The Nutritive Value of Canned Foods. II. Changes in Ascorbic Acid of Vegetables During Storage Prior to Canning*

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The authors report ascorbic acid values for corn, peas, green beans, lima beans and spinach in the raw and canned state as influenced by varying periods and conditions of storing and washing the freshly picked vegetables.

Factors affecting the nutritive value of canned vegetables are being widely studied. The aspects of the problem investigated in this study were the changes in ascorbic acid, thiamine, riboflavin and carotene in vegetables stored under varying conditions and for different times between harvesting and canning. The conditions and times of storage were representative of those used by commercial canners or considered to have some possibility of use during periods of peak load. The ascorbic acid values are reported in this paper.

A number of studies have been made on the changes in ascorbic acid content of vegetables during storage. Mack and Tressler *(9)* found that peas in the pod lost very little ascorbic acid when held at 1 and 9° C., but that there was considerable loss at 18 and 22° C. Tressler, Mack and Jenkins *(12)* reported that refrigeration retarded the loss of ascorbic acid in lima beans and that shelled lima beans lost ascorbic acid about twice as rapidly as did the unshelled ones. Eheart, et al *(3)*, concluded that lima beans should be stored in the refrigerator in the pod for maximum retention of ascorbic acid.

Dunker, Fellers, and Fitzgerald *(2)* found that corn stored in the husk either at room or refrigerator temperatures lost almost no ascorbic acid the first day and showed only a 20% loss after three days' storage. Lamb *(6)* found that green beans lost ascorbic acid rapidly during the first 24 hours at room temperature, but that subsequent losses were small. Mack and Tapley *(8)* stated that snap beans lost ascorbic acid rapidly at all temperatures, but the rate of loss was somewhat less at lower temperatures. Gordon, Griswold and Porter *(4)* found that the use of snow ice in holding green beans improved the ascorbic acid retention materially over that of beans held at room temperature. The work of Brasher, et al *(1)* indicated that for shelled lima beans, ice refrigeration was preferable to cracked ice storage. They suggested that the increased loss of ascorbic acid of the beans stored in cracked ice might be attributed to the effect of extra moisture in favoring enzyme activity. The use of a propionate solution as a dip or spray to prevent microbial growth in stored produce has been suggested by Wolford and Anderson *(13)*.

Jackson *(5)* investigated the changes in reduced, dehydro- and total ascorbic acid during refrigerated storage of peas and spinach. She reported that peas retained nearly all their ascorbic acid for 48 hours, while spinach lost 7% of the reduced and 23% of the total ascorbic acid. Most of the samples showed a decrease in ascorbic acid during the first hour of storage, followed by an increase after three hours, then a gradual drop to or below the original value with increased time of storage.

Materials and Methods

Details concerning the growing, harvesting and handling of the vegetable crops are given in the first paper of this series, (Marshall and Robertson *10*).

Field samples were obtained by random hand picking of the field just before the crops were harvested, and were analyzed as rapidly as possible, usually within 30 minutes after leaving the field. Therefore, these samples were analyzed one to three hours before the samples marked as "prompt handling" in the storage series, since all the storage series samples went through the usual commercial handling procedures. The field samples were not canned since it was not possible to provide a large enough sample to process with cannery equipment.

Five to 10 pounds of each sample of raw vegetables were brought to the laboratory for analysis. Samples which contained dirt were washed in tap water, then dried with towels. The samples which had been washed as part of the storage treatment did not require further washing. Four ascorbic acid determinations were made on each sample of corn, green beans and lima beans, and five on each sample of peas and spinach. Total solids determinations were done in duplicate.

In the lots that were canned, one number 10 can from each storage sample was opened and drained five minutes in a large colander. Weights of the solid and liquid portions were recorded. Solids and liquids were analyzed for ascorbic acid and total solids. The ascorbic acid values for the total can contents were calculated from the ascorbic acid content of the solids and liquid, and the original weight of each contained in the can.

Because of technical difficulties, it was necessary to do total, rather than reduced ascorbic acid on the corn. The method used was that of Roe and Oesterling *(11)*. Ascorbic acid determinations for the peas, string beans, lima beans and spinach were made by the Loeffler and Ponting method *(7)*. Five percent metaphosphoric acid was used for the original blend and the blend diluted to conform with the method as described.

Total solids were determined by drying weighed samples for 48 hours in a 70° C. oven with forced air circulation.

The times indicated in the discussion of results and in

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the tables correspond to those given by Marshall and Robertson *(10)* as elapsed time from harvest to processing.

Results

The ascorbic acid contents of the vegetables are listed in Tables 1 to 5. Data are given for the raw and canned vegetables, on both the wet and dry basis. The values for the canned samples are based on the total can contents.

Corn: The data obtained on corn are summarized in Table 1. The two lots of raw corn followed about the same pattern, the ascorbic acid decreasing slightly with holding, then increasing for the longest holding period. The results were about the same when calculated on the dry basis, indicating that the increase was not due to water loss. The two lots differed in maturity as well as variety, which would account for the higher level of ascorbic acid in the second lot.

The canned samples all had about the same amount of ascorbic acid remaining in them, with the exception of the "prompt handling" sample of Seneca Golden, which had the lowest ascorbic acid content in both the raw and canned samples.

TABLE 1

Ascorbic acid values for corn

Variety	Method of holding	Time hrs.	Raw		Canned	
			mg/100gm. raw weight	mg/gm. solids	mg/100gm. total can contents	mg/gm. solids
Seneca Golden	Field sample	....	9.7	....†	....*	....†
	Prompt handling	2.3	7.7	0.23	2.8	....†
	Held on wagon	5.9	8.5	0.27	4.1	....†
		8.7	8.1	0.25	4.4	....†
		25.5	9.5	0.29	4.3	....†
Golden Bantam	Field sample	....	13.6	0.48	....*	....*
	Prompt handling	2.0	13.8	0.55	4.8	0.32
	Held on wagon	4.9	12.3	0.47	4.7	0.30
		7.4	13.6	0.52	4.7	0.31
		23.8	15.3	0.56	4.4	0.30

*Not canned. †Not determined.

TABLE 2

Ascorbic acid values for peas

Variety	Method of holding	Time, hrs.	Raw		Canned	
			mg/100gm. raw weight	mg/gm solids	mg/100gm. total can contents	mg/gm solids
Thomas Laxton	Field sample	....	22.2	1.10	....*	....*
	Prompt handling	2.3	20.5	1.04	9.3	0.64
	Shade	5.5	14.1	0.94	9.8	0.76
	Washed, shade	5.5	15.1	0.82	6.8	0.48
	Unvined	4.3	19.8	1.11	....*	....*
	Running water	9.3	12.9	0.84	7.3	0.52
	Cold storage	9.4	10.8	0.57	8.6	0.60
		22.8	9.8	0.49	7.5	0.51
		46.8	6.7	0.34	7.6	0.52
	Washed, cold storage	9.4	10.4	0.64	8.3	0.58
		22.8	11.0	0.63	6.1	0.46
		46.8	10.2	0.54	5.9	0.46
	Snow ice	22.8	11.8	0.64	7.8	0.58
		46.8	10.6	0.58	4.7	0.37
Pride	Field sample	....	22.4	1.11	....*	....*
	Prompt handling	1.3	18.5	0.97	8.0	0.49
	Shade	4.8	15.0	0.70	8.4	0.49
		10.3	15.9	0.81	7.0	0.45
	Washed, shade	4.8	16.6	0.80	8.5	0.68
		10.3	16.1	0.89	5.9	0.39
	Running water	10.3	14.6	0.90	5.9	0.40
	Cold storage	10.3	17.8	0.94	8.7	0.44
		26.0	13.3	0.63	6.9	0.48
		48.3	16.1	0.79	6.2	0.39
	Washed, cold storage	10.3	15.0	....†	5.7	0.42
		26.0	12.4	0.65	11.0	0.73
		48.3	15.9	0.81	6.7	0.44
	Snow ice	26.0	13.0	0.66	5.9	0.41
		48.3	16.2	0.82	6.1	0.43
Shasta	Field sample	....	24.6	1.27	....*	....*
	Prompt handling	1.2	16.2	0.80	10.6	0.56
	Shade	4.4	16.0	0.75	10.3	0.71
		7.9	18.3	....†	10.6	0.68
	Washed, shade	4.4	15.3	0.74	11.3	0.84
		7.9	21.9	1.24	....†	....†
	Unvined	17.3	15.9	0.75	11.2	0.73
	Running water	7.9	16.2	0.95	10.9	0.74
	Cold storage	7.9	23.2	1.21	11.0	0.72
		24.2	17.5	0.83	....†	....†
	Washed, cold storage	7.9	24.0	1.35	9.7	0.63
		24.2	21.5	1.17	8.5	0.55
	Snow ice	24.2	19.5	1.00	8.9	0.58

*Not canned. †Not determined.

Peas: The ascorbic acid values for the peas are given in Table 2. The highest ascorbic acid retention in the raw Thomas Laxton peas was found in the "prompt handling" sample. The sample held 4.3 hours before vining was the next highest. Washing the shelled peas before holding increased the ascorbic acid retention.

The "prompt handling" sample of raw Pride peas was also highest in ascorbic acid retention, the second highest being the sample held 10.3 hours in cold storage. The washed samples of raw Pride peas were slightly higher than the unwashed when held in the shade, but not when held in cold storage.

The samples of raw Shasta peas increased in ascorbic acid content with increased time of holding in the shade, also when held in cold storage 7.9 hours. The highest ascorbic acid content was found in the washed sample held 7.9 hours in cold storage, and the second highest was in the unwashed sample held the same length of time.

The highest ascorbic acid values for the canned peas were: Thomas Laxton, 5.5 hours in shade; Pride, 26 hours in cold storage; Shasta, washed and 4.4 hours in shade. In most instances, the ascorbic acid of the canned samples decreased as the time of holding the raw product under any one set of conditions increased.

Green beans: Table 3 summarizes the values obtained for green beans. The ascorbic acid content of the raw green beans remained high for 5-6 hours in the shade, and 48 hours in cold storage, then decreased. The sample held 11 hours in the shade had decreased in moisture content so that the ascorbic acid content was lowered when calculated on the dry basis. The use of snow ice on the beans in cold storage did not increase the retention of ascorbic acid.

TABLE 3

Ascorbic acid values for green beans (Landreth's Stringless Greenpod)

Method of holding	Time, hrs.	Raw		Canned	
		mg/100gm. raw weight	mg/gm solids	mg/100gm. total can contents	mg/gm solids
Field sample	....	29.2	2.71	....*	....*
Prompt handling	1.6-2.1	26.1	2.51	7.9	0.94
Shade	5-6	26.0	2.44	8.4	0.81
	11	26.3	2.10	7.2	0.77
	23-24	22.0	1.89	6.6	0.74
	48	18.1	1.57	5.1	0.55
	11	27.4	2.66	8.8	0.97
	23-24	26.7	2.29	8.8	0.98
Cold storage	48	28.4	2.69	9.5	0.84
	72	25.0	2.18	7.5	0.82
	120	19.9	1.86	6.7	0.68
	48	27.7	2.67	8.3	0.91
Snow ice	72	22.0	2.29	8.3	0.85
	120	19.1	1.88	7.2	0.85

*Not canned.

The values for the canned beans showed about the same trend as for the raw beans, the ascorbic acid content holding up for the samples stored 5-6 hours in the shade and 48 hours in cold storage, then decreasing. The use of snow ice apparently improved the retention of ascorbic acid in the canned samples which had been held the longest period (120 hours) in cold storage prior to canning.

Lima beans: The ascorbic acid content of the raw lima beans decreased gradually with increased holding time under any conditions (Table 4). Washing the beans after vining improved the retention of ascorbic acid. The use of a 10% Calcium propionate dip decreased the retention of ascorbic acid. Holding in running water or in snow ice was not beneficial. The unwashed beans could be held 8.2-9.2 hours in the shade or 48 hours in cold storage with only small loss of ascorbic acid as compared to the "prompt handling" sample. The washed beans held up well for 24 hours in the shade.

TABLE 4

Ascorbic acid values for lima beans (Thorogreen)

Method of holding	Time hrs.	Raw		Canned	
		mg/100gm. raw weight	mg/gm solids	mg/100gm. total can contents	mg/gm solids
Field sample	....	41.9	3.43	....*	....*
Prompt handling	1.5-1.9	32.7	1.83	13.3	0.45
Shade	5.2	30.8	1.62	12.4	0.46
	8.2-9.2	31.8	1.52	11.4	0.40
	24	26.9	1.36	10.2	0.34
Running water	8.2-9.2	26.2	1.51	9.1	0.33
	24	22.5	1.29	8.9	0.32
Washed, shade	8.2-9.2	33.3	1.99	10.5	0.38
	24	30.7	1.76	10.6	0.39
10% Ca Pr†, shade	24	23.8	1.22	10.8	0.39
Cold storage	24	28.6	1.48	11.2	0.40
	48	28.7	1.42	....*	....*
	120	24.4	1.26	....*	....*
Washed, cold storage	120	26.1	1.44	....*	....*
10% Ca Pr†, cold storage	120	20.6	1.06	....*	....*
Snow ice	24	24.0	1.25	10.7	0.38
	120	18.9	0.90	....*	....*

*Not canned. †Calcium propionate.

The ascorbic acid values for the canned lima beans were more nearly alike than were the values for the raw beans, but the trends were the same.

Spinach: The two runs of spinach differed in original ascorbic acid content, due to differences in variety, planting date, and soil. However, the pattern of change in ascorbic acid content with holding was the same, all the samples retaining a high level of ascorbic acid except those held longer than 24 hours in the shade. There was little difference between holding in baskets or in piles in the shade. These results are summarized in Table 5.

Most of the canned samples were lost through spoilage, so no ascorbic acid values are reported for these.

TABLE 5

Ascorbic acid values for spinach

Method of holding	Time hrs.	Raw			
		Upland		Muck	
		mg/100gm. raw weight	mg/gm solids	mg/100gm. raw weight	mg/gm solids
Field sample	....			31.8	4.90
Prompt handling	2			31.4	4.16
Overnight in field	17	51.0	6.69		
Shade, baskets	7			32.2	4.75
	21	54.5	6.80		
	24			32.3	4.62
	37	44.3	6.40		
	72			18.4	2.55
Shade, pile	24			32.6	4.82
	37	47.9	6.19		
Cold storage	24			34.7	5.13
	37	57.7	7.13		
	61	56.0	7.32		
	72			31.0	5.22
	133	56.8	7.91		

Summary

The changes in ascorbic acid content have been determined for vegetables held different lengths of time under various conditions. The data were calculated on both the wet and the dry basis.

Under the conditions of this series of experiments, the following conclusions seem tenable:

1. Where the length of storage was comparable, cold storage usually gave better ascorbic acid retention than storage at outdoor temperatures, especially as the holding time increased.

2. Holding peas and lima beans in running water generally decreased the ascorbic acid retention.

3. Washing before holding definitely increased the ascorbic acid retention of the lima beans, but made little difference in the peas.

4. The use of a 10% Calcium propionate wash decreased the ascorbic acid retention in the lima beans, the only vegetable on which this was tried.

5. Ascorbic acid retention in corn was not much affected by any of the treatments used.

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