Iodimetric Determination of Ascorbic Acid (Vitamin C) in Citrus Fruits

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Abstract: The ascorbic acid content of the juices of four different citrus fruits – orange, tangerine, grapefruit and lime was determined iodimetrically in order to know which fruit would best supply the ascorbic acid need for the body. Results showed that orange had the highest value of ascorbic acid, 600 µg/mL followed by grape, 446 µg/mL and then tangerine, 415 µg/mL. Lime had the least value, 306 µg/mL. It therefore follows that orange would supply more ascorbic acid per milliliter for body need compared to the other three fruits. In fact, the value of ascorbic acid in orange is about twice that of lime.

Key words:

INTRODUCTION

Long before the discovery of vitamin C (ascorbic acid) in 1932, nutrition experts recognized that something in citrus fruits could prevent scurvy, a disease that killed as many as 2 million sailors between 1500 and 1800[1].

The use of lime for the prevention of spoilage of palm oil on storage had for long been in practice among the traditional farmers, especially in the western part of Nigeria. Without any formal education they knew that lime contained something that would not allow the oil to go rancid. The practice was to press the sliced lime to release its juice on the spongy cover used for sealing the tin containing the palm oil for storage. By so doing, the farmers could preserve their oil for several months without getting spoilt. With the discovery of vitamin C, it is now known that the antioxidant in the lime that prevented the oil spoilage is vitamin C or ascorbic acid.

Vitamin C is a white crystalline compound highly soluble in water. It is not a carboxylic acid but a lactone, and owes its acidic properties and ease of oxidation to the presence of an enediol grouping[2]. The vitamin plays a role in controlling infections and the body’s response to stress. It is also found to be a powerful antioxidant that can neutralize harmful free radicals; helps make collagen, a tissue needed for healthy bones, teeth, gums and blood vessels[3,4,5]. As early as the 1700’s, vitamin C was referred to as the “antiscorbutic factor”, since it helped prevent the disease called scurvy. This disease was first discovered in British sailors, whose sea voyages left them far from natural surroundings for long periods of time. Their body stores of vitamin C fell bellow 300 mg, and their gums and skin lost the protective effects of vitamin C. Vitamin C is reported to lower cancer risk, regenerate vitamin E supplies, improve iron absorption[6] and high-dose of it protects the eye against cataracts[7]. Vitamin C is said to have important interactions with other vitamins. For example, excessive intake of vitamin A is less toxic to the body when vitamin C is readily available[8].

Various reports show that fruits are excellent sources of vitamin C. Citrus fruits, tomatoes, strawberries, bell peppers and broccoli are good examples of food fruits rich in vitamin C[3]. The reports of the vitamin C content of natural food-fruits include the citrus fruits. A serving size ¾ cup of orange juice from frozen concentrate is reported to contain 75 mg of vitamin C; one medium size orange, 60 mg; half a white grapefruit, 40 mg; and one medium size tangerine, 25 mg of vitamin C[3]. Lime juice is reported to contain 29 mg of vitamin C per 100 g juice[3].

Nutritionists generally regard any ‘serving’ of food that provides 10% to 25% of the daily vitamin C need in a relatively low calorie package as a ‘good’ source[8]. The 1989 recommended daily allowance (RDA) for an adult is 60 mg per day (this is based on the amount of vitamin C needed to prevent clinical scurvy and provide body stores sufficient to prevent scurvy for around 30 days plus “a margin of safety”). At April 1999 it was being officially recommended, based on new information that the RDA ought to be changed to 120 mg per day[9].

In the United States, the current (2000) recommended daily allowance (RDA) or Adequate Intake (AI) for vitamin C is 90 mg per day for men

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and 75 mg per day for women. The given AI value for men is for males 19 years and older, while that for women is for females 19 years and older. It is recommended that smokers consume 35 more milligrams of vitamin C per day. Pregnant and lactating women have AI values as high as 85 and 120 mg respectively for 19 years or older[9]. In the April 10, 2000 press release, National Academy of Sciences (NAS) set a Tolerable Upper Intake Level (UL) for vitamin C at 2000 mg (2 g) for adults 19 years or older[9].

Recent surveys of the U.S. Department of Agriculture (USDA) show that the average intake of vitamin C by American adults was over the AI for vitamin C. Women tended to consume less than men of the same age[11]. Taking too much vitamin C is reported to cause side effects such as nausea and diarrhea[1].

Vitamin C is lost from foods during preparation, cooking, or storage. Therefore to prevent loss of vitamin C, the following precautions are recommended[11]:

- Serve fruits and vegetables raw whenever possible;
- Steam, boil, or simmer foods in a very small amount of water, or microwave them for the shortest time possible;
- Cook potatoes in their skins. Be sure to wash the dirt off the outside of the potato;
- Refrigerate prepared juices and store them for no more than two to three days;
- Store cut, raw fruits and vegetables in an airtight container and refrigerate - do not soak or store in water.

The objective of the study was to determine the vitamin C content of the citrus fruits with the view of making recommendations for their intake.

MATERIALS AND METHODS

A standard iodine solution was prepared by dissolving 0.2g of KIO₃ and 1.6g of KI in some distilled water in a 500 mL volumetric flask. The KI was well in excess to keep the I₂ generated in solution as I⁻. The solution was acidified by adding 1 mL of concentrated tetraoxosulphate (VI) acid (H₂SO₄). The mixture was swirled and the volume of solution raised to 500 mL with distilled water. The flask was stoppered and shaken to ensure homogeneity of content. Thus, the concentration of iodine solution was 5.6076 x 10⁻³ M. The iodine solution was kept in a closed cupboard.

Some fresh ripe oranges, grapefruits, tangerine and lime were obtained from their respective trees for the study. Some of the fruits were peeled and cut into two transversely and then squeezed to discharge their juice into a pre-washed beaker. Sufficient juice was obtained for each kind of citrus fruit used for the experiment. The seeds were carefully picked out from the juice. A 25 mL aliquot of each juice was titrated against the standard 5.6076 x 10⁻³ M iodine solution to a light blue end point using freshly prepared starch as indicator.

RESULTS AND DISCUSSIONS

The average titre of iodine in three determinations having corrected for blanks are reported in Table 1. Iodine is produced in the reaction according to the following equation:

\[\text{IO}_3^- + 5\text{I}^- + 6\text{H}^+ \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O} \quad (1)\]

\[\text{IO}_3^- + 8\text{I}^- + 6\text{H}^+ \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O} \quad (2)\]

**Triiodide ion**

Equation (2) is as a result of excess KI that keeps the iodine in solution as a triiodide ion.

The equation for the quantitative reaction of the triiodide ion and the vitamin C (ascorbic acid) is

\[\text{IO}_3^- + \text{C}_6\text{H}_8\text{O}_6 \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O} + 2\text{H}^+ + 3\text{C}_6\text{H}_4\text{O}_6 \quad (3)\]

From equation (2), it is seen that vitamin C and the Triiodide ion react in ratio 1:1. It is therefore easy to calculate the molar concentration of the vitamin C in each juice as expressed in Table 1.

Since the molar mass of vitamin C is known (molar mass = 176.123 g/mol), and the volume of juice used in each determination was 25 mL, then,

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Average titre of three determinations (mL)</th>
<th>Molar concentration of vitamin C in the juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>15.20</td>
<td>3.4094 x 10⁻³</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>11.30</td>
<td>2.3552 x 10⁻³</td>
</tr>
<tr>
<td>Tangerine</td>
<td>10.50</td>
<td>2.5346 x 10⁻³</td>
</tr>
<tr>
<td>Lime</td>
<td>7.75</td>
<td>1.7384 x 10⁻³</td>
</tr>
</tbody>
</table>

Table 2: Various expressions of concentrations of vitamin C in citrus fruits

<table>
<thead>
<tr>
<th>Citrus fruit juice</th>
<th>Concentration of vitamin C in juice in µg/mL/mg/L/mg/10cL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>600/600/60</td>
</tr>
<tr>
<td>Tangerine</td>
<td>415/415/41</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>446/446/44</td>
</tr>
<tr>
<td>Lime</td>
<td>306/306/30</td>
</tr>
</tbody>
</table>
its concentration could be expressed in µg/mL, mg/L or mg/10cL as shown in Table 2.

To meet the 90 mg recommended daily allowance (RDA) for vitamin C\[^{[10]}\], as much as 15 cL or 150 ml of orange juice will have to be taken. A medium size orange, 216.7g yielded 76mL juice. This implies that taking two oranges of that size daily would ensure adequate of vitamin C. Drinking 25 cL of either grapefruit or tangerine juice would supply 90 mg of vitamin C required for daily need. However, about 30 mL of lime will have to be taken to meet the same daily requirement of vitamin C.

**Conclusion:** Of the citrus fruits only orange and tangerine have a sweet taste and are more convenient to swallow. The juices of grapefruit and lime are somewhat bitter and sour to taste respectively. To meet the RDA of 90 mg, their juices may be more conveniently taken at different times in portions.

The juices of oranges and tangerine are hereby recommended, preferably, to be taken daily during meal at quantities sufficient to meet daily vitamin C need. Taking vitamin C especially during meal will assist in reducing iron III to iron II, which is of benefit to the body.

**REFERENCES**

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