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Original Article

Vitamin C Content of Dehydrated Vegetables

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The changes in the vitamin C content in vegetables due to solar drying were measured in green sweet pepper, broccoli and Japanese radish. Compared with content per edible portion, vitamin C content in all vegetables increased after drying. However, compared with content per dry matter, vitamin C content in all of vegetables decreased after drying. Ascorbic acid is oxidized to dehydroascorbic acid by enzymatic or non-enzymatic reactions. The quantitative ratio of dehydroascorbic acid increased in all vegetables by drying. The increase in the quantitative ratio of DHAA shows that the freshness of vegetables is lowered.

Key Words: Dehydrated Vegetables, Ascorbic acid, Dehydroascorbic Acid, Solar Drying

Introduction

Most vegetables have high moist contents, above 70%. Therefore, those vegetables decay and deteriorate by enzymes contained in the microorganism and vegetables themselves which are attached at room temperature. Drying is an ancient method for food preservation that has been successfully applied in fruits and vegetables to minimize their biochemical, chemical and microbiological deterioration by reducing moisture to levels which allow safe storage over a long period of time [1]. Dried vegetables have emerged to fulfill consumer demands for healthy and safe plant foods that are easy to prepare.

Fresh vegetables are the best source of vitamins and, among them, vitamin C is one of which they contain important amounts; it is a potent antioxidant involved in essential biological functions that reduce the damage caused by free radicals to cell membranes. There have been several investigations on ascorbic acid metabolism and its function in plants which provide the major source of dietary vitamin C for humans [2]. Ascorbic acid is oxidized by enzymatic or non-enzymatic reactions. Vitamin C content is possible to decrease by drying vegetables.

Negi and Roy [3] found a noticeable decrease in the β-carotene and ascorbic acid content of carrots stored at room temperature. Similarly, Bechoff et al. [4] observed a total carotenoid loss of 84% during storage of sweet potato for 4 months at ambient on-farm conditions.

Ascorbic acid (AA) and dehydroascorbic acid (DHAA) are equally biologically active forms of vitamin C in humans and guinea pigs [5]. Therefore, AA and DHAA levels should be determined to know the total amount of vitamin C in vegetables.

In the present report, the changes in the vitamin C content in vegetables due to solar drying were measured, and the quantitative ratio of AA and DHAA was discussed.

Materials and Methods

1. Reagents

L (+)-ascorbic acid, tetra-n-butylammonium bromide and other chemicals were obtained from the Wako Pure Chemical Ind. , Ltd., Osaka Japan.

DL-homocysteine was obtained from Sigma-

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Aldrich Inc., St. Louis, USA. All the reagents used were of reagent grade.

2. Samples

Green sweet pepper, broccoli and Japanese radish were obtained from local supermarkets on the day of purchase.

3. High-performance liquid chromatography [*6*]

Separation of AA was achieved with a Shodex DS-4 Liquid chromatographic apparatus equipped with a Rheodyne Model 7125 injector. Column effluents were monitored at 265 nm with a Shodex UV-41 variable-wavelength detector. Peak areas were determined using an SIC μ7 Data Station. A Shodex RSpak DE-613 column (150 mm × 6 mm inside diameter) was used. The mobile phase was composed of 8 mM phosphate buffer, pH 6.8, containing 3 mM tetra-n-butylammonium bromide. The flow rate was 1.0 ml/min.

4. Preparation of sample

Samples of green sweet pepper, broccoli and Japanese radish were divided in half. One was immediately analyzed for the vitamin C content and moisture, and the other was dehydrated by solar drying for two days and then was analyzed. All samples were then chopped into small sections with a kitchen knife. Ten grammes of these small sections were homogenized with 10 ml of 10% metaphosphoric acid and sea sand in a mortar. The slurry obtained was transferred to a centrifuge tube with 20 ml of 5% metaphosphoric acid and centrifuged for 20 min at 3000 rpm. The supernatant was diluted 20 fold with distilled water.

5. AA assay

Ten ml of diluted supernatant was diluted with 0.13 ml of 2.5 M K_2HPO_4 to give a final pH of 7.0. A 20-μl aliquot of this solution was injected into the HPLC system.

6. Total amount of vitamin C assay

TAA was assayed by adding 0.015 g of homocysteine to 5 ml of neutralized sample for AA assay. After 30 min at 25℃, 20-μl aliquot of this solution was injected into the HPLC system. The concentration of DHAA was calculated by subtracting the amount of AA from that of TAA.

7. Measurement of moisture content

Moisture content of all samples was measured using Infrared moisture measuring instrument FD-620.

Results and Discussion

The method of analysis used in this study was high-performance liquid chromatography. It is an excellent method to measure the AA and DHAA in vegetable.

The change of vitamin C per 100 g edible portion is shown in Fig. 1-3. Green sweet pepper has very high vitamin C content compared to other vegetables. The content of vitamin C was 101 mg/100 g e.p. before drying. After drying it was 830mg/100g e.p.. The content in edible portion has increased to 8.2 times in Green sweet pepper (Fig. 1).

The content of vitamin C in broccoli was 90 mg/100 g e.p. before drying. After drying it was 311mg/100 g e.p.. The content in edible portion has increased to 3.5 times in broccoli (Fig. 2). Japanese radish has a low vitamin C content compared to other vegetables. The content of vitamin C in Japanese radish was 10 mg/100 g e.p. before drying. After drying it was 118 mg/100 g e.p.. The content in edible portion has increased to 11.8 times in broccoli (Fig. 3).

Compared with content per edible portion, vitamin C content in all of vegetables increased. However, this result is because concentrated by reduction of water content. Therefore, it is necessary to measure the changes in moisture content.

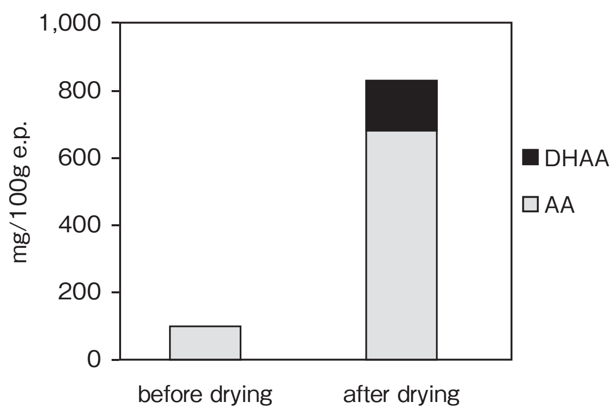

Fig. 1 The change of vitamin C per 100 g edible portion in green sweet pepper before drying and after drying
e.p.: edible portion
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

Table 1 shows the comparison of the moisture content before drying and after drying.

Moisture content was decreased in all vegetables after drying. Moisture content was 90% or more was reduced to less than 40%.

The data of per edible portion was re-calculated to per dry matter. The change of vitamin C per 100 g dry matter after drying is shown in Fig. 4–6. The content of vitamin C in green sweet pepper was

Table 1 Comparison of the moisture content before drying and after drying (%)

	before drying	after drying
Green sweet pepper	94.1	21.1
Broccoli	93.0	36.7
Japanese radish	94.5	30.6

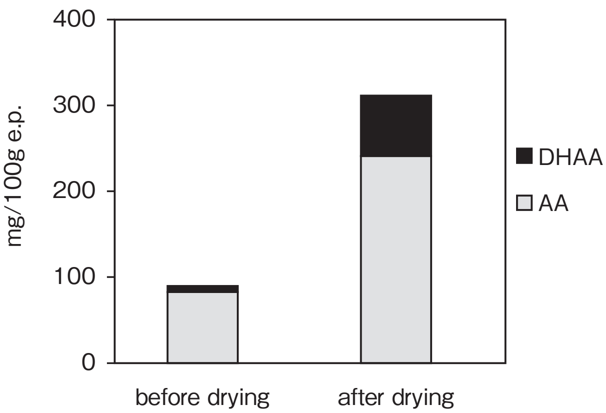

Fig. 2 The change of vitamin C per 100 g edible portion in broccoli before drying and after drying
e.p.: edible portion
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

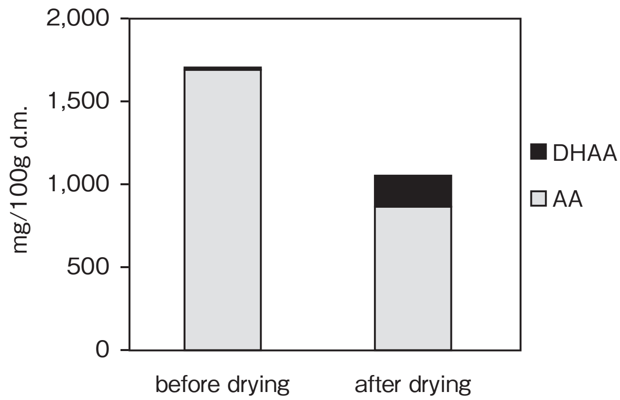

Fig. 4 The change of vitamin C per 100 g dry matter in green sweet pepper before drying and after drying
e.p.: dry matter
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

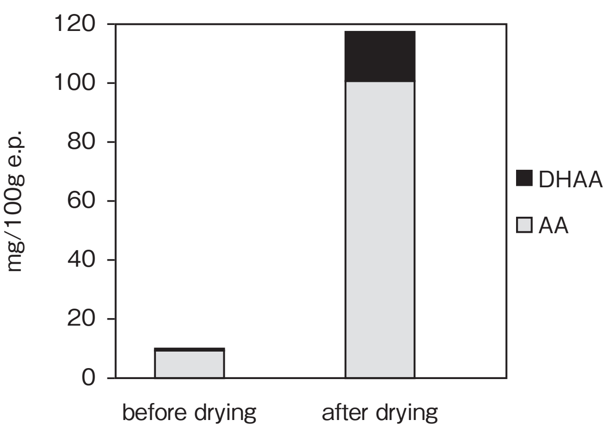

Fig. 3 The change of vitamin C per 100 g edible portion in Japanese radish before drying and after drying
e.p.: edible portion
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

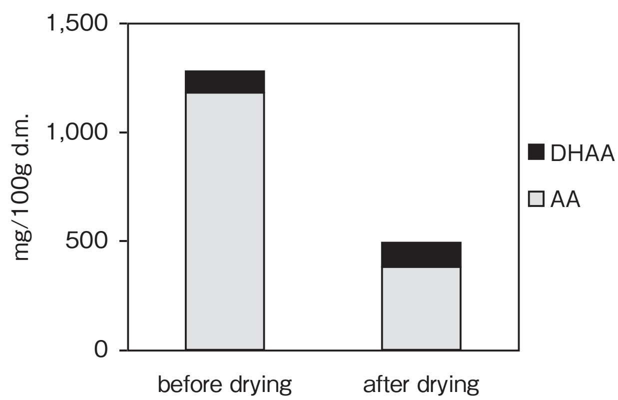

Fig. 5 The change of vitamin C per 100 g dry matter in broccoli before drying and after drying
e.p.: dry matter
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

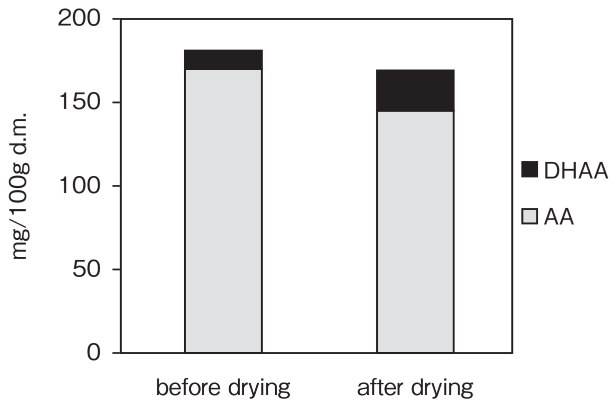

Fig. 6 The change of vitamin C per 100g dry matter in Japanese radish before drying and after drying
e.p.: dry matter
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

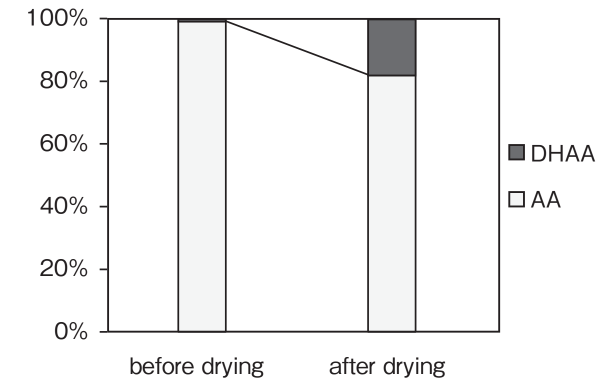

Fig. 7 The change in thequantitative ratio of AA and DHAA after drying in green sweet pepper before drying and after drying
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

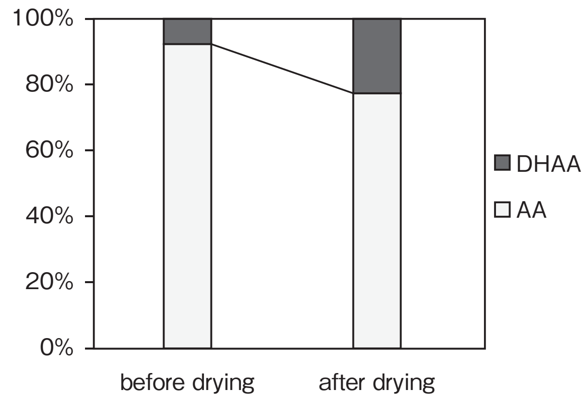

Fig. 8 The change in the quantitative ratio of AA and DHAA after drying in broccoli before drying and after drying
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

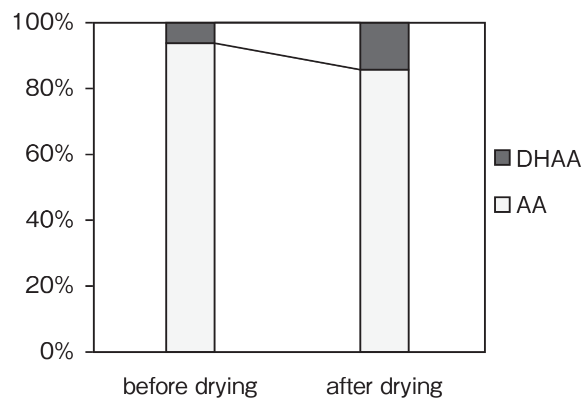

Fig. 9 The change in the quantitative ratio of AA and DHAA after drying in Japanese radish before drying and after drying
AA: Ascorbic Acid
DHAA: Dehydroascorbic Acid

1,704 mg/100 g d.m. before drying. After drying it was 1,053 mg/100 g d.m.. The content in dry matter was reduced to 38% in green sweet pepper (Fig. 4). The content of vitamin C in broccoli was 1,281 mg/100 g d.m. before drying. After drying it was 492 mg/100 g d.m.. The content in dry matter was reduced to 62% in broccoli (Fig. 5). The content of vitamin C in Japanese radish was 181 mg/100 g d.m. before drying. After drying it was 169 mg/100 g d.m.. The content in dry matter was reduced to 7% in Japanese radish (Fig. 6). Compared with content per dry matter, vitamin C content in all of vegetables was decreased.

The change in the quantitative ratio of AA and DHAA after drying is shown in Fig. 7–9. The quantitative ratio of DHAA has increased from 0.8% to 17.9% in green sweet pepper after drying (Fig. 7). The quantitative ratio of DHAA has increased from 7.7% to 22.6% in broccoli (Fig. 8). The quantitative ratio of DHAA has increased from 6.0% to 14.2% in green sweet pepper after drying (Fig. 9). The quantitative ratio of DHAA increased in all vegetables by drying. AA is oxidized to DHAA by enzymatic or non-enzymatic reactions. Therefore, the increase in the quantitative ratio of DHAA shows that freshness of vegetables is lowered.

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