A COMPARISON OF THE PALATABILITY, ASCORBIC ACID CONTENT, AND COST OF MARKET FRESH BROCCOLI WITH COMMERCIALLY FROZEN BROCCOLI SPEARS AND CUTS

by

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B. S., Saint Mary-of-the-Woods College, 1953

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

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INTRODUCTION

Fresh vegetables are usually considered cheaper than their frozen counterparts. In addition, fresh vegetables contain the less stable nutrients which are oftentimes lost in the freezing process.

Convenience, ease of preparation, out-of-season availability, and relatively consistent quality, regardless of season of purchase, are several factors contributing to the popularity of frozen vegetables. The desirable characteristics of fresh vegetables can be retained satisfactorily in the frozen product by means of modern processing.

Broccoli, one fresh vegetable readily available on the market throughout much of the year, possesses a comparatively high ascorbic acid content. Because of the fewer processes required in its handling and distribution, a lower cost is indicated for the fresh product. Commercially frozen broccoli spears have enjoyed moderate demand for several years. Both the fresh and frozen spears have recently found competition in the frozen cuts. A newcomer on the market, the broccoli cuts will undoubtedly be selected occasionally to add variety to the menu.

Therefore, it should be of interest to the homemaker to know if a difference in palatability and ascorbic acid content exists among fresh broccoli and frozen broccoli spears and/or cuts, and whether this difference, if it occurs, be sufficiently great to warrant the choice of one type over the others. The relative cost

of the three types should also interest the homemaker, since the food budget is usually one of her chief concerns.

The present study was undertaken to determine: (1) the relative palatability, ascorbic acid content, and cost of market fresh broccoli and commercially frozen broccoli spears and cuts during two separate months of the year; and (2) the seasonal variation in the palatability, ascorbic acid content, and cost of the three types of the vegetable.

Palatability tests were made as an indication of consumer acceptance; ascorbic acid determinations were conducted to ascertain the relative content of the vitamin in each type; and unit costs of the three kinds were recorded for comparison.

REVIEW OF LITERATURE

Composition and Characteristics of Broccoli

Broccoli is a type of cabbage made up of small heads, composed of rudimentary flowers, and colored green (Lee, 1951). It is a good source of ascorbic acid, as based on allowances recommended by the Food and Nutrition Board, National Research Council (1953).

Broccoli varies somewhat in size and color, habit of growth, and the manner in which the young sprouts are formed, but in all cases, it is the young shoots or branches with their flower clusters or heads that are eaten, stated Hill (1933). He described good quality broccoli as not overmature, as indicated by tender, firm stalks, compact buds in clusters, and the absence of

color in the flower. The general color would be either dark green or purplish green, depending on the variety. Overmature broccoli, Hill (1933) indicated, is woody, tough, and stringy with the toughest portion at the lowest part of the stalk. Bud clusters are open to the extent that the full yellow or purple color of the blossom is distinct; an occasional open blossom, however, does not indicate overmaturity.

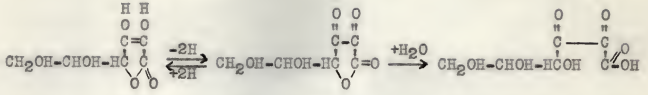
Broccoli is in season on the market starting in November, is at its peak of supply in December through April, and tapers off at the end of June (American Fruit Growers, Incorporated, n.d.). In western Oregon, broccoli planted under favorable conditions during late summer was harvested continually throughout the fall, winter, and early spring, Hansen (1945) reported. Wheeler, et al. (1939) observed that broccoli showed a higher ascorbic acid content in autumn than in summer, regardless of variety. Quality was found best by Knott and Hanna (1948) if the flower-bud clusters reached maturity in cool weather, although early growth might have taken place at high temperatures.

Properties of Ascorbic Acid

Ascorbic acid retention is often taken as the criterion of quality in vegetables. If it is retained, other attributes known as quality--desirable aroma, color, flavor, and texture--also are thought to be retained. Ascorbic acid, or vitamin C, Fenton (1940) found, was most easily destroyed of all the vitamins, and dissolved more readily than any vitamin or mineral. The

destruction was catalyzed by copper and the ascorbic acid oxidizing enzyme found in nearly all vegetables. She reported that crushing, grinding, and bruising of raw vegetables, which might occur in preparation, increased the activity of the enzyme. Although the enzyme was merely inactivated at low storage temperatures, it was actually destroyed in vegetable extracts by boiling for one minute, and apparently by boiling for slightly longer periods when in plant tissue. Most of the ascorbic acid destruction in peas, Swiss chard, carrots, and cabbage occurred during the first two minutes of cooking; that is, while the enzyme was still active. This author stressed the importance of destroying the enzyme as quickly as possible after the vegetable is put on to cook, by plunging it into boiling water and returning the water to the boil immediately. A sufficiently low pH decreases the activity of the enzyme; thus, acid extraction of vitamin C was recommended by Loeffler and Ponting (1942). Suder and Dodds (1952) found that oxidation of ascorbic acid was greatly accelerated when vegetable extracts were exposed to light.

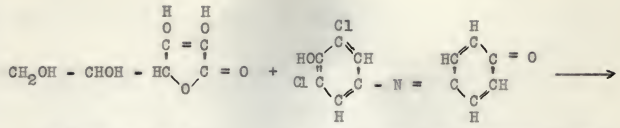
Fenton (1940) reported that ascorbic acid was present in the reduced form in growing plants but was readily oxidized to dehydro-ascorbic acid and then to products not biologically active. Rosenberg (1951) stated that ascorbic acid occurs predominantly in nature in the free, or reduced form. Both authors attributed the same biological activity to the reduced and dehydro-forms. The latter defined the product of oxidation not having biological activity as diketogulonic acid. The entire process is represented thus:



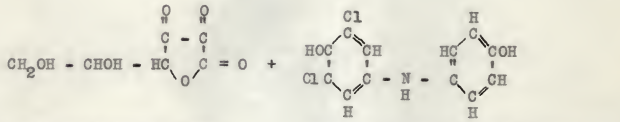
ascorbic acid (reduced form) dehydroascorbic acid (oxidized form) diketogulonic acid

Methods of Determining Ascorbic Acid Content

Early studies of the losses of ascorbic acid during cooking involved biological assays that were not as sensitive as chemical methods, McIntosh, et al. (1940) pointed out. Loeffler and Ponting (1942) devised a chemical means of determination equally adaptable to many kinds and varieties of fruits and vegetables that may be fresh, frozen, or dehydrated. It numbers among its advantages, non-interference due to pigment or moderate turbidities and negligible loss of ascorbic acid in preliminary blending of sample in acid. Extraction was by acid to inhibit enzyme action and autoxidation, and determination with 2,6-dichlorophenol indophenol. Eddy (1949) represented the reaction of ascorbic acid with indicator dye thus:



l-ascorbic acid 2,6-dichlorophenol indophenol dye



dehydroascorbic acid leuco-indophenol dye (colorless)

It was generally assumed that the quantity of dehydroascorbic acid present in fresh raw and cooked vegetables was so small that no serious error in the vitamin C values results if the assay was made by the indophenol method. Noble and Hanig (1948) compared the indophenol method, which measures the reduced form of ascorbic acid, with the phenylhydrazine method, which measures both the oxidized and reduced forms. They found that the average amount of dehydroascorbic acid present in raw and cooked samples and in the cooking waters of several vegetables was 10 percent or less of the total ascorbic acid present, a margin of error which they concluded was allowable.

However, Watt, et al. (1950) cautioned that foods which have undergone storage or processing have been found to contain significant quantities of the dehydro-form. Furthermore, recent developments in methods for determining ascorbic acid have shown

that some foods contain interfering substances which react chemically like the vitamin, but do not have the same physiological activity. These interfering substances were found most frequently in high carbohydrate foods that had been subjected to heat or unfavorable storage conditions. Barnes, et al. (1943) reported no dehydroascorbic acid in quick-frozen broccoli, either before or after cooking.

Ascorbic Acid Contents of Some Broccoli

Most values in the literature for ascorbic acid content have been expressed for the reduced form only. The values given in this review are reported in this form and are expressed in mg of ascorbic acid per 100 grams of vegetable.

Seasonal variation in ascorbic acid content was noted by several workers. Tucker (1948) reported that broccoli harvested in Rhode Island in two succeeding years contained more ascorbic acid in the raw sample in the fall than in early July of the same year--112 mg and 93 mg, and 104 mg and 88 mg, respectively. Evidence by Van Duyne, et al. (1945) showed an average of 120 mg for broccoli harvested in Illinois in September and tested raw. Hansen (1945) noted the ascorbic acid content of broccoli decreased from September (181.8 mg) to February (116.5 mg) and was greater again in April (159.8 mg). Concentration in broccoli tended to remain high irrespective of changes in the climatic or soil conditions during the growing period, September to April.

"Garden fresh" Italian Sprouting broccoli was reported by

Burrell and Ebright (1940) to contain 137.5 mg, while the market broccoli contained only 80.1 mg. Length of time and conditions of storage, methods of cooking and processing, variety, stage of development, climatic conditions, soils and fertilizers were several explanations offered for widely different quantities of ascorbic acid in the same kind of fruit or vegetable being reported by reliable investigators using the same method of determination.

The ascorbic acid content of broccoli cooked in institutional quantities varied widely. Storvick, et al. (1950) found 28.2 mg. Schauss (1945) recorded for the fresh vegetable: 85 mg in raw; 54 mg in freshly cooked, 60 percent of which was lost after 30 minutes on a steam table; for frozen broccoli, 44 mg in the blanched, 29 mg in the cooked, 45 percent of which was lost on the steam table. Fenton (1940) substantiated these observations when she reported that keeping cooked vegetables warm resulted in large ascorbic acid losses in most vegetables.

Watt, et al. (1950) reported 118 mg in the raw, 74 mg in the freshly cooked, and 75 mg in the frozen broccoli. This was slightly more than the 69 mg reported by Harris and Olliver (1942) for freshly cooked samples. In testing broccoli, Lampitt, et al. (1945a, 1945b) quoted 159 mg for the raw, and 84 mg for cooked Whitsuntide broccoli. McHenry and Graham (1935) and Roe (1936) gave results in close agreement for the ascorbic acid content of freshly cooked broccoli--68 and 68-71 mg, respectively. For freshly harvested broccoli, Wheeler, et al. (1939) reported

130 mg and Trefethen, et al. (1951) 97-109 mg; for market fresh, Harries (1952) 109 mg; for home-frozen, Causey and Fenton (1950) cited Ritchie's results of 21-55 mg; for commercially frozen, Fitzgerald and Fellers (1938) 100-149 mg, and Causey and Fenton (1950) 71 mg.

The portion of the vegetable that was tested appeared to affect the amount of ascorbic acid found for a particular vegetable. In work on broccoli Van Duyne, et al. (1945) observed slight differences in average ascorbic acid content of the buds (125 mg) and the stems (142 mg). The work of Wheeler, et al. (1939) revealed broccoli blossoms tested in July contained an average of 146 mg, the stems 107 mg. However, Barnes, et al. (1943) noted the opposite to be true in stalks of quick-frozen broccoli; the buds contained less (60 mg) ascorbic acid than the stems (107 mg). They also found that the vitamin C content of the frost in the packages varied from 18-30 mg, but the amount of frost in the package was small (10-30 mg) when compared with the weight of the vegetable. These workers also found the ascorbic acid content of different stalks of quick-frozen broccoli varied from 74-100 mg with an average of 88 mg. The upper three-fourths inch of the stalks contained as much as 40 mg more ascorbic acid than the lower three-fourths inch.

Methods of Retaining Ascorbic Acid

Methods for retaining ascorbic acid in the cooking process have been studied by several workers. Fenton (1940) suggested

the addition of salt to the cooking water, the salt probably retarding oxidation or solution, or both. Addition of sugar to a pure solution of ascorbic acid seemed to aid retention also.

The amount of cooking water has been demonstrated to exert a very definite influence on the amount of ascorbic acid retained. Fenton (1940) stated that the greatest loss during cooking of vegetables was due to solution. The extent of such dissolving depends on the amount of cut surface, the amount of cooking water, the length of time it takes for the water to return to the boiling point, the length of the cooking period, and the nature of the vegetable.

Oser, et al. (1943) varied the amount of water from the bare minimum to a large proportion to show the results obtained when no care is taken to preserve nutrients. Broccoli netted significant losses when cooked by the first method but tremendous losses by the second. From 95 mg in the raw vegetable, the ascorbic acid content was reduced to 66 mg when cooked in a small amount of water and to 43 mg in the large amount of water. McIntosh, et al. (1942) reported that frozen Brussels sprouts, cauliflower, lima beans, peas, and spinach lost increasing amounts of ascorbic acid to the cooking water as the volume of the water in which they were boiled was increased. This did not hold true for fresh snap beans and potatoes, according to Ireson and Eheart (1944); no significant difference in losses was noted with varying volumes of water. However, with cabbage the loss increased from 16 percent for 40 ml per 240 grams of vegetable to 46 percent for

1200 ml per 240 grams of vegetable.

Barnes, et al. (1943) reported that, when solidly frozen broccoli was boiled in a covered enamel pan in only sufficient water to keep it from burning, it retained 82 percent of its ascorbic acid. When boiled in five times as much water in an uncovered enamel pan, it retained 57 percent. When boiled in 10 times as much water in an uncovered enamel pan, it retained 53 percent. In general, they concluded that covering or uncovering the pan made no appreciable difference in the loss or solution of the vitamin.

The composition or type of cooking utensil seemed to have little effect on ascorbic acid retention, observed McIntosh, et al. (1942); they used covered and uncovered stew pans of aluminum, enamel, pyrex, and stainless steel. The amount of ascorbic acid leached from the vegetable varied with each vegetable but was quite constant for each, regardless of the composition of the cooking utensil. With few exceptions, the retention was essentially the same, whether boiled in covered or uncovered utensils.

Van Duyne, et al. (1951) found more ascorbic acid was retained when Italian Green Sprouting broccoli was cooked in a tightly covered saucepan than in a pressure saucepan, 91 mg and 88 mg, respectively. There were no significant differences between the percentage retentions obtained when the vegetable was cooked until "done" in a pressure saucepan and when it was overcooked. However, the cooking time was increased only from one

to one and one-half minutes, and additional cooking might have resulted in greater losses. Barnes, et al. (1943) reported that overcooking frozen broccoli for two minutes in a pressure saucepan at 15 pounds pressure caused increased losses of 5-8 percent. They further found quick-frozen broccoli boiled in pans of stainless steel, aluminum, and pyrex showed little difference in amount of ascorbic acid retained.

Broccoli prepared in a pressure saucepan received higher ratings than did similar portions prepared in a tightly covered saucepan, Van Duyne, et al. (1951) noted. This finding is in direct opposition to that of Brinkman, et al. (1942), who stated that broccoli was definitely inferior when cooked in an aluminum pressure saucepan compared with that prepared in enamelware open kettles and aluminum "waterless" cookers.

Broccoli cooked under four pressures, zero (atmospheric), five, ten, and fifteen pounds, was considered acceptable in a study by Trefethen, et al. (1951). Retentions of ascorbic acid under the four above pressures ranged from 74-83 percent and in the cooked vegetable plus cooking water from 86-94 percent. These findings were similar to those of Causey and Fenton (1950) under the same pressures; ascorbic acid retention in the cooked broccoli averaged 78 percent with 14 percent in the cooking water. Other reported retentions during the cooking of frozen broccoli ranged from as low as 50-59 percent in home-frozen, as determined by Ritchie (Causey and Fenton, 1950), to as high as 82 percent in commercially frozen broccoli, by Barnes, et al. (1943). In their

work on the effect of different cooking methods on the vitamin C content of quick-frozen broccoli, Barnes, et al. (1943) observed that solidly frozen broccoli cooked in a pressure saucepan retained 72 percent of its ascorbic acid, and the product was not uniformly cooked. Slightly defrosted broccoli retained 76-80 percent and was an acceptable product.

Freezing alone caused no loss in the vitamin C content of vegetables, Fenton (1940) and Fenton and Tressler (1938) maintained, but processes associated with freezing--blanching, cooking, packaging, sealing, and shipping--each caused some loss before commercially frozen vegetables appeared on the market. Unless frozen vegetables have been stored at very low temperatures, about -40° F., Fenton (1940) asserted that ascorbic acid was slowly lost. She also stated that normal or high ascorbic acid content is good evidence that a vegetable was not overmature at time of harvest, that it was properly handled during blanching and other operations preparatory to freezing, and that it was stored at a sufficiently low temperature, 0° F. or lower.

Preliminary blanching given quick-frozen broccoli appeared to stabilize the color, and the short time required for cooking was offered as explanation for conservation of color and nutrients in a study by McIntosh, et al. (1940). In most instances the color of properly cooked frozen vegetables--Brussels sprouts, cauliflower, lima beans, peas, and spinach--was better than that of the fresh.

In a study of the effect of variation in blanching on the

quality of fresh Early Sprouting broccoli, Fisher and Van Duyne (1952) reported that, although broccoli blanched in the pressure saucepan retained the largest amounts of ascorbic acid, the use of this method was not recommended because the palatability of these samples was significantly lower than the palatability of those blanched in hot water. Deterioration was chiefly in color and flavor. On the basis of ascorbic acid retention and palatability, blanching by immersion in boiling water and removal after three minutes proved the most satisfactory procedure.

Hartzler and Guerrant (1952) found a correlation between enzyme inactivation and ascorbic acid retention in their study on different hot water blanching times on DeCicco broccoli. A progressive increase in ascorbic acid stability seemed apparent during freezing and storage when the longest blanching time (four minutes at 400° F.) was used. They concluded that, though mere inactivation of ascorbic acid oxidase insured vitamin C retention, to prevent excessive loss, a blanch severe enough to cause rapid inactivation should be employed.

Studies on Cost of Broccoli

In a survey of purchases of frozen foods by urban families as related to home refrigeration facilities, Bitting (1954) reported that 38 percent of the people questioned bought frozen broccoli, irrespective of refrigeration facilities. Average per capita consumption of all United States civilians was listed at two packages or 20 ounces at 43 cents per pound.

Price and quality comparison of selected fresh and frozen vegetables in four Columbus, Ohio, stores during the first four months of 1948 was studied by Sherman, et al. (1949). Fresh broccoli averaged 25.8 cents per pound; frozen broccoli, 50.4 cents. The highest and lowest price quotations per pound during the 11-week period were, for fresh broccoli, 35.0 cents and 18.0 cents, respectively, and, for frozen broccoli, 56.0 cents and 43.2 cents, respectively. The average price of frozen broccoli expressed in percentage of average price of fresh broccoli was 195.3. Of the 12 samples of frozen broccoli studied by these workers, 11 were Grade A and one Grade B. The highest and lowest price per pound by grade was, for Grade A, 55.6 cents and 34.4 cents, respectively, and for the one available Grade B, 58.3 cents. The average price per pound by grade was, for Grade A, 47.1 cents, and for Grade B, 58.3 cents.

"Diced" broccoli described by Singleton (1952) had the advantage over whole spears and cuts, especially with monosodium glutamate added, in that flavor was uniform throughout. In whole spears and cuts, the head portions were well seasoned while the stalk pieces were not penetrated in the short cooking time required.

PROCEDURE

Purchasing and Preliminary Preparation

Fresh broccoli and commercially frozen broccoli spears and cuts were purchased from a local market on the morning of testing.

The marketing was done three times a week for a period of three weeks during December, and was then repeated during a second period in February. The quantity of each type of broccoli purchased was large enough to provide four 100-gram samples for duplicate palatability and ascorbic acid tests. Two bunches of fresh broccoli and two 10-ounce packages of each type of frozen broccoli were used.

As the fresh broccoli was received, the weight, per bunch as purchased, was recorded in grams. Note was also made of the cost per bunch and of any apparent or outstanding defects. The stalks were cut into six-inch lengths as measured from the head to the solid portion. The lower section was discarded since it was nearly always woody. Any large leaves or damaged portions were removed. The weight, in grams, of the edible portion of each bunch was then taken. The trimmed broccoli from the two bunches was combined and four 100-gram samples were selected at random. If a stalk needed to be divided in the weighing process, a lengthwise split was made so as to include proportional amounts of both flower and stem. These portions were then stored, unwashed, in individual Shellene bags at 40° F. until tested.

The frozen spears and cuts were removed from their containers while still hard frozen. The contents of each package were weighed and the weights recorded in grams. The price per package and condition of the vegetable were recorded. Two 100-gram portions of each product were removed from the package. These samples were placed in individual Shellene bags, with as much air

excluded as possible; then immediately returned to the freezer, before appreciable thawing occurred, where it remained until tested.

Palatability Tests

All cooking for the palatability tests was done on a gas range. The height of the flame was regulated by sight rather than by the indicator on the range, since the dial did not always give flames of equal intensity for the same heat. The aluminum saucepans were of one-pint capacity, with tight-fitting lids having valves for steam escape. Throughout the cooking of both the fresh and frozen broccoli, the pans were covered.

In preparation of the fresh broccoli for cooking, the six-inch stalks were removed from the bags, washed quickly under distilled water, and shaken lightly three times to remove surplus moisture. They were cut into three-inch lengths, so that the broccoli could be cooked standing upright in the saucepans. If the stem portion measured more than three-fourths inch in diameter, it was cut in half. A one-half-inch gash was made in the lower end of each stem piece.

Distilled water (200 ml) containing one gram of salt was quickly brought to a boil in a saucepan equipped with an aluminum foil rack, similar to that previously described by Harries (1952) (PLATE I). The flower portions were set upright in the rack and the stem portions placed on the bottom of the pan. The pan was covered and, as soon as the water returned to a full, rolling

EXPLANATION OF PLATE I

Market fresh broccoli in readiness for cooking in aluminum saucepan equipped with aluminum foil rack.

PLATE I

boil, the broccoli was cooked for 10 minutes.

The frozen broccoli spears and cuts were removed from the freezer just prior to immersion in the cooking liquid. Seventy ml of distilled water and one gram of salt were used. After the water had come to a boil over high heat, the spears, which had been cut in half, were set in the racks in the same manner as the fresh broccoli. For the cuts, no rack was necessary. The pieces were simply broken apart and placed in the boiling water. Both the spears and cuts were cooked two minutes in boiling water; the heat was reduced to low, and the remainder of the six-minute cooking periods finished in simmering water. At the completion of the cooking process, the broccoli was immediately removed from the cooking liquid by stainless steel forks, drained of excess liquid, and placed on numbered dishes (PLATE II) for the judges' scoring according to Form I (Appendix).

One 100-gram portion of each of the three types of broccoli was scored for palatability and acceptability by a panel of judges numbering from four to six. The scoring was done in the morning and again in the afternoon at approximately the same time each day. After both periods, the results were tabulated, analyzed statistically, and summarized.

Ascorbic Acid Determinations

Preparation of Samples and Solutions. The ascorbic acid content was determined by a modification of the Loeffler-Ponting method (1942). The cooking of the samples for the ascorbic acid

EXPLANATION OF PLATE II

Frozen broccoli spears (1), market fresh broccoli (2), and frozen broccoli cuts (3) placed in numbered dishes for judges' scoring.

PLATE II

determinations was the same as that for the palatability tests, except that the salt was omitted. Each 100-gram portion was cooked at a time when the entire process could be carried through without interruption; that is, each successive treatment-cooking, blending, filtering, and running of the determination--was done on each individual sample as soon as the preceding treatment was completed for that sample.

After cooking, each sample was drained of its cooking liquid, for two minutes, by retaining the solids in a strainer. The solids were then weighed and the reading recorded; the volume of the cooking liquid was taken in a graduate cylinder.

Solutions used in the analysis were at room temperature. The dye solution was prepared by weighing approximately 10 mg of sodium 2,6-dichlorobenzenone indophenol dye on a chainomatic analytical balance. The weight of the dye needed to be only approximate because it was standardized against a known amount of ascorbic acid. The dye was dissolved and filtered into a 500-ml volumetric flask by hot distilled water, and cooled to room temperature before being made up to volume. The dye was stored at refrigerator temperature.

The ascorbic acid solution was made by weighing out exactly 25 mg of ascorbic acid (Cebione-Merck) on an analytical balance and brushing it through a funnel into a 250-ml volumetric flask containing a small amount of freshly prepared one percent metaphosphoric acid solution. More metaphosphoric acid was added to wash down the funnel and to make the solution up to volume.

The one percent metaphosphoric acid solution was made from a 10 percent stock solution, prepared daily by dissolving 100 grams of metaphosphoric acid pellets in a 1000-ml volumetric flask with distilled water. This was stoppered until used for standardization and extractions.

Standardization of the Dye. The Klett-Summerson photoelectric colorimeter was used for standardizing the dye and for determining the ascorbic acid content of the broccoli. Three dilutions were made from the ascorbic acid solution--three, four, and five ml, respectively, were pipetted with a 10-ml graduated pipette into each of three 100-ml volumetric flasks, containing a small amount of freshly prepared one percent metaphosphoric acid solution. The dilution was quickly made up to volume with the one percent metaphosphoric acid solution and then thoroughly mixed by inverting 10 times. Thus, each dilution contained three, four, and five micrograms per ml, respectively.

The Klett colorimeter tubes had previously been wiped free of lint and dust and, with the exception of one tube, each had pipetted into it five ml of the dye solution which had been warmed to room temperature. The one tube had five ml of distilled water instead of dye. This tube was used to adjust the colorimeter to zero.

Into one of the tubes containing dye, five ml of the one percent metaphosphoric acid solution was quickly injected by means of a five-ml volumetric pipette. The tube was inverted three times and a reading taken in the colorimeter within 15

seconds after the beginning of the injection of the dye. This process was repeated with duplicate samples until two successive readings were the same. The 15-second periods were measured by an electric interval timer. The reading of the dye plus metaphosphoric acid was called the blank reading.

A similar procedure was followed with the three dilutions of the ascorbic acid solution, excepting that they were pipetted into the dye rather than into the metaphosphoric acid solution. The purpose of this was to establish the range in which the dye was most sensitive to the acid.

The ascorbic acid factor, which was used in calculating the ascorbic acid content of unknown solutions, was determined as follows:

$$\text{ascorbic acid factor} = \frac{\text{concentration of ascorbic acid}}{\text{blank reading - ascorbic acid reading}}$$

Extraction of Ascorbic Acid. In order that maximum ascorbic acid be extracted from the vegetable and that a homogeneous filtrate be obtained, each 100-gram sample was mixed in a Waring blendor, immediately after cooking and draining, with approximately 300 ml of one percent metaphosphoric acid solution, to protect the ascorbic acid present, and a few drops of butyl stearate to retard foaming. At the end of five minutes, the mixture was transferred quantitatively to a 1000-ml volumetric flask, made up to volume with acid, and inverted 10 times. It was filtered through fluted filter paper (No. 1 Whatman) into a 125-ml erlenmeyer flask for later use in determinations. The

cooking liquid was diluted to 200 ml with one percent metaphosphoric acid solution and filtered in the same manner.

Analysis of the Filtrate. Dilutions of the broccoli filtrate were made, so that the readings of the dye plus the dilution would fall within the range determined in the dye standardization process. During both periods of testing, the dilution of the filtrate varied from two to six ml per 50 ml. These dilutions were made up to volume in 50-ml volumetric flasks with one percent metaphosphoric acid solution and mixed thoroughly by inverting 10 times.

The methods of ascorbic acid analysis and standardization of the dye were similar. However, correction was required for the turbidity of the filtrate and its natural color. This was done by pipetting five ml of the dilution of the filtrate into a Klett tube containing five ml of distilled water, and calibrating the colorimeter to zero. Then five ml of the dilution were pipetted into five ml of the dye and a reading taken within 15 seconds so that successive readings coincided.

The dye was made ahead of time and stored in the refrigerator. Therefore, unless the dye had been standardized on the day of testing, a check was run by pipetting five ml of the one percent metaphosphoric acid into five ml of the dye and a reading taken. If this reading and the previous blank reading did not coincide, the dye was restandardized before use.

The unknown readings were those obtained with dye and the dilutions of the filtrate. The difference between the blank

reading and the unknown reading was called the corrected unknown. The ascorbic acid content, expressed in mg per 100-gram sample, was determined by the following formula:

$$\frac{\text{ascorbic acid factor} \times \text{corrected unknown} \times \text{dilution}}{\text{aliquot}} = \text{mg of ascorbic acid per 100-gram sample}$$

RESULTS AND DISCUSSION

Throughout the discussion, periods I and II refer to December and February, respectively. Treatments I, II, and III correspond to fresh broccoli, frozen spears, and frozen cuts, in that order. The analyses of variance of the data were computed according to the methods given by Snedecor (1946) and Anderson and Bancroft (1952).

Palatability

Averages of mean palatability scores are given in Table 1. Tables 4, 5, and 6 (Appendix) present the average palatability scores for each day of testing the three types of broccoli. Data for the analyses of variance of the palatability scores are given in Tables 7, 8, and 9 (Appendix). The score card, Form I, is reproduced in the Appendix.

Fresh Broccoli. In general, fresh broccoli purchased during December, period I, was of better quality than that of February, period II. The size and proportion of leaf to stem and flower was less in period I than in period II. The buds were not quite

so mature and the stems not so woody and large; the overall color and appearance were better. Fresh broccoli of period II was characterized by large leaves, woody stalks, wilted appearance, and grayed green color; more flowers had blossomed and few buds were tight. During the second period the bunches usually consisted of a few large stalks, rather than several smaller ones. The differences in quality were reflected in the judges' scores (Table 1) and in photographs taken of bunches purchased during each period (PLATE III). At no time was an entire bunch, as purchased, judged by the investigator to be of excellent or optimum quality.

Table 1. Averages of the mean palatability scores and percent of acceptability of market fresh broccoli and frozen broccoli spears and cuts during two periods. (Standard, 0.0)

Type of broccoli	Period	Aroma	Appearance	Flavor	Texture	Total	Percent of acceptability
Market fresh	I	-0.8	-0.7	-0.8	-0.3	-0.7	71.5
Frozen spears	I	-0.7	-0.2	-0.4	-0.6	-0.5	80.4
Frozen cuts	I	-0.3	-0.1	-0.1	-0.4	-0.2	88.3
Market fresh	II	-1.0	-1.6	-1.4	-0.7	-1.2	66.4
Frozen spears	II	-0.3	-0.3	-0.8	-0.6	-0.5	85.6
Frozen cuts	II	-0.2	+0.1	-0.5	-0.8	-0.4	89.5

The total weight of the bunches, as purchased, averaged nearly the same for both periods, but after trimming, a difference of four percent was noted in the weight of the edible portion, with the broccoli of period I retaining the larger amount

EXPLANATION OF PLATE III

Fig. 1. One bunch of market fresh broccoli typical of that purchased in period I.

Fig. 2. One bunch of market fresh broccoli typical of that purchased in period II.

Fig. 3. Frozen broccoli spears (left) and frozen broccoli cuts (right) typical of that purchased in periods I and II.

PLATE III

Fig. 1

Fig. 2

Fig. 3

(Table 15, Appendix). This was expected on the basis of the original quality of the vegetable.

For all four palatability factors--aroma, appearance, flavor, and texture--market fresh broccoli of period I scored higher than that of period II (Table 1). Average total palatability of period I was scored -0.7, indicating that a standard to a very slightly inferior product was available on the local market at that time. Two months later an average score of -1.2 pointed out that broccoli deteriorated in quality until it was considered very slightly to slightly inferior (Table 1). This difference was not great enough to be significant. At periods I and II, the vegetable was 71.5 and 66.4 percent acceptable, respectively, to the judges.

Texture of the fresh vegetable during both periods more nearly approached a standard product, -0.3 and -0.7, than did any other quality. A frequently recurring criticism of the judges was that the stalks were stringy, mushy, and/or slightly tough.

Aroma differed only slightly, -0.8 and -1.0, between the two periods and was seldom mentioned in the judges' comments; however, several notations were made that the aroma was slightly strong and not truly characteristic of the vegetable. Aroma was considered slightly inferior for the fresh broccoli during both periods.

Appearance and flavor were the most significant factors in the scoring of the judges, and were the points of greatest difference between the two periods. From a very slightly inferior

appearance and flavor in period I, -0.7 and -0.8, respectively, it deteriorated in quality to approach the slightly inferior mark in period II, -1.6 and -1.4, respectively. The physical characteristics of the raw broccoli, as purchased, were reflected in the product when tasted. A slightly yellow tinge in the color of the head was intensified by cooking. Variability in the samples was borne out by the judges' scores and presented a great deal of difficulty in analyzing the data. In order that a judge score an entire stalk of broccoli and report a true picture of the vegetable, he had previously been instructed to taste portions of the head and stalk. Because of the variability, one judge may have taken a young, tender portion of good quality, while another took a mature piece of poorer quality broccoli. It followed that the scores would probably differ.

Frequently the fresh broccoli was described as yellow and overmature in appearance with a strong, often bitter flavor. Because of the separate tasting of the stalk and flower portions, varying degrees of saltiness were observed in the different sections. The head portion was likely to taste saltier than the stalk, since the flowers were more easily penetrated during the shorter cooking. This may have had an influence on the judges' scoring.

Acceptability, in general, tended to follow the average total scores. Exceptions to this statement could be spotted. On three successive times of tasting during period I, the average total score was the same, -0.8, but the acceptability varied from 40 to

60 to 80 percent (Table 4, Appendix).

Frozen Broccoli. The quality of the two types of frozen broccoli was essentially consistent for both periods. For this reason photographs of only one package of each type are shown (PLATE III). On several occasions a comparatively large amount of ice crystals was found upon opening the package. This did not noticeably affect the quality but may explain the low reading obtained for ascorbic acid on the third day of period I (Table 10, Appendix). Since these occasions came in close succession, it is proposed that partial thawing may have occurred in transporting or storing the broccoli with the result that a layer of ice crystals formed on the bottom of the package. Packages purchased within a few days of each other, reflected the same conditions.

Spears. Slight difference was noted in the frozen broccoli spears during the two periods of testing. Both had an average total score of -0.5, or standard to very slightly inferior quality (Table 1). Texture scores coincided for the two periods, and appearance scores nearly so. For these factors the spears were judged standard to very slightly inferior. But for aroma and flavor, greater differences were noted. In period I aroma was scored -0.7, approaching very slightly inferior, but at the end of period II, the aroma was slightly less than standard, -0.3. The flavor deteriorated slightly during the two periods of tasting. None of these differences were great, however, and the seasonal variation as analyzed statistically was not significant.

This was true under the conditions of this study, but it is believed that a frozen product could be subject to seasonal variations at the time of processing and freezing, as well as a fresh one.

Criticism most often made by the judges concerned texture; objections were that it was stringy, watery, and/or mushy. Frequently the outer skin of the stalk portion was quite tough and resisted cutting, while the interior was mushy and watery. Varying degrees of saltiness were again detected. This observation seemed to emphasize Singleton's suggestion (1952) that "diced" broccoli may offer the solution to uneven distribution of the seasoning.

Acceptability during the periods varied by about five percent, 80.4 and 85.6 for periods I and II, respectively (Table 1). This was probably within the limits of error attributable to variability of sampling and judges, but it was evident that the frozen spears constituted a more acceptable product than the fresh broccoli.

Cuts. The frozen broccoli cuts proved to be the most palatable and acceptable of the three types studied. No significant difference was noted between the two periods; averages of -0.2 and -0.4 indicated that the cuts ranked slightly below standard. Slight variability was found among the palatability factors. Aroma and appearance ranged around standard or slightly below, while flavor and texture approached very slightly inferior.

Criticisms offered for the cuts were similar to those for

the spears. Mushy, stringy, or watery texture was frequently recorded. On several occasions both the investigator, upon opening the package, and the judges, when scoring, noted many more stalk pieces than head pieces in the sample.

The percent of acceptability closely coincided for both periods, 88.3 and 89.8. It can be concluded, then, that in this study frozen broccoli cuts were considered, by the tasting panel, superior to either frozen broccoli spears or market fresh broccoli.

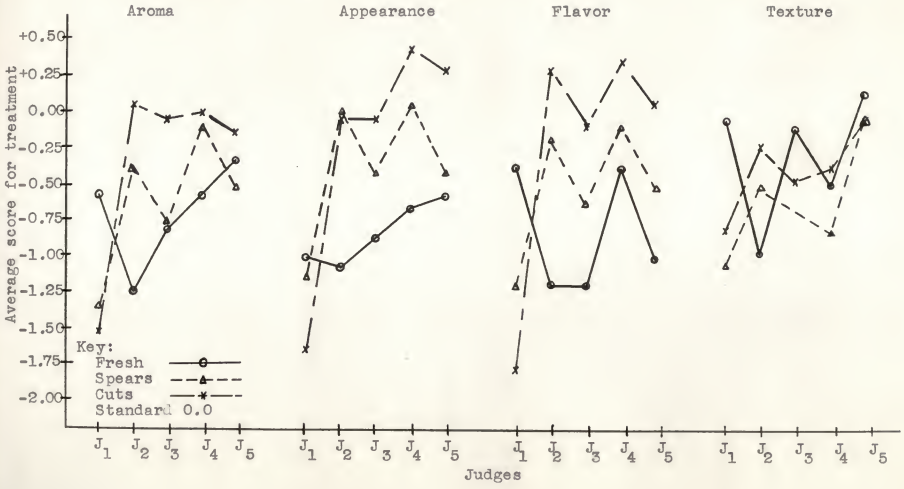
In Table 1 it will be noted that, with one exception, all averages fell below standard for that particular type. It is suggested that perhaps the judges were overly critical of the broccoli, since a similar score card used for various fruits and vegetables, fresh and frozen, had generally given scores of standard or higher.

Statistical Analyses. In general, the differences between the judges' scoring of the products from day to day were not significant, regardless of sample variation; that is, though the judges differed in the score they assigned to the various types, they maintained a consistent difference of opinion of the samples during the entire testing period. One judge during both periods quite consistently scored lower than the others. Each judge's score in relation to the others is shown on PLATES IV and V. While the differences among judges' scores were fairly consistent throughout the study, the scores did tend to converge as the judges became more experienced and more consistent; hence, the

EXPLANATION OF PLATE IV

Average scores of the three types of broccoli for period I.

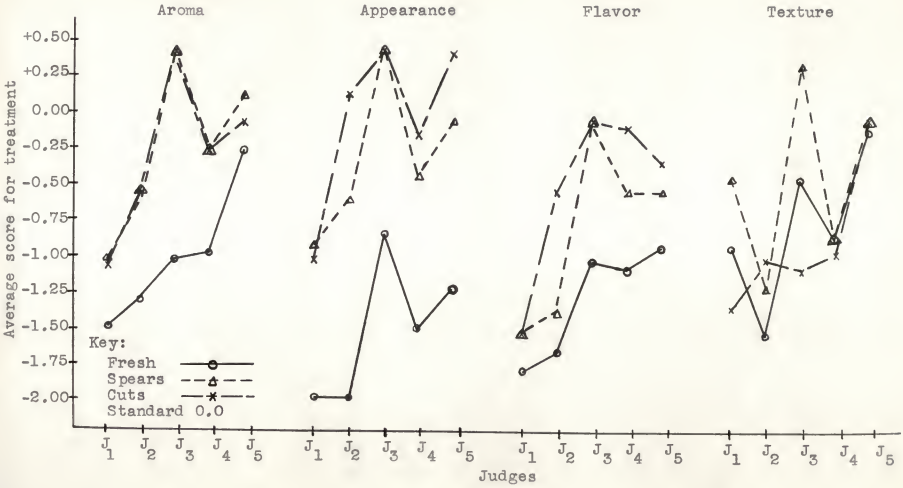
PLATE IV


Aroma
Appearance
Flavor
Texture
Average score for treatment
+0.50
+0.25
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
-2.00
Key:
Fresh
Spears
Cuts
Standard 0.0
J1 J2 J3 J4 J5
Judges

EXPLANATION OF PLATE V

Average scores of the three types of broccoli for period II.

PLATE V


Aroma
Appearance
Flavor
Texture
+0.50
+0.25
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
-2.00
Average score for treatment
Key:
Fresh
Spears
Cuts
Standard 0.0
J1 J2 J3 J4 J5
Judges

differences in scores of period II were slightly smaller than those of period I.

A significant day-to-day variation was found to exist in treatments I and II (market fresh and frozen spears, respectively) during period I. Differences were found in the aroma and appearance of the market fresh at the one percent level. No difference was distinguished in the cuts at either level.

In period II, no difference for any factor was found for the spears at either the one or five percent level (Table 8, Appendix). At the five percent level differences were found in the appearance and flavor of the cuts, and the appearance and texture of the fresh broccoli. On the basis of this work, the cuts were most consistent in quality while the fresh broccoli was quite variable.

In general, the difference between morning and afternoon testing of duplicate samples was not significant, indicating a fairly consistent product, successful repetition of the preparation and cooking processes, and consistent judging. A difference might have been expected, however, since generally it has been believed that judges' perception is more acute during morning hours. Any differences were confined chiefly to treatment I.

During both periods it was observed that the appearance of the fresh broccoli generally seemed to differ from morning to afternoon. This could be attributed, at least in part, to the variability within the samples rather than imagined differences by the judges, since the judges were shown to be quite consistent

in scoring.

When the judges' scores for the various treatments were graphed (PLATES IV and V), it was noticeable that, with the exception of the scores of judge 1 and a few isolated cases, the cuts were scored highest, followed rather closely by the spears. Fresh broccoli ranked comparatively far below the frozen broccoli. Judge 1 seemed to prefer the spears to the cuts, and, during period II, scores fresh broccoli considerably higher than either of the frozen types.

Ascorbic Acid Content

The average ascorbic acid content of the three types of broccoli during both periods for the solid and liquid portions is given in Table 2 as well as in Tables 10, 11, and 12 in the Appendix. Discussion will be confined, unless otherwise specified, to that of the solid portions, since that is the part consumed, hence, of greater importance. Little use seems to be made of the liquid in which broccoli is cooked.

Table 2. Average of mean ascorbic acid content with percentage retention of 18 samples of market fresh broccoli and frozen broccoli spears and cuts, during each of two periods.

Type of broccoli:	Period	Solids, mg/100 g	Liquids, mg/100 g	Percentage retention
Market fresh	I	90.39	15.48	85.34
Frozen spears	I	57.52	15.20	78.82
Frozen cuts	I	52.71	15.62	77.32
Market fresh	II	83.83	16.40	83.49
Frozen spears	II	64.37	16.14	79.97
Frozen cuts	II	47.12	14.39	76.46

Fresh Broccoli. The higher quality of the fresh broccoli purchased in period I was reflected in the ascorbic acid content. With an average of 90.39 mg and a range of 65.63-117.12 mg, it dropped about eight percent in period II to an average of 83.83 mg and a range of 62.73-101.48 mg. This difference was not great enough to be significant. The values for both periods were slightly higher than those reviewed in the literature for market broccoli freshly cooked.

Duplicate samples weighed from the same bunch contained widely varying amounts of ascorbic acid on several occasions. This may be partly explained by the variability between the bunches and within a single 100-gram sample. Difficulty was experienced in securing uniform samples, since a bunch often was comprised of several tender, young stalks of good quality, while other stalks were poor and overmature. In order to have a sample which represented the overall quality of the bunch, some of each would necessarily be included.

Generally the loss of ascorbic acid to the liquids did not correlate well with the vitamin content of the solids (Table 2). As often as not, a sample with a higher than average ascorbic acid content relinquished approximately the same amount of ascorbic acid to the cooking liquid, as an average or slightly below average sample. For both periods the percentage retention in the solids was maintained at about 84 percent of the total amount of the vegetable; there was comparatively slight variation from this figure, regardless of the original quantity of ascorbic acid

present. These findings were not in accordance with Fenton (1940), McIntosh, et al. (1942), and Oser, et al. (1943). No specific reasons could be given for this difference.

Spears. Slightly greater variation between periods was found in the ascorbic acid content of the frozen spears than in the fresh broccoli (Table 11, Appendix). In period I the spears averaged 57.52 mg (range, 34.45-83.71 mg) and rose in period II to an average of 64.73 mg (range, 53.72-77.45 mg). Obtaining a uniform distribution of the samples, as in the fresh broccoli, was difficult. These values were much less than those quoted by Fitzgerald and Fellers (1938) and slightly lower than those by Causey and Fenton (1950). This difference could be partially attributed to differences in commercial processes, variety, and seasonal variation.

In general, each sample of spears contained much less ascorbic acid than the fresh product, in spite of the fact that the quality of the spears was considered superior. Several reasons could be suggested for this. In commercial blanching ascorbic acid lost in the blanching water is lost to the vegetable, because this water is not packed with the vegetable. The total cooking time for the spears, including blanching time, may have equalled or even exceeded that used for the fresh vegetable. Storage time and temperature may have exerted some deleterious effect on the vitamin content. On the other hand, the frozen broccoli was probably harvested and processed at optimum maturity, whereas the fresh broccoli, with which it was compared, was most

often judged overmature.

On several occasions when a large amount of ice crystals had formed in the package, the ascorbic acid content was found lower for the samples of that day than the average of that period (Table 11, Appendix). It is proposed that this difference may be due to the increased water present in a 100-gram sample, which contributed more weight to the sample in proportion to the vegetable than usual. The results showed that the original amount of ascorbic acid present was less, and more was probably lost in the greater amount of water.

Ascorbic acid determination of the liquid portion of the spears showed that an average of 15.20 mg in period I, and 16.14 mg in period II was lost to the cooking water (Table 11, Appendix). It is noteworthy that the average loss of the spears and fresh broccoli was almost identical, although the original amounts in the solids were quite different. A shorter cooking time and smaller amount of cooking liquid have been said to aid in retaining a larger percentage of ascorbic acid, although present data indicate they did not. This is not in agreement with the results of workers mentioned earlier which stated that loss of the vitamin to the cooking liquid is proportional to the amount of water used.

The retention of ascorbic acid during both periods was about 79 percent, and less than that retained by the fresh, though a shorter cooking time and less cooking liquid were used.

Cuts. Of the three types of broccoli studied, the frozen cuts averaged the least ascorbic acid, 52.71 mg in period I, and 47.12 mg in period II. This was to be expected, since the ascorbic acid loss is believed to be related to the amount of surface area exposed. Again a wide range of values was obtained; in period I, 42.92-68.12 mg, period II, 25.91-62.84 mg. On the day in which the extremely low reading of 25.91 mg was taken, no reason could be given to account for it. Slight variation found between the two periods was not significant.

The amount of ascorbic acid lost in the cooking liquid varied considerably in both periods, but the overall averages corresponded closely with one another. In period I, an average of 15.62 mg was lost with a range of 9.86-20.99 mg; in period II, average, 14.39 mg; range, 8.95-17.64 mg.

Little difference was found between the percentage retentions of both periods; approximately 77 percent of ascorbic acid remained in the solids (Table 2). This was a greater loss by about two percent than that of the spears. With all other factors remaining constant, it could be said that, under the conditions of this study, the amount of surface area exposed exerted little effect upon the amount of ascorbic acid retained by the vegetable during cooking.

Statistical Analyses. A summary of the analyses of variance appears in Table 14, Appendix. The difference in the ascorbic acid content between the fresh broccoli and the two types of frozen broccoli was highly significant during both periods. In

period I, the difference between the spears and cuts was not significant, but was significant at the one percent level in the second period. Seasonal variation for the two periods was not significant for any of the three types.

Cost

The cost of the fresh broccoli and frozen broccoli spears and cuts appears in Table 3 as well as in Tables 15, 16, and 17, respectively, in the Appendix.

Fresh Broccoli. The average cost per pound of fresh broccoli, as purchased, for the two periods was approximately 17 cents with a range of about 13-24 cents. The average for period I was considerably higher, 19.9 cents, than for period II, 13.8 cents. These were less than the values found by Sherman, et al. (1949) in Ohio, and those reported by Harries (1952) in Kansas.

Table 3. Summary of average cost of market fresh broccoli, and frozen spears and cuts purchased during two periods.

Type of broccoli	Period	Cost per pound, in cents, A.P.*	Cost per pound, in cents, E.P.**
Market fresh	I	19.9	27.0
Frozen spears	I	32.0	49.5
Frozen cuts	I	24.3	36.4
Market fresh	II	13.8	19.5
Frozen spears	II	32.0	50.8
Frozen cuts	II	25.0	39.1

* A.P., as purchased

** E.P., edible portion

On the basis of the edible portion, the broccoli purchased in period I averaged 27 cents per pound and in period II, 20 cents, with a range of 13-32 cents.

Spears. Frozen broccoli cost considerably more per pound than fresh broccoli. The spears averaged about 50 cents for the first period and 51 cents for the second, with a comparatively narrow range of costs (Table 16, Appendix). These values were nearly identical with the 50.4 cents per pound for frozen broccoli recorded in the study by Sherman, et al. (1949). In the present study the cost of a 10-ounce package remained constant at 32 cents for the entire testing period. The slight variance in price when expressed in cost per pound was due to small differences in the weight of the contents on which the cost per pound was based.

Cuts. The cost per pound of cuts averaged approximately 14 cents less than the spears and was about 36 cents for both periods. The cost per 10-ounce package was constant at 25 cents during both periods with the exception of one day during period I, when it was on sale at 19 cents per package (Table 17, Appendix).

The cost of fresh broccoli was higher during period I when the quality was judged higher by the tasting panel. In period II a lower price was charged for poorer quality broccoli. The cost of the fresh vegetable could be expected to be lower in period I, since that is the peak of the season according to the American Fruit Growers, Incorporated (n.d.). However, the good quality of

broccoli in period I is suggested as the reason for the higher price charged by the local market at that time.

The cost of the frozen broccoli as well as its quality remained fairly constant over the two periods. There was a direct relationship between the cost and quality of the two types of frozen broccoli.

On the basis of the edible portion, frozen spears were about twice as expensive, per pound, as fresh broccoli, while the cuts were approximately 33 percent more costly (Table 3). These comparisons showed the cost considerably less than that given by Sherman, et al. (1949).

Under the conditions of this study, seasonal variation seems to be a minor consideration in the selection of broccoli, purchased on the local market, whether fresh or frozen. Though fresh broccoli remains a good source of ascorbic acid, the more palatable frozen spears and cuts might contribute more ascorbic acid to the diet, since their acceptability would likely result in greater consumption. However, the comparatively low price of the fresh vegetable is in its favor. As far as the consumer is concerned, the added palatability and convenience of frozen broccoli may not outweigh its 50-100 percent higher cost. If cost is unimportant, frozen broccoli cuts appear to be the most palatable and consistent type, though the difference in ascorbic acid content and price between this type and the spears tended to fluctuate. However, the choice of broccoli still remains a matter of consumer preference.

SUMMARY

The purpose of the present study was to determine: (1) the relative palatability, ascorbic acid content, and cost of market fresh broccoli and commercially frozen broccoli spears and cuts during two separate months of the year; and (2) the seasonal variation in the palatability, ascorbic acid content, and cost of the three types of the vegetable.

Duplicate tests were run on nine days in December (period I) and nine days in February (period II). On the day of purchase, the broccoli was scored by a taste panel and the ascorbic acid content determined by a modification of the Loeffler-Ponting method.

In general, the physical appearance of the fresh broccoli purchased in period I was slightly better than that of period II. After trimming, there was an average of four percent difference in weight of the edible portions, although the total weight of the broccoli, as purchased, averaged about the same. The slight difference in quality was semmingly not apparent enough to the judges to have much effect upon the scoring, though mention was made in the comments. Though the aroma, appearance, flavor, and texture of the broccoli of period I scored slightly higher than that of period II, the difference was not significant. During both months the broccoli was considered from a slightly below standard to a slightly inferior product.

The greatest differences between the two periods were in

appearance and flavor. Aroma and texture varied only slightly. In general, texture of fresh broccoli was comparable to that of the frozen vegetable. During period I the acceptability of fresh broccoli was 71.5 percent; period II, 66.4 percent.

Ascorbic acid content reflected the original quality of the vegetable. Broccoli of period I averaged 90.39 mg; of period II, 83.83 mg, but these differences were not significant. Loss of ascorbic acid to the cooking liquid did not agree well with the vitamin C content of the vegetable; during both months retention of ascorbic acid in the solids remained about 84 percent. During both periods the average cost per pound, 17 cents, as purchased, showed little variation.

In this study quality of the frozen broccoli was essentially consistent for both periods, though large amounts of ice crystals, which appeared to affect the ascorbic acid content, were noticed on several occasions.

Slight difference was noted in frozen broccoli spears during both periods. The spears rated standard to very slightly inferior in quality. Texture and appearance were consistent, while aroma and flavor displayed greater variability. The criticisms most frequently appearing referred to the stringy, watery, and/or mushy texture of the spears.

Acceptability of the spears was higher than for the fresh broccoli--80.4 percent in period I and 85.6 percent in period II. The frozen spears averaged about 40 percent less ascorbic acid than the fresh vegetable; period I, 57.52 mg, period II, 64.37 mg.

Commercial blanching may, in part, have caused this difference. Retention of ascorbic acid in the spears, averaging around 79 percent, was slightly less than for the fresh.

Frozen broccoli cost considerably more per pound than fresh broccoli. Spears varied only slightly, about 50 cents for both periods. Average cost per pound of cuts ranged around 36 cents for both periods, a cost lying about half way between that of fresh broccoli and frozen broccoli spears.

Frozen broccoli cuts in the present study proved to be the most palatable, acceptable, and consistent of the three types of broccoli. However, the total score averaged slightly below standard. Acceptability was 88.3 percent and 89.8 percent for periods I and II, respectively. At the same time the cuts averaged the least ascorbic acid for both periods, 52.71 mg and 47.12 mg. This observation is in accordance with the belief that ascorbic acid loss is related to the amount of surface area exposed.

The difference in the ascorbic acid content between the fresh broccoli and the two types of frozen broccoli was highly significant during both periods. The difference between the spears and cuts was significant during period II only. Seasonal variation during the two months was not found significant for any of the three types.

Under the conditions of this study seasonal variation seems to be a minor consideration in the selection of broccoli, purchased on the local market, whether fresh or frozen. Though fresh

broccoli remains a good source of ascorbic acid, the more palatable frozen spears and cuts might contribute more ascorbic acid to the diet, since their acceptability would likely result in greater consumption. However, the comparatively low cost of the fresh vegetable is in its favor. As far as the consumer is concerned, the added palatability and convenience of frozen broccoli may not outweigh its 50-100 percent higher cost. If cost is unimportant, frozen broccoli cuts appear to be the most palatable and consistent type, though the difference in ascorbic acid content and cost between this type and the spears tended to fluctuate. However, the choice of broccoli still remains a matter of consumer preference.

ACKNOWLEDGMENT

The author wishes to express her appreciation to Miss Gwendolyn L. Tinklin, Acting Head of the Department of Foods and Nutrition, for her guidance and aid in this study; to Mr. Henry Tucker, Assistant Professor of the Department of Mathematics, for his assistance in the statistical analysis of the data; to Dr. Dorothy L. Harrison, Professor of the Department of Foods and Nutrition, for her constructive criticism; and to the tasting panel of the Department of Foods and Nutrition for their evaluation of the palatability of the products.

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APPENDIX

SCORE CARD

MARKET FRESH BROCCOLI
AND COMMERCIALLY FROZEN
BROCCOLI SPEARS AND CUTS

Date_____

Name_____

			1	2	3	4	5	6
1. Aroma - fresh, mild but distinct odor	Use the following numbers as a guide for scoring:							
2. Appearance	Very superior	+5						
Color - medium to dark green buds, medium green stalks	Superior	+4						
	Moderately sup.	+3						
	Slightly sup.	+2						
	Very sl. sup.	+1						
Shape	Standard	0						
(a) Fresh broccoli and frozen broccoli spears- uniform pieces, no large leaves, stalks of medium thickness, buds compact and closed, moist, non-shriveled appearance.	Very sl.inferior	-1						
	Sl. inferior	-2						
	Moderately inf.	-3						
	Inferior	-4						
	Very inferior	-5						
(b) Broccoli cuts- cuts of uniform length, good proportions of stalk to flowers; moist, non-shriveled appearance.								
3. Flavor - true broccoli flavor, neither bitter nor salty, but well-developed								
4. Texture - tender yet firm, not mushy or stringy								
Would you consider this as an acceptable product to serve at a meal?								

Comments:

_____

Table 4. Average palatability and acceptability scores for market fresh broccoli for two periods. (Standard, 0.0)

Period	Day of period	No. of judges	Time of day	Average scores: Aroma	Appearance	Flavor	Texture	Total	% acceptability
I	1	5	AM	0	0	1	1	0.5	100
		5	PM	-1	-1	-1	-1	-1.0	80
	2	6	AM	-1	-1	-1	-1	-1.0	50
		5	PM	-1	-1	-1	0	-0.8	40
	3	5	AM	-1	-1	-1	0	-0.8	80
		5	PM	-1	-1	-1	0	-0.8	60
	4	5	AM	-1	-1	0	0	-0.5	80
		5	PM	-1	-1	-1	-1	-1.0	60
	5	6	AM	-1	-1	-2	0	-1.0	83
		5	PM	-1	-1	-2	0	-1.0	60
	6	5	AM	-1	-1	-1	0	-0.8	60
		5	PM	0	0	-1	0	-0.2	60
	7	4	AM	0	0	1	0	0.2	100
		4	PM	-1	1	-1	-1	-0.5	50
	8	6	AM	-1	0	-1	-1	-0.8	66
		4	PM	-1	-1	-1	0	-0.8	75
	9	6	AM	-1	-1	-1	-1	-1.0	83
		5	PM	-1	-1	0	0	-0.5	100
Average				-0.8	-0.7	-0.8	-0.3	-0.7	71.5
II	1	6	AM	-1	-2	0	0	-0.8	83
		5	PM	-1	-3	-2	0	-1.5	60
	2	6	AM	-1	-1	-1	-1	-1.0	83
		5	PM	-1	-1	-1	0	-0.8	100
	3	6	AM	-1	-1	-2	-1	-1.2	33
		4	PM	-2	-2	-2	-1	-1.8	50
	4	7	AM	-1	-3	-2	-1	-1.8	28
		6	PM	-2	-3	-3	-2	-2.5	16
	5	7	AM	-1	-1	-1	-1	-1.0	85
		4	PM	-1	-2	-2	-1	-1.5	75
	6	5	AM	-1	-1	-1	-1	-1.0	80
		4	PM	-1	0	-1	-1	-0.8	100
	7	5	AM	-1	-2	-1	0	-1.0	80
		4	PM	-2	-3	-2	-2	-2.2	50
	8	6	AM	0	1	0	1	0.5	83
		5	PM	-1	-1	-2	-1	-1.2	40
	9	6	AM	-1	-2	-2	-1	-1.5	50
		4	PM	0	-1	-1	0	-0.5	100
Average				-1.0	-1.6	-1.4	-0.7	-1.2	66.4
Grand average				-0.9	-1.2	-1.1	-0.5	-1.0	69.0

Table 5. Average palatability and acceptability scores for frozen broccoli spears for two periods. (Standard, 0.0)

Period	Day of period	No. of judges	Time of day	Average scores					
				Aroma	Appearance	Flavor	Texture	Total	% acceptability
	1	5	AM	0	0	1	1	0.5	100
		5	PM	-1	0	-1	-1	-0.8	100
	2	6	AM	0	0	0	-1	-0.2	83
		5	PM	0	1	0	0	0.2	100
	3	5	AM	-1	-1	0	-2	-1.0	80
		5	PM	-1	0	-1	-1	-0.8	60
	4	5	AM	-1	0	-1	-1	-0.8	80
		5	PM	0	-1	0	0	-0.2	60
I	5	6	AM	-1	0	-1	-1	-0.8	100
		5	PM	0	0	0	-1	-0.2	100
	6	5	AM	-1	0	-1	-1	-0.8	60
		5	PM	-2	-2	-2	0	-1.5	60
	7	4	AM	0	1	1	0	0.5	100
		4	PM	0	-1	0	-1	-0.5	75
	8	6	AM	-1	0	-1	-1	-0.8	66
		4	PM	-2	-1	-1	1	-0.8	100
	9	6	AM	0	0	0	-1	-0.2	83
		5	PM	-1	0	-1	-1	-0.8	40
Average				-0.7	-0.2	-0.4	-0.6	-0.5	80.4
	1	6	AM	0	0	0	-1	-0.2	66
		5	PM	0	0	-1	0	-0.2	80
	2	6	AM	0	0	0	-1	-0.2	100
		5	PM	0	0	0	-1	-0.2	100
	3	6	AM	0	0	-1	-1	-0.5	83
		4	PM	-1	0	-1	-1	-0.8	75
	4	7	AM	0	0	-1	-1	-0.5	71
		6	PM	0	0	-1	-1	-0.5	83
II	5	7	AM	0	-1	-1	0	-0.5	100
		4	PM	-1	-1	-1	-1	-1.0	75
	6	5	AM	-1	-1	0	0	-0.5	100
		4	PM	-1	-1	-1	0	-0.8	100
	7	5	AM	-1	-1	-1	0	-0.8	80
		4	PM	-1	-1	-1	-1	-1.0	100
	8	6	AM	-1	0	-1	0	-0.5	83
		5	PM	0	0	-1	0	-0.2	60
	9	6	AM	0	0	-1	0	-0.2	83
		4	PM	1	1	-1	-1	0.0	100
Average				-0.3	-0.3	-0.8	-0.6	-0.5	85.6
Grand average				-0.5	-0.2	-0.6	-0.6	-0.5	83.0

Table 6. Average palatability and acceptability scores for frozen broccoli cuts for two periods. (Standard, 0.0)

Period	Day of period	No. of judges	Time of day	Average scores: Aroma	Appearance	Flavor	Texture	Total	% acceptability
I	1	5	AM	0	0	-1	0	-0.2	80
		5	PM	0	0	0	-1	-0.2	80
	2	6	AM	0	0	0	-1	-0.2	83
		5	PM	0	0	1	0	0.2	80
	3	5	AM	0	-1	0	0	-0.2	80
		5	PM	-1	0	-1	0	-0.5	100
	4	5	AM	0	0	1	0	0.2	100
		5	PM	-1	-1	0	-1	-0.8	80
	5	6	AM	0	0	0	0	0.0	83
		5	PM	-1	0	0	0	-0.2	80
	6	5	AM	0	0	-1	-1	-0.5	80
		5	PM	0	0	-1	-1	-0.5	80
	7	4	AM	0	0	1	-1	0.0	100
		4	PM	0	1	1	0	0.5	100
	8	6	AM	-1	0	-1	0	-0.5	100
		4	PM	-1	0	0	0	-0.2	100
	9	6	AM	-1	0	0	-1	-0.5	83
		5	PM	1	-1	0	-1	-0.2	100
Average				-0.3	-0.1	-0.1	-0.4	-0.2	88.3
II	1	6	AM	0	1	-1	-1	-0.2	83
		5	PM	0	1	0	0	0.2	80
	2	6	AM	0	1	0	-1	0.0	100
		5	PM	0	0	0	-1	-0.2	100
	3	6	AM	-1	0	0	-1	-0.5	100
		4	PM	0	0	-1	-1	-0.5	75
	4	7	AM	-1	0	-1	-1	-0.8	85
		6	PM	0	0	-1	-1	-0.5	83
	5	7	AM	0	0	-2	-1	-0.8	85
		4	PM	0	-1	-1	-1	-0.8	100
	6	5	AM	0	0	0	-1	-0.2	100
		4	PM	0	0	1	0	0.2	100
	7	5	AM	0	0	-1	-1	-0.5	80
		4	PM	0	1	0	-1	0.0	100
	8	6	AM	0	-1	-1	-1	-0.8	83
		5	PM	-1	0	0	-1	-0.5	80
	9	6	AM	1	0	0	-1	0.0	83
		4	PM	-1	0	-1	-1	-0.8	100
Average				-0.2	0.1	-0.5	-0.8	-0.4	89.8
Grand average				-0.2	0.0	-0.3	-0.6	-0.3	89.0

Table 7. Analysis of variance of broccoli scores according to periods. (Source of variation--judges)

Period	Treatment		Aroma	Appearance	Flavor	Texture
I	I - Market fresh	D/F	4	4	4	4
		SS	8.93	2.62	15.05	15.17
		MS	2.23	0.66	3.76	3.79
		F	5.15	0.74	2.68	4.16
			**		*	**
	II - Frozen spears	D/F	4	4	4	4
		SS	13.23	18.55	16.49	9.89
		MS	3.31	4.64	4.12	2.47
		F	3.76	6.54	4.79	3.29
			*	**	**	*
	III - Frozen cuts	D/F	4	4	4	4
		SS	38.38	53.94	62.85	7.00
		MS	9.60	13.48	15.71	1.75
		F	24.62	17.28	6.77	1.06
			**	**	**	
II	I - Market fresh	D/F	4	4	4	4
		SS	18.29	20.62	13.49	24.06
		MS	4.57	5.16	3.37	6.02
		F	3.57	3.31	2.12	6.14
			*	*		**
	II - Frozen spears	D/F	4	4	4	4
		SS	26.18	24.04	27.84	28.07
		MS	6.54	6.01	6.96	7.02
		F	6.88	5.51	7.73	7.80
			**	**	**	**
	III - Frozen cuts	D/F	4	4	4	4
		SS	28.56	31.33	27.63	18.29
		MS	7.14	7.83	6.91	4.57
		F	9.15	15.14	6.06	8.46
			**	**	**	**

* Significant at the five percent level

** Significant at the one percent level

Table 8. Analysis of variance of broccoli scores according to periods. (Source of variation--days)

Period	Treatment		Aroma	Appearance	Flavor	Texture
I	I - Market fresh	D/F	8	8	8	8
		SS	11.96	19.29	15.36	8.22
		MS	1.49	2.41	1.92	1.03
		F	3.31 **	2.71 *	1.37	1.13
	II - Frozen spears	D/F	8	8	8	8
		SS	26.89	21.69	36.29	12.89
		MS	3.36	2.71	4.54	1.61
		F	3.82 **	3.82 **	5.28 **	2.15
	III - Frozen cuts	D/F	8	8	8	8
		SS	3.60	5.96	38.29	6.20
		MS	0.45	0.74	4.79	0.78
		F	1.15	0.95	2.06	0.47
II	I - Market fresh	D/F	8	8	8	8
		SS	10.20	71.80	16.09	18.22
		MS	1.28	8.98	2.01	2.28
		F	1.00	5.76 **	1.26	2.33 *
	II - Frozen spears	D/F	8	8	8	8
		SS	9.69	7.60	12.26	5.40
		MS	1.21	0.95	1.53	0.68
		F	1.27	0.87	1.70	0.76
	III - Frozen cuts	D/F	8	8	8	8
		SS	3.16	15.02	22.96	3.02
		MS	0.40	1.88	2.87	0.38
		F	0.51	2.76 *	2.52 *	0.70

* Significant at the five percent level

** Significant at the one percent level

Table 9. Analysis of variance of broccoli scores according to periods. (Source of variation--AM vs PM in days)

Period	Treatment	Aroma	Appearance	Flavor	Texture
I	I - Market fresh				
	D/F	9	9	9	9
	SS	14.90	6.90	17.40	16.40
	MS	1.66	0.77	1.93	1.82
	F	6.38 **	2.66 *	1.38	2.80 *
	II - Frozen spears				
	D/F	9	9	9	9
	SS	5.70	9.30	11.00	9.30
	MS	0.63	1.03	1.22	1.03
	F	1.15	5.15 **	1.18	1.27
	III - Frozen cuts				
	D/F	9	9	9	9
	SS	5.60	1.60	7.90	5.40
	MS	0.62	0.18	0.88	0.60
	F	0.67	0.53	1.69	1.50
II	I - Market fresh				
	D/F	9	9	9	9
	SS	14.30	19.80	28.40	27.60
	MS	1.59	2.20	3.16	3.07
	F	1.96	3.93 **	3.40 **	3.74 **
	II - Frozen spears				
	D/F	9	9	9	9
	SS	5.20	14.00	2.80	3.90
	MS	0.58	1.56	0.31	0.43
	F	1.32	4.33 **	0.30	1.48
	III - Frozen cuts				
	D/F	9	9	9	9
	SS	6.00	4.50	13.50	6.00
	MS	0.67	0.50	1.50	0.67
	F	1.42	2.27 *	1.81	1.37

* Significant at the five percent level

** Significant at the one percent level

Table 10. Average ascorbic acid content, with percentage retention, of duplicate cooked samples, and of cooking liquid, of market fresh broccoli during two periods.

Period	Day of period	Solids: Duplicate samples	Solids: Average	Liquids: Duplicate samples	Liquids: Average	Total	Retention in solids in percent
				mg/100 g			
I	1	99.38		13.00			
		65.63	82.50	7.50	10.25	92.75	88.95
	2	77.50		13.00			
		80.00	78.75	13.00	13.00	91.75	85.83
	3	82.73		14.84			
		76.65	79.69	14.11	14.48	94.17	84.62
	4	66.92		16.06			
		74.22	70.57	12.65	14.36	84.93	83.09
	5	81.52		13.63			
		75.43	78.48	13.63	13.63	92.11	85.20
	6	102.20		13.87			
		113.15	107.68	14.36	14.12	121.80	88.41
	7	109.44		22.27			
		117.12	113.28	19.20	20.74	134.02	84.52
	8	101.76		17.28			
		74.88	88.32	21.50	19.39	107.71	82.00
	9	113.28		16.51			
		115.20	114.24	22.27	19.39	133.63	85.49
Average			90.39		15.48	105.87	85.34
II	1	92.25		16.97			
		101.48	96.86	16.97	16.97	113.83	85.09
	2	90.40		17.71			
		75.64	83.02	15.13	16.42	99.44	83.49
	3	62.73		15.74			
		92.25	77.49	19.19	17.46	94.95	81.61
	4	71.96		15.87			
		92.25	82.10	16.24	16.06	98.16	83.64
	5	96.39		14.36			
		100.17	98.28	11.09	12.72	111.00	88.64
	6	96.39		16.38			
		77.49	86.94	16.25	16.32	103.26	84.20
	7	75.60		15.88			
		76.86	76.23	15.88	15.88	92.11	82.76
	8	90.72		20.03			
		79.38	85.05	18.52	19.28	104.33	81.52
	9	67.62		19.84			
		69.46	68.54	13.23	16.54	85.08	80.56
Average			83.83		16.40	100.24	83.49
Grand average			87.11		15.94	103.06	84.42

Table 11. Average ascorbic acid content, with percentage retention, of duplicate cooked samples, and of cooking liquid, of frozen broccoli spears during two periods.

Period	Day of period	Solids: Duplicate samples	Solids: Average	Liquids: Duplicate samples	Liquids: Average	Total	Retention in solids in percent
				mg/100 g			
I	1	70.65		15.25			
		63.17	66.91	14.25	14.75	81.66	81.94
	2	53.02		13.75			
		57.85	55.44	14.25	14.00	69.44	79.84
	3	34.45		11.19			
		40.56	37.50	13.38	12.28	49.78	75.33
	4	75.26		16.30			
		68.77	72.02	15.33	15.82	87.84	81.99
	5	41.72		12.65			
		65.79	53.76	16.54	14.60	68.36	78.64
	6	46.46		11.92			
		83.73	65.10	19.35	15.64	80.74	80.63
	7	54.86		12.54			
		45.82	50.34	16.64	14.59	64.93	77.53
	8	64.00		18.43			
		39.07	51.54	14.98	16.70	68.24	75.53
	9	60.48		18.43			
		69.69	65.08	18.43	18.43	83.51	77.93
Average			57.52		15.20	72.72	78.82
II	1	64.74		11.44			
		71.42	68.08	16.97	14.20	82.28	82.74
	2	62.84		14.27			
		58.79	60.82	15.74	15.00	75.82	80.22
	3	62.17		13.04			
		61.50	61.84	14.51	13.78	75.62	81.78
	4	69.52		19.93			
		69.10	69.31	19.56	19.74	89.05	77.83
	5	60.92		15.12			
		61.69	61.30	14.62	14.87	76.17	80.48
	6	58.89		17.77			
		61.67	60.28	15.88	16.82	77.10	78.18
	7	72.38		18.14			
		71.95	72.16	15.88	17.01	89.17	80.92
	8	56.63		17.77			
		53.72	55.18	11.34	14.56	69.74	79.12
	9	77.45		19.11			
		62.18	70.32	19.40	19.26	89.58	78.50
Average			64.36		16.14	80.50	79.97
Grand average			60.95		15.67	76.61	79.40

Table 12. Average ascorbic acid content, with percentage retention, of duplicate cooked samples, and of cooking liquid, of frozen broccoli cuts during two periods.

Period	Day of period	Solids: Duplicate samples	Solids: Average	Liquids: Duplicate samples	Liquids: Average	Total	Retention in solids in per-cent
		mg/100 g					
I	1	43.88		16.13			
		48.36	46.12	16.13	16.13	62.25	74.09
	2	65.00		8.81			
		46.73	55.86	11.06	9.94	65.80	84.89
	3	45.77		9.86			
		40.08	42.92	9.86	9.86	52.78	81.32
	4	60.18		18.62			
		51.96	56.07	20.08	19.35	75.42	74.34
	5	60.83		22.63			
		59.51	60.17	19.35	20.99	81.16	74.14
	6	74.77		8.47			
		61.47	68.12	17.52	13.00	81.12	83.97
	7	53.11		14.98			
		40.42	46.76	15.87	15.42	62.18	75.20
	8	57.19		16.13			
		44.54	50.86	17.66	16.90	67.76	76.53
	9	50.09		17.66			
		44.87	47.48	20.35	19.00	66.48	71.42
Average			52.71		15.62	68.33	77.32
II	1	51.03		16.60			
		42.02	46.52	13.53	15.06	61.58	75.54
	2	27.41		8.12			
		24.41	25.91	9.78	8.95	34.86	74.32
	3	49.75		15.25			
		42.98	46.36	17.71	16.48	62.84	73.77
	4	49.38		16.24			
		49.67	49.52	18.45	17.34	66.86	74.06
	5	48.26		10.84			
		39.79	44.02	12.85	11.84	55.86	78.80
	6	33.60		10.58			
		39.54	36.57	11.34	10.96	47.53	76.94
	7	63.34		16.38			
		62.35	62.84	18.90	17.64	80.48	78.08
	8	76.70		23.44			
		40.21	58.46	11.09	17.26	75.72	77.20
	9	56.86		14.41			
		50.98	53.92	13.52	13.96	67.88	79.43
Average			47.12		14.39	61.51	76.46
Grand average			49.92		15.00	64.92	76.89

Table 13. Average losses or gains in weight in solids and liquids after the cooking of 100-gram samples of market fresh broccoli in 200 ml of water, and of 100-gram samples of frozen broccoli spears and cuts in 70 ml of water.

Period	Day of period	Market fresh		Frozen spears		Frozen cuts	
		Weight in g	ml of water	Weight in g	ml of water	Weight in g	ml of water
I	1	107	38	92	44	94	43
	2	111	49	96	40	104	22
	3	108	55	98	41	104	25
	4	104	69	94	46	96	45
	5	108	107	85	59	94	41
	6	110	100	90	54	96	25
	7	108	101	89	53	94	47
	8	108	114	88	56	96	46
	9	113	105	90	49	92	51
Average		108.5	82.0	91.3	49.1	96.6	38.3
II	1	110	104	94	43	92	45
	2	106	109	92	44	93	40
	3	102	99	93	54	88	43
	4	110	100	90	45	95	43
	5	108	112	94	43	94	34
	6	108	99	94	57	92	36
	7	106	103	91	41	94	39
	8	108	114	92	41	93	37
	9	98	120	91	51	94	38
Average		106.2	106.6	92.3	46.5	92.8	39.4
Grand average		107.4	94.3	91.8	47.8	94.7	38.8

Table 14. Summary of the analysis of variance of the ascorbic acid content of market fresh broccoli and frozen broccoli spears and cuts for two periods.

Period	Portion	Fresh vs frozen	Treatment I vs Treatment II	Interaction
	Solid			
	D/F	1	1	16
I	SS	14932.00	208.00	4464.00
	MS	14932.00	208.00	279.00
	F	53.52 **	0.07	1.89
	Solid			
	D/F	1	1	16
II	SS	9469.00	2674.00	2969.00
	MS	9469.00	2674.00	185.60
	F	51.02 **	14.41 **	2.53 **
	Liquid			
	D/F	1	1	16
I	SS	0.0616	1.59	227.19
	MS	0.0616	1.59	14.20
	F	0.0043	0.11	2.41 **
	Liquid			
	D/F	1	1	16
II	SS	15.60	27.49	162.06
	MS	15.60	27.49	10.13
	F	1.54	2.71	1.57

* Significant at the five percent level

** Significant at the one percent level

Table 15. Number of bunches, total weights, and cost of market fresh broccoli purchased during two periods.

Period	Day of period	No. of bunches	Total wt. in g A.P.*	Total wt. in g E.P.**	% E.P.**	Total wt. in lbs. A.P.*	Total wt. in lbs. E.P.**	Cost per bunch in cents	Cost per lb. A.P.* in cents	Cost per lb. E.P.** in cents
I	1	2	1366	1246	91.22	3.01	2.75	29.0	19.3	21.1
	2	2	1565	1065	68.05	3.45	2.35	33.0	19.1	28.1
	3	2	1626	1167	71.77	3.58	2.57	33.0	18.4	25.7
	4	2	1731	1185	68.46	3.82	2.61	33.0	17.3	25.3
	5	2	1411	1035	73.35	3.11	2.28	33.0	21.2	28.9
	6	2	1244	940	75.56	2.74	2.07	33.0	24.1	31.9
	7	2	1528	1073	70.22	3.37	2.36	33.0	19.6	28.0
	8	2	1684	1249	74.17	3.71	2.75	33.0	17.8	24.0
	9	2	1346	998	74.09	2.97	2.20	33.0	22.2	30.0
Average		2	1500	1106	74.10	3.31	2.44	32.6	19.9	27.0
II	1	2	1678	1213	72.29	3.70	2.67	25.0	13.5	18.7
	2	2	1713	1020	59.54	3.78	2.25	25.0	13.2	22.2
	3	2	1292	993	76.86	2.85	2.19	25.0	17.5	22.8
	4	2	1157	851	73.55	2.55	1.88	25.0	19.6	26.6
	5	2	1698	1161	68.37	3.74	2.56	33.0	17.6	25.8
	6	2	1700	1215	71.47	3.75	2.68	19.0	10.1	14.2
	7	2	1300	1023	78.69	2.86	2.26	19.0	13.3	16.8
	8	2	1887	1266	67.09	4.16	2.79	19.0	9.1	13.6
	9	2	1712	1155	67.46	3.77	2.55	19.0	10.1	14.9
Average		2	1571	1100	70.59	3.46	2.43	23.2	13.8	19.5
Grand average		2	1536	1103	72.34	3.38	2.44	27.9	16.8	23.3

* As purchased

** Edible portion

Table 16. Number of 10-ounce packages, total weights, and cost of frozen broccoli spears purchased during two periods.

Period	Day of period	Number of packages	Total wt. in grams	Total wt. in pounds	Cost per package in cents	Cost per pound in cents
I	1	2	584	1.29	32.0	49.6
	2	2	538	1.19	32.0	53.8
	3	2	634	1.40	32.0	45.7
	4	2	583	1.28	32.0	50.0
	5	2	645	1.42	32.0	45.1
	6	2	568	1.25	32.0	51.2
	7	2	590	1.30	32.0	49.2
	8	2	586	1.29	32.0	49.6
	9	2	563	1.24	32.0	51.6
Average		2	588	1.30	32.0	49.5
II	1	2	594	1.31	32.0	48.8
	2	2	567	1.25	32.0	51.2
	3	2	573	1.26	32.0	50.8
	4	2	568	1.25	32.0	51.2
	5	2	569	1.25	32.0	51.2
	6	2	612	1.35	32.0	47.4
	7	2	572	1.26	32.0	50.8
	8	2	565	1.24	32.0	51.6
	9	2	540	1.19	32.0	53.8
Average		2	573	1.26	32.0	50.8
Grand average		2	581	1.28	32.0	50.1

Table 17. Number of 10-ounce packages, total weights, and cost of frozen broccoli cuts purchased during two periods.

Period	Day of period	Number of packages	Total wt. in grams	Total wt. in pounds	Cost per package in cents	Cost per pound in cents
I	1	2	578	1.27	25.0	39.4
	2	2	564	1.24	25.0	40.3
	3	2	617	1.36	19.0	27.9
	4	2	591	1.30	25.0	38.5
	5	2	584	1.29	25.0	38.8
	6	2	591	1.30	25.0	27.9
	7	2	637	1.40	25.0	35.7
	8	2	567	1.25	25.0	40.0
	9	2	577	1.27	25.0	39.4
Average		2	590	1.30	24.3	36.4
II	1	2	596	1.31	25.0	38.2
	2	2	604	1.33	25.0	37.6
	3	2	607	1.34	25.0	37.3
	4	2	595	1.31	25.0	38.2
	5	2	643	1.42	25.0	35.2
	6	2	592	1.30	25.0	27.9
	7	2	608	1.34	25.0	37.3
	8	2	606	1.34	25.0	37.3
	9	2	582	1.28	25.0	39.1
Average		2	604	1.33	25.0	36.5
Grand average		2	597	1.32	24.6	36.4

A COMPARISON OF THE PALATABILITY, ASCORBIC ACID CONTENT, AND COST OF MARKET FRESH BROCCOLI WITH COMMERCIALLY FROZEN BROCCOLI SPEARS AND CUTS

by

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1954

INTRODUCTION

Fresh broccoli and frozen broccoli spears and cuts are competing on the market for the homemaker's favor. Each possesses individual characteristics and advantages. Therefore, the homemaker should be interested in knowing of any difference in palatability, ascorbic acid content, relative cost, and seasonal variation among the three types.

PROCEDURE

Duplicate tests on market fresh broccoli and commercially frozen broccoli spears and cuts were run on nine days in December (period I) and repeated in February (period II). On the day of purchase, the broccoli was scored by a taste panel, unit costs recorded, and ascorbic acid content determined by a modification of the Loeffler-Ponting method. Results were tabulated, analyzed statistically, and summarized.

DISCUSSION OF RESULTS

In general, the physical appearance of the fresh broccoli purchased in period I was slightly better than that of period II. The slight difference in quality was seemingly not apparent enough to the judges to have much effect upon the scoring. Though the aroma, appearance, flavor, and texture of broccoli of period I scored slightly higher than that of period II, the difference was not significant. Texture of fresh broccoli was generally comparable to that of the frozen vegetable. During both months the

broccoli was considered from slightly below standard to slightly inferior. Acceptability in period I was 71.5 percent; in period II, 66.4 percent.

Ascorbic acid content reflected the original quality of the vegetable. Broccoli of period I averaged 90.39 mg, of period II, 83.83 mg; these differences were not significant. Ascorbic acid retention in the vegetable after cooking was about 84 percent. During both periods the average cost per pound, 17 cents, as purchased, showed little variation.

Quality of the frozen broccoli was essentially consistent for both periods. Spears rated standard to very slightly inferior in quality. Criticisms most frequently appearing referred to the stringy, watery, and/or mushy texture. Acceptability during period I averaged 80.4 percent; during period II, 85.6 percent. Frozen spears averaged 57.52 mg of ascorbic acid in period I and 64.37 mg in period II, an overall average of about 40 percent less ascorbic acid than was found in the fresh broccoli. Average vitamin retention in the spears was about 79 percent.

Frozen broccoli cost considerably more per pound than fresh broccoli. Spears varied only slightly, about 50 cents per pound for both periods. Cost per pound of cuts averaged about 36 cents for both periods.

Frozen broccoli cuts in the present study proved to be the most palatable, acceptable, and consistent of the three types of broccoli. However, the total score averaged slightly below standard. Acceptability was 88.3 percent and 89.8 percent for

periods I and II, respectively. At the same time the cuts averaged the least ascorbic acid for both periods, 52.71 mg and 47.12 mg for periods I and II, respectively.

The difference in the ascorbic acid content between the fresh broccoli and the two types of frozen broccoli during both periods was highly significant. Difference between the spears and cuts was significant during period II only. Seasonal variation during the two months was not significant for any of the three types.

Under the conditions of this study, seasonal variation seems to be a minor consideration in the selection of broccoli, purchased on the local market, whether fresh or frozen. Though fresh broccoli remains a good source of ascorbic acid, the more palatable frozen spears and cuts might contribute more ascorbic acid to the diet, since their acceptability would likely result in greater consumption. However, the comparatively low cost of the fresh vegetable is in its favor. As far as the consumer is concerned, the added palatability and convenience of frozen broccoli may not outweigh its 50-100 percent higher cost. If cost is unimportant, frozen broccoli cuts appear to be the most palatable and consistent type, though the difference in ascorbic acid content and cost between this type and the spears tended to fluctuate. However, the choice of broccoli still remains a matter of consumer preference.