Studies on The Ascorbic Acid Content of Dehydrated Vegetables, and Its Retention in Cooking.

by

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A Thesis

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INTRODUCTION

Vegetable dehydration, or the scientific drying of vegetables for domestic use has made great progress particularly during recent months. Contrary to popular opinion however, the demand for these vegetables is very limited. Small quantities have been bought for certain branches of the services, and limited amounts have been purchased as emergency reserve rations for military and naval establishments (25). But keeping in mind the constantly changing conditions created by war, it is quite probable that in the future, dehydrated vegetables might be required in considerable quantity.

The outstanding advantage of dehydrated vegetables is that the weight and bulk of the products is greatly reduced, thus making possible economy in storage and transportation (4). However, the vegetables will be of little use unless they can be made into good palatable products of fairly high nutritive value. Fenton (12), Olliver (29) have taken ascorbic acid as a general basis of quality in vegetable cookery, for if it is retained color, flavour, texture, water soluble vitamins and certain soluble minerals will not be appreciably changed.

The purpose of the thesis is to determine the ascorbic acid content of dehydrated vegetables, and its retention in cooking, with special reference to the proper methods of preparation of good edible products.

HISTORICAL

Vegetable dehydration in Canada goes back almost as far in history as does fruit drying, which is an ancient art. However, its record has not been as satisfactory, because of the problems of enzyme deterioration, flavor loss, excessive hardening of the outer skin and loss of nutrients. Due to their poor quality, dried vegetables were used little, except under circumstances where the fresh products were unobtainable for long periods of time.

In times of war, however, they were often used. The British used dried vegetables during the Boer War (24), and in the World War I, some 9,000,000 pounds were sent overseas to the American and Canadian Armies (39). These vegetables were found to be very tough and tasteless, and only dire necessity compelled consumption.

In the years immediately following 1919, the drying of vegetables declined rapidly and for the last ten years or more, production has been comparatively small.

It was not until 1938 that C. C. Eidt (25) published a bulletin on methods of apple dehydration and the proper mechanical equipment to use with these methods. The success of this method for the dehydration of apples led to its being introduced for the dehydration of vegetables.

Briefly the complete process of vegetable dehydration consists of sorting, washing, peeling, coring, hand trimming, slicing, blanching with either steam or water, dehydrating and packaging. The two important steps are those of blanching and of actual drying.

Cruess and Mrak (5) have shown that the failure to blanch the vegetables before dehydration results in unpalatability and toughness. Blanching stops destructive chemical changes by destroying the agents that produce them and prevents darkening or discoloration; it coagulates some of the soluble constituents; and it destroys the protoplasm and consequently accelerates the escape of moisture in drying (3). To-day, the blanching is accomplished by one of two systems, (a) steam blanching in a steam tunnel preceded by the loading of trays and (b) hot water blanching with the vegetables in wire buckets conveyed through the tank and loaded on trays after blanching. Carrots and turnips are treated by the first method, whereas potatoes are blanched by the second method.

After the enzymes have been inactivated, modern vegetable dehydration depends largely for its success upon drying the product to a moisture content of 4-5% in as short a time as possible (25). This method preserves the natural color and aids in preventing toughness. This also may be a factor in the retention of essential nutrients in the finished product.

For vegetable dehydration, the best method is the single tunnel drier developed by Eidt employing hot end loading and preliminary parallel current operation under counter current conditions (25). This method results in rapid drying and a reduction of fuel costs due to complete control of temperature at all stages of drying. The low humidity of the finishing air makes it possible to produce the low moisture content demanded in the finished product. Another important feature is that during the course of drying the air is passed through the trucks from both directions resulting in absolute uniformity of drying throughout.

Following drying, the vegetables are stored in a room that can be fumigated with a satisfactory fumigant until packed in insect proof containers (4). All packages are hermetrically sealed as absorbed moisture will affect keeping qualities. At present all the common vegetables with the exception of potatoes, onions and beets are packed in an oxygen free atmosphere. This is accomplished by vacuum packing in sealed containers or by packing in an inert atmosphere such as carbon dioxide.

PART I EXPERIMENTAL

DETERMINATION OF ASCORBIC ACID IN DEHYDRATED VEGETABLES AND IN COOKED DEHYDRATED VEGETABLES

The method adopted for the determination of ascorbic acid in dehydrated vegetables is the titrimetric procedure of King (18) as modified by Burrel and Ebright (2). It was found in this laboratory after preliminary work, that several changes in the above method were necessary in order that the estimation of ascorbic acid in dehydrated vegetables could be more accurate.

1. The use of the Waring Blender

One source of error was thought to be in the method of extraction of the ascorbic acid from the raw or cooked material. Thus, it was decided to try to extract ascorbic acid by a new procedure which utilized the Waring Blender. Davies (8) claimed that this method was just as efficient and less laborious than the older grinding method. The Home Economics Institute of Westinghouse Electrical Manufacturing Company (40), who also favored the new method, bubbled CO_2 into the mixture during extraction to help prevent the loss of ascorbic acid through oxidation.

A comparison of the two procedures as applied to dehydrated vegetables is shown in Tables I and II. In the case of the uncooked dehydrated vegetables, all samples were ground in the Wiley Mill to 100 mesh. With the cooked product, there was no preliminary sub division.

In the trituration method, a 5 gram sample of uncooked or a 25 gram sample of the cooked material was ground in a mortar with purified sand (A.O.A.C. Method 41) and 40 ccs. of equal proportions of 4% HPO_3 and 2N H_2SO_4, until a smooth pulp was obtained. The material was centrifuged, washed and made up to volume in the usual manner.

With the Waring Blender, the same sample weights were used, but in this case the volume of the extractant was 100 ccs. The uncooked vegetable was extracted for twelve minutes and the cooked for eight minutes at low speed.. The final solution for titration of the vitamin was obtained by the usual centrifuging method.

In every case, the grinding method gave a higher titration value for the uncooked vegetable. With the cooked product, the reverse was true. It would seem that when uncooked dehydrated vegetables which have been ground in a Wiley Mill were treated in a Waring Blender, no appreciable further subdivision occurred, whereas when this material was ground with sand, there was a greater bursting of the cells, and hence a greater extraction of ascorbic acid. The preliminary grinding in the Wiley Mill was valuable for obtaining a representative sample, but the particles thus obtained were not as readily caught and broken by the revolving knives of the Waring Blender, as would be the larger fragments. This fact may partially account for the more complete extraction by the blender of the larger pieces of the cooked material. Finally the greater bulk and softness of the cooked product must also be considered in any explanation of these results.

TABLE I. - A COMPARISON OF TWO METHODS OF EXTRACTING ASCORBIC ACID FROM DEHYDRATED VEGETABLES.

Reduced Ascorbic Acid - mgs. per 100 gms.

Vegetable	A Trituration	B Waring Blender
Cabbage		
I	372	342
II	412	337
III	355	305
Potato		
I	12.8	12.6
Turnip		
I	186	172
II	192	150

TABLE II. - A COMPARISON OF TWO METHODS OF EXTRACTING ASCORBIC ACID FROM COOKED DEHYDRATED VEGETABLES.

Reduced Ascorbic Acid - mgs. per 100 gms.

Vegetable	A Trituration	B. Waring Blender
Cabbage		
I	218	210
II	193	197
Potato		
I	3.25	4.46
II	3.80	5.73
Turnip		
I	33.7	30.1
II	33.7	35.7

2. The advantage of the Wiley Mill.

Considerable variations were found in the ascorbic acid content of the different portions of the same can. This error was overcome by using a Wiley Mill. About 100 grams of the dehydrated vegetables were put into the mill and ground up to pass through a 100 mesh sieve, which gave a much finer product than could be obtained by grinding in a mortar. The vegetables were quite dry and thus there was comparatively little danger that iron or copper contamination from the mill would take place.

A 5 gram sample was ground with the extractant

(4% HPO_3 and 2N H_2SO_4), centrifuged and finally titrated against indophenol dye to determine the amount of ascorbic acid present. In the case of hand grinding, a 5 gram sample taken directly from the tin was broken up as finely as possible in a mortar and again ground with the extractant and the ascorbic acid determined in the usual manner.

Table III illustrates the difference between hand grinding in a mortar with grinding in a Wiley Mill. From these results, it may be concluded that the Wiley Mill can be employed without loss of ascorbic acid.

TABLE III. - A COMPARISON OF HAND GRINDING IN A MORTAR WITH GRINDING IN A WILEY MILL AS METHODS FOR PREPARING THE SAMPLES FOR ASCORBIC ACID ANALYSES.

Reduced Ascorbic Acid - mgs. per 100 gms.

Sample	A. Mortar	B. Wiley Mill
Potato	30.5	34.5
Bean	37.6	42.7
Cabbage	147.1	139.6
Carrot	7.4	7.8

3. The use of Sulphuric Acid as an extracting agent.

Owing to the war, metaphosphoric acid has become very difficult to procure. By the method of King (18), the only extractant used was 3% metaphosphoric acid. Burrel and Ebright (2) reduced the amount of metaphosphoric by extracting with a mixture of equal proportions of 2N sulphuric acid and 4% metaphosphoric acid. Their results compared very favorably with those of King (Table VI), and consequently it was thought that sulphuric acid alone might be employed.

The results are shown in Table IV. One set of samples was extracted with equal proportions of 2N sulphuric acid and 4% metaphosphoric acid and the others extracted with 2N sulphuric acid alone. It was evident that sulphuric acid could not be used alone, for the results were too variable and very low.

However, since sulphuric acid could not be used alone, it was thought that an effective extracting agent might be obtained with a small proportion of metaphosphoric acid present in the solution. In the experiment the amounts of sulphuric acid and metaphosphoric acid were in such proportions that the titratable acidity was always the same. It was shown in Table V that sulphuric acid could be increased considerably and metaphosphoric decreased, but not completely removed from the solution. The conclusion was that without metaphosphoric acid, the extracting solution was of little use, for the latter was necessary to stabilize the ascorbic acid present in the material.

TABLE IV. - EXTRACTION OF ASCORBIC ACID WITH HPO_3 VERSUS EXTRACTION WITH H_2SO_4.

Reduced Ascorbic Acid per 100 grams

Vegetable	4% HPO_3 & 2N H_2SO_4	H_2SO_4 alone
Cabbage	mgs.	mgs.
Trial I	372	118
" II	352	103
" III	382	222
" IV	347	134
" V	332	94

TABLE V. - SHOWING THE EFFECT OF VARIOUS AMOUNTS OF HPO_3 IN THE EXTRACTING SOLUTION.

Reduced Ascorbic Acid per 100 grams

Vegetable	Proportion of H_2SO_4 to HPO_3		Trial I	Trial II
	ccs.	ccs.	mgs.	mgs.
Cabbage	-	100	337	354
	50	50	332	347
	56.3	25 *	330	353
	59.4	12.5	331	355
	60.9	6.25	328	356
	62.5	-	94	134

* The solution was made up to 100 cc. volume with distilled water.

4. The modified method used in determining the ascorbic acid content of dehydrated vegetables.

Following is a description of the procedure employed for ascorbic acid determination in dehydrated vegetables, which is essentially a modification of Burrel and Ebright's method. This modified method followed very closely the principles of ascorbic acid determination as set forth by Harris and Olliver (14). They emphasized the necessity of representative sampling, complete extraction, inactivation of the oxidase and rapid titration. They believed that if the above precautions were taken, then direct titration of the acid extract against 2,6, dichlorophenolindophenol could be recommended as a measure of total antiscorbutic activity in all routine analyses of plant materials. Harris and Olliver (14) were of the opinion that "bound ascorbic acid" and "dehydro ascorbic acid" did not exist, but that the apparent rise in ascorbic acid content was due to faulty technique.

The contents of the can were thoroughly mixed, and a representative sample of about 100 grams was ground in a Wiley Mill to pass through a 100 mesh sieve. A 5 gram sample was transferred to a mortar and ground up with acid washed sand and 40 ccs. of a mixture of equal parts of 2N H_2SO_4 and 4% HPO_3. (Metaphosphoric acid forms catalytically inactive complexes with copper and iron ions, inactivates ascorbic acid oxidase, and functions as a general protein precipitant to give a fairly clear solution suitable for titration with 2,6, dichlorophenolindophenol.) The finely ground material was transferred to a 250 ml. centrifuge bottle, the mortar washed out with 50 ccs. of the extractant and the washings added to the original material. After centrifuging at a 2,000 r.p.m. for ten minutes, the supernatent liquid was transferred to a 200 cc. volumetric flask. The residue was washed twice with 50 and 30 ccs. of the extractant, centrifuging after each addition. The combined extracts were made up to 200 ccs. with 2N $H_2SO_4$and 4% HPO_3. From the above extract, 10 cc. aliquots were taken and titrated in an inert atmosphere with standard 2,6, dichlorophenolindophenol until a faint pink color was obtained.

For cooked dehydrated vegetables the procedure was slightly different. A 25 gram sample was transferred to a Waring Blender, 100 ccs. of 2N H_2SO_4 and 4% HPO_3 were added, and the material was agitated at high speed for eight minutes. The finely dispersed material was transferred to a 250 cc. centrifuge bottle, the blender washed out with 50 ccs. of the extractant, and the washing added to the original material. From here on, the procedure was the same as that already described for the uncooked dehydrated vegetables.

The indicator 2,6, dichlorophenolindophenol was prepared and standardized against $Na_2S_2O_3$ according to Menaker and Guerrant (23). The stock solution of $Na_2S_2O_3$ was prepared and its normality determined by the method of Steven (33).

To determine the accuracy of this method, it was compared to the Bessy and King titrimetric procedure, which employed 3% metaphosphoric as the only extractant. In Table VI the results showed that there was little significant difference.

TABLE VI. - A COMPARISON OF THE BESSY & KING METHOD WITH THE MODIFIED BURREL AND EBRIGHT METHOD.

Reduced Ascorbic Acid (mgs. per 100 gms.)

Vegetable	Bessy & King Method	Modified Burrel & Ebright Method
Turnip		
Sample I	182	186
" II	173	168
" III	232	250
" IV	164	166
" V	87	94
Potato		
Sample I	16.0	15.20
" II	23.2	23.4
Cabbage		
Sample I	358	350

B. ASCORBIC ACID CONTENT OF DEHYDRATED VEGETABLES

1. Loss of ascorbic acid during the Dehydration of vegetables.

The data in the literature concerning the ascorbic acid content of dehydrated vegetables are not very extensive.

The presence in vegetables of an enzyme which catalyses the oxidation of ascorbic acid is of extreme importance. This enzyme is more active or is present in larger amounts in some vegetables than in others; it is apparently not so active in acid as in non acid vegetables. Tressler, Mack and King (35) have shown that non acid vegetables lost ascorbic acid more rapidly during dehydration than did fruits which are relatively more acidic.

In 1918 Delf and Shelton (9) reported that the antiscorbutic factor was almost completely destroyed during slow dehydration of cabbage. Beckley and Naltey (2) showed that dried blanched cabbage contained about 20% more ascorbic acid than did the dried unblanched material. Paikina (31) has proved that cabbage dried at a temperature of 28-65°C gave less loss of ascorbic acid than when dehydrated at a temperature of 70°C.

According to Javiller (34), the ascorbic acid content of commercially dehydrated potatoes was about 20 mgs. per 100 gms., and that of the untreated potatoes containing 70% water was 6 mgs. per 100 gms. Kraner and Volksen (34) indicated that the loss of ascorbic acid in dehydrating potatoes was not due to peeling since the peel and immediately adjacent tissues were poor in ascorbic acid.

Diemar (11) found that cabbage and carrots lost about 70-90 percent of their original ascorbic acid content.

In Table VII, the loss of ascorbic acid in the dehydration of the fresh vegetable was about 25-40%. The losses were somewhat lower than those found by the above workers, but this was probably due to the recent improvements in methods of dehydration.

To show the loss due to dehydration, the fresh vegetables and the corresponding dehydrated vegetables were used in these analyses.

TABLE VII. - SHOWING THE LOSS OF ASCORBIC ACID IN THE DEHYDRATION OF VEGETABLES.

Reduced Ascorbic Acid (mgs. per 100 grams)

Vegetable	Fresh	Dehydrated	Loss in dehydration	
	mgs.	mgs.	mgs.	%
Cabbage	515	325	190	37.03
Potato	49	31	18	36.7
Turnip	243	183	60	24.8

2. The effect of storage and variety

The vitamin content of dehydrated vegetables was affected by variety and length of storage (see Table VIII) This was to be expected as Tressler, Mack and King (36) have already shown that the ascorbic acid content of fresh vegetables was influenced by variety. The duration of storage was also important, since potatoes dehydrated last fall had a much higher ascorbic acid content than the stored potato dehydrated this winter.

TABLE VIII. - THE ASCORBIC ACID CONTENT OF DEHYDRATED VEGETABLES

Vegetable		Variety	Reduced Ascorbic Acid (mgs./ 100 gms.)	
Potatoes	I	N.B. Green Mountain	16.0	Dehydrated stored potato.
	II	N.B. Katahdin	23.2	
	III	N.S. Green Mountain	17.5	
	IV	Manitoba	22.0	
	V	"	20.3	
	VI	"	22.1	
	VII	"	18.7	
	VIII	B.C. Netted gem	17.5	
	IX	"	19.4	
	X	Ontario potatoes	54	Dehydrated fresh potato
	XI	"	58	

3. Stability of ascorbic acid in dehydrated vegetables

The question now arises as to the loss of ascorbic acid in dehydrated vegetables after the tin has been opened. Considerable data in this connection is given in Table IX. The potato sample was powdered and stored in a corked colored bottle while the cabbage sample was exposed to the air in the original tin.

No appreciable loss was found if the tin was opened for a few days, but if opened for several weeks, the loss was considerable. With the powdered potato, the loss was slow but progressive. Mathiesen (22) has shown that the loss in powdered samples was continual and after storing for a few months, little ascorbic acid remained.

TABLE IX. - THE STABILITY OF ASCORBIC ACID IN DEHYDRATED VEGETABLES EXPOSED TO THE AIR FOR VARYING PERIODS OF TIME

Cabbage		Potato	
Duration of exposure from time can first opened	Reduced ascorbic acid mgs/ 100 gms	Duration of exposure from time can first opened	Reduced & Reversibly oxidized ascorbic acid
Days	Mgs.	Days	Mgs.
0	267	0	53.74
41	142.1	16	51.12
78	76.1	23	51.85
86	69.7	30	43.05
		37	42.25
		44	42.31
		51	33.80
		72	33.87
		79	22.71

C. METHODS OF COOKING DEHYDRATED VEGETABLES

No matter how well vegetables have been dehydrated, they are of little use unless they can be made into good palatable products through the proper methods of cooking. Cruess and Mrak (6) have found that if the vegetables are properly dried, they should, upon soaking for a few hours, absorb the water and return to their original size, form and appearance. They should be tender, not tough when cooked; should not collapse or become mushy, and should retain a considerable portion of their original odor, flavor and nutrients.

To obtain such results, it has been found necessary to standardize the cooking procedures so they may be applicable to all samples of a particular vegetable. In addition to their use in laboratory testing work, these standardized methods should form the basis of methods for cooking dehydrated vegetables on a large scale.

The following is a description of the laboratory methods of cooking dehydrated vegetables, with an account of the experimental work involved.

In all tests the vegetables were cooked by boiling, in medium sized household enamel pots on a hot plate, the surface of which was a 1/4" iron sheet, 18 inches square. This plate was maintained at a temperature of 275°C, which permitted rapid boiling.

The water used in all tests unless otherwise specified was cold tap water.

A medium sized (4" diameter) household tin strainer was used for draining the vegetables. Two minutes were allowed in all cases to obtain complete drainage of the refreshed and cooked vegetables.

For each of the vegetables studied, 15 gram samples of dehydrated material were soaked in 250 mls. of water for different periods of time, and with different water temperatures. The initial temperature of the water was recorded; then at the end of each period of soaking, the temperature was again noted, the vegetables drained and weighed. This weight gave a measure of the completeness of refreshing. At a certain point, additional refreshing time gave little increase in weight.

At the end of each of the several refreshing periods, 1/4 tsp. of salt was added to each sample. The refreshed material was then cooked for a period of 15-30 minutes depending on the vegetable.

Following cooking, the palatability of the product as influenced by color, texture, flavor and drained weight was determined. To accomplish this, each individual characteristic was given a numerical rating as in Table X. Deductions were made for off odors, or any other objectionable defect.

The details of the experiment with dehydrated cabbage, carrot, potato and turnip are described below.

1. Cabbage

Samples of the dehydrated vegetables were refreshed in hot and in cold water for varying periods of time as shown in Table X and the score of each sample of the cooked vegetable determined.

This study was made on cabbage processed in Ontario from fresh Texas cabbage, samples of which were sent along with the dried products. For comparison both the dehydrated and fresh samples were cooked. It was found in all tests that the color and texture of the dehydrated product compared favorably with that of the fresh vegetable.

In this study, the following conclusions were reached:-

(1) Cabbage soaked in hot water rehydrated more quickly than did the vegetable soaked in cold water.

(2) The longer soaking periods resulted in slightly increased amounts of hot water being taken up by the vegetable.

(3) The most palatable product was the sample refreshed in hot water for 15 minutes. This cabbage was quite tender and had a fairly good flavor.

The following standard procedure has been adopted for all refreshing and cooking tests on cabbage; rehydrate by soaking a 15 gram sample for 15 minutes in 250 mls. of hot water (temperature 80°C); then add 1/4 tsp. of salt, boil rapidly for 15 minutes and drain.

TABLE X. - THE EFFECT OF DIFFERENT SOAKING PERIODS ON THE PALATABILITY OF COOKED CABBAGE

	Refreshed Cabbage				The Cooked Product					
Test No.	Total Refreshing time (mins.)	Initial temp. (°C)	Temp. at end of period (°C)	Wt. of Refreshed Product (gms)	Points alloted	Color (10)	Texture (30)	Flavour (30)	Odor (5)	Drained Wt. (25)
I	20	20	20	105		grayish green 5	tough woody 15	very artifical 15	nothing 2	25
II	0	100*	-	-		grayish green 5	tough rubbery 15	very distasteful 15	very little 2	25
III	5	100	79	115		grayish green 5	rubbery 18	not very palatable 18	very little 2	25
IV	10	100	80	130		darker than fresh vegetables 5	not as rubbery as above 22	mild 20	very little 2	25
V	15	100	70	133		similar to fresh 8	very tender 28	mild 20	not repulsive 2	25

* Boiling water was used.

2. Carrots

Samples of the dehydrated vegetable were refreshed by various treatments as indicated in Table XI. The scoring of the cooked product in the three best tests was also described.

This study was made on dehydrated carrots processed in British Columbia, from fresh carrots grown in that province.

The following conclusions were drawn from the results of this experiment.

(1) There was an increase in the weight of the refreshed vegetable after three and four hours of soaking, but this was not accompanied by improved palatability in the cooked product. Even the still greater refreshed weights after eleven hours soaking in cold water and twenty minutes soaking in hot water did not lead to a greater palatability of the product.

(2) Some variation was found in the amount of water taken up by different samples of the same dehydrated vegetable. This seemed to be related to the size of the particles constituting the sample, for greater amounts of water were taken up when the sample consisted of very small pieces, than when the sample consisted of larger particles of fairly uniform size.

(3) The most palatable cooked product was the sample refreshed for one hour.

The following procedure was used as a standard in all refreshing and cooking tests with carrots. Rehydrate by soaking a 15 gram sample for one hour in 250 mls. of water; then add 1/4 tsp. of salt and boil rapidly for 25-30 minutes and drain.

TABLE XI. - THE EFFECT OF DIFFERENT SOAKING PERIODS ON THE PALATABILITY OF COOKED CARROTS

Test No.	Refreshing Data: Total Refreshing time	Temp. (°C)	Wt. after draining gms.	Points alloted	Cooking Data: Color 10	Texture 30	Flavour 30	Odor 5	Drained wt. 25	Total 100
1.	1 hr.	20	77		excell-ent	excellent	very sweet marked carrot taste	very good		
					10	30	29	5	23	99
2.	3 hrs.									
	(a) after 1 hr.	18.5	86							
	(b) " 2 "	17.5	97.5							
	(c) " 3 "	20	97.5		-	-	-	-	-	-
3.	4 hrs.									
	(a) after 1 hr.	19	83		lighter yellow	excellent	less sweet	mild		
	(b) " 2 "	18	97.5		8	30	26	4	23	91
	(c) " 3 "	20	97.5							
	(d) " 4 "	20	98							
4.	11 hrs.	20	113		-	--	-	-	-	-
5.	20 mins.	79	100		excellent	not as tender	similar to fresh carrot			
					10	24	27	5	24	90

3. Turnip

Samples of dehydrated turnip were refreshed by the treatments indicated in Table XII, and the palatability of the cooked product determined. This study was carried out on dehydrated Ontario fresh turnips. This particular sample of dehydrated turnip was not of very good quality. It had many "woody" spots which may have come from portions of the woody core of the fresh vegetable, which was incompletely removed in the preparation of the vegetable for dehydration. However, later samples have proved to be free from this woodiness, and on cooking have given good tender products.

These experiments were similar to those with carrots, and the following conclusions were drawn:-

(1) From one to five hours refreshing at room temperature gave no appreciable change in the amount of water taken up. The vegetables refreshed by soaking for five hours did however show somewhat greater plumpness; but this was not accompanied by greater palatability.

(2) Samples containing many small pieces seemed again to take up greater amounts of water than an equal sample containing fewer small pieces.

(3) The most palatable product after cooking was the sample soaked for one hour.

The standard procedure adopted for refreshing and cooking turnip was as follows; rehydrate by soaking a 15 gram sample for one hour in 250 mls. of water; then add 1/4 tsp. of salt, boil rapidly for 25 minutes and drain.

TABLE XII. - THE EFFECT OF DIFFERENT SOAKING PERIODS ON THE PALATABILITY OF COOKED TURNIPS

Test No.	Refreshing Data: Total Refreshing time	Temp. (°C)	Wt. after draining gms.	Points alloted	Cooking Data: Color 10	Texture 30	Flavour 30	Odor 5	Drained wt. 25	Total 100
1.	1 hr.	18	116		excellent	good large pieces "woody"	mild pleasant	exce-llent		
					10	25	26	5	22	88
2.	3 hrs.									
	(a) after 1 hr.	18	92							
	(b) " 2 "	17	98							
	(c) " 3 "	20	111		-	-	--	-	-	-
3.	5 hrs.									
	(a) after 1 hr.	11	-							
	(b) " 2 "	12.5	-							
	(c) " 3 "	16	105							
	(d) " 4 "	18	115							
	(e) " 5 "	19	123.5		-	-	-	-	-	-
4.	11 hrs.	20	153.5		yellowish orange	as above	very little not bitter	very mild		
					9	25	25	3	22	84
5.	20 mins.	73	92		-	-	-	-	-	-

4. Potato

Samples were refreshed in cold water for varying periods of time as shown in Table XIII. The refreshed products were then cooked for nine minutes and the quality of the best products recorded.

It should be noted that this method applied only to potatoes dehydrated at Berwick, Nova Scotia, and Belleville, Ontario. For British Columbia and Beardmore potatoes, steaming was the only method that was found satisfactory. By this procedure, the potatoes did not disintegrate as they did when boiled.

This study was made on dehydrated potatoes "Julienne type" prepared at Belleville, Ontario. Laboratory examination showed that this sample was insufficiently blanched as indicated by the strong enzyme activity still present in the material. Therefore, these potatoes had a questionable storage life, but were quite suitable for preliminary cooking trials.

The results may be summarized as follows:-

(1) Soaking for three hours gave a potato that was more mealy in texture when cooked and at the same time there was less tendency for the water to adhere to the surface.

(2) After three hours soaking, the amount of water taken up was very slight, and thus overnite refreshing was unnecessary. In numerous experiments, it was shown that at least 25 ccs. of water were taken up by the potato on cooking rather than during soaking.

TABLE XIII. - THE EFFECT OF DIFFERENT SOAKING PERIODS ON THE PALATABILITY OF COOKED POTATOES

Refreshing Data					Cooking Data					
Test No.	Total Refreshing time	Temp. (°C)	Wt. after draining gms.	Points alloted	Color	Texture	Flavour	Odor	Drained wt.	Total
					10	30	30	5	25	100
1.	1 hr.	20	44		good	rather lumpy when mashed	mild almost taste-less	mild	fair	
					9	20	18	3	15	65
2.	1½ hrs.									
	(a) after 1 hr.	18	45							
	(b) " 1½ "	17	46		-	-	-	-	-	-
3.	3 hrs.									
	(a) after 1 hr.	18	43		good	very good quite mealy	fair	mild	fair	
	(b) " 2 "	17	48							
	(c) " 3 "	19	51		9	25	22	3	15	74
4.	5 hrs.									
	(a) after 1 hr.	19	46							
	(b) " 2 hrs.	19	49							
	(c) " 3 "	18	52							
	(d) " 5 "	19	54		-	-	-	-	-	-
5.	11 hrs.	18	56		good	very mealy	nothing	poor	fair	
						25	17	2	15	68

(3) Refreshing for three hours gave a potato strip that easily broke in two, whereas one hour soaking did not accomplish this but gave a rubbery product.

(4) Refreshing for one hour produced a potato that had a slightly milder odor and more flavor than did soaking for three hours, but this one advantage of one hour soaking could not compensate for the poorer texture that resulted on cooking.

From these results, the standard method of cooking developed for all laboratory tests was as follows:- rehydrate 15 grams of potatoes in 250 ccs. of water for three hours; then add 1/4 tsp. of salt and boil eight minutes and drain.

However, palatability is not the only factor to be considered, for if the method of cooking is to be successful, the nutritive value must be retained to a considerable extent. In the following pages, vitamin analyses are reported showing the value of proper cooking methods.

D. THE ASCORBIC ACID CONTENT OF COOKED DEHYDRATED VEGETABLES

1. The losses of ascorbic acid during cooking.

During the last war, the vitamins in dehydrated vegetables were probably quite low because of the poor methods of dehydration. But much research in the last two years has indicated that dried vegetables of superior table quality can be manufactured and that a major percentage of the vitamins can be kept. However, the retention of the vitamin in the original dehydrated vegetable is of little value, unless a considerable portion can be retained on refreshing and cooking.

Of all the vitamins, ascorbic acid is the most easily destroyed and is readily dissolved from the vegetable. For this reason it was believed that if ascorbic acid was retained in the vegetable, then the other water soluble vitamins, as well as color, texture and flavor, would not be appreciably changed.

There is relatively little information concerning the loss of ascorbic acid in dehydrated vegetables. Beckley and Natley[(2)] have found that the cooked edible portion of cabbage contained 16.8 percent of the original ascorbic acid, and the drainage water 28.9 percent; figures which are just the reverse of the present findings.

As noted in Table XIV the amount of ascorbic acid destroyed in cooking dehydrated vegetables was considerable. Enzyme action may have been partly responsible for this. It is important that the enzyme be inactivated as quickly as possible during cooking. This means that if the vegetable is to be boiled, it should be plunged into boiling water, and the water brought back to the boil as quickly as possible. In cooking dehydrated vegetables this procedure was not carried out as the vegetable was cooked in the soaking water; thus the enzyme was not inactivated as readily.

Some of the vitamin was leached into the soaking water as shown in Table XV. Mathiesen, Jakobsen and Knalhein (22) noted a loss of ascorbic acid when dehydrated vegetables were soaked in water. Although the loss was very small, it did increase the total ascorbic acid present in the drainage water. To prevent such losses, theoretically, dehydrated vegetables should not be soaked but immediately immersed in boiling water. This method of cooking was tried but resulted in a very undesirable product, unfit for table use and hence was not used.

Then again, the loss of ascorbic acid in cooked dehydrated vegetables may be due to the shape and size of the pieces. Wellington and Tressler (37) have found that shredded fresh cabbage on cooking lost 2/3 of its ascorbic acid content while with larger pieces of cabbage the amount lost was considerably reduced.

TABLE XIV. - SHOWING THE LOSS OF ASCORBIC ACID DURING THE COOKING OF DEHYDRATED VEGETABLES ON A SMALL SCALE

Reduced ascorbic acid per 100 grams dehydrated vegetable

Vegetable		Wt. of original sample	Wt. of edible portion of cooked veg.	Volume of drainage H_2O	In original sample	In edible portion	In drainage water	Destroyed
		gms.	gms.	mls.	mgs.	%	%	%
Cabbage	I	15	145	52	400	32.5	18.7	48.8
						33.5	18.6	47.6
	II	15	129	32	400	37.8	14.3	47.6
						39.8	13.9	46.5
	III	15	139	23	400	44.5	10.3	45.3
						44.2	10.9	44.6
	IV	15	136	22	400	42.2	10.3	47.4
						42.5	10.1	47.4
	Average					39.6	13.4	47.03
Potato	I	15	71	75	16.5	22.6	42.3	33.9
						26.5	34.6	38.9
	II	15	78	62	16.5	25.3	29.6	45.6
						28.1	29.6	42.9
	III	15	80	45	16.5	30.5	20.5	48.4
						27.7	20.5	51.6
	IV	15	80	48	16.5	27.7	24.9	48.4
						30.7	24.9	44.3
	Average					27.4	28.4	44.2

TABLE XIV. (Cont'd.) - SHOWING THE LOSS OF ASCORBIC ACID DURING THE COOKING OF DEHYDRATED VEGETABLES ON A SMALL SCALE

Reduced ascorbic acid per 100 grams dehydrated vegetable

Vegetable	Wt. of original sample	Wt. of edible portion of cooked veg.	Volume of drainage water	In original sample	In edible portion	In drainage water	Destroyed
	gms.	gms.	mls.	mgs.	%	%	%
Turnip I	15	110	35	190	31.8 30.8	15.8 15.8	52.3 53.2
II	15	103	18	190	41.6 40.1	5.7 5.5	52.7 54.5
III	15	109	57	190	23.1 24.2	20.5 20.0	56.5 56.0
IV	15	108	56		23.3 22.8	19.6 19.6	57.5 58.0
Average					29.7	15.31	55.1

TABLE XV. - THE LOSS OF ASCORBIC ACID IN SOAKING WATER

Vegetable		Length of soaking period	Remaining soaking water from 250 ccs. used	Reduced ascorbic acid per 100 gms In original sample (mgs.)	Reduced ascorbic acid per 100 gms In soaking water (%)
Cabbage soaked in hot water	I	15 mins	46	400	16.5 16.7
	II	15 "	58	400	19.0 18.5
	III	15 "	45	400	15.7 15.7
Average					17.0
Turnip soaked in cold water	I	1 hr.	138	190	28.5 29.2
	II	1 "	135	190	31.8 31.8
	III	1 "	140	190	31.8 32.3
Average					30.9
Potato soaked in cold water	I	3 hrs.	200	23.1	26.4 26.9
	II	3 "	205	23.1	27.2 27.2
	III	3 "	205	23.1	29.9 27.3
Average					27.5

2. Cooking of dehydrated vegetables in varying amounts of water.

In Table XVI are shown the results of soaking and cooking dehydrated vegetables in large quantities of water, namely 400 ccs. Cooking with a larger volume of water resulted in a greater loss of ascorbic acid in the edible portion and an increased amount in the drainage water. Nevertheless, most people prefer to cook with large amounts of water so as to prevent scorching. If the drainage water, which contained an appreciable amount of ascorbic acid, was utilized in soups etc. instead of being thrown out, the cooking of vegetables in large quantities of water would not be such a serious offence. To-day, according to army regulations, the drainage waters are required to be saved and used in soup stocks.

The distribution of the vitamin between the solid and liquid appears to be dependent on the volume of liquid used. In Table XVII the cooking of vegetables in small and large quantities of water are compared. It was found that the greater the volume of liquid the greater was the amount of ascorbic acid extracted from the vegetable. This has been observed by various workers in fresh vegetable cooking (Daniels (7), Tressler and Fenton (27) and Mack, Tressler and King (35)), and as stated above was borne out in cooking dehydrated vegetables. It was also interesting to note that Fenton (3) has said that if the cooking water contained a large percentage of ascorbic acid, it would also contain some of the other water soluble vitamins such as B_1 and B_2, as well as many soluble minerals.

TABLE XVI. - SHOWING THE LOSS OF ASCORBIC ACID WHEN DEHYDRATED VEGETABLES WERE COOKED IN LARGE VOLUMES OF WATER

Reduced ascorbic acid (mgs/100 gms)

Vegetable		Wt. of original sample	Wt. of edible portion	Volume of drainage water	In original	In edible portion	In drainage water	Destroyed
		gms.	gms.	ccs.	mgs.	%	%	%
Cabbage	I	15	143	140	400	23.0 22.6	37.0 38.2	39.9 39.3
	II	15	150	120	400	27.1 27.7	35.5 34.6	37.3 37.7
	III	15	163	147	400	23.5 24.0	33.4 33.4	43.8 42.7
	IV	15	152	150	400	22.9 22.5	34.9 35.7	42.2 41.7
	Average					24.2	35.3	40.6
Turnip	I	15	118	150	190	10.9 12.2	33.8 34.6	54.2 53.1
	II	15	121	156	190	13.2 12.3	30.2 28.6	56.5 59.0
	III	15	121	175	190	13.5 14.9	33.1 31.1	53.6 54.0
	IV	15	120	150	190	12.5 14.3	30.1 27.3	57.1 58.3
	Average					13.0	31.1	55.7

TABLE XVI (cont'd.) - SHOWING THE LOSS OF ASCORBIC ACID WHEN DEHYDRATED VEGETABLES WERE COOKED IN LARGE VOLUMES OF WATER

Reduced ascorbic acid (mgs/100 gms)

Vegetable	Wt. of original sample	Wt. of edible portion	Volume of drainage water	In original	In edible portion	In drainage water	Destroyed
	gms.	gms.	ccs.	mgs.	%	%	%
Potato I	15	72	410	23.1	27.2 21.4	61.2 55.2	11.5 22.9
II	15	74	380	23.1	18.9 21.9	51.3 58.8	29.5 19.4
III	15	73	385	23.1	21.8 21.8	57.3 62.1	20.2 15.7
IV	15	74	405	23.1	21.9 21.9	55.2 60.0	18.7 17.8
Average					22.3	58.1	19.5

Table XVII. - SHOWING THE COMPARATIVE LOSS OF ASCORBIC ACID WHEN DEHYDRATED VEGETABLES WERE COOKED IN LARGE AND SMALL QUANTITIES OF WATER

	Small Quantities of water		Large Quantities of water	
Vegetable	Amt. of water used in soaking	Ascorbic acid 100 gms.-in edible portion	Amt. of water used in soaking	Ascorbic acid 100 gms. -in edible portion
	ccs.	%	ccs.	%
Cabbage				
Trial I	250	32.50 33.50	400	22.60 23.00
II	"	37.80 39.80	"	27.10 27.70
III	"	44.20 44.50	"	23.50 24.00
IV	"	42.20 42.50	"	22.90 22.50
Average		39.63		24.41
Turnip				
Trial I	250	31.80 30.80	400	10.90 12.20
II	"	40.10 41.60	"	13.20 12.30
III	"	23.10 24.20		14.90 13.50
IV	"	23.30 22.80		12.50 14.30
Average		29.71		12.98

3. The effect of salt on the retention of ascorbic acid in dehydrated vegetables

The addition of salt has been reported by Kellie and Zilva (17) to prevent the oxidation of ascorbic acid during cooking. This has been observed by Hygoard and Rasmussen (15) who found that at a pH of 7, salt has an inhibiting effect on the oxidation of ascorbic acid. However they used distilled water controls, and their results may be of little practical value since vegetables are never cooked in distilled water. Olliver (29) claimed that the addition of salt, in amounts conducive to palatability, did not have any significant effect on the retention of the vitamin during the boiling of vegetables.

The results in Table XVIII showed that there was little significant difference in cooking dehydrated vegetables with and without salt. The amount of salt added in the experiment was 1/4 of a teaspoon, which was just enough to produce a good flavor. The pH of the cooking water was 6.3. Perhaps one reason why there was no appreciable change was that the addition of a little salt had practically no effect on the natural buffer system. When large amounts of salt were added (as in Table XIX), there was a greater retention of ascorbic acid, due to a greater tendency for the water to remain at a pH of 6.3 because of a strengthening of the buffer system.

The cabbage used in the experiment (Table XIX) was processed last October. At that time, the dehydration methods were not perfected and hence the loss of ascorbic

TABLE XVIII. - SHOWING THE EFFECT OF ADDED SALT ON THE RETENTION OF ASCORBIC ACID DURING THE COOKING OF DEHYDRATED VEGETABLES

Mgs. per 100 gms. dehydrated vegetables.

Vegetable	Cooked Without Salt			Cooked With Salt		
	In edible portion	In drainage water	Destroyed	In edible portion	In drainage water	Destroyed
	%	%	%	%	%	%
Cabbage contained 400 mgs. of ascorbic acid per 100 gms.						
Trial I	32.5	18.7	48.8	44.3	10.3	45.3
	33.5	18.6	47.6	44.2	10.9	44.6
Trial II	37.8	14.3	47.6	42.2	10.3	47.4
	39.8	13.9	46.5	42.5	10.1	47.4
Average	35.9	16.3	47.6	43.3	10.4	46.2
Potato contained 16.5 mgs. of ascorbic acid per 100 gms.						
Trial I	22.6	42.3	33.9	30.5	20.5	49.0
	26.5	34.6	38.9	27.7	20.5	51.6
Trial II	25.3	29.6	45.6	27.7	24.9	48.3
	28.1	29.6	42.9	30.7	24.9	44.3
Average	25.6	34.0	45.3	29.1	22.7	48.1
Turnip contained 190 mgs. of ascorbic acid per 100 gms.						
Trial I	31.8	15.8	52.3	23.1	21.6	55.0
	30.8	15.8	53.2	24.2	20.	56.8
Trial II	41.6	5.69	52.72	23.3	19.6	57.5
	40.1	5.45	54.5	22.8	19.6	57.9
Average	36.1	10.68	53.18	23.3	20.2	56.9

TABLE XIX. - THE DESTRUCTION OF ASCORBIC ACID DURING THE COOKING OF DEHYDRATED CABBAGE WITH EXCESSIVE AMOUNTS OF SALT

The cabbage contained 78.1 mgs/100 gms

Amount of salt		Wt. of edible portion of cooked cabbage	Volume of water drained from cooked cabbage	In edible portion	In drained water	Destroyed
tsp.		gms.	ml.	%	%	%
1/4	I	110	140	14.4	35.2	50.5
	II	110	143	15.6	31.3	53.0
	Average			15.0	33.25	51.75
1/2	I	90	40	17.9	35.0	47.2
	II	86	27	21.8	28.6	48.5
	Average			19.85	31.8	47.85
1	I	93.5	132	22.9	54.2	22.8
	II	91.5	113	19.1	50.0	31.0
	Average			21.0	52.1	26.9

was considerable on dehydration as well as in cooking.

4. Rapid Boiling versus Slow Boiling

The loss of ascorbic acid from vegetables when the rate of boiling was varied has been studied by Delf (10), Olliver (29) and Laughlin (19). Their results showed that a short cooking period at the boiling point or just below was less destructive to ascorbic acid than was the longer cooking periods.

Our experiments were carried out with dehydrated vegetables. The only variable in the methods of cooking was the temperature. Slow boiling was carried out at a hot plate temperature of 175°C and rapid boiling at 275°C. At the lower hot plate temperature, the vegetables took about ten minutes longer to come to the boil and five to ten minutes longer to boil to complete cooking.

The results shown in Table XX suggested that with rapid boiling more ascorbic acid was retained in the edible portion, and less leached into the cooking water. This bears out the fact that quick cooking protects the vitamins in foods by reducing to a minimum the time they are exposed to heat and air.

5. The destruction of ascorbic acid in vegetables cooked in covered and opened utensils

McIntosh, Tressler and Fenton (28) have shown that the retention of ascorbic acid in vegetables with the exception of brussel sprouts and cauliflower, was the same within the limits of error of the method, whether boiled

TABLE XX.- SHOWING THE EFFECT OF RATE OF BOILING ON RETENTION OF ASCORBIC ACID DURING THE COOKING OF DEHYDRATED VEGETABLES

Vegetable		In original veg.	Rapid Boiling (mgs/100 gms) In edible portion	In drainage water	Destroyed	Slow Boiling (mgs/100 gms) IN edible portion	In drainage water	Destroyed
		mgs.	%	%	%	%	%	%
Cabbage	I	450	52.8	9.35	37.8	35.3	24.0	41.0
			53.8	9.12	37.1	34.9	24.2	41.2
	II	450	52.0	12.20	35.4	34.2	20.2	45.6
			52.4	12.42	35.1	34.9	20.0	45.1
	Average		52.7	10.77	36.3	34.8	22.1	41.4
Turnip	I	175	26.4	11.3	62.0	14.9	23.1	62.0
			27.3	10.6	61.9	13.4	23.8	62.6
	II	175	25.0	15.9	59.0	15.4	26.0	58.6
			26.0	15.3	58.7	14.1	26.4	59.6
	Average		26.2	13.2	60.4	14.4	24.8	60.7
Potato	I	15.2	25.0	22.4	52.6	23.7	31.6	44.8
			25.0	19.1	55.9	19.1	31.6	49.4
	II	15.2	26.9	26.9	46.0	19.1	28.9	52.0
			23.6	23.0	53.2	19.1	27.0	53.9
	Average		25.1	22.8	51.8	20.2	29.8	50.0

TABLE XXI. - EFFECT OF COVERED AND UNCOVERED UTENSILS ON THE ASCORBIC ACID CONTENT OF COOKED DEHYDRATED VEGETABLES

Reduced ascorbic acid mgs/100 gms.

Vegetable		Ascorbic acid in original sample	Covered: % Retained in edible portion	Uncovered: % Retained in edible portion
		mgs.	%	%
Cabbage	I	429	42.3 40.9	42.3 41.9
	II	429	40.6 41.2	41.6 40.0
	Average		41.25	41.4
Turnip	I	252	25.1 24.2	22.9 24.5
	II	252	23.5 24.5	22.4 23.3
	III	252	25.6 25.0	24.2 23.7
	Average		24.6	23.5
Potato	I	23.1	15.4 17.4	15.2 17.4
	II	23.1	17.6 19.8	17.5 17.3
	III	23.1	17.7 17.7	19.7 19.9
	Average		17.6	17.8

in covered or in uncovered utensils. Floyd and Fraps (13) have also found that the loss of ascorbic acid in turnips cooked in an enameled utensil was not increased when the vessel was uncovered.

In the following experiment the vegetables were cooked according to the standard methods. The only variable was the use of covered and uncovered enamel utensils.

The result in Table XXI showed that the retention of ascorbic acid was quite constant with both the covered and uncovered samples. This was important as dehydrated cabbage had a slightly better appearance when cooked in an uncovered utensil.

6. Distilled Water versus Tap Water

As long ago as 1928, Hess (17) demonstrated the destruction of ascorbic acid through the catalytic action of metals. In 1935 Kellie and Zilva (17) showed that the oxidation of ascorbic acid took place as rapidly in distilled water as in tap water. This was found to be due to the presence of Cu. salts in the distilled and tap water. However they did show that if the copper was eliminated by distilling three times in a glass apparatus, the rate of oxidation of ascorbic acid was greatly reduced.

The results in Table XXII show that there was little difference in the ascorbic acid content of vegetables cooked in tap water and distilled water. The water used in the experiments was distilled in a copper still, and passed

TABLE XXII. - THE ASCORBIC ACID CONTENT OF DEHYDRATED VEGETABLES COOKED IN DISTILLED AND TAP WATER

		Tap Water (mgs./100 gms)			Distilled Water (mgs./100 gms)		
Vegetable	In orig. mat.	In edible portion	In drainage water	Destroyed	In edible portion	In drainage water	Destroyed
	mgs.	%	%	%	%	%	%
Cabbage	450						
Trial I		44.8 44.8	17.5 17.8	37.8 38.0	45.4 44.8	18.2 18.4	36.9 36.9
" II		43.6 43.9	18.4 18.8	37.9 37.6	46.2 47.1	17.7 17.3	37.2 36.9
Average		44.3	18.1	37.8	45.9	17.9	36.97
Potato	15.2						
Trial I		52.6 49.3	37.9 33.6	10.2 17.1	58.0 56.0	38.1 36.2	4.0 7.9
Trial II		45.8 45.8	48.0 48.0	6.6 6.6	45.8 52.0	48.0 47.5	6.6 .5
Average		48.4	41.8	10.1	52.9	42.4	4.75
Turnip	195						
Trial I		26.9 25.6	-- --	73.1 76.4	26.2 27.7	-- --	73.8 72.3
Trial II		18.1 18.4	20.0 17.9	61.9 63.5	20.3 18.3	18.9 19.5	60.6 62.4
Average		22.2	18.95	68.7	23.1	19.2	67.27

through lead pipes to copper outlets. Thus cooking in laboratory distilled water has no great advantage over tap water, for although the former may be somewhat purer, like tap water it does contain traces of metals, which increase the oxidation of ascorbic acid.

PART II INSTITUTIONAL INVESTIGATIONS

E. COOKING OF DEHYDRATED VEGETABLES IN LARGE QUANTITIES

The optimal conditions for laboratory cooking methods were applied in large scale cooking trials carried out in the dining room at Macdonald College.

In most instances little difference was noted in the cooked product from fresh and dehydrated vegetables. At first it was difficult to obtain a cooking method for potatoes, for numerous experiments indicated that these products were difficult to cook in large quantities. There was a great tendency for water to adhere to the surface of the potato, thus making the mashed product very soggy. However a method was finally worked out in which the potatoes were immersed in boiling water for nine minutes. This method will be discussed later.

The following is a description of the methods which have been adopted for cooking dehydrated vegetables in large quantities.

In all tests, standard army equipment consisting of a ten gallon tin kettle, an eight gallon aluminum kettle and four and six gallon granite kettles were used. Each of these kettles had a tap through which the drainage water could be removed. Cooking was done on large coal stoves which permitted rapid boiling.

(a) Carrots

The quality of this particular sample, processed in British Columbia was good but inclined to be very powdery. Larger sized pieces would be more economical to serve, and would have a better appearance.

The carrots were cooked in two lots as follows:-

Veg.	Amt.	Water added	Length of soaking period	Length of time to bring to boil	Boiling time	Amount salt	Servings
Carrot	10 lbs.	9 gals. (cold)	40 mins.	50 mins	45 mins	6 tbsp.	450
"	5 lbs.	4½ gals	45 mins	25 mins	30-35 "	3 tbsp	200

The drainage water from both samples amounted to less than a quart.

Cooking of smaller quantities of vegetables namely five to eight pounds gave a product that was uniformily well done, whereas with the larger quantities, many pieces were undercooked. This can be overcome by longer cooking. It was also difficult to stir a large kettleful and difficult to drain, even with an outlet tap. If it is at all possible, smaller quantities of vegetables should be cooked.

(b) Cabbage

Dehydrated Texas fresh cabbage processed in Ontario was cooked as follows:-

Veg.	Wt. of Veg.	Amt. of boiling water added	Length of soaking period	Length of time to bring to boil	Boiling time	Amt. salt	Servings
Cabbage	3 lbs.	3½ gals.	10 mins.	15 mins.	20 mins	3 tbs.	175
"	5 lbs.	6 gals.	15 mins.	20 mins.	23 mins.	5 "	300

The drainage water from each sample amounted to 2½ quarts.

The cooked products had good texture and flavor but there was some difference of opinion as to color. It was thought that cooking without a lid would preserve the color a little better, but several tests failed to show any significant difference. Furthermore it was found that the material of which the cooking utensil was composed made little difference to the color of the product that was cooked in it. McIntosh, Tressler and Fenton (27) have also arrived at the same conclusion.

(c) Turnip

The sample was grown and processed in Ontario. It was cooked as follows:-

Wt. of veg.	Amount of H_2O added	Length of soaking period	Length of time to bring to boil	Boiling time	Amount of salt	No. of servings
5 lbs.	3½ gals	40 mins.	30 mins.	30 mins.	5 tbsp.	215
6½ lbs.	4-2/3 "	30 mins.	40 mins.	36 mins.	6 tbsp.	285

The drainage water from each sample amounted to about 2-2/3 quarts.

The cooked turnips had good texture, flavor and color. The turnips cooked in the tin kettle were scorched although there was plenty of water present. This indicated that tin cooking utensils could not stand much direct heat (ie. coal stoves with red hot plates). However, the granite kettles were excellent for cooking under such conditions.

(d) Potatoes

Many experiments were carried out before a satisfactory method was found to cook dehydrated potatoes. The procedure now recommended is to soak the material, drain well, place in a perforated wire basket and immerse in boiling water for 9-18 minutes, depending on the amount of potato. The details of the experiment are as follows:-

Wt. of Veg.	Amt. of H_2O	Length of soaking period	Soaking water drained	Preboiling time	Cooking time	Amt. of salt	No. of servings
5 lbs.	2½ gals.	3 hrs.	1½ qts.	-	9 mins. cooked in 5 gals of boiling water including drainage water.	-	175-200

To obtain a satisfactory product, the potato was drained from three to five minutes. The vegetable was then mashed and ½ lb. of butter and 5 tbsp. of salt were added to make it palatable. This gave a good mashed potato. However, boiling too long or standing for any unnecessary long time gave a grayish colored product which was poor for table service

Large scale cookery trials were also carried out at one of the army camps. The methods already described were followed with as little variation as possible.

At the army camp, it was necessary to cook the vegetables in even larger quantities than at Macdonald College. This gave rise to a few difficulties.

1. The amounts of water had to be increased considerably and as a result the length of the preboiling and the actual boiling time was greatly lengthened. This was not desirable for naturally the vitamin destruction was greatly increased.

2. There was some difficulty in stirring large amounts, especially if little water was present. For this reason, the chefs preferred to use large amounts of water so that stirring might be easier and scorching avoided.

3. Draining large quantities of vegetables was difficult particularly from pots without taps. Wire or perforated steel baskets were used as strainers in place of taps, but they involved additional work.

4. The stoves did not seem to produce as much heat as the ones at Macdonald College and as a result the vegetables took a longer time to come to the boil.

Nevertheless the cooked products resembled the fresh vegetables very closely. They were of good color, texture and flavor, and as a result were well liked by the army in general.

Steaming Methods

Dehydrated vegetables may also be cooked by live steam.

The vegetables were soaked for the usual length of time, and then drained well and put into large institutional steamers. Turnips and carrots had to be steamed for 50-60 minutes and even then several pieces were not well done. The color of the steamed turnip was very poor and certainly unfit for table use. Steaming potatoes was preferable to boiling. The vegetable was well done within ten minutes and the color and texture excellent. Steamed cabbage was not nearly as good a product as the boiled for the color was very poor - a grayish yellow. Furthermore the time required to steam cabbage was considerably longer than was required for boiling and this was very undesirable when cooking green vegetables.

From these results, it can be concluded that steaming is an excellent method for cooking potatoes but a very poor method for all other vegetables.

F. THE ASCORBIC ACID CONTENT OF VEGETABLES COOKED IN LARGE QUANTITIES

Cooking in large quantities and holding vegetables warm are two problems for the institutional worker. McHenry and Young (26) have found that the loss of ascorbic acid in large quantity cookery was very high. Steaming is the most widely used method in institutions for cooking vegetables, but more ascorbic acid is likely to be destroyed, because it is a slower method of heating a vegetable through than boiling. However, it has been found that the rate of heat penetration and hence the destruction of ascorbic acid depends on the shape and size of the vegetable particle. Zehentova (38) has shown that steaming destroys one half of the ascorbic acid in cabbage. Large scale steaming of turnip according to Sysoeva et al (32), caused a considerable loss.

It is more difficult to boil large amounts of vegetables, but more ascorbic acid is retained. Kardo et al (16) have shown that the loss of ascorbic acid in mashed potato is 80%. Fenton (12) has found that from 22 to 60 percent of the ascorbic acid was destroyed in boiling cabbage, the destruction depending on the size and shape of the pieces. Large scale cooking of turnips generally caused about 75% loss of ascorbic acid according to Sysoeva et al (32).

Some data arepresented in Table XXIII on cooking dehydrated vegetables by steaming and boiling. The losses of ascorbic acid were quite high by both methods, yet not as great as the losses found by Sysoeva et al (32) and Kardo et al (16). By the boiling method less ascorbic acid was destroyed in all vegetables except potatoes, where steaming gave a higher retention of the vitamin. Of particular interest was the difference in the ascorbic acid content of two samples of cabbage cooked by both steaming and boiling methods (Table XXIII). This difference was due to the length of the cooking periods, for sample No. I took twice as long to cook as sample No. II. These results stress the necessity of rapid cooking.

TABLE XXIII. - BOILING VERSUS STEAMING

Reduced ascorbic acid per 100 grams

Vegetable	In original vegetable	Boiling Destroyed %	Steaming Destroyed %
Cabbage I	415	74.2	91.4
II	415	63.4	73.7
Potato	11.4	74.0	63.2
Turnip	179	53.6	56.0

The drainage water from the boiled vegetables was also found to be a good source of ascorbic acid, and for this reason it is advisable that all drainage waters be saved for soup stocks and gravies. The high ascorbic acid content of the drainage water is given in Table XXIV.

TABLE XXIV. - ASCORBIC ACID CONTENT OF DRAINAGE WATER OF DEHYDRATED VEGETABLES.

Reduced ascorbic acid mgs per 100 ccs.

Vegetable	Drainage water mgs.
Cabbage I	23.57 23.40
II	40.86 36.30
Turnip	24.00 18.00

Fenton, (12), Olliver (29) and Levy (20) have shown that holding cooked vegetables in a warmer destroyed ascorbic acid. With dehydrated vegetables the losses were particularly high, about 76-93%. To overcome this vegetables should be cooked ten to fifteen minutes and not two or three hours before serving. This is possible with proper planning even in institutions.

The results in Table XXV were obtained by cooking the vegetables by the standard methods, but some of the product was allowed to stand for two hours in steam tables. As already stated, the loss of ascorbic acid due to standing was very great.

In conclusion, it must be admitted that cooking in large quantities is very difficult. However, if certain fundamental principles of vegetable cookery are followed, (as discussed in Part I), then good palatable products with fair nutritive content should be obtained.

TABLE XXV. - ASCORBIC ACID CONTENT OF COOKED VEGETABLES BEFORE AND AFTER STANDING FOR TWO HOURS

Vegetable	Ascorbic Acid/100 grams Vitamin Content of dehydrated vegs.	Destroyed No Standing	 Standing for 2 hours
	mgs.	%	%
Turnip I	160	53.1	92.8
II	179	46.4	88.2
Cabbage I	395	72.2	92.3
II	425	44.1	93.48
Potato	11.7	75.4	76.2

PART I SUMMARY AND CONCLUSIONS

The cooking of dehydrated vegetables has been studied with particular regard to the effect on the ascorbic acid content. It was considered that the extent to which ascorbic acid was retained during cooking would indicate that other desirable characteristics, such as color, texture and nutritional values had also been preserved.

At the beginning, it was apparent that the methods for the determination of ascorbic acid in dehydrated vegetables required further investigation. The titrimetric procedure of Burrel and Ebright (2) was chosen and modified so that the determination of ascorbic acid would be more accurate. First, it was found that the ascorbic acid in samples taken from different regions of the same can varied considerably. This sampling error was overcome by grinding a relatively large portion of the material in a Wiley Mill, and from this a part was taken for analysis. The use of the Wiley Mill did not introduce any extraneous materials which would affect the accuracy of the analysis. Secondly, the various methods which have been proposed for extracting ascorbic acid from plant tissue were investigated. It was found that with dried vegetables, reproducable results could be obtained by triturating the sample in a mortar with the solvent. The Waring Blender permitted complete extraction of ascorbic acid from the cooked material but not from the uncooked sample. Subsequent steps in the determination of ascorbic acid were carried out according to directions of Burrel and Ebright and found to give good results.

Numerous determinations of the ascorbic acid content of samples of dehydrated vegetables, supplied by the Federal Department of Agriculture, were made and the results compared with the analysis of the same sample of fresh vegetable from which the dehydrated product was prepared. Prior to the adoption of an improved method of dehydration, a loss of 60-90% was observed. The improved dehydration process reduced this loss to 25-40%. As was to be expected, storage of the vegetable prior to dehydration had a pronounced effect on the ascorbic acid content of the dehydrated product, e.g. dehydrated new potatoes had a much higher ascorbic acid content than dehydrated stored potatoes. There was a further loss of ascorbic acid during the storing of the dehydrated product. This loss took place slowly but at a relatively constant rate so that after the product had been stored for a few months, very little ascorbic acid remained.

The technique of rehydrating and cooking dehydrated potatoes, carrots, cabbage and turnip has been studied and standardized methods evolved for comparative cooking trials on different samples of the same product. By the standard cooking methods, the dehydrated products prepared by the improved processes could be cooked to give palatable products with excellent color and texture.

The destruction of ascorbic acid during the cooking of dehydrated vegetables by the standard methods was next studied. The total loss of ascorbic acid was found to be of the order of 40-60% of that contained in the original dehydrated vegetable. The recovery of ascorbic acid in the edible portion of the cooked product was 30-40% for cabbage, 25-30% for turnip and 25-35% for potatoes. If however, larger quantities of water than those employed in the standard method were used, the retention of ascorbic acid in the edible portion was considerably less, that is 20-30% for cabbage, 12-15% for turnip and 20-25%for potatoes. In this case however, the drainage water contained a larger proportion of the ascorbic acid so that the total loss of ascorbic was about the same in the two cases.

The addition of salt to the cooking water has been claimed to reduce the losses of ascorbic acid. In our experiments, the amounts of salt up to the limits of palatability of the cooked product, had little effect on the further retention of ascorbic acid. However, if very large amounts of salt were added, the loss was reduced.

It was observed that the rate of boiling affected the destruction of ascorbic acid. By rapid boiling, more ascorbic acid was retained in the edible portion and a smaller amount leached into the drainage water. No difference was found in the destruction of ascorbic acid whether the cooking was carried out in covered or uncovered utensils, nor was there any difference observed between cooking in ordinary distilled water as compared to tap water.

From the above results, it could be concluded that great improvements have been made in the methods of dehydrating vegetables. The products produced during the last war were tough and unpalatable and probably of low nutritive value. The first products which were studied were possibly somewhat similar to those produced during the last war. The new products now being produced are greatly improved and with proper methods of cooking, palatable products with good color and texture can be obtained.

A considerable proportion of the ascorbic acid contained in dehydrated vegetables can be conserved by proper methods of cooking such as those outlined herein. However, the loss of ascorbic acid during dehydration and cooking is still considerable, and thus indicates the necessity for further improvements in methods.

Part II INSTITUTIONAL INVESTIGATIONS

It does not necessarily follow that the optimal conditions for cooking dehydrated vegetables as studied in Part I will prove to be equally applicable to cooking on an institutional scale. Cooking trials were carried out in the Dining Hall at Macdonald College and at a local army camp in amounts sufficient to serve 500 or more people. The best cooking methods were found to be similar in principle to those employed in a laboratory scale, but the length of time required to bring the material to the boil and the actual boiling period had to be increased because of the larger amounts of material used.

Under the conditions of large scale cookery, the losses of ascorbic acid in the edible portion caused by boiling amounted to 50-75%, while the losses due to steaming were somewhat higher, namely 55-90%. It was also noted that if samples of vegetables took a longer time to cook because of a slow heat, then the ascorbic acid content was lower than those cooked in the required length of time. Finally, if cooked vegetables were held over for periods up to two hours before serving, the loss of ascorbic acid was as high as 90%. For this reason, keeping vegetables hot should be rigorously avoided.

In conclusion, it must be said that much work has yet to be done in institutional cooking of dehydrated vegetables, so that the nutritive value particularly the ascorbic acid content will not be appreciably changed.

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