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IODOMETRIC DETERMINATION OF THE VITAMIN C CONTENTS OF SELECTED CITRUS FRUITS SOLD IN LAFIA METROPOLIS

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ABSTRACT

This study aimed at determination of vitamin C content of five citrus fruits sold in Lafia metropolis using iodometric method of titration. Vitamin C concentrations of the juices and fibers from the five citrus fruits were compared. The results obtained indicated that orange juice had the highest vitamin C concentration of 53.5 mg/100L followed by grapefruit (51.30 mg/100L), lemon (36.3mg/100L), tangerine (30.40 mg/100L) and lime (24.70 mg/100L). Similar trend was also followed in the vitamin C contents of citrus fruit fibers with the order: orange (2.80 mg/10g) > grapefruit (2.60 mg/10g) > lemon (1.00 mg/10g) > tangerine (0.70 mg/10g) > lime (0.20 mg/10g). The results clearly showed that the juice of studied citrus fruits had higher contents of vitamin C than their fibers. The orange is highly rich in vitamin C content followed by grapefruit while lime was of the lowest concentration in both the juice and fiber. Lemon and tangerine had moderate concentrations of vitamin C in both their juices and fibers. This analysis provides essential insights into the nutritional variability of the different citrus fruits, aiding consumers in making informed dietary decision and potentially offering valuable information for the food industry.

Key Words: Vitamin C, Citrus fruits, Iodometric titration, Lafia metropolis.

1.0 Introduction

Vitamins are organic substances found in most natural foods in rather small amounts and required by the organism in also small amount for the conduct of several chemical and biochemical processes on which the attainment of good nutritional health depends (Budiarto *et al.*, 2023).It can also be defined as organic compounds which occur in natural foodstuffs, either as such or as utilizable precursors, and which are necessary usually in minute's amounts, for normal growth maintenance, reproduction and health in animals (Kareem and Jabir, 2020).

Ascorbic acid is of great importance in biochemical reactions as a reducing agent (Moeslinger *et al.*, 1995; Rahman *et al.*, 2006; Wonsawat, 2006; Fadhel, 2012). Vitamin C is the L-enantiomer of ascorbic acid, it is a water-soluble vitamin used by the body for several purposes. It is the most important vitamin in fruits and vegetables. Most animals can synthesize their own vitamin C, except human and other primates (Kumar *et al.*, 2013).

Vitamin C differ from other organic compounds of the diet in that they do not enter into the structure of tissues (at least in the normal sense, although certain of them may function by stabilizing the integrity of cell membranes) nor do they undergo metabolism to provide energy (Ball, 1998). The discovering of vitamins, the so-called accessory food factors is one of the

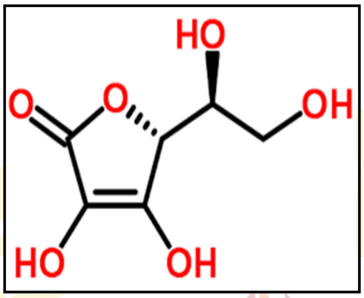

Figure 1: Structure of Ascorbic Acid

great achievements of the 20thcentury (Honarbakhsh. and Schachter, 2008).This great contribution to the science of animal and human nutrition was, in the main, conceived in terms of somewhat nebulous food principles brought to function in terms of modern chemistry and production virtually with the spam of one generation.

Although nutritional deficiency diseases such as scurvy and rickets has been down for centuries, their causes were either unknown or wrapped in mystery and also their treatment remain empirical. However, even in the 18th and 19th centuries, it was recognized that some diseases were related to diet (Morrissey and Hill, 2009).

Dumes J.B.A (1800 to 1884) seems to have been the first practical scientist to question the adequacy of human diet based solely on protein, fats, carbohydrates and minerals. By 1900, several scientists all over the world carried out experiments that led to the conclusion that purified diets were unable to support life and production in animals as diverse as rats, chicks and dogs. It seemed clear that certain foodstuffs must contain small amount of substances essential for vital processes (Liu *et al.*, 2019).

Funk (1912) propounded the etiology of deficiency diseases. Funk stated that beriberi, scurvy, pellagra and perhaps rickets were nutritional diseases caused by a lack of special substances which are of the nature of organic bases, which were called vitamins. The concept took some years to establish, but opened the way for modern nutritional research. By the end of the next four decades nearly all the presently known vitamins were discovered, isolated, identified and synthesized (Liu *et al.*, 2019).

Citrus fruits, such as oranges, lemons, and grapefruits, are rich in vitamins, particularly vitamin C. Vitamin C is an essential nutrient that supports immune function, collagen production, and acts as an antioxidant. Citrus fruits also contain smaller amounts of other vitamins, such as vitamin A, vitamin B6, and vitamin E, as well as minerals likepotassium and magnesium. Including citrus fruits in your diet can help boost your vitamin intake and support overall health (Budiarto *et al.*, 2023).

It is worth noting that the vitamin C content in citrus fruits can vary. Factors such as ripeness, storage conditions, and the specific fruit variety can influence the vitamin C levels. For example, freshly picked and ripe citrus fruits tend to have higher vitamin C content than those that have been stored for extended periods (Aurelia *et al.*, 2011).

Vitamin C is known for its antioxidant properties. Antioxidants are essential because they help protect our cells from damage caused by free radicals, which are unstable molecules that can lead to various health issues, including cancer and heart disease (Carr and Maggini, 2017).

Additionally, vitamin C is a key component in collagen synthesis, a protein that is crucial for the health of our skin, tendons, and blood vessels. It also aids in wound healing, and boosts the immune system, helping the body fight off infections and illnesses (Colado and Fontella, 2015). Ascorbic acid is a water soluble vitamin required in the body for the up keep of all enzymatic actions, healing of wound and regeneration of body cells (Colado and Fontella, 2015). The deficiency of vitamin C (Ascorbic acid) in the body leads to a diseases condition known as scurvy (Colado and Fontella, 2015).When not properly treated it predispose the affected individual to tooth decay and falling of teeth, brittle bones and inability of wounds to heal (Colado and Fontella, 2015).Fruits are the main source of (vitamin C) Ascorbic acid. Some fruits contain more ascorbic than others disease (Carr and Maggini, 2017).

This study therefore aimed at determination of the vitamin C contents of different citrus fruits sold in Lafia and, to compare their vitamin C contents in juices and fibres. And to the best of knowledge of the data available on the literature this study has little or no data in Lafia metropolis.

2.0 Materials and Methods

2.1 Chemicals and Apparatus

All the chemicals used for the experimental purposes were of analytical grade and used without further purification. The chemicals used for this study include: doubly distilled water, soluble starch (10 g), solid potassium iodate ($KIO_3$10 g), solid potassium iodide (KI, 25 g) and 3 M sulphuric acid (H_2SO_4) (Dereje and Girma, 2015).

Apparatus: Burette, retort stand, tile, funnel, 250 cm^3 conical flask, Buchner funnel, Cheesecloth, 20 cm^3 Pipette, 25, 50, 100 and 500 cm^3 measuring cylinders, 250 cm^3 beaker, a knife, cutting board, filter papers, spatula and digital weighing balance (Dereje and Girma, 2015).

2.2 Description of Study Area

Lafia local area government area has a population of 374,000 people. It has a geographic coordinate of 8^{o}29′30″N 8^{o}31′0″E and altitude of 181.5m above sea level. It is known for its commercial activities in which Lafia modern market is included (NEITI, 2013).

Lafia modern market where the samples were collected is located at Lafia town which is on latitude 8^{o}35N, Longitude 8^{o}32E and altitudes 181.53 m above sea level with mean temperature of 34 ^{o}C (NEITI, 2013).

2.3 Sample Collection

Fresh fruits samples were collected from Lafia modern market, Makurdi road, Lafia, Nasarawa State. The samples used in this study were orange (*Citrus sinensis*), lime (*Citrus aurantiifolia*),

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lemon (*Citrus limon*), grapefruit (*citrus aurantium f. aurantium*) and tangerine (*Citrus reticulate*), which were the most common citrus fruits present at Lafia modern market. Samples were thoroughly cleaned with water to remove dust and unwanted particles (Bekele and Geleta, 2015).

2.4 Preparation of sample fruit juices and fibres from the different citrus fruits

One piece of each of the citrus fruit sample (orange, lime, lemon, grapefruit and tangerine) was weighed, peeled and crushed/extracted with ZHDBD commercial manual juicer/juice extractor machine (an industrial fruit press, model - ZHDBD) to get all the juice into pre-washed beaker. The juice was obtained by filtering through cheesecloth (clean cotton cloth) to remove any pulp and seed. The volume of each fruit juice was measured using 100 cm^3 measuring cylinder. Then, the juice was made up to 100 cm^3 with distilled water and transferred back to the beaker. This formed sample 1 of the fruits varieties which were used for titration. The mass of the fruit and volume of the juice from each fruit were recorded. Ascorbic acid is susceptible to oxidation by atmospheric oxygen over time. Thus, the samples were freshly prepared and titrated immediately. The mass of the fruit and the volume of its juice were used for the calculation of concentration of ascorbic acid in each citrus fruit (Fatin and Azrina, 2016).

The fibers of each citrus fruit were dried for a period of one week, and then ground to powder which was then soaked in water for two hours and then, titrated against the standardized iodine solution (Fatin and Azrina, 2016).

2.5 Preparation of 1% Starch Indicator Solution

Distilled water (200 cm^3) was heated in a beaker on the stove to a temperature of about 80°C and soluble starch (2 g) was added to it. The solution was then stirred for 15 minutes to dissolve the starch and then the beaker removed from the burner and the solution, allowed to cool (Budiarto *et al.*, 2023).

2.6 Preparation of Standard Iodine Solution

A standard iodine solution was prepared by dissolving 0.26 g Potassium iodate (KIO_3) and 5 g potassium iodide (KI) in some distilled water in a 500 cm^3 volumetric flask. The KI was in excess. The solution was acidified by adding 3M sulphuric acid (30 cm^3). The mixture was swirled and the volume of solution made to 500 cm^3 with distilled water. The flask was stoppered and shaken to ensure homogeneity of content. The Equation 1 as used by Izuagie and Izuagie (2007).

was used to calculate concentration of the Iodine (I_2) in the solution.

$$IO_3{}^- + 5I^- + 6H \rightarrow 3I_2 + 3H_2O \quad (1)$$

Thus, using the Equation 1, the concentration of the iodine solution was determined as '$7.8 \times 10^{-3} M'$

2.7 Determination of the vitamin C concentration in fruit juices and Fibres

Vitamin C (Ascorbic acid) concentration was determined according to the method used by Nweze *et al.* (2015).The prepared sample juice (20 cm^3) was pipetted and transferred into 250 cm^3 conical flask and then followed by 1% starch solution (10 drops) and 1M H_2SO_4 (10 cm^3). It was then titrated with the standard iodine solution. The iodine oxidized the ascorbic acid to dehydroascorbic acid as the iodine was reduced to iodide ions. The results were recorded and the amount of ascorbic acid was calculated using mole ratio from the reaction equation:

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

A convenient, and common, oxidizing agent is iodate ion, $IO_3{}^-$

$IO_3{}^-$ (iodate) oxidizes I^- (iodide) to I_2 (iodine)

$$IO_3{}^- - 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O \quad (3)$$

Liberated I_2 (iodine), oxidizes $C_6H_8O_6$ (Reduced Ascorbic Acid) to form $C_6H_6O_6$ (Dehydro-ascorbic acid)

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

The amount of vitamin C in the citrus fruit samples were determined using the formulas

$$M_1V_1 = M_2V_2 \quad (5)$$

Where

M_1 is the molar concentration of ascorbic acid

V_1 is the volume of the juice extract taken for titration

M_2 is the molar concentration of the iodine solution

V_2 is the volume of the iodine solution at which it turns the extract blue-black

Concentration of ascorbic acid in g/L=$(M_1 \times mm)$

Concentration of ascorbic acid in mg/L = $(M_1 \times mm \times 1000)$

Concentration of ascorbic acid in mg/100mL = $(M_1 \times mm \times 100)$

*mm = molar mass in g/mol

3.0 Results and Discussion

3.1 Concentration of vitamin C in different citrus fruit juice samples

The results obtained from the iodometric titration for various citrus fruits exhibited variations in their ascorbic acid (Vitamin C) content. Vitamin C (Ascorbic acid) contents of the different citrus fruit juices were significantly higher than those of their fibers. The results from Table 1 indicated that orange juice had the highest concentration of ascorbic acid at 53.5 mg/100 L, indicating its richness in vitamin C, followed closely by grapefruit at 51.3 mg/100 L, and then lemon juice with value of 36.3 mg/100 L. Lime and tangerine juices displayed relatively lower concentrations of Vitamin C, with values of 24.7 mg/100L and 30.4 mg/100 L, respectively.

Table 1: **Various Expressions of Concentrations of Vitamin C in Different Citrus Fruit Juices**

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Fruit Samples	Concentration of Vitamin C in		
	g/L	**mg/L**	**mg/100 mL**
Orange	0.535	535	53.5
Lemon	0.363	363	36.3
Grapefruit	0.513	513	51.3
Lime	0.247	247	24.7
Tangerine	0.304	304	30.4

Factors such as variations in species, ripeness at harvest, storage conditions, and processing methods could contribute to these discrepancies (Aurelia *et al.*, 2011). Considering the results, individuals aiming to meet their daily Vitamin C requirements can strategize their fruit intake accordingly. For example, the higher concentration of Vitamin C in orange and grapefruit juice (53.5 mg/100 L and 51.3 mg/100 L, respectively) suggests that consuming these fruits juices can significantly contribute to meeting daily Vitamin C needs. Incorporating these fruits into one's diet, whether through direct consumption or freshly squeezed juices, can be an effective means of obtaining this essential nutrient. On the other hand, while lemon, lime, and tangerine juices exhibited slightly lower concentrations of Vitamin C (36.3 mg/100 L, 24.7 mg/100 L, and 30.4 mg/100 L, respectively), they still contribute meaningfully to daily intake. While their Vitamin C content might be slightly lower compared to oranges or grapefruits, consuming these fruits regularly can supplement one's overall Vitamin C intake. Individual dietary needs, taste preferences, and availability might influence the choice of citrus fruits. However, by incorporating a variety of these fruits into the diet, individuals can ensure a diverse intake of nutrients, including Vitamin C. For instance, combining oranges or grapefruits with lemons, limes, or tangerines in meals or as snacks can provide a balanced and rich source of Vitamin C.

3.2 Concentration of vitamin C in the fibres of the citrus fruits

The obtained results from analyzing the Vitamin C content in the fibers of various citrus fruits showcase interesting variations in the concentration of this essential nutrient (Table 2). These findings shed light on the potential nutritional benefits that these fruits, particularly their fibrous parts, offer to individuals seeking Vitamin C in their diet. Looking at the results, orange fibers exhibited a notably high Vitamin C content at 2.80 mg/10 g, affirming their nutritional value beyond just the juice. Grapefruit fibers followed closely behind at 2.60 mg/10 g, demonstrating their relevance as a source of this essential nutrient even in their fibrous form. On the other hand, lemon and tangerine fibers showed slightly lower concentrations of Vitamin C at 1.00 mg/10 g and 0.70 mg/10 g, respectively. Lime fibers displayed the lowest concentration among the tested fruits at 0.20 mg/10g. Understanding the Vitamin C content in citrus fruit fibers is crucial as it underscores the potential benefits of consuming these fruits whole or in less processed forms.

Table 2: **Concentration of vitamin C in the fibres of the citrus fruits**

Fruit Sample	Concentration of vitamin C in the Fibres of Citrus Fruits	
	mg/g	mg/10 g
Orange	0.280	2.80
Lemon	0.100	1.00
Grapefruit	0.260	2.60
Lime	0.020	0.20
Tangerine	0.070	0.70

This study was similar to works done by Izuagie and Izuagie (2007), Ikewuchi and Ikewuchi (2011) and Huma *et al.* (2015) where orange had the highest content of vitamin C followed by grapefruit.

However, a study done by Dereje and Girma (2015) showed that lemon had higher content of vitamin C than orange, contrary to the findings of this present work. This may be attributed to factors such as variations in species, ripeness at harvest, storage conditions, and processing methods (Aurelia *et al.*, 2011).

4.0 Conclusion

The sequence of vitamin C contents in citrus fruit juice and fiber order of decrease was: orange > grapefruit > lemon > tangerine > lime. Considerable amount of vitamin C present in these fruits showed that when they are consumed in relative large amount, they will certainly contribute to the daily human dietary intake of the vitamin.

This study also indicated that vitamin C is not just present in citrus fruit juices alone but also in their fibers. Thus, the fruit fibers should also be consumed to get more vitamin C.

This research provides essential insights into the vitamin C nutritional variability of the different citrus fruits, aiding consumers in making informed dietary decision and potentially offering valuable information for the food industry.

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Conflict of Interest

The authors declare no conflict of interest.

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