EFFECTS OF CERTAIN CALCIUM TREATMENTS ON THE QUALITY OF FROZEN GREEN BEANS

by

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INTRODUCTION

Green snap beans are found in many Kansas gardens, but their period of production is short. Since they are a popular vegetable, many homemakers would like to have a supply of green beans all year around. Freezing is continually increasing in popularity as a method of preserving a surplus of home-grown fruits and vegetables, and frozen green beans are more like fresh beans than those preserved by other methods. However, many homemakers hesitate to freeze them because of the flabby, watery texture and sloughed appearance of the frozen beans after cooking. It was considered desirable, therefore, to attempt to develop a simple pre-freezing treatment for green beans that would insure retention of the texture and appearance of the fresh bean.

Calcium chloride has been found beneficial in improving the texture of such foods as canned tomatoes and frozen apple slices, and it seemed possible that calcium chloride also could be used to improve frozen green beans. The present study was undertaken to determine the palatability and ascorbic acid content of green beans treated with calcium chloride solutions of varying concentrations. The beans were subjected to the solutions by: (1) blanching in a given solution or (2) soaking in the solution before or after blanching.

REVIEW OF LITERATURE

Characteristics Desired in Green Snap Beans to be Frozen

As with other fruits and vegetables, various varieties of green snap beans have been developed to suit different commercial and home requirements. For some time, the canning industry and the fresh vegetable retail markets regulated the desired characteristics of green snap beans. The increased market for frozen products, however, has brought with it a demand for a new kind of product.

Singleton (1951) stated that it was difficult to find a variety of green bean that was entirely suitable for freezing. He explained that the bean must have enough fibers to prevent its losing its shape, yet must not be tough. Both Singleton (1951) and Gould (1954) emphasized that the flesh of the bean must fit closely around the seed, because this factor may decide the firmness of the cooked product. Gould believed that there was a definite correlation between the presence of cavities around the seed, and sloughing of the outer skin after freezing. Gould (1954) and Singleton (1951) agreed that for optimum appearance the skin must not slough after processing.

Gould (1954) preferred a bean with a round, straight pod and small seeds. Tucker (1948) found that beans of the Tendergreen variety gave a good frozen product, and Singleton (1951) agreed that of all the beans he tested, this variety was nearest to meeting the qualifications desired by commercial packers. Tucker (1948) also stated that the bush beans tested, including Greenpod

and Tendergreen, were preferred to the pole varieties such as Kentucky Wonder. This latter type of bean is wide and flat, and rated poor because of appearance.

Plant Structure and Treatment with Calcium Salts

Plant structure and composition are important factors in the behavior of maturing plant products. According to Lowe (1955), cellulose and pectic substances constitute the structural part of a plant. Kertesz (1951) described protopectin as a water insoluble substance that binds together immature fruit and vegetable cells. An enzyme designated as protopectinase hydrolyzes protopectin to soluble pectic products, resulting in the separation of plant cells from each other. As the plant tissue matures, and smaller polygalacturonic acid molecules replace the parent protopectin molecules, the tissue loses its structure and becomes soft.

Calcium treatment to retain the original texture of a fruit or vegetable has been used successfully with a variety of canned and frozen products. Working with tomatoes, Kertesz (1939b) first explained the mechanism of calcium firming of plant tissue. He believed that the calcium acted by being available to form calcium pectate when pectin in the tissue was demethoxylated to pectic acid. The formation of an insoluble calcium pectinate supported the tomato against softening and disintegration. Work by Loconti and Kertesz (1941) and Baker (1947) confirmed this idea of the role of calcium in the retention of tissue firmness.

Kertesz (1948) especially emphasized the growing importance

of calcium treatment to the tomato canning industry, whereas, Rhodes, et al. (1945), in England, have reported developing a calcium chloride treatment to prevent canned potatoes from breaking up during processing. Powers, et al. (1950) reported significant firming of canned pimientos when calcium chloride was added to the can. Kertesz (1948) believed that calcium treatment could prevent disintegration of asparagus tips during cooking.

Good results with calcium treatment of peaches, strawberries, maraschino cherries, and other small fruits were reported by Kertesz (1948). Erikson and Boyden (1947) found that addition of calcium chloride to the can improved the texture of plums and raspberries. Board and Seale (1954) stated that the use of calcium chloride in the sirup of canned bananas improved their texture and reduced the cloudiness of the sirup.

The application of calcium salts has been less extensive with frozen than with canned products. Calcium treatment of frozen apples is common, however. Powers and Esselen (1946); Hills, et al. (1947); Morris (1953); Esselen, et al. (1947); Rasmussen, et al. (1948); Esselen, et al. (1949); Kilby and Brown (1949); and Stirton and Hills (1950) all have reported on satisfactory retention of firmness in frozen apples treated with calcium chloride. According to Kertesz (1950), frozen apple slices have become commercially popular. They are used for pies and for ice cream containing bits of apple.

Kertesz (1939b) stated that even frozen tomatoes were greatly improved in texture when they were soaked in a solution of calcium chloride before being frozen. He said, however, that poor results

were obtained when pears were treated with calcium, since the texture change produced was not that associated with the fresh fruit. Two European investigators, Gerber and Kessler (1950), reported successful results when apricots were treated with calcium chloride before freezing.

Erikson and Boyden (1947) found that the ascorbic acid content of frozen strawberries, raspberries, and gooseberries treated with calcium chloride was higher than that of untreated samples. However, the increase in ascorbic acid retained was not in proportion to the amount of calcium chloride used.

No work was found concerning the treatment of green snap beans with calcium salts.

Application of Calcium Chloride

Several methods have been used to apply calcium chloride to foods. According to Kertesz (1939a), canned tomatoes were most frequently treated by adding calcium tablets to the can before closing.

Hills, et al. (1947) studied five methods for applying calcium salts to frozen apples. The methods examined were: (1) and (2) dipping in a solution of calcium chloride either before or after blanching, (3) blanching in a boiling solution of calcium chloride, (4) covering the blanched apple slices with a sirup containing the calcium salt, and (5) evacuating the air and impregnating the slices with the calcium solution before blanching. From the standpoint of ease of application and the uniformity of

the product obtained, the authors preferred dipping in the calcium chloride solution before blanching.

Kilby and Brown (1949) believed that for whole apples, the evacuation and impregnation method was more successful than the dip method. The amount of time consumed in the treatment was a disadvantage, however. Stirton and Hills (1950) cooled apple slices in the calcium chloride solution after blanching. Gerber and Kessler (1950) treated apricots in the same manner. This method of treatment proved successful for both fruits.

Concentration of Calcium Chloride Solutions

The literature indicates that the optimum concentration of the salt used and the time of contact with the product being treated varied with the product, the condition of the product, and the method of application employed.

Hills, et al. (1947) obtained satisfactory results by treating apple slices with solutions that varied from 0.2 percent to 1.0 percent calcium chloride. They also reported that the time of contact of the product and solution varied from two to 30 minutes with no appreciable difference in the degree of firmness of the apple slices. According to Esselen, et al. (1949), cubed fresh apples dipped 15 minutes in a solution containing 0.1 percent calcium chloride were frozen satisfactorily. The cooling bath used by Gerber and Kessler (1950) in processing apricots contained only 0.02 percent calcium chloride. Powers and Esselen (1946) varied the concentration of the solution used to treat apple slices from

0.03 percent to 1.5 percent, depending on the processing method. Rhodes, et al. (1945) reported soaking potatoes for one hour in 2 percent calcium chloride solution. Kertesz (1948) also mentioned that solutions used to treat potatoes were more concentrated than for other products.

The maturity and softness of the fruit being processed was found to be important in studies conducted on apples by Kertesz (1950); Morris (1953); and Powers and Esselen (1946). Apples that were mushy before freezing could not be satisfactorily treated under any conditions, and higher concentrations of the calcium salt were required for riper fruit than for firmer fruit.

Kertesz, et al. (1940) found that unpeeled tomatoes would not take up enough calcium to affect the firmness of the flesh. Likewise, Kertesz (1948) stated that peaches must be treated after peeling.

The Use of Other Calcium Salts

Although calcium chloride has been used most often in studies relative to the retention of texture in frozen and canned products, other calcium salts also have been tried and recommended. Hills, et al. (1947) considered calcium acetate slightly more effective than calcium chloride in treating apple slices, whereas they found that calcium gluconate and calcium chloride were equally effective when they were used as solutions with the same concentration of calcium ions. Similarly, comparison of several calcium salts in the treatment of canned and frozen apple slices

by Holgate and Kertesz (1948) showed that calcium chloride, phosphate, citrate, malate, and lactate were comparable in effectiveness when used in solutions containing an equal percentage of calcium. The firming effect and the calcium uptake, however, indicated a slight superiority of calcium lactate when compared to the other salts. Products treated with phosphate, malate, and lactate did not show the slight salty flavor sometimes noticed in calcium chloride treated products.

In further work Kertesz (1950) found that calcium lactate was preferable to calcium chloride for apples, in spite of the fact that calcium lactate was more expensive and more was needed to furnish the same amount of calcium ions. He believed that it was less apt to cause corrosion of metal equipment used to treat either canned or frozen products. Atkinson (1941) felt that the use of calcium chloride resulted in tomatoes with a superior appearance when compared to the appearance of tomatoes treated with calcium citrate.

Relationship of Drained Weight to Retention of Firmness

In many studies the recording of the drained weight of products treated with calcium salts has been considered essential. Erikson and Boyden (1947) stated that drained weights were taken because they were directly related to the firmness of the treated product. Powers, et al. (1950) reported that the greater the firmness of canned pimientos, the higher the drained weights. Atkinson (1941) mentioned that calcium citrate gave slightly higher drained weights for tomatoes than did calcium chloride. According

to Kertesz (1939a) the addition of increased quantities of calcium chloride to the tomato can before closing resulted in increased quantities of calcium being taken up by the tomato flesh. The drained weights also increased as the concentration was raised.

Ascorbic Acid Contents of Some Green Beans

The nutritive content of a vegetable is important in determining the value of the product as food. The ascorbic acid content of fruits and vegetables is widely used as a criterion to the nutritive value and over-all quality. Fenton (1940) explained that ascorbic acid was more easily destroyed or dissolved from foods than were other vitamins. Therefore, if a large proportion of the original ascorbic acid content was retained, other factors making up the quality of the food also should be retained.

A wide range of ascorbic acid values of fresh green snap beans has been reported. Many factors, including variety, season harvested, and storage temperatures before processing, were found to affect the ascorbic acid content of fresh beans. Tucker (1948) found that samples of raw Logan beans contained only 14.6 mg ascorbic acid per 100 g of sample, whereas Bountiful beans contained 20.2 mg per 100 g. Wade and Kanapaux (1943) reported that Bountiful beans had the highest ascorbic acid content of the varieties they studied. Varieties examined by Mack, et al. (1939) contained from nine to 28 mg ascorbic acid per 100 g.

The ascorbic acid content varied among varieties and with the season in which green beans were harvested. Strains grown in South Carolina by Wade and Kanapaux (1943) contained an average of

14.1 to 28.7 mg ascorbic acid per 100 g of the vegetable in the spring and from 16.2 to 26.4 mg per 100 g in the fall. On the other hand Heinz, et al. (1944) reported that the average ascorbic acid content of South Carolina bush beans harvested in the spring ranged from 23 to 33.2 mg per 100 g, and that of pole beans averaged from 21.6 to 38.2 mg per 100 g. During the fall, bush beans contained from 16.2 mg to 33.1 mg per 100 g and pole beans ranged from 17.9 to 31.2 mg per 100 g. Raw Burpee Stringless Greenpod beans tested during two seasons in Montana by Mayfield and Richardson (1939) had an average ascorbic acid content of 27 and 19 mg per 100 g for spring and fall, respectively.

Wade and Kanapaux (1943) believed that storage temperature before processing was important to the retention of ascorbic acid. In their work, green beans held at room temperature dropped sharply in ascorbic acid content after only 48 hours of storage. Beans held under refrigeration, however, gradually decreased in ascorbic acid during 72 hours of storage. Paul, et al. (1949) also found that after picking, immediate refrigerator storage gave better ascorbic acid retention than continued holding at field temperature. Mack, et al. (1939) stated that raw green beans lost ascorbic acid during storage at all temperatures, but higher temperatures were correlated with higher losses. Garden fresh raw Tendergreen beans tested by Burrell and Ebright (1940) contained 45.3 mg ascorbic acid per 100 g. Similar beans purchased from a retail market by the same investigators contained only 19.5 mg per 100 g.

Mack, et al. (1939) discovered a relationship between the

stage of maturity and the ascorbic acid content of green beans. The least ascorbic acid occurred in beans of the mature marketable stage. Wade and Kanapaux (1943) however, found no significant difference in the ascorbic acid content of small, medium, and large beans.

PROCEDURE

Preliminary Studies

No reports were found in the literature relative to the use of calcium chloride in the freezing of green beans, hence preliminary work was needed before the main investigation could be started. Tests were made to establish: (1) methods of applying calcium solutions to the beans, (2) the length of time the beans would be subjected to the solutions, (3) the concentration of calcium salt, and (4) the kind of calcium salt to use.

The green beans used for the preliminary study were purchased at a local retail market on the day of processing. Duplicate control samples, i.e., those blanched in boiling water without calcium treatment, and at least two samples of beans for each of the two to six pre-freezing treatments being tested were prepared at one time. After at least 24 hours in a home freezer (-20° F.), the beans were cooked in 70 ml of water containing one g of salt for eight to nine minutes. A panel of experienced judges scored and commented on the cooked samples. The palatability scores were used as an indication of the desirability of further work with a specific treatment.

Twenty-two pre-freezing treatments were evaluated, and six of them were selected for the main part of the study. A description of each of the treatments that were chosen follows:

A. Control- blanched in boiling water, then cooled in cold running water for two minutes.

B. Blanched in a 1 percent solution of calcium chloride, then cooled in cold running water for two minutes.

C. Blanched in a 2 percent solution of calcium chloride, then cooled in cold running water for two minutes.

D. Dipped two minutes in a 1 percent solution of calcium chloride, then blanched in boiling water and cooled in cold running water for two minutes.

E. Dipped two minutes in a 10 percent solution of calcium chloride, then blanched in boiling water and cooled in cold running water for two minutes.

F. Blanched in boiling water, cooled on ice for three minutes, then dipped in a 1 percent solution of calcium chloride for two minutes.

The time of blanching was two minutes for each treatment.

The Main Experiment

Design of the Experiment. The six pre-freezing treatments selected as a result of preliminary work were applied to green beans processed one day each week over a period of four weeks in

the early summer of 1955. The order in which beans were processed by a given treatment is presented in Table 1.

Table 1. Order of processing the green beans.

Treatment	Blocks (days) I	II	III	IV
A	5	5	4	2
B	4	4	3	1
C	1	3	1	6
D	6	6	5	4
E	2	2	6	5
F	3	1	2	3

Preparation of Samples. Green snap beans, Topcrop variety, raised by the Department of Horticulture, were picked and delivered to the foods laboratory on the morning the beans were processed. A sufficient quantity was obtained to permit sorting and selecting beans of near optimum maturity and quality for freezing. The green beans were handled as rapidly as possible from the field to the freezer in order to allow maximum retention of palatability and ascorbic acid.

The beans were washed, dried on cheesecloth, and snapped into pieces approximately 1.5 inches long. Each day of processing, 38 100-g portions of beans were weighed into cheesecloth squares to facilitate handling throughout the pre-freezing treatment. Thirty-six of these portions were divided into six lots of six samples each, and the pre-freezing treatments were assigned at random to

the six lots. Two samples from each treated lot were refrigerated (from two to four hours) after the pre-freezing treatment was completed. These samples were used for palatability tests and determination of drained weight and ascorbic acid on the day of processing. The other samples were frozen and two from each lot were tested after 24 hours and three months of frozen storage.

The two remaining 100-g portions of beans were refrigerated (from two to four hours) until they were cooked and tested for palatability, drained weight, and ascorbic acid content. These untreated samples provided reference material useful in evaluating data collected on the treated beans.

Blanching and Dipping. USP (Granular) $CaCl_2.2\ H_2O$ was used to make up solutions of 1, 2, and 10 percent by weight. A separate lot of solution was prepared for each group of six samples. This procedure helped to prevent lowering the percent of calcium available for treating the beans.

All samples were blanched two minutes in boiling water or a calcium chloride solution, depending on the treatment being applied. Twelve-quart aluminum kettles with lids were used for blanching. The blanching liquid was brought to a rolling boil before placing the 100-g samples in the kettle, and the blanching process was timed from the instant the liquid returned to a rolling boil.

Calcium solutions used in treatments requiring dipping were made up in four-quart enamel kettles. One sample at a time was placed in the kettle so that there was ample room for circulation of the solution about the sample.

Packaging and Freezing. After being treated, each sample was dried on cheesecloth. The green beans then were placed in pliofilm bags, two by four by eight inches, excess air was removed from the bags, and they were "goosenecked" and fastened tightly with plastic covered wire strips. Duplicate samples were placed in labeled cardboard freezer boxes for protection during storage. Immediately after packing the boxes were placed on the coils of a home freezer maintained at -20° F. Samples stored for three months were held in the same home freezer.

Palatability Tests. A cooked sample of fresh, untreated beans and a sample from each of the treated lots, cooked without freezing, were tested for palatability on the day of processing. A sample of each of the treated lots of green beans also were tested for palatability after 24 hours and three months of frozen storage.

The beans were cooked in one-pint covered aluminum saucepans containing 70 ml of water and one g of salt. When the water reached a rolling boil, the beans were added and the lids of the pans replaced. In order to quickly return the water to a rolling boil, the cooking was done on a high gas flame for the first minute. The flame was then regulated by sight to a low position, and cooking was continued until the beans were tender when pierced with a fork. Fresh and frozen treated beans were cooked over the low flame for seven minutes, and the fresh untreated beans for 14 minutes.

At the end of the cooking period, the beans were lifted from the saucepan with a stainless steel fork and placed in a numbered, shallow, white china bowl. The dishes were covered with saucepan

lids to keep the samples warm and to prevent excess evaporation from the surface of the beans.

The panel of four to seven experienced judges who scored the products observed each sample, then removed portions of the sample for individual tasting and scoring. The scorecard shown in Form I (Appendix) was used throughout the study.

Determination of Ascorbic Acid and Drained Weight. A modification of the method developed by Loeffler and Ponting (1942) was used to obtain values for the ascorbic acid content of the beans. The changes in their method which were made for the present study were: (1) an increase in the size of the sample from 25 or 50 g to 100 g, (2) the addition of five ml of diluted filtrate to five ml of dye instead of adding nine ml of dye to one ml of filtrate, and (3) the substitution of a Klett-Summerson photoelectric colorimeter for the Evelyn photoelectric colorimeter.

All samples tested for ascorbic acid were cooked on a three-speed electric hotplate. A one-pint aluminum saucepan with a vented lid was used for cooking. The hotplate was turned on high, and 70 ml of distilled water were added to the saucepan and brought to a rolling boil. A 100-g sample of beans was added, and heating was continued on high until the liquid had returned to boiling. The green beans were cooked one minute on high, then turned to low for seven minutes.

At the end of the cooking time, the sample was removed from the saucepan and emptied into a large sieve. The cooking liquid was allowed to drain into a graduated cylinder for one minute, then the weight of the drained sample, in grams, and the volume of the

drained liquid, in milliliters, was noted and recorded.

Next both the liquid and solids were placed in a Waring Blendor jar, and a few drops of butyl stearate were added to prevent foaming during blending. One percent metaphosphoric acid was added until the jar was one-fourth to one-third full, and the sample was blended for five minutes. The blended material was then rinsed into a 1000-ml volumetric flask with 1 percent metaphosphoric acid, made up to volume with acid, and mixed by inverting ten times.

A clear filtrate for analysis was obtained by filtering the blended sample through fluted filter paper (#1 Whatman) into a 125-ml Erlenmeyer flask. The first portion of the filtrate that ran through the filter was discarded, thus only the clearest liquid remained.

The clear filtrate was analyzed using a procedure similar to that followed in standardizing the dye (Appendix). Unless the dye had been prepared the same day, it was always checked by repeating the blank reading before starting the ascorbic acid analysis. If the previous blank reading did not coincide with the one obtained that day, the dye was restandardized.

Correction for turbidity was accomplished by mixing five ml of the diluted filtrate with five ml of distilled water and adjusting the colorimeter to zero. Dilutions of the filtrate were necessary to bring the colorimeter readings within the range observed when standardizing the dye. The mg of ascorbic acid present in 100 g of sample and cooking liquid were calculated by the following formula:

$$\frac{\text{ascorbic acid factor} \times \text{corrected unknown reading} \times \text{dilution}}{\text{five ml}} = \text{mg of ascorbic acid / 100-g sample}$$

RESULTS AND DISCUSSION

Palatability

The mean palatability scores are presented in Table 2, and detailed data are given in Tables 8, 9, and 10 (Appendix). There were no consistent differences among the scores for beans given the various treatments. Furthermore, statistical analysis of appearance, flavor, and texture scores failed to show any significant differences among the treatments (Table 3). Therefore, the calcium treatments could not be related to any improvement in the palatability of frozen green beans.

Mean scores reflected a general deterioration in all the palatability factors with storage (Table 2), and statistical analyses showed that differences attributable to storage were very highly significant (Table 3). Calculation of least significant differences among storage means indicated that freezing per se was responsible for the differences caused by frozen storage (Table 4). The differences between the scores for the fresh and 24-hour frozen beans were highly significant, whereas differences in scores between those stored for 24 hours and three months were non-significant.

Table 2. Mean palatability scores of four replications of green beans[1] (possible range, -5 to +5).

Treatment	Frozen storage period	Palatability factors: Aroma	Appearance	Flavor	Texture	% acceptability
X	0 (fresh)	0.03	-1.28	-0.10	0.28	95.0
A	0 (fresh)	0.03	-0.40	-0.43	-0.10	95.0
	24 hrs	-0.25	-0.90	-0.68	-1.53	76.3
	3 mo	-0.08	-0.70	-1.20	-1.38	66.0
B	0 (fresh)	0.13	-0.53	-0.10	-0.15	90.0
	24 hrs	-0.10	-0.83	-0.70	-0.95	88.8
	3 mo	-0.30	-0.83	-1.20	-1.00	69.0
C	0 (fresh)	0.13	-0.33	0.05	0.23	85.0
	24 hrs	-0.03	-0.95	-1.08	-1.18	66.3
	3 mo	-0.10	-0.95	-0.78	-1.00	77.3
D	0 (fresh)	0.08	-0.23	-0.30	0.20	100.0
	24 hrs	-0.10	-0.80	-1.20	-1.28	76.3
	3 mo	-0.18	-0.75	-1.18	-1.23	71.0
E	0 (fresh)	0.13	-0.13	0.00	0.20	95.0
	24 hrs	-0.05	-0.50	-1.38	-0.93	76.3
	3 mo	-0.20	-1.10	-1.10	-0.98	71.0
F	0 (fresh)	0.20	-0.48	0.00	0.03	95.0
	24 hrs	-0.05	-0.98	-0.93	-1.33	82.5
	3 mo	-0.23	-1.25	-1.08	-0.85	77.3

[1] Means of daily average scores of the palatability panel

X - fresh, untreated beans
A - blanched in boiling water
B - blanched in 1% $CaCl_2$
C - blanched in 2% $CaCl_2$
D - dipped in 1% $CaCl_2$ before blanching
E - dipped in 10% $CaCl_2$ before blanching
F - dipped in 1% $CaCl_2$ after blanching

Table 3. Mean squares and significance for appearance, flavor, and texture scores; drained weight and ascorbic acid values, and percent retention of ascorbic acid.

Source of variation	D/F	Factors analyzed					
		Appearance	Flavor	Texture	Drained weight	Ascorbic acid mg/100 g	Ascorbic acid, % retention
Storage	2	2.32***	7.26***	11.62***	255.32***	5.6**	358.5**
Treatment	5	0.17 ns	11.62 ns	0.26 ns	5.55 ns	2.50*	147.8*
Storage x treatment	10	0.11 ns	0.35 ns	0.10 ns	5.23 ns	0.86 ns	48.6 ns
Other	1	1.25	1.67	3.85	47.72	26.61	0.0
Replication	3	2.84***	8.19***	11.60***	126.50***	19.68***	100.0 ns
Error	54	0.23	0.29	0.25	10.74	0.88	49.3

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

Table 4. Mean appearance, flavor, and texture scores, and drained weight values with storage as the source of variation.

Frozen storage period	Mean score			
	Appearance	Flavor	Texture	Drained weight
0 (fresh)	-0.34	-0.13	0.67	94.9
	**	**	**	**
24 hours	-0.82	-1.07	-1.07	90.1
	ns	ns	ns	ns
3 months	-0.93	-1.09	-1.20	88.6
	lsd* = 0.28	lsd* = 0.31	lsd* = 0.29	lsd* = 1.9

The mean aroma scores were not analyzed statistically, however, they decreased gradually during storage. They dropped less than did the scores of other palatability factors.

Mean texture scores for the treated fresh beans were slightly lower than the mean texture score for the untreated group. Therefore, some of the decrease in the desired texture of the green beans probably could be ascribed to the blanching process as well as to freezing. The mean appearance score of the untreated fresh green beans was lower than the scores of those cooked after being treated with the calcium solutions, either before or after frozen storage. This result may have been caused by the usual accentuation of bright color in green vegetables after they have been blanched. Continued storage was paralleled with a general decrease in mean appearance scores.

Drained Weight

Mean values for drained weights of the beans are given in Table 5. The detailed data are in Tables 11, 12, and 13 (Appendix).

Table 5. Mean drained weight and ascorbic acid values and percent retention of ascorbic acid of four replications of green beans.[1]

Value	Frozen storage period	Treatments						
		X	A	B	C	D	E	F
Drained weight	0 (fresh)	94.8	95.3	95.3	94.3	96.0	94.1	94.4
	24 hrs	---	91.8	88.4	88.3	91.4	91.0	89.8
	3 mo	---	90.0	88.8	89.8	87.6	88.3	87.5
Ascorbic acid, mg/100 g	0 (fresh)	13.25	9.74	10.81	11.11	9.58	10.80	10.60
	24 hrs	---	11.01	10.95	11.43	10.26	11.60	11.63
	3 mo	---	9.81	9.21	10.92	10.41	10.23	10.74
Percent retention	0 (fresh)	---	73.9	81.4	84.0	72.6	81.8	79.7
	24 hrs	---	83.3	82.7	87.4	77.8	88.3	87.4
	3 mo	---	74.1	69.3	82.8	78.5	76.8	80.9

[1] Means of daily average scores of the palatability panel

X - fresh, untreated beans
A - blanched in boiling water
B - blanched in 1% $CaCl_1$
C - blanched in 2% $CaCl_2$
D - dipped in 1% $CaCl_2$ before blanching
E - dipped in 10% $CaCl_2$ before blanching
F - dipped in 1% $CaCl_2$ after blanching

Drained weight values were similar for beans subjected to all treatments, and no significant differences were found when analyzing these values (Table 3). This indicated that there was little relationship between the calcium treatments and the retention of weight in the green beans.

A general decline in mean weights with frozen storage was apparent (Table 5). A highly significant difference was found between mean weights of beans tested after zero and 24 hours of frozen storage, but between 24 hours and three months the difference was non-significant (Table 4).

Ascorbic Acid Content and Percent Retention

Mean ascorbic acid values and percent retention of the ascorbic acid of the beans are given in Table 5, and detailed data are given in Tables 11, 12, and 13 (Appendix). The mean values for the ascorbic acid content and percent retention showed that treatment C was superior to the other treatments (Table 6). Mean values of beans given treatment A, the control, and of those given treatment D, dipped in 1 percent calcium chloride before blanching, were lower than the other four. Treatment C, beans blanched in 2 percent calcium chloride, resulted in significantly higher ascorbic acid retention than did B, blanched in 1 percent calcium chloride; A, blanched in boiling water; or D. Treatment F, dipped in 1 percent calcium chloride after blanching, was superior to A and D, and treatment E, dipped in 10 percent calcium chloride before blanching, was superior to treatment D.

Table 6. Mean ascorbic acid values and percent retention of the ascorbic acid with treatment as the source of variation.

Treatment	Mean: Mg/100 g	Mean: Percent retention
C	11.15	84.7
F	10.99	82.7
E	10.87	82.2
B	10.32	77.6
A	10.18	77.1
D	10.09	76.3
	lsd* = 0.77	lsd* = 5.7

The most noticeable change in mean ascorbic acid content and percent retention occurred between zero and 24 hours of frozen storage. The ascorbic acid content and percent retention increased significantly during that time, then it dropped back to essentially its original content at the end of three months of storage (Table 7).

Table 7. Mean ascorbic acid values and percent retention of the ascorbic acid with storage as the source of variation.

Frozen storage period	Mean: Mg/100 g	Mean: Percent retention
0	10.44	78.9
	**	*
24 hours	11.14 ns	84.5 ns
	*	*
3 months	10.22	77.0
	lsd* = 0.38	lsd* = 2.87

Replications

Although an effort was made to obtain beans of uniform quality for processing each day of the study, beans representing block IV were considered to be of poorer quality than the others. These beans had a hot, sunny growing period for approximately two weeks prior to picking, in contrast to the relatively cool and cloudy growing weather for the beans packed on the first three days. As a result, the last group of beans were larger than the others. Also, they were stringy, and had thin, paper-like pods with large seeds.

Analysis of variance of the scores for appearance, flavor, and texture indicated very highly significant differences in palatability of the beans distributed among blocks, and average palatability scores showed that these differences could be ascribed to the low scores given to beans from block IV (Table 3 and Tables 8, 9, and 10, Appendix). Very highly significant differences in the drained weight also were detected among the beans within the four blocks. This result apparently was caused by a greater moisture-retaining quality of the beans used for block IV.

Although there were also very highly significant differences in the ascorbic acid content of beans in the four blocks, due to those in block IV, there were no differences in the percent retention of ascorbic acid among blocks. This was because the values used as bases for calculating percent retention were considered to be representative of the ascorbic acid content of fresh, uncooked beans in each block.

Photographs of beans in block I taken at various stages of processing and at two storage periods are most representative of beans packed on the first three days of the experiment (Plate I). They illustrate the size and appearance of the fresh beans used in the experiment. Beans from block IV, photographed after three months of frozen storage, are shown in Plate II. The photographs reflect the differences in color and size between the beans in the first three blocks and those in block IV. The seeds from beans in block IV were large and dark. Photographs of the cooked samples show little difference in appearance of beans given the six treatments.

CONCLUSIONS

Since no treatment was less desirable than another from the standpoint of palatability, treatment C was preferred to others because it produced beans with the highest ascorbic acid content. It was also one of the easiest treatments to apply, which would be an advantage to the homemaker. However, even treatment C did not accomplish the primary purpose of the experiment which was improvement of the appearance and texture of frozen green beans. The beans given treatment C contained an average of one mg more ascorbic acid than the beans subjected to the other treatments. Although the mean ascorbic acid content for beans given treatment C was significantly higher than that for beans given three of the treatments, practically it would not justify the added expenditure of time necessary to apply the treatment. The homemaker would not

EXPLANATION OF PLATE I

Fig. 1. Freshly harvested green beans, block I.

Fig. 2. Fresh green beans after cleaning and snapping, block I.

Fig. 3. Freshly cooked green beans before freezing, block I.

(1) No treatment (X)

(2) Treatment A

(3) Treatment B

(4) Treatment C

(5) Treatment D

(6) Treatment E

(7) Treatment F

PLATE I

Fig. 1.

Fig. 2.

Fig. 3.

EXPLANATION OF PLATE II

Fig. 1. Cooked green beans after three months of frozen storage, block I.

(2) Treatment A

(3) Treatment B

(4) Treatment C

(5) Treatment D

(6) Treatment E

(7) Treatment F

Fig. 2. Cooked green beans after three months of frozen storage, block IV.

(2) Treatment A

(3) Treatment B

(4) Treatment C

(5) Treatment D

(6) Treatment E

(7) Treatment F

PLATE II

Fig. 1.

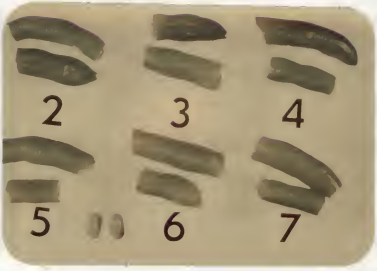

Fig. 2.

be able to see any improvement in palatability from calcium treatment, therefore the five calcium treatments studied in this experiment are not considered sufficiently advantageous to be recommended for home use.

SUMMARY

The purpose of the experiment was to attempt to improve the palatability of frozen green snap beans by treatment with calcium chloride before freezing. Freshly picked green beans, Topcrop variety, were given the following treatments during the processing prior to freezing: A - blanching in boiling water (control), B - blanching in 1 percent calcium chloride, C - blanching in 2 percent calcium chloride, D - dipping in 1 percent calcium chloride before blanching, E - dipping in 10 percent calcium chloride before blanching, and F - dipping in 1 percent calcium chloride after blanching. All beans were blanched and were cooled in water for two minutes, with the exception of the last treatment which was cooled three minutes on ice. Samples of each treatment were packed on four days during the early summer. They were tested for palatability, drained weight, and ascorbic acid content and the percent retention of the ascorbic acid after zero, 24 hours, and three months of storage in a home freezer maintained at -20° F.

Results indicated that there were no differences in the palatability of the green beans that could be attributed to the treatments administered prior to freezing. All palatability scores decreased with frozen storage, with highly significant differences occurring between zero and 24 hours of storage. Differences in

scores for beans stored 24 hours and three months were non-significant.

There were no significant differences in the drained weights of beans given different treatments, thus no relationship was established between the calcium treatments and retention of weight. Statistical analysis of drained weight values showed a highly significant decrease between fresh beans and those stored in the freezer for 24 hours, and a non-significant decrease between beans stored for 24 hours and three months.

Both ascorbic acid content of the beans and the percent retention of ascorbic acid in beans treated by method C were significantly higher than those for beans given treatments B, A, and D. Treatment F was significantly superior to A and D, and treatment E was significantly superior to D. A significant increase in ascorbic acid was noted after freezing, but the content returned to approximately the original level after three months of frozen storage.

The beans given treatment C contained an average of one mg more ascorbic acid than beans given other treatments. Although the mean ascorbic acid content for beans given treatment C was significantly higher than that for beans given three of the treatments, practically it would not justify the added expenditure of time necessary to apply the treatment. Since calcium treatment did not improve the palatability of frozen green beans, it would not be recommended as a practical home processing method.

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APPENDIX

FORM I

SCORE CARD

FROZEN FRUITS AND VEGETABLES

Date_____

Sample No._____

_____

Name_____

			1	2	3	4	5	6
1. Aroma	Use the following numbers as a guide for scoring							
2. Appearance Color Shape	Very superior	+5						
	Superior	+4						
	Moderately sup.	+3						
	Slightly sup.	+2						
	Very sl. sup.	+1						
3. Flavor	Standard	0						
	Very sl. inferior	-1						
	Sl. inferior	-2						
	Moderately inf.	-3						
4. Texture	Inferior	-4						
	Very inferior	-5						
Would you consider this as an acceptable product to serve at a meal?								

Comments:

Preparation of Solutions

Metaphosphoric acid. Metaphosphoric acid was prepared fresh on the day it was used. One hundred grams of metaphosphoric acid pellets were weighed and dissolved in distilled water. This solution was made up to volume in a 1000-ml volumetric flask and mixed by inverting 15 times. The resulting 10 percent solution of metaphosphoric acid was used to prepare a fresh solution of 1 percent metaphosphoric acid, which was used to protect the ascorbic acid during the extraction and analysis procedure. The 1 percent acid solution was prepared by mixing 900 ml of distilled water with 100 ml of 10 percent metaphosphoric acid in a 1000-ml stoppered graduated cylinder.

Dye. The solution referred to as dye was an aqueous solution of sodium 2,6-dichlorobenzenone indophenol dye. It was prepared by weighing out approximately 10 mg of dye on a chainomatic balance. The dye was brushed into a funnel containing #1 Whatman filter paper. Hot distilled water was poured over the dye, and the solution filtered into a 500-ml volumetric flask. When all of the dye was dissolved in the hot water, the solution was cooled to room temperature and made up to volume with distilled water.

Ascorbic acid. A standard solution of ascorbic acid was prepared to use in standardizing the freshly prepared dye. Exactly 25 mg of ascorbic acid (Cebione-Merck) was weighed, then brushed into a flask containing a small amount of freshly prepared 1 percent metaphosphoric acid. The flask was then made up to volume with 1 percent metaphosphoric acid and mixed by inverting 10 times.

Portions of three, four, and five ml were pipetted into 100-ml volumetric flasks, made up to volume, and used to standardize the dye. The three dilutions represented concentrations of three, four, and five μg respectively, per 100 ml of solution.

Standardization of the Dye

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

Next, the blank reading was obtained. This was done by quickly injecting five ml of 1 percent metaphosphoric acid into a test tube containing dye. The contents of the tube were quickly inverted and shaken, and a reading was taken within 15 seconds. This procedure was continued until two identical readings had been obtained from duplicate samples of acid. Those readings represented the blank reading. Duplicate readings were obtained for each of the three dilutions of ascorbic acid in the same manner, except that five ml portions of the ascorbic acid dilution were used instead of the 1 percent metaphosphoric acid. The purpose of using three dilutions was to establish the range in which the dye was most sensitive to the ascorbic acid. The detailed reaction of

the ascorbic acid was explained by Huguenard (1953).

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

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

Table 8. Average palatability scores for fresh green beans, zero frozen storage.

Treatment	Block	Palatability factors: Aroma	Appearance	Flavor	Texture	% acceptability
X	1	0.5	-0.8	1.0	0.8	100
	2	0.0	-1.3	-0.3	0.3	100
	3	0.0	-1.0	0.3	1.0	100
	4	-0.4	-2.0	-1.4	-1.0	80
	Av.	0.03	-1.28	-0.10	0.28	95.0
A	1	0.5	0.3	0.5	0.8	100
	2	0.0	-0.3	-0.5	0.3	100
	3	0.0	-1.0	-0.5	-0.3	100
	4	-0.4	-0.6	-1.2	-1.2	80
	Av.	0.03	-0.40	-0.43	-0.10	95.0
B	1	0.5	0.3	1.3	0.8	100
	2	0.0	0.0	0.0	0.3	100
	3	0.0	-1.0	-0.5	-0.3	100
	4	0.0	-1.4	-1.2	-1.4	60
	Av.	0.13	-0.53	-0.10	-0.15	90.0
C	1	0.5	0.0	1.3	0.8	100
	2	0.0	0.0	-0.8	0.3	100
	3	0.0	-0.5	1.3	1.0	100
	4	0.0	-0.8	-1.6	-1.2	40
	Av.	0.13	-0.33	-0.05	0.23	85.0
D	1	0.5	0.3	-0.3	0.8	100
	2	0.0	-0.3	0.0	0.3	100
	3	0.0	-0.3	0.3	0.5	100
	4	-0.2	-0.6	-1.2	-0.8	100
	Av.	0.08	-0.23	-0.30	0.20	100.0
E	1	0.5	0.3	0.8	0.8	100
	2	0.0	-0.5	0.5	0.3	100
	3	0.0	0.3	-0.5	0.3	100
	4	0.0	-0.6	-0.8	-0.6	80
	Av.	0.13	-0.13	0.00	0.20	95.0
F	1	0.8	0.3	0.5	0.8	100
	2	0.0	-0.5	-0.3	0.0	100
	3	0.0	-1.3	0.8	0.3	100
	4	0.0	-0.4	-1.0	-1.0	80
	Av.	0.20	-0.48	0.00	0.03	95.0

Table 9. Average palatability scores for green beans stored at -20° F. for 24 hours.

Treatment	Block	Palatability factors: Aroma	Appearance	Flavor	Texture	% acceptability
A	1	-0.3	0.0	-0.8	-1.3	100
	2	0.0	-0.7	0.3	-0.3	100
	3	-0.4	-1.4	-0.2	-1.0	80
	4	-0.3	-1.5	-2.0	-3.5	25
	Av.	-0.25	-0.90	-0.68	-1.53	76.3
B	1	0.0	0.0	-0.8	-0.8	100
	2	0.0	-1.3	0.3	-1.0	100
	3	-0.4	0.0	-0.8	-0.2	80
	4	0.0	-2.0	-1.5	-1.8	75
	Av.	-0.10	-0.83	-0.70	-0.95	88.8
C	1	0.5	-0.3	-1.0	-0.5	75
	2	0.0	-1.0	-0.7	-0.3	100
	3	-0.6	-0.2	-1.6	-0.6	60
	4	0.0	-2.3	-3.0	-3.3	25
	Av.	-0.03	-0.95	-1.08	-1.18	66.3
D	1	0.0	0.3	-0.3	-1.0	100
	2	0.0	-0.3	-1.0	-0.3	100
	3	-0.4	-1.4	-1.2	-0.8	80
	4	0.0	-1.8	-2.3	-3.0	25
	Av.	-0.10	-0.80	-1.20	-1.28	76.3
E	1	0.3	-0.3	-0.8	-0.3	100
	2	0.0	0.0	-0.7	0.0	100
	3	-0.2	-0.2	-1.2	-0.4	80
	4	-0.3	-1.5	-2.8	-3.0	25
	Av.	-0.05	-0.50	-1.38	-0.93	76.3
F	1	0.3	-0.5	-0.8	-0.8	100
	2	0.0	-1.3	0.0	0.0	100
	3	-0.2	-0.6	-0.6	-1.2	80
	4	-0.3	-1.5	-2.3	-3.3	50
	Av.	-0.05	-0.98	-0.93	-1.33	82.5

Table 10. Average palatability scores for green beans stored at -20° F. for three months.

Treatment	Block	Palatability factors: Aroma	Appearance	Flavor	Texture	% acceptability
A	1	0.3	-0.5	-0.5	-0.8	100
	2	-0.3	-0.8	-1.5	-1.0	67
	3	-0.1	-0.7	-1.4	-1.1	57
	4	-0.2	-0.8	-1.4	-2.6	40
	Av.	-0.08	-0.70	-1.20	-1.38	66.0
B	1	0.0	-0.8	-1.5	-0.5	75
	2	-0.5	-0.8	-1.2	-0.8	50
	3	-0.3	-0.7	-1.1	-1.3	71
	4	-0.4	-1.0	-1.0	-1.4	80
	Av.	-0.30	-0.83	-1.20	-1.00	69.0
C	1	0.3	-1.0	0.0	-0.5	100
	2	-0.2	-1.0	-0.5	-1.0	83
	3	-0.1	-0.6	-0.4	-0.9	86
	4	-0.4	-1.2	-2.2	-1.6	40
	Av.	-0.10	-0.95	-0.78	-1.00	77.3
D	1	0.3	-0.3	-0.8	-0.5	100
	2	-0.3	-0.8	-1.2	-1.3	67
	3	-0.3	-1.3	-1.1	-1.3	57
	4	-0.4	-0.6	-1.6	-1.8	60
	Av.	-0.18	-0.75	-1.18	-1.23	71.0
E	1	0.0	-1.3	-0.5	-0.8	100
	2	-0.3	-1.5	-1.2	-0.8	67
	3	-0.1	-1.0	-1.1	-1.3	57
	4	-0.4	-0.6	-1.6	-1.0	60
	Av.	-0.20	-1.10	-1.10	-0.98	71.0
F	1	0.3	-1.0	-0.5	-0.3	100
	2	-0.3	-1.5	-1.0	-1.0	83
	3	-0.3	-0.7	-1.0	-0.7	86
	4	-0.6	-1.8	-1.8	-1.4	40
	Av.	-0.23	-1.25	-1.08	-0.85	77.3

Table 11. Drained weight and ascorbic acid values, and percent retention of the ascorbic acid for fresh green beans, zero frozen storage.

Treatment	Block	Drained weight	Ascorbic acid: mg/100 g	Ascorbic acid: % retention
X	1	95.5	12.50	---
	2	95.0	11.96	---
	3	93.5	13.14	---
	4	95.0	15.40	---
	Av.	94.8	13.25	---
A	1	93.5	9.37	75.0
	2	94.0	9.75	81.5
	3	94.5	9.30	70.8
	4	99.0	10.52	68.3
	Av.	95.3	9.74	73.9
B	1	93.5	10.71	85.7
	2	96.0	9.02	75.4
	3	93.5	10.79	82.1
	4	98.0	12.71	82.5
	Av.	95.3	10.81	81.4
C	1	93.0	10.47	83.8
	2	95.0	9.57	80.0
	3	93.0	12.40	94.4
	4	96.0	11.98	77.8
	Av.	94.3	11.11	84.0
D	1	94.5	9.24	73.9
	2	95.0	9.20	76.9
	3	94.5	9.49	72.2
	4	100.0	10.40	67.5
	Av.	96.0	9.58	72.6
E	1	94.5	11.97	95.8
	2	93.0	9.38	78.4
	3	93.0	9.85	75.0
	4	96.0	11.98	77.8
	Av.	94.1	10.80	81.8
F	1	93.5	10.49	83.9
	2	92.5	8.83	73.8
	3	93.5	10.17	77.4
	4	98.0	12.90	83.8
	Av.	94.4	10.60	79.7

Table 12. Drained weight and ascorbic acid values for green beans stored at -20° F. for 24 hours.

Treatment	Block	Drained weight	Ascorbic acid mg/100 g	Ascorbic acid % retention
A	1	89.0	9.64	77.1
	2	94.5	10.30	86.1
	3	89.5	12.09	92.0
	4	94.0	12.00	77.9
	Av.	91.8	11.01	83.3
B	1	83.0	9.92	79.4
	2	85.5	10.49	87.7
	3	91.0	10.79	82.1
	4	94.0	12.58	81.7
	Av.	88.4	10.95	82.7
C	1	81.5	12.67	101.4
	2	98.0	10.67	89.2
	3	86.5	12.40	94.4
	4	87.0	9.96	64.7
	Av.	88.3	11.43	87.4
D	1	88.0	10.08	80.6
	2	88.5	10.12	84.6
	3	95.5	9.30	70.8
	4	93.5	11.55	75.0
	Av.	91.4	10.26	77.8
E	1	87.5	11.70	93.6
	2	94.5	11.04	92.3
	3	92.0	12.09	92.1
	4	90.0	11.55	75.0
	Av.	91.0	11.60	88.3
F	1	86.0	10.29	82.3
	2	90.5	10.67	89.2
	3	92.0	10.91	83.0
	4	90.5	14.63	95.0
	Av.	89.8	11.63	87.4

Table 13. Drained weight and ascorbic acid values for green beans stored at -20° F. for three months.

Treatment	Block	Drained weight	Ascorbic acid mg/100 g	Ascorbic acid % retention
A	1	82.0	8.83	70.6
	2	88.0	9.33	78.0
	3	94.0	9.70	73.8
	4	96.0	11.37	73.8
	Av.	90.0	9.81	74.1
B	1	87.0	7.73	61.8
	2	90.0	7.69	64.3
	3	87.0	10.44	79.5
	4	91.0	10.99	71.4
	Av.	88.8	9.21	69.3
C	1	80.0	11.78	94.2
	2	91.0	9.33	78.0
	3	90.0	11.00	83.7
	4	98.0	11.56	75.1
	Av.	89.8	10.92	82.8
D	1	80.0	9.94	79.5
	2	88.0	9.33	78.0
	3	92.0	10.07	76.6
	4	90.5	12.31	79.9
	Av.	87.6	10.41	78.5
E	1	90.0	10.67	85.4
	2	85.0	7.50	62.7
	3	87.0	10.07	76.6
	4	91.0	12.68	82.3
	Av.	88.3	10.23	76.8
F	1	81.0	10.30	82.4
	2	83.0	8.78	73.4
	3	91.0	11.56	88.0
	4	95.0	12.31	79.9
	Av.	87.5	10.74	80.9

EFFECTS OF CERTAIN CALCIUM TREATMENTS ON THE QUALITY OF FROZEN GREEN BEANS

by

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INTRODUCTION

Green snap beans are grown in many Kansas gardens, and homemakers would like to have a supply all year around. Many hesitate to freeze them because of the flabby, watery texture and sloughed appearance of the frozen beans after cooking. Since calcium chloride was beneficial in improving the texture of other foods, it was hoped that it also could be used to improve frozen green beans. The present study was undertaken to determine the palatability and ascorbic acid content of green beans treated by blanching or soaking in calcium chloride solutions of varying concentrations.

PROCEDURE

Freshly picked green beans, Topcrop variety, were given the following treatments during the processing prior to freezing: A - blanching in boiling water (control), B - blanching in 1 percent calcium chloride, C - blanching in 2 percent calcium chloride, D - dipping in 1 percent calcium chloride before blanching, E - dipping in 10 percent calcium chloride before blanching, and F - dipping in 1 percent calcium chloride after blanching. All beans were blanched and were cooled in water for two minutes, with the exception of the last treatment which was cooled three minutes on ice.

Samples of beans given each treatment were packed on four days during the early summer. They were tested for palatability, drained weight, ascorbic acid content and the percent retention of the ascorbic acid after zero, 24 hours, and three months of

storage in a home freezer maintained at -20° F.

RESULTS

Results indicated that there were no differences in the palatability of the green beans that could be attributed to the treatments administered prior to freezing. All palatability scores decreased with frozen storage, with highly significant differences occurring between zero and 24 hours of storage. Differences in scores of beans stored for 24 hours and for three months were non-significant.

There were no significant differences in the drained weights of beans given different treatments, thus no relationship was established between the calcium treatments and retention of weight. Statistical analysis of the drained weight values showed a highly significant decrease between the values for fresh beans and those stored in the freezer for 24 hours, and a non-significant decrease between the values of beans stored for 24 hours and for three months.

Both the ascorbic acid content of and the percent retention of ascorbic acid in beans treated by method C were significantly higher than those for beans given treatments B, A, and D. Treatment E was significantly superior to D. A significant increase in ascorbic acid was noted after freezing, but the content returned to approximately the original level after three months of frozen storage.

The beans given treatment C contained an average of one mg

more ascorbic acid than beans given other treatments. Although the mean ascorbic acid content for beans given treatment C was significantly higher than that for beans given three of the treatments, practically it would not justify the added expenditure of time necessary to apply the treatment. Since calcium treatment did not improve the palatability of frozen green beans, it would not be recommended as a practical home processing method.