BIU Journal of Basic and Applied Sciences 7(1): 53 – 61, 2022.

ISSN: 2563-6424

COMPARATIVE DETERMINATION OF VITAMIN C CONTENT OF FRESH FRUIT JUICE OF SELECTED 'EXPENSIVE' AND 'LESS EXPENSIVE' FRUITS IN OKHA MARKET IN BENIN CITY, EDO STATE, NIGERIA

***OKUNGBOWA, A. I., CHUKWUEMEKE-NWANI, P. O., MWESIGWA, L. S., OMOARELOJIE, F. O. AND ADESINA-OJOBARO, A. G.**
Biochemistry Unit, Department of Biological Sciences, Benson Idahosa University, Benin City, Edo State, Nigeria
*Corresponding author: aokungbowa@biu.edu.ng

ABSTRACT
There is increasing concern over micronutrient malnutrition, especially in low and middle-income countries, resulting in poor health and higher morbidity and mortality rates. Vitamin C, one of the essential micronutrients, is a water-soluble antioxidant vitamin that plays pleiotropic cellular roles in human health. A 'healthy-is-expensive' intuition may account for the reduced consumption of some low-cost fruits that are also good sources of vitamin C. This study assessed the vitamin C content of some fresh fruits purchased from Okha market in Benin City, Edo State, Nigeria. The less expensive fruits included sweet orange, key lime, tomatoes and lemon, while the expensive fruits were apples, pineapples, watermelon and grapes. They were washed, peeled and juice obtained by squeezing, blending and sieving. Vitamin C concentration of each juice was determined by Iodometric titration and compared with standard vitamin C. Results showed that sweet orange had the highest concentration of vitamin C (61.22mg/100ml) followed by tomatoes (38.16 mg/100ml), lemon (35.92mg/100ml), key lime (30.20 mg/100ml), pineapple (27.35 mg/100ml), watermelon (23.67), grape (18.78 mg/100ml) and apple (8.16 mg/100ml). Therefore, the less expensive fruits have a higher concentration of vitamin C than the expensive ones, thereby serving as an affordable and adequate source of the vitamin.

KEY WORDS: *Vitamin C, Antioxidants, Iodometric titration, Fruits, Vegetables*

INTRODUCTION

Fruits and vegetables are sources of essential vitamins and minerals. A high intake of fruits and vegetables is linked to a lowered risk of non-communicable diseases (NCDs) including cardiovascular disease, glaucoma, type 2 diabetes and cancer among others (Aune *et al*., 2017). The intake of fruits and vegetables is particularly important in settings where micronutrient deficiencies are prevalent (Anjorin *et al*., 2019). About 3.0% (approximately 1.7 million) of deaths are attributable to low fruits and vegetable consumption globally (Okop *et al*., 2019). Insufficient intake of fruits and vegetables accounts for about 14% of gastrointestinal cancer deaths, 11% of ischaemic heart disease deaths and 9% of stroke deaths (WHO and FAO, 2005). In Nigeria micronutrient deficiencies are a significant problem that has persisted for decades. Affordability is one of the critical determinants of daily fruit and vegetable consumption among low-income households despite the availability of diverse fruits and vegetables in many urban areas (Okop *et al*., 2019; De Filippo *et al*., 2021).

Vitamin C ($C_6H_8O_6$) is an essential water-soluble vitamin present in fruits, vegetables and foods. The term vitamin C is commonly used to describe Hexuronic acid, cevitamin acid or xiloascorbic acid even though the representative is ascorbic acid (Jose and María-Del, 2013). The term vitamin C is not only used for ascorbic acid, but it includes all compounds exhibiting biological activity such as oxidized, ester and synthetic form. The main biological form of vitamin C is L-ascorbic acid, and it can reversibly change to an oxidized form called dehydroascorbic acid (Fenoll and Martinez, 2010). Most plant and animal species can synthesize vitamin C from glucose and galactose via the uronic acid pathway, but humans and other primates are unable to do so because they lack the L-gulono-1,4-lactone oxidase enzyme which catalyzes the conversion of L-gulono-g-lactone to ascorbic acid- the final step in vitamin C biosynthesis (Linster and Schaftingen, 2007). Therefore, more than 90% of the vitamin C in human diets is supplied by fruits and vegetables.

Vitamin C participates in several biochemical processes including, collagen synthesis, synthesis of hormones (noradrenaline/adrenaline and peptide hormones), synthesis of carnitine, gene transcription, and regulation of translation via different mechanisms (hydroxylation of transcription factors, tRNA and ribosomal proteins, demethylation of DNA, and histones), elimination of tyrosine, protection against reactive oxygen species (ROS), and reduction of iron in the gastrointestinal tract. It serves as a powerful antioxidant by donating hydrogen atoms and also enhances iron absorption by reducing Fe^{3+} to Fe^{2+} from non-heme iron sources (Hacışevki, 2009; Halliwell and Gutteridge, 1999). Ascorbic acid (AA), which is the reduced form of vitamin C, can undergo two-electron oxidation, producing dehydroascorbic acid (DHA), due to its high electron-donating power. A semi-dehydro-ascorbyl radical can be produced by oxidizing AA with one electron (Kocot *et al.,* 2017). The main biological form of vitamin C is L-ascorbic acid, and it can reversibly change to the oxidized form, dehydroascorbic acid (Fenoll and Martinez, 2010). Several factors can cause oxidation of vitamin C such as pH, light, temperature, presence of oxygen and metal ion (Wantz *et al*., 2005). Vitamin C (ascorbic acid) exists in two redox forms: ascorbic acid (AA) is the reduced form, and ascorbate (which is a result of AA deprotonation at physiological pH). Vitamin C boosts hydroxylation reactions by keeping metal ions' active centres in a reduced state for optimal hydroxylase and oxygenase activity. Thus, it is crucial in maintaining collagen, which represents about one-third of the total body proteins. Vitamin C deficiency is associated with scurvy, anaemia, infections, bleeding gums, poor wound healing, capillary haemorrhage, muscle degeneration, atherosclerotic plaques and neurotic disturbances fatigue, lethargy and mood changes, e.g., irritability and depression (Lykkesfeldt *et al*., 2014).

The recommended dietary intake (RDI) of vitamin C has been increased by many regulatory authorities in different countries. The RDI for vitamin C is up to one hundred-fold higher than that for many other vitamins (Monsen, 2000). Vitamin C intakes of 100–200 mg/day will maintain blood concentrations at adequate to saturating status i.e., 50–75µmol/l (Rowe and Carr, 2020). At doses above 1g/day (in a day), the body absorbs less than 50% ascorbic acid, and the metabolized ascorbic acid is excreted in the urine (Institute of Medicine, 2020). Vitamin C is generally safe and well-tolerated even when ingested at 2g/day, although gastrointestinal disturbances have been reported in some individuals at higher doses (Food and Nutrient Board, 2000). A blood concentration of <23µmol/L is regarded as hypovitaminosis C range which increases the risk of Vitamin C deficiency, defined by blood concentration of less than 11 µmol/l (Levine *et al*., 1996; Johnston and Corte, 1999; Rowe and Carr, 2020). According to Camarena and Wang (2016), ascorbate derived from either the liver or dietary sources, enter cells primarily through the sodium-dependent Vitamin C transporters (SVCTs). Vitamin C is absorbed by SVCT1 in the epithelial cells of the small intestine or diffuses into the surrounding capillaries and then into the circulatory system when eaten in the food or as a dietary supplement (Malo and Wilson, 2000; Takanga *et al.,* 2004).

The importance of vitamin C to health cannot be overemphasized. Thus, awareness must be encouraged for conscious inclusion of fruits as a component of daily dietary intake. However, this trend is becoming obsolete as the cost of living continues to increase daily. Epidemiological studies indicate that vitamin C hypovitaminosis and deficiencies are common in low-income countries although not uncommon in high-income countries. This research was therefore carried out to ascertain the adequacy of vitamin C content of inexpensive fruits consumed by low-income earners in comparison with expensive fruits consumed by high-income earners in Benin City, Edo State. The fruits were selected based on availability and affordability. The less expensive fruits included sweet orange, key lime, tomatoes and lemon, while the expensive fruits were apples, pineapples, watermelon and grapes.

MATERIALS AND METHODS

The reagents include distilled water, potassium iodide KI, potassium iodate 3M Sulphuric acid (H_2SO_4), Iodine and fresh starch indicator or solution. Eight fresh fruits; sweet orange, key lime, tomatoes, lemon, apples, pineapples, watermelon and grapes were purchased from Okha market in Benin city, Edo State, Nigeria in June 2021. These fruits were classified as expensive (apples, pineapples, watermelon and grapes) or less-expensive (sweet orange, key lime, tomatoes and lemon) based on relative affordability in the community. The samples were washed with distilled water, peeled, sliced into two and squeezed. The juice obtained was filtered with a muslin cloth. Fresh juice collected from the fruits were used in this study.

Vitamin C concentration was determined by Iodometric titration method (Nweze *et al*., 2015). The method was carried out with potassium iodate in the presence of potassium iodide. Iodine solution (Containing a mixture of KI (600 mM) and KIO_3 (2.6 mM) in distilled water) was titrated with the vitamin C standard solution (5.6 mM). In brief, 25ml of vitamin C (5.6 mM) was pipetted into an Erlenmeyer flask followed by 10 drops of 1% starch solution. The mixture was then titrated against the iodine solution until a blue-black colour was observed. Similarly, 25ml of each fruit juice sample was titrated against iodine solution. Titrations for all juices were done in triplicates. The volume of each fruit sample used was measured and the concentration of ascorbic acid of each fruit and their respective standard deviations were calculated. The addition of iodine oxidizes the ascorbic acid to dehydroascorbic acid, and the iodine is reduced to iodide ions as shown in the equation below:

Ascorbic acid ($C_6H_8O_6$) + $I_2 \rightarrow 2I^-$ + Dehydroascorbic acid ($C_6H_6O_6$)
(Reduced form) (Oxidized form)

Titration was carried out in triplicate. The mean and standard deviation for each sample was done with the aid of Microsoft excel version 2202.

RESULTS

Table 1 shows the mean concentration of vitamin C in each fruit. The values obtained reveal that orange has the highest vitamin C concentration while apple has the lowest concentration when compared with standard ascorbic acid. Vitamin C content in sweet orange was highest, followed by tomatoes, lemon, key lime, pineapple, watermelon, grape and apple.

Table 1: Iodometric Determination of Vitamin C Content of Some Expensive and Less Expensive Fruits

Fruits Samples and Vitamin C Standard	Sample	Scientific Name	Mean Titre Value	Mean Value of Vitamin C (mg/100ml)
Standard solution	Vitamin C		16.33	100 ± 1.04
Less expensive fruits	Lime	*Citrus aurantifolia*	4.93	30.20 ± 0.15
	Lemon	*Citrus limon*	5.87	35.92 ± 0.25
	Tomatoes	*Solanum lycopersicum*	6.23	38.16 ± 0.87
	Orange	*Citrus sinensis*	10.00	61.22 ± 0.69
Expensive fruits	Apple	*Malus domestica*	1.33	8.16 ± 0.58
	Grape	*Vitis vinifera*	3.07	18.78 ± 0.96
	Watermelon	*Citrullus lanatus*	3.87	23.67 ± 0.99
	Pineapple	*Ananas comosus*	4.47	27.35±1.27

DISCUSSION

Results obtained from the present study has revealed that the vitamin C content in the fruits juices examined were comparable as follows; sweet orange > tomatoes > lemon > lime > pineapple > watermelon > grape > apple. Lemon juice is used as a flavour for baking and as salad toppings. It is also taken as a tea since it is believed to relieve stomach upset, flatulence, aid digestion, and ease symptoms of common cold, including cough and catarrh (Eeoghene *et al*., 2017; NPCS, 2012). Vitamin C content from this study was similar to those reported by Okie *et al*., (2009), who reported that the ascorbic acid content of freshly prepared lemon juice is 48.61mg/100 ml, and Tiruwork and Ghirma (2012), reported the ascorbic acid content of freshly prepared lemon juice and old lemon juice were 41.4mg/100 ml.

Key lime is commonly used in many cultural cuisines and in juice production, due to its aroma and high content of phytochemicals (Narang and Jiraungkoorskul, 2016). Vitamin C content of key lime obtained in this study was higher than that observed by Najwa and Azrina (2017) (27.78mg/).

Watermelon is a juicy fruit with high water content. Aurelia *et al.* (2011) reported ascorbic acid content of watermelon juice was 21mg/100ml, Nour *et al*. (2010), reported that the ascorbic acid content was highest in lemon juice followed by watermelon juice.

Sweet orange is one of the most common citrus fruits known to possess high vitamin C concentration. This study supports that of Melo *et al.* (2006), who reported vitamin C concentration of orange juice as 37.34 mg/100ml, which is lower than values from this research. Razmi and Harasi (2008) obtained a much higher ascorbic acid values of 49.24mg/100 ml for orange. The disparity may be due to cultivation, environmental factors or species of orange.

Grapes are one of the expensive fruits that are palatable but usually out of reach for low-income earners. Results from this study were higher than that reported by Razmi and Harasi, (2008), who obtained ascorbic acid values of 8.80 mg/100 cm^3 for grapes, but lower than those from Vanderslice *et al.* (1990) and Najwa and Azrina, 2017 who reported ascorbic acid level of 23.60mg/100ml and 49.15mg/100g respectively.

Tomato is a very common juicy fruit, used in culinary dishes to make food appear attractive and enjoyable. It forms the basic recipe for many delicacies including soups and stews. They are also eaten raw as a snack or in salad. Vitamin C values obtained from this research is higher than that reported by Abebe *et al.* (2017) (13.03 mg/100g).

Pineapples and apples are very juicy fruits enjoyed by children and adults alike. Although common, they are quite expensive. Values for the vitamin C content of pineapple and apple in this study were found to be higher than values obtained by Nweze *et al.* (2015) who reported ascorbic acid level of 6.40mg/100ml for pineapple and 7.94mg/100ml for apple.

The observed differences in the contents of vitamin C studied in the same method may be as a result of differences in maturity stage and regional varieties of fruits. Different techniques of measuring and squeezing process, methodologies, method of juice extraction, different storage temperatures may also affect the vitamin C content of fruit juices. Factors including climate, temperature and amount of nitrogen fertilizers used in growing the plant and climatic conditions such as light can affect the concentration of ascorbic acid in fruits (Dosedˇel *et al.,* 2021).

The results of this study showed that the less expensive fruits have a higher content of vitamin C, compared to the expensive ones, thereby serving as an affordable and adequate source of vitamin C to low-income earners as well.

REFERENCES

Abebe, Z., Tola, Y. B., and Mohammed, A. (2017). Effects of edible coating materials and stages of maturity at harvest on storage life and quality of tomato (*Lycopersicon esculentum* Mill.) fruits. *African Journal of Agricultural Research*, 12(8): 550-565.

Ajayi, I. E., Ajibade, O. and Oderinde, R. A. (2011). Preliminary phytochemical analysis of some plant seeds. *Research Journal of Chemical Sciences*, 1: 58-62.

Anjorin, O., Okpala, O. and Adeyemi, O. (2019). Coordinating Nigeria's micronutrient deficiency control programs is necessary to prevent deficiencies and toxicity risks. *Annals of the New York Academy of Sciences,* 1446(1): 153-169.

Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., and Tonstad, S. (2017). Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality—a systematic review and dose-response meta-analysis of prospective studies. *International Journal of Epidemiology*, 46(3): 1029-1056.

Aurelia, M. P., Aneta, P., Gheorghe, P. N. and Aurel, P. (2011).

Determination of Ascorbic Acid Content of Some Fruit Juices and Wine by Voltammetry Performed at Pt and Carbon Paste Electrodes. *Molecules*, 16: 1349-1365.

Camarena, V. and Wang, G. (2016). The Epigenetic role of Vitamin C in Health and disease. *Cellular and Molecular Life Sciences*, 73(8): 1645-1658.

De Filippo, A., Meldrum, G., Samuel, F., Tuyet, M. T., Kennedy, G., Adeyemi, O. A. and Brouwer, I. D. (2021). Barrier analysis for adequate daily fruit and vegetable consumption among low-income residents of Hanoi, Vietnam and Ibadan, Nigeria. *Global Food Security*, 31: 100586.

Dosedˇel, M., Jirkovský, E., Macáková, K., Krˇcmová, L. K., Javorská, L. Pourová, J., Mercolini, L., Remião, F., Nováková, L. and Mladˇenka, P. (2021) Vitamin C—Sources, Physiological Role, Kinetics, Deficiency, Use, Toxicity, and Determination. *Nutrients,*13: 615-649.

Eseoghene, O., Banu, A. and Nisha, M., (2017). Assessing the Antibacterial Activity of Honey and Lemon Juice against Bacterial Isolated from Upper Respiratory Tract Infections. *International Journal of Management and Applied Science,* 3(5): 41-45.

Fenoll, J. and Martinez, A. (2010). Simultaneous Determination of Ascorbic and Dehydroascorbic acids in Vegetables and Fruits by Liquid Chromatography with Tandem-Mass Spectrophotometry. *Food Chemistry,* 127(1): 340-344.

Food and Nutrition Board, (2000). Dietary reference intakes for vitamin C, vitamin E, selenium and carotenoids. A report of the Panel on Dietary Antioxidants and Related Compounds. National Academy Press, Washington, DC. ISBN-10: 0-309-06949.

Hacışevki, A. (2009). An overview of ascorbic acid biochemistry. *Journal of Faculty of Pharmacy, Ankara,* 38(3): 233-255.

Halliwell, B. and Gutteridge, J. M. C. (1999). Free Radicals in Biology and Medicine. In: Halliwell, B. and Gutteridge, J.M.C., Eds., Free Radicals in Biology and Medicine, 3rd Edition, Oxford University Press, Oxford, 1-25.

Institute of Medicine. (2000). *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*. Washington, DC: The National Academies Press. https://doi.org/10.17226/9810.

Johnston, C. S. and Corte, C. (1999). People with marginal vitamin C status are at high risk of developing vitamin C deficiency. *Journal of the Academy of Nutrition and Dietetics*, 99(7): 854.

Jose, S. B. and María-Del, S. S. (2013). Antioxidant Role of Ascorbic Acid and His Protective Effects on Chronic Diseases. Chapter 18: Oxidative Stress and Chronic Degenerative Diseases - A Role for Antioxidants (Ed. J. A. Morales-Gonzalez). Pp. 449-484.

Kocot, J., Luchowska-Kocot, D., Kielczykowska, M., Musik, I. and Kurzepa, J. (2017). Does Vitamin C Influence Neurodegenerative

Diseases and Psychiatric Disorders? *Nutrients,* 9: 659.

Levine, M., Conry-Cantilena, C., Wang, Y., Welch, R. W., Washko, P. W., Dhariwal, K. R. and Cantilena, L. R. (1996). Vitamin C pharmacokinetics in healthy volunteers: evidence for a recommended dietary allowance. *Proceedings of the National Academy of Sciences*, 93(8): 3704-3709.

Linster, C. L. and Van Schaftingen, E. (2007). Vitamin C. *Federation of European Biochemical Societies Journal*, 274(1): 1-22.

Lykkesfeldt, J., Michels, A. J. and Frei, B. (2014). Vitamin C. *Advances in Nutrition*, 5(1): 16-18.

Malo, C. and Wilson, J. X. (2000). Glucose modulates vitamin C Transport in Adult Human Small Intestinal Brush Border Membrane Vesicles. *Journal of Nutrition,* 130: 63–69.

Melo, E. A., Lima, V. L., Maciel, M. I. S., Caetano, A. C. and Leal, F. L. (2006). Polyphenol, Ascorbic Acid and Total Carotenoid Contents in Common Fruits and Vegetables. *Brazilian Journal of Food Technol*ogy, 9: 89-94.

Ministry of Health Malaysia (2005). Recommended Nutrient Intakes (RNI) for Malaysia. Kuala Lumpur National Coordinating Committee on Food and Nutrition. Selangor: Yeoh Print Co.

Monsen, E. R. (2000). Dietary reference intakes for the antioxidant nutrients: vitamin C, vitamin E, selenium, and carotenoids. *Journal of the American Dietetic Association*, 100(6): 637-640.

Najawa, F. R. and Azrina, A. (2017). Comparison of vitamin C content in citrus fruits by titration and high-performance liquid chromatography (HPLC) methods. *International Food Research Journal,* 24(2): 726-733.

National Institute of Health. (NIH) (2021). Vitamin C: Fact sheet for health professionals. ODS. https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/

Nour, V., Trandafir, I., Ionica, M. E. (2010). HPLC organic acid analysis in different citrus juices under reversed phase conditions. *Notulae Boanicae Horti Agrobotanici Cluj-Napoca,* 38(1): 44-48.

NIIR Project Consultancy Services NPCS (2012). *Handbook on Agro Based Industries* (2nd Edition). NIIR Project Consultancy Services, Delhi, India.

Nweze, C. C., Abdulganiyu, M. G. and Erhabor, O. G. (2015). Comparative Analysis of Vitamin C In Fresh Fruits Juice of *Malus domestica, Citrus sinensi, Ananas comosus* and *Citrullus lanatus* by Iodometric Titration. *International Journal of Science, Environment and Technology,* 4(1): 17-22.

Okiei, W., Ogunlesi M., Azeez L., Obakachi V., Osunsanmi M. and Nkenchor G. (2009). The Voltammetric and Titrimetric Determination of Ascorbic Acid Levels in Tropical Fruit Samples.

International Journal of Electrochemical Science, 4: 276-287.

Okop, K. J., Ndayi, K., Tsolekile, L., Sanders, D. and Puoane, T. (2019). Low intake of commonly available fruits and vegetables in socio-economically disadvantaged communities of South Africa: influence of affordability and sugary drinks intake. *BioMed Central Public Health*, 19(1): 1-14.

Razmi, H. and Harasi, M. (2008). Voltammetric Behaviour and Amperometric Determination of Ascorbic Acid at Cadmium Pentacyanonitrosylferrate Film Modified GC Electrode. *International Journal of Electrochemical Science,* 3: 82-95.

Rowe, S. and Carr, A. C. (2020). Global vitamin C status and prevalence of deficiency: a cause for concern? *Nutrients*, 12(7): 2008.

Takanga, H., Mackenzie B. and Hediger, M. A (2004). Sodium Dependent Ascorbic Acid Transporter Family SLC23. *Pflügers Archiv European Journal of Physiology,* 447(5): 677–682.

Tiruwork, M. and Ghirma, M. (2012). All-Solid-State Iodide Selective Electrode for Iodimetry of Iodized Salts and Vitamin C. *Oriental Journal of Chemistry*, 28(4): 1547-1555

Vanderslice, J. T., Higgs, D. J., Hayes, J. M. and Block, G. (1990). Ascorbic acid and dehydroascorbic acid content of food-as-eaten. *Journal of Food Composition and Analysis*, 3: 105 – 118.

Wantz, F., Banks, C. E. and Compton, R. G. (2005). Direct oxidation of ascorbic acid at an edge plane pyrolytic graphite electrode: a comparison of the electroanalytical response with other carbon electrodes. *Electroanalysis*, 17(17): 1529-1533.

World Health Organization (WHO) and Food and Agriculture Organization of the United Nations (FAO). (2005). Fruit and Vegetables for Health. Report of a Joint FAO/WHO Workshop. Kobe, Japan1–3 September 2004.