries for both the frozen and the canned fruit, whereas the reduced ascorbic acid of the frozen pineapple and cherries gave almost identical retentions (108 per cent and 107 per cent respectively), the canned cherries had a much higher retention than did the canned pineapple (66.7 per cent and 134 per cent).

Apricots and peaches served as salad did not have as wide a range of variation in total ascorbic acid retention. Apricots were higher than peaches (94.3 per cent and 69.3 per cent respectively) in the frozen state, while the reverse was true for the canned (83 per cent and 93.5 per cent). No reduced ascorbic acid was found in the apricots, whether frozen or canned, before or after preparation, while the frozen peaches showed a retention of 115 per cent and canned peaches 64 per cent. Strawberries served on the counter as a fruit cup gave a retention of total ascorbic acid of 68.6 per cent and 51.8 per cent for reduced.

These data support the evidence that the ascorbic acid values of frozen pack fruits are superior to the canned. From this, together with the results of a previous study, Welch and Boney,[26] it may be concluded that frozen fruits may be advantageously used for institutional service.

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[26] Welch and Boney, _op. cit._

SUMMARY

The total and reduced ascorbic acid content was determined on seven fruits, both frozen and canned apples, apricots, blackberries, cherries, peaches, pineapple, and frozen strawberries. An average size serving of these fruits was analyzed before and after preparation for quantity service in a residence hall cafeteria. Three lots of each fruit and three samples of each lot were taken for analysis both before and after preparation for serving. The values for these samples were averaged and the percentage of retention was determined. Frozen and canned fruits were compared for total and reduced ascorbic acid values before and after preparation. In all cases the frozen fruit was higher than the canned in total ascorbic acid content, with the exception of pineapple after preparation.

Average retentions of total and reduced ascorbic acid after preparation for quantity serving were higher for the canned fruits, but the initial content was lower so that the frozen fruit actually was superior to the canned.

No relationship was found between the method of preparation and the retention of total and reduced ascorbic acid. The widest range of variation was in fruits prepared as cobblers, and the least variation in fruits prepared as salads.

These results together with those of a previous study indicate that frozen fruits are preferable to canned fruits for institutional use.

APPENDIX

TABLE 4

BASIC CHEMICAL ANALYSES DATA OF ASCORBIC ACID CONTENT OF AN INDIVIDUAL SERVING OF FROZEN FRUIT BEFORE PREPARATION FOR QUANTITY SERVICE

Fruit		Total Ascorbic Acid						
Kind	Lot	Sample I		Sample II		Sample III		Ave.
Apples	I			4.1	4.1	4.0	3.4	3.9
	II	4.4	4.4	4.4	4.4			4.4
	III	4.7	4.0			4.6	4.6	4.4
Apricots	I			19.2	19.2	20.3	20.3	19.7
	II	17.3	18.5			17.7	17.7	17.8
	III			18.4	16.9	14.3	15.7	16.3
Black-berries	I			8.1	8.1	8.0	8.0	8.1
	II			7.2	8.9	6.8	6.8	7.4
	III	37.7	37.7	29.3	29.3			33.5
Cherries	I			14.3	12.0	14.0	12.7	13.2
	II			8.3	10.8	10.4	10.4	10.0
	III			10.7	10.7	13.7	11.2	10.6
Peaches	I			15.2	15.2	13.6	13.6	14.4
	II			8.0	8.0	10.9	10.9	9.4
	III			6.0	6.0	11.1	15.3	9.6
Pine-apple	I			7.8	7.8	6.3	6.3	7.1
	II	7.0	7.0			11.5	11.5	9.2
	III	8.5	6.6			8.4	8.4	8.0
Straw-berries	I	17.0	17.0			12.9	12.9	14.9
	II			10.8	10.8	9.3	9.3	10.0
	III			12.3	12.3	12.1	13.6	12.5
Straw-berries after prep.	I	10.0	10.0	14.1	10.1			11.1
	II	5.2	7.4	5.5	5.5			6.1
	III	9.0	6.9			9.8	9.8	8.9

TABLE 4—Continued

Reduced Ascorbic Acid						
Sample I		Sample II		Sample III		Ave.
0.5	0.5	0.5	0.5	0.5	0.5	0.5
0.0	0.0	0.5	0.0	0.5	0.0	0.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.6	0.6	0.6	0.6	0.6
0.6	0.6	0.0	0.7	0.6	0.6	0.6
		0.7	0.7	0.7	0.7	0.7
3.7	4.2	3.8	3.8	4.4	4.4	4.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.5	0.0	0.0	0.0	0.0	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.5	0.0	0.5	0.5	0.5
1.1	1.1	1.4	1.7	0.9	0.9	1.3
1.4	0.6	1.4	1.4	0.5	1.2	1.0
1.5	0.6	0.5	1.4	1.5	1.5	1.1
0.4	0.4	0.4	0.9	0.4	0.4	0.6
0.6	0.6	0.6	0.6			0.6
0.6	0.6	0.6	0.6	0.6	0.6	0.6

TABLE 5

BASIC CHEMICAL ANALYSES DATA OF ASCORBIC ACID CONTENT OF AN INDIVIDUAL SERVING OF FROZEN FRUIT AFTER PREPARATION FOR QUANTITY SERVICE

Fruit		Total Ascorbic Acid						
Kind	Lot	Sample I		Sample II		Sample III		Ave.
Apples	I			5.6	5.6	3.1	5.5	5.0
	II	5.8	3.3			5.7	3.1	4.5
	III	5.6	5.6			5.5	5.5	5.5
Apricots	I	17.1	17.1			18.1	18.1	17.6
	II	15.4	15.4	15.9	14.2			15.2
	III	18.0	18.0			17.9	17.9	17.9
Black-berries	I			2.5	2.5	2.7	2.7	2.6
	II	1.0	1.0	2.2	2.2			1.6
	III	1.3	4.6			4.4	4.4	3.7
Cherries	I	5.1	2.9	5.1	5.1			4.5
	II			5.6	5.6	5.6	5.6	5.6
	III			3.4	3.4			4.1
Peaches	I	11.9		11.0	11.0	11.9	11.1	11.3
	II			6.1	6.1	8.9	8.9	7.5
	III			4.6	4.2	5.6	5.6	5.0
Pine-apple	I			6.0	6.0	4.4	6.3	5.7
	II			4.8	4.8	5.0	5.0	5.0
	III	4.6	4.6			6.4	4.5	5.0

TABLE 5--<u>Continued</u>

Reduced Ascorbic Acid						
Sample I		Sample II		Sample III		Ave.
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.6	0.0	0.0	0.0	0.6	0.6
1.6	0.6	0.6	0.6	0.6	0.6	0.8
0.0	0.0	0.0	0.7	0.0	0.0	0.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.6	4.6	4.3	4.3	5.0	5.0	4.6
0.5	1.0	0.5	0.5	0.0	0.0	0.6
0.6	0.6	0.5	0.5	0.0	0.0	0.6
0.5	0.5	0.5	0.5	0.0	0.5	0.5

TABLE 6

BASIC CHEMICAL ANALYSES DATA OF ASCORBIC ACID CONTENT OF AN INDIVIDUAL SERVING OF CANNED FRUIT BEFORE PREPARATION FOR QUANTITY SERVICE

Fruit		Total Ascorbic Acid						
Kind	Lot	Sample I		Sample II		Sample III		Ave.
Apples	I			1.1	1.1	1.1	2.1	1.4
	II			1.3	1.3	1.2	1.2	2.5
	III			1.3	1.3	1.1	1.1	1.2
Apricots	I			1.3	2.6	1.2	1.2	1.6
	II	1.4	2.9			2.8	2.8	2.5
	III	0.0	0.0	1.4	0.0	0.0	0.0	1.4
Black-berries	I	2.4	1.2			1.2	2.4	1.8
	II	1.1	1.1			1.0	1.0	1.0
	III	1.2	1.2	4.4	1.2			2.0
Cherries	I			0.9	0.9	0.9	0.9	0.9
	II			1.1	1.1	1.1	1.1	1.1
	III			1.0	1.3	1.0	1.3	2.1
Peaches	I	1.1	1.1			2.1	1.1	1.3
	II	1.2	0.0	1.1	1.1	0.0	1.1	1.1
	III	1.3	0.0	1.2	1.2		1.2	1.2
Pine-apple	I			4.5	4.5	5.0	7.1	5.3
	II			6.5	6.5	4.2	4.2	5.3
	III			5.1	9.4	5.2	5.2	6.2

TABLE 6—Continued

Reduced Ascorbic Acid						
Sample I		Sample II		Sample III		Ave.
0.5	0.0	0.0	0.0	0.0	0.0	0.5
0.0	0.0	0.5	0.0	0.0	0.0	0.5
0.0	0.0	0.0	0.0	0.0	0.5	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
		2.0	2.0	1.9	1.9	2.0
1.1	1.1	1.8	1.4			1.4
0.5	1.2	1.5	1.2	2.0	1.3	1.8
0.0	0.5	0.3	0.2	0.2	0.2	0.3
0.0	0.3	0.0	0.0	0.0	0.3	0.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	0.0	0.0	0.0	0.0	0.0	0.4
1.9	1.2	1.1	1.1	0.9	1.1	1.2
0.0	0.0	0.5	0.0	0.0	0.0	0.5
0.5	0.5	0.4	0.4	1.4	1.4	0.8
0.0	0.0	0.5	0.5	0.5	0.5	0.5
0.6	0.0	0.0	0.0	0.6	0.6	0.6

TABLE 7

BASIC CHEMICAL ANALYSES DATA OF ASCORBIC ACID CONTENT OF AN INDIVIDUAL SERVING OF CANNED FRUIT AFTER PREPARATION FOR QUANTITY SERVICE

Fruit		Total Ascorbic Acid						
Kind	Lot	Sample I		Sample II		Sample III		Ave.
Apples	I	2.3	0.0	0.0	0.0	0.0	0.0	2.3
	II	2.6	2.6	0.0	0.0	1.2	1.2	1.9
	III	1.2	0.0	0.0	0.0	1.1	1.1	1.2
Apricots	I	0.0	0.0	1.4	0.0	1.4	1.4	1.4
	II	0.0	0.0	1.5	0.0	1.5	1.5	1.5
	III	0.0	0.0	1.4	0.0	1.4	1.4	1.4
Black-berries	I	1.2	1.2			1.2	1.2	1.2
	II			1.2	2.3	2.1	1.0	1.6
	III	1.2	1.2	4.4	1.0			2.0
Cherries	I			0.6	0.6	0.9	0.6	0.7
	II			0.7	1.1	0.7	1.1	0.9
	III	1.0	1.0	0.6	1.0			0.9
Peaches	I	1.1	1.1	1.0	0.0	1.1	0.0	1.1
	II			1.1	1.1	1.1	1.1	1.1
	III	1.3	1.3			1.2	1.2	1.2
Pine-apple	I			7.7	7.7	5.0	7.1	8.9
	II	7.5	4.4	7.3	7.3			6.6
	III			7.2	7.2	6.6	6.6	6.9

TABLE 7—Continued

Reduced Ascorbic Acid						
Sample I		Sample II		Sample III		Ave.
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.5	0.0	0.5
0.0	0.5	0.0	0.0	0.0	0.0	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.6	0.0	0.0	0.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	0.4	0.5	0.5	0.0	0.0	0.5
0.0	0.0	0.5	0.5	0.0	0.0	0.5
0.5	0.3	0.5	0.5	0.3	0.2	0.4
0.3	0.3	0.3	0.6	0.6	0.3	0.4
0.3	0.3	0.0	0.3	0.3	0.5	0.3
0.0	0.4	0.0	0.0	0.4	0.0	0.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.5	0.0	0.0	0.0	0.0	0.5
0.5	0.5	0.5	0.5	0.6	0.6	0.5
0.5	0.5	0.0	0.0	0.0	0.0	0.5
0.6	0.6	0.6	0.6	0.6	0.6	0.6

TABLE 8

AVERAGE ASCORBIC ACID OF EACH LOT OF FROZEN AND CANNED FRUITS BEFORE AND AFTER PREPARATION FOR QUANTITY SERVING WITH PERCENT RETAINED

Fruit		Total Ascorbic Acid			Reduced Ascorbic Acid		
Kind	Lot	Before	After	Amount Retained	Before	After	Amount Retained
		Mg.	Mg.	%	Mg.	Mg.	%
Apples	I	3.9	5.0	127	0.5	0.0	0
	II	4.4	4.5	101	0.2	0.0	0
	III	4.4	5.5	125	0.0	0.0	0
Apricots	I	19.7	17.6	89	0.0	0.0	0
	II	17.8	15.2	86	0.0	0.0	0
	III	16.3	17.9	108	0.0	0.0	0
Black-berries	I	8.1	2.6	32	0.0	0.0	0
	II	7.4	1.6	21	0.0	0.0	0
	III	33.5	0.7	1	0.0	0.0	0
Cherries	I	13.2	4.5	34	0.6	0.6	96
	II	10.0	5.6	56	0.7	0.8	124
	III	11.6	4.1	35	0.7	0.7	102
Peaches	I	14.4	11.3	78	4.0	4.6	115
	II	9.4	7.5	80	0.0	0.0	0
	III	9.6	5.0	52	0.0	0.0	0
Pine-apple	I	7.1	5.6	80	0.5	0.6	123
	II	9.2	4.9	53	0.0	0.6	100
	III	8.0	5.0	63	0.5	0.5	100
Straw-berries	I	14.9	11.1	74	1.3	0.6	44
	II	10.0	6.1	61	1.0	0.6	59
	III	12.5	8.9	71	1.1	0.6	53

TABLE 8—Continued

Total Ascorbic Acid			Reduced Ascorbic Acid		
Before	After	Amount Retained	Before	After	Amount Retained
Mg.	Mg.	%	Mg.	Mg.	%
1.4	2.3	169	0.5	0.0	0
2.5	1.9	76	0.5	0.5	91
1.2	1.2	97	0.5	0.5	105
1.6	1.4	91	0.0	0.0	0
2.5	1.5	59	0.0	0.0	0
1.4	1.4	99	0.0	0.6	100
1.8	1.2	67	2.0	0.0	0
1.1	1.6	152	1.4	0.5	33
2.0	2.0	97	1.3	0.5	39
0.9	0.7	15	0.3	0.4	125
1.1	0.9	84	0.3	0.4	134
2.1	0.9	42	0.0	0.3	100
1.3	1.1	80	0.4	0.4	99
1.1	1.1	99	1.2	0.0	0
1.2	1.2	102	0.5	0.5	107
5.3	8.9	168	0.8	0.5	69
5.3	6.6	124	0.5	0.5	100
6.2	6.9	111	0.6	0.6	96

TABLE 9

BRANDS OF FRUITS AND UNIT AMOUNT USED

Fruit	Frozen	Canned
Apples	"Honor" (Stokely-Van Camp), 10 lbs.	"White Swan" (Waples Platter), #10 can.
Apricots	"Honor" (Stokely-Van Camp), 10 lbs.	"White Swan" (Waples Platter), #10 can.
Blackberries	Wicker distributor (brand unavailable), 10 lbs.	"Star" (Monroe Pearson), #10 can.
Cherries	Wicker distributor (brand unavailable) 30 lbs.	"Montmorency" (Monroe Pearson), #10 can.
Peaches	"Honor" (Stokely-Van Camp), 10 lbs.	"Tri-Valley", #10 can.
Pineapple	"Royal Scot" (Trinity) 7 lbs.	"Edelweiss" (Sexton) #10 can.
Strawberries	Wicker distributor (brand unavailable) 30 lbs.	

BIBLIOGRAPHY

Antonov, M. V. and T. A. Svereva, "Vitamin C in Fresh and Frozen Berries". Chem. Zentr., Chemical Abstract 36: 7167, 1942.

Bolomey, R. A. and A. R. Kemmerer, "Simplification of the Roe Method". Journal of Biological Chemistry, 165: 377-378, 1946.

Brush, M. K., W. F. Hinman and E. G. Halliday, "Nutritive Value of Canned Foods, Distribution of Water Soluble Vitamins Between the Solid and Liquid Portions of Canned Vegetables and Fruits". Journal of Nutrition, 28: 131-140, 1944.

Conn, Lillian and A. H. Johnson, "Vitamin C Content of Frozen Orange and Grapefruit Juice". Industrial and Engineering Chemistry, 25: 218-221, 1933.

Fitzgerald, G. A. and C. R. Fellers, "Carotene and Ascorbic Acid Content of Fresh Market and Commercially Frozen Fruits and Vegetables". Food Research, 3: 109-120, 1938.

Hamner, K. C., L. Berstein, and L. A. Maynard, "Effects of Light Intensity, Day Length, Temperature, and Other Environmental Factors on the Ascorbic Acid Content of Tomatoes". Journal of Nutrition, 29: 85-97, 1945.

Hochberg, Melvin, D. Melnick and B. Losner, "Photometric Determination of Reduced and Total Ascorbic Acid", Industrial and Engineering Chemistry, 15: 182-188, 1942.

Kaski, I. J., G. L. Webster, and E. R. Kirch, "Ascorbic Acid Content of Tomatoes". Food Research, 9: 386-391, 1944.

Kirk, M. M. and D. K. Tressler, "Ascorbic Acid Content of Pigmented Fruits, Vegetables, and Their Juices". Food Research, 6: 375-411, 1941.

Loeffler, H. J. and J. D. Ponting, "Ascorbic Acid, Rapid Determination in Fresh, Frozen, or Dehydrated Fruits and Vegetables." Industrial and Engineering Chemistry, 14: 846-849, 1942.

Nagel, A. H. and R. S. Harris, "Effect of Restuarant Cooking and Service on Vitamin Content of Foods." Journal of American Dietetics Association, 19: 23-25, 1943.

Nelson, E. M. and H. H. Mottern, "Vitamin C Content of Frozen Orange Juice". Industrial and Engineering Chemistry, 25: 216-218, 1933.

Newman, K. R. and C. R. Fellers, "Vitamin C in Packaged Foods Purchased in Retail Markets." Journal of American Dietetics Association, 16: 695-696, 1940.

Pressley, A., C. Ridder, M. C. Smith, and E. Caldwell, "Nutritive Value of Canned Foods, Distribution of Water Soluble Vitamins Between the Solid and Liquid Portions of Canned Vegetables and Fruits". Journal of Nutrition, 28: 131-140, 1944.

Roe, Joseph H. and C. A. Kuether, "Determination of Ascorbic Acid in Whole Blood and Urine Through the 2,4-dinitrophenylhydrazine Derivative of Dehydroascorbic Acid". Journal of Biological Chemistry, 147: 399-407, 1943.

Roe, Joseph H. and M. J. Oesterling, "Determination of Dehydroascorbic Acid and Ascorbic Acid in Plant Tissues by the 2,4-dinitrophenylhydrazine Method". Journal Biological Chemistry, 152: 511-517, 1944.

Schroder, G. M., G. H. Satterfield, and A. D. Holmes, "Influence of Variety, Size, and Degree of Ripeness on the Ascorbic Acid Content of Peaches". Journal of Nutrition, 25: 503-509, 1943.

Scrudi, J. V. and H. D. Ratish, "A Colorimetric Method of Determination of Ascorbic Acid". Industrial and Engineering Chemistry, Anal. Edition, 420-423, 1938.

Somers, G. F., and K. C. Hamner, and W. L. Nelson, "Field Illumination and Commercial Handling as Factors in Determining Ascorbic Acid Content of Tomatoes Received at the Cannery". Journal of Nutrition, 30: 425-433, 1945.

Todhunter, E. N., "Some Factors Influencing the Ascorbic Acid Content of Apples". Food Research, 1: 435-442, 1936.

Welch, Frances and Marette Boney, "The Comparative Cost of Serving Frozen, Fresh, and Canned Fruits as Salads and Desserts". Accepted for publication, Practical Home Economics.