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Estimation of Vitamin C (ascorbic acid) Concentration in selected fruit samples by volumetric and UV-Spectrophotometry methods

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Abstract

Ascorbic acid is an important water-soluble vitamin required for neurotransmitter synthesis. Humans cannot manufacture ascorbic acid because they lack the gulonolactone oxidase enzyme, forcing them to rely on fruits and vegetables. Vitamin C is a six-carbon lactone which acts as an antioxidant in biological fluids and has therapeutic properties. The ascorbic acid content of ten (10) selected fruits was purchased from a local market across Ilorin metropolis and the concentration of ascorbic acid in these fruits was evaluated using volumetric and UV-spectroscopic methods. The findings are presented as mean ± standard deviation. Orange had the highest ascorbic acid concentration at 26.78 ± 2.19 mg/100g, while lemon had the lowest at 10.13 ± 1.54 mg/100g. When comparing the two methods, the spectroscopy method was found to be more effective than the titrimetric method for determining ascorbic acid levels. These findings clearly indicate that a wide range of fruits can be ingested to achieve the daily vitamin C requirements at a reasonable cost.

Key words: ascorbic acid; concentration; fruits; UV- spectroscopic; volumetric.

1. Introduction

L-ascorbic acid, often known as vitamin C, was discovered to be a crucial component in the treatment of scurvy (scorbutus in Latin; hence, "a-scorbutus"). The name vitamin C was created as a replacement for the phrases "fat-soluble vitamin A" and "water-soluble vitamin B," which were previously in use (Gonzalez-Fuentes, 2018). The most crucial vitamin in fruits and vegetables is vitamin C (also known as ascorbic acid). Fruits and vegetables provide the majority of the vitamin C in human diets, accounting for over 90% (including potatoes). The phrase "vitamin C" refers to any substance that exhibits L-ascorbic acid's biological activity. Although L-dehydroascorbic acid, an oxidation byproduct, also has biological activity, ascorbic acid is the most physiologically active form (Vasanth et al., 2013).

The primary reason vitamin C is so popular with the general public is its antioxidant properties. This is demonstrated by the body's extremely high vitamin C concentration compared to other vitamins. The amount of vitamin C in the human body is estimated to be roughly 1.5 g, or 20 mg/kg. Human daily needs are difficult to determine since they depend on many factors, such as physiological state, stress levels, and overall health (Langlois et al., 2019; Baker and Maria, 2021). Depending on the country, recommendations range from 40 to 120 milligrams per day (Zhan et al., 2019). This dosage reflects the estimated average dietary requirement for vitamin C in humans. The suggested dosage for pregnant women is an additional 5–10 mg (25 mg for lactating mothers) (Padayatty and Levine, 2016).

The majority of vitamin C consumed today comes from fruits and vegetables, which are now more readily available in many countries than in the past (de Carvalho et al., 2019). Additionally, potatoes and soft drinks, particularly juices, contribute significantly. Even though most vertebrates can produce

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vitamin C, the amount of vitamin C found in animal sources is typically low, except for some fish eggs and the rarely consumed livers of cattle.

Most people obtain the majority of their recommended daily intake of vitamin C by regularly consuming fruits and fruit juices. The species composition varies by region. Star fruit, guava, black currant, kiwi, and strawberry are reliable sources worldwide. Citrus fruits provide a slightly lesser quantity of vitamin C than the richest sources but still contain sufficient amounts (Ellong et al., 2016).

The structure of the L-ascorbic acid molecule (C6H8O6), which has six asymmetric carbon atoms, is similar to that of glucose. Ascorbic acid's physical and chemical properties are determined by its chemical structure (Calder et al., 2009).

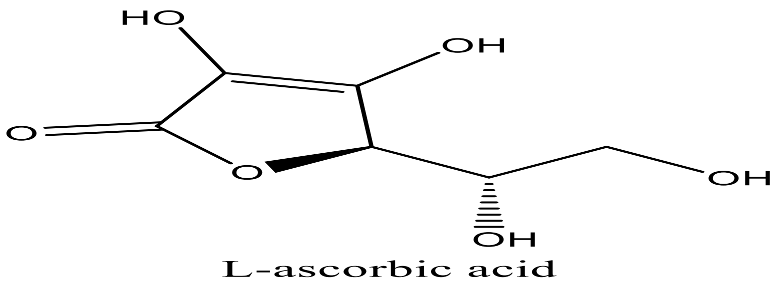

Figure 1: Chemical structure of Vitamin C (Baker and Maria, 2021)

The iodometric technique, used to measure vitamin C levels, works on the fundamental premise that an iodine solution will oxidize ascorbic acid in an acidic environment to form dehydroascorbic acid (Ashor et al., 2019; Baker and Maria, 2021).

$$KIO_3 + 5KI + 3H_2SO_4 \rightarrow 3K_2SO_4 + I_2 + 3H_2O \quad (1)$$

$$I_2 + 2Na_2S_2O_3 \rightarrow 2I^- + S_4O_6^{2-} \quad (2)$$

$$C_6H_8O_6 + I_2 \rightarrow C_6H_6O_6 + 2I^- + 2H^+ \quad (3)$$

To avoid interfering with the I_2 and $C_6H_6O_6$ reactions, the starch is introduced as the titration nears its endpoint. The quantity of sodium thiosulfate used in the titration determines how much vitamin C is present in the sample (Helmenstine, 2019). The estimation of vitamin C concentration in selected fruit samples using volumetric and UV-spectrophotometry methods reveals the efficiency and complementarity of these two techniques. While volumetric titration provides a simple, accessible, and relatively accurate method for determining vitamin C content, UV-spectrophotometry offers greater precision and sensitivity, particularly for low concentrations. The comparison of results from both methods validates the findings and highlights the importance of using multiple techniques in chemical analysis. This study emphasizes the nutritional value of fruits and provides valuable insights for food science, nutrition, and health-related research.

2. Materials and Method

Ten freshly picked, delicious fruits were bought from sellers around the university's campus in the University of Ilorin, and Tanke road, Ilorin, Nigeria. The juices were extracted from the orange, lime, watermelon, mango, lemon, and tangerine fruits after the peels were peeled and split in half transversely (before carefully picking out the seeds from the juice). The pineapple, apple, avocado, and banana fruits were individually mashed into fine pastes, then filtered using a cheese cloth.

Ascorbic acid levels is determined by iodometric titration when iodine react with starch to form a blue-black starch-iodine colour. The ascorbic acid is oxidized to dehydroascorbic acid while the iodine is reduced to iodide ions.

$$C_6H_8O_6 + I_2 \rightarrow C_6H_6O_6 + 2I^- + 2H^+ \quad (4)$$

By titrating the iodine reagent against 25ml of 1.00% ascorbic acid solution (to which three drops of 1% starch were added) until the blue starch-iodine hue appeared, the reagent was standardized. 25ml of the remaining samples underwent the same procedure (Helmenstine, 2091). Preparation of Iodine solution was done by dissolving 5.00 g Potassium Iodide (KI) and 0.268g Potassium Iodate (KIO_3) in 200 ml of distilled water, then 30 ml of 3 M Sulfuric acid (H_2SO_4) was added to the solution and transferred into a 500 ml graduated cylinder and diluted it to a final volume of 500 ml with distilled water. The concentration of ascorbic acid was determined by titremetric analysis techniques (Ikewuchi and Ikewuchi, 2010).

$$\text{Concentration in mg/100ml} = \frac{titre\ fron\ titration\ of\ the\ sample\ solution}{titre\ fron\ titration\ of\ the\ standard\ solution} \quad (5)$$

3. Result and Discussion

The result of estimated ascorbic acid using titremetric and uv-visible analysis technique is presented in Table 1:

S/N	Sample	pH	Colour	Alkaloid	Glicoside	Flavonoids	Vitamin C in (mg/ml)	UV analysis results (mg/ml)
1.	Orange	5.8	Light yellow	+ve	+ve	+ve	0.269	0.234
2.	Pineapple	4.5	Yellow	+ve	+ve	-ve	0.204	0.198
3.	Watermelon	5.2	Red	+ve	+ve	+ve	0.168	0.176
4.	Apple	4.5	Green	+ve	+ve	+ve	0.120	0.134
5.	Banana	5.4	Cream	+ve	+ve	+ve	0.242	0.124
6.	Lime	3.2	Light green	+ve	+ve	+ve	0.191	0.097
7.	Avocado	5.9	Green	+ve	+ve	+ve	0.250	0.123
8.	Lemon	2.9	Transparent yellow	+ve	+ve	-ve	0.269	0.207
9.	Mango	4.4	Pale yellow	+ve	+ve	+ve	0.165	0.131
10.	Tangerine	3.5	Orange	+ve	+ve	-ve	0.227	0.206

A total of 10 fruits were studied, Vitamin C content, phytochemicals, and physiochemical parameters of the 10 types of fruits is tabulated in Table 1. It shows presence or absence of flavonoids, alkaloids, glycoside and also the pH and colour of each sample.

It is evident that from the result obtained in the titrimetric method of vitamin C determination, ascorbic acid was used as reference standard in the titrimetric method. It was seen that orange has the highest vitamin C content of all the fruits samples analyzed followed by avocado fruit extract with a concentration of 0.250 mg/100ml and then banana with a concentration of 0.242 mg/100ml. The lowest vitamin C content was Mango with concentration 0.165mg/100ml. Other reducing components in food (other than ascorbic acid) might affect the result since the iodometric titration method is based on the oxidation-reduction process. The ascorbic acid can be reduced by a wide variety of compounds (such as phenols, sulphydryls, and triose reductones) as well as ions (such as ferrous, cuprous, or sulphite), which can lead to erroneously high titration findings. Generally, interference can be overcomeby adjusting the pH and other reaction conditions so that most other materials react only very much more slowly than does ascorbate (Nwese et al., 2015). The amount of ascorbic acid (vitamin C) in fruits can also be influenced by environmental factors including climate, temperature, and the quantity of nitrogen fertilizers used to grow the plant. Environmental factors like light can also have an impact (Motora, 2017). Another major practical problem associated with the titrimetric method of ascorbic acid is the difficulty in ascertaining endpoint when the food extracts are coloured, especially reddish purplish colors.

4. Conclusion

In conclusion, the estimation of Vitamin C (ascorbic acid) concentration in selected fruit samples using both volumetric titration and UV-spectrophotometry methods demonstrates the effectiveness of these techniques in determining nutrient content. While volumetric titration provides a simple and cost-effective approach, UV-spectrophotometry offers greater sensitivity and precision. The results from both methods highlight the variation in Vitamin C levels across different fruit samples, emphasizing the importance of method selection based on the required accuracy and available resources for such analyses.

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