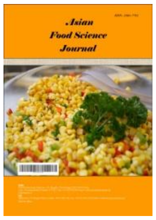

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Comparison of Vitamin C Content of Commercially Available Fresh Fruits

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: The aim of the current paper is to identify the ascorbic acid level in ten commercially available fruits in order to expand the existing database about fruits rich in Vitamin C and to promote their daily consumption.
Study Design: Research was conducted experimentally.
Place and Duration of Study: University of food technologies, Plovdiv, Bulgaria, October 2019.
Methodology: Ascorbic acid levels were determined with the use of two oxidation-reduction titration methods – Dichlorophenoliodophenol (DCPIP) and N-Bromosuccinimide (NBS).
Results: All studies samples possessed different amounts of ascorbic acid. Both DCPIP and NBS assay resulted in determining strawberries as the fruit with the highest ascorbic acid levels – 55.1 ± 1.6 mg/100 g and 59.8 ± 2.2 mg/100 g respectively. Lowest values were obtained for fig. All results are commensurable to those obtained in other studies. Ascorbic acid levels were as follows: strawberries > grapefruit > pear > green apple > blueberries > quince > banana > plum > white grapes > fig.
Conclusion: In this study, ten commercially available fruits were studied for their ascorbic acid levels. Comparison between two titration methods showed moderate differences in the results confirming that the NBS method is more sensitive. All reported data confirms that differences occur, but fruits can be considered sources of vitamin C.

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Keywords: Ascorbic acid; fruit; commercially available; fresh.

1. INTRODUCTION

According to the Food and Agriculture Organization, some of the most common and debilitating eating disorders in the world, including birth defects, mental and physical retardation, weakened immune systems, blindness and even death, are caused by a lack of vitamins and minerals in the daily diet [1]. Low intake of fruits and vegetables is a major contributing factor for such a deficiencies of trace elements. Fruits provide a wide variety of minerals and vitamins, especially vitamin C and are a fast source of hydration. They positively affect the functioning of the digestive system. Due to their diuretic nature, they facilitate the purification of the body and contain natural antioxidants [2].

Phytochemical studies have attracted the attention of specialists in the search for additional raw material resources with beneficial properties [3]. Consumption of fresh fruits contributes to the sustainability of the food system because it reduces energy consumption and generates less carbon dioxide emissions since it does not need to be transported from remote farming areas. The natural production cycle is respected as it is more environmentally friendly and respectful of the environment. In addition, fruits grown outdoors have a better taste because they lose some of their flavor in a greenhouse [4].

In the early 21st century, nutritionists began to highlight the benefits of plant-based foods, further emphasizing the benefits of a plant-based diet [5]. There is an ambition to provide affordable, natural and personalized food. The food industry relies not only on products but also on consumers' dietary preferences. A lifestyle that promotes the consumption of foods that contribute to a healthy diet and have less impact on the planet's ecosystem is encouraged [6]. Awareness of healthy behaviors can contribute to a more sustainable European healthcare system by reducing the severity of diseases, which can be avoided with the help of appropriate nutritional advice.

Fruit production is undoubtedly of great importance in the agricultural sector because of its economic importance and its beneficial effects on human health. Consumption of fresh fruits and/or vegetables and their juices is associated with beneficial substances intake for the human body [7]. According to Eurostat, 64% of the people living in the European Union put fruits on their table every day [8]. Fruits comprise of mainly polysaccharides, polyphenolic compounds, vitamins and minerals. Fruits can be consumed raw or as a material for the preparation of certain new products with health-promoting properties.

It is well known that Vitamin C is a water-soluble, heat-sensitive and very important for human health [9,10]. Many plant-based products have been reported to possess ascorbic acid in different amounts. For instance, oranges have 58.30 mg/100 g vitamin C levels [11], and lemons – 50.4 mg/100 g [12]. Vitamin C is probably most famous for its scurvy prevention [13]. In addition to that, ascorbic acid aids in many processes including acting as cofactor for mono- and dioxygenases, and histone demethylases [14,15]. Vitamin C also enhances iron absorption in the body [16].

Daily doses of ascorbic acid vary from 30 mg/day to 250 mg/day [17]. In fruits from different species or even within the same species, large differences in Vitamin C levels can be observed [18]. Considering all this, it is important to extend the knowledge in ascorbic acid rich fruits.

Previous studies focus on the evaluation of several species with the use of various methods i.e. spectrophotometry, electrophoresis, chromatography [19,20]. Still, the most commonly used method is the oxidation-reduction titration method [21,22]. The aim of the current paper is to identify the ascorbic acid level in ten commercially available fruits in order to expand the existing database about fruits rich in Vitamin C and to promote their daily consumption.

2. MATERIALS AND METHODS

Vitamin C levels were established with the use of 2,6-dichlorophenoliodophenol and N-Bromosuccinimide titration as described by Singh and Harshal [23].

2.1 Dichlorophenoliodophenol Titration (DCPIP)

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)

10 ml sample was titrated against 0.01% N-bromosuccinimide. The amount of Vitamin C was estimated using a standard ascorbic acid curve made from serial dilutions (50 mg, 40 mg, 30 mg, 20 mg and 10 mg of ascorbic acid in 100cm3 of 0.5% oxalic acid solution) titrated against 0.01% N-bromosuccinimide solution.

2.3 Fruits Selection and Evaluation

Fruits were selected based on their popularity and availability in the autumn season at the farmer's market. Ten fruits were purchased (green apple, pear, blueberry, banana, white grapes, grapefruit, strawberry, quince, plum, and fig) and used the same day. All fruits were thoroughly washed and grinded for sample preparation. Filtrate produced while grinding was used to evaluate the Vitamin C content. The treated samples were extracted in 0.5% oxalic acid and volume of the filtrate was made up to 100 ml; 10 ml of the sample solution was titrated against DCPIP and NBS.

2.4 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 = .05 were used to determine the significance of differences between mean values.

3. RESULTS AND DISCUSSION

Fruit evaluation started with determining some physical characteristics of the samples (Table 1). Characteristics i.e. weight, diameter and skin color are very important when it comes to purchasing fruit at the farmer's market. Fruits are highly prized for their unique aesthetic and organoleptic characteristics [24]. Traditionally, fruit quality indicators include appearance, sugar and acid content. In the field of food technology, product quality and its sensory evaluation are priority criteria for the consumer. The intention to buy is related to the attitude towards the product as a whole. It is shaped both by external signals, such as variety (in fruits and vegetables), and internal, as sense gratification. When it comes to fruits, color, shape, firmness and aroma are the main factors that influence choice. Other motivating factors are brand and potential benefits to the body [25].

Plant foods, such as fruits that contain significant amounts of bioactive phytocomponents, can provide the desired health benefits beyond basic nutrition, such as reducing the risk of chronic diseases [26,27]. Ascorbic acid is a very important vitamin for the human body since it cannot be synthesized and has to be introduced with food or tablets. Table 2 is a visual presentation of the ascorbic acid levels of ten commercially available fruits.

Both DCPIP and NBS assay resulted in determining strawberries as the fruit with the highest ascorbic acid levels – 55.1 ± 1.6 mg/100 g and 59.8 ± 2.2 mg/100 g respectively. From all of the studied fruits, strawberries are the ones with the shortest storage ability after ripening. This may explain the currently established highest levels. Lowest values were obtained for fig. It has to be noted that colorful filtrates are to some extent harder to titrate, therefore another assay may result in different values. Other authors [28] have documented and average level of 24.70 mg/100 g in strawberries, which is 2.4 times lower than the current results.

Table 1. Physical characteristics of fruit samples

Samples/Particulars	Weight, g	Diameter, mm	Skin color
Banana	225	44	Yellowish
Blueberry	17	11	Violet
Fig	87	52	Red-violet
Grapefruit	256	121	Dark-pink
Green apple	221	93	White
Pear	154	76	Yellowish
Plum	78	56	Dark violet
Quince	320	123	Yellowish
Strawberry	64	42	Vivid red
White grapes	43	33	Green-yellow

Table 2. Vitamin C levels of commercially available fresh fruits determined by two titration methods

Samples/Method	DCPIP, mg/100g sample	NBS, mg/100 g sample
Banana	7.7±0.01^{a}	8.7±0.07^{b}
Blueberry	15.4±0.04^{a}	16.3±0.03^{a}
Fig	1.1±0.05^{b}	1.9±0.04^{a}
Grapefruit	47.0±0.03^{a}	48.2±0.05^{a}
Green apple	21.3±0.02^{a}	24.6±0.05^{b}
Pear	47.2±1.5^{b}	48.5±0.09^{b}
Plum	3.2±0.01^{a}	4.8±0.02^{a}
Quince	11.4±1.9^{a}	14.6±0.8^{a}
Strawberry	55.1±1.6^{b}	59.8±2.2^{a}
White grapes	3.1±0.07^{a}	4.0±0.05^{a}

******Means followed by different letters within a column are significantly different at P = .05 according to fisher's LSD test*

Strawberries are one of the most desirable fruits when it comes to consumers preferences, because of their excellent sensory characteristics [29]. Sapei and Hwa [30] report a relatively high content of vitamin C, which is around 40-70 mg/100 g. These results are commensurable the results of the current study.

Vitamin C levels and nutritional value in general is influenced by growing conditions, soil profile, meteorological conditions, and variety/cultivar of fruit [31]. Ascorbic acid content may be lower during storing and depending on harvesting condition [32].

Pears and grapefruit showed rather similar results in both DCPIP and NBS methods. Mussa and Sharaa [33] have reported 9.27 mg/100 ml ascorbic acid content in pears and 18.54 mg/100ml in banana using DCPIP method. Bananas resulted in 7.7 ± 0.01 mg/100 g (DCPIP) which is lower, compared to the abovementioned results. Quince and apples can be stored for a rather long period. Green apples contained 21.3 ± 0.02 mg/100 g and quince 11.4 ± 1.9 mg/100g (DCPIP). Other authors [34], documented 21.5 mg/100 g for apples, which is practically the same value as the currently established values. Blueberries had ascorbic acid levels comparable to those of quince. White grapes and plum had rather low levels of vitamin C 3.1 ± 0.07 mg/100g and 4.8 ± 0.02 mg/100 g (NBS) respectively. Literature data reports different values for white grapes established by Derradji-Benmeziane et al. [35] 12.33 mg/100 ml and Matei et al. [36] by 1.48 mg/100 g. Bozhkova [37] documents 11.92 mg/100 g vitamin C content for plum fruits of 'Stanley' cultivar.

All reported data confirms that differences occur, but fruits can be considered sources of vitamin C.

4. CONCLUSION

In this study, ten commercially available fruits were studied for their ascorbic acid levels. All studies samples possessed different amounts of ascorbic acid. Ascorbic acid levels were as follows: strawberries > grapefruit > pear > green apple > blueberries > quince > banana > plum > white grapes > fig. Among all, strawberries contained the most vitamin C – 59.8 ± 2.2 mg/100 g (NBS). The least vitamin C levels were registered in figs – 1.9 ± 0.04 mg/100 g (NBS). Comparison between two titration methods showed moderate differences in the results confirming that the NBS method is more sensitive. Modern genome technology suggests that a future trend will be to use genome editing to target favorable modifications in plant products including ascorbic acid content. Further studies may clear out different ways to retain vitamin C levels during storage and product processing.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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