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Effect of ripening stage on vitamin C content in selected fruits

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Abstract
Quantitative determination of vitamin C in fresh fruits of apple, mango, guava, orange, sour orange, pineapple, cashew, and watermelon was conducted using iodometric titration method. The concentration (mg/100g) of vitamin C in the fruits were 23.83±6.98 for sour orange, 9.52±0.65 for cashew, 6.46±0.49 for apple, 13.99±4.26 for mango, 8.90±1.70 for pineapple, 48.08±3.45 for orange, and 32.05±8.14 for guava respectively. The results indicate that fruits can serve as source of vitamin C. From the results also, the vitamin C contents of many fruits such as sour orange, cashew, apple, mango, pine apple, orange and guava is higher when they are slightly immature, and declines as they hits peak ripeness. For a few, such as water melon, the vitamin C contents does the opposite, it rises with increased ripeness. Finally, increase consumption of fruits is been recommended as one of the measures to prevent and curtail coronary heart disease, cancer, and various age relating chronic diseases.

Keywords
Vitamin C, Ripening Effect, Fruits

1. Introduction

Fruits are divided into climacteric and non climacteric classes based on their respiration pattern during ripening. In non -climacteric category are the grape fruit, lemon, orange, melon, pine apple and the strawberry. In these fruits the respiratory pattern show slow drift downwards after detachment from the parent plant while climacteric classes undergo a distinct ripening phase e.g. bananas, pears and avocados. Ascorbic acid also known as Vitamin C, when pure is white crystalline water -soluble vitamin found especially in citrus fruits and vegetables. Ascorbic acid is the most abundant vitamin in orange, lemon and grape fruit. There is a considerable variation in the ascorbic acid content of juice of different fruit (Luisa *et al.,* 2014).

Vitamin C is the most important Vitamin for human nutrition that is supplied by fruits and vegetables. It is a valuable food component because of its antioxidant and therapeutic properties (Okiei *et al.,* 2009).

Most plants and animals have the ability to synthesize vitamin C. the only mammals that are unable to synthesize vitamin C are primates including man, and guinea pigs. Therefore humans depend on exogenous source of the vitamin which includes fruits and vegetables as well as food supplements and pharmaceutical preparations (Okiei *et al.,* 2009). Current recommendation of health experts is to increase the consumption of fruits, since there is convincing evidences linking a diet rich in fruits with reduced incidence of coronary heart disease, cancer, and various age relating chronic diseases. These protective effects are hypothesized to owe, at least in part, to antioxidant and anti-proliferative effects of various poly phenols and vitamin such as vitamin C that is present in fruits and their products. Vitamin C is an essential phyto nutrients for the metabolism of living cells, that occurs in different concentrations in natural foods especially fruits and their products. It is considered as the major antioxidant in the diet (Mahdavi *et al.,* 2010).

An accurate and specific determination of the nutrients content of fruits is extremely important to understand the relationship of dietary intake and human health. A wide variety of food exists that contains vitamin C. Fruits, vegetables, and organ meats are generally the best sources of ascorbic acid. For better utilization of fruits and vegetables as a human food, clear understanding of their nutritional value as well as the content of vitamin C estimation is essential. The amount of ascorbic acid in plants varies greatly, depending on such factors as the variety, weather and maturity (Rahman *et al.,* 2007). Ascorbic acid content of fruits is never constant but varies with some factors which include climatic/environmental conditions, maturity state and position on the tree, handling and storage, ripening stage, specie and variety of the fruits as well as temperature (Luisa *et al.,* 2014).

1.1. Vitamin C

Vitamin C is one of the most potent antioxidant vitamins. We need vitamin C for growth, healthy body tissue, wound repair and an efficient immune system. In addition, it helps with the normal function of blood vessels and helps to absorb iron from plant sources. The upper daily limit is currently 1g/day. More than this safe level of vitamin C has been linked to damage of the inner lining of arteries, predisposing to the formation of cholesterol plaques and heart disease (Gurcharan, 2004).

1.2. Function of Vitamin C

Vitamin C is required for the synthesis of collagen, an important structural component of blood vessels, tendons, ligaments, and bone. Vitamin C also plays an important role in the synthesis of the neurotransmitter, norepinephrine. Neurotransmitters are critical to brain function and are known to affect mood. In addition vitamin C is required for the synthesis of carnitine, a small molecule that is essential for the transport of fat into cellular organelles called mitochondria, where the fat is converted to energy. Research also suggests that vitamin C is involved in the metabolism of cholesterol to bile acids. Vitamin C is also highly effective antioxidant. Even small amounts vitamin C can protect indispensable molecules in the body such as proteins, lipids (fats), carbohydrates, and nucleic acids (DNA and RNA), from damage by free radicals and reactive oxygen species that can be generated during normal metabolism as well as through exposure to toxins and pollutants (e.g. cigarette smoke). Vitamin C may also be able to regenerate other antioxidants such as Vitamin E. Vitamin C is the major water soluble antioxidant within the body. It lowers blood pressure and cholesterol levels. Numerous analysis have shown that an adequate intake of vitamin C is effective in lowering the risk of developing cancers of the breast, cervix, colon, rectum, lung, mouth, prostate and stomach. Vitamin C is generally non-toxic for maintaining a good and sound health and for prevention from common cold. Human body should be kept saturated with vitamin C (Rahman *et al.,* 2007).

1.3. Deficiency of Vitamin C

Severe vitamin C deficiency has been known for many centuries as the potentially fatal disease, scurvy. Symptoms of scurvy include bleeding and bruising easily, hair and tooth loss, joint pain and swelling. Such symptoms appear to be related to the weakening of blood vessels, connective tissue and bone, which all contain collagen (Gurcharan, 2004). A shortage of ascorbic acid may also result in haemorrhages under the skin and a tendency to bruise easily, poor wound healing, oedema and weakness. Lack of energy, poor digestion, bronchial infection and colds are also indicative of an under-supply of ascorbic acid. Many of the deficiency symptoms can be explained by a deficiency in the hydroxylation of collagen, resulting in defective connective tissues (Luisa *et al.,* 2014).

1.4. Disease Prevention and Treatment

Ascorbic acid is required in the synthesis of collagen in connective tissues, neurotransmitters, steroid hormones, carnitine, and conversion of cholesterol to bile acid and enhances iron bio -availability. Ascorbic acid is a great antioxidant and helps to protect the body against pollutants. It is also a biological reducing agent linked to prevention of degenerative disease such as cataracts, certain cancers and cardio vascular diseases. It promotes healthy cell development, proper calcium absorption, normal tissue growth and repairs such as healing of wounds and burns and strengthening the wall o f the capillaries.

Ascorbic acid is needed for healthy gums, to help protect against infection and assisting with clearing up infection; and is thought to enhance the immune system and help reduce cholesterol levels and high blood pressure. A deficiency of ascorbic acid in the body results in scurvy, a disease characterized by sore, spongy gums, loose teeth, fragile blood vessels, swollen joints and anemia. Ascorbic acid is widely used as antioxidant in frozen fruits, canned meat, beverages, beer and other food items. It is used medically as drug and in pharmaceutical industry for the manufacture of drugs rich in ascorbic acid. Ascorbic acid is used in the treatment of scurvy and prickly heat and thus required in the tropics in relatively larger quantities so as to ensure among other things the normal functioning of the hyperactive sweat glands. Its application in animal feed is fast growing as it supplements the Vitamin C content of the feed (Luisa *et al.,* 2014). These health benefits of citrus fruit have mainly been attributed to the presence of bioactive compounds, such as ferrulic acid, hydrocinnamic acid, cyanidinglucoside, hisperidine, vitamin C, carotenoid and naringin content (Fereshteh and Hamideh, 2014).

1.4.1. Cardiovascular Disease

Until recently, the results of most prospective studies indicated that low or deficient intakes of vitamin C were associated with an increased risk of cardiovascular diseases, and that modest dietary intakes of about 100mg/day were sufficient for maximal reduction of cardiovascular disease risk among nonsmoking men and women (Gurcharan, 2004).

1.4.2. Cancer

A large number of studies have shown that increased consumption of fresh fruits and vegetables is associated with reduced risk for most types of cancer. Such studies were the basis for dietary guidelines endorsed by the U.S. Department of Agriculture and the National Cancer Institute, which recommended at least five servings of fruits and vegetables per day. The recommended serving number depends by age, gender, body composition and physical activity level. Laboratory experiments indicate that vitamin C inhibits the formation of carcinogenic compounds in the stomach (Gurcharan, 2004).

1.4.3. Cataracts

Cataracts are a leading cause of visual impairment throughout the world. Cataracts occur more frequently and become more severe as people age. Decreased vitamin C levels in the lens of the eye have been associated with increased severity of cataracts in humans. Some, but not all studies have observed increased dietary vitamin C intake and increased blood levels vitamin C to be associated with decreased risk of cataracts. In general, those studies that have found relationship, suggest that, Vitamin C intake may have to be higher than 300mg/day for a number of years before a protective effect can be detected (Gurcharan, 2004).

1.4.4. Lead Toxicity

Lead toxicity continues to be a significant health problem, especially in children living in urban areas. Abnormal growth and development have been observed in infants of women exposed to lead during pregnancy, while children who are chronically exposed to lead are more likely to develop learning disabilities, behavioral problems, and to have low IQ. In adults, lead toxicity may result in kidney damage, high blood pressure, and anemia. In a study of 747 older men, blood lead levels were significantly higher in those reported total dietary vitamin C intakes averaging less than 109 mg/day compared to those who reported higher vitamin C intake (Gurcharan, 2004).

1.4.5. Vasodilation

The ability of blood vessels to relax or dilate (vasodilation) is compromised in individuals with atherosclerosis. Damage to the heart muscle caused by a heart attack and damage to the brain caused by a stroke are related, in part, to the inability of blood vessels to dilate enough to allow blood flow to the affected areas. Many studies have shown that the treatment with vitamin C consistently results in improved vasodilation. Improved vasodilation has been demonstrated at an oral dose of 500mg of vitamin C daily (Gurcharan, 2004).

1.4.6. Hypertension

Individuals with high blood pressure (hypertension) are at increased risk of developing cardiovascular diseases, several but not all studies have demonstrated a blood pressure lowering effect of vitamin C supplementation. A small study in individuals with hypertension found that vitamin C supplementation with 500mg/day for six weeks slightly decreased systolic blood pressure (1.8mmHg reduction) compared to a placebo (Gurcharan, 2004).

1.4.7. Diabetes Mellitus

Coardiovascular diseases (heart disease and stroke) are the leading cause of death in individual with diabetes. Evidence that diabetes is a condition of increased oxidative stress led to the hypothesis that higher intakes of antioxidant nutrients could help decrease cardiovascular disease risk in diabetic individuals. In support of this hypothesis, a 16 years study of 85,000 women, 2% of whom were diabetic, found that vitamin C supplement use (400mg/day or more) was associated with significant reductions in the risk of fatal and nonfatal coronary heart disease as well as in those with diabetes (Gurcharan, 2004).

The increasing use of pharmaceutical and other natural samples containing vitamin C has necessitated for an accurate and specific determination of vitamin C content in fruits, this will also be extremely important to understand the relationship of dietary intake and human health. Several analytical methods have been reported for the determination of vitamin C. These include iodometric, fluorometric,and complexometric titration, liquid chromatography, higher performance liquid chromatography, spectrophotometric, amperometric and enzymatic methods (Okiei *et al.,* 2009). The purpose of this research work is to analyze the vitamin C content in different fruits at different stages of ripeness. The results will give a guide to which fruit is to be consumed most, and at what stage of ripeness. This will give a major boost in monitoring the vitamin C daily intake. The research will encourage the utilization of vitamin C in locally available fruits and will also help to facilitate the rate of production of these fruits. The research will be limited to the assessment of the concentration of vitamin C in Guava, Mango, Orange, Sour Orange, Pineapple, water melon, cashew and Apple fruits at three different stages of ripeness, that is, unripe, middle and ripe stage.

2. Materials and Method

2.1. Materials

The apparatus used in this research work include Measuring cylinder, Conical flask, Volumetric flask, Burette, Watch glass, Weighing balance, Beaker, Blender, Pipette, Retort stand, Spatula, Mortar and Pestle, Desicator, and Hot air oven.

All the reagents were of analytical standard and include Potassium iodide, Potassium iodate, Hydrochloric acid, and Starch indicator.

2.2. Method

2.2.1. Preparation of Reagents

i. Potassium Iodate Solution (0.002mol/L)

1 gram of potassium iodate was oven dried for several hours at 100^0c. It was allowed to cool and 0.43g was dissolved in 1 liter volumetric flask with distilled water and the volume was adjusted to the mark (Harris, 2000).

ii. Starch Indicator Solution (0.5%)

Soluble starch (0.25g) was transferred into a beaker containing $50cm^3$ of near boiling water. The solution was constantly stirred until it dissolved, and it was allowed to cool (Harris, 2000).

iii. Potassium Iodide Solution (0.6 Mol/L)

Ten gram (10g) of solid potassium iodine was dissolved in a beaker containing $50cm^3$ of distilled water, and the solution was diluted to $100cm^3$ using distilled water (Harris, 2000).

iv. Dilute Hydrochloric Acid (1 Mol/L)

Ten ($10cm^3$) of 0.1M HCL was dissolved in a beaker containing $100cm^3$ of distilled water, and the solution was further dissolved in 1 litre volumetric flask and was diluted to the mark using distilled water(Harris,2000).

v. Preparation of Vitamin C Standard Solution

Five hundred (500mg) of vitamin C tablet was dissolved in 500 cm^3 volumetric flask with distilled water and the solution was diluted to the mark with distilled water (Harris, 2000).

vi. Standardization of the Iodine Solution with Vitamin C Standard Solution

25 cm^3 of vitamin C standard solution was pipetted into a volumetric flask, 150 cm^3 of distilled water was added, 5 cm^3 of 0.6mol/L potassium iodide was also added to the same beaker, 5 cm^3 and 1 cm^3 of 1mol/L hydrochloric acid and starch indicator solution was added respectively. The solution was titrated with 0.002 mol/L potassium iodate solution until the end point, which is, when permanent trace of dark blue-black colour appeared. Titrations were repeated three times (Harris, 2000).

2.3. Sample Collection and Treatment

2.3.1. Sample Collection

Eight different samples of fruits, namely, apple, mango, guava, pineapple, cashew, orange, sour orange, and water melon, were collected from Gusau central market, Zamfara State, Nigeria. The samples were obtained in three different ripening stages (unripe, half-ripe, and ripe fruits).

2.3.2. Samples Treatment

Exactly 100g of each sample was cut into small pieces and grounded in a blender using $50cm^3$ portion of distilled water, the solution was diluted to $100cm^3$ using distilled water (Harris, 2000).

2.3.3. Titration Procedure

Twenty five (25) cm^3 of the sample solution was pipetted into 250 cm^3 conical flask, 150 cm^3 of distilled water was added, 5 cm^3 of 0.6mol/L potassium iodide was also added to the same beaker, 5 cm^3 and 1 cm^3 of 1mol/L hydrochloric acid and starch indicator solution was added respectively. The solution was titrated with 0.002 mol/L potassium iodate solution until the end point, which is, when permanent trace of dark blue-black colour appeared. Each sample was run three times to obtain three replicates measurements (Harris, 2000).

3. Results and Discussion

3.1. Results

The table I below expressed the concentration of vitamin C in (Mg/100g) for the fruits sample analyzed.

Table I. *Vitamin C Contents in the Fruits Sample*

Fruit	Average Concentration of Vitamin C (mg/100g)			Total Average (mg/100g)
	Half-ripe	Un ripe	Ripe	
Sour orange	21.89+1.02	33.1+0.78	16.42+0.89	23.83+6.98
Cashew	8.71+0.08	10.24+0.14	9.61+0.03	9.52+0.65
Watermelon	7.05+0.03	5.85+0.05	6.48+0.29	6.46+0.49
Apple	6.03+0.60	7.69+0.16	3.03+0.16	5.58+1.93
Mango	15.16+0.18	18.53+0.41	8.28+0.05	13.99+4.26
Pineapple	8.37+0.09	11.32+0.62	7.01+4.94	8.90+1.70
Orange	48.77+0.10	51.93+0.19	43.55+0.40	48.05+3.45
Guava	31.52+0.19	42.27+0.66	22.35+0.96	32.05+8.14

All the analytical data are the mean of triplicate measurements of three samples ± standard deviation.

3.2. Discussion

The results of vitamin C contents (Mg/100g) obtained from this study are indicated in table I. The mean values of the vitamin C contents were of the order, Orange >Guava > Sour orange > Mango > Cashew > Pineapple > Water Melon > Apple. Orange had the highest concentration of Vitamin C in all the fruits analyzed while apple had the least concentration of vitamin C, this is in agreement with the data of the United State Department of Agriculture National Nutrient Data base (2000), as reported in the literature review. The slight differences that can be observed in terms of the concentrations of vitamin C in fruits analyzed, and the concentrations reported in the literature, is as a result of differences in, production factors and climatic conditions, maturity state and position on the tree, type of fruits (species and Varity) as well as handling and storage (Mahdavi *et al.,* 2010).

Sour orange

The contents of vitamin C in sour orange as indicated in the table I were in the order, Half-ripe > Ripe > Unripe. That is, the half-ripe had the highest concentration of 33.18 $\pm$ 0.78(mg/100g) followed by ripe with concentration of 21.89 $\pm$1.02 (mg/100g) and the unripe had least concentration of 16.42$\pm$0.89(mg/100g) with a total average contents of 23.83$\pm$6.98(mg/100g).

Cashew

The amounts of vitamin C in cashew as indicated in the table I were in the order, Half-ripe >Unripe >Ripe. That is, the half ripe had the highest amounts of 10.24$\pm$0.14(mg/100g), followed by unripe with concentration of 9.61$\pm$0.03(mg/100g). The ripe had the least amounts of 8.71$\pm$0.08(mg/100g). The total average contents of vitamin C in the cashew analyzed is 9.52$\pm$0.56(mg/100g).

Water Melon

The concentration of vitamin C in water melon as indicated in table I were in the order, Ripe >Unripe > Half-ripe. That is, ripe had the highest concentration of 7.05$\pm$0.03(mg/100g), followed by the half-ripe with a concentration of 6.48 $\pm$0.29 (mg/100g). The unripe had the least concentration of 5.85$\pm$ 0.05mg/100g. The total average concentration is 6.46$\pm$0.49mg/100g.

Apple

The contents of vitamin C in apple as indicated by table I were of the order, Half-ripe < Ripe > Unripe. That is, the half-ripe had the highest concentration of 7.69 ± 0.16 (mg/100g), followed by the ripe with a concentration of 6.03 ± 0.60(mg/100g). The unripe had the least concentration of 3.03 ± 0.16(mg/100g). The total average concentration is 5.58$\pm$ 1.93(mg/100g).

Mango

The concentration of vitamin C in mango as indicated by table I were of the order, Half-ripe > Ripe > Unripe. That is, the half-ripe had the highest concentration of 18.53 ± 0.41(mg/100g), followed by the ripe with a concentration of 15.16 + 0.18 (mg/100g). The unripe had the least concentration of 8.28 $\pm$ 0.05(mg/100g). The total average concentration is 13.99 + 4.26(mg/100g).

Pineapple

The concentration of vitamin C in pineapple as indicated by table I, were of the order, Half-ripe> Ripe> Unripe. That is, half-ripe had the highest contents of 11.32 $\pm$ 0.62(mg/100g), followed by ripe with a concentration of 8.37 ± 0.09(mg/100g). The unripe had the least concentration of 7.01 $\pm$ 4.94(mg/100g). The total average concentration is 8.90 $\pm$1.70(mg/100g).

Orange

The concentration of vitamin C in orange as indicated by table I, were of the order, Half-ripe> Ripe> Unripe. That is, half-ripe had the highest contents of 51.93$\pm$ 0.19(mg/100g), followed by ripe with a concentration of 48.77 ± 0.10(mg/100g). The unripe had the least concentration of 43.55 $\pm$ 0.40(mg/100g). The total average concentration is 48.08 $\pm$0.23(mg/100g).

Guava

The concentration of Vitamin C in guava as indicated by table I were of the order, Half-ripe > Ripe >Unripe. That is, half-ripe had the highest concentration of 42.27 $\pm$ 0.66(mg/100g), followed by ripe with a concentration of 31.52 $\pm$ 0.19 (mg/100g). The unripe had the least concentration of 22.35 +0.96(mg/100g). The total average concentration is 32.05 $\pm$ 8.14(mg/100g).

When we compare these results, with the result obtained by Okei *et al.,* (2009), in case of Mango, Guava, Orange, and Pineapple, they reported higher values 36.13 (mg/100g), 50.3 (mg/100g), 61.36 (mg/100g),and 24.81(mg/100g) respectively. There is agreement in the case of Water melon and Apple where they reported 6.80(mg/100g) and 6.0 (mg/100g) respectively. Harnandez *et al.,* (2005), they determine the concentration of Mango in unripe, half-ripe and ripe, they obtained the following results,44.8$\pm$2.8(mg/100g), 43.0$\pm$3.0 and 45.5$\pm$3.4 respectively, this result is different from what we obtained in table I, but this order is similar to the order we obtained in case the of water melon. Navarro *et al.,* 2006, they determined vitamin C contents in pepper at different ripening stages. They found the contents in this order, Turning (Half-ripe) > Red (Ripe) > Green (Unripe). This result is in agreement with the order we obtained in table I, in the case of sour orange, apple, mango, pineapple, orange and guava. Mahdavi *et al.,* (2010), reported 24.51$\pm$0.15 (mg/100g), 17.45$\pm$0.15 (mg/100g), 15.46$\pm$0.17(mg/100g), and 14.65$\pm$0.15(mg/100g), for orange, apple, pineapple and mango respectively. The result is lower than the result obtained in table I, in the case of orange, and is higher in case of apple and pineapple, but there is agreement in case of Mango. Arif *et al.,* (2010) determined the contents of vitamin C in berries at three different ripening stages. They found higher concentration of vitamin C during 2nd stage (399.0mg/100g), the concentration of Vitamin C decreased during the ripening stage and found to be (263.05mg/100g) for 3rd stage. The vitamin C contents obtained during the 1st stage was slightly lower than the vitamin C contents at 3rd stage of ripening and was (294.66mg/100g). This result was consistent with order obtained in table I, except for water melon and cashew respectively. The results suggest that the ascorbic acid levels in the unripe fruits were higher than the ripe ones but generally decreased upon increase in temperature, ripening and time of exposure. Oxygen is the most destructive element in juice causing degradation of ascorbic acid. At increased temperature, the juice was more susceptible to oxidation and the effects of temperature and consequently experienced more degradation of ascorbic acid. All types of fruit juices are inherently unstable and rapidly undergo microbial attack by organisms already present in the fruit, which gained access to the product during ripening. They are also subjected to enzymatic and non-enzymatic changes. The longer the juice stays in the atmosphere, the more the degradation hence the lesser the ascorbic acid content. Also, as the temperature increased, the ascorbic acid content decreased. However, one of the major sugars found in juices, fructose, can also cause ascorbic acid breakdown. Conversely, higher levels of citric and malic acids stabilize ascorbic acid. However, the ascorbic acid content of the selected unripe fruits was found to be greater than that of the ripe ones. Also, the ascorbic acid decreased upon ripening, temperature increase and time which are attributed to degradation caused by heat and oxidation. It has been reported that high nitrogen fertilizer rates can lower ascorbic acid levels in fruits and that proper potassium levels are needed for good ascorbic acid levels. Additionally, climate, especially temperature-total available heat affects ascorbic acid levels. Areas with cool nights produce fruits with higher ascorbic acid levels while hot tropical areas produce citrus fruit with lower levels of ascorbic acid. Environmental conditions that increase the acidity of citrus fruits also increase ascorbic acid levels. The position of citrus fruits on the tree also affects ascorbic acid levels. All these and more contributed to the reasons behind the erratic values of ascorbic acid contents of citrus fruits all over the world (Okenwa, 2014).

4. Conclusion

The determination of Vitamin C contents in Apple, Mango, and Guava, Orange, Sour orange, pineapple, and Cashew and Water melon was conducted using iodometric titration. The results obtained showed that, fruits are very essential source of vitamin C. These results will provide a suitable guide to the population in their choice of fruits with high levels of vitamin C. adequate consumption of the fruits with high vitamin C contents can result in improved health, thereby reducing diseases such as diabetes, cataract, glaucoma, macular degeneration, stroke, heart disease, atherosclerosis, and cancer that are prevalent in Africa.

Recommendation

In view of the results obtained from this study, the following recommendations are hereby forwarded.

a. It is recommended that, people should be eating fruit in order to meet up the recommended daily intake of vitamin C.
b. It is also recommended that, consumption of uncooked fruit should be strongly encourage because cooking of fruit leads to a considerable loss in ascorbic acid contents.
c. Then, people should avoid drying of fruits completely as a means of preserving them because it also leads to a considerable loss in vitamin C.
d. Freezing of fruits should be strongly encouraged than drying.
e. Further studies are required to investigate the total vitamin C contents of more of our local fruits and vegetables to enable one compile food composition table reference to vitamin C as a status.

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