FACTORS INFLUENCING THE VITAMIN C CONTENT AND PALATABILITY OF HOME DEHYDRATED GREEN BEANS

by

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CHAPTER I

INTRODUCTION

History reveals that during every period of great conquest, the pique of war has tended to combine the powers of business and industry for the production of newer methods and better materials. This present world-wide conquest has resulted in the development of many improved products in almost every phase of our economic system. The food industry is an example of one which has recently made startling and momentous advances--especially in the discovery of a successful method of dehydrating foods.

The development of dehydrated vegetables is the phase of this problem to be discussed here. The idea of drying vegetables is not new. According to Prescott, the Union Forces during the Civil War used vegetables, which had been dried and compressed into briquet form.[1]

After the close of the Civil War, we find little mention of dried foods, and it is not until during World War 1 that we again find reports of the thousands of pounds of dried vegetables that were served by the A.E.F. in France. Unfavorable comments about these products came back from the battle front; they were said to have been tasteless, tough, and often "hay-like" in both odor and flavor.

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[1] Samuel C. Prescott, "Dried Vegetables For Army Use," American Journal of Physiology, XXXXIX (1919), 573.

Again the dehydration industry experienced a "lull" and, with few exceptions, little research was carried on in this field until around 1940. During this year, the food technologists aroused to the demand for satisfactorily dried foods to meet the needs of the Army, Navy, and Lend-Lease.

The commercial development of satisfactorily dehydrated products has assumed its present place of prestige and importance quite rightfully for dehydration has many advantages, in war-time especially, over other well-known methods of food preservation. The development of satisfactory methods of dehydrating vegetables at home has been stimulated by many of the same factors which influenced the commercial producers. Some of the advantages of dehydrated foods are listed below.

First, dehydrated foods save space. Mrak reports that:

> "String beans, for example, weighing 1500 lbs. when prepared for canning or dehydration would weigh 3,822 lbs. when canned and packed as compared to 200 lbs. when dehydrated and packed."[2]

It is obvious, therefore, that when foods must be transported long distances and to varied milieu; or when shipping and storage space are at a premium, the production of dehydrated vegetables equal to canned vegetables in quality but yet having a weight of 1/18 to 1/5 less and a volume from 1/3 to 1/9 less is desirable.

Another advantage of dehydrated foods is that they require less material for containers. For shipment abroad

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[2]E. M. Mrak, "Developments in Dehydration," American Dietetics Association Journal, XIX (1943), 7.

the tin can has been shown to be the ideal package. This is not disadvantageous, as it might first appear, since the ratio of tin needed to adequately package the dehydrated foods is quite small in comparison to the ratio needed to adequately package the same amount of food preserved by other methods. The use of tin in the packaging of home dehydrated foods, however, may be eliminated entirely since there are several kinds of materials--such as glass jars, waxed paper, specially treated cardboard, and others, which have been found to be especially adaptable to home storage methods.

Other advantages of dehydrated foods are that they require no sugar in preserving; are economical to process; have good keeping qualities if properly stored; and require a minimum investment in equipment.

It might be remembered however, that the overwhelming acceptance of dehydration as an outstanding method of preserving food in the home has been hindered by its disadvantages. Because of a lack of perfected methods and techniques, home dehydrated vegetables are often inferior in quality--both esthetically and nutritionally; they require a period of rehydration; the duration of their storage is limited; and they are subject to insect infestation if improperly stored.

In spite of these hindrances, however, the process is outstandingly practical as a "supplement" method of preserving the enormous quantities of food necessary to meet the demands of this emergency period.

The continued employment of dehydration as a method of home preservation of food after the war will depend upon the

successful completion of the following steps: (1) choice of a suitable variety of raw material, (2) proper culturing and growth of the raw material, (3) harvesting at optimal stage of maturity, (4) immediate use of harvested vegetable, (5) proper preparation, (6) immediate and proper dehydration, (7) immediate and proper packaging, and (8) proper storage. The unsuccessful completion of any one step may cause the resultant product to be undesirable--even to the extent of being inedible.

The prime consideration in the home dehydration of vegetables is the attaining of a product, through successful methods of processing, which is equally desirable from a nutritive and esthetic standpoint as the same food preserved by any other method. The scope of the problems involved is almost limitless, for each of the eight steps just mentioned in the foregoing paragraph offers a subject for thorough and detailed study.

The green bean has been chosen for study in this problem since it is a non-acid vegetable and is considered to require a pressure cooker for safety in canning. Too, green beans are easily produced in this state and are found in almost every summer garden. Considering these facts, plus the shortage of canning equipment of all kinds, the writer feels that investigation of a method of successfully dehydrating this vegetable merits the expenditure of the time and effort involved.

The literature on the various phases of dehydration presents many contradictions, as is apparent in the following

chapter which gives a review of the literature. It is also apparent that science is struggling to improve methods and techniques of dehydration and there is evidence to show that great progress is being made in this field.

In this study emphasis was placed on the effect of varying certain controllable factors on the ascorbic acid content and palatability of a dried vegetable. The factors studied included: (1) different methods of blanching, (2) different periods of blanching time, (3) use of different types of home dehydration equipment, and (4) various methods of rehydrating and cooking.

CHAPTER II

REVIEW OF THE LITERATURE

Variety, Maturity, and Freshness of the Raw Material

Dehydration, as a method of preserving food, does not within itself insure a good quality product. There are many factors which influence the success of the operation--and if good results are to be obtained, great care must be shown in the control of each factor. Some of the factors which have a definite influence on the quality of the final product are variety, maturity and freshness of the raw product; method of pretreatment; method of blanching; method of dehydrating; packaging and storing; and method of rehydrating and cooking.

The selection of a suitable variety of food for preservation by dehydration has been shown to be as important as the selection of proper varieties for freezing and canning. Because of their chemical composition and physical structure, Loesecke reports that, as yet, not all vegetables have yielded a satisfactory dried product. He cites as a specific example asparagus and says that by any dehydration method the stalks collapse and upon rehydration do not regain their original shape.[1]

Beavens reports that certain varieties of vegetables develop bitter off-flavors when they are dehydrated while

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[1] H. W. Von Loesecke, Drying and Dehydration of Food, (New York: Reinhold Publishing Corporation, 1942), 82.

others lose considerable amounts of their natural color and nutritive value.[2]

As a general statement, several writers including Prudent[3] and Loesecke[4] say that varieties of vegetables suitable for freezing are also suitable for dehydration. In general, it might be said that the varieties of vegetables suited for dehydration are really those found, after the preparation and dehydration processes, to have retained their potential color, flavor, texture, and nutritive value.

Beavens suggests that it is impossible to predict which variety will or will not yield a satisfactory dehydrated product since vegetables grown under varying conditions of soil, climate, and geographic location are by nature quite different.[5]

Caldwell and Culpepper in their work on varieties of snap beans suited to dehydration find that the three varieties, Asgrow Stringless Green Pod, Lazy Wife, and Dwarf Horticultural, in the order named, are best suited in all respects. Their criteria for judging these beans are based on the ability of the beans to refreshen, the retention of

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[2]E. A. Beavens, "Advances in Methods of Food Dehydration," Rural New Yorker, C11 (1943), 202.

[3]Inez Prudent, and Forrest B. Wright, "Drying Fruits and Vegetables at Home," Cornell University Extension Bulletin, No. 618, (July, 1943), 202.

[4]Loesecke, op. cit., 82.

[5]Beavens, loc. cit.

color, the tenderness, and the flavor. A second group including Bountiful, Asgrow Stringless Valentine, and Stringless Kidney Wax, although not equal to the first group in color, maintain a very good texture and flavor.[6]

Tressler, Mack, and King have reviewed the influence that the factors of variety, maturity, and freshness have on the ascorbic acid content of snap beans. These workers report that Tendergreen, Kidney Wax, Ideal Market, and Kentucky Wonder varieties contain approximately twice as much vitamin C as the Georgian and Blue Lake varieties.[7]

The ascorbic acid content of ten different varieties of snap beans at the same stage of maturity was found by these same investigators to range from 0.09 mg. per gm. of vegetable to 0.24 mg. per gm. The average of all their titrations was 0.18 mg. per gm.[8]

Mack, Tapley, and King report that the Red Kidney and White Pea varieties ranked above the regular snap bean varieties in ascorbic acid content. These workers believe this is due to the fact that the former had well-developed seeds. Experiments that they conducted show that the seeds have a much higher ascorbic acid content than the containing pods; the ratio being as high as 4:1 in some cases.[9]

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[6]J. S. Caldwell, and C. W. Culpepper, "Snap-bean Varieties Suited to Dehydration," Experiment Station Record, XC (1944), 271.

[7]Donald K. Tressler, Guilford L. Mack, and C. G. King, "Factors Influencing the Vitamin C Content of Vegetables," American Journal of Public Health, XXVI (1936), 906.

[8]Guilford L. Mack, W. T. Tapley, and C. G. King, "Vitamin C Content of Vegetables. X. Snap Beans," Food Research, IV(1939), 311.

[9]Ibid., 312.

Heinz, Kanapaux, and others, report that the Mammouth Horticultural, and Alabama 3 were consistently the two highest ranking varieties in vitamin C among the pole beans. Unrivalled Wax, Low's Champion, Giant Stringless, and Masterpiece were within the highest five among the bush varieties.[10]

These same workers find that the season of the year also influences the vitamin C content of snap beans. The fall varieties are not nearly so high in ascorbic acid content as the spring varieties; and this is true of both the pole and the bush beans.[11] This finding is in agreement with the work of Wade and Kanapaux[12] who studied a number of different strains of snap beans but is contrary to the report of Mack, and coworkers,[13] who found that there was little variation in the vitamin C content of the Refugee variety over a period of three years.

Another factor which many investigators report it is well to consider in the selection of vegetables for dehydration is the stage of maturity of the raw product. Tressler, and all, found that, in the case of snap beans, the percentage of ascorbic acid was approximately the same at all stages of maturity at which the vegetable was

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[10] P. H. Heinz, Margaret S. Kanapaux, B. L. Wade, P. C. Grimball, and Ruth L. Foster, "Ascorbic Acid Content of 39 Varieties of Snap Beans," Food Research, IX (1944), 21.

[11] Heinz, loc. cit.

[12] B. L. Wade, and Margaret S. Kanapaux, "Ascorbic Acid Content of Strains of Snap Beans," Journal of Agricultural Research, LXVI (1943), 319.

[13] Mack, op. cit., 311.

examined.[14] In agreement with this, Mack, Tapley and King report little variance in vitamin C content of the same varieties of snap beans at different stages of maturity. The variation was greater, however, in the larger seeded varieties due to the distribution of ascorbic acid between the seed and the seed pod.[15]

In contrast to these reports, Beckley and Notley give the following figures which indicate a definite variation in vitamin C content in the different stages of maturity of the bean.

"Very young beans	19 -19.6	mg. per 100 gms.
More mature pods (with strings forming)	24.7-26.0	mg. per 100 gms.
Older beans	24.1-26.2	mg. per 100 gms.
Very old beans	27.7-29.4	mg. per 100 gms." [16]

They suggest that the increase in ascorbic acid in the very old bean is not sufficient to warrant the extra manual labor needed in "stringing" the beans preparatory to dehydration. They recommend that beans for dehydration are best when they are devoid of string or are slightly immature.[17]

Caldwell and Culpepper suggest that the very young beans are not satisfactory for drying since experiments show that these beans, regardless of variety, remained shriveled

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[14] Tressler and Others, Ibid., 908.

[15] Mack and Others, Ibid., 316.

[16] V. A. Beckley and Violet E. Notley, "Ascorbic Acid Content of Dried Vegetables," Biochemistry Journal, XXXV (August,1941), 1401-1402.

[17] Beckley, Ibid., 1402.

after rehydration and were flavorless or even astringent and bitter when cooked.[18]

A third factor which influences the quality of a dehydrated product is that of the freshness of the raw vegetable. Many writers recognize the following conditions as being those which are most likely to affect the quality of the dehydrated vegetable: (1) the time of day the vegetable is harvested; (2) the care shown in handling the vegetable; (3) the length of the haul; (4) the storage conditions; and (5) the length of the storage time.

A recent report by Elvehjem indicates that a 25 per cent loss in ascorbic acid occurs in string beans during a storage period of only 48 hours at room temperature.[19] This loss, along with other vitamin, mineral, and general "good-quality" losses will be avoided if careful but speedy handling of the vegetable is observed from the initial steps of harvesting clear through the preparation processes prior to placing the food in the drier.

If then, the raw material used for dehydration has been carefully selected, is of high-quality, is at an optimal stage of maturity, and is fresh, it can be assumed that the resulting qualities of the dehydrated product will be commensurate with those of the raw vegetable.

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[18]Caldwell, Ibid., 272.

[19]C. A. Elvehjem, "Newer Findings in Vitamin Research," American Dietetics Association Journal, XIX (October, 1943), 745.

Pretreatment of Green Beans for Dehydration

The general process of preparation of vegetables for dehydration is very similar to the preparation of vegetables for canning or other methods of preservation. Many of the operations are very simple and therefore will not be treated at length--except in the case of blanching. In that case, the reasons behind the operations are equally as important as the process itself and therefore a complete understanding of the subject is necessary.

The first process in the preparation of green beans for dehydration is that of washing and trimming. It is essential that all materials be thoroughly washed and sorted to remove dirt and defective parts. Woodroof and DuPree suggest that as soon as possible after the vegetable comes from the garden, it should be placed in cold water and allowed to soak for a few minutes.[20] This causes loosening of the dirt and grit and aids in assuring a thoroughly clean product after washing. In any case, it must be thoroughly washed with either running water or with several changes of fresh water, according to Loesecke.[21] He also indicates that the water should be of potable quality.

Davis, and co-workers, report that thorough washing will show up the bruises, blemishes, and withered leaves,

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[20]J. G. Woodroof, W. E. DuPree, and Helen H. Thompson, "Dehydration of Fruits and Vegetables and Utilization of Dehydrated Products," Georgia Experiment Station Bulletin No. 225, (February 1943), 16.

[21]Loesecke, op. cit., 84.

which must be removed. Even bruises that may be hard to detect is the raw vegetable will be highly undesirable for dehydration because of their tendency to cause deterioration.[22]

The method of slicing or cutting the bean prior to dehydration has been shown to affect the retention of vitamin C during blanching. Batchelder finds that the ascorbic acid loss in green beans steamed whole to be greater than when the beans are shredded or cut before blanching. She suggests that this result may be explained by the fact that the enzyme is more effectively destroyed in the shredded or cut beans since the heat is able to penetrate the bean tissue to a greater degree.[23]

Stillman, and Others, find that beans split lengthwise rehydrate much more readily than do those cut crosswise. The latter beans are said to have a wrinkly appearance even after having soaked for a thirty-hour period.[24]

It is apparent, therefore, that further experimental evidence is needed before any one method of cutting or slicing of the vegetable, prior to dehydration, can be recommended.

Blanching

The next process in the preparation of vegetables for

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[22]S. Gilbert Davis, William B. Esselen, Jr., and Francis P. Griffiths, "Home Dehydration of Vegetables," Massachusetts Agricultural Experiment Station Bulletin No. 404, (April,1943),16.

[23]Esther L. Batchelder, "Home Drying Methods and Their Effect on the Palatability, Cooking Quality, and Nutritive Value of Foods," American Journal of Public Health, XXXIII (August,1943), 946.

[24]Judith T. Stillman, Betty M. Watts, and Agnes Fay Morgan, "Palatability Studies on Home Dehydrated Vegetables," Journal of Home Economics, XXXVI (January, 1944), 31.

dehydration is that of blanching. The term, blanching, has the same meaning in dehydration that it has in other methods of food preservation, i.e., it means to scald or precook. More technically, blanching is the term applied to the pretreatment, by the use of heat, of foods to be processed. The purpose of the blanching is the inactivation of the enzymes present in the plant or animal tissue.

Enzymes are the natural chemical bodies of plant and animal origin which cause chemical transformation, such as hydrolysis and oxidation. Catalase and perioxidase are two common enzymes of vegetable tissues which cause oxidation and thus hasten deterioration. The activity of these two oxidative enzymes may be greatly inhibited by the use of heat, sulfur dioxide, and antioxidants--although, slow oxidation seems inevitable even after their destruction.[25]

In dehydrating vegetables, the use of heat is employed most extensively to destroy these oxidative enzymes. Watts reports that the use of sulfur for the pretreatment of vegetables offers possibilities which need further exploration. She found that string beans split lengthwise, blanched 10 minutes in steam and then dipped for 15 seconds in a 1 per cent sulfite solution, which contained 2000-3000 parts per million of sulfur dioxide, showed a much higher vitamin C retention and were rated higher on palatability than similar beans pretreated only by blanching.[26]

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[25]Betty M. Watts, "Pretreatment of Food for Dehydration," Journal of Home Economics, XXXVI (January, 1944), 13.

[26]Ibid., 14.

> "The chief drawback," says Watts, "is the difficulty of obtaining the proper concentration of sulfur. Vegetables vary greatly in size and shape, in the permeability of their tissues, and in the amount of sulfite solution retained through incomplete drainage after dripping.
>
> Also, the destructive action of sulfur dioxide on thiamine must be balanced against its preservative action on ascorbic acid and carotene."[27]

From these data we may conclude that the use of sulfur in the pretreatment of vegetables for drying probably has noteworthy potentialities which need further development by our research workers.

Although the primary consideration in blanching is the inactivation of the enzymes, it is believed that blanching is valuable in other respects. Loesecke summarizes these advantages in the following manner:

> "(1) It aids in preserving vitamins during drying.
> (2) It makes for better keeping quality of the dried product.
> (3) It improves the color of the pigmented vegetables.
> (4) It aids in a more rapid reconstitution of the dried product.
> (5) It increases the drying rate.
> (6) It expels at least part of the oxygen.
> (7) It decreases the bacterial population."[28]

Blanching may be accomplished conveniently by anyone of three methods: steaming the food, steaming it under pressure, or by immersing it in hot water--the latter method being referred to as "hot-water" or "dip" blanching.

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[27] Ibid., 14

[28] Loesecke, op. cit., 84.

Many investigators, Davis,[29] Sheets,[30] Stillman,[31] Hollingshead,[32] and Mrak,[33] agree that steaming is the most desirable method of blanching. The formulation of this opinion rests mainly upon the fact that there seems to be considerably less loss of food value, especially of ascorbic acid, than when other methods of blanching are used. Sheets reports in her experiments a greater loss of vitamin C during the dip blanching of certain vegetables than by the steam blanching procedure.[34] From the work of Hollingshead comes the following table:[35]

PERCENTAGE LOSS OF VITAMIN C

	Steam Blanching %	Dip Blanching %
Kale	19	23
Beets	14	36
Potatoes	22	37
Cabbage	14	51

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[29]S. G. Davis, W. B. Esselen, Jr., and F. P. Griffiths, "Small Dehydrators for Vegetables," Food Industry, XV (June, 1943), 54.

[30]Olive Sheets, "How Dehydration Affects the Nutritive Value of Fruits and Vegetables," Mississippi Agriculture Experiment Station Circular No. 113, (October, 1943), 2.

[31]Stillman, op. cit., 33.

[32]R. S. Hollingshead, "Dehydration Procedures and Their Effect on Vitamin Retention," American Journal of Public Health, XXXIII (August, 1943), 970.

[33]Mrak, op. cit., 17.

[34]Sheets, op. cit., 2.

[35]Hollingshead, op. cit., 970.

Another reason for its preference as given by Watts is that the steam blanched vegetables are more palatable.[36] Cruess, and Others, find that steam blanching before drying not only helps save the vitamin content but also sets the color, hastens drying, checks the ripening processes, helps prevent undesirable changes in flavor during storage and insures satisfactory restoration during cooking.[37] Work done by the Foods and Nutrition Division, Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture indicates that steam blanched vegetables keep better, require less soaking before they are cooked for the table, and have a better flavor and appearance.[38]

Although steam blanching is the preferred method of pretreating the vegetables before dehydration it does not necessarily mean that the dip-blanching method will be totally discarded. Therefore, investigators have made several recommendations as to the possible ways of improving the efficiency of the dip-blanch method. Loesecke says it is desirable to use soft-water, in hot-water blanching, since hard water may cause a toughening of the product.[39]

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[36]Watts, op. cit., 13.

[37]W. V. Cruess, Hilda Faust, and Vera D. Greaves, "Drying of Vegetables and Fruits in the Home," Agriculture Extension Service, College of Agriculture, Berkeley, California, (No date), 1.

[38]U. S. Department of Agriculture, Bureau of Home Economics, Foods and Nutrition Division, Farmer's Bulletin No. 1918, (August, 1942), 3.

[39]Loesecke, op. cit., 86.

Bulletin No. 1918, of the U. S. Department of Agriculture, reports that when foods are being pretreated for dehydration by the dip-blanch method it is best to work with small amounts of food at a time so that the water will not be cooled more than necessary. Also,

> "To conserve vitamins and minerals, hold the vegetable in boiling water the shortest time necessary to cook them until almost tender--and use the same water for several lots."[40]

Loesecke on this same subject says,

> "Losses brought about by water-blanching may be reduced by repeated use of the blanching water until the Brix (soluble solids) of the water is about 1.0 or 1.5°. This technique is what the English call "serial scalding." In the case of some vegetables, water-blanching gives a better appearing dried product."[41]

The third method of blanching vegetables for dehydration is the use of steam under pressure. Loesecke reports that this method is really cooking rather than blanching, and it is used in the attempt to make certain the destruction of the enzyme peroxidase. In blanching under pressure, the vegetable is placed in baskets in the pressure cooker and heated to 240° F. Loesecke suggests that there is some question as to the effect of this treatment upon the quality of the product.[42]

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[40]U. S. Department of Agriculture, op. cit., 3.

[41]Loesecke, op. cit., 85-86.

[42]Ibid., 85.

It is interesting to note that a few data were found which indicate that the blanching of vegetables is disadvantageous. Beckley and Notley report that:

> "Blanching depressed the yield of dry material by 1.5 per cent. The ascorbic acid content of the blanched beans was 74.5 mg. per gm., while that of a parallel lot of dried unblanched beans was 95.1 mg. per gm. The color of the dried blanched beans was a faded yellow-green, whereas that of the unblanched dried beans was a good green with a silvery tint. On cooking, the difference in color was even more marked; the blanched beans were tough, hard, and of a brown color, while the unblanched were quite normal in texture and of a good color. Unexpectedly, blanching had a deleterious effect on the vitamin C."[43]

To summarize, the use of steam at atmospheric pressure is recommended by the majority of investigators whose work has been reviewed. The use of sulfur and steam under pressure bring about the destruction and inhibition of the enzymes in the same manner as does the steam, but their use in the dehydration of vegetables at home is not frequently recommended.

Blanching Time

The situation concerning the length of time required for the blanching of green beans is much the same as that noted above in reference to the need for blanching, i.e., the reports in the literature are contradictory. The suggested time for optimum results by the blanching process vary from 1 to 20 minutes.

One writer states that all the desirable effects of blanching--namely, improvement of flavor, color, and texture,

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[43]Beckley, op. cit., 1402.

reduction in weight and volume,--are produced in the first two minutes of blanching. This author says, "Blanching is to be considered necessary but should be as short as possible."[44]

In contrast to this idea, Davis states:

> "Improperly blanched products rapidly lose their color and develop off flavors and odors. Preliminary experimental results indicate that the loss of ascorbic acid and carotene during storage of insufficiently blanched products is greater than the loss resulting from a longer blanching period, owing to the activity of the enzymes which destroy the vitamin. Work in this laboratory indicates that longer blanching periods than usually recommended are required; snap beans being 20 minutes in steam."[45]

A third report, by Moyer, warns against overblanching although no definite blanching time is given. The author says,

> "While it is serious to err by underblanching, too long a blanching period causes a large loss of the water-soluble vitamins. Jenkins, Tressler, and Fitzgerald demonstrated that there is a progressive loss of ascorbic acid with increased blanching time."[46]

Sheets also warns against the overblanching of vegetables because it results not only in the loss of the minerals and water-soluble vitamins which are leached out in the water but it also causes a greater loss of flavor.[47]

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[44] _____, "The Effect of Blanching Upon Vegetable Nutrients," Nutrition Reviews, I (January, 1943), 69.

[45] Davis, op. cit., 54.

[46] J. C. Moyer, "The Nutritive Value of Dehydrated Vegetables," American Dietetics Association Journal, XIX (January, 1943), 13.

[47] Sheets, op. cit., 2.

In conclusion, the preferred blanching time for green beans has been set by most of the investigators (Loesecke;[48] U.S.D.A., Bulletin No. 1918;[49] Cruess, and Co-workers;[50] Vandaveer;[51] and others) at 15-20 minutes in the steam blanch.

Blanching Temperature

Pyke and Charkey suggest that the blanching temperature of the food material to be dehydrated should be raised to 175° F. for a short time if the enzymic action is to cease. The blanching time, they report, should only be sufficient to raise the temperature at the center of the food to 175° F.[52]

Cruess, and Co-workers, suggest that vegetables be steamed only until each piece is heated through and is relaxed in appearance and texture. These workers suggest that this state of doneness may be tested by removing a piece from the center of the container and pressing it. It should feel soft but not be completely cooked.[53]

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[48]Loesecke, op. cit., 91.

[49]U. S. Department of Agriculture, op. cit., 2.

[50]Cruess, op. cit., 2.

[51]F. E. Vandaveer, "Dehydration of vegetables in Domestic Gas Range Ovens," Reprint from the American Gas Association Monthly, (September, 1943), 7.

[52]W. E. Pyke, and L. W. Charkey, "Making and Using a Food Dehydrator," Colorado Agricultural Experiment Station Bulletin 477, (May, 1943), 9.

[53]Cruess, op. cit., 1.

Method and Equipment for Steaming

The use of improvised equipment for blanching is quite satisfactory. Pyke and Charkey report the following:

> "For blanching, a basket of hardware cloth or other wire mesh should be made to fit some large kettle or other similar container that is available. A cold-pack canner, or 50 pound or 100 pound lard can or large covered kettle will serve. Then two to three inches of water is placed in this container and brought to a vigorous boil. The wire basket containing the food to be blanched is set in the container on a rack that will hold it above the surface of the boiling water. To confine the steam, the container is closed but not tightly covered. If a large pressure cooker is available for this purpose, the cover should be used with the petcock open. The same equipment may be used for dip blanching by adding more water."[54]

The method of blanching and the equipment suggested by Cruess, and others is:

> "1. Use a kettle having a close-fitting lid and equipped with a wire basket, colander, or sieve placed so that the steam will circulate freely around the vegetables. Water should not come in contact with the product.
> 2. Have the water boiling briskly before putting the prepared vegetable into the kettle.
> 3. Do not have the layer of vegetables in the steamer more than $2\frac{1}{2}$ inches deep.
> 4. Steam the vegetables until each piece is heated through and is relaxed in appearance and texture.
> 5. Test by removing a piece from the center of the container and pressing it. It should feel soft but not completely cooked."[55]

Davis reports a slightly different method for blanching in which the best procedure for most vegetables

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[54]Pyke, op. cit., 7

[55]Cruess, loc. cit.

is to spread them on trays and subject the whole tray to the steam process.

> "This may be done," says Davis, "in a large kettle, wash boiler or other vessel of sufficient size--which has a relatively tight cover. Approximately 2 inches of rapidly boiling water provides ample steam. The trays are stacked one above the other in such a manner that the steam has intimate access to all parts of the tray. This is of extreme importance, since adequate and uniform blanching is a requisite for quality products. Every piece must be heated through to the center. Therefore, not more than 3 trays should be blanched at once. It must also be stressed that the water should be vigorously boiling at all times."[56]

It is readily seen that the principle of this method is exactly the same as that suggested by the other workers.

Shuey suggests that the containers for blanching purposes should be of aluminum, enamelware, tin, or stainless steel. Copper vessels are undesirable. Uncoated iron vessels should not be used for processing vegetables because the juices will react with the metal and the vegetables become discolored and of a poor flavor. Shuey suggests also that a pressure cooker or a steam cooker is highly satisfactory for steam blanching. Enamelware or tin vessels of 12-20 quart capacity with tight fitting covers, or even a wash boiler will serve for steam blanching."[57]

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[56]Davis, op. cit., 55.

[57]G. A. Shuey, "Dehydration of Fruits and Vegetables in the Home," University of Tennessee Agriculture Experiment Station Bulletin No. 183, (May, 1943), 9.

Tests for Blanching

Considerable emphasis has been placed on the importance of destroying the enzymes, catalase and peroxidase, during the blanching period if the dehydrated product is to be of the best possible quality. The next objective is to find a means of successfully checking the adequacy of the blanching.

Fortunately, there are definite chemical tests which may be done with relatively simple apparatus and without much experience. With one exception, however, these tests are not practical for use in home dehydration since the housewife would not have access to the required chemicals or equipment for the test. Therefore, they shall not be discussed in t his paper.

The catalase test is the simplest of all the enzyme activity tests and is recommended by Shuey for home use.[58] Proctor,[59] and Cruess,[60] however, cite experiments which show that, for some vegetables, blanching merely enough to inactivate the catalase but not the peroxidase is entirely inadequate to protect against undesirable enzymic changes in the later stages of the dehydration process.*

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[58]Ibid., 11.

[59]Bernard E. Proctor, "Simple Tests Reveal Improper Blanching," Food Industry, XIV (November, 1942), 52.

[60]Cruess, op. cit., 3.

*For information regarding the testing of the enzyme peroxidase, the reader should consult "Simple Tests Reveal Improper Blanching," by Bernard E. Proctor, Food Industry, 14: 51-52, (1942)

It might be well to note at this point that the proper time to make use of this catalase test is immediately after the completion of the blanching process. As Proctor states,

> "The results must be known before dehydration, or the knowledge will be of no avail. To learn, after the dehydration has been carried out, that blanching was incomplete is too late, for it is impossible to go back and increase the temperature or the duration of blanching."[61]

Proctor,[62] Loesecke,[63] and Shuey,[64] describe the procedure of the test very similarly. According to these workers, the test may be successfully performed as follows: (Substituting improvised equipment when the test is being done at home.) Place a small quantity of the raw, unblanched vegetable (a piece about the size of a pea is recommended by Shuey)[65] into a glass test tube. Pour enough of a 3 per cent hydrogen peroxide solution over the material to cover it from 3/4 to 1 inch. Allow this to stand for several minutes and note the small gas bubbles rising from the material.

Repeat this test (using clean equipment) substituting the same sized piece of blanched material for the raw, unblanched vegetable. If the vegetable is satisfactorily blanched, there should be no gas bubbles given off within

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[61] Proctor, op. cit., 52.

[62] Ibid., 51.

[63] Loesecke, op. cit., 87.

[64] Shuey, op. cit., 11.

[65] Cruess, op. cit., 1.

a period of 2 minutes. If a small stream of gas bubbles rise to the surface, it is evident that the material is incompletely blanched. The incompleteness of the blanch may be due to one of two factors or the combination of the two factors--namely, too short a duration of heat treatment or too low a temperature of the water used in blanching.

In spite of the fact that it is known that this quality control test is not always accurate, it serves as a useful means of checking on the blanching operation and is recommended for use in the commercial and home dehydration of vegetables.

Dehydration Processes

Dehydration Equipment

Recent advances in the field of research in dehydration have been accompanied by advances in the construction of more modern, efficient equipment for the dehydrating process. There are many types of home dehydrating apparatus now available on the market--ranging greatly in size and capacity, and in the method of their use.

The selection of a drier for home use would depend upon the size of the family, the amount of surplus garden produce to be dried, the source of heat to be used, and the amount of money to be invested. The efficiency of the different driers is virtually the same when they are used under similar conditions. Therefore, this discussion shall be limited to a description of the two types involved in the problem, namely, apparatus to be used in a gas-oven and a cabinet-type dehydrator.

Oven apparatus is the simplest in design and is quite easy to construct. It may consist merely of a square, wooden frame, at least 1 inch in height, with a piece of close-meshed wire or cloth screening stretched tightly and fastened securely over the bottom of the frame. Not more than three of these trays may be placed on the oven racks at one time in the average gas-range oven. A variation of this type of equipment consists of a wooden frame which provides support for a series of three or four trays. The dimensions of the frame, as well as the size of the individual trays, will naturally depend upon the size of the oven. This type of equipment has been tested and it has been shown that foods may be successfully dried in this manner.

The second type of drying equipment used in this experiment was the cabinet-type dehydrator. Very briefly, this is a wooden box which usually supports not more than eight trays and is provided with a full length, tightly fitting door in which there is an opening near the center top and the center bottom for ventilation. The box is equipped with electric light bulbs and an electric fan--thus producing artifical heat and forced draft. The addition of a thermostat to control the temperature of this electrically operated dryer would be valuable for it insures a resulting good product as well as requiring less attention on the part of the operator.

It may be reiterated, however, that good results may be obtained by the use of the simpler and less expensive driers

which are especially practicable when only small amounts of food are to be dried.

Factors influencing dehydration process

After a suitable dehydrator has been selected, the success of the process depends upon the successful completion of the following steps: (1) constant maintenance of the desirable temperature; (2) correct relation of weight per tray or correct tray-load; (3) interchanging of trays and stirring of food; (4) proper moisture content at the finish point; (5) and correct rate of removal of moisture. A discussion of these factors follows.

The temperature at which the vegetable is dried is of great importance. A temperature over 185°F produces spoilage due to a scorching of the food, while a temperature below 120°F causes spoilage due to the souring of the vegetable. Again, if too high a temperature is used, the product may develop what is called a "case-hardening" (simply a hardening of the outer surface of the vegetable) which makes it more difficult to remove moisture from the inside of the food. This results in losses in flavor, odor, cooking and keeping qualities. Davis and Co-workers,[66] Loesecke,[67] Vandaveer,[68] and others suggest that a temperature of around 150°F is suitable for most vegetables. The majority of

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[66]Davis, op. cit., 17.

[67]Loesecke, op. cit., 92.

[68]Vandaveer, op. cit., 5

investigators advise the maintenance of a constant temperature during the entire dehydration process although Tressler,[69] and others suggest a higher initial temperature with a final temperature of 140-145°F for most vegetables.

Loesecke suggests that, in considering the desirable temperature for dehydrating vegetables, the quality of the product dried at any given temperature will vary according to the inherent chemical nature of fresh vegetable.[70] Authorities seem to agree that the desirable temperature to be used in the dehydration of snap beans is 150°F and that it should remain constant throughout the entire dehydration period.

The use of an accurate meat or candy thermometer placed in the middle of the top rack is recommended by many writers to check the temperature of the drier. If a good thermometer is not available, however, you may learn to judge the correct rate of drying by feeling the product. It should feel cooler than the surrounding air and should be slightly moist to the touch. If these two characteristics are not present, the food is probably drying too fast.[71]

A second factor which is important in dehydration is the rack-weight capacity. Vandaveer reports that the drying

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[69]Donald K. Tressler, "Nutritive Value of Dried and Dehydrated Fruits and Vegetables," New York State Agricultural Experiment Station Bulletin No. 262, (March, 1942), 29.

[70]Loesecke, op. cit., 87.

[71]United States Department of Agriculture, op. cit., 9.

period with a 3 lb. load per tray is approximately twice as long as when ½ of the weight of the same vegetable is dried.[72] The majority of investigators suggest a tray load of from 1-1½ lbs. per tray for most vegetables.

Experiments indicate that there is no advantage in stirring the food or interchanging the trays more often than every two hours.[73] Woodroof suggests that stirring the vegetable during dehydration increases the rate of drying. He reports that the trays may be loaded twice as heavily without increasing the dehydration time over that required when no stirring is done.[74] Interchanging of the trays is advantageous in that it provides a more rapid and uniform drying due to the higher humidity at the top of the drier. The foods on the top shelves would take longer to dry if they were not interchanged, especially after the first two hours of drying.

The moisture content of the vegetable after it has been dried should not exceed 5 per cent if the keeping qualities are to be optimal. There is no danger of decreasing the palatability or the preservative qualities by allowing it to become too dry; the danger lies in not drying the food sufficiently.

There are two recommended methods for testing the dryness of the finished product. Davis and others suggest that the

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[72]Vandaveer, op cit. 3.

[73]Ibid., 4

[74]Woodruff, op. cit. 21

tray of dried material be made into a mound and that the bulb end of the thermometer be placed in the center of the mound. If in 5 minutes of continued heating in the dehydrator the temperature of the dried vegetable is the same as that of the air, i.e., around 150° F., the product is sufficiently dry.[75] A thorough inspection for moist pieces of vegetable should be made before the final removal of the product from the dehydrator.

A second method of testing for adequate dryness, which is recommended by Vandaveer, is to place a piece of the dried product on a flat hard surface and strike it with a hammer. If the vegetable shatters, the end point is said to have been reached. If the vegetable does not shatter, dehydration must be continued until the test proves positive.[76]

The data concerning the retention of the nutritive value in dehydrated vegetables have been quite contradictory. According to the majority of evidence presented in the literature carbohydrates, proteins, minerals and some of the vitamins are largely retained during dehydration. Vitamin C, however, is lost; it would appear that the dried product is almost totally devoid of this substance. Pyke and Charkey,[77] Shuey,[78] Prudent and Wright,[79] and Moyer,[80] believe that since

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[75]Davis, op. cit., 19.

[76]Vandaveer, op. cit. 3.

[77]Pyke, op. cit., 9.

[78]Shuey, op. cit., 22.

[79]Prudent, op. cit., 3.

[80]Moyer, op. cit., 16.

ascorbic acid is so unstable, its loss is almost inevitable. Farrell and Fellers find that the vitamin C found in dried snap beans is very negligible.[81]

From these data it may be assumed that the retention of vitamin C is possible but not probable under home-drying conditions. Further research on all the processes involved in dehydration will reveal the percentage loss of the different nutrients at each stage of their production--and new methods will undoubtedly be proposed to overcome this disadvantage.

Packaging and Storing

Since experimental evidence in the literature indicates that dehydrated vegetables are subject to insect infestation, mold, undesirable chemical changes and moisture absorption, the problem of correctly packaging and storing the product is of great importance.

Simon suggests that since dehydrated vegetables are perishable in nature and should not be kept over long periods of time, they should be stored in small containers--each container holding enough of the product to be used at one meal.[82]

The ideal package for the storing of dehydrated vegetables would be one which would be moistureproof, vaporproof, airproof,

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[81]Kenneth T. Farrell, and Carl Fellers, "Vitamin Content of Green Snap Beans. Influence of Freezing, Canning and Dehydrating on the Content of Thiamine, Riboflavin, and Ascorbic Acid," Food Research, VII (April, 1942), 177.

[82]Mildred Simon, "Dehydrated Foods and Their Preparation," Alabama Polytechnic Institute Circular No. 262, (July, 1943) 7.

greaseproof, gasproof, noncorrosive, insoluble in water, capable of holding a vacuum; adaptable to gas-packing, punctureproof; or not easily punctured, strong and durable, and almost proof against changes in temperature.[83] Experiments which have been conducted in recent years show that the tin can possesses more of these good qualities than any other type of container. For home use the glass jar, heavy waxed paper, or tin cans such as coffee cans, if used correctly, prove satisfactory. The cans and jars must have well-fitting lids and all three types of packages must be carefully and completely sealed. The use of scotch tape or paraffin may be used in addition to the regular methods of sealing these types of containers.

The individual packages of food sealed in the heavy-waxed paper should be placed in cartons and then stored in a cool, dark, dry place. A cool place is essential because high temperatures in storing have been shown to produce undesirable chemical changes.[84] A dark place is desirable for the prevention of further losses in color and flavor. A dry place is necessary to keep the material from reabsorbing moisture and thereby becoming moldy.

Storage tests as reported by Mack and Co-workers,[85]

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[83]L. K. Harper, "What Packages to Use for Dehydrated Foods," Food Industry, XIV (July, 1942), 53.

[84]Mrak, op. cit., 11.

[85]Mack and Others, op. cit., 314.

and Cruess,[86] indicate that ascorbic acid, if it survives dehydration, is difficult to retain in the dehydrated vegetable during the storage period. An experiment on the loss of vitamin C during the storage of green beans was conducted at the Massachusetts Experiment Station. It was found, after one year of storage, that the beans had lost 96 per cent of their vitamin C content.[87]

If then, the food is packaged in an air-tight container; stored in a cool, dark, dry place; and consumed within a relatively short period of time, all has been done to properly care for the product that can be done and a further loss in nutritive value of the dried product is uncontrollable.

Rehydrating and Cooking

Dehydrated foods must be rehydrated or reconstituted before they can be satisfactorily cooked for table use. The amount of water to be added, the length of the soaking period, the length of the cooking period, the method used in cooking, and the length of the storage time are some of the most important factors which influence the palatability and nutritive value of the rehydrated product, and merit discussion at this point.

Reports on the amount of water required to satisfactorily rehydrate vegetables varies from the proportions

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[86] W. V. Cruess, "The Nutritive Value of Dried Fruits and Vegetables," Fruit Products Journal, XXII (February, 1943), 173.

[87] Sheets, op. cit., 3.

of 1:1 to 1:3--the latter figure in each case being the amount of water suggested. A good rule to follow is to add only slightly more water, regardless of measure, than is needed to completely rehydrate the vegetable. It is considered better to add more water to replace that which boils away during the cooking than it is to have an excess at the end of the cooking period because too much water was added during the initial steps of reconstitution.

The results of an experiment conducted by Oser, and Co-workers, shows that cooking in large amounts of water resulted in substantial loss of minerals and of the water-soluble vitamins.[88] Fresh vegetables were used in this experiment but it is reasonable to assume that the results are applicable to dehydrated vegetables as well.

Tressler and associates, report that in the case of snap beans, approximately one-third of the ascorbic acid dissolved in the cooking water in 20 minutes,[89] so it is important that as little water as possible remain at the completion of the cooking period. If any water remains, it should be conserved for use in soups, gravies, and other appropriate dishes.

The search for an optimal soaking period has shown that the temperature of the soaking water is important. Cruess states that most vegetables soaked one-half to one

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[88]Bernard Oser, Daniel Melnick, and Mona Oser, "Influence of Cooking Procedure Upon Retention of Vitamins and Minerals in Vegetables," Food Research, VIII (1943), 117.

[89]Tressler and Others, op. cit., 908.

hour in cold water will yield acceptable products,[90] but it is the opinion of Moyer,[91] that soaking vegetables causes a loss of flavor and a tendency towards a water-soaked product. He suggests dropping the unsoaked, dried vegetable into briskly boiling water, and boiling it slowly until the product is tender.

It has been suggested that green beans require two and one-half cups of water to each cup of dried beans, plus a soaking period of at least two and one-half hours for the best results.[92] In contrast to this report, Beckley and Notley recommend that dried green beans should not be pre-soaked but should be dropped directly into briskly boiling water.[93]

The length of the cooking period is believed by all the writers to depend upon the vegetable under consideration. The unanimous suggestion is to slowly boil the vegetable in a covered vessel until it is tender. Dried green beans have been found to be completely tender after a 35-40 minute period of cooking.

The best method of cooking dehydrated vegetables, for the maximum retention of nutritive value, has been found to

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[90]Cruess, op. cit., 3.

[91]Moyer, op. cit., 15.

[92]_____, "How to Dehydrate Food at Home," The Alabama Polytechnic Institute Extension Service Circular No. 244, (May, 1943), 2.

[93]Beckley, op. cit., 17.

be comparable to the accepted method for the cooking of fresh vegetables. Kohman reports that losses in cooking become increasingly greater in the following order: steaming, boiling, baking, and pressure cooking.[94] Sheets indirectly confirms the work of Kohman by saying that the losses in flavor and nutritive value of dehydrated vegetables would correspond to those which occur in the cooking of fresh vegetables so that the best method for cooking one would also be the preferred method for the other.[95]

In summarizing, it may be said that the principles which apply to the cooking of fresh vegetables also apply to the cooking of dehydrated ones; i.e., the shorter the soaking time, and the shorter the cooking time (if a plump, tender product is obtained) the greater the retention of flavor, color, texture, and nutritive value.

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[94]E. F. Kohman, "The Preservation of the Nutritive Value of Foods in Processing," Journal of American Medical Association, CXX (March, 1942), 831.

[95]Sheets, op. cit., 4.

CHAPTER III

PROCEDURE

General

The green beans obtained throughout this experiment were purchased on the local retail market. Great care was taken in selecting fresh beans at approximately the same stage of maturity. Unfortunately, they were of unknown variety and from an unknown source which presented one of the uncontrollable limitations of the present study.

Vitamin C Determination

The beans were taken to the research laboratory where a chemical analysis of the vitamin C potency was made. The sampling, extraction, and titration procedure used throughout this experiment was essentially that of Tillmans as modified by Bessey and King[1] and Mack and Tressler.[2]

Precautions were taken in the sampling procedure because of the uneven distribution of ascorbic acid within the bean pod. Different pods, six or seven in number, were cut into 1-2 gram sections--each part of the bean being included. These sections were thoroughly mixed, and a 10 gram sample selected so that every part of the bean pod was proportionately represented.

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[1] O. A. Bessey, and C. G. King, "The Distribution of Vitamin C in Plant and Animal Tissues, and Its Determination," Journal of Biological Chemistry, CIII (1933), 687-698.

[2] G. L. Mack, and D. K. Tressler, "Vitamin C in Vegetables. VI. A Critical Investigation of the Tillmans Method for the Determination of Ascorbic Acid," Journal of Biological Chemistry, CXVIII (1937), 735-742.

The sample was placed in a mortar and covered with approximately 2 grams of acid-washed sand. Over this was poured 25 ml. of an acid mixture containing 10 per cent sulfuric and 2 per cent metaphosphoric acids. After grinding with a pestle until the cells were thoroughly ruptured, the solid material was separated centrifugally. The mortar and pestle was washed with two successive 10 ml. portions of the acid mixture and this was centrifuged until the extract was clear. The extract was decanted into a flask and was made up to 50 ml. by the addition of distilled water. From this mixture, 10 ml. aliquots were taken for titration against a solution of 2,6 dichlorophenolindophenol dye. The amount of dye required to attain a tentatively stable, faint-pink color was taken as the endpoint and the reading was recorded.

A pure ascorbic acid solution of known strength was titrated against an unknown strength of dye. This permitted calculation of a standardization factor for the dye which could be used in calculating the amount of ascorbic acid present in the green bean extract.

Titrations to determine the vitamin C values were made not only upon the raw bean but upon the blanched bean, the dehydrated cooked bean, and upon the cooking liquid.

Dehydration Procedures

The initial steps in the preparation of the remaining beans for the dehydration process remained the same throughout the entire study. The beans were thoroughly washed,

rinsed, drained, snipped, cut crosswise into one inch pieces, and weighed.

The next step in the dehydration procedure is that of blanching. The equipment used in this study was always the same but the method and length of time of blanching varied. The blanching equipment consisted of a steam pressure cooker with a tight fitting lid which was equipped with a wire basket supported so that the water would not come in contact with the vegetable. Any container with a tight fitting lid would suffice for this procedure.

In steam blanching, the water (which was approximately one and one-half inches deep) was brought to a brisk boil. The wire basket, containing a two and one-half to three inch layer of beans, was then placed on the supports in the bottom of the cooker and the lid was replaced. When the steam flowed freely from around the edge of the cooker, the time was noted and the period of blanching had begun. The blanching time was varied: periods of three, ten, fifteen, and twenty minutes were used.

The equipment and periods of time used for dip blanching were the same as those used for steam blanching. The method differed in that the beans were immersed in the briskly boiling water.

When the vegetable was taken from the blanch, it was immediately placed on the trays (the weight of vegetable per tray not exceeding one and one-half pounds) and placed in the dehydrator which had previously been heated to a temperature of 150° F.

Drying was continued at this temperature for approximately eight hours or until the vegetable was greenish-black, "bone-dry" in feeling, and brittle enough to shatter when placed on a flat, hard surface and struck with a hammer. The range of the dehydration period was from six to ten hours, the average time being eight hours.

At the end of the dehydration period, the beans were again weighed (to give the ratio of raw to dry weight); placed in clean, dry, glass jars with tight fitting lids; labeled; and placed in a cool, dark room for storage. The labels on the jars contained the following information: (1) date, (2) fresh weight, (3) dried weight, (4) blanching method, (5) blanching time, and (6) vitamin C content of the raw bean.

The dehydrators used in this study were of two types--a gas oven, and a forced-draft, electrically controlled, home dehydrator. A description of both of these dehydrators may be found on page 27.

Rehydration and Cooking Procedures

The soaking and cooking procedures were varied. The amount of water to be added was adjusted after a preliminary trial so that the vegetable was just covered during the entire soaking and cooking period. The soaking water was used for cooking, and the excess evaporated during cooking so that only enough remained to prevent the food from scorching. When some of the beans were cooked without preliminary soaking, the amount of water added to these beans at the

beginning of the cooking period was the same as that which was added to the beans that were allowed to presoak. The soaking period was varied from no time at all to thirty minutes, one hour, two hours, three hours, and seven hours.

The cooking equipment consisted of pyrex saucepans with tight-fitting lids, aluminum saucepans with tight-fitting lids, and a pressure saucepan with a sealflex lid. The method of cooking (when using the first two types of pots) was to bring the vegetable quickly to a boil, and then turn the flame as low as possible until the product was tender. The directions for using the pressure saucepan were followed in the third method. The cooking times were varied as follows: three, five, eight, ten, and fifteen minutes.

Scoring of Palatability

The method of scoring for palatability was that used by Stillman and Co-workers in a study on home dehydrated vegetables.[1]

The judges (fifteen in number) were selected from those who ate regularly at the home economics cafeteria of the Woman's College of the University of North Carolina. Of course, the selection of judges was further limited to those who were willing to pledge their cooperation throughout the entire experiment. The group included both men and women; their ages ranged from 18 to 40 years. They were given no information about the product and were asked not to comment

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[1]Stillman, op. cit., 29.

to the other judges during the testing. They rated the qualities of flavor, texture, odor, and general appearance according to whether they thought these factors were excellent, good, fair, poor, and very poor. A sample score card follows:

Score Card for Home Dehydrated Cooked Vegetables

Points to Consider	Green Bean Samples				Criteria for Judging
	1	2	3	4	
1. Appearance					(+25) Excellent--quality equal to the best fresh vegetable.
2. Odor					(+20) Good--quality equal to the best canned vegetable.
3. Flavor					(+15) Medium--satisfactory
4. Texture					(+10) Fair--below average but not objectionable.
					(+ 5) Poor--objectionable but edible.

In the following chapter on "Presentation and Discussion of Results" are summarized the effects of varying the blanching, dehydration, rehydration and cooking procedures as here described. The effects both upon the Vitamin C content and upon the palatability of the green beans are discussed.

CHAPTER IV

PRESENTATION AND DISCUSSION OF RESULTS

In judging the results of varying the factors of: (1) method and time of blanching, (2) method of dehydrating, and (3) method and time of rehydrating and cooking, two criteria were used throughout. These two criteria were palatability and vitamin C content.

Blanching

The palatability test scores, as shown in Table I, revealed that the judges consistently gave higher scores to the green beans that had been blanched long enough to destroy the peroxidase before dehydration. The average of the scores for the beans which had been steam blanched for 20 minutes was 68 as compared to an average score of 40 for those which had been dehydrated without being blanched.

TABLE I

EFFECT OF BLANCHING PROCESS UPON PALATABILITY

Beans	Blanching Method	Blanching Time	Total Score
		Min.	
Lot #1	Steam	3	45
" "	"	15	60
" "	"	20	68
" "	Dip	3	47
" "	"	15	61
" "	"	20	66
" "	No blanch	-	40

Contrary to some reports in the literature, the method of blanching seemed to make no significant difference in the

flavor or appearance of the rehydrated beans. The palatability test scores obtained on the series of beans served were analogous. It is therefore impossible, from these data, to recommend one method of blanching as yielding a more palatable, better appearing dried product.

Both the time and the method of blanching affected the ascorbic acid content of the beans. Upon chemical analysis, it was found that the beans which had been steam blanched for 3 minutes had lost 15.3 per cent of their original ascorbic acid content as compared with 43.8 per cent for those which had been blanched 15 minutes and 55.5 per cent for the 20 minute blanch. (See Table V, page 51)

The influence of the method of blanching on the loss of ascorbic acid was even greater than the influence of the time of blanching. Green beans steam blanched for 20 minutes lost 55.5 per cent of their original ascorbic acid content while the beans from the same lot that were dip blanched for the same time lost 66.2 per cent.

Dehydration

The beans dehydrated in the gas oven were found to have maintained a better color, upon rehydration and cooking, than did the beans which were dried in the electric dehydrator. The palatability test scores, however, were so nearly alike that they cannot be used to justify any statement of a "preferred" method of dehydration--judging from a palatability standpoint.

TABLE II

EFFECT OF METHOD OF DEHYDRATION UPON PALATABILITY

Method Used	Total Score
Gas Oven:	
Steam blanched 15 minutes Soaked 2 hours Cooked in pyrex pan	60
Steam blanched 20 minutes Soaked 2 hours Cooked in pyrex pan	68
Electric Dehydrator:	
Steam blanched 15 minutes Soaked 2 hours Cooked in pyrex pan	58
Steam blanched 20 minutes Soaked 2 hours Cooked in pyrex pan	65

The average loss of the original vitamin C content of the gas oven dehydrated beans was 70.2 per cent while that of the beans dried in the electric dehydrator was 83.9 per cent. Vitamin C is prone to rapid destruction especially in the presence of oxygen. Thus, the factor which may be partially or wholly responsible for this greater loss of ascorbic acid in the electrically dehydrated beans is the increase in the flow of air during the dehydration process. The electric dehydrator is equipped with a fan which is operated during the entire dehydration period; thus producing a much greater air current than is present in the gas oven.

Rehydration and Cooking

The scores on palatability indicate that all of the green beans tested improved in palatability and appearance

when they were soaked before cooking. The optimum soaking time is judged to be one to one and one-half hours. These data are shown in Table III which follows. A longer soaking

TABLE III

EFFECT OF LENGTH OF REHYDRATION TIME UPON LENGTH OF COOKING PERIOD AND UPON PALATABILITY

Steam Blanching Period	Soaking Period	Weight of Cooked Bean	Amount of Water	Cooking Time	Palatability Score
min.	hrs.	gms.	ml.	min.	
15	none	18	275	60	40
15	½	18	225	45	53
15	2	18	225	40	60
15	3	18	225	40	61
20	none	18	275	50	44
20	½	18	225	45	58
20	2	18	225	35	68
20	3	18	225	35	68

period is not necessarily undesirable but the slight increase in the plumpness of the rehydrated green bean (and thus a slight improvement in the appearance of the cooked product) is not great enough to compensate for the expenditure of time involved or the probable losses of soluble nutrients.

The temperature of the water appeared to have had little effect on the palatability of the cooked beans. The judges made no discrimination between the beans which had been dropped into boiling water for soaking and those which had been placed in cold water. The recommendation, therefore, is that cold water be used since the hot water might cause an additional loss in the heat labile vitamins.

After preliminary trials, the amount of water used was adjusted to one and one-half cups of water to each cup of dried vegetable. This amount provided coverage for the vegetable during the soaking period and was sufficient for the entire cooking process. The average amount of water remaining after the beans were cooked was 8 ml. which is barely enough to prevent the beans from scorching.

All three factors studied, (amount of water used in rehydration, the length of the rehydration period, and the type of pan used in cooking), were found to have an influence on the palatability and appearance of the beans prepared for table use.

When the amount of water remaining at the end of the cooking period was greatly in excess (about three-fourths to one cup in measure), the beans were very soft, unattractive, and had less flavor than when a small amount of cooking water remained. As has already been stated, the optimal amount of water was found in this experiment to be one and one-half cups to one cup of vegetable.

All of the vegetables, with the exception of the beans which had received no blanch prior to dehydration, improved in palatability and appearance when they were soaked before cooking. A direct correlation between the length of the rehydration period and the length of the cooking period was observed. (See Table III, page 47). The longer the rehydration period, up to a given point, the shorter the cooking period. The beans which had been soaked before cooking

required a 30 to 35 minute period of cooking, whereas those which were cooked without soaking required a slightly longer time--40 to 45 minutes being the average time needed. A method--sticking the vegetable with a cooking fork--was used to test the beans for the same state of tenderness. From these data, therefore, the optimal time was chosen. The beans which had been blanched for 20 minutes were found to consistently require less time to cook than the beans which had been blanched only 15 minutes.

The type of pan used in cooking was found to have an effect on the palatability scores of the beans. These data are summarized in Table IV.

TABLE IV

EFFECT OF VARIOUS COOKING METHODS UPON PALATABILITY

Pretreatment of Beans	Cooking Method	Cooking Time min.	Average Score* Flavor	Texture	Odor	Color	Total Score
Steam blanched 15 minutes Soaked 2 hrs.	Pyrex pan with tight lid.	35	17	12.5	15	15	60
"	Aluminum pan with tight lid	35	15	15	15	10	55
"	Pressure saucepan	10	8.5	0	15	8.5	32
Steam blanched 20 minutes Soaked 2 hrs.	Pyrex	35	18.5	14.5	18.8	15.8	68
"	Aluminum	35	17.5	13.7	18.8	15	65
"	Pressure Saucepan	10	10	4.7	6.5	11.5	32

*Represents the mean scores of two tests.

When the beans were cooked in the pyrex or the aluminum saucepan (each with a tight fitting lid) there was no apparent difference in either the palatability or the ascorbic acid content of the beans. The pressure saucepan, however, with the seal-flex lid was highly unsatisfactory in every instance. The texture was very tough and undesirable and the flavor quite inferior in comparison with the dehydrated beans prepared in other cooking vessels. This finding is contrary to what might be expected. The pressure saucepan has been shown to be highly satisfactory (from a nutritive and esthetic standpoint) in the cooking of fresh vegetable. No explanation for this difference in texture and appearance is offered.

In the present study, there was no significant difference in the ascorbic acid content of the beans which had been cooked in (1) varying amounts of water (ranging from one to two and one-half cups); (2) varying lengths of time (ranging from 30 to 45 minutes); and (3) various types of pans. The amount of ascorbic acid retained in any of the beans tested was very small (see Table V, page 51), and should not be relied upon to contribute appreciably towards the daily requirement. This finding is in agreement with the reports of Sheets,[1] Farrell and Fellers,[2] and Kohman.[3]

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[1]Sheets, op. cit., 3.

[2]Farrell, op. cit., 177.

[3]Kohman, op. cit., 831.

The percentage of ascorbic acid lost by the beans at the various stages of the dehydration process as compared with the ascorbic acid content of the raw green beans are given in Table V which follows.

TABLE V

LOSS OF ASCORBIC ACID AT VARIOUS STAGES OF THE DEHYDRATION PROCESS

Stage of Processing		Loss of Original Ascorbic Acid Content
	min.	%
Blanching:		
Steam blanched	3	15.3
"	5	25.7
"	10	33.6
"	15	43.8
"	20	55.5
Dip blanched	10	45.1
"	15	57.1
"	20	66.2
Dehydrated:		
Steam blanched	15	72.7
"	20	74.9
Dip blanched	15	81.5
"	20	83.2
Rehydrated and Cooked:		
Steam blanched	15	87.2
"	20	88.2

It might appear to the reader that the method of blanching green beans which has been recommended by the writer is not justifiable. The beans which were steam blanched 20 minutes had lost 55.5 per cent of their original

ascorbic acid content while the beans which were steam blanched for 3 minutes had lost only 15.3 per cent. The recommendation (which is to steam blanch for 20 minutes) is based on the consideration of several factors rather than on the sole factor of choosing a product with a high ascorbic acid content. One consideration is that experimentation has proven that if the enzyme peroxidase is not destroyed in the blanching process, its continued action will not only cause destruction of the ascorbic acid content during storage but will also produce other undesirable characteristics (such as "hay-like" odors and flavors) of the dehydrated product.

The criteria used in judging the most satisfactory method of dehydrating green beans in the home placed emphasis on palatability. It is believed that regardless of nutritive value, dehydrated products will not be accepted by the public unless the dried product is commensurate with the same food preserved by other methods. The palatability test scores gave the 20 minute steam blanched dehydrated beans a total score of 68 as compared with a total score of 45 to the 3 minute steam blanched beans from the same lot.

It is believed that the improvement in the palatability score plus the assurance that the peroxidase enzyme will not cause deterioration during the storage period offers a firm basis for the recommendation of the longer blanching period.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Nutritionists have recently placed great stress on the production and consumption of adequate food. This emphasis has been based primarily on the quality of foodstuffs as judged by their nutritive value. In considering dehydrated foods, however, the factor of palatability must not be overlooked. Dehydrated foods undergo changes in processing which alter their natural characteristics when they are rehydrated and prepared for table use. These changes have often been severely judged and have led to taste and appearance prejudices. Consequently, the public acceptance of dehydrated foods will depend upon their judgment of both factors--nutritive value and palatability.

Since a thorough study of all the factors which might influence the palatability and nutritive value of dehydrated green beans was impractical for this type of research, the problem was limited. The procedure of this study was to vary the method and time of blanching, the method of dehydrating, and the method and time of rehydrating and cooking. Further limitations imposed by the writer include: (1) selection of green beans as the vegetable for study, (2) selection of vitamin C for analysis (representative of nutritive value), and (3) selection of two types of home dehydrators to be used.

Limitations of another type were encountered in the execution of this research plan. These uncontrollable difficulties are listed below: (1) the beans were of unknown

variety and from an unknown source, and (2) the beans were not all from the same source, (3) only one electrically controlled home dehydrator was used: other models might have yielded different results, and (4) the results of the palatability study are not completely reliable because the group of taste testers was too small and the number of samples tested each time was somewhat large for a completely reliable comparison.

In spite of these limitations, certain valuable findings emerge from this study and are summarized below.

Blanching

A steam blanch of twenty minutes duration was shown to yield a more palatable product than was produced by the use of any other method. The method of blanching did not affect the flavor or appearance of the cooked, dried beans but it did affect the ascorbic acid content. The dip blanched beans consistently showed greater loss of ascorbic acid with an increase in blanching time over the steam blanch method using corresponding blanching periods. These findings agree with the majority of evidence presented in the literature.

Dehydrating

The method of dehydrating was found to affect the vitamin C content but not to affect the palatability. The beans which retained the largest amount of ascorbic acid were dehydrated in a gas oven. The method of dehydrating did not cause a variability in the time required to dry the beans; the average time was eight hours in each case.

Rehydrating

A rehydration period of one to one and one-half hours before the cooking of dried green beans was found to be desirable. It improved both the palatability and appearance of the cooked beans. This period of rehydration also decreased the length of the cooking period.

The initial temperature of the water used for the rehydrating of the beans did not affect the palatability according to the taste test scores. The amount of water, however, affected both the palatability and appearance of the cooked dried beans. When the water was greatly in excess the beans were very soft, unattractive, and had less flavor than those cooked in smaller amounts of water. Palatability test scores, when averaged, gave a score of 30.1 to the beans which were cooked in two and one-half cups of water to one cup of beans. The score of the same beans cooked in one and one-half cups of water to one cup of dried beans was 67.6.

Cooking

The cooking procedure was found to cause a variation in both the vitamin C content and the palatability of the cooked, dried beans.

The type of pan best suited for the cooking of the beans was found to be a pyrex or aluminum saucepan with a tight fitting lid. A pressure saucepan was unsatisfactory.

The cooking period was found to be approximately thirty five minutes in all cases when the beans had been blanched prior to being dehydrated. A longer cooking

period was required for those beans which had not been blanched prior to dehydration.

It was found that a palatable dehydrated product may be produced by using the same cooking procedure as is most commonly used in cooking fresh beans, namely, (1) shortest desirable cooking period, (2) smallest amount of cooking water, and (3) a saucepan with a tight fitting lid.

Conclusions

Within the limits of this study, the following conclusions were reached:

1. The twenty minute steam blanch is the most desirable method of pretreating the beans for the dehydration process.

2. The green beans dried in the gas oven appeared to be superior in quality to the electrically dehydrated product.

3. A rehydration period of one to one and one-half hours yielded the most palatable product.

4. Best results were obtained when one and one-half cups of cold water was used for each cup of dried green beans.

5. A cooking period of thirty-five minutes was needed to yield a tender product.

6. The type of pan best suited for the cooking of the beans was found to be a pyrex or aluminum saucepan with a tight fitting lid.

Recommendations

In conclusion, the findings of this study prompt the writer to offer the following recommendations:

1. That home dehydration, as a method of preserving food for the family, be initiated gradually so as to accustom the family to the difference in taste and in appearance of dehydrated vegetables. This tends to prevent prejudice.

2. That home dehydration be used as a "supplement" method; especially desirable now to conserve the enormous quantities of food needed during war-time.

3. That home dehydrated string beans not be relied upon as a good source of vitamin C since the home dehydration process (even under controlled conditions) destroys a large percentage of the ascorbic acid content of the raw bean.

4. That further study be made on home dehydration methods and techniques for the purpose of securing more nutritious, more palatable, and better appearing dehydrated products.

5. That study be made to improve present methods of testing the palatability of dehydrated vegetables.

6. That further study be made on all factors of the home dehydration process to produce a more nutritious, more palatable, home dried product.

APPENDIX

EFFECT OF STEAM BLANCHING UPON PALATABILITY

Judge	3 Minute Blanch		15 Minute Blanch		20 Minute Blanch	
	Test Scores		Test Scores		Test Scores	
	1	2	1	2	1	2
1	50	60	70	75	65	75
2	65	55	75	70	80	65
3	35	45	80	60	75	80
4	45	45	55	70	55	60
5	40	30	65	65	70	55
6	60	55	55	45	60	70
7	35	45	60	70	70	65
8	30	40	55	65	45	60
9	55	40	85	65	80	65
10	35	40	55	50	70	60
11	40	45	70	60	60	70
12	45	65	70	65	65	85
13	40	50	45	50	75	65
14	30	40	50	60	80	75
15	40	45	60	70	55	55
16	55	40	70	55	60	65
17	50	40	45	55	65	75
18	65	35	75	60	80	70
19	35	50	60	65	70	80
20	50	35	70	60	80	70
Average	45		60		68	

EFFECT OF DIP BLANCHING UPON PALATABILITY

Judge	3 Minute Blanch		15 Minute Blanch		20 Minute Blanch	
	Test Scores		Test Scores		Test Scores	
	1	2	1	2	1	2
1	45	55	65	60	75	80
2	50	45	70	50	70	65
3	45	50	70	65	80	75
4	45	35	50	55	60	55
5	50	45	65	70	70	55
6	45	40	60	70	65	75
7	45	50	60	60	70	65
8	55	45	40	45	80	65
9	40	50	60	75	45	60
10	65	55	55	70	60	70
11	45	35	65	70	70	75
12	40	30	50	55	65	75
13	55	45	60	55	80	75
14	60	50	50	55	75	80
15	45	35	70	60	55	65
16	60	55	55	60	65	60
17	40	50	50	55	65	75
18	55	45	70	60	70	80
19	50	40	75	80	75	80
20	45	55	65	75	75	70
Average	47		61		66	

EFFECT OF REHYDRATION TIME UPON PALATABILITY

Judge	15 Minute Blanch No Soak		15 Minute Blanch 30 Min. Soak		15 Minute Blanch 2 Hr.Soak		15 Minute Blanch 3 Hr.Soak	
	Test Scores		Test Scores		Test Scores		Test Scores	
	1	2	1	2	1	2	1	2
1	45	35	45	40	70	75	70	65
2	50	35	65	60	75	70	75	80
3	35	30	55	45	80	60	70	55
4	25	35	40	35	55	70	55	50
5	45	40	55	60	65	65	60	55
6	40	45	35	40	55	45	70	60
7	35	40	60	50	60	70	6C	50
8	25	30	50	45	55	65	60	50
9	40	50	45	55	85	65	55	50
10	35	45	55	40	55	50	65	70
11	45	35	60	55	70	60	70	55
12	40	30	50	65	70	65	60	75
13	55	45	65	55	45	50	45	40
14	30	40	35	50	50	60	60	60
15	35	45	55	60	60	70	60	70
16	60	55	65	65	70	55	70	65
17	40	30	60	50	45	55	55	50
18	35	45	50	65	75	60	65	70
19	50	40	40	45	60	65	50	70
20	45	35	50	55	70	60	65	60
Average	40		53		60		61	

EFFECT OF REHYDRATION TIME UPON PALATABILITY
(Continued)

Judge	20 Minute Blanch No Soak		20 Minute Blanch 30 Min. Soak		20 Minute Blanch 2 Hr. Soak		20 Minute Blanch 3 Hr. Soak	
	Test Scores		Test Scores		Test Scores		Test Scores	
	1	2	1	2	1	2	1	2
1	60	45	65	70	65	70	70	80
2	60	50	75	70	80	65	80	65
3	45	35	65	45	75	80	75	80
4	35	45	50	65	55	60	60	70
5	40	30	60	45	70	55	65	75
6	60	55	70	75	60	70	65	60
7	35	45	50	65	70	65	75	65
8	30	40	45	45	45	60	55	65
9	55	40	60	60	80	65	75	70
10	40	35	45	60	70	60	75	65
11	45	40	60	50	60	70	70	70
12	65	45	60	70	65	85	75	70
13	40	50	50	60	75	65	60	75
14	30	40	55	70	80	75	75	80
15	35	40	65	70	55	55	60	70
16	40	55	50	35	60	65	60	60
17	45	50	50	55	65	75	70	75
18	65	35	60	55	80	70	75	80
19	35	50	50	60	70	80	80	70
20	50	35	65	50	80	70	70	65
Average	44		58		68		68	

EFFECT OF COOKING UTENSIL UPON PALATABILITY

Judge	Pyrex Pan		Aluminum Pan		Pressure Saucepan	
	Test Scores		Test Scores		Test Scores	
	1	2	1	2	1	2
1	65	80	65	50	30	20
2	70	65	60	55	25	40
3	75	80	85	70	35	30
4	60	55	65	50	45	35
5	55	70	80	70	15	25
6	60	70	60	75	20	15
7	65	70	75	60	25	35
8	80	65	70	65	45	45
9	60	45	60	75	30	45
10	70	60	65	70	35	20
11	70	70	65	75	40	45
12	65	75	85	65	20	35
13	75	75	80	65	35	20
14	80	75	75	65	25	35
15	55	65	70	65	30	35
16	60	65	75	65	40	45
17	65	75	60	70	30	40
18	80	70	70	75	35	40
19	80	75	80	70	20	35
20	75	70	60	50	35	25
Average	68		65		32	

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