Vitamin C content in three local fruits (Rubber vine, Golden apple, and Tamarind) available in Zanzibar

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Abstract
This study reports on the levels of vitamin C in each of the local fruits namely; Saba comorensis (Rubber vine, Bungo), Spondias cytheera (Golden apple, Embe sakua), and Tamarinda indica (Tamarind, Ukwaju), which are widely used by local population in Zanzibar. The amount of vitamin C in the samples studied was determined by oxidation stoichiometric using iodometric titration method. Two of the studied fruits (Saba comorensis and Spondias cytheera) had been found to contain reasonable amounts of vitamin C per 100 g of each of the raw fruit. Saba comorensis contained the highest amount of vitamin C (31 mg per 100 g of the fruit), while vitamin C content in Spondias cytheera was 18 mg per 100 g of the fruit. Vitamin C content found in Tamarinda indica was only 9.36 mg per 100 g of the fruit. Of the three studied fruits, it is advisable to consume more of S. Comorensis fruits for excellent intake of vitamin C. This can help to reduce severe health problems including cancer, diabetes, cardiovascular disease and other diseases.

1. Introduction
Vitamin C (ascorbic acid) is among vitamins and essential micronutrient required for normal metabolic function of the body (Jaffe, 1984). Because humans cannot synthesize ascorbic acid, thus their main source of the vitamin C comes from dietary fruit and vegetables. Fruits such as citrus are the best sources of this vitamin (Li, and Schellhorn, 2007).

The daily ascorbic acid consumption for male and female as recommended by the national academy of science of USA is 90 mg/kg body wt. and 75 mg/kg body wt. respectively. However, smokers require 35 mg/kg body wt more vitamin C than nonsmokers per day (Institute of Medicine, 2000).

Vitamin C is a vital physiological antioxidant. It is also an important component of connective tissues because it is involved in collagen formation. Collagen is used in
wound healing (Frei et al., 1989). Indeed, vitamin C plays many fundamental roles in biochemical processes such as protein metabolism. In addition, it is used for the biosynthesis of certain neurotransmitters, L-carnitine, and collagen. Moreover, epidemiological evidence shows that higher consumption of fruits and vegetables is linked with lower risk of several types of cancer (Li and Schellhorn, 2007; Carr and Frei, 1999). This is because; vitamin C can prevent the formation of carcinogens, such as nitrosamines (Carr and Frei, 1999; Hecht, 1997).

Vitamin C is not only an important antioxidant but also a vital electron donor (Padayatty et al., 2002). Antioxidants are key components in the prevention of oxidative damage to proteins and DNA (Halliwell, 2002). Oxidative damage is associated with the development of both mild and severe health conditions including cancer, diabetes, cardiovascular disease, arthritis, and cataracts (Antioxidant Vitamin Research, 2000).

In Zanzibar, there are number of edible fruits and vegetables, which are widely used by local population. The vitamin C content in these substances is presently not well known. This has instigated for the embark of the vitamin C investigation in some of the Zanzibar local fruits. This study reports on the amount of vitamin C in fruits from three trees *Saba comorensis* (Rubber vine, Bungo), *Spondias cytheera* (Golden apple, Embe sakua) and *Tamarind indica* (Tamarind, Ukwaju). The amount of vitamin C in the samples studied was determined by oxidation stoichiometric calculations using iodometric titration method.

### 1.1. Theory

If the diet is deficient in vitamin C, the cells in the body may begin to stop growing and even die. The disease that results from severe deficiency in vitamin C is called scurvy. People with scurvy get bruises easily because their blood vessels become very weak.

Other symptoms include hemorrhaging, joint pain, and exhaustion. Moreover, the skin and teeth also become very unhealthy. In the old days, sailors often got scurvy while at sea because their diets had little or no fresh fruits or vegetables (Brody, 1994; Pauling, 1976). Because vitamin C is water-soluble, it is readily excreted from the body. Therefore, excessive intake of vitamin C is not a major health concern. However, extremely high levels intake of vitamin C can result in severe diarrhea (Burns, 1975).

Vitamin C can be determined by using an oxidation-reduction reaction. Redox titration with molecular iodine is among excellent method for the determination of vitamin C in fruits. In an iodometric titration, molecular iodine (*I*₂) is used as an oxidizing agent against a solute of unknown concentration. Usually the solute is an organic compound oxidized by losing two hydrogen atoms as well as two electrons. During this process, a molecular iodine is reduced by gaining the two electrons and becoming two atoms of iodide (**I**⁻) (equation 1). The end point is reached when all of the organic substrate has been oxidized.

#### Equation 1

\[
I_2 + 2e^- \rightarrow 2I^-
\]

The general chemical equation above represents a simple complete redox reaction equation. The specific reaction for vitamin C is given in equation 2 below, whereby ascorbic acid is oxidized to dehydroascorbic acid.

#### Equation 2

Vitamin C acts as an organic reducing agent in the iodometric titration. Iodine is reduced while vitamin C is oxidized. The end point is reached when all of the vitamin C has been oxidized. This makes the reaction suitable for determining the concentration of vitamin C in a solution. During this process, molecular iodine is produced when potassium iodate (**KIO**₃) under acidic conditions reacts with potassium iodide (**KI**). The disproportionation reaction that results in to the formation of molecular iodine is given in equation 3 below.

#### Equation 3

\[
5I^- + IO_3^- + 6H^+ \rightarrow 3I_2 + 3H_2O
\]

The iodine produced reacts rapidly with vitamin C in solution according to the redox reaction outlined earlier. The solubility of iodine is increased by complexation with iodide to form triiodide as shown in equation 4.
Equation 4

$I_2 (aq) + I^- (aq) \rightarrow I_3^-(aq)$

Triiodide then oxidizes vitamin C to dehydroascorbic acid as shown in equation 5.

Equation 5

$C_6H_8O_6 + I_3^- \rightarrow C_6H_6O_6 + 3I^- + 2H^+$

Since the stoichiometries of both reactions are known, the amount of vitamin C can be easily obtained. End point is marked by the production of a blue-black coloration, which is the reaction of iodine with starch suspension. As long as vitamin C is present, the triiodide is quickly converted to iodide ion, but no blue-black iodine coloration is produced. However, when all the vitamin C has been oxidized, the excess triiodide (in equilibrium with iodine) reacts with starch to form the expected blue-black color.

The redox reaction is preferable to an acid-base titration because a number of other species in juice can act as acids, but relatively few interfere with oxidation of ascorbic acid by iodine.

Table 1. Vitamin C Ranking Guide Line

<table>
<thead>
<tr>
<th>Fruit name</th>
<th>Scientific name</th>
<th>Vitamin C (mg/100 g)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>Mangifera indica</td>
<td>28</td>
<td>Excellent</td>
</tr>
<tr>
<td>Orange</td>
<td>Citrus sinensis</td>
<td>53</td>
<td>Excellent</td>
</tr>
<tr>
<td>Pineapple</td>
<td>Ananas comosus</td>
<td>15</td>
<td>Good</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>Hycopersicon sp.</td>
<td>19</td>
<td>Very good</td>
</tr>
<tr>
<td>Custard apple</td>
<td>Anana reticulate</td>
<td>19</td>
<td>Very good</td>
</tr>
<tr>
<td>Babaco</td>
<td>Casimiro edulis</td>
<td>30</td>
<td>Very good</td>
</tr>
<tr>
<td>Banana</td>
<td>Musa paradisiacal</td>
<td>9</td>
<td>Good</td>
</tr>
<tr>
<td>Kiwakiwi green</td>
<td>Actinidia delicosa</td>
<td>98</td>
<td>Exceptional</td>
</tr>
<tr>
<td>Guava tropical</td>
<td>Psidium guajava</td>
<td>183</td>
<td>Exceptional</td>
</tr>
<tr>
<td>Jujube</td>
<td>Ziziphus jujube</td>
<td>500</td>
<td>Exceptional</td>
</tr>
</tbody>
</table>

Table 2. The volume of iodine solution titrated with the standard vitamin C solution

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of ascorbic acid (g)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Final burette reading (mL)</td>
<td>14.20</td>
<td>28.50</td>
<td>42.60</td>
</tr>
<tr>
<td>Initial burette reading (mL)</td>
<td>0.00</td>
<td>14.20</td>
<td>28.50</td>
</tr>
<tr>
<td>Volume of Iodine used (mL)</td>
<td>14.20</td>
<td>14.30</td>
<td>14.10</td>
</tr>
</tbody>
</table>

The mean titre of iodine solution = $\frac{(14.2+14.3+14.1)}{3} = 14.20$ mL.

2.5. Titration of Each of Three Fruit Juices

2.5.1. Titration of T. Indica with Iodine Solution

The iodine solution was titrated against 25.0 mL (in a 125 mL Erlenmeyer flask) of T. Indica juice obtained by blending 56.86 g of T. Indica fruit. The titration was repeated until three good measurements agreeing to 0.1 mL difference were obtained (Table 3).
Table 3. The volume of iodine solution titrated with the T. Indica solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of raw T. Indica (g)</td>
<td>56.86</td>
<td>56.86</td>
<td>56.86</td>
</tr>
<tr>
<td>Final burette reading (mL)</td>
<td>0.50</td>
<td>3.00</td>
<td>3.6</td>
</tr>
<tr>
<td>Initial burette reading (mL)</td>
<td>0.00</td>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Volume of Iodine used (mL)</td>
<td>0.50</td>
<td>0.50</td>
<td>0.60</td>
</tr>
</tbody>
</table>

The mean titre of iodine solution = 0.53 mL.

2.5.2. Titration of S. Comorensis with Iodine Solution

The iodine solution was titrated against 25.0 mL (in a 125 mL Erlenmeyer flask) of S. Comorensis juice obtained by blending 52.04 g of S. Comorensis fruit. The titration was repeated until three good measurements agreeing to 0.1 mL difference were obtained (Table 4).

Table 4. The volume of iodine solution titrated with S. Comorensis solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of raw S. Comorensis (g)</td>
<td>52.04</td>
<td>52.04</td>
<td>52.04</td>
</tr>
<tr>
<td>Final burette reading (mL)</td>
<td>3.00</td>
<td>6.10</td>
<td>13.10</td>
</tr>
<tr>
<td>Initial burette reading (mL)</td>
<td>0.00</td>
<td>3.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Volume of Iodine used (mL)</td>
<td>3.00</td>
<td>3.10</td>
<td>3.10</td>
</tr>
</tbody>
</table>

The mean titre of iodine solution = 3.07 mL.

2.5.3. Titration of S. Cytheera with Iodine Solution

The iodine solution was titrated against 25.0 mL (in a 125 mL Erlenmeyer flask) of S. Cytheera juice obtained by blending 180.53 g of S. Cytheera fruit. The titration was repeated until three good measurements agreeing to 0.1 mL difference were obtained (Table 5).

Table 5. The volume of iodine solution titrated with the S. Cytheera solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of raw S. Cytheera (g)</td>
<td>180.53</td>
<td>180.53</td>
<td>180.53</td>
</tr>
<tr>
<td>Final burette reading (mL)</td>
<td>3.10</td>
<td>9.90</td>
<td>16.30</td>
</tr>
<tr>
<td>Initial burette reading (mL)</td>
<td>0.00</td>
<td>6.80</td>
<td>13.10</td>
</tr>
<tr>
<td>Volume of Iodine used (mL)</td>
<td>3.10</td>
<td>3.10</td>
<td>3.20</td>
</tr>
</tbody>
</table>

The mean titre of iodine solution = 3.13 mL.

3. Calculations

The amount of vitamin C in each fruit was determined by stoichiometric calculation in relation to that of standard solution titrated with known concentration of vitamin C. Detailed calculations are shown in the Appendix. Table 6 depicts the amount of vitamin C in each fruit as obtained from the calculations shown in appendix.

Table 6. Vitamin C in three fruits (S. Comorensis, S. Cytheera, and T. Indica)

<table>
<thead>
<tr>
<th>Fruits’ local names</th>
<th>Scientific name</th>
<th>Vitamin C (mg/100 g)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bungo</td>
<td>S. Comorensis</td>
<td>31.00</td>
<td>Excellent</td>
</tr>
<tr>
<td>Embe sakua</td>
<td>S. Cytheera</td>
<td>18.00</td>
<td>Very good</td>
</tr>
<tr>
<td>Ukwaju</td>
<td>T. Indica</td>
<td>9.36</td>
<td>Good</td>
</tr>
</tbody>
</table>

4. Results and Discussion

S. Comorensis fruit has the highest amount of vitamin C (31 mg/100 g), which is three times higher than that of T. Indica (Fig. 1). The lowest vitamin C content (9.36 mg/100 g) was measured from T. Indica. However, vitamin C in S. Comorensis is less than that of citrus fruits, such as orange. Nevertheless, vitamin C content in S. Comorensis is comparable to that of mango fruit (Table 6). The vitamin C content in S. Cytheera was 18 mg/100 g. Vitamin C content in T. Indica fruit is quantitatively comparable to that banana (Table 1 and 6).

Figure 1. Vitamin C Content in S. Comorensis, S. Cytheera, and T. Indica
5. Conclusion

At least each of the studied fruits (S.Comorensis, S.Cytheera, and T.Indica) had been found to contain reasonable amounts of vitamin C per 100 g of each of the raw fruit. Of the three studied fruits, it is advisable to consume more of S.Comorensis fruits for excellent intake of vitamin C. This can help to reduce severe health problems including cancer, diabetes, cardiovascular disease and other diseases.

Appendix

Calculations for Standard Ascorbic Acid

Mean titre was 14.20 mL

Equations:

\[
KIO_3 + 5KI + 6H^+ → 3I_2 + 6 K^+ + 3H_2O \\
(C) \text{(As in Equation 3)}
\]

\[
C_6H_8O_6 + I_3^- + H_2O → C_6H_6O_6 + 3I^- + 2H^+ \\
(As \text{ in Equation 5})
\]

Mole IO_3^- = Mass/RMM = 0.268/214 = 1.252 × 10^{-3} mole IO_3^-

Note: Relative Molecular Mass of KIO_3 = 214 g mole^{-1}

Since 1 mole IO_3^- = 3 moles I_2

Therefore 1.252 × 10^{-3} mole IO_3^- = 3.757 × 10^{-3} mole I_2

From:

Number of mole (n) = MV/1000; Where:

M = Molarity
V = Volume in mL
Molarity of iodine = 3.757 × 10^{-3} × 1000/500

Thus, molarity of iodine = 7.56 × 10^{-3} M

Molar concentration of iodine:

\[
M_1 = \frac{M_2 V_2}{V_1 n_2}
\]

\[
= \frac{7.56 \times 10^{-3} \times 0.5 \times 1}{25}
\]

\[
= 1.512 \times 10^{-4} M
\]

Since n = MV/1000 = Mass/RMM

Mass = RMM × MV/1000 = 176 × 1.512 × 10^{-4} × 200/1000 = 5.322 × 10^{-3} g ascorbic acid per 56.86 g of T.Indica.

That is 9.36 × 10^{-3} g vitamin C per 100 g of T.Indica. This is equal to 9.36 mg vitamin C per 100 g T.Indica.

Similar calculations gave 31.5 mg and 18.0 mg as the level of vitamin C in each 100 g of S.Comorensis and S.Cytheera respectively.

References


