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The purpose of this study was to compare the flavor and general appearance of frozen broccoli cooked in a high pressure steamer, a low pressure steamer, and a steam jacketed kettle.

Institutional packages of frozen broccoli spears to be used in the study were purchased from a wholesale company. Samples for cooking were randomly selected from the purchased containers. These samples were cooked according to the recommendations of the manufacturers of the equipment used. In the steam jacketed kettle, broccoli spears were cooked uncovered with a sufficient amount of distilled water to cover the vegetable. The low pressure steamer was set to operate with five pounds of pressure per square inch. The high pressure unit was set to operate at fifteen pounds of pressure per square inch. The times required to cook the vegetable to a desirable state of tenderness were established by preliminary tests. Coded samples of the cooked broccoli spears were rated subjectively for flavor and general appearance by a panel of six members.

Experimental results indicated a significant difference between the flavor and appearance scores for broccoli cooked in the steam jacketed kettle and that cooked in a high pressure steamer. A marked lowering of the flavor score occurred for broccoli cooked in a low pressure steamer. Ratings for appearance also were lowest for the broccoli samples cooked in the low pressure steamer.

EFFECT OF HIGH PRESSURE STEAMING, LOW PRESSURE STEAMING, AND A STEAM JACKETED KETTLE ON THE FLAVOR AND APPEARANCE OF FROZEN BROCCOLI

by

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APPROVAL SHEET

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX MATERIALS

Appendix A

Appendix B

Appendix C

CHAPTER I

INTRODUCTION

The study reported here was concerned with the preparation of frozen broccoli by methods employed in institutional food services. Broccoli is one of the popular green vegetables. Frozen broccoli is often the choice for institutional cookery. The frozen form is economical and readily available. Moreover, frozen broccoli requires no preparation prior to cooking. However, the choice of the method used for the cooking of this food can influence the quality of the product as served.

When cooked by suitable methods, frozen broccoli compares favorably with the fresh product where flavor, appearance, and content of nutrients are concerned. Cooked, frozen broccoli may be a very good source of ascorbic acid and a number of other nutrients, including beta-carotene (provitamin A), riboflavin, calcium, and iron. These nutrients do not occur in the same concentrations in many other popular vegetables.

Potential nutritive values, though, are seldom the main determinants in the food choices of individuals eating in restaurants. The choice of food probably is more often influenced by the appearance, flavor, and texture of the food rather than by nutritive values. Foods that rate poorly in terms of one or more of the above properties may be completely rejected, despite the potential nutritive contributions.

The cooking of fresh and frozen broccoli presents some difficulties where the properties that influence choice are concerned. Undesirable changes in flavor and color readily occur. These changes are more difficult to prevent when the vegetable is cooked in large quantities. Mushy overcooked vegetables also frequently result when vegetables are cooked in large quantities. Underdone vegetables, especially stems, are not unknown.

The changes that occur in flavor and color of broccoli during cooking are related to the chemical nature of the compounds that are responsible for these properties. The production of cooked broccoli of optimum quality is complicated further by the difference in texture of the stems and heads of the vegetable. The desired degree of doneness for stems may result in mushy heads and greater changes in flavor and color.

Broccoli is a member of the family Brassicaceae, as are cabbage, Brussels sprouts, cauliflower, and turnips (1,2). These vegetables contain compounds of sulphur, one of which is in the form of the glucoside, sinigrin. Sinigrin is split by an enzyme in the plant cells to give "mustard oil" (allyl isothiocyanate). Volatile compounds of sulphur, including dimethyl disulfide and hydrogen sulfide, are formed when vegetables of this family are cooked. The extent of decomposition of the sulphur compounds and of the appearance of new disagreeable flavors seem to be related to decomposition of the original sulphur containing compounds and the length of the cooking period. According to both Myer (3) and Griswold (4), the overcooking of these vegetables results in a larger production of hydrogen sulfide. The appearance of

new disagreeable flavors may increase when the vegetables are cooked in a tightly closed kettle. When the lid is removed or is loosely fitting, volatile compounds escape as well as other compounds that appear to hasten decomposition of the original sulphur compounds.

The pigment chlorophyll is responsible for the attractive color of all green vegetables. Chlorophyll is a complex molecule containing magnesium in its center. In the presence of mild acids, the magnesium is replaced by two atoms of hydrogen. The resulting product, known as pheophytin, is yellowish green to olive brown in color; and it occurs in many cooked green vegetables, especially those overcooked or cooked by unsuitable methods.

The acid that is responsible for the formation of the yellow brown color generally comes from the cell sap of the vegetable itself. In the raw state, chlorophyll is protected from the acid cell sap by its location in the tightly organized cellular compartments, the plastids (chloroplasts). Heat causes changes in the plastids and possibly in the chlorophyll so that chemical change by the acid is hastened.

Some of the acids of the cell sap of the vegetable are volatile. Cooking without a lid or with a loosely fitting cover, especially during the first few minutes of cooking, permits the escape of the volatile acids, and gives a better color and flavor. In general, color and flavor of vegetables such as broccoli are found to be more pleasing when the cooking methods employ water rather than steam alone. Sweeney, *et al.* (5,6) suggest that water dilutes the soluble plant acids that are responsible in part for the changes of the original color and flavor.

The purpose of this study was to compare the flavor and general appearance of frozen broccoli cooked in (1) a high pressure steamer, (2) a low pressure steamer, and (3) a steam jacketed kettle.

CHAPTER II

REVIEW OF LITERATURE

The literature pertinent to the study will be considered under the following headings: (1) methods of cooking, (2) palatability, and (3) nutritive values.

Methods of Cooking

Methods of institutional cookery include all of those used in the home. For institutions, though, food is cooked in greater quantities and in larger containers. The equipment used may include either a steam jacketed kettle, a low pressure steamer, and a high pressure steamer, used singly or in combination depending upon the type of food and the type of service.

The steam jacketed kettle is frequently used in institutional cookery for the preparation of vegetables (7). This kettle is basically two stainless hemispheres or bowls, the one sealed inside the other with about two inches of space in between for steam. When the steam comes into the jacket, the molecules touch the cold inner wall and condense. When this happens the heat of the steam molecule penetrates the metal and is transferred into whatever is being cooked. Although frozen vegetables do not need to be defrosted before cooking, they may be defrosted slightly for quicker separation during the cooking process. Vegetables can be boiled in an amount of water varying from less than enough to cover to more than enough. According to Wilkinson (7), two

methods of vegetable cookery in the steam jacketed kettle have been developed. The first method is as follows:

1. Use enough water to cover the vegetable.
2. Salt water.
3. Bring water to boil and put vegetable in water.
4. When water begins to boil again, turn pressure down until water just boils gently.
5. Remove vegetable from water as soon as it becomes tender.

The second method makes use of considerably less water as shown in the following directions:

1. Use just enough water to create steam vapor as vegetable is cooked.
2. Place cover on kettle and turn on steam to correct temperature.
3. Add vegetable, place cover on kettle and cook until vegetable is just tender. Remove vegetable.

Avery (8) reported that cooking in the steam jacketed kettle is little different from cooking in an ordinary pot except that in most cases it is faster.

The low pressure steamer derives heat from unpressured condensing steam which comes into direct contact with the food. Three to five pounds of pressure are attained during the cooking process. Cooking times are shortened because steam is available quickly and because of the increase in pressure. Frozen vegetables, however, should be partially defrosted before cooking. Vegetable cookery in the low pressure steamer involves the following steps:

1. Place vegetable in container and then into steamer. Close steamer.
2. Turn steam control on. Exhaust steam three to four times. Begin cooking time as soon as steam indicator shows desired steam level. Adjust steam to maintain this level.
3. When cooking time is over turn off steam and exhaust it from steamer.
4. Remove vegetable from steamer when steam indicator shows zero pounds of pressure.

According to West and Wood (9), the low pressure steamer is comparable with the pressure saucepan used in some homes. This similarity is with respect to the steam surrounding the food rather than to the maximum temperature of fifteen pounds attainable in several pressure saucepans used in the home.

The high pressure steamer used in institutional cookery was developed during recent years in an attempt to shorten cooking times. This steamer operates with twelve to fifteen pounds pressure in an atmosphere of dry steam from which the air has been expelled. Cooking results from dry steam being introduced directly into the food. Frozen foods do not have to be thawed prior to cooking because the food is automatically defrosted before the cooking cycle is begun. The following method is used when cooking vegetables in the high pressure steamer:

1. Place vegetable in container and then into steamer.
2. Turn steamer on and partially close door. Turn automatic timer control past position three. Immediately turn control

to the number of minutes desired for cooking. Completely close door.

3. Open door and remove vegetable after the timer has cut steamer off automatically and pressure has dropped to zero.

Expelling the air prevents oxidation of vitamins and mineral salts and should result in better nutrient and color retention. Overcooking is considered by the manufacturer to be impossible because of the automatically activated timer system.

Palatability

Simpson and Halliday (10) investigated the development of an unpleasant flavor and odor during the cooking of vegetables in the cabbage family. This was accomplished by determining the total volatile sulphur and hydrogen sulfide released when the vegetables were cooked until just tender and when they were somewhat overcooked. The decomposition products of the sulphur compounds were found to increase as the length of the cooking period increased. Samples of cabbage were most suitable for serving after they had been boiled from seven to eight minutes. After eight minutes of boiling, a disagreeable taste and odor developed as a result of decomposition products.

Brinkman *et al*. (11) studied the retention of flavor, odor, color, and texture in vegetables cooked by three methods. Cooking equipment used for this study included: an open kettle with large amounts of water, a waterless cooker with a tightly fitting lid, and a pressure saucepan. Broccoli and cabbage, the two Brassicaceous vegetables studied, were found to be markedly inferior in flavor and color when cooked in either the pressure saucepan or the waterless cooker.

Palatability of these two vegetables was best when they were boiled in an open kettle with large amounts of water.

Gilpin et al. (1) experimented with thirteen different cooking methods to determine the effects on the quality of fresh broccoli. Differences in flavor which occurred as a result of the cooking method were less pronounced than differences in color and texture. A five minute cooking period was insufficient to produce an optimum flavor in several of the techniques that employed boiling water and steam. The best flavor was obtained with these methods when a cooking period of ten minutes was used. In contrast with the results of Brinkman (11), large amounts of water for cooking were judged to leach out flavor. According to the judges of the study by Gilpin (1) the best flavor for fresh broccoli was obtained by cooking the vegetable for either six minutes at five pounds of pressure or for one minute at fifteen pounds of pressure.

As the cooking period was increased in any of the methods, the color deteriorated significantly. Texture scores were highest when a ten minute cooking period was used for the methods employing a steamer and for most of the boiling water immersion methods. When the cooking method employed pressure, cooking the vegetable for six minutes at five pounds of pressure resulted in optimum doneness.

Gordon and Noble (12) reported that vegetables of the cabbage family were milder in flavor when cooked in boiling water than when cooked by either the pressure saucepan or with the electronic range methods.

Charles and Van Duyne (13), while investigating the effects of "waterless" cooking on the palatability of vegetables, concluded that this method resulted in inferior color, flavor, and texture. Vegetables boiled in water in a covered saucepan were rated superior in color, flavor, and texture. This, too, is in contrast with the ratings given different methods of cooking by Brinkman (11) and Simpson and Halliday (10).

In a comparison of boiling water and pressure saucepan with waterless or steaming methods of cooking, Gordon and Noble (14) found broccoli samples cooked in the pressure saucepan to be mildest in flavor. The boiling water method consistently resulted in good retention of green color. The pressure saucepan method resulted in a decrease in the green color. These findings were not in agreement with the findings of other researchers (1,5,13).

In studying the effects of cooking procedures on taste, texture, and nutritive value of frozen broccoli, Sweeney et al. (5) concluded that samples were best when boiled for ten minutes in a covered saucepan or cooked under fifteen pounds pressure for one-half minute. Scores recorded for flavor indicated that flavor increased with the cooking time until a maximum was obtained. Flavor, however, decreased as the cooking time increased beyond the maximum time previously established. In general, the quality of the texture decreased as cooking times increased. Color of the vegetable also decreased as cooking times increased for all methods except those involving pressure. Scores for broccoli cooked under pressure fluctuated but showed that judges indicated only minimal color changes for periods of one minute or less.

Sweeney et al. (5) also compared the effects of different storage periods on the palatability of frozen broccoli. After four months of storage, flavor scores were only slightly decreased. A storage period of nine months resulted in scores which were lower for broccoli cooked under pressure.

Noble (15) reported that green vegetables gained a hue of yellow as the cooking period increased when cooked in either boiling water or in the pressure saucepan. However, broccoli retained some of its greenness even after fifty minutes in boiling water. In the pressure saucepan, the vegetable had turned yellow after three to five minutes of overcooking.

Sweeney and Martin (16) found that in broccoli the percentage of chlorophyll converted to pheophytin during cooking increased as the cooking time increased.

Noble (17) stated that the open kettle method of cooking resulted in cabbage samples which were either as green or more green than the raw samples. When cooked in the pressure saucepan, samples were not as green as in the open kettle, but did retain a portion of the green color. Cooking in a tightly covered pan or by steaming resulted in a marked loss of green color.

Gordon and Noble (13) also reported that hues for broccoli cooked in either boiling water or the pressure saucepan were more green than were samples cooked in a steamer or a tightly covered pan.

In studying color retention of quick-frozen broccoli, Jones et al. (19) found that broccoli cooked in a steam jacketed kettle to be more green than that cooked in a low pressure steamer.

MacGibbon and Halliday (20) reported the steam jacketed kettle, whether alone or followed by two and one-half minutes of steaming, resulted in vegetables as green as those cooked by the method of choice for small quantities of vegetables.

Nutritive Values

Jones et al. (19) studies ascorbic acid, thiamin, and riboflavin retention in quick-frozen broccoli in institution food service. A steam jacketed kettle and a low pressure steamer were among the pieces of cooking equipment used in the study. Greater retention of all three nutrients resulted in broccoli cooked in the steamer.

Gilpin et al. (1) investigated the effects of several different cooking methods on the retention of ascorbic acid in fresh broccoli. These cooking methods included boiling water techniques, steaming, and pressure cooking. These researchers found that broccoli cooked to optimum texture retained from sixty to eighty-five percent of its ascorbic acid with the methods using small amounts of water. Large amounts of water used for cooking resulted in excessive leaching of ascorbic acid into the water.

Gordon and Noble (14) experimented with the "waterless" method versus boiling water cooking of fresh vegetables. Good retention of ascorbic acid occurred with both the boiling water method and the "waterless" method, but the highest retention of ascorbic acid resulted when the pressure saucepan method was used.

Summary

A review of the literature indicated that institutional cookery methods, while similar to methods used in homes, may include special equipment such as the steam jacketed kettle, the low pressure steamer, and the high pressure steamer.

The effects of various cooking methods on the palatability of broccoli have been studied by several researchers. In general the boiling water method of cooking, whether in a covered or uncovered kettle, was reported by researchers (5,11,12,13) to result in broccoli having the best flavor and texture. In contrast, Gordon and Noble (14) found that broccoli samples had the best flavor when cooked in the pressure saucepan. Other researchers (1,11) reported different effects on flavor as the amount of water used for cooking was increased. Results of several studies (11,14,15,17,19,20) indicated that broccoli retained more of its green color when cooked by the boiling water method. Color was shown to decrease as the cooking time increased (5,15,16).

In studies to determine the effects on the nutritive values of broccoli cooked by different methods, Gordon and Noble (14) and Jones et al. (19) reported a greater retention of nutrients when the vegetable was cooked in the pressure saucepan.

CHAPTER III

EXPERIMENTAL PROCEDURES

The purpose of this study was to compare the flavor and general appearance of frozen broccoli cooked in a high pressure steamer, a low pressure steamer, and a steam jacketed kettle.

The frozen broccoli spears used in this study were purchased by the case from a wholesale company. Each case contained twelve 2-pound institutional packages. The broccoli was stored in a freezer at zero degrees F. until it was used in the study.

Samples for cooking were randomly selected from the purchased containers. The general procedures used for cooking the vegetable followed the recommendations of the manufacturers of the equipment. Cooking times were established by preliminary tests. These cooking times were just sufficient to give a tender product.

After completion of the preliminary tests, the original brand of broccoli could no longer be obtained. Thus, it was necessary to purchase another brand for use throughout the experimental period. The first test indicated that the cooking times established by the preliminary tests resulted in an overcooked product when the second brand of broccoli was used. The cooking times in tests 2 - 5 were decreased to avoid overcooking. Preparation and cooking information used in the study is given in Table I.

TABLE 1

PREPARATION AND COOKING PROCEDURES FOR FROZEN BROCCOLI SPEARS COOKED BY THREE INSTITUTIONAL METHODS

Procedure	Steam Jacketed Kettle	Food Service Equipment Low Pressure Steamer	High Pressure Steamer
	Test 1		
Broccoli Spears [a]			
Thawing time	None	Overnight in refrigerator	None
Amount of water added (cups)	20	None	None
Cooking time (minutes)	4	10	1½
	Tests 2 to 5		
Thawing time	None	Overnight in refrigerator	None
Amount of water added (cups)	20	None	None
Cooking time (minutes)	2	8	1

[a]Each cooking sample contained two pounds of broccoli spears.

The equipment used was furnished by a commercial equipment company[1]. In the steam jacketed kettle, broccoli spears were cooked uncovered with a sufficient amount of water to cover the vegetable. Distilled water was used in the study. This was to overcome the effect of the alkaline pH of the tap water of the area. The broccoli spears were placed in the kettle after the water had come to a rapid boil. Timing of the cooking period began when the water returned to boiling. The boiling point was maintained throughout the cooking period.

The other equipment used included the low pressure steamer[2] and a high pressure steamer[3]. The low pressure unit was set to operate with five pounds of pressure per square inch. The high pressure unit was set to operate at fifteen pounds of pressure per square inch.

Coded samples of broccoli were rated subjectively for flavor and general appearance by a panel of six members. This panel of judges consisted of the faculty, staff, and graduate students in the School of Home Economics at the University of North Carolina in Greensboro. The panel were given preliminary instructions and training. The procedures for scoring and the sample score card used are given in Appendix A. The rating scale used was adapted from that suggested by Griswold (4). The room used by the judges during judging periods was air conditioned, and a stool was provided for each judge.

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[1]The Groen Division/Dover Corporation, Elk Grove Village, Illinois, distributors of the Model TDC-20 steam jacketed kettle.

[2]Model 1 W-S unit of the Market Forge Company, Everett, Massachusetts.

[3]Model 75 unit of Vischer Products Company, Chicago, Illinois.

Distractions during the judging period were kept at a minimum by placing the judges in different parts of the room. Five replications of the ratings were obtained.

The data were analyzed by standard analysis of variance procedures. Mean scores were determined from the scores for five evaluations.

CHAPTER IV

RESULTS AND DISCUSSION

Results of the comparison of the flavor and general appearance of frozen broccoli cooked in a high pressure steamer, a low pressure steamer, and a steam jacketed kettle will be given in this chapter. Detailed data are presented in Appendix B.

The effects of three methods of cooking on the mean scores for flavor and appearance of frozen broccoli are shown in Table 2. The mean flavor scores for broccoli obtained in this study were 4.1 for broccoli cooked in a high pressure steamer, 4.1 for broccoli cooked in a steam jacketed kettle, and 3.2 for broccoli cooked in a low pressure steamer. Although an analysis of the data revealed an overall significant difference ($P \leq 0.05$) between the flavor of broccoli cooked by boiling in a steam jacketed kettle and that cooked by steaming, it is apparent that the mean flavor score of broccoli cooked under high pressure steam was the same as the mean flavor score of broccoli cooked in the steam jacketed kettle. Broccoli cooked in the low pressure steamer not only resulted in a marked lowering of the mean flavor score, but also in differences which were highly significant ($P \leq 0.01$). In general, these results would suggest that the flavor of broccoli cooked in a low pressure steamer is not as acceptable as the flavor of broccoli cooked in a steam jacketed kettle or in a high pressure steamer. These findings are in agreement with results obtained by Brinkman et al. (11).

TABLE 2

MEAN SCORES OBTAINED ON FLAVOR AND APPEARANCE OF FROZEN BROCCOLI SPEARS COOKED BY THREE INSTITUTIONAL METHODS

Method of Cooking	Mean Scores[a]	
	Flavor[b]	Appearance[b]
High Pressure Steamer	4.1	4.2
Steam Jacketed Kettle	4.1	4.5
Low Pressure Steamer	3.2	3.0

[a]Each score is the mean of 5 evaluations.

[b]A score of 5 denotes very good; 4, good; 3, fair; 2, poor; 1, very poor.

The mean appearance scores for broccoli cooked in a high pressure steamer, a steam jacketed kettle, a low pressure steamer were 4.2, 4.5, and 3.0, respectively. Analysis of the data indicated a highly significant difference ($P \leq 0.01$) in the appearance of broccoli cooked in a steam jacketed kettle and the appearance of broccoli cooked by steaming. Although the mean appearance scores for broccoli cooked in

a high pressure steamer and a steam jacketed kettle were quite similar, analysis of the data revealed a significant difference ($P \leq 0.05$) between the two mean scores. This difference indicated that broccoli cooked in a steam jacketed kettle had a better appearance than broccoli cooked in a high pressure steamer. Analysis of the data revealed a highly significant difference ($P \leq 0.01$) in the appearance of broccoli cooked in a high pressure steamer and broccoli cooked in a low pressure steamer. Of the three methods studied, the low pressure steamer had the most adverse effect on the appearance of cooked broccoli. These findings are in agreement with those of Noble (15,17) and Jones et al. (19). The mean score for broccoli cooked in a low pressure steamer indicated that the green color had decreased and that the stems and heads appeared somewhat mushy.

Although the mean flavor score for broccoli cooked by the steam jacketed kettle and the high pressure steamer methods were the same, the improved appearance of broccoli cooked in the steam jacketed kettle would seem to suggest that the steam jacketed kettle method of cooking may well be the best choice for institutional cookery with respect to the frozen broccoli studied.

The steam jacketed kettle can also be considered a good method of cooking for the retention of ascorbic acid in broccoli (21). Although broccoli cooked in a high pressure steamer retained more ascorbic acid than broccoli cooked in the steam jacketed kettle, the steam jacketed kettle method of cooking also resulted in broccoli which retained significant amounts of ascorbic acid. The loss of ascorbic acid which occurs in the steam jacketed kettle would seem to be offset

by the better appearance of broccoli cooked by this method. As a result of the improved appearance of broccoli cooked in a steam jacketed kettle, the vegetable might well be a more frequent choice of individuals.

Results of this study indicated that the cooking time required for one brand of frozen broccoli may differ from that required for another brand. This could easily present difficulties in institutional cookery when fixed cooking times are applied to all brands or even to different lots of the same brand.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

This study was undertaken to compare the flavor and general appearance of frozen broccoli cooked in a high pressure steamer, a low pressure steamer, and a steam jacketed kettle.

Institutional packages, 2 pounds in weight, of frozen broccoli were purchased from a wholesale company. Randomly selected samples of the vegetable were cooked according to the recommendations of the manufacturers of the equipment used. The times required to cook the vegetable to a desired state of tenderness were established by preliminary tests. Coded samples of the cooked broccoli were rated subjectively for flavor and general appearance by a panel of six members.

Experimental results indicated a significant difference between the flavor and appearance scores for broccoli cooked in the steam jacketed kettle and that cooked in a high pressure steamer. A marked lowering of the flavor scores occurred for broccoli cooked in the low pressure steamer. Ratings for appearance also were lowest for the broccoli samples cooked in the low pressure steamer.

Recommendations for Further Study

In view of the increased number of meals now taken outside the home, study on the effects of different methods of institutional

cookery on a number of well-liked vegetables would seem to be indicated. Such study might well include the effects of the methods on such factors as flavor and appearance, and on the retention of nutrients as well.

Study of the extent to which the cooking time of different lots of broccoli differs would be useful to food service managers who are interested in attaining a product uniformly acceptable to a majority of persons.

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APPENDIX A

BROCCOLI EVALUATION CHART

BROCCOLI EVALUATION CHART

Name_____Date_____Position_____

SCORE CARD FOR EVALUATING FLAVOR OF FROZEN BROCCOLI

DIRECTIONS: Write the number of the adjective which best describes the flavor of the sample in the score blanks.

SCORE SCALE:

5 - very good (in all respects; you know of no improvement)

4 - good (enjoyed it; minor improvement desirable)

3 - fair (could eat it without enthusiasm, improvement needed)

2 - poor (edible, but that is all)

1 - very poor (inedible)

SAMPLE:	A	B	C
SCORE:	_____	_____	_____

COMMENTS:

BROCCOLI EVALUATION CHART

Name_____Date_____Position_____

SCORE CARD FOR EVALUATING APPEARANCE OF FROZEN BROCCOLI

DIRECTIONS: Write the number of the adjective which best describes the appearance of the sample in the score blanks.

SCORE SCALE:

5 - very good (closely retains original green color with texture of stems and heads firm but not appearing tough)

4 - good (slight fading of color; texture does not appear to be as firm)

3 - fair (color could be better; stems and heads appear somewhat mushy)

2 - poor (yellow color; stems and heads appear to be overcooked)

1 - very poor (color is unacceptable; stems and heads appear to be mushy)

SAMPLE:	A	B	C
SCORE:	_____	_____	_____

COMMENTS:

APPENDIX B

FLAVOR AND APPEARANCE SCORES OF FROZEN BROCCOLI

TABLE 1

FLAVOR SCORES FOR FROZEN BROCCOLI SPEARS COOKED BY THREE INSTITUTIONAL METHODS

Method of Cooking	Judge	SCORES				
		TEST NUMBER				
		One	Two	Three	Four	Five
High Pressure Steamer	A	4	4	5	4	4
	B	4	2	3	4	4
	C	4	5	4	5	4
	D	5	4	4	4	4
	E	4	3	3	5	5
	F	3	4	4	5	5
Steam Jacketed Kettle	A	3	4	4	4	4
	B	5	4	5	5	5
	C	5	4	5	4	5
	D	3	3	3	3	3
	E	3	4	5	3	4
	F	3	5	5	5	4
Low Pressure Steamer	A	3	3	5	3	5
	B	3	3	4	2	3
	C	2	3	3	2	3
	D	2	3	3	2	4
	E	3	4	4	3	4
	F	4	3	3	4	4

TABLE 2

APPEARANCE SCORES FOR FROZEN BROCCOLI SPEARS
COOKED BY THREE INSTITUTIONAL METHODS

Method of Cooking	Judge	SCORES				
		TEST NUMBER				
		One	Two	Three	Four	Five
High Pressure Steamer	A	3	4	4	4	4
	B	5	4	4	4	4
	C	5	5	4	5	4
	D	4	4	4	4	3
	E	4	3	5	5	5
	F	4	4	5	4	4
Steam Jacketed Kettle	A	3	5	4	5	5
	B	4	5	5	5	5
	C	4	5	5	4	5
	D	5	3	5	5	4
	E	3	5	4	4	5
	F	5	5	5	4	5
Low Pressure Steamer	A	3	2	4	3	3
	B	4	3	3	2	3
	C	2	2	4	2	3
	D	2	2	3	2	2
	E	2	4	4	3	4
	F	4	2	4	4	4

APPENDIX C

ANALYSIS OF VARIANCE DATA

TABLE 1

ANALYSIS OF VARIANCE OF FLAVOR AND APPEARANCE DATA

Sources of Variance	Degrees of Freedom	Sum of Squares	Mean Square
		Flavor	
Total	89	65	
Between Methods	2	14	7.00**
Within Methods	87	51	.58
		Appearance	
Total	89	85	
Between methods	2	40	20.00**
Within methods	87	37	.47

* Significant ($P \leq 0.01$)
** Highly Significant ($P \leq 0.01$)