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(RESEARCH ARTICLE)

The effect of heating on the vitamin C content of selected vegetables

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Abstract

Vitamin C is important for the human body function. People usually fulfill their vitamin C needs with food intake. A supplement intake also exists when needed. Vegetables are rich in various phytochemicals, biologically active substances with beneficial health effects, and are daily sources of vitamins and minerals for the body. The vitamin C content of eight widely used vegetables was established with the use of two assays (NBS and DCPIP). Food processing i.e. boiling, steaming and microwaving was used to establish vitamin C retention in cauliflower, peppers (red and green), potatoes (yellow and red), carrots, cabbage, and eggplant. The results obtained suggest that the most suitable cooking technique in terms of vitamin C retention is steaming.

Keywords: Vitamin C; Vegetables; Cooking; Retention levels

1. Introduction

Vitamin C, also called L-ascorbic acid (fig. 1), is a water-soluble vitamin. Due to the large number of beneficial effects on the human body, vitamin C is used as a nutritional supplement and is included in a number of medicines for influenza and colds. Synthetic vitamin C can be taken orally in the form of effervescent or chewable tablets, as well as ampoules.

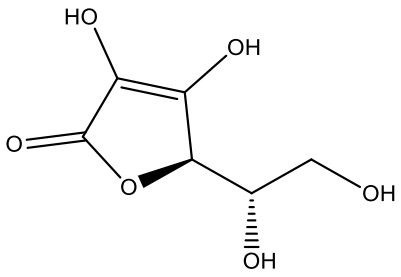

Figure 1 Structure of Vitamin C

Ascorbic acid performs many important functions in the human body. It significantly increases the absorption of iron, participates in the formation of bones, teeth and tissues [1]. Without vitamin C, the synthesis of collagen, which is a major protein in connective tissue formation, will be impossible. Taking the right doses of vitamin C helps to heal skin wounds faster and keep them in good condition [2]. Vitamin C is also involved in the absorption of calcium, which makes it clear that it promotes bone formation, growth and timely and trouble-free healing when broken [3]. It is very important to know that this vitamin cannot be formed in the human body, so it needs to be taken through food or tablets. The daily doses of the vitamin vary from 30 mg to 60 mg according to age, and in pregnant women and nursing

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mothers - 100 mg/day. Under winter conditions and high levels of exercise, doses of about 250 mg per day are required. With an active disease process, these needs increase to 500 mg/day, reaching up to 1000 mg [4].

A healthy balanced diet is the best way to get enough vitamins and minerals. There are foods with a higher vitamin content (peppers, broccoli, tomatoes, green leafy vegetables, etc.) [5].

Vegetables have a special place in human nutrition. They are one of the food groups recognized as a leader in healthy eating. Food specialists recommend three or more servings of a variety of vegetables per day. Vegetables supply carbohydrates that are important for the body, taking part in maintaining the optimal humoral environment and the functioning of all cells in the body. Vitamins and minerals contained in vegetables are a source of health and vitality for the body [6]. Vegetables are rich in various phytochemicals, and biologically active substances with beneficial health effects. They promote optimal health by reducing the risk of a number of chronic diseases. Vegetables are consumed both fresh and processed. It has to be noted that much of the vitamin C is destroyed by heat treatment, freezing and even longer storage [7].

With ascorbic acid deficiency, scurvy disease develops. It occurs in people who have not taken fresh fruits and vegetables for a long time, eating unhealthy or having indigestion [8]. With scurvy and milder forms of deficiency, different size haemorrhages in the body and oral mucosa are detected. High doses of Vitamin C can cause nephrolithiasis, gastritis, severe diarrhea, sometimes dizziness. It acidifies the pH of the body, which adversely affects individuals suffering from cirrhosis, gout, tubulopathies, paroxysmal hemoglobinuria [9].

The aim of this paper was to determine the amount of vitamin C is widely used in culinary practice vegetables, as well as to establish the most suitable processing technique in terms of vitamin C retention; and to pinpoint the necessity of up-to-date nutritional data concerning the vitamin C content in different food products in order to meet the recommended dietary allowance.

2. Material and methods

Vitamin C levels were established with the use of dichlorophenoliodophenol and N-Bromosuccinimide titration as described by Singh and Harshal [10].

2.1. Dichlorophenoliodophenol titration (DCPIP)

Standard - 5ml of standard solution was pipetted out in a conical flask, 10 ml of 4% oxalic acid was added and titrated against the dye. The amount of dye consumed corresponds to the amount of ascorbic acid. Test - 5ml of test sample was pipetted out in a 100 ml conical flask. 10ml of 4% oxalic acid was added and titrated against the dye. The end point appeared as pink color which persists for a few minute and reading was noted.

2.2. N-Bromosuccinimide titration (NBS)

Take 10 ml of sample and titrate against 0.01% N-bromosuccinimide. The amount of Vitamin C was estimated using a standard ascorbic acid curve made from serial dilutions (50mg, 40mg, 30mg, 20mg and 10mg of ascorbic acid in 100cm^3 of 0.5% oxalic acid solution) titrated against 0.01% N-bromosuccinimide solution.

2.3. Vegetable selection

Vegetables were selected based on their popularity and availability in the autumn season at the farmer's market. Fresh vegetables were purchased (potatoes, cabbage, peppers, cauliflower, eggplants, and carrots) and used the same day. All vegetables were thoroughly washed and grinded for sample preparation. Filtrate produced while grinding was used to evaluate the Vitamin C content.

2.4. Treatment methods

5 g of vegetable samples were taken, and subjected to 20 min boiling, 10 min steaming, and 5 min of microwave heating. Then the vegetables were crushed in a mortor and pestle along with 0.5% oxalic acid. After that, they were filtered and the volume was made up to 100 ml using a measuring cylinder. The filtrate obtained was re-filtered. The treated samples were extracted in 0.5% oxalic acid and volume of the filtrate was made up to 100ml; 10ml of the sample solution was titrated against DCPIP and NBS. The content of Vitamin C was determined before and after the extracts were exposed to steaming, boiling and microwave radiation.

2.5. Statistical analysis

Data were analyzed using MS Excel software. All assays were performed in at least three repetitions. Results were presented as mean ± SD (standard deviation). Fisher's least significant difference test at a level of $p < 0.05$ were used to determine the significance of differences between mean values.

3. Results and discussion

Vitamin C is an important water-soluble and temperature-liable vitamin. Cooking, especially long time processing, leads to severe losses of vitamin C content [7]. It is also well known that the growing conditions and varieties/cultivars alter the nutritional content of vegetables [11, 12]. Table 1 visually presents the vitamin C content in the studied raw vegetables.

Table 1 Vitamin C content in studied raw vegetables

Sample	Vitamin C, mg/100g sample	
	DCPIP	NBS
Potato		
-yellow	21.3±3.8a	25.6±3.0ab
-red	7.2±2.2a	8.5±1.5b
Bell pepper		
-green	47.8±2.3b	52.6±3.3b
-red	63.8±1.0c	76.4±4.8a
Carrot	12.2±0.5a	14.9±2.1ac
Cauliflower	60.0±0.9b	68.5±5.6a
Cabbage	78.2±5.6ab	80.3±4.3b
Eggplant	10.9±1.4c	13.3±2.6c

Means followed by different letters within a column are significantly different at $P < 0.05$ according to Fisher's LSD test.

The vitamin C content in red potatoes was significantly lower than in yellow potatoes, using both DCPIP and NBS assays. The NBS assay appeared to be more sensitive than the DCPIP assay. These findings are consistent with the results of previous investigations by Love and Pavek. [13] reporting that different potato varieties possess a vitamin C content ranging from 11.5 to 29.4 mg/100g.

Red bell peppers had more vitamin C compared to green bell peppers. The vitamin C content ratio in green and red peppers was 1:0.74 in the DCPIP assay and 1:0.68 in the NBS assay. Nerdy [14] reported significantly lower amount of vitamin C in the green peppers and higher in red peppers determined by DCPIP 16.52 mg/100g and 81.19 mg/100g respectively.

Cauliflower and cabbage had 60.0±0.9 mg/100g and 78.2±5.6 mg/100g vitamin C (DCPIP). In a study, fresh cauliflower was reported to contain 769.23 mg/100 g (on dry weight basis) level of ascorbic acid [15]. Carrots and eggplant possessed commensurate levels of vitamin C 14.9±2.6 and 13.3±2.1 mg/100g (NBS) respectively. The findings for carrots in the current study are much higher than the reported by Noella et al. [16], while those of eggplant are comparable to the established by Niño-Medina et al. [17].

Vitamin C is easily degraded during cooking so it is of importance to study different processing condition in order to establish the optimal for vitamin retention. Elevated temperatures and long cooking times have been found to cause particularly severe losses of vitamin C [18]. Table 2 presents the results of vitamin C content after the samples have been subjected to steaming, boiling and microwave radiation.

Table 2 Vitamin C content in processed vegetables

Sample	Vitamin C, mg/100g sample	
	DCPIP	**NBS**
Potato, yellow		
- steamed	13.0±0.9[a]	15.3±1.1[b]
- boiled	10.1±0.8[a]	12.5±0.9[c]
- microwaved	12.8±0.5[a]	14.7±0.3[ad]
Potato, red		
- steamed	5.3±0.2[a]	5.6±0.7[b]
- boiled	4.8±0.1[b]	5.9±0.4[c]
- microwaved	4.9±0.6[a]	6.1±1.0[c]
Bell pepper, green		
- steamed	22.2±2.5[b]	28.6±7.4[b]
- boiled	19.5±3.1[c]	25.3±4.1[b]
- microwaved	19.1±4.1[c]	22.4±3.5[b]
Bell pepper, red		
- steamed	23.2±0.8[a]	36.9±3.6[b]
- boiled	20.4±0.7[b]	34.5±2.5[b]
- microwaved	21.5±0.5[b]	30.3±1.7[b]
Carrot		
- steamed	7.8±2.8[c]	9.3±1.1[a]
- boiled	8.5±0.5[a]	8.6±1.5[a]
- microwaved	7.4±0.9[c]	7.9±1.9[a]
Cauliflower		
- steamed	40.8±5.3[b]	50.2±8.1[c]
- boiled	39.6±4.2[b]	49.7±4.6[c]
- microwaved	36.7±4.3[b]	45.6±3.3[b]
Cabbage		
- steamed	45.5±6.2[ab]	48.6±5.1[b]
- boiled	42.3±3.3[b]	45.7±4.6[b]
- microwaved	39.7±2.5[b]	41.2±6.3[b]
Eggplant		
- steamed	5.2±0.2[ac]	7.8±0.7[a]
- boiled	4.9±0.3[c]	6.9±0.4[a]
- microwaved	4.6±0.5[b]	5.4±0.2[a]

Means followed by different letters within a column are significantly different at $P < 0.05$ according to Fisher's LSD test

Vitamin C content decreased in all of the examined vegetables (Fig. 2). Steaming appeared to be the most sparing method when it comes to vitamin C retention. Boiling had less of an impact on vitamin C content, with moderate retention observed for cauliflower and cabbage. Agbemafle et al. [19] report a reduction of 85% in vitamin C in boiled cabbage, which is higher compared to the currently established results. In a study conducted by Ahmed and Rehab [15] the highest loss of vitamin C in cauliflower was observed for boiling (52%). In this study, boiling destroyed vitamin C in all the samples, with nutrient retention ranging from 31 to 73% (fig. 2); the greatest loss was found in red bell pepper. Lee and Kader [20] explain the loss of ascorbic acid by water leaching and thermal degradation. Boiling treatment significantly reduced the retention of vitamin C in all vegetables except for red potato. Contrary to the current findings, Lee et al. [21] documented that microwaving retained higher concentrations of vitamin C than boiling. This can be due to the differences in the sample preparation and hydro modules used. Igwemmar et al. [22]

reported 9.96 mg/25ml and 3.62 mg/25ml vitamin C levels after 15 minutes of thermal treatment in peppers and carrots respectively. These findings are consistent with the results of Bureu et al. [23] where levels of vitamin C in raw samples were significantly higher than those in cooked ones.

With compliance of the results for peppers (reduction of 55 to 65 %), Hwang et al. [24] have registered that boiling and steaming significantly reduced vitamin C content (from 24 to 66 %).

Most vitamin C levels were retained in steamed red potatoes, while the least levels were registered for boiled red peppers.

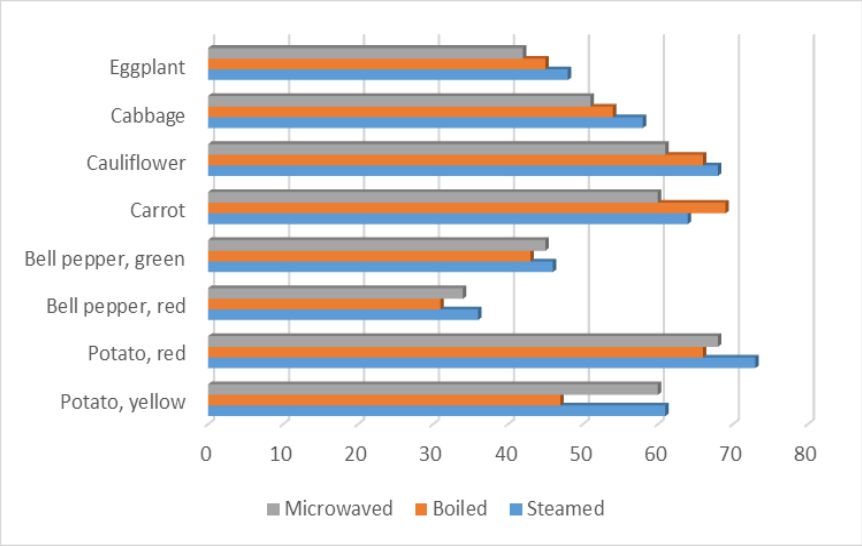

Figure 2 Vitamin C retained in studied vegetables, %

4. Conclusion

Vitamin C has undeniable health benefits. Proper intake can prevent serious health conditions and help the body maintain its good state. Vegetable intake can provide the necessary daily doses of the vitamin and reduce the need of supplement intake. In terms of food processing, steaming appeared to be the most sparing when it comes to vitamin C retention. Microwave treatment led to the biggest losses of the vitamin content. From all of the studied vegetables cabbage and red peppers contained the most vitamin C, and red potatoes - the least. After processing, approximately 31 to 73 % were retained in the studied vegetables. Future studies should establish optimized cooking methods in order to maximize nutritional value.

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