

Quantitative Determination of Ascorbic Acid in Fruits by Using Iodometric Titration

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التحديد الكمي لحمض الأسكوربيك في الفواكه باستخدام المعايرة اليودية

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Abstract

Ascorbic acid commonly known as vitamin C, integral to human health and plays a vital role in numerous physiological functions. Ascorbic acid is potent antioxidant. And is readily dissolved easily in water, allowing it to function effectively throughout the body. Fruits are among the richest dietary sources of vitamin C, making them important contributors to daily intake.

The main of this study is to determine the Ascorbic acid content in selected fruits. The analytical method used was inexpensive, accurate, and suitable for routine analysis. Fruit samples were collected from various markets in Darna city. Among all the sample tested fruits, kiwi was found to have the highest vitamin C content (167 mg/10g). Vitamin C concentrations were evaluated using an iodometric titration method, with standardized iodine serving as the titrant.

The results demonstrated significant differences in vitamin C content revealing considerable difference among citrus varieties as well as variability between samples of the same variety. Sweet orange and sour orange showed the highest vitamin C concentrations (114 mg/10 g and 103 mg/10 g, respectively), whereas blood orange samples exhibited the lowest levels (95 mg/100 g). Other fruits showed the following concentrations: banana and peach (93 mg/10 g), mango (90 mg/10 g), and lemon (96 mg/10 g).

These findings clearly demonstrate that vitamin C concentrations vary significantly among fruit types, highlighting the importance of fruit selection for meeting dietary vitamin C needs.

Keywords: vitamin C; Ascorbic acid; antioxidant; iodine; iodometric titration.

المخلص

حمض الأسكوربيك، المعروف شائعًا باسم فيتامين ج، عنصر أساسي لصحة الإنسان ويلعب دورًا حيويًا في العديد من الوظائف الفسيولوجية. يُعد حمض الأسكوربيك مضادًا قويًا للأكسدة، كما أنه يذوب بسهولة في الماء، مما يسمح له بالعمل بفعالية في جميع أنحاء الجسم. تُعد الفواكه من أغنى المصادر الغذائية لفيتامين ج، مما يجعلها مساهمًا هامًا في الاستهلاك اليومي.

تهدف هذه الدراسة إلى تحديد محتوى حمض الأسكوربيك في فواكه مختارة. استُخدمت طريقة تحليلية غير مكلفة ودقيقة ومناسبة للتحليل الروتيني. جُمعت عينات الفاكهة من أسواق مختلفة في مدينة دارنا. من بين جميع عينات الفاكهة المختبرة، وُجد أن الكيوي يحتوي على أعلى نسبة من فيتامين ج (167 ملغم/10 غرام). قُيِّمت تركيزات فيتامين ج باستخدام طريقة المعايرة اليودية، حيث استُخدم اليود المعياري كمعايير.

أظهرت النتائج اختلافات كبيرة في محتوى فيتامين ج، كما شُفِّت عن تباين ملحوظ بين أصناف الحمضيات، بالإضافة إلى تباين بين عينات من الصنف نفسه. أظهر البرتقال الحلو والبرتقال الحامض أعلى تركيزات لفيتامين ج (114 ملغم/10 غ و 103 ملغم/10 غ على التوالي)، بينما سجلت عينات البرتقال الأحمر أدنى المستويات (95 ملغم/100 غ). أما الفواكه الأخرى، فقد سجلت التركيزات التالية: الموز والخوخ (93 ملغم/10 غ)، والمانجو (90 ملغم/10 غ)، والليمون (96 ملغم/10 غ). تُظهر هذه النتائج بوضوح أن تركيزات فيتامين ج تختلف اختلافًا كبيرًا بين أنواع الفاكهة، مما يُبرز أهمية اختيار الفاكهة لتلبية الاحتياجات الغذائية من فيتامين ج.

الكلمات المفتاحية: فيتامين ج؛ حمض الأسكوربيك؛ مضاد للأكسدة؛ اليود؛ المعايرة اليودية.

1. Introduction

vitamin C is regarded as an essential for nutrition vital for human health, sometimes referred to as ascorbic acid, which is found in fruits.

Because of its therapeutic and antioxidant qualities, it is a valuable nutrient (Adebayo, 2015). Because the human body is unable to synthesize it, it is one of the vitamins that must be obtained through diet (Mussa et al. 2014). In a solid state, it is stable, but in a solution, it breaks down readily (Eskova 2006).

Ascorbic acid **the molecular formula C₆H₈O₆** Figure 1, is recognized in its active form for its strong, antioxidant properties. Interestingly, it does not contain a carboxyl group (-COOH), which is commonly associated with acids. The acidity of ascorbic acid arises from its unique structure, particularly the presence of an indole group, also referred to as enediol. This characteristic contributes to its effectiveness in various biological processes

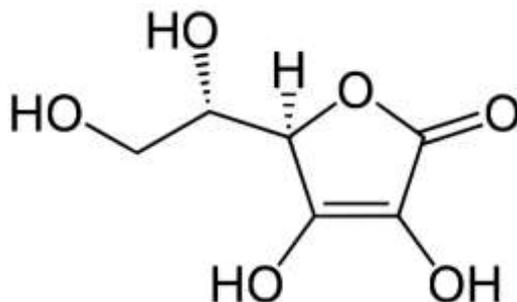


Figure 1: Ascorbic acid

Ascorbic acid is a lactone, existing in multiple forms, including reduced and oxidized forms: L-ascorbic acid (reduced form) and dehydro-L-ascorbic acid (oxidized form), as illustrated in Figure 2. The hydroxyl groups at positions 2 and 3 are capable of ionization, with dissociation constants (pKa) approximately 4.17.

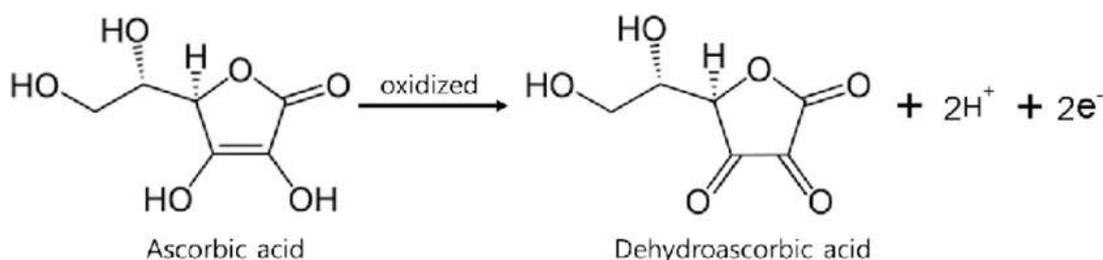


Figure 2: oxidation of Ascorbic acid

Ascorbic acid is an essential micronutrient vital to human health and serving as a precursor for coenzymes involved in a wide range of metabolic and specialized cellular processes (Mussa et al. 2014). It is particularly critical for the biosynthesis of collagen, a structural protein that confers mechanical strength and elasticity of the skin, bones, and blood vessels (Ruiz et al. 2018). Insufficient intake of vitamin C impairs collagen formation, leading to compromised connective tissue integrity, bleeding gums, and joint pain, which are hallmark manifestations of scurvy (Offor et al. 2015).

It contains antioxidants that mitigate cellular oxidative damage and facilitate optimal immune system function. While the body only requires a small amount of vitamin C to prevent deficiency (around 60 mg per day, as you mentioned), ensuring adequate intake is still vital for maintaining the body's structural integrity and preventing conditions like scurvy. (Padayatty et al. 2013) (Sarkivayi et al. 2010)

The recommended amount of vitamin C per day may vary depending on age and individual health conditions, but typically it is 60 mg per day for adults. This amount can generally be met through a diet balanced in fruits and vegetables, that are high in vitamin C such as citrus fruits, strawberries, mango, bell peppers, and broccoli, (Ogbuanu et al. 2014) (Zaman et al. 2013) furthermore, it promotes the proper functioning of the immune system, and enhances the bioavailability of iron from plant-based foods. Furthermore, as an antioxidant,

Vitamin C is a potent antioxidant that plays a critical role in mitigating oxidative stress. Free radicals are highly reactive molecules that can induce cellular damage, contributing to the aging process and the pathogenesis of various diseases, including cardiovascular disorders. By scavenging these reactive species, vitamin C helps preserve cellular integrity and supports overall physiological health. and certain cancers. Research also suggests that it may help lower cholesterol and blood pressure, making it an important factor in cardiovascular health. (Zerati et al. 2014) (Harrison et al. 2014).

Fruits constitute the principal dietary vitamin C sources, contributing a approximately 90% of daily intake that is advised for humans. The concentration of vitamin C varies widely among plant species, with some containing extremely high levels—up to 5,000 mg/100 g. In contrast, animal-derived foods are generally poor sources, usually containing less than 30–40 mg/100 g. This makes plant sources essential for meeting dietary vitamin C requirements. However, in regions with limited vegetation, such as the Arctic, traditional populations have relied on alternative sources, including medicinal herbs such as extracts derived from pine needles, rose hips, and tree bark, as well as animal organs like raw liver and whale skin (Igwe 2014). Determining the amount of vitamin C present in fruits was the study's primary goal. A redox titration using a standardized iodine solution can be used to estimate the vitamin C (Anal et al. 2019).

UV/VIS spectrophotometric method was used to estimate the scorbic acid content of variety of fruits and vegetables sample . The procedure involved oxidation of the ascorbic acid with 2,4-dinitrophenylhydrazine (2,4-DNPH) at 37 °C. The resulting solution was then treated with 85 % H₂SO₄ ,resulting red-colored complex , with an absorbance of measured at 560 nm.

analysis showed that Ascorbic acid levels in fruits ranged from **0.841 mg/10 g to 17.416 mg/10 g**, with an overall average of **51.74 ± 1.868 mg/10 g**. Specifically, Ascorbic acid concentration in selected fruits were measured as follows: **banana—17.93 mg/L, kiwi—11.98 mg/L, and orange—18 mg/L.**(Malo et al .2000)

Researchers employed titration and spectroscopic techniques for quantifying the vitamin C content in both fresh and commercially available fruits. Their findings indicated that lemons and oranges showed the highest concentrations of vitamin C, while apples and grapes contained comparatively lower levels. The study concluded that the titration is a simple and dependable means of determination of ascorbic acid.(Mohammed et al. 2009). A previous study conducted in Al-Khums city estimate the vitamin C concentration in different varieties of oranges and lemons . Orange samples were analyzed by titrating their filtered juice directly with iodine solution. The results indicated that vitamin C concentration varied significantly among the different varieties. Specifically, the concentrations were approximately 6 mg/100 ml in sour oranges, 45 mg/100 ml in blood oranges, 69 mg/100 ml in mandarin oranges, 90 mg/100 ml in sweet oranges, and 76 mg/100 ml in lemons (Sharma et al .2019)

A study was conducted to estimate the vitamin C content in fresh samples of local fruits, including lemons, sweet oranges, sour oranges, peaches, strawberries, pears, and mangoes. The determination was carried out by titration with standardized iodine solution (Tee et al.1988)

The study compared two analytical methods titration and spectrophotometry to determine of vitamin C in various fruit types , including apples, oranges, lemons, tangerines, and grapes. In spectrophotometric method, potassium permanganate was used as an indicator, absorbance was measured ware conducted wavelength of 530 nm. Quantitative calibration was achieved via iodine titration. The results revealed no statistically significant difference between the two methods, suggesting that both are equally reliable for vitamin C analysis in fruits(Isam et al. 2017).

Rapid and cost-effective analytical techniques are becoming increasingly essential for facilitating timely decision-making in environmental and industrial contexts. a range of methodologies can be employed to quantify of vitamin C in fruit juices using including classical titration, spectrophotometric assays, biological testing approaches, electrochemical techniques (such as voltammetry, fluorometry, and potentiometry), as well as chromatographic methods (Desai et al .2019)(Rardas et al.2004).

2. Method

2.1. Sample preparation

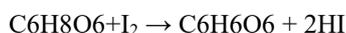
Sample collection was conducted the months during November and December 2024, where fresh lemon, sweet orange, sour orange and peach samples were obtained from a regular market in Darna , Table (1) shows the samples used and their corresponding numbers. After collecting the samples, they were washed well with water. To extract the juice, the edible portions were chopped into small pieces and homogenized using an electric blender. The resulting mixture was filtered through muslin cloth, and the filtrate was calibrated on the same day.

Table (1) samples used in study

S.N	S.n	S.N	S.n
1	Lemon	5	Kiwi
2	Sweet Orange	6	Mango
3	Banana	7	Blood orange
4	Peach	8	sour orange

2.2 using iodine solution for Redox titration

This method measure the concentration of vitamin C in a solution by performing a redox titration with iodine. Vitamin C, also called as ascorbic acid or L(+)-ascorbic acid, is an organic compound that belongs to the class of butanolides. During the titration, iodine is reacts with ascorbic acid , oxidizing it to dehydroascorbic acid, while the iodine itself is reduced to iodide ions. The reaction can be represented as:



2.3 . Preparing solution

2.3.1 iodine solution(0.1N)

A 0.05% iodine solution was prepared as follows: Accurately weigh approximately 2.0 grams of KI and 1.278 grams of iodine crystals, and dissolve them together in a little distilled water. The solution was transferred quantitatively to a 1-liter volumetric flask and made up to volume with distilled water. [19]Adjusting the Molarity of Iodine Solution Accurately weigh approximately 15% of arsenic trioxide (As) that was dried for 1 hour. Then Dissolve it in 20 ml of 1 M NaOH with gentle heating. Subsequently Dilute the resulting solution with 40 ml of distilled water, and add approximately 0.1 ml of methyl orange as indicator. Add drops of dilute HCl until the color turns yellow to pink. Add 2 grams of Na₂CO₃, and dilute the solution by adding 50 ml of distilled water. Add 30 ml of starch reagent to the solution , and titrate the solution with iodine solution until the appearance of persistent a blue color . the iodine solution should be Store glass bottle in an upright position.

2.3.2 starch indicator Solution (0.5%)

the starch indicator solution, was prepared by accurately weight 0.250 g of soluble starch and transferring to a 100-mL beaker. Distilled water (50 mL) was brought to a gentle boil, subsequently , starch was added slowly under continuous stirring. while The mixture was maintained at boiling temperature until the starch dissolved completely, yielding a 0.5% (w/v) starch indicator solution. The solution was then allowed to reach room temperature before use.

2.4 Preparation of sample solution

Accurately measure and Withdraw 10 g of the liquid sample then transfer the aliquot into a clean conical flaska Add 5 mL of 1% starch solution and 100 mL of distilled water. Mix the contents thoroughly.

2.5 Estimation of vitamin C content in fruit using iodine redox titration .

To estimate the ascorbic acid content in fruit using iodine redox titration, first fill the burette with 0.1 N iodine solution and cover it completely with cellophane to protect it from light. Similarly, cover the titration flask entirely with cellophane to prevent light exposure. Pierce the cellophane covering the titration flask with the burette tip, then titrate 10 mL of the sample with the iodine solution. Add the iodine slowly continue the titration until a blue color appears . Repeat the procedure titration three times to ensure accuracy and reproducibility.

3. Results and Discussion

The amount of can be calculated using the following relationship

1 mL of iodine solution (0.1 N)= 0.008807 g of ascorbic acid and through equation :

1ml of I₂= 176.14/1000 * 10 * 2 = g of ascorbic acid

Where the number (176.1400) represents the molecular weight of vitamin C Including the weight of the acid in grams in the titrated solution the average volume of iodine consumed x 0.008807

Table (2) vitamin content of the studied samples.

Sample Number	First Burette readings (cm ³)	Second Burette readings(cm ³)	Third Burette reading (cm ³)	Mean	Vitamin C (g/10g)	vitamin C (mg/100g)	Standard deviation (SD)
1	1.0	1.1	1.2	1.1	0.0096	96	-0.62
2	1.2	1.3	1.4	1.3	0.0114	114	-0.568
3	1.2	1.0	1.0	1.06	0.0093	93	-0.628
4	1.1	0.9	1.2	1.06	0.0932	93	1.764
5	1.9	1.8	2.0	1.9	0.0167	167	-0.417
6	1.2	1.1	0.8	1.03	0.0907	90	1.693
7	1.09	1.05	1.1	1.08	0.0095	95	-0.623
8	1.15	1.18	1.19	1.17	0.0103	103	-0.600

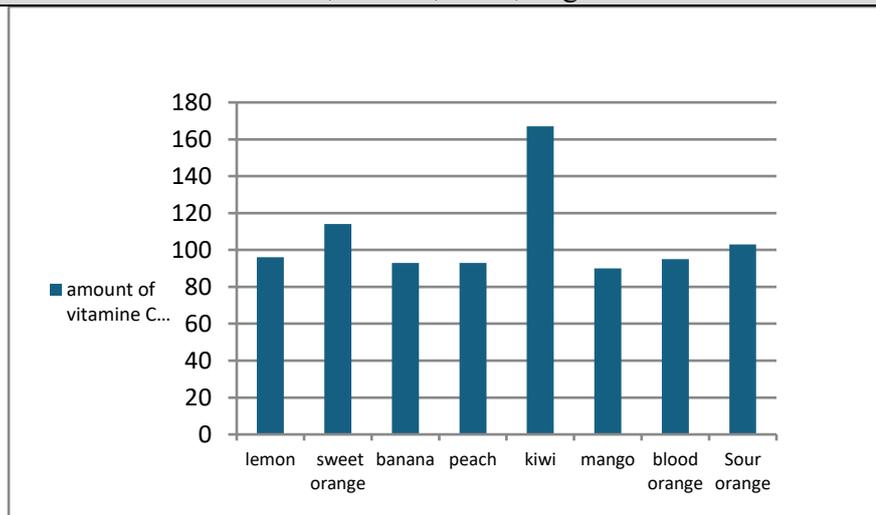


Figure 3: Different level of vitamin C concentration present in some fruits

Table 2 shows that the lemon samples contained 0.0096 g/10 g, corresponding to 96 mg/100 g of ascorbic acid, a value higher than those reported in earlier studies (Ogbuanu et al . 2014) (Zeraati et al. 2014) In contrast, the orange samples—including sweet, sour, and blood varieties—exhibited ascorbic acid concentrations ranging from 95.1 to 114 mg/100 g, also exceeding previously reported values (Zeraati et al. 2019) .

banana sample contained 93 mg/100 g of vitamin C, surpassing the values documented in earlier studies(Anal et al. 2013) . Notably, this concentration is substantially higher than the highest values previously reported, which ranged from 18.65 to 28.0 mg/100 g (Malo et al .2000).

Peach samples contained 93 mg/100 g of vitamin C, while kiwi samples exhibited the highest concentration among all evaluated fruits, reaching 167 mg/100 g. Mango samples reached 90.4 mg/100 g. All of these finding indicate values notably higher than those reported in prior studies (Offor et al . 2015) (Zeraati et al. 2014)here concentrations ranged from 56.5 to 77.1 mg/100 g.

The higher vitamin C concentration observed in most samples in the present study, compared to previous reports, may be attributed to the use of fully matured fresh fruits. Vitamin C levels are known to be influenced by storage conditions and temperature. Alternatively, the higher values may reflect differences in the analytical methodology, which is highly dependent on the precision of the analyst.

Conclusion

The study demonstrated that vitamin C concentrations exhibit significant variability across different types of samples and even among samples of the same category. These variations are shaped by a rang of factors, such as growth and harvesting conditions, storage practices, temperature, and analytical methodologies. Notably, elevated temperatures were found to accelerate the degradation of vitamin C.

Analysis confirmed that vitamin C concentration in the selected samples generally fell within the range considered acceptable. Specifically, the consumption of 100 grams of any of the fruits analyzed—except for kiwi—aligns with the recommended daily intake of 100 mg per kilogram of body weight, as established by FAO/WHO in conjunction with the European Union Scientific Committee on Food (EU SCF).

Overall, the findings underscore the nutritional and antioxidant significance of locally available fruits. Kiwi and citrus fruits, particularly lemons and oranges, were identified as excellent sources of vitamin C. These results support dietary recommendations advocating for the inclusion of a diverse array of fresh fruits, with a focus on citrus varieties, to enhance antioxidant intake, strengthen immune health, and lower the risk of chronic diseases.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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