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NUTRIENTS IN FROZEN FOODS

Variations in Nutritive Value of Frozen Green Baby Lima Beans as a Result of Methods of Processing and Cooking

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As methods of food processing are changed continually to enable the commercial processor to increase production volume and minimize production costs, it is desirable to reassess the values of processed foods to determine if the changes unnecessarily destroy nutritive quality. The effect of different blanching methods and cooking on five B vitamins and ascorbic acid was determined on baby Lima beans. Beans blanched experimentally in hot water and treated with 12 or 28% (by weight) salt solution—concentrations commonly used in commercial freezing plants for quality grading of beans and peas—had greater loss of all vitamins than steam- or hot water–blanched beans. Vitamin losses were less in beans cooked by the steam-boil method in 1/6 cup of water per 10-ounce package than in those cooked in 1 cup of water according to package directions.

FROZEN FOODS are becoming increasingly important in the diets of our population. To maintain a high standard of health, it is important to determine and practice methods of processing, storage, and preparation—both commercially and in the home—by which the food will retain a maximum amount of its original nutritive value.

Frozen green baby Lima beans are a good source of most of the B-complex vitamins, and a fair source of protein and minerals. They rank as good as or better than the cereal grains in several minerals and vitamins.

Published values for nutrients in green Lima beans vary considerably. The variations become important to the consumer when they represent losses of nutrients which could have been prevented in processing and handling. The nutritive quality of the final product is affected by variety, degree of maturity or grade, holding temperature during transit, time in transit from field to packing plant (or laboratory), methods of cleaning, grading, and blanching in preparation for freezing, and cooking methods. These factors could be controlled, to a certain degree, more often than they are, with a resulting gain in retention of original nutrients.

Of the many studies published on the effect of various types of blanching and freezing of green Lima beans, none has determined the effect of all the commercial processing stages preceding freezing on all of the food nutrients in the same sample of beans, and none has attempted to reproduce such methods in order to determine why certain nutrients are considerably lower in the frozen beans than in beans of the same lot freshly harvested. Methods of processing are changed continually to enable commercial processors to increase the volume of production and to keep production costs at a minimum. Therefore, it is desirable to reassess the value of processed foods from time to time to determine if changing processing methods are unnecessarily destroying nutritive quality. Consumers need to learn how to handle these products in institutions and in the home, so that maximum food values are retained.

Experimental Procedures

Preparation of Samples. Commercially frozen Clark's Bush variety of baby Lima beans of the 1956 and 1957 crops were obtained from a frozen foods plant in Stanislaus County, California, and Clark's Bush baby Lima beans of the Thorogreen variety, 1957 and 1958 crops, were obtained from a freezing plant in Santa Clara County.

The beans used as controls for the experiments were obtained as a truck load of the vined and podded beans from the growing field was dumped onto the platform of the freezing plant ready to be put into the flume which carried them through the various processes in preparation for freezing. Frozen packaged beans from the same load of beans were set aside for the experiments after freezing.

The methods for cleaning, for separation into grades, and for blanching used in the two frozen foods plants were essentially the same as those described by Tressler and Evers (*11*). Briefly, the beans were prepared for freezing in the following stages: pumped from the unloading platform through a flume, with water for partial cleaning; passed through salt brine solution for partial grading into mature and immature beans, and for removal of shriveled beans, pieces of pods and vines, and other extraneous materials; blanched for about 3 minutes in water at temperatures ranging from 98° to 100° C.; cooled in cold water for about 2 minutes; passed

through a pneumatic separator for further separation into grades and removal of extraneous materials; elevated to the salt brine separator for final separation into grades; washed to remove brine; and packaged and frozen by the quick-freezing process. The principal difference in the processing of the beans in the two freezing plants was in the concentration of the salt brine solution used. The Stanislaus County plant used a brine saturation of 80 to 85% (28 to 30% salt, by weight), and the Santa Clara County plant used 28 to 33% saturation (10 to 12% salt, by weight). The elapsed time from harvest to freezing was 2 to 3 hours longer at the Santa Clara than at the Stanislaus County freezing plant because of the greater distance from field to plant.

The frozen beans, in retail packages, were kept frozen during transit between the plant and laboratory by packing in an insulated container with dry ice. They were placed in freezing storage at −23° C. and analyzed as soon as possible after reaching the laboratory. The fresh beans were kept cool and from drying out during the trip to the laboratory.

On reaching the laboratory, the fresh control beans were thoroughly washed in cold water and graded by hand, so that the experimental sample contained only beans of sizes comparable with the plant-frozen, Grade A beans.

Santa Clara County beans, fresh and plant-frozen from the same lot of beans, were used to study the effect of different methods of blanching and different concentrations of salt brine solution on the retention of ascorbic acid, thiamine, riboflavin, niacin, vitamin B_6, and pantothenic acid. The washed, hand-graded fresh beans were divided into five lots and treated as follows:

Lot A, the control, was analyzed immediately for ascorbic acid, and for the other vitamins as quickly as possible.

Lot C was steam blanched by placing one layer of beans—about 120 grams—in a wire basket about 2 inches above the surface of vigorously boiling water, covering the pot, and allowing the beans to steam for 3 minutes.

Lots D, E, and F were tied into loosely fitted, cheesecloth bags, in amounts of about 300 grams, for blanching. Lot D beans were blanched by dropping the bag of beans into about 3 liters of vigorously boiling water, allowing the water to return to full boil, and boiling for 1 1/2 minutes; lot E beans were placed in 3 liters of cold salt brine (12% salt, by weight) for 10 minutes, washed in cold water, blanched in boiling water for 1 1/2 minutes, cooled in ice water for 2 minutes, and returned to the brine for 10 minutes; and lot F beans were treated as lot E beans except that the solution contained 28% salt, by weight.

All of the samples, after blanching and/or brining, were cooled in ice water, blotted dry on a paper towel, tied in polyethylene freezer bags, and placed in the freezing storage room, maintained at −23° C., until vitamin analyses could be made.

The plant-frozen beans (lot B) were analyzed for the vitamins simultaneously with the laboratory-blanched beans.

Fresh green peas from a local market were blanched for about 3 minutes in distilled water at 99° to 100° C., or in salt solution, 10 or 25% by weight, washed thoroughly to remove excess salt, and cooled, and thiamine and niacin were determined in the same manner as in the Lima beans.

Nutrient analyses were made on the uncooked frozen beans and on beans from the same lot cooked in various ways. All cooking was done in a tightly covered, Desco Ware saucepan 8 1/2 inches in diameter. This utensil was selected because it is porcelain-lined; thus the food does not come into contact with iron, to give misleading high iron values on analysis. The tightly fitted cover also incurred minimum loss of moisture by steam and minimized losses from oxidation. All the beans were kept frozen until cooking was started in boiling distilled water. No salt was added.

The beans referred to as cooked by the "steam-boil" method were cooked in 1/6 cup of water per 10-ounce package. This amount was determined experimentally to be just sufficient to prevent sticking and scorching of the beans, with no water to discard at the end of the cooking period. This small amount of water can be used successfully only if the heat is lowered to simmering as soon as boiling has resumed after the frozen beans are added to the boiling water. The beans referred to as cooked by "package directions," and the "overcooked" beans, were cooked in 1 cup of water per package. Except for the overcooked beans, which were cooked for 1 hour, all of the beans were cooked just until tender—about 15 minutes. All of the cooked samples were thoroughly drained and blotted with paper towels to remove excess water, but were not dried. The cooked and uncooked samples, except for those on which iron determinations were made, were ground in a meat grinder, placed in polyethylene freezing bags, and kept in freezing storage at −23° C. until a complete analysis for all nutrients was made.

Analytical Methods. Representative samples were taken from the thoroughly mixed, hand-graded fresh beans. Samples of frozen beans were taken from at least two packages of the frozen beans. Five separate extracts were made for each vitamin measured and duplicate determinations were made on each extract. Five to 10 determinations were made for the proximate analyses and for each of the minerals. Reassays were made on questionable values.

Table I. Average Vitamin Content of Fresh and Frozen Baby Green Lima Beans

(Values given in mg. per 100 g. beans)

	Stanislaus County, Calif.					Santa Clara County, Calif.		Various U. S. Areas	
	Current Study (1956 Crop)		Yamaguchi et al. (1953 Crop)			Current Study		Burger et al. (3)	
	Fresh	Frozen[a]	Fresh	Frozen[b]	Frozen[a]	Fresh	Frozen[a]	Av.	Range
Thiamine	0.19	0.06 (33)[c]	0.11	0.10 (91)[c]	0.06 (54)[c]	0.10	0.08 (80)[c]	0.10	(0.06–0.16)
Riboflavin	0.08	0.07 (87)	0.09	0.08 (88)	0.07 (77)	0.13	0.10 (76)	0.06	(0.04–0.09)
Niacin	0.833	0.392 (47)	1.2	0.9 (75)	0.90 (75)	1.220	1.050 (86)	1.24	(0.88–1.70)
Vitamin B_6	0.172	0.140 (82)	...	...	...	0.152	0.134 (88)	0.113	(0.054–0.175)
Ascorbic acid									
Total	24.3	24.7 (100)	11	13	13	30.1	18.3 (60)	18.8	(7.8–26.0)
Reduced	15.8	22.6	...	...	...	15.9	13.5	17.6	(7.7–23.7)
Dehydro	7.5	2.1	...	...	...	14.2	5.8	1.2	(0.0–3.3)
Pantothenic acid									
Total[d]	0.261	0.169 (65)	...	...	...	...	...	0.239	(0.151–0.448)
Total[e]	...	...	...	...	...	0.430	0.316(73)	...	...
Free[e]	...	...	...	...	...	0.235	0.173	...	...
Folic acid	0.028	0.030 (100)	...	...	...	...	...	0.016	(0.008–0.038)

[a] Commercially frozen. Except for those of Burger, commercially frozen beans are from corresponding lot of fresh beans.
[b] Laboratory graded, steam-blanched, and frozen, comparable in size and maturity to average U. S. grade A frozen beans.
[c] Per cent retention of vitamin calculated on basis of fresh, unprocessed sample of same lot.
[d] Mylase-P used in extraction by method of Ives and Strong (*8*).
[e] Double-enzyme extraction by method of Zook *et al.* (*13*).

The proximate analyses, the calcium, iron, and phosphorus, and the thiamine, riboflavin, niacin, vitamin B_6, folic acid, biotin, and pantothenic acid (measured by the Mylase-P method of extraction) were determined by the methods described by Hall *et al.* (*6*). Free and total pantothenic acid were determined in later crops of beans by the double-enzyme system of extraction described by Zook, MacArthur, and Toepfer (*13*) for assay of common foods.

Reduced, dehydroascorbic acid and total ascorbic acid were determined by the method of Shaffert and Kingsley (*9*), using oxalic acid instead of metaphosphoric acid, in extraction of the samples. Copper sulfate, instead of Norit, was used as the oxidizing agent according to the method of Bessey, Lowry, and Brock (*2*).

Carotene was determined by chromatographic column (*1*), with modifications necessary to overcome difficulties specific to Lima beans.

Results and Discussion

Average vitamin content of fresh and frozen baby green Lima beans, as determined in the current study, is compared with published values on the same type of beans in Table I. In the commercially frozen Stanislaus County beans, 1956 crop, vitamin retentions were: thiamine, 33; riboflavin, 87; niacin, 47; vitamin B_6, 82; and total pantothenic acid, 65%. Corresponding figures for the 1953 crop, grade A beans reported by Yamaguchi *et al.* (*12*) were: 54, 77, and 75%, respectively, for thiamine, riboflavin, and niacin. The concentration of the salt brine solution used commercially for cleaning and grading the 1953 crop beans was not given, but losses of thiamine, niacin, and riboflavin were greater than in the steam-blanched beans of the same lot. Except for riboflavin, the losses were greater than in Santa Clara County beans. Commercially frozen beans from the Santa Clara County plant, which used a 10 to 12% brine solution, had the following percentage retentions: thiamine, 80; riboflavin, 76; niacin, 86; vitamin B_6, 88; total ascorbic acid, 60; and total pantothenic acid, 73. Except for the riboflavin, which was the same, the losses in these beans were considerably less than losses in the commercially frozen Stanislaus County beans of the 1953 and 1956 crops.

Thiamine and niacin determinations on frozen beans (1956 crop) taken off the processing line just before and after freezing showed no change in percentage as a result of freezing. This agrees with findings in other laboratories summarized by Harris and von Loesecke (*7*), that the actual freezing process does not injure vitamins. Losses occur only when the slow freezing method is used, resulting in change of texture of the food, so that water-soluble factors are lost in leakage of liquids during and after defrosting. Sharp freezing techniques, such as those used in most freezing plants today, minimize these losses. Guerrant and O'Hara (*4*) found some additional loss of ascorbic acid from freezing peas and Lima beans but no loss of thiamine, riboflavin, and niacin. However, their vegetables were frozen in a chest-type freezer which would not provide temperatures as low as those used commercially in sharp freezing of foods. As the principal variation in the preparation for freezing in the two processing plants was in the concentration of the brine solution used, it seemed likely that some of the losses of vitamins in commercially frozen beans could be correlated with this phase of the treatment.

To test this theory, a laboratory experiment was planned to compare retention of some of the water-soluble vitamins in commercially frozen beans with those in beans from the same lot treated with 12 and 28% salt solution before and after blanching with hot water. Retentions of these vitamins were also measured in beans of the same lot blanched with hot water, or with steam, by methods recommended for home freezing of Lima beans. Details of the preparations of these beans are given in experimental procedures. The apparent percentage retentions of the vitamins, computed on the basis of 100 grams of sample, are shown graphically in Figure 1. The actual amounts of vitamins in the fresh, unprocessed beans used for comparison are given in Table I under Santa Clara beans. The mean averages of the vitamin in two samples were compared by calculating t by the method of Snedecor.

The probability that the decreased retentions of vitamins, as result of treatment in 12 or 28% salt solution, are statistically significant, is shown in Table II. The losses of all the vitamins, except pantothenic acid, were significantly greater in the laboratory, salt-treated beans, than in the commercially frozen beans. Increasing the salt concentration from 12 to 28% caused significantly higher losses in only thiamine and riboflavin. As the beans were in solution for the same time in both salt concentrations, the increased amount of salt was probably responsible for the greater loss of thiamine and riboflavin in the beans processed in the 28% salt solution.

The retentions of pantothenic acid in commercially frozen beans and in beans treated with 12 or 28% salt solution were approximately the same—70, 76, and 72%, respectively. The high retention of pantothenic acid (94% in the steam-

Table II. Statistical Significance of Changes in Percentage Retentions of Vitamins Resulting from Different Blanching or Blanching and Salt Treatment

Treatment of Beans and Samples Compared	Probability That Difference Is Significant: Highly significant, $P < 0.01$	Not significant
Commercial and 12% salt solution	Lower in salt solution Thiamine Riboflavin Niacin Vitamin B_6 Ascorbic acid	Pantothenic acid
Commercial and 28% salt solution	Lower in salt solution Thiamine Riboflavin Niacin Vitamin B_6 Ascorbic acid	Pantothenic acid
12 and 28% salt solutions	Lower in 28% salt Thiamine Riboflavin	Niacin Vitamin B_6 Pantothenic acid Ascorbic acid
Steam-blanch and commercial	Lower in commercial Thiamine Vitamin B_6 Pantothenic acid Niacin[a]	Riboflavin Ascorbic acid
Hot water–blanch and commercial	Lower in hot water Riboflavin Vitamin B_6 Higher in hot water Pantothenic acid	Thiamine Niacin Ascorbic acid
Hot water–blanch and steam-blanch	Lower in hot water Thiamine Riboflavin Niacin Vitamin B_6	Pantothenic acid Ascorbic acid

[a] $P < 0.05$.

blanched and 92% in the hot water-blanched beans) might appear to indicate that the lack of salt in their treatment is responsible for the improved retention of this vitamin. However, since the beans receiving salt treatment, plus the extra washing required to remove the salt, were in solution considerably longer than the hot water- and steam-blanched beans, it is probable that the losses were caused only by the prolonged period in water.

Although ascorbic acid retentions were significantly less at both salt concentrations, it was also lost to a large extent in commercial treatment and in steam and hot water blanching. More of the loss was probably due to the leaching effect of water and to oxidation than to the brining treatment. One might question the use of ascorbic acid retention in food processing as the only criterion for judging the nutritive quality of frozen foods. On the basis of these data, it would seem that thiamine and riboflavin retentions should also be determined, especially in foods which are graded by brine flotation. Since the laboratory solution containing 12% salt was of the same concentration as that used in processing the commercially frozen beans, the higher vitamin losses indicate that the treatment was more severe than the commercial treatment. The 20-minute total time used for brining, arbitrarily chosen because the exact time used commercially was not known, was undoubtedly greater than the actual time used in commercial plants, and would account for the greater vitamin losses in the laboratory-prepared samples.

The salt brine method of cleaning and grading is also widely used in preparing green peas for freezing. As a matter of interest, a sample of fresh green peas was obtained from a local market and blanched for 3 minutes at 99° to 100° C. either in water, or in 12 or 25%, by weight, salt solution. Table III shows the losses of thiamine and niacin in the peas after these treatments. Although these experimental conditions were not identical with the commercial treatment of these foods, the results point out that excessive brine treatment endangers the nutritive value of the product. Brine treatment is not used for all frozen vegetables or in all freezing plants in processing beans and peas.

Figure 1 shows that thiamine, niacin, and ascorbic acid were retained equally well in the hot water-blanched and the commercial beans, but vitamin B_6 was significantly decreased by the hot water blanch. The amounts of all six vitamins were higher in the steam- than in the hot water-blanched beans, but only thiamine, riboflavin, and vitamin B_6 were significantly higher. Similar findings have been made by others. Yamaguchi (Table I) shows higher retentions of thiamine, riboflavin, and niacin in laboratory steam-blanched than in commercially blanched and frozen beans. Guerrant *et al.* (*5*) compared the effect of duration and temperature of water-blanch with that of steam blanching on the retention of ascorbic acid, thiamine, riboflavin, niacin, and carotene in peas, spinach, and Lima beans. They concluded from their work that the high temperature blanch of short

Table III. Retentions of Thiamine and Niacin after Blanching Fresh Green Peas for 3 Minutes at 99° to 100° C.

Blanching Solution	Per Cent Retention[a]			
	Thiamine		Niacin	
	Fresh	Dry solids	Fresh	Dry solids
Distilled water	92	95	81	85
10% salt, by weight	91	87	77	73
25% salt, by weight	89	68	72	61

[a] Values calculated on basis of 100 grams of sample on fresh and dry solids basis.

Table IV. Nutrient Content of 1957 Crop of Uncooked and Cooked Frozen Baby Lima Beans from Stanislaus County, Calif.

Content	Uncooked		Cooked[a]	
	Av.	Range	Av.	Range
		PER CENT		
Moisture	67.4	66.5 – 68.6	66.9	66.4 – 67.6
Protein	5.41	5.28 – 5.48	5.48	5.62 – 6.10
Ether extract	0.261	0.26 – 0.275	0.341	0.323 – 0.347
Carbohydrate[b]	25.64	...	26.58	...
Ash	1.29	1.18 – 1.42	1.15	1.08 – 1.22
		MILLIGRAMS PER CENT		
Calcium	35.6	24.2 – 47.1	37.5	30.6 – 43.8
Iron	1.74	1.65 – 1.96	1.76	1.67 – 1.83
Phosphorus	115	106 –117	131	120 –149
Thiamine	0.057	0.056 – 0.058	0.054	0.050 – 0.057
Riboflavin	0.073	0.065 – 0.077	0.075	0.072 – 0.077
Niacin	0.382	0.366 – 0.417	0.320	0.300 – 0.334
Vitamin B_6	0.140	0.119 – 0.168	0.117	0.107 – 0.127
Pantothenic acid[c]				
Total	0.186	0.167 – 0.209	0.185	0.173 – 0.198
Free	0.087	0.082 – 0.089	0.088	0.181 – 0.092
Pantothenic acid[d]	0.169	0.156 – 0.190	0.151	0.143 – 0.159
Folic acid	0.030	0.032 – 0.035	0.032	0.028 – 0.035
Biotin	0.0030	0.0028– 0.0031	0.0031	0.0031– 0.0032
β-Carotene	0.122	0.116 – 0.130	0.128	0.120 – 0.135
Ascorbic acid				
Total	24.7	22.2 – 28.9	21.5	19.2 – 24.4
Dehydro-	2.1	1.7 – 2.4	3.3	2.3 – 3.9
Reduced	22.6	19.8 – 26.5	18.2	16.0 – 20.5

[a] Cooked 15 minutes by steam-boil method, using 1/6 cup of water per 10-ounce package of beans.
[b] Calculated by difference.
[c] Extracted by double-enzyme method of Zook *et al.* (*13*).
[d] Extracted by use of Mylase-P according to method of Ives and Strong (*8*).

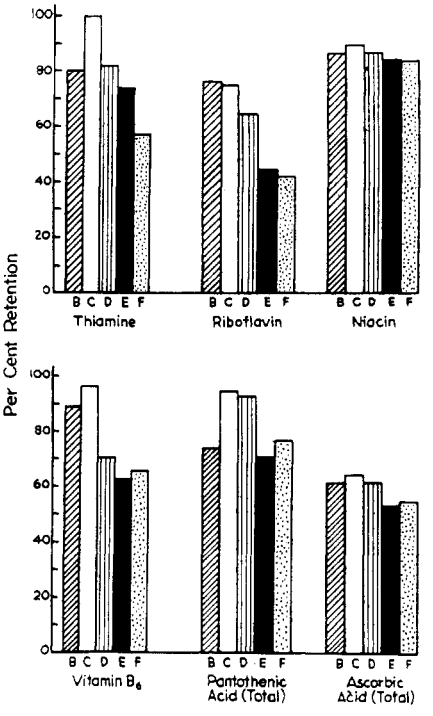

Figure 1. Retentions of B vitamins and ascorbic acid in laboratory-blanched, blanched and brined, and commercially frozen beans from same growing field

Calculated as percentage of vitamin in fresh beans

B. Commercially frozen beans
C. Steam-blanched 3 minutes
D. Hot water-blanched1 1/2 minutes
E. Hot water-blanched and brined in 12% salt solution
F. Hot water-blanched and brined in 28% salt solution

duration resulted in highest retentions of the water-soluble vitamins studied. Steam blanching was least destructive of these vitamins. Carotene was not affected by any of the blanching procedures studied. Guerrant and O'Hara (*4*), using peas and Clark's Bush variety of baby green Lima beans, measured the retention of ascorbic acid, thiamine, riboflavin, and niacin following hot water blanching. Of the vitamins studied, ascorbic acid retention was most adversely affected by blanching and carotene least affected.

Figure 2 graphically compares the percentage retentions of certain vitamins in frozen beans of the 1957 crop, Stanislaus County, when cooked by the steam-boil method, by directions given on the retail package of the frozen beans, and by overcooking. Retentions of these vitamins as reported by Teply and Derse (*10*) are also given. Table IV gives the complete nutritive analysis of the uncooked and steam-boiled beans, including proximate analysis, calcium, iron, phosphorus, thiamine, riboflavin, niacin, vitamin B_6, pantothenic acid [measured on Mylase-P extract and also on extract prepared by the double-enzyme method of Zook *et al.* (*13*)], folic acid, biotin, β-carotene, and total, dehydro-, and reduced ascorbic acid.

These results indicate that the greater part of the loss occurred from simple leaching out of the vitamins with the larger amounts of water, and that the greater part of the damage to the vitamins occurred within the first few minutes of cooking. Thiamine has long been considered more sensitive to high temperatures for long periods of time than are the other B vitamins. But in this case, the temperature did not rise above boiling, and the cooking time of only one hour did not cause significantly greater loss. The retention of ascorbic acid was most seriously affected by the prolonged cooking, probably a result of the combined effects of continued heating and oxidation. Teply and Derse (*10*), in a continuation of the work published by Burger *et al.* (*3*) on commercially frozen vegetables, found the retentions of thiamine and riboflavin to be about 10% less by their method of cooking—$^1/_2$ cup of water per 10-ounce package—than by the steam-boil method used in the present study, and those of niacin, vitamin B_6, folic acid, and ascorbic acid to be about 20% less. Retention of pantothenic acid was about equal in the two methods of cooking. Teply and Derse (*10*) recovered a small percentage of the vitamins in the left-over liquor, but the amount was not equal to the total lost in the cooking process. Many cooks refuse to save the liquor for use in other cooking, and thus retain only the nutrients that actually remain in the solid part of the food.

While amounts of nutrients in different batches of beans vary as result of experimental error, variations in treatment from one batch to another, variations in the beans themselves, and other conditions, some general conclusions can be drawn in regard to total losses of nutrients that may be expected from different methods of processing combined with the losses resulting from commonly recommended home cooking methods. Summarizing and rounding off the percentage losses of certain vitamins found in the Stanislaus County beans, where 28% salt brine was used, and in the laboratory-prepared beans, also processed with 28% salt brine, it seems reasonable to say that beans processed in this manner can be expected to lose the following percentages of nutrients: thiamine, 50 to 70; riboflavin, 40 to 60; niacin, 25 to 50; vitamin B_6, 20 to 30; pantothenic acid 30 to 35; and ascorbic acid, 50. The vitamins that remain in the commercially frozen product are further depleted by use of $^1/_2$ to 1 cup of cooking water, at the following percentages: thiamine, 15 or 35; niacin, 25 or 35; vitamin B_6, 25 or 35; pantothenic acid, 15 or 35; and ascorbic acid, 35 or 45. When the processing and cooking losses are combined, the figures become rather startling. No doubt similar losses occur in other frozen vegetables when improperly handled. Of the vegetables, only Lima beans and peas are subjected to brine processing. Fresh vegetables are also subjected to similar cooking procedures as well as storage losses.

A survey of cooking directions on 10-ounce packages of commercially frozen beans shows that a majority of the brands recommend starting the beans to cook in 1 cup of boiling water and cooking covered for 12 to 14 minutes; a few brands recommend the use of $^1/_2$ cup of water in directions otherwise the same. None was found which recommended less water. Teply's workers, using $^1/_2$ cup of water per package, achieved significantly better retention of the vitamins and minerals than we did in the current study, using 1 cup of water, but we achieved better retention than did Teply *et al.* when we used $^1/_6$ cup of water per package. The use of a steamer would save the vitamins equally as well as does steam-boiling in an ordinary tightly covered pan.

Acknowledgment

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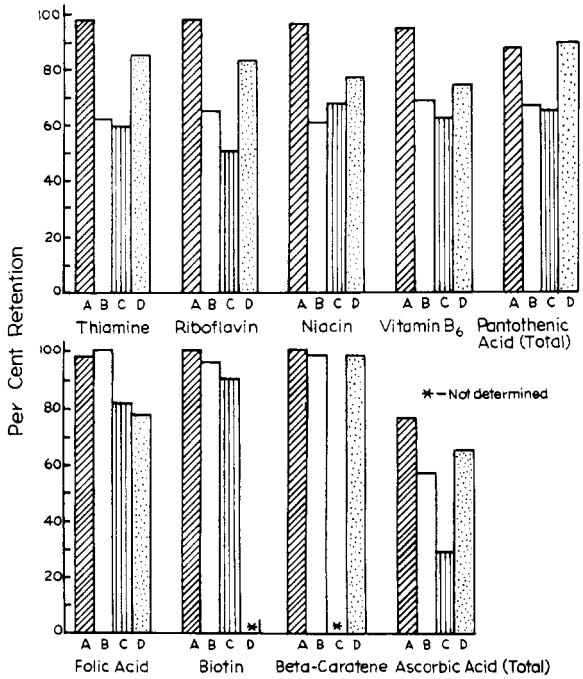

Figure 2. Percentage retention of B vitamins and ascorbic acid in frozen beans cooked by various methods

Calculated on basis of corresponding uncooked, frozen beans
A. Cooked 15 minutes by "steam-boil" method using 1/6 cup of water per 10-ounce package
B. Cooked 15 minutes by package directions—1 cup of water per package
C. Overcooked. Cooked 1 hour in 1 cup of water
D. Teply and Derse (10)

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STORAGE EFFECTS ON WINTER SQUASHES

Associations between the Sugar and Starch Content of and the Degree of Preference for Winter Squashes

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Six varieties of winter squashes were studied to determine the differences between and effect of storage on the total sugar and starch content and the extent to which varietal differences and changes in these constituents were associated with preference. Increases in total sugar content resulted in varietal differences during storage. Varietal differences in starch content varied depending on the extent and rate of decrease in starch during storage. While the major sugar accumulation occurred within the first 5 weeks of storage with little or no change thereafter, starch decreased in an exponential fashion throughout storage. The sugar-starch ratio was approximately the same for all six varieties at harvest, and increased to approximately 1.00 after 5 weeks of storage. Subsequent increases in the ratio, due primarily to continuous decrease in starch, differed between varieties. Varietal differences in acceptability appear to be related to the sugar-starch ratio and total solids content as well as the absolute amount of total sugar and starch.

For many years it has been an accepted practice to store winter squashes for a period after harvest, preliminary to marketing. This practice is based not only on economic considerations, but also on the assumption that due to certain chemical changes, the eating quality of winter squashes is improved during this storage. This study was made to provide additional data on the effect of storage on, and the differences between, the total sugar and starch content of six varieties of winter squashes and to determine the extent to which varietal differences and changes in these constituents were associated with changes in preference.

Since 1905, when LeClerc du Sablon reported a decrease in total solids and starch content and an increase in total sugar content of fruits of cucurbits during storage (*13*), various reports have appeared in the literature to confirm these findings.

Probably, the most elaborate study to date on the composition of Cucurbita fruits was conducted by Culpepper and Moon (*2*). Thirty-six varieties of pumpkin and winter squashes were grown from 1 to 4 years. Chemical analyses were conducted at different stages of development and after different periods of storage and the findings were analyzed statistically to determine differences between and among varieties and the effect of storage on the constituent content. Varietal differences in total solids and total starch at harvest were apparent as were the differences in the rates of decrease during storage. On the average, two thirds of the decrease in total solids and one half of the decrease in total starch occurred in the first 4 weeks of storage. The major increase in total sugar occurred, on the average, during the first 4 weeks of storage, but this average is not too meaningful since there were wide varietal differences at harvest and the rate of increase varied considerably between varieties. Varieties relatively high in total starch at harvest tended to be the varieties relatively high in sugar following storage.

These authors also found that varietal differences in total sugar, starch, and solids content at harvest and during storage were related to the flavor, consistency, and appearance of many of the squashes. Thus both variety and length of storage were important factors in selecting winter squashes for a specific culinary use.

Cummings and Stone (*4*) found that with Blue Hubbard squashes edibility tests, substantiated by chemical analyses, showed that specimens of good quality contain more carbohydrates and less water than do others of poor quality. Yeager and Latzke (*16*) found high positive correlation coefficients between dry matter and texture, dry matter and high quality, total sugars and high quality, and total sugar and sweetness in Buttercup squashes.

This paper presents the findings of comparisons between the sugar and starch content of six varieties of winter squashes, the changes during 25 weeks of storage, the relative preference for these six varieties, and associations between and among the relative preference