McGRATH, SISTER MARY DANIEL. Effect of High Pressure Steaming, Low Pressure Steaming, and a Steam Jacketed Kettle on Frozen Vegetables. Ascorbic Acid and Color Retention. (1968) Directed by: Dr. Aden C. Magee. pp. 50

This study was conducted to determine the effect of high pressure steaming, low pressure steaming, and a steam jacketed kettle on the retention of ascorbic acid and color in frozen broccoli spears and frozen tiny, new, whole potatoes.

Institutional packages, each weighing 2 pounds, of broccoli and a 20 pound bulk case of potatoes were obtained from a local wholesale food company. The vegetables were cooked according to the times specified by the manufacturers of the equipment used. When cooking times were not specified for a particular vegetable, the times were determined by preliminary tests. Samples of uncooked and cooked broccoli were randomly selected from individual packages and analyzed for ascorbic acid content. Two pound portions of potatoes were weighed, and uncooked and cooked samples were analyzed for ascorbic acid. Color comparisons of the uncooked and cooked vegetables were made by a panel of five judges.

Experimental results indicated a highly significant retention of ascorbic acid in broccoli cooked in the high pressure steamer. There were losses of this vitamin when broccoli and potatoes were cooked in the steam jacketed kettle and in the low pressure steamer, the latter method resulting in the greater losses. The overall results of the study indicated that the retention of ascorbic acid was greatest when

the high pressure steamer method was used. The least retention of ascorbic acid resulted in the low pressure steamer method. Color evaluations were similar among all methods except when broccoli was cooked in the low pressure steamer. This method resulted in a cooked product which was rated lowest in color by the judges.

EFFECT OF HIGH PRESSURE STEAMING, LOW PRESSURE STEAMING, AND A STEAM JACKETED KETTLE ON FROZEN VEGETABLES, ASCORBIC ACID AND COLOR RETENTION

by

Sister Mary Daniel McGrath

A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Science in Home Economics

Greensboro
February, 1968

Approved by

Aden C. Magee
Thesis Adviser

APPROVAL SHEET

This thesis has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

Thesis Adviser Aden C. Magee

Oral Examination Committee Members Mildred B. Johnson

Mary A. Dickey

Laura G. Anderton

Aden C. Magee

November 17, 1967
Date of Examination

ACKNOWLEDGEMENTS

The author wishes to express her sincere appreciation to her adviser, Dr. Aden C. Magee, for his guidance and recommendations during this study. Gratitude is also extended to the members of the advisory committee, Dr. Laura Anderton, Mrs. Mary Dickey, and Dr. Mildred Johnson, for their interest and helpful suggestions and to the members of the Home Economics Staff and graduate students who comprised the panel.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX MATERIALS

Appendix A

Appendix B

Appendix C

Appendix D

CHAPTER I

INTRODUCTION

Despite the fact that the supply of food in the United States is abundant, dietary surveys have revealed that ascorbic acid consumption is sometimes less than the allowances recommended by the National Research Council. An outstanding source of ascorbic acid is found in vegetables. Because of the increasing and widespread use of frozen vegetables both in the home and in institutions, much research has been conducted to compare ascorbic acid retention with various cooking methods. Most of the research, however, has been done with the home type of cooking equipment rather than with institutional equipment. Since vegetables are important because of their high nutritive value as well as for their pleasant taste, it is essential to use a method of cooking that will minimize loss of food value.

Chemically, ascorbic acid is a white, water soluble, crystalline material that is stable in dry form but easily destroyed by heat, oxidation, and alkali. Consequently, under certain conditions, much ascorbic acid may be lost in cooking or discarded in the cooking water. The choice of cooking methods, therefore, is an important criterion in determining the retention of nutrients.

Good color retention in cooked vegetables is also an important factor in the choice of cooking methods, particularly with green vegetables. During cooking, it is often difficult to maintain the bright green color of the vegetables because certain acids are released when vegetables are heated and these acids are partly responsible for the change in color in vegetables. Also, the length of cooking time may affect the appearance of green vegetables. According to Halliday and Noble (1), the green color may be best conserved by keeping the cooking period short and using rapidly boiling water to cover the vegetables. Halliday and Noble also recommend the use of a pressure saucepan as another satisfactory method of cooking green vegetables. In this method, the temperature reached is sufficiently high to shorten the cooking time so that the color will remain good.

Limited information is available on the effect of standard institutional food service cooking methods on the nutrient and color retention of frozen vegetables. The lack of this type of information makes it virtually impossible to compare the capabilities and limitations of various institutional cooking equipment with respect to nutrient retention. The studies reported here were conducted to obtain information which would make it possible to define more accurately the effects of institutional cooking procedures on the nutrient content and color of frozen broccoli and tiny whole potatoes. Comparisons will be made among the methods used.

CHAPTER II

REVIEW OF LITERATURE

A review of literature revealed many factors which affect the amount of ascorbic acid in cooked vegetables. Some of these factors are the variety of vegetables, seasonal variation, climatic and growing conditions, methods of cutting a given vegetable, procedure used for cooking, volume of water added for cooking, and length of the cooking period.

Chlorophyll retention is generally used in research as a measure of quality for green vegetables (2, 3), and many investigators have reported that color is an important factor in consumer acceptance. Gordon and Noble (4) reported that the retention of ascorbic acid has been used as a criterion for measuring quality in vegetables. Thus, it appears that the use of both of these criteria for determining the quality of vegetables is an accepted practice.

Since broccoli is a rich source of ascorbic acid, Sweeney et al. (5) stated that the methods of cooking frozen broccoli needed investigating because some of the methods had significant effects on palatablity, nutritive value, and consumer acceptance. Broccoli, which contains large amounts of chlorophyll, serves as an excellent experimental product for studies on color retention.

While not strikingly high in any nutrient, white potatoes are important in the diet because they are eaten in larger amounts than many other vegetables (6). They contain good amounts of a number of important nutrients, especially ascorbic acid but the time of processing is an important indicator of the total ascorbic acid content of potatoes (7).

In the American diet commercially prepared potato products are increasingly replacing products made in the home from fresh potatoes. According to the United States Department of Agriculture (8), 12 per cent of the total potato production for 1964 was used in chip and shoestring products, a record high. A new record high was also set for frozen products--nearly 10 per cent of 1964 production--and for dehydrated products, 7 per cent above the previous record high. In contrast, the proportion of the crop sold fresh for table use declined (9).

The demand for frozen whole potatoes is gradually increasing as their practical application becomes known. In large quantity cookery as well as in home type cooking, the use of frozen whole potatoes saves labor and time in preparation. King et al. (10) compared fresh potato products with frozen, dehydrated, and canned potato products, and they concluded that the total preparation time and the worker time, in most cases, were longer for the products made from fresh potatoes. Acceptability ratings of most products were good, and in many cases comparable to products made from fresh potatoes. Processed potato

products cost more per serving, but many processed products are cheaper if the homemaker's time is considered valuable. No available research has been conducted to determine the retention of ascorbic acid in frozen whole potatoes.

Methods of Cooking

Cookery methods in which steam is the means of transference of heat include steaming, or cooking, (1) in water vapors above water, (2) in the so-called waterless cooker in which cooking is done in the presence of a small amount of liquid and the steam it produces, and (3) under pressure in a vessel which in institutions is called a steamer and which is comparable to the pressure cooker found in many homes (11). The methods used in institution cookery include all of those used in home cookery, but in institutions, food is cooked in greater quantities and in larger containers.

Vegetable preparation leads the list of items most frequently prepared in steam jacketed kettles (12). There is general agreement that frozen vegetables should be cooked in small quantities so that there is less chance for overcooking. The steam jacketed kettle ranges in size from 5 gallons up to 100 gallons capacity. Vegetables are cooked in boiling water by a process in which steam operates in two stainless steel hemispheres, or bowls, one sealed inside the other with about two inches of space in between for steam.

The free-flow atmospheric steamer depends only on unpressured condensing steam in direct contact with the food for its heating ability. Practically all of today's low pressure steamers use at least 3 to 5 pounds steam pressure. Actual cooking times are shortened because steam is available quickly.

During recent years manufacturers have attempted to design new types of equipment for institutional use which will shorten cooking time and thereby increase the retention of nutrients during cooking. The most recent development has been high pressure steamers operating with 12 to 15 pounds pressure in an atmosphere of dry steam from which the air has been expelled. Expelling the air prevents oxidation of vitamins and mineral salts, and should result in better nutrient and color retention. Little or no water is used and supposedly natural flavors, water-soluble vitamins, and minerals are not dissolved. Frozen foods are automatically defrosted, and overcooking is supposed to be impossible because of the automatically activated timer system. Cooking is achieved by impinging dry steam directly into the food.

Ascorbic Acid Retention

Streightoff et al. (13) investigated the effects of institutional methods of steaming, mashing, boiling, and baking on fresh raw potatoes. Although these researchers found that the destruction of ascorbic acid was marked in potatoes prepared by each of the four

methods, they recommended steaming as the most satisfactory method of preparation since this method resulted in the least amount of destruction of ascorbic acid. In another study, Branion et al. (14) reported that the percentage loss of ascorbic acid from new potatoes during cooking was less than that from old potatoes.

Jones et al. (15) investigated ascorbic acid, thiamine, and riboflavin retention in quick-frozen broccoli in institution food services. A low pressure steamer and a steam jacketed kettle were among the pieces of cooking equipment used in this study. Greater retention of all three nutrients resulted in the broccoli cooked in the steamer.

Some researchers (16, 17) have reported that samples cooked in boiling water varied sufficiently between applications in the retention of ascorbic acid to make it inadvisable to rate methods of cooking. Additional information (17) on the effect of common household methods of cooking on ascorbic acid retention in green beans indicated that samples cooked in boiling water retained significantly less ascorbic acid than those cooked by 15 pounds of pressure in a pressure saucepan and by steaming. The samples cooked in boiling water retained an average of 60 per cent of the ascorbic acid in the raw vegetable and those cooked by the other methods, an average of 70 per cent.

Gordon and Noble (4) also studied ascorbic acid retention in a representative group of vegetables to determine whether any general trends existed in the effect of different cooking methods on ascorbic

acid retention. The results indicated that, as a whole, vegetables cooked by the boiling water method retained approximately 45 per cent of their original ascorbic acid while vegetables cooked by the steaming method retained approximately 69 per cent of the ascorbic acid. These differences were significant. With the pressure saucepan method which uses short cooking times but high temperatures, the retention of ascorbic acid was not significantly different from the average retention in the other two methods which used longer cooking time but lower temperatures. Within each cooking method, however, the different vegetables retained varying amounts of ascorbic acid.

Sweeney et al. (18), experimenting with 13 different cooking procedures on the quality of fresh broccoli, found that the best retention of ascorbic acid resulted when the least amount of cooking water was used. Cooking in large amounts of water caused excessive leaching of ascorbic acid into the water. Sweeney et al. (5) investigated the effect of cooking method and length of cooking time on the palatability and nutritive value of frozen broccoli. Cooking with 15 pounds of pressure for a period of 3 minutes resulted in an unevenly cooked product. The ascorbic acid content of uncooked frozen broccoli was somewhat lower than that of fresh broccoli, but the percentage retained in the cooked frozen broccoli did not differ greatly from that reported previously for the cooked fresh product (18).

Gilpin et al. (3) studied the effects of 13 different procedures including several boiling water techniques, steaming, and pressure cooking on fresh broccoli. Broccoli cooked to optimum texture retained from 60 to 85 per cent of its ascorbic acid with the methods using small amounts of water. Cooking in large amounts of water resulted in excessive leaching of ascorbic acid into the water.

Experimentation concerning the effect of blanching methods on ascorbic acid retention in frozen vegetables was conducted by Noble and Gordon (19). They concluded that the retention of ascorbic acid for each frozen vegetable was considerably less than in cooked fresh samples. Broccoli was the only vegetable which retained significantly different percentages of ascorbic acid in water and steam blanched samples, the latter retaining the higher percentage.

Gordon and Noble (20) have also experimented with the "waterless" method (using water clinging to the vegetable after washing) versus boiling water cooking of fresh vegetables. With broccoli and Brussels sprouts, the boiling water method resulted in equally as good retention of ascorbic acid as did the "waterless" method. The pressure saucepan method resulted in the highest retention of ascorbic acid.

Eheart (21) collected data which indicated that the largest loss of ascorbic acid in frozen cooked broccoli was caused by blanching. The most satisfactory method of blanching in which the greatest

retention of ascorbic acid occurred was the conventional method of water blanching at 100°C.

Noble (22) investigated the effect of overcooking in boiling water and in a pressure saucepan at 15 pounds of pressure on the ascorbic acid content of frozen vegetables. Cooking periods were "until tender" and 5, 10, 50 or 1, 2, 3, 5 minutes beyond this time in boiling water and in the pressure saucepan, respectively. Ascorbic acid retention decreased significantly with both cooking methods as the cooking periods increased. Percentages of ascorbic acid dissolved in the cooking waters did not change with longer cooking time which confirms the results of several researchers (4, 5, 18, 20) who stated that the greatest loss of ascorbic acid in cooking water occurs during the first 3 to 5 minutes of cooking. After this initial loss there is usually no significant decrease in ascorbic acid content. Approximately 15 per cent of the original ascorbic acid, regardless of cooking method, was not present in either the cooked vegetable tissue or the cooking water. Presumably, this ascorbic acid had been changed to a biologically inactive form during cooking.

Color Retention

Jones et al. (15) reported that the color of quick-frozen broccoli cooked by a steam jacketed kettle was greener than that cooked by

a low pressure steamer. These results are similar to those made by others (3, 4).

Noble (16) stated that cabbage cooked in boiling water was as green or greener than corresponding raw cabbage while cabbage cooked in a tightly covered pan or a household steamer showed little or no trace of green. Cabbage samples cooked in a pressure saucepan were never as green as the raw vegetable, but some of the cooked samples retained a portion of the original green color.

Noble and Gordon (17) reported that the color of green beans cooked in boiling water or in a pressure saucepan was almost as green as that of the raw vegetable while the color of the samples cooked in the tightly covered pan or steamer was yellow. Gordon and Noble (4) made these same observations when working with a representative group of vegetables. The only exception was asparagus.

Sweeney et al. (18) found that fresh broccoli cooked for five minutes by any of 13 different cooking procedures, except under pressure, was rated as moderately bright to bright green. Broccoli cooked at 15 pounds of pressure retained nearly all of its original color after a half or one minute cooking period. The color of broccoli cooked under 5 pounds of pressure for 3 minutes was characterized as bright green and was comparable to broccoli at 15 pounds of pressure for a half minute.

In investigating the effects of cooking method and length of cooking time on the color retention of frozen broccoli, Sweeney et al. (5) observed that the mean panel scores for color in general decreased as the length of cooking time increased. The storage period did not appear to have any appreciable effect on the panel color scores of broccoli cooked by methods not involving pressure. Broccoli which had been stored for nine months had significantly poorer color when cooked under pressure than broccoli which had been stored for four months and cooked under pressure.

Gilpin et al. (3) found that when broccoli was cooked for increasing lengths of time by 13 different procedures including several boiling water techniques, steaming, and pressure cooking, color deteriorated significantly. Cooking in large amounts of water also caused color losses.

In studying the effects of blanching methods on color in frozen vegetables, Noble and Gordon (19) stated that the hue of the samples blanched by steam or water were not significantly different. Many samples were slightly greener than their raw or cooked counterparts. These observations also agree with those made by Eheart (21).

Gordon and Noble (20) also reported that the boiling water method consistently resulted in good retention of green color in vegetables. The pressure saucepan method, however, resulted in less

green color. These findings were not in agreement with the findings of other researchers (5, 18).

Noble (22), while investigating the effect of overcooking in boiling water and in a saucepan at 15 pounds of pressure, concluded that the hues of all green vegetables progressed from a green-yellow toward yellow as cooking time increased. The hues of all vegetables also showed considerable change with five minutes of overcooking in boiling water and with one minute overcooking in the pressure saucepan.

CHAPTER III

EXPERIMENTAL PROCEDURES

The purpose of this study was to obtain information concerning the ascorbic acid and color retention of frozen broccoli and frozen whole potatoes cooked by a high pressure steamer, a low pressure steamer, and a steam jacketed kettle. Comparisons among these three types will be made.

The frozen vegetables used in this study were purchased from a local wholesale company[1] and were shipped by a refrigerated truck. The vegetables were held in a freezer at 0^{o}F. until they were used in the study. The brands of the products were Vahlsing broccoli spears and McKenzie tiny, new, whole potatoes.

Broccoli was purchased by the case, which contained twelve 2 pound institutional packages. The potatoes were purchased in 20 pound bulk cartons.

Analytical samples of cooked and uncooked broccoli were taken from individual packages randomly selected from a case. Cooked and uncooked analytical samples of potatoes were selected from 2 pound portions removed from a bulk carton at the time of use. The vegetables were cooked according to the recommendations of the

---

[1] W. I. Anderson Company, Greensboro, North Carolina.

manufacturers of the equipment used in the study. When cooking times were not available for a particular vegetable, they were established by preliminary tests. Preparation and cooking information used in the study is given in Table 1.

TABLE 1

PREPARATION AND COOKING PROCEDURES FOR FROZEN VEGETABLES COOKED IN THREE TYPES OF FOOD SERVICE EQUIPMENT

Procedure	Food Service Equipment		
	Steam Jacketed Kettle	Low Pressure Steamer	High Pressure Steamer
Broccoli			
Thawing time	None	Overnight in refrigerator	None
Cooking time (minutes)	10	10	1
Amount of water added (cups)	10	None	None
Potatoes			
Thawing time	None	Overnight in refrigerator	None
Cooking time (minutes)	15	20	7
Amount of water added (cups)	8	None	4

The analytical samples of broccoli and potatoes varied in weight because an attempt was made to take whole spears and whole potatoes for analytical purposes. In general, the analytical samples weighed between 12 and 45 grams. All samples, cooked and uncooked, were mixed with 1 per cent metaphosphoric acid, and the mixture was blended in an Osterizer for 3-5 minutes at high speed. The slurry was transferred to a graduated cylinder, and the mixing jar was rinsed with metaphosphoric acid. The rinsing was added to the graduated cylinder containing the slurry, and sufficient 1 per cent metaphosphoric acid was added to give a pre-determined total volume of slurry mixture. The amount of metaphosphoric acid used for each sample was determined by the ratio of 1:7 (vegetable to liquid) if the vegetable was low in ascorbic acid and by the ratio of 1:14 if the vegetable was high in ascorbic acid. The former ratio was used for the potatoes and the latter for the broccoli.

The slurry was filtered through Whatman No. 12 fluted paper. In order to facilitate the filtering of the cooked potato slurries, centrifugation of the slurries for 15 minutes at 2000 r.p.m. was necessary. The first 10 ml. portion of each filtrate was discarded. Five 1 ml. aliquots of each filtrate was taken for subsequent ascorbic acid analyses.

Reduced ascorbic acid concentrations of the cooked and uncooked vegetables were determined by the 2,6-dichlorophenolindophenol

method of Loeffler and Ponting (23) as modified by the Association of Vitamin Chemists (24). Details of this method are given in Appendix A.

The ascorbic acid data was analyzed by standard analysis of variance procedures, and statements of significance were based on odds of 19 to 1.

The color of cooked and uncooked samples of broccoli and potatoes was evaluated subjectively by a panel of five members. This panel consisted of the faculty, staff, and graduate students in the School of Home Economics at the University of North Carolina in Greensboro who were available during the color evaluation phase of the study. The panel was given some preliminary instructions and training prior to the color testing. The procedure for scoring and the sample scorecards used are given in Appendix C. The rating scale used to score broccoli was based on that used by Sweeney et al. (5).

The steam jacketed kettle used was a Groen[2] Model TDC-20 unit. The vegetables were cooked uncovered with a sufficient amount of water to cover the vegetables. The low pressure steamer was a Market Forge[3] Model 1 W-S unit, set at 5 pounds of pressure per

---

[2]Groen Manufacturing Company, Elk Grove Village, Illinois.

[3]Market Forge Company, Everett, Massachusetts.

square inch. The high pressure steamer was a Vischer[4] Model 75 unit which was set to operate with 15 pounds of pressure per square inch.

The pressure, however, was not always consistent since the low pressure steamer usually registered 6 pounds of pressure and the high pressure steamer registered 12 pounds of pressure during the entire cooking period.

---

[4]Vischer Products Company, Chicago, Illinois.

CHAPTER IV

RESULTS AND DISCUSSION

Results of the chemical analyses to compare the ascorbic acid contents of frozen broccoli and tiny, new, whole potatoes, before and after cooking, will be given in this chapter. Detailed analytical data are presented in Appendix B.

The mean ascorbic acid values of frozen broccoli and potatoes obtained in this study were 49 mg./100 gm. and 16 mg./100 gm., respectively (Tables 2 and 3). The retention of ascorbic acid in broccoli cooked in the steam jacketed kettle was approximately 80 per cent and that in the low pressure steamer was approximately 51 per cent. Broccoli cooked in the high pressure steamer not only resulted in greater ascorbic acid retention, but also in differences which were highly significant ($P \leq 0.01$). Why higher levels of ascorbic acid were found in samples of broccoli cooked in the high pressure steamer than were found in samples of the raw vegetable is not apparent, but there is the possibility that this apparent inconsistency was due to the way that analytical samples were taken in this study. In this study an attempt was made to obtain a representative analytical sample consisting of both heads and stems. Jones et al. (15) have reported that the stems of broccoli contained more ascorbic acid than did the heads. In

a later study, Sweeney et al. (18) recorded an average ascorbic acid value of 158 mg./100 gm. for the heads of fresh broccoli and 11 mg./100 gm. for the stems. Broccoli cooked by the boiling water method retained an average of 60 per cent ascorbic acid for the heads and 82 per cent for the stems. They attribute these differences to the variation in stem size. They noted that broccoli stems less than 1/2 inch in diameter contained a higher percentage of acid than did those which were greater than 1 inch in diameter. In another study on frozen broccoli (5), these same researchers reported the ascorbic acid content of uncooked frozen broccoli to be somewhat lower than that of fresh broccoli, but the percentage retained in the cooked frozen broccoli did not differ greatly from that reported for the cooked fresh product. These facts would suggest that a composite analytical sample could vary widely in ascorbic acid content, depending upon the ratio of stem to head in the sample.

These results do not agree with those of Gordon and Noble (4) and Jones et al. (15). The former reported no significant difference between the pressure saucepan method and the steaming method, and the latter indicated a greater retention in a steamer as opposed to a steam jacketed kettle. In the present study, greater losses of ascorbic acid resulted when broccoli was cooked in the low pressure steamer. Some also occurred in the steam jacketed kettle.

During the latter part of these investigations, analyses of cooking liquid for broccoli were also made. Individual data are shown in Appendix B. Results obtained in this study indicate that the practice of discarding water in which a vegetable is cooked results in appreciable losses of ascorbic acid.

The color rating of broccoli cooked in the low pressure steamer was considerably lower than the ratings for the uncooked broccoli and broccoli cooked by the other methods (Table 2). The broccoli cooked in the low pressure steamer was rated between dark brownish green to dull yellow green whereas the other methods were rated as moderately bright green.

Results of the color evaluation of broccoli conducted in this study were different than the findings of other investigators (4, 16, 17, 19). Broccoli was greener when it was cooked in the high pressure steamer or in the steam jacketed kettle than when cooked in the low pressure steamer.

TABLE 2

MEAN ASCORBIC ACID AND COLOR RATINGS OF BROCCOLI COOKED IN A STEAM JACKETED KETTLE, A LOW PRESSURE STEAMER AND A HIGH PRESSURE STEAMER

Method of Cooking	Ascorbic Acid[a]	Color Rating[b]
	mg./100 gm. wet weight	
Uncooked	49	4.2
Steam jacketed kettle	39	4.2
Low pressure steamer	25	1.4
High pressure steamer	72	4.2

[a]Each value is the mean of 6 determinations.

[b]A score of 5 denotes bright green; 4 moderately bright green; 3 slightly dull green; 2 dull yellow green; 1 dark brownish green. Each rating is the mean of 5 evaluations.

Potatoes cooked in the high pressure steamer or in the steam jacketed kettle retained approximately 50 per cent and 45 per cent of the ascorbic acid, respectively (Table 3). Those cooked in the low pressure steamer retained approximately 37 per cent of the ascorbic acid. Statistical analysis, however, revealed no significant differences between cooking methods.

TABLE 3

MEAN ASCORBIC ACID AND COLOR RATINGS OF POTATOES COOKED IN A STEAM JACKETED KETTLE, A LOW PRESSURE STEAMER AND A HIGH PRESSURE STEAMER

Method of Cooking	Ascorbic Acid[a]	Color Rating[b]
	mg./100 gm. wet weight	
Uncooked	16	2.9
Steam jacketed kettle	7	3.1
Low pressure steamer	6	2.9
High pressure steamer	8	3.8

[a]Each value is the mean of 5 determinations.

[b]A score of 5 denotes very white; 4 moderately white; 3 slightly grey; 2 dull grey; 1 grey black. Each rating is the mean of 5 evaluations.

The color rating of potatoes cooked in the high pressure steamer was the highest while the ratings of the uncooked potatoes and those cooked in the other equipment were approximately the same (Table 3).

The overall results of this study indicate that broccoli and potatoes retain more ascorbic acid when cooked in a high pressure

steamer. The least retention of this vitamin resulted when these vegetables were cooked in the low pressure steamer. Color evaluations were similar among all methods for both vegetables except when broccoli was cooked in the low pressure steamer. The color ratings were lowest when this method was used.

In some cases values for ascorbic acid in the cooked vegetables were higher than the values determined for the uncooked vegetables. It should be pointed out that several factors could contribute to the variability of ascorbic acid retained in cooked vegetables. Among these are: the vegetable per se in each individual package; the ratio of vegetable to volume of cooking water; the length of cooking time; and the method of cooking. It would be possible to control the last three factors to some extent but it would be difficult to control the first one since the vegetables are not of uniform size within packages. One or more of the foregoing factors may have varied among the investigations concerned with the retention of ascorbic acid in broccoli and potatoes.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

This investigation was undertaken to study the effect of high pressure steaming, low pressure steaming, and a steam jacketed kettle on the retention of ascorbic acid and color in frozen broccoli and tiny, new, whole potatoes.

Institutional packages, 2 pounds in weight of broccoli, and a 20 pound bulk case of tiny, new, whole potatoes were purchased at a local wholesale distributing company in Greensboro, North Carolina. With the exception of potatoes and broccoli cooked in the low pressure steamer, all vegetables were frozen when cooked. The vegetables were cooked according to the times recommended by the manufacturers of the equipment used. Representative samples of uncooked and cooked samples were taken from individual packages, mixed with metaphosphoric acid, blended in an osterizer for 3-5 minutes and filtered. Appropriate aliquots of the filtered samples were used for subsequent ascorbic acid determinations.

Experimental results indicated some loss in ascorbic acid in broccoli cooked by the steam jacketed kettle and an increased loss

when cooked in the low pressure steamer. Analyses of variance of the data revealed a highly significant retention of the vitamin when broccoli was cooked by the high pressure steamer. Mean color values rated lowest for broccoli cooked in the low pressure steamer and showed no differences among the other methods.

Results also indicated a high percentage of loss in ascorbic acid in potatoes cooked by each method. Analyses of the data did not indicate any significant differences in these losses. Color ratings were lowest for the uncooked samples and those cooked in the low pressure steamer.

Recommendations for Further Investigations

Studies similar to this one should be conducted with other vegetables which are good sources of ascorbic acid so that a more complete comparison can be made of the cooking capabilities of the types of equipment used in this study. Vegetables which would be appropriate for such studies are Brussels sprouts, cabbage, collard greens, and turnip greens.

Results of this study indicated a wide variation in the ascorbic acid contents between and within vegetable packages of broccoli. In future studies of this type, more samples and sub-samples should be analyzed so that a better indication of the true ascorbic acid content of the vegetable could be obtained. Additional care may be necessary

when taking an analytical sample since a composite sample of a particular vegetable may vary considerably in nutrient content due to differences in the nutrient content of various portions of the vegetable.

In future studies of this type, evaluations of flavor and texture, in addition to nutrient retention and color retention, should be considered because all of these factors serve as criteria for the choice of a cooking method for vegetables. Studies designed to correlate all of these factors in vegetables cooked by the methods used in this study could yield more information than studies which are more limited in scope because cooking methods which result in satisfactory nutrient retention may or may not result in acceptable color, flavor, or texture.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Halliday, E. and Noble, I. 1946. Hows and Whys of Cooking. 3rd. Edition. Chicago: University of Chicago Press. p. 5.

2. Sweeney, J. P. and M. Martin. 1958. The determination of chlorophyll and pheophytin in broccoli heated by various procedures. Food Research. 23:635-647.

3. Gilpin, G. L., J. P. Sweeney, V. P. Chapman and J. M. Eisen. 1959. Effect of cooking methods on broccoli. II. Palatability. J. Am. Dietet. A. 35:359-363.

4. Gordon, J. and I. Noble. 1959. Effect of cooking method on vegetables. J. Am. Dietet. A. 35:578-581.

5. Sweeney, J. P., G. L. Gilpin, M. E. Martin and E. H. Dawson. 1960. Palatability and nutritive value of frozen broccoli. J. Am. Dietet. A. 36:122-128.

6. Vail, G. E., R. M. Griswold, M. M. Justin and L. O. Rust. 1967. Foods. 5th. Edition. Boston: Houghton Mifflin Company. p. 127.

7. Bring, S. V. and F. P. Raab. 1964. Total ascorbic acid in potatoes. J. Am. Dietet. A. 45:149-152.

8. Irish Potatoes--Utilization of 1964 Crop with Comparisons. 1965. U.S.D.A. Statistical Reporting Serv. Release Pot. 1-3 (9-65).

9. Murphy, E., A. C. Marsh, K. White and S. Hagan. 1966. Proximate composition of ready-to-serve potato products. J. Am. Dietet. A. 49:122-127.

10. King, P. L., G. L. Gilpin and E. H. Dawson. 1962. Comparison of several market forms of potato products. J. Home Econ. 54:837-841.

11. West, B. and L. Wood. 1955. Food Service in Institutions. 3rd. Edition. New York: John Wiley & Sons, Inc.

12. Wilkinson, J. 1963. Put the kettle on. Institutions. pp. 131-136.

13. Streightoff, F., H. Munsell, Ben-Ami Ben-Dor, M. L. Orr, B. Caillear, M. H. Leonard, S. R. Ezwkiel, R. Kornblum and F. G. Koch. 1946. Effect of large scale methods of preparation on vitamin content of foods. I Potatoes. J. Am. Dietet. A. 22:117-127.

14. Branion, H. D., J. S. Roberts, C. R. Cameron and A. M. McCready. 1947. The loss of ascorbic acid in the preparation of old and freshly harvested potatoes. J. Am. Dietet. A. 23:414-419.

15. Jones, J. B., M. A. Wood, M. G. Phillips, F. Fenton and K. W. Harris. 1944. Ascorbic acid, thiamin, and riboflavin retention in quick-frozen broccoli in institution food service. J. Am. Dietet. A. 20:369-372.

16. Noble, I. 1951. Color and ascorbic acid variations in cabbage cooked by different methods. Food Research. 16:71.

17. Noble, I. and J. Gordon. 1956. Ascorbic acid and color retention in green beans cooked by different methods. J. Am. Dietet. A. 32:119-122.

18. Sweeney, J. P., G. L. Gilpin, M. G. Staley and M. E. Martin. 1959. Effect of cooking methods on broccoli. J. Am. Dietet. A. 35:354-358.

19. Noble, I. and J. Gordon. 1964. Effect of blanching method on ascorbic acid and color of frozen vegetables. J. Am. Dietet. A. 44:120-123.

20. Gordon, J. and I. Noble. 1964. Waterless vs. boiling water cooking of vegetables. J. Am. Dietet. A. 44:378-381.

21. Eheart, M. S. 1967. Effects of microwave vs. water-blanching on nutrients in broccoli. J. Am. Dietet. A. 50:207-211.

22. Noble, I. 1967. Effect of length of cooking. Ascorbic acid and color of vegetables. J. Am. Dietet. A. 50:304-307.

23. Loeffler, H. M. and J. D. Ponting. 1942. Ascorbic acid. Rapid determination in fresh, frozen, or dehydrated fruits and vegetables. Indust. & Engin. Chem. Anal. Ed. 14:846.

24. Association of Vitamin Chemists, Inc. 1951. Methods of Vitamin Assay. 2nd. Edition. New York: Interscience Publishers, Inc. p. 86.

APPENDIX A

ANALYTICAL METHOD FOR ASCORBIC ACID

ANALYTICAL METHOD FOR ASCORBIC ACID

Procedure

One ml. of each vegetable filtrate was transferred to a test tube. Simultaneously, a reagent blank was prepared by transferring 1 ml. of the filtrate to a test tube and adding 9 ml. of distilled water. One ml. of each standard used in the assay was pipetted into separate test tubes, and a standard blank was prepared by pipetting 1 ml. of 1% metaphosphoric acid and 9 ml. of distilled water into another test tube.

Nine ml. of indophenol dye were added with a padi delivery pipette to each vegetable filtrate aliquot and to each standard, and the per cent transmittance of each solution was determined 15 seconds after the addition of the dye in a Bausch and Lomb Spectronic 20 colorimeter with the wave length set at 520 mμ. The respective reagent blanks and standard blanks were used as reference solutions.

The milligrams of ascorbic acid in the samples were calculated from the regression equation of the ascorbic acid standards.

Reagents

1. Metaphosphoric acid, 1 per cent - One gram of metaphosphoric acid pellets was dissolved in 90 ml. of distilled water and diluted to 100 ml. This solution was kept in the refrigerator.

2. Indophenol dye - An amount of 0.0668 of 2,6-dichlorophenolindophenol sodium salt was dissolved in 50 ml. of distilled water. The solution was allowed to sit approximately 20 minutes, filtered, and diluted to 100 ml. with distilled water. The concentration of the dye solution was checked by adding 9 ml. of dye to 1 ml. of 1% metaphosphoric acid in a test tube. Fifteen seconds after the addition of the dye, the solution was read on the colorimeter with the wave length set at 520 mμ. In order to give accurate ascorbic acid readings, a transmittance reading of around 30 is required. The dye solution was stable for 5 days when kept in the refrigerator.

3. Ascorbic acid standards

   a. Solution A (1.25 mg./ml.) - an amount of 0.00625 grams (fifth decimal place estimated) of ascorbic acid reference standard was dissolved in 5 ml. of 1% metaphosphoric acid.

   b. Solution B (0.05 mg./ml.) - 2 ml. of Solution A were diluted to 50 ml. with 1% metaphosphoric acid.

   c. Working standards

      (1) 0.01 mg./ml. - 2 ml. of Solution B were diluted to 10 ml. with acid.

(2) 0.02 mg./ml. - 4 ml. of Solution B were diluted to 10 ml. with acid.

(3) 0.03 mg./ml. - 6 ml. of Solution B were diluted to 10 ml. with acid.

APPENDIX B

DETAILED ASCORBIC ACID DATA OF BROCCOLI AND POTATOES

TABLE 1

ASCORBIC ACID CONTENT OF BROCCOLI

Method of Cooking	Package 1 Samples			Package 2 Samples		
	1	2		1	2	3
	mg./100 gm. of wet weight					
Uncooked	53.9	35.3	24.0	55.0	58.7	70.8
	57.0	33.6	22.4	55.0	59.2	67.3
	51.5	33.6	22.4	53.7	57.6	68.8
	56.1	36.3	21.6	55.0	58.7	70.3
	53.4	36.3	21.1	56.0	57.6	68.3
Total	271.9	175.1	111.5	274.7	291.8	345.5
Mean	54.3	35.0	22.3	54.9	58.3	69.1
Steam jacketed kettle	41.3	43.2	39.0	43.2	42.0	27.2
	44.4	44.0	37.7	39.9	38.9	30.0
	45.9	44.5	35.9	38.6	40.2	30.0
	45.9	43.2	38.5	37.3	40.2	29.2
	44.4	43.2	37.2	39.3	40.2	29.2
Total	221.9	218.1	188.3	198.3	201.5	145.6
Mean	44.3	43.6	37.6	39.6	40.3	29.1

TABLE 1 (continued)

ASCORBIC ACID CONTENT OF BROCCOLI

Method of Cooking	Package 1 Samples			Package 2 Samples		
	1	2		1	2	3
			mg./100 gm. of wet weight			
Low pressure steamer	09.5	06.6	35.3	37.8	21.5	40.6
	07.9	07.4	35.9	36.0	22.3	40.6
	09.5	07.4	35.3	36.5	18.5	41.3
	10.0	07.4	36.4	36.0	20.0	41.3
	10.8	06.1	36.4	34.0	18.5	39.3
Total	47.7	34.9	179.3	180.3	100.8	203.1
Mean	09.5	06.9	35.8	36.0	20.1	40.6
High pressure steamer	48.7	69.2	84.2	79.2	72.1	79.2
	51.6	71.9	82.1	79.2	72.1	80.1
	48.2	71.4	83.6	80.6	70.1	78.3
	46.4	70.9	83.4	80.6	71.1	81.0
	47.4	70.9	87.9	79.7	69.1	79.2
Total	242.3	354.3	421.2	399.3	354.5	397.8
Mean	48.4	70.8	84.2	79.8	70.9	79.5

TABLE 2

ASCORBIC ACID CONTENT OF BROCCOLI COOKING LIQUID

Method of Cooking	Sample A	Sample B
	mg./1605 ml.	mg./1750 ml.
Low pressure steamer	110.1	268.5
	50.1	258.9
	76.4	227.3
	82.9	248.3
	82.9	248.3
Total	402.4	1251.3
Mean	80.0	250.2
	mg./555 ml.	mg./375 ml.
High pressure steamer	38.0	129.7
	49.4	110.2
	47.1	143.9
	34.5	143.9
	47.1	108.7
Total	216.1	636.4
Mean	43.2	127.2

TABLE 3

ASCORBIC ACID CONTENT OF POTATOES

Method of Cooking	Portion 1 / Samples			Portion 2 / Samples		Portion 3 / Samples
	1	2	3	1	2	1
	mg./100 gm. of wet weight					
Uncooked	20.6	13.5	23.9	5.0		15.0
	19.5	12.3	26.5	5.4		13.7
	19.9	14.6	26.2	3.9		15.6
	19.9	12.3	26.2	3.9		15.7
	20.6	11.9	25.0	3.9		15.0
Total	1.5	64.6	127.8	22.1		75.0
Mean	20.1	12.9	25.5	04.4		15.0
Steam jacketed kettle	16.6		7.5	3.5	3.9	1.8
	17.1		12.8	3.5	3.5	2.1
	16.2		7.5	3.9	2.7	3.6
	16.6		8.9	3.9	3.5	3.2
	17.8		8.0	4.3	3.1	2.9
Total	84.3		44.7	19.1	16.7	13.6
Mean	16.8		8.9	3.8	3.3	2.7

TABLE 3 (continued)

ASCORBIC ACID CONTENT OF POTATOES

Method of Cooking	Portion 1 Samples			Portion 2 Samples		Portion 3 Samples
	1	2	3	1	2	1
			mg./100 gm. of wet weight			
Low pressure steamer	1.8	7.6	6.1	5.5	6.9	
		7.6	7.1	5.8	6.9	
	1.1	6.6	7.1	6.7	6.9	
	2.1	6.6	6.8	5.5	6.9	
	1.6	6.3	7.4	7.1	6.3	
Total	6.6	34.7	34.5	30.6	33.9	
Mean	1.6	6.9	6.9	6.1	6.7	
High pressure steamer		9.6	13.0	1.8	1.0	13.5
		11.3	12.6	1.0	1.0	13.5
		10.5	13.0	0.5	.1	14.0
		10.1	13.3	1.0	.6	13.5
		10.5	13.0	0.5	.6	13.3
Total		52.0	64.9	4.8	3.3	67.8
Mean		1.4	12.9	0.9	.6	13.5

APPENDIX C

COLOR EVALUATION OF BROCCOLI AND POTATOES

TABLE 1

COLOR EVALUATION OF BROCCOLI*

Method of Cooking	Panel Member	Position 1	2	3	4	5
Uncooked	A	5	4	3	4	5
	B	4	4	5	4	5
	C	4	5	5	5	5
	D	3	5	4	5	4
	E	3	4	3	5	4
Total		19	22	20	23	23
Mean		3.8	4.4	4	4.6	4.6
Steam jacketed kettle	A	4	5	4	5	4
	B	5	3	5	5	4
	C	5	4	4	4	4
	D	5	4	2	4	3
	E	5	5	4	5	3
Total		24	21	19	23	18
Mean		4.8	4.2	3.8	4.6	3.6

TABLE 1 (continued)

COLOR EVALUATION OF BROCCOLI*

Method of Cooking	Panel Member	Position 1	2	3	4	5
Low pressure steamer	A	2	1	2	1	1
	B	3	2	2	3	1
	C	2	1	1	1	1
	D	1	1	1	1	1
	E	2	2	1	2	1
Total		10	7	7	8	5
Mean		2	1.4	1.4	1.6	1
High pressure steamer	A	5	3	5	5	5
	B	4	5	4	5	4
	C	4	4	4	4	4
	D	4	3	4	4	5
	E	4	3	5	4	5
Total		21	18	22	22	23
Mean		4.2	3.6	4.4	4.4	4.6

*Score: 5 denotes bright green
4 denotes moderately bright green
3 denotes slightly dull green
2 denotes dull yellow green
1 denotes dark brownish green

TABLE 2

COLOR EVALUATION OF POTATOES*

Method of Cooking	Panel Member	Position 1	2	3	4	5
Uncooked	A	3	3	4	4	3
	B	3	2	2	2	3
	C	3	3	3	3	4
	D	1	4	3	3	1
	E	1	3	4	5	3
	Total	11	15	16	17	14
	Mean	2.5	3	3.2	3.4	2.8
Steam jacketed kettle	A	2	3	4	3	4
	B	3	4	3	3	5
	C	3	3	4	2	4
	D	2	2	4	2	4
	E	2	4	3	2	4
	Total	12	16	18	12	21
	Mean	2.4	3.2	3.6	2.4	4.2

TABLE 2 (continued)

COLOR EVALUATION OF POTATOES*

Method of Cooking	Panel Member	Position 1	2	3	4	5
Low pressure steamer	A	3	3	2	4	4
	B	3	2	2	4	4
	C	2	3	3	3	3
	D	3	1	2	3	2
	E	4	2	2	4	5
Total		15	11	11	18	18
Mean		3	2.2	2.2	3.6	3.6
High pressure steamer	A	4	4	5	3	3
	B	4	5	4	3	3
	C	4	4	4	4	3
	D	4	3	5	2	4
	E	5	5	5	3	2
Total		21	21	23	15	15
Mean		4.2	4.2	4.6	3	3

*Score: 5 denotes very white
4 denotes moderately white
3 denotes slightly grey
2 denotes dull grey
1 denotes grey black

INSTRUCTIONS FOR JUDGES AT EVALUATION SESSIONS

1. There are five positions, each including four samples.

2. Only one person should be at a position at a time.

3. Scorecards and pencils are provided at each position for each set of samples. Pick up one. Write the date, position number, and your name on it.

4. Look at one sample at a time. Mark the score number for that sample in the proper space on the scorecard.

5. Follow this same direction for all four samples in each position.

6. When you complete the scorecard, turn it face down on the counter to the right of the samples.

7. In judging each sample work from left to right.

8. When finished judging at one position move to the next position at your right.

9. Please do not talk or make any unnecessary comments during the evaluation session.

SCORECARD FOR COLOR EVALUATION

BROCCOLI

SCORE: 5 denotes bright green
4 denotes moderately bright green
3 denotes slightly dull green
2 denotes dull yellow green
1 denotes dark brownish green

Date: _____

Position: _____

Name: _____

Sample:	A	B	C	D
Score:	____	____	____	____

Comments:

POTATOES

SCORE: 5 denotes very white
4 denotes moderately white
3 denotes slightly grey
2 denotes dull grey
1 denotes grey black

Date: _____

Position: _____

Name: _____

Sample:	A	B	C	D
Score:	____	____	____	____

Comments:

APPENDIX D

ANALYSES OF VARIANCE DATA

TABLE 1

ANALYSIS OF VARIANCE OF ASCORBIC ACID DATA

Source of Variance	Degrees of Freedom	Sum of Squares	Mean Square
		Broccoli	
Total	23	1.068	
Between methods	3	.717	.239**
Within methods	20	.351	.018
		Potatoes	
Total	19	.088	
Between methods	3	.029	.0096
Within methods	16	.059	.0036

**Highly significant ($P \leq .01$)