

THE ASCORBIC ACID CONTENT
OF SELECTED VEGETABLES DURING STAGES
OF PREPARATION AND SERVICE AT A COLLEGE CAFETERIA

by

SISTER FRANCIS HUGH WALKER, O. S. U.

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INTRODUCTION

Within recent years the increase in mass feeding has been phenomenal. Institutional, commercial, and industrial concerns as well as our Army and Navy have been the users of large quantities of the nation's food supply. Numerous investigations are being made to ascertain the quality of food served by the various types of eating establishments. The challenge that must be met by these establishments to a greater or lesser extent is that of offering "short orders," of providing some choice of selection, and of giving satisfactory service involving quantity preparation.

Some of the culinary practices that prevail in large quantity cooking undoubtedly cause much destruction of certain nutritive values in food. Moreover, there is no reason to assume that the price the consumer pays for his food is an index of the nutritive value of his diet, whether he chooses his meals from expensive hotel dining rooms, coffee shops, cafeterias, or from the lowest class restaurants.

The effect of preliminary preparation and methods of cooking upon the nutritional value of foods has long been recognized. In order to encourage the use of the best methods in the preparation of foods for institutional service, it is necessary to know what standards should be set up. Since there is essentially a vast difference between the problems found in cooking in the home and in the commercial or industrial food unit, many investigations are needed on the nutritive values

of food as they are prepared for large quantity serving. Recently some studies on institutional service have been made. The results that have been reported have intensified the interest of those who are responsible for large group feeding.

The purpose of this thesis was to make a study on an investigation carried out on selected vegetables in the cafeteria at Kansas State College where it was felt that in most instances the practices commonly used in its kitchen preparation and counter service were very commendable. For example, the use of a staggered time schedule would be expected to be effective in conserving the nutritional values of foods. Cooking vegetables in small quantities made it possible to have freshly cooked ones ready for serving as soon as the limited supply previously taken to the counter had been depleted. Such a plan eliminated the necessity of keeping some of the cooked foods warm for an extended length of time on the stove or steam table or in a bain marie. Also, a great deal of the cooking was done in a pressure steamer, and the cooking periods of vegetables were not prolonged. Moreover, this cafeteria featured dishes using uncooked vegetables on the steam table. There were other details of procedure that appeared to contribute to the conservation of food values.

These were some of the reasons for choosing to make an investigation of the effects of certain preparations and serving techniques on the ascorbic acid content of selected vegetables at the college cafeteria.

That difficulties would be encountered in carrying out

this study were recognized from the beginning. A cafeteria kitchen does not readily lend itself to scientific laboratory experiments. Many variable factors have to be brought under control in order to draw conclusions from data collected. This is especially true in the case of ascorbic acid studies. However, in this work the student was so directed that she could discover for herself the numerous problems involved.

It is hoped that further value can be derived from this investigation by making many applications of the information gained to the problems of the food service in her own institution.

REVIEW OF LITERATURE

Determinations of the ascorbic acid content of the various foods known to be the best and most common sources of this vitamin have resulted in the accumulation of data that vary to a remarkable extent. Sherman (1946) stated that a table of single average figures would be unduly tentative and that in most cases a range of the values "within which it is reasonable to expect that the mean values when settled will be found" should have much more meaning.

There are many reasons to which the differences of the original ascorbic acid content of fresh raw foods have been attributed. Some of these are the horticultural selection of seed, variety, locality, climate, soil, fertilizer, season, exposure to rainfall and sunshine, stage of maturity, parts of the plant tested, conditions of harvest, handling,

storage, and methods of transportation. Many studies have increased our knowledge of the importance of these factors but further investigation is needed.

Tomatoes

Somers, Hamner, and Nelson (1945) in order to determine some of the factors that might affect the ascorbic acid content of tomatoes received at a cannery made a correlated study of the several factors operating in a specific location. They found that a certain uniform manner of processing tomatoes did not result in marked changes of ascorbic acid values. Therefore, the variation of the ascorbic acid content of canned tomatoes must have been due to two sources: differences in the ascorbic acid content of tomatoes in the field and losses subsequent to picking and processing. These investigators verified the findings of Hamner, Bernstein, and Maynard (1945) who reported that the greatest influence of environmental variables on the ascorbic acid content of tomatoes was that due to variations in light intensity two weeks previous to harvest. Probably fluctuations hitherto attributed to location or season at which tomatoes were produced were due to the differences in amount of sunshine.

Wide differences in ascorbic acid content of tomatoes have been found to occur within single varieties. Hallwork and Lewis (1944) found a range of 24 to 51 mg. per 100 grams in the same variety grown in the same plot.

Intervarietal differences would be expected to cause even

greater fluctuations. Currence (1940) showed that varietal differences in the ascorbic acid content of tomatoes were difficult to demonstrate statistically. Reynard and Kanapaux (1942) concluded from several reviews of literature that most commercial varieties of tomatoes ranged from about 15 to 40 mg. of ascorbic acid per 100 grams of fresh weight. However, caution should be used in recommending any one variety because of variations to be expected under the wide range of conditions where it might be grown. Of edible varieties tested by Reynard and Kanapaux, a small-fruited species gave an ascorbic acid range of 35.3 to 72.6 mg. per 100 grams. Thirty commercial varieties ranged from 11.2 to 21.6 mg. per 100 grams. Currence (1940) stated that emphasizing varietal differences to the grower might be misleading since the variety recommended as being of high vitamin C content might prove to be low under some conditions. Murphy (1942) pointed out that although variations within variety caused by geographical situation were comparatively large, this should not lessen the importance of varietal values. She stated that tomatoes may be rendered useless as a source of vitamin C if a variety of low ascorbic acid content is subjected to adverse environmental influences. Contrariwise, a high vitamin variety subjected to the same unfavorable conditions could still contribute materially to vitamin C requirements.

Brown and Moser (1941) found that an 18-day storage period of tomatoes either at laboratory temperature or in the refrigerator at 6.6° C. resulted in complete retention of their ascorbic acid. However, Somers et al. (1945) suggested

that holding tomatoes more than a day, if they were injured and in a poor condition, might affect their ascorbic acid retention considerably.

The rate of destruction of ascorbic acid during cooking varies greatly with different foods. Since this vitamin is not autoxidizable in an acid solution, and since tomatoes are not ordinarily subjected to much manipulation a great loss of ascorbic acid during cooking would not be expected. Much work has been done to determine the effect of cooking upon the ascorbic acid retention in some vegetables. Apparently few, if any studies, have been made on the effect of cooking raw tomatoes. This may be due to the fact that fresh tomatoes are usually served raw and that when cooked tomatoes are wanted, the canned ones are used. Such seems to be the case especially in institutions.

Daum, Aimone, and Hollister (1943) reported the results of a study on the ascorbic acid retentions in institutional food service at University Hospital, Iowa City. Approximately 1400 persons were served in three groups; therefore the vegetables were necessarily prepared in large quantities. The ascorbic acid retention in canned tomatoes cooked for a period of thirty minutes was 94.5 per cent. Holding the cooked, canned tomatoes fifteen minutes on the steam table did not lessen their ascorbic acid value. Cooking for thirty minutes and holding for one hour on the steam table gave an 83.4 per cent retention of the original ascorbic acid content of the canned tomatoes.

Somewhat different results were found by Hinman, Brush,

and Halliday (1944) who reported no effect on the retention of the original ascorbic acid value of canned tomatoes during a boiling period of thirty minutes and subsequent holding period of one and one-half hours on a steam table.

Gleim et al. (1946) reported that heating canned tomatoes by various methods required for quantity preparation caused no change in the retention of ascorbic acid when tomatoes were heated to serving temperature. Simmering for thirty minutes affected the retention slightly, and simmering for three hours decreased the retention to 75 per cent.

Cabbage

Numerous investigations have been made on the ascorbic acid value of cabbage. Murphy (1942) found that environmental agencies, e.g., sunlight and rainfall and perhaps temperature, had a marked influence on the ascorbic acid content of cabbage. Evidence also indicated that the ascorbic acid tended to decrease as the tissues became more fully matured.

Others have reported wide ranges of ascorbic acid content of cabbage due to varietal differences. Gould, Tressler, and King (1936) found a range of 26 to 56 mg. per 100 grams in six varieties and strains. They found that the same variety did not have the same ascorbic acid content at different seasons or in different years but that varieties high in ascorbic acid yield as compared with other varieties tended to remain so from year to year.

Van Duyne, Chase, and Simpson (1943) reported that the

storage of cabbage in tightly closed containers for two months at a temperature of -0.5° to 4.0° C. gave good ascorbic acid retentions. Losses did occur during the third month of storage and when the stored cabbage was held subsequently at room temperature, 19.4° C. for three days. Holding the cabbage for a week in the refrigerator at a temperature of 2.0° to 2.5° C. did not affect the retention. These findings seemed to correlate with the report of Mayfield and Richardson (1940) who observed that a six-months' storage at 7.2° C. and a relative humidity of about 55 per cent resulted in approximately 75 per cent retention of the ascorbic acid value of cabbage.

Pyke (1942) performed an experiment to show the comparative effects of various methods of shredding or mincing cabbage. He demonstrated that the less the injury to the tissue cells, the greater the ascorbic acid retention. The use of (1) a sharp knife which caused no noticeable bruising or discoloration in shredding, (2) a household shredder which caused more bruising than the above, and (3) a household grater which caused considerable bruising and even discoloration of the cabbage gave results in harmony with theoretical considerations. In (1) the ascorbic acid content was not lessened. A ninety per cent retention was found in (2) and (3) showed a 66 per cent retention. The greatest decrease in the ascorbic acid content in (2) and (3) occurred during the first five minutes after the cabbage was shredded. After the initial changes, the retentions did not vary significantly within a three-hour holding period.

Lampitt et al. (1942) being interested also in finding a

correlation between mechanical breakage of cells and the retention of ascorbic acid, resorted to the expedient of testing the liquid pressed out of shredded cabbage. They confirmed the results of Pyke that the retention varied with the extent of rupture of the cells and that the concentration of ascorbic acid fell rapidly during the first ten to 15 minutes. The ascorbic acid value remained constant for three-hour periods when cabbage was held at 15° C.

Van Duyne, Chase, and Simpson (1943) reported that the advance preparation of shredding cabbage and allowing it to stand for one hour in air gave an ascorbic acid retention of 97 ± 2 per cent. Allowing the shredded cabbage to stand in water for one hour resulted in the retention of 94 ± 1 per cent, and that held in water for three hours retained 96 ± 2 per cent.

McCay, Pijoan, and Taubken (1944) reported that the use of a plastic knife for cutting cabbage caused greater retention of ascorbic acid during holding periods of the cabbage than did the use of a steel knife or food chopper.

Quinn et al. (1946) reported that cabbage that had stood at room temperature for 20 minutes did not show a marked difference in ascorbic acid content whether the cabbage had been prepared by shredding or by cutting with a knife.

Wellington and Tressler (1938) having reviewed various reports concerning the ascorbic acid content of cooked cabbage found that great differences had been observed. They made a comparison of three methods of cooking--boiling, steaming, and pan-frying. They concluded that the amount of ascorbic

acid extracted by the cooking water in boiling and in steaming varied somewhat according to the more or less finely divided condition of the cabbage. About two-thirds of the original ascorbic acid was retained in panning, and since there was no excess liquid the cabbage itself retained the greatest amount of vitamin C when cooked by this method.

Having made an investigation on the cooking of cabbage by boiling, Gould, Tressler, and King (1936) pointed out that the length of time required to bring the water to a boil after the cabbage was added seemed to be of significance. They found that about 25 per cent of the ascorbic acid was destroyed before the cooking water began to boil and that very little was lost thereafter, although a considerable amount was dissolved in the cooking water.

Van Duyne, Chase, and Simpson (1943) reporting on the effect of various home practices on the ascorbic acid content of cabbage, stated that when cabbage was boiled for seven minutes in the proportions of one part by weight of cabbage to one-half, two, and four parts of water the percentage retentions were, respectively, 76 ± 2 , 60 ± 3 , and 51 ± 1 . They made a study on the effect of boiling cabbage in twice its weight of water for different lengths of time. The results showed percentage retentions of ascorbic acid as follows: after seven minutes, 55 ± 2 ; after 15 minutes, 52 ± 1 ; after 25 minutes, 52 ± 2 . Having compared the effects of cooking cabbage to the same degree of "doneness" by boiling (1) covered in twice its weight of water for seven minutes, (2) uncovered in twice its weight of water for eight and one-half

minutes, and (3) uncovered in four times its weight of water for five and one-half minutes, they found these percentage retentions of ascorbic acid: in (1), 56 ± 2 ; in (2), 50 ± 2 ; and (3), 49 ± 1 .

Ireson and Eheart (1944) reported that using a large amount of water, 1200 cc. to 240 grams of cabbage, resulted in a 54 per cent retention of ascorbic acid. About 37 per cent of the vitamin was extracted in the water and nearly nine per cent was oxidized. When a smaller amount of water was used, 40 cc. to 193.7 grams of cabbage, the 16 per cent loss of ascorbic acid was due to oxidation.

Noble and Waddell (1945) showed that cooking cabbage in a tightly covered pan with just enough water to cover, or in a steamer, or in a pressure saucepan, retained approximately the same proportion of its original ascorbic acid. Cabbage cooked in an open kettle with enough water to cover during all of the cooking period retained much less than that cooked in the steamer or pressure saucepan. In another study reported in 1946, these same workers found results comparable to those just mentioned. The retention of ascorbic acid in cabbage cooked in a steamer and in a pressure saucepan averaged slightly less than 70 per cent, whereas that of cabbage cooked by the tightly covered pan method retained about 60 per cent and that by the open kettle method retained about 35 per cent.

Higgins (1942) in a comparative study of institution and home-cooked vegetables found that cabbage cooked in large quantity was comparable in quality and ascorbic acid retention to that cooked according to ordinary home procedures.

Holding over steam for one hour affected the retention of ascorbic acid.

Daum, Aimone, and Hollister (1943) reported a study on large quantity cookery of cabbage. About 300 pounds of cabbage were usually cooked at one time, but excellent flavor and color were retained. The range of ascorbic acid in the raw cabbage in 12 determinations was found to be 21.0 to 26.0 mg. per 100 grams. After the cabbage was cooked the range was 12.0 to 19.0 mg. The percentage retentions of ascorbic acid in cabbage in cooking, in holding 15 minutes on the steam table, and one hour on the steam table were: 59.1, 54.6, and 45.5 per cent respectively.

Potatoes

Although extensive research has been carried out on potatoes, it is difficult to conclude to what extent they enrich the vitamin C content of our diet. The various factors which influence the ascorbic acid value of potatoes have been investigated by many scientists. In some cases the work is being continued.

Leichsenring (1944) made a compilation of data from the agricultural experiment stations of Illinois, Nebraska, North Dakota, and Minnesota. In reporting the studies made on variety, she stated that marked varietal differences in the ascorbic acid content of potatoes were found. The highest and lowest values attributed to variety showed a difference of 113 per cent. It was indicated that some varieties having

comparatively higher ascorbic acid values tended to have approximately the same values from year to year.

Dove, Murphy, and Akeloy (1943) also reported evidence showing that potatoes of higher ascorbic acid value could probably be counted on to yield similar values from year to year.

Ijdo (1937) found varietal differences up to 60 per cent in the ascorbic acid content of potatoes and not more than a ten per cent difference in tubers of the same variety.

Esselen et al. (1942) in a study on the effect of variety found that in many cases differences between varieties were less than differences within a single variety. They gave 13.1 mg. per 100 grams as an average yield of Irish Cobbler and 9.7 mg. per 100 grams as an average of Chippewa potatoes. These figures were based on the results of tests made on potatoes from several states.

Leichsenring (1944) said that although locality appeared to be a factor of some importance in the ascorbic acid content of potatoes, maturity and season seemed to be concomitant factors. Her data showed that the same varieties of potatoes harvested during October, 1943, in Nebraska and North Dakota had higher ascorbic acid values than those harvested in Minnesota during October, 1942. In these reports the Irish Cobbler variety was consistently the highest. Its ascorbic acid values were these: in North Dakota, 27.1 mg. per 100 grams; in two different places in Nebraska, 23.8 mg. and 33.2 mg.; and at three places in Minnesota, 12.6, 16.4, and 19.0 mg.

Esselen et al. (1942), having made a study on potatoes

immediately after they were dug at their own station in Massachusetts and on those shipped "soon after harvest" from California, Kentucky, Maine, and New York, did not attribute very great importance to the effect of different geographical areas.

According to Leichsenring (1944) the investigations carried out by the Nebraska station on five varieties of potatoes showed marked and continuous decrease during the growing period as well as after harvesting and during storage. An ascorbic acid content of 36.8 mg. per 100 grams of immature Irish Cobbler potatoes was found on June 30, 1943. Weekly analyses thereafter showed continuous decreases in ascorbic acid content. At the time of harvest on August 10, 1943, a value of 23.8 mg. per 100 grams was found.

Reports concerning the distribution of ascorbic acid in the potato tuber vary somewhat. Rolf (1940) found that the concentration of ascorbic acid was higher in the bud end than in the stem end. Immature potatoes of the Chipewa variety showed practically no difference in the distribution of ascorbic acid in the various sections of the tubers, although there was a slight tendency toward higher concentration in the bud end as they reached maturity. New Green Mountain potatoes bought on the market showed only a slight tendency to have a higher ascorbic acid content in the bud end than in the stem end when purchased. This difference became very apparent by the end of a week and increasingly more pronounced thereafter. The Leichsenring data (1944) seemed to indicate that the ascorbic acid content of potatoes was greater at the apical end

than at the stem end of the tuber.

Ijdo (1938) reported that there was a uniform distribution of ascorbic acid throughout the potato, but Julen (1944) found that the concentration of vitamin C was greater in the layer nearest the peel than in the core.

Esselen et al. (1942) found that in raw potatoes there was an even distribution of ascorbic acid in the tuber itself with a lesser amount in the skin. However, in boiled potatoes there was a greater amount of ascorbic acid in the area between the central and epidermal portions. The skin and part just beneath it were about equal in ascorbic acid content. In baked potatoes the greatest concentration of ascorbic acid was in the central portion with the amount decreasing progressively toward the skin. These workers concluded that something happened during cooking to change the distribution of ascorbic acid in potatoes. They suggested that this effect might be due to the higher temperature maintained in the outer portions because of direct contact with the heating medium. In the case of boiling some of the vitamin was leached into the water. Rolf (1940) reported that she found a similar distribution in cooked and uncooked potatoes; therefore there was but little diffusion of the vitamin during cooking.

According to Leichsenring (1944) the Minnesota station found that the size of the tuber was not a significant factor in the ascorbic acid content of potatoes. Esselen et al. (1942) also reported that there was no correlation between the size of tubers and their ascorbic acid content. They found marked

variations in both small and large mature raw potatoes.

Rolf (1940) pointed out that although a range of 1.5 mg. to 53.0 mg. of ascorbic acid per 100 grams of potatoes had been reported by various workers, their investigations showed that newly harvested potatoes were highest in ascorbic acid and that this quantity diminished very rapidly during the first part of storage and more gradually later. She stated that storage at 25.5° C. of immature Chippewa potatoes resulted in an 88 per cent retention of ascorbic acid after one week and 64 per cent after three weeks. New Green Mountain potatoes bought on the market showed a retention of 86 per cent in about ten days at 25.5° C. She found that the ascorbic acid value of three varieties of potatoes stored at 15.5° C. decreased rapidly during the first few weeks and then more gradually until at the end of 26 weeks, the ascorbic acid had nearly reached a plateau value. A storage temperature of 4.5° C. caused a greater decrease. The Green Mountain variety stored at 15.5° C. lost 50 per cent in five months. This worker stated, however, that evidence seemed to indicate that the detrimental effects of storage at low temperature upon the ascorbic acid content of potatoes might be offset to some extent by later storage at a higher temperature.

All the station reports summarized by Leichsenring (1944) indicated that during the storage of potatoes their ascorbic acid retentions were gradually and significantly decreased. A storage temperature of 10.0° C. seemed to be more favorable for ascorbic acid retention than 4.4° C. In Nebraska Triumph

potatoes harvested in August and stored at 10.0° C. showed ascorbic acid values of 16.5 mg. per 100 grams in December and 7.9 mg. in April. Those stored at 4.4° C. had an ascorbic acid value of 5.3 mg. in December and 5.2 mg. in April.

Other studies on the effect of temperature and length of storage correlate rather closely with the data given above. Esselen et al. (1942) observing the effect of storage reported that two varieties held five months at 2.2° C., approximately the temperature of cold storage, had a higher ascorbic acid value than the same varieties held at 4.4° to 10.0° C., similar to the temperature of dry underground storage; but four varieties had greater ascorbic acid value after being stored for five months at the higher temperature. Storage seemed to level off the differences between varieties in ascorbic acid content.

At the University of Wyoming Agriculture Experiment Station (1940-1941) it was found that the ascorbic acid retention in potatoes ranged from 43 to 60 per cent during the four-month storage period between December and May. The temperature of the storage was not given.

Julen (1944) of Sweden reported that potatoes stored indoors at 18.0° to 20.0° C. retained more vitamin C than those stored at 2.0° to 3.0° C.

Leichsenring (1944) noted that the differences in the ascorbic acid retentions of potatoes during cooking were attributable to such factors as amount of water used, size of potato pieces, length of cooking time, method of cooking, and manner

of sampling. The Illinois station reported the following percentage retentions of ascorbic acid in potatoes during cooking: after baking, 87; boiling in skins, 103; peeling and steaming, 86; peeling and boiling, 85; peeling, halving, and cooking in the pressure cooker, 85. Work at the Nebraska station showed that allowing cooked potatoes to stand for 15 minutes before analysis decreased the retention of ascorbic acid.

Rolf (1940) found that the boiling and steaming of unpared potatoes were the cooking methods least destructive of vitamin C. Baking and pressure cooking caused slightly decreased retentions while boiling pared potatoes affected the retention to a greater extent. The ascorbic acid retention in any of these methods was not less than 75 per cent.

Esselen et al. (1942) found that in eight varieties of potatoes there was a smaller average retention of ascorbic acid in baking than in boiling the whole potatoes in the skin. These workers made the observation that the addition of one per cent NaCl to the cooking water of potatoes seemed to aid in the retention of ascorbic acid. They reported that boiling in the skin, baking and French frying appeared to be the best methods of cooking potatoes from the standpoint of ascorbic acid retention. The percentage retentions after cooking by various methods ranged from 20 to 67. The procedures of peeling, cutting in half, and slicing of raw potatoes, and the mashing of potatoes, in the order named, caused increasing losses of ascorbic acid. Potatoes boiled and then fried retained 21 per cent of their original ascorbic acid value.

At the University of Wyoming Agricultural Experiment

Station it was reported that one-third of the ascorbic acid of potatoes was extracted by the water in which they were boiled.

Richardson and Mayfield (1943) found that boiling unpared potatoes caused no significant effect on their ascorbic acid retention. Cut, pared potatoes retained approximately 81 per cent after boiling. They reported that cooking pared potatoes in a pressure saucepan under steam pressure of 15 pounds gave better retention of ascorbic acid than did boiling in an ordinary kettle.

Recently there have been studies on the ascorbic acid content of potatoes as affected by institutional methods of preparation and service.

Higgins (1942) found that the retention of ascorbic acid of potatoes cooked by institutional methods was significantly less than of those cooked by home methods.

Kahn and Halliday (1944) reported a study on the vitamin values in foods prepared in institutional quantities. Steaming in the skin was the only method of preparation which did not affect the retention of ascorbic acid in potatoes. New potatoes, steamed in the skin, can take the place of a citrus fruit as a source of ascorbic acid. French-fried potatoes showed good retentions of ascorbic acid when the temperature of the frying fat was kept constant. Baked potatoes retained 80 per cent of their ascorbic acid during baking. The retention was decreased to 50 per cent after a 45-minute holding period on the steam table. A 61 per cent retention of the

ascorbic acid value was found as the result of cooking and mashing potatoes. The average retention of the mashed potatoes after being held for 75 minutes was five per cent of the original value.

Daum, Aimone, and Hollister (1943) reported that both new and old potatoes showed slightly decreased values of ascorbic acid after cooking. A 15-minute holding period affected the retention and holding one hour greatly decreased the retention.

Streightoff et al. (1946) undertook a study to determine the effect on the ascorbic acid content of potatoes of large-scale methods of preparation such as those practiced in the army consolidated mess and company mess. They reported evidence to show that holding peeled raw potatoes covered with water in a refrigerator overnight, or as long as 22 hours, or in running water for four hours, did not greatly affect the retention of ascorbic acid. This is a point of significance because holding potatoes in water is a practice frequently resorted to, especially in institutions. Richardson and Mayfield (1943) found that the presoaking of pared potatoes in water for four hours decreased the subsequent retention of ascorbic acid in boiling or pressure cooking by about four per cent. Soaking for four hours in 2.5 per cent salt solution before cooking resulted in better retention of vitamin C than occurred when potatoes were cooked at once after preparation.

Streightoff et al. (1946) found that cooking potatoes in the pressure steamer was most conservative of the ascorbic

acid value. The retention in this case was about 94 per cent. Baking in the jackets a minimum length of time and boiling gave percentage retentions of 88 and 87. When steamed potatoes were mashed, there was very little retention of ascorbic acid.

Jenkins (1943) reported that cooked whole potatoes held at room temperature retained more ascorbic acid than mashed potatoes. Whether the potatoes were kept hot in small portions or large quantities did not seem to affect the retention. Keeping mashed potatoes warm for one hour gave a 25 per cent retention of ascorbic acid. The length of time consumed in the mashing of potatoes was a factor in ascorbic acid retention.

Spinach

Cutlar et al. (1944) in making a review of literature reported various ascorbic acid values for spinach. The amounts ranged from 19.8 to 123.9 mg. per 100 grams. Tressler, Mack, and King (1936) found that variety was an important factor in the ascorbic acid content of spinach. Broad Flanders yielded an ascorbic acid value of 89.0 mg. per 100 grams and Princess Juliana had the lowest value, 38.0 mg. per 100 grams. They also reported that soil and growing conditions exerted a definite influence on the ascorbic acid content of spinach. Twelve varieties of spinach grown on upland clay loam soil averaged 50 per cent higher than those grown on muck soil. Spinach grown in the autumn had higher ascorbic acid values than that grown in the spring. Isgur and Fellers (1938) in

a study on the effect of fertilizer on New Zealand spinach found that high nitrogen treatments did not increase the ascorbic acid value.

Slepykh (1940) reported that the ascorbic acid of the spinach leaf reached its maximum content during the middle stage of development and decreased with the maturity of the plant. Sheets et al. (1941) found that the ascorbic acid value of spinach was more concentrated in the leaf blades than in the petioles. Tressler, Mack, and King (1936) gave data to show that the ascorbic acid in spinach is principally in the leaves and that the stems are almost devoid of this vitamin.

Tressler, Mack, and King (1936) reported that spinach stored for three days at 1.0° to 3.0° C. retained nearly all its vitamin C, but that held at room temperature lost approximately one-half its ascorbic acid value in three days and almost all in seven days. Wheeler and Tressler (1939) found that freshly harvested New Zealand spinach had an ascorbic acid content of 44.0 mg. per 100 grams. After storage at room temperature for four days the value decreased to 21 mg. and storage of the fresh spinach for two weeks at 1.0° to 3.0° C. decreased the value to 16.0 mg. per 100 grams. Ranganathan (1936) tested the effect of storage at room temperature on samples of fresh spinach collected during dry weather and of spinach collected during wet weather. The initial ascorbic acid contents were 36.9 and 55.3 mg. per 100 grams, respectively. After 24 hours the percentage retention of ascorbic acid in the dry weather spinach was 70.0 and after 192 hours, 21.7. The wet weather spinach showed retentions

of 87.1 and 59.3 per cent, respectively, for the two storage periods.

Procter and Greenlie (1938) reported that even for short-time storage of spinach, temperatures below 4.4° C. tended to conserve vitamin C which deteriorated rapidly at ordinary room temperatures. Zeppelin and Elvehjem (1944) tested spinach soon after harvesting that had a high original ascorbic acid content of 79 to 90 mg. per 100 grams. The retention decreased rapidly during storage at room temperature for 24 to 48 hours but was more stable thereafter. Refrigerator storage offered some protection and after 72 hours the retention was slightly more than 50 per cent. When spinach was exposed to room temperature again, the oxidation proceeded at a high rate.

Platenius and Jones (1944) said that spinach held in an atmosphere of low oxygen content retained more than three times as much ascorbic acid as the lots in normal air. The presence of 18 per cent CO₂ at a temperature of 68.0° F. accelerated the destruction of ascorbic acid but 5.3 per cent CO₂ at 50.0° F. slightly retarded the loss of ascorbic acid.

Halliday and Noble (1936) having made a comparison of the ascorbic acid retention during cooking of a number of vegetables, found that spinach retained the least amount, 24 per cent, during boiling for eight to nine minutes in a large amount of water, i.e., 2½ C. to 570 grams of spinach. Of the 76 per cent loss, 47 per cent was totally destroyed and 29 per cent was dissolved in the cooking water. When cooked in only the water clinging to the leaves, approximately 36 per cent

was retained. Of the amount lost about 45 per cent was destroyed and 19 per cent was dissolved in the cooking water. Dunker and Fellers (1938) made a study on the effect of the amount of water used in cooking spinach. The retention of ascorbic acid in spinach decreased as the volume of cooking water increased. The solid portion retained a range of 32 to 67 per cent depending on the amount of water used. One pound of spinach steamed with 100 cc. of water retained about 68 per cent. One pound of spinach cooked with 450 cc. of water retained about 33 per cent. Ten to 15 per cent of the ascorbic acid was leached out into the liquid during steaming and during cooking with the larger amount of water.

Phillips, Dickerson, and Fenton (date of the report was not given) found that cooking 600 grams of spinach with no more water than that which clung to the leaves gave an ascorbic acid retention of 60 per cent. The cooking time required was 12 minutes. Cooking the same amount of spinach in 250 grams of water and in 625 grams of water for six minutes gave retentions of 55 and 41 per cent respectively. They found that cooking 600 grams of spinach in 625 grams of water at an initial temperature of 98.5° C. gave a 41 per cent retention of ascorbic acid. The same amount of spinach in the same amount of water at an initial temperature of 20.0° C. gave a 34 per cent retention. The cooking times required were six minutes when the initial temperature was higher and 15 minutes when it was lower.

Cutlar et al. (1944) reported that in quantity cooking

the retention of the ascorbic acid of spinach was decreased by ten percent when the amount of water was increased four times above the amount required to cover the spinach as it began to cook in steam-jacketed kettles. Spinach, in 15-pound lots, boiled in steam-jacketed kettles with eight quarts of water retained 50 per cent of the original ascorbic acid but only 40 per cent when four times as much water was used. The same amounts of spinach cooked in a container on top of the range with eight quarts and two quarts of water retained, respectively, 32 and 33 per cent of the ascorbic acid. These workers observed that when the smaller amount of water was used, more time was required for the spinach to reach a stage of "doneness" than that cooked in the larger amount of water. The length of time required for the water to reach the boiling point after the epinaeh was added depended on the amount of water and the concentration of heat on the bottom and sides of the cooking utencil. Increasing the quantities of spinach cooked at one time decreased the aecorbic acid content. Spinach in five-pound lots cooked in the pressure steamer, steam-jacketed kettle, and in a stockpot on the range had decreasing amounts of ascorbic acid according to the order of equipment named. The retentions for the pressure steamer were 78 per cent; for the steam-jacketed kettle, 67 per cent; and for the stockpot on the range, 53 per cent. Spinach in 15-pound lots cooked in a 25-gallon steam-jacketed kettle gave a retention of 50 per cent. The same amount cooked in the same amount of water in a 16-gallon stockpot on the range gave a retention of

32 per cent.

Cutlar et al. (1944) also found that drained cooked spinach held at 150° F. in a heated food service unit retained 85 per cent of its ascorbic acid after 15 minutes, 61 per cent after 30 minutes, and 26 per cent after 120 minutes.

SAMPLING PROCEDURE

Since the purpose of this study was to make comparative determinations of the ascorbic acid content of selected vegetables during stages of preparation and service, it was found advisable to take samples as representative as possible from the lots of vegetables as they were ordinarily prepared by the regular workers of the cafeteria. Thus no effort was made to determine the highest possible original content in any case. Samples were also tested to determine the effects of 15-minute holding periods on the steam table because during ordinary serving periods 15 minutes was the longest time any food was held on the steam table before it was served and the dish replenished by a new supply from the kitchen. At the cafeteria all the samples of the vegetables to be tested were collected into previously prepared bottles of metaphosphoric acid, taken to the laboratory, and there analyzed at once for their ascorbic acid content.

In order to become familiar with kitchen procedures and details of the problems involved in this study, small numbers of samples were taken over a period of several days, first of tomatoes and then of cabbage. Later a larger group of samples

of each of the vegetables were taken for more extensive study.

Tomatoes

At the cafeteria work was usually started on tomatoes about 10:30 a.m. when they were taken from the refrigerator, weighed, washed, cored and quartered. Then they were sent to the kitchen.

For sampling, tomatoes were selected that were free from blemish and of uniform ripeness as indicated by color and firmness. For the analyses of raw tomatoes each of four washed, cored tomatoes was cut into quarters. One quarter of each of the tomatoes was put into each of four bottles of acid. For analyses of cooked tomatoes, a whole raw tomato, washed and cored, was weighed and put into each of six individual baking dishes. The small porcelain dishes were used in order to keep the weighed tomatoes separate. These dishes of tomatoes were placed in a shallow stainless steel pan, covered with a damp cloth and held at kitchen temperature until the tomatoes to be served on the steam table were cooked. Then three of the dishes were placed in the steamer or oven at the same time and for the same length of time as were the tomatoes to be served first. The remaining three dishes were held for a longer period at kitchen temperature and then cooked as above. After the samples were cooked, they were transferred into bottles of acid. Approximately 50 samples of tomatoes were thus studied over a period of five days.

For a larger number of samples, four tomatoes were cut

into fifths. One-fifth was placed into each of five bottles of acid which had been previously weighed. Another four tomatoes were cut into fifths and put into each of five baking dishes and the procedure was repeated using bottles or baking dishes until the following samples were collected: ten for testing tomatoes raw, ten for testing tomatoes after they had been steamed for five minutes, and ten for testing tomatoes steamed five minutes and held on the steam table for 15 minutes.

Cabbage

Over a period of five days 39 samples of cabbage were analyzed for their ascorbic acid content. The preliminary work on the cabbage was usually begun about 10:00 a.m. in a basement room of the cafeteria and continued until the cabbage was ready for cooking. Approximately 15 pounds of cabbage were cleaned, washed, quartered, cored and sent to the kitchen where the cabbage was shredded on an electric Hobart slicer. The shredded cabbage was put into a large stainless steel pan 20" x 19" x 4", covered with a well dampened cloth and allowed to stand until it was cooked. Generally there was a standing period of 30 to 45 minutes in the kitchen before the cabbage to be served first on the counter was placed in the steamer.

In order to get random sampling, the cabbage as soon as it was shredded, was well mixed with forks, and samples were taken for chemical analysis. Approximately two-ounce portions were weighed and put into each of three bottles of acid which had been prepared for this purpose. In all instances great

care was taken to have the samples well covered with acid. Immediately preparation for taking samples of cabbage for steaming was begun. About one pound of shredded cabbage was placed in a small stainless steel pan. Fifty-gram portions were weighed into each of six porcelain baking dishes which were placed in a large shallow stainless steel pan, covered with a damp cloth and allowed to remain in the kitchen until the cabbage that was to be served first on the counter was cooked. This cabbage for serving on the counter and the samples for testing for ascorbic acid content were placed in the steamer at the same time and for the same length of time. When the cabbage was taken from the steamer, three of the samples were put into acid. Three of the cabbage samples, as soon as they had been removed from the steamer, were placed on the steam table for 15 minutes during a regular serving period when the steam was turned on as usual, and then collected into acid. The baking dishes did not cool rapidly, but it was decided they were the best small containers for this purpose. The retention of heat might have been somewhat similar to that in a larger quantity of vegetable.

Samples were also taken from the large quantity of raw shredded cabbage after it had stood at kitchen temperature for 45 to 60 minutes.

When a larger number (40) of samples were taken, about six pounds of cabbage, cleaned, washed, and shredded, were placed in a stainless steel pan. From this three sets of samples were taken alternately, i.e., as cabbage was weighed, one

portion was put into acid, the next portion into a baking dish for steaming, and the third portion into a baking dish for steaming and holding 15 minutes on the steam table. This was repeated until there were ten samples in each lot. After being steamed ten samples were collected into acid at once and ten were placed on the steam table for 15 minutes. The steam table was heated the same as it was during a regular serving period. The remainder of the raw cabbage was left in a large stainless steel bowl for one hour. It was then mixed with forks and ten weighed samples were put into acid.

Potatoes

Exploratory work was done on ten samples of potatoes. The samples were taken from the potatoes that were being prepared for serving on the counter. About 20 pounds of potatoes had been washed, peeled in a Hobart machine, eyed by hand, cut into quarters, and allowed to stand in water at room temperature. Usually the preparation was begun about 8:30 a.m. and finished between 9:30 and 10:00 when the potatoes were sent to the kitchen. Thus some of the potatoes were in water for a longer period of time than others. An attempt was made to take random samples by selecting potatoes from different parts of the container.

Raw potatoes were weighed in 50-gram portions and put into four bottles of acid. For samples of cooked potatoes 50 grams of raw potatoes were placed in each of four cheesecloth bags and inserted in various parts of the perforated steamer pan

among the potatoes being prepared for the counter, and steamed for 30 minutes. These cooked samples were weighed and put into acid. The average loss of weight was found to be 1.4 grams per 50 grams of potatoes. Therefore, it was assumed that 48.6 grams of cooked potatoes were equivalent to 50 grams when raw. Accordingly four 48.6-gram portions were taken from the potatoes mashed in the Hobart mixer after four minutes of mashing before the addition of milk. This was not representative procedure since the mashed potatoes for serving were ordinarily subjected to mixing and whipping for a much longer time.

It was decided to use a dry weight basis for comparison of ascorbic acid values of potatoes when making observations on a larger number (40) of samples. It was felt that this method would be more accurate than that of assuming that 1.4 grams represented the loss in weight per 50 grams of potatoes as was done in the exploratory work.

For this set of samples ten 50-gram portions of raw potatoes were weighed and put into acid. Ten samples taken from the lot of potatoes that had been steamed 35 minutes were put into acid. Ten samples of the mashed potatoes ready for serving were collected into acid. About 600 grams of the mashed potatoes for serving were placed in a stainless steel bowl and allowed to stand on the back of the kitchen stove for 45 minutes. Fifty-gram amounts were put into each of ten bottles of acid.

For calculating the percentage of dry weight a little more than 60 grams of potatoes from each lot from which samples

had been taken, i.e., raw, steamed 35 minutes, mashed, mashed and held 45 minutes, were put into wide-mouthed, pint-size, Kerr canning jars which were then tightly sealed and taken to the laboratory. Twenty grams of each were put into each of three aluminum drying dishes which had been previously prepared and weighed. These samples were dried in a Freas vacuum oven at 100° C. and 18 pounds pressure for 18 hours. They were weighed and the percentage of dry weight of the various lots of potatoes from which they were taken was determined.

Spinach

In order to obtain a number of samples of spinach large enough to be indicative of results, ten samples were collected during various stages of preparation of the spinach. The first samples were taken from the spinach as it was delivered, unwashed. Fifty-gram portions were weighed and put into acid. The rest of the spinach was washed three times and the long stems were removed so that about one inch of stem was left. The spinach was dried by being spread out on tea towels and paper toweling and patted dry with paper and cloth towels. It was placed on a board and cut with a French knife as was ordinarily done for the serving of raw spinach on the steam table. Twenty 50-gram portions of this spinach were collected alternately into acid and into baking dishes. The ten baking dishes of spinach were held for 15 minutes on the steam table which was heated as for ordinary serving, and then the samples were put into acid.

The remainder of the raw, washed, and cut spinach was held in a large stainless steel bowl at room temperature for one hour. Ten 50-gram samples were then put into the acid.

CHEMICAL PROCEDURE

The indophenol titration method of Bessey and King (1933), modified by Mack and Tressler (1937), as described by Bessey (1939) was used in analyzing samples for their ascorbic acid content.

To prepare a 0.05 per cent solution of sodium, 2,6-dichlorophenolindophenol, the indicator or dye used, 125 mg. of indophenol (Eastman) was placed on a filter paper and washed into a volumetric flask with hot water. After cooling, the volume was made up to 250 cc. The aqueous solution of the dye changes slowly even at low temperature; hence it was kept in the refrigerator and fresh solutions were made not less frequently than every four days. The dye was standardized against ascorbic acid each day it was used.

The ascorbic acid solution for the standardization of the dye was carefully prepared by dissolving one ampule (0.1 gm.) of crystalline ascorbic acid (Cebione Merck) in three per cent metaphosphoric acid and bringing the volume up to 200 cc.

To standardize the dye, five cc. of ascorbic acid solution were diluted with a small amount of distilled water and titrated with dye until a very faint pink color persisted for 30 seconds.

The strength of the ascorbic acid solution was checked by titrating a five-cc. portion, to which a small amount of sodium

bicarbonate had been added, with 0.01N iodine until the end point was almost reached. Then two drops of starch solution were added to the ascorbic acid solution and titration continued by drops until a blue color first appeared. The iodine solution was prepared by taking 25 cc. of a stock solution of approximately 0.2N iodine and making it up to 500 cc.

A ten cc. portion of 0.01N standard arsenious oxide was titrated against the iodine solution in the manner just described.

For all standardizations and titrations care was taken to have all reagents at room temperature.

Ascorbic acid is rendered fairly stable in an acid medium of proper pH value. Three per cent metaphosphoric acid has been found very satisfactory for this purpose. Therefore, the vegetables to be analyzed were collected into metaphosphoric acid of sufficient concentration to insure a three per cent solution after the sample was mixed, and brought up to volume. The day before samples were to be taken, 62.5 cc. of 12 per cent metaphosphoric acid was put into clear glass bottles with unlined plastic lids. These bottles of acid were weighed, if necessary for sample collection, and placed in the refrigerator until they were used.

The samples were collected at the college cafeteria as described in the sampling procedure.

For the determination of ascorbic acid content, it was necessary to have the cellular structure of plant tissues well broken down. For this purpose the Waring blender was used.

To prevent excessive frothing, two to three drops of butyl stearate were added to the material before it was ground in the blender. The use of the Waring blender for cooked potatoes resulted in a nonfilterable starch solution. The use of a mortar and pestle for grinding proved satisfactory. Kahn and Halliday (1944) reported that samples of cooked potatoes macerated in a Waring blender formed an "opaque gelatinous mass."

After each sample was macerated and thoroughly mixed either in the blender, or in the case of potatoes, with mortar and pestle, distilled water was added to the solution to make up its volume to 250 cc. It was mixed well, filtered, and ten cc. aliquot portions were diluted with a small amount of distilled water and titrated in duplicate with sodium 2,6-dichlorophenolindophenol. A very faint pink which faded within 30 seconds was considered the end point. Duplicate titrations were always made for standardizations and for ascorbic acid determinations. Greater speed and greater precision were possible the second time. From the sundry titrations calculations were made to determine the milligrams of ascorbic acid per 100 grams of vegetable. The following formulas were used in making the calculations:

The dye factor or mg. ascorbic acid per cc. dye =

$$\frac{\text{cc. As}_2\text{O}_3 \times .98 \times \text{cc. iodine against ascorbic acid}}{\text{cc. iodine against As}_2\text{O}_3 \times \text{cc. dye against ascorbic acid}}$$

(1 cc. of N/100 iodine = .98 mg. ascorbic acid.)

The mg. ascorbic acid per 100 grams vegetable =

$$\frac{100 \text{ mg. of vegetable} \times \text{vol. of sol.} \times \text{dye factor} \times \text{dye titration}}{\text{wt. of vegetable used} \times \text{vol. used for titration}}$$

DISCUSSION OF RESULTS

Tomatoes

Experiments carried out on approximately 50 samples of tomatoes taken over a period of five days indicated that their ascorbic acid values varied somewhat and that it was difficult to ascribe these fluctuations entirely to any of the various steps in preparation. The mean ascorbic acid content in 29 samples of raw tomatoes was 17.1 ± 1.3 mg. per 100 grams. This average corresponds to the lower values in the range of 15 to 40 mg. per 100 grams of most commercial varieties of tomatoes as reported by Reynard and Kanapaux (1942). It was impossible to find out where and under what conditions the tomatoes used in these experiments had been grown. Storage and transportation problems were great because of the war conditions. It was evident, in some cases, that the tomatoes had been picked when very green. Moreover, they were not sorted according to size, and they were not always well packed. The fact that the ascorbic acid value of the tomatoes in this study was not generally high added interest to the project. Since tomatoes are usually included among the foods that contribute substantially to the vitamin C content of our diet, it was of practical value to make this investigation.

The range of 14.9 to 20.2 mg. per 100 grams did not show as great variation in the raw tomatoes as might have been expected because many workers have reported greater ranges even in tomatoes of the same variety. In general samples of cooked tomatoes seemed to indicate a decrease of the original

ascorbic acid content but in the small groups of samples greatly varying results were obtained. In one set of three samples there was apparently a 61 per cent retention of the original ascorbic acid content when tomatoes were held at room temperature after being washed, cored and baked for 22 minutes. Similar procedures seemed to result in a retention of 94 per cent in another set of three samples. In two instances cooked tomatoes appeared to have a greater ascorbic acid content than did the raw tomatoes sampled on the same day. These discrepancies could have been due to the variable content of ascorbic acid within the tomatoes. The samples of raw tomatoes were made up of quarters from four different tomatoes but for sampling cooked tomatoes, whole tomatoes were used. Thus a whole tomato of high original ascorbic acid content could have greater value even after being cooked than the samples made up of parts of four raw tomatoes if these tomatoes happened to be of lower original ascorbic acid content. With one exception, the groups of small samples indicated that the retention of ascorbic acid was decreased by an increased cooking time.

Since steaming in the pressure steamer for five minutes was the most typical method of cooking tomatoes at the cafeteria, that method of cooking was the one used in this experiment when a larger number of samples were taken on the same day. Composite samples were taken for testing both raw and cooked tomatoes as described in the sampling procedure. The mean ascorbic acid values found in the tomatoes were these: raw, 16.4 ± 0.5 ; steamed for five minutes, 14.1 ± 2.4 . Thus

the retention during cooking was approximately 87 per cent. Holding the cooked tomatoes on the steam table for 15 minutes caused no further decrease. This latter result is in accordance with the report of Gleim et al. (1946) in their study on the effect of quantity preparation procedures on canned tomatoes. They found that heating the canned tomatoes in a steamer for 15 minutes caused "practically no destruction of ascorbic acid."

Cabbage

The range of the ascorbic acid content of raw shredded cabbage per 100 grams for 25 samples was 35.2 to 54.2 mg. Many investigators have shown that the original ascorbic acid content of cabbage may fluctuate greatly. In this study nothing could be done to control the factors of variety, exposure to sunlight during the growing period, and storage of the cabbage previous to purchase. Since the work was done in June and the first part of July, 1945, summer cabbage was used. However, it could not be determined how much time had elapsed since it was harvested, nor at what temperatures it had been held.

An average of 43.5 ± 5.9 mg. per 100 grams found in 25 samples of raw cabbage indicated a fairly high original ascorbic acid content.

Shredded cabbage was used for sampling as shredding was typical of the manner of preparation for serving at the cafeteria and gave an opportunity to have the various parts of the

cabbage well mixed. Bray and Thorpe (1944) found an ascorbic acid range of 25 to 79 mg. per 100 grams in ten samples of cabbage that had been cut into wedges, then cooked and strained. They concluded that "minced or chopped" cabbage would give better agreement between replicate samples.

Shredded cabbage held at room temperature for one hour showed 94 to 96 per cent retentions of the original ascorbic acid content of nine samples and 100 per cent retention in the group of ten samples. There was only 88 per cent retention in one group of three samples. The loss in this case, which might have been due to finer shredding, was greater than the losses reported in the literature by recent workers. In these experiments the shredding was done on a Hobart electric slicer. Ordinarily the cabbage was cut into shreds about three-eighths of an inch wide.

Six samples of shredded cabbage held for 45 to 60 minutes and steamed for seven minutes showed an ascorbic acid retention of 79 to 81 per cent of the original value. Ten samples steamed for seven minutes immediately after the cabbage was shredded showed an average retention of 88 per cent.

The retention of ascorbic acid during holding on the steam table for 15 minutes was apparently less when the shredded cabbage had been held from 45 to 60 minutes before being put into the pressure steamer. Six samples of shredded cabbage held for 45 to 60 minutes, steamed seven minutes, and held on the steam table for 15 minutes showed ascorbic acid retentions of 66 to 74 per cent. Ten samples steamed seven minutes and held 15 minutes on the steam table showed an

average retention of 85 per cent.

Potatoes

The potatoes used in this study were of the Red Triumph variety locally produced. Since the work was done about the middle of July, it is probable that the potatoes had been recently harvested. The mean ascorbic acid value of 14 raw samples 34.2 ± 3.1 mg. per 100 grams, on the basis of wet weight, showed that the potatoes had a comparatively high original ascorbic acid content. According to the report of Leichsenring (1944) immature Irish Cobbler potatoes at the Nebraska station had an ascorbic acid content of 36.8 mg. per 100 grams on June 30. The highest value given for Triumph potatoes was 29.8 mg. in October. Values were not recorded for this variety during June and July in the National Cooperative Project. The range of 28.3 to 38.2 mg. per 100 grams for the 14 samples of raw potatoes was not greater than was expected because there were some variables that could cause such results. The fluctuations could have been due to the parts of the tubers tested. The samples were chosen from various portions of the lot of potatoes being prepared for serving.

The potatoes cooked in a pressure steamer showed a retention of approximately 86 per cent. This was comparable to some of the results reported in the literature. Mashing the potatoes in the manner ordinarily done for serving resulted in a retention of 55 per cent of the original ascorbic acid content. The calculations made on the dry weight gave almost

the same results that were obtained on the wet basis. It was noticed that some cooks subjected the mashed potatoes to longer periods of mixing and whipping than others.

Holding the mashed potatoes on the back of the stove for 45 minutes resulted in an additional loss of ascorbic acid. The average ascorbic acid value of potatoes tested immediately after mashing was 19.6 ± 1.3 mg. per 100 grams (wet basis) and that of potatoes, mashed and held on the stove, was 14.7 ± 1.1 mg.

Spinach

Raw spinach is often served at the college cafeteria. The washed, cut, raw spinach is placed in a stainless steel bowl. A hot vinegar dressing is poured over the spinach which is then held on the steam counter where it is served.

Since cooking destroys ascorbic acid to a greater or lesser extent, there is an advantage in serving some vegetables raw. However, the amount of this vitamin retained during the preparation of vegetables to be served raw and during their holding periods is subject to considerable variation.

An experiment was made to determine the results of holding the cut spinach on the steam table for 15 minutes, and at room temperature for one hour. No tests were made on the effect of adding the dressing. The vinegar dressing itself probably did not cause a marked destruction of the ascorbic acid content of the spinach although adding it when hot might have resulted in some decrease. Quinn et al. (1946) found that adding a vinegar mayonnaise to shredded cabbage aided the retention of ascorbic

acid. Similar results might be expected for spinach.

In this experiment the original ascorbic acid value of the spinach was low. Of the first ten samples taken from the unwashed, uncut spinach the mean value was 13.8 ± 1.2 mg. per 100 grams. This was lower than the mean of 15.0 ± 2.4 mg. found in the ten determinations of the washed, cut spinach. The lower values in the unwashed, uncut spinach may have been due to the greater quantity of stems which had not been removed. According to Tressler, Mack, and King (1936) the ascorbic acid content of the stems of spinach is comparatively low. The mean ascorbic acid value of the raw, washed, cut samples was used for calculating percentage retentions because the purpose of this experiment was to determine the effect of holding spinach on the steam table for 15 minutes and at room temperature for one hour. The variety of spinach and the length of time since harvesting could not be determined. However, the spinach showed marked deterioration. Nearly half of the amount purchased, one bushel, had to be discarded as the leaves were badly wilted and slimy. According to the literature reported, variety as well as storage time and temperatures are very important factors in the ascorbic acid content of spinach.

Holding the cut spinach on the steam table for 15 minutes gave a mean value of 12.3 ± 1.9 mg. per 100 grams for ten samples. This was an 82 per cent retention of the original. Holding the cut spinach at room temperature, 26.0° C., for one hour gave a mean value of 10.8 ± 1.7 mg. for ten samples. This was a 72 per cent retention of the original and indicated a

very rapid destruction. The loss might have been due to the fact that the spinach had been cut into small pieces. The loss would probably have been retarded if the spinach had been held uncut in the refrigerator and cut as needed for serving.

The results obtained in these experiments carried out on tomatoes, cabbage, potatoes, and spinach showed that these vegetables as served in the cafeteria at Kansas State College contained appreciable amounts of ascorbic acid. By a judicious choice of vegetables one could select at this cafeteria a day's diet that would contribute an adequate amount of vitamin C without including citrus fruit or juice in the menus.

Sarett et al. (1946) in reporting a study made on the vitamin content of restaurant foods found that "most of the cooked foods contained less than ten mg. ascorbic acid per 100 grams" and that the daily ascorbic acid requirements could be met only by the inclusion in the diet of fresh fruit juices.

Certainly ascorbic acid is extremely labile and great care should be taken to conserve the amounts that may be present in various vegetables.

SUMMARY

In this study investigations were made to determine the effects of certain preparations and serving techniques on the ascorbic acid content of selected vegetables at the cafeteria of Kansas State College.

Experiments were carried out on tomatoes, cabbage, potatoes, and spinach.

The results indicated that the ascorbic acid content of tomatoes is somewhat decreased by cooking. Steaming in the pressure steamer for five minutes resulted in an 87 per cent retention of the original ascorbic acid content of tomatoes. Holding cooked tomatoes on the steam table for 15 minutes caused no further loss in their ascorbic acid values.

Shredded cabbage held at room temperature for one hour retained, in most of the samples studied, from 94 to 100 per cent of its original ascorbic acid content. Cabbage steamed for seven minutes showed 79 to 88 per cent retentions of ascorbic acid. Holding cooked cabbage on the steam table for 15 minutes caused a slight decrease in its ascorbic acid value.

The retention of the ascorbic acid in potatoes during cooking was about 86 per cent. Mashed potatoes showed a 55 per cent retention of their original ascorbic acid content. Holding mashed potatoes on the back of the stove for 45 minutes caused a considerable decrease.

Raw spinach held on the steam table for 15 minutes gave an ascorbic acid retention of 82 per cent. Cut spinach held at room temperature lost its ascorbic acid rapidly.

The data indicated that during June and July of 1945 the ranges of ascorbic acid values in 100-gram amounts of some vegetables were as follows:

Tomatoes, raw.	14.9 - 20.2 mg.
" steamed.	12.8 - 15.7 "
" held on steam table 15 minutes .	11.7 - 17.9 "
Cabbage, raw.	35.2 - 54.2 "
" steamed.	34.4 - 39.0 "
" held on steam table 15 minutes .	33.0 - 38.1 "
Potatoes, raw.	28.3 - 38.2 "
" mashed	17.7 - 21.7 "
" " held on stove 45 minutes. .	13.2 - 17.1 "
Spinach, raw	10.9 - 16.7 "
" held on steam table 15 minutes. .	8.8 - 14.4 "
" " at room temperature 60 minutes	8.5 - 12.6 "

The findings in this study showed that commendable procedures were used in the preparation and serving of these vegetables at the college cafeteria.

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APPENDIX

Table 1. Ascorbic acid content of raw and cooked tomatoes in 1945.

Date	Description of sample	No. of samples	Mean	S.D.	Retentions
			ascorbic acid / 100 gms.		Per cent
			Range		
6/12	Raw	4	16.1 - 20.2	18.3	
6/14	do	3	15.8 - 16.5	16.1	
6/19	do	4	14.9 - 17.6	16.2	
6/22	do	4	17.8 - 18.8	18.3	
6/25	do	4	15.4 - 18.8	17.7	0.5
7/10	do	10	15.9 - 17.6	16.4	1.3
		29	14.9 - 20.2	17.1	
6/12	Held 40 min., steamed 6 min., baked 10 min.	3	14.0 - 15.3	14.8	81.0
6/14	Steamed 1½ min., Peeled	3	13.6 - 14.0	13.9	86.0
6/14	Steamed 1½ min., Peeled	3	11.2 - 13.5	12.5	77.0
6/19	Held 40 min., steamed 7 min.	3	9.2 - 10.1	9.8	61.0
6/22	Held 20 min., baked 22 min.	3	16.4 - 18.5	17.3	94.0
6/25	do	3	16.5 - 20.2	18.5	104.0
	do	9	9.2 - 20.2	15.2	4.35
6/19	Held 60 min., baked 33 min.	3	14.3 - 22.4	17.2	107.0
6/22		3	14.7 - 15.3	15.0	82.0
6/25		3	13.5 - 13.9	14.8	83.0
7/10	Steamed 5 min.	9	14.3 - 22.4	15.7	2.6
	Steamed 5 min. On steam table 15 min.	10	12.8 - 15.7	14.2	1.0
		10	11.7 - 17.9	14.4	2.4

* based on the ascorbic acid content of the raw product tested on the same day.

Table 2. Ascorbic acid content of raw and cooked cabbage in 1945.

Date	Description of sample	No. of samples	% ascorbic acid	Mean	S.D.	Retention ^a
			Range			
6/6	Raw, freshly shredded	3	35.2 - 36.5	35.7		
6/8	do	3	50.1 - 51.7	50.7		
6/11	do	3	36.6 - 38.1	37.1		
6/18	do	3	51.1 - 54.2	52.6		
6/20	do	3	46.4 - 49.0	47.3		
7/3	do	10	37.9 - 44.6	41.8	2.0	
		25	35.2 - 54.2	43.5	5.9	
5/6	Raw, shredded, held 45 min.	3	33.2 - 33.9	33.6		94
6/11	Raw, shredded, held 60 min.	3	35.3 - 36.3	35.8		96
6/18	Raw, shredded, held 60 min.	3	45.1 - 47.4	45.8		88
6/20	do	3	43.4 - 45.4	44.4		94
7/3	do	10	40.4 - 42.0	41.2	0.7	100
	Raw, shredded, held 45-60 min.	22	33.2 - 47.4	40.5	4.1	
6/18	Held 45 min., steamed 7 min.	3	40.7 - 42.7	41.5		79
6/20	Held 60 min., steamed 7 min.	3	37.7 - 39.8	38.3		81
7/3	Shredded, steamed 7 min.	10	34.4 - 39.0	36.6	1.5	88
6/18	Held 45 min., steamed 7 min. and held on steam table 15 min.	3	34.0 - 35.3	34.7		66
6/20	Held 60 min., steamed 7 min. held on steam table 15 min.	3	33.5 - 36.8	34.9		74
7/3	Steamed 7 min. Held on steam table 15 min.	10	33.0 - 38.1	35.1	1.5	85

^a based on the ascorbic acid content of the raw product tested on the same day.

Table 3. Ascorbic acid content of raw and cooked potatoes in 1945.

Date	Description of sample	No. samples	Wet basis		U.S. ascorbic acid /100 gms.		Dry weight	Per cent retention*
			Range	Mean: S.D.	Range	Mean: S.D.		
7/13	Raw, pared, cut	4	32.5 - 37.4	34.5				
7/13	Steamed for 30 min.	4	25.7 - 32.1	30.2	87			
7/13	do and mashed	4	24.9 - 25.3	25.3	73			
	Raw, pared, cut	14	28.5 - 36.2	34.2	3.1			
7/19	Raw, pared, cut	10	26.3 - 36.2	34.0	3.5	173.7 - 234.5	206.6	21.2
7/19	Steamed 35 min.	10	27.6 - 35.1	31.4	2.4	157.5 - 200.3	179.5	13.7
7/19	do and mashed	10	17.7 - 21.7	19.6	1.3	102.9 - 126.5	114.4	7.4
7/19	Steamed 35 min., mashed, held on stove 45 min.	10	15.2 - 17.1	14.7	1.1	76.5 - 99.1	86.1	4.7

* based on the ascorbic acid content of the raw product tested on the same day.

Table 4. Ascorbic acid content of raw spinach held on the steam table and held at room temperature in 1945.

Date:	Description of sample	No. of samples	Mg. ascorbic acid / 100 gms. Range	Mean	S.D.	Retention *
6/28	Raw, unwashed, uncut	10	8.8 - 19.6	13.8	1.2	
	Raw, washed, cut	10	10.9 - 18.7	15.0	2.4	
	Raw, washed, cut, held on steam table 15 min.	10	8.8 - 14.4	11.3	1.9	82
	Raw, washed, cut, held 60 min. at room temperature	10	8.5 - 12.6	10.8	1.7	72

* based on the ascorbic acid content of the raw product tested on the same day.