THE EFFECT OF STORAGE AND PROCESSING ON THE ASCORBIC ACID CONTENT OF DIFFERENT VARIETIES OF CABBAGE PEAS AND POTATOES

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INTRODUCTION

In Canada today there is considerable evidence of suboptimal nutrition as shown by dietary surveys carried out in a number of cities across the country. (83) In each study it was found that the ascorbic acid consumed by the family was below the standard requirement, and that it was one of the most extreme deficiencies in a large proportion of the people.

There are two distinctly separate dietary standards used in Canada today. To determine the requirement of a nutrient for an individual, a standard was drawn up by the National Research Council of the United States in 1941, (54) and tentatively accepted by the Canadian Council of Nutrition (58) in 1942. This standard allows a wide margin of safety for each nutrient to insure optimum nutrition for everyone. The daily adult allowances suggested are 75 mgm. for men and 70 mgm. for women. Allowances are given also for children of various ages. The second dietary standard was constructed by the Canadian Council of Nutrition (11) in 1945 for the purpose of planning food supplies for a population. The average requirement for a representative group of people was used to construct the standard, and the suggested daily allowances for ascorbic acid are 50 mgm. for adults and 30 mgm. for children.

Although the nutritional status of the people of Canada may be below the optimum level, extreme malnutrition is practically unknown. (57) In other parts of the world, however, particularly in Europe and India starvation is prevalent. The shortage of food supplies is extremely grave, and it is imperative that the losses in nutrient value caused by such universal practises as transportation, storage and cooking should be determined and minimized as much as possible. It is also of extreme importance that the food which is produced is of the highest possible nutritional value.

Ascorbic acid, or vitamin C is one of the most unstable of the vitamins. It is water-soluble and destroyed by oxidation in the air, especially in an alkaline solution. The losses caused by storage, cooking and canning of fruits and vegetables may be so large as to impair the usefulness of these foods as sources of the vitamin in question.

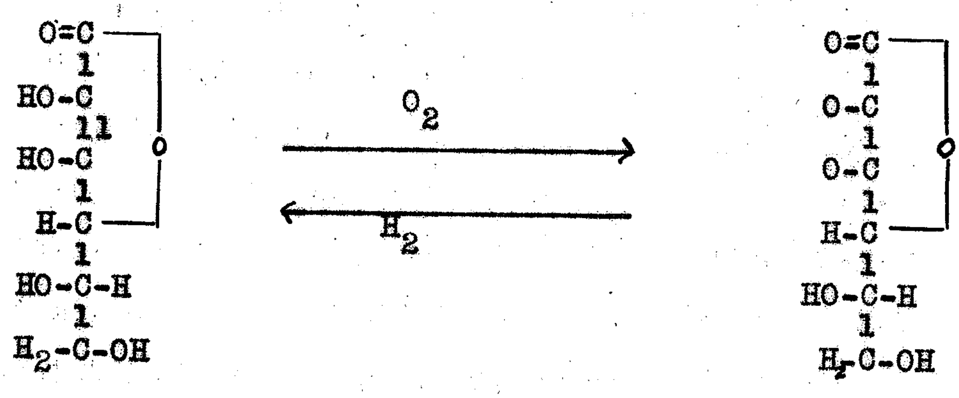
Although there are many data on the ascorbic acid content of vegetables grown elsewhere, there is little known concerning the amount in Manitoba vegetables. Therefore it was considered worth while to study Manitoba vegetables along these lines. The three vegetables chosen for this study are cabbage, peas and potatoes, since they are all good sources of ascorbic acid and commonly grown in the province. The purpose of the work is threefold; firstly to determine the ascorbic acid content of several varieties of cabbage, peas and potatoes grown in Manitoba, and to compare these results with those of other workers; secondly, to compare the ascorbic acid content of these vegetables grown at the University of Manitoba with that of vegetables grown in other districts of the province; and thirdly, to determine the effect of maturation, short-term refrigerator storage, long-term root-house storage, cooking, canning and other household practises on the ascorbic acid content of the vegetables.

History

Scurvy was well-known in Europe before the introduction of the potato but after that time it was rarely seen on land. (8) It was, however, a familiar disease to sailors who were long away from shore. (66) In 1847 an interesting experiment was carried out by a British surgeon, Lind, (63) for the purpose of finding a cure for scurvy in sailors. Many suggested remedies were tested but only oranges and lemons were found to be effective. In the same year it was suggested by Budd (63) that scurvy was caused by the deficiency of some essential element, but it was not until 1907 that Holst and Frolich (25, 26) proved this prophecy to be true, and showed that scurvy was caused by the deficiency of a specific substance - later called vitamin C.

The constitution of vitamin C was established by the work of a number of investigators. Zilva, (84) in 1924, succeeded in concentrating the antiscorbutic substance to an almost pure state, and using the concentrate established the molecular formula $C_6H_8O_6$. He also noticed its resemblance to hexoses and its instability towards oxygen. In 1920 Drummond (21) suggested that the antiscorbutic substance be called vitamin C - fat-soluble A and water-soluble B having been named already.

While studying the oxidation - reduction system of the adrenal cortex, Szent-Györgyi (67) isolated a strongly reducing substance in lemon juice and cabbage, and also an enzyme which oxidizes hexuronic acid in the presence of oxygen into a reversible oxidation product. Waugh and King (79) identified hexuronic acid as vitamin C when they isolated the latter from lemon juice in 1932. In the next year the dehydro form of the vitamin was produced by oxidation and isolated by Karrer, Solomon and Schopp. (33) The structural formulae of the two forms were established by Haworth, (22) Hirst, (23) Karrer, Schöpp and Zehender, (34) Micheel and Kraft (44) and Von Euler and Klussmann (14)



(63)

It was suggested by Szent-Gyorgyi and Haworth (69) that the name hexuronic acid be changed to ascorbic acid, since the former is the name of a class of substances rather than an individual compound. The American Medical Association, however, preferred to call it cevitamic acid to prevent therapeutic suggestiveness, but later they accepted the name ascorbic acid because of its more common usage.

The first synthesis of ascorbic acid was accomplished in 1933 by Reichstein, Grussner and Oppenauer (60) using l-xylose as a base. The l-xylose was treated with phenylhydrazine and hydrolysed to l-xylosone. Hydrocyanic acid was then added and it was further hydrolysed to 3-Ketogulanic acid, and finally l-ascorbic acid. Three other synthetic processes have been developed, and one which has been used commercially was developed by Reichstein and Grussner using d-glucose as a base.

Methods

The first quantitative determination of vitamin C in food was made by Holst and Frolich. (26) They found that guinea-pigs on a diet deficient in the vitamin developed a hemorrhagic disease which was similar to scurvy in humans. The amount of the food necessary to prevent scurvy in the animal was used as an index of the vitamin C concentration. The diet consisted of oats and water and therefore was deficient in other factors as well as vitamin C. Cohen and Mendel, (12) and Sherman, La Mer and Campbell (64) made improvements in the diet until it was free from vitamin C but contained all the other essential factors.

There are three general types of biological methods. Sherman, La Mer and Campbell (64) used the growth or preventive method to determine the minimum amount of vitamin C necessary to prevent scurvy. In 1932 a curative method was developed by Birch, Harris and Ray (7) which determines the amount of the vitamin necessary to cure scurvy, and the third method, developed by Hojer, (65) used the histological changes in the teeth of the guinea-pigs as an indication of vitamin C concentration. Biological methods are used today mainly as a check for chemical procedures.

The first color test for vitamin C was developed by Bezsanoff (65) using the Folin-Denis phenol reagent. The dye 2-6 dichlorophenolindophenol was first suggested by Tillmans and Hirsch (70) as being specific for Vitamin C, and in 1933 Bessey and King (6) used this dye in a quantitative test to determine vitamin C in plant and animal tissues. The samples were ground in a mortar and the vitamin extracted with three per cent metaphosphoric acid. It was then centrifuged and the determination carried out by direct titration. In 1938 Bessey (4) modified the dye titration method to use a photoelectric colorimeter. The machine automatically corrects for extraneous matter, and the subjective reading of the end-point is eliminated.

In 1941 Morell (50) revised Bessey's method to determine ascorbic acid in plant materials. A Waring Blendor was used for extracting and grinding, and the solution was filtered through number twelve Whatman fluted filter paper. To simplify calculations a standard curve was prepared using solutions of pure ascorbic acid. The log of the galvanometer reading was plotted against the amount of ascorbic acid in the sample to form a straight line.

In 1942 Loeffler and Ponting (41) modified Morell's method to make it adaptable for the determination of many kinds of fruits and vegetables, fresh, frozen and dehydrated. A solution of one per cent metaphosphoric acid was used in place of the three per cent in order to eliminate the need for buffering. It was found that a one per cent solution, with a ratio of seven volumes of acid to one volume of plant material, yielded a PH low enough to prevent losses during blending and yet sufficiently high to prevent the fading of the dye.

Dichlorophenolindophenol determines reduced ascorbic acid only. When dehydroascorbic acid is present in materials it must be reduced to ascorbic acid before it can be determined by this dye. The most generally used reduction technique is that originated by Tillmans and Hirsch. (70) Hydrogen sulfide was used as the reducing agent and the excess driven off by carbon dioxide or nitrogen. The total ascorbic acid was then determined by 2-6 dichlorophenolindophenol titration. However it has been shown by King (35) that sulfhydryl salts produce a noticeable error,