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DEGRADATION OF ASCORBIC ACID DURING STORAGE OF SYRUP FROM GUAVA FRUIT (Psidium guajava)

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Abstrak

Penelitian ini bertujuan untuk mengevaluasi penurunan kandungan ascorbic acid pada sirup jambu biji pada saat penyimpanan. Selama pasteurisasi sirup jambu biji pada suhu 90°C selama 30 detik tidak diperoleh perbedaan nyata (p<0,05) terhadap penurunan kandungan ascorbic acid. Penyimpanan yang dilakukan selama 64 hari pada suhu ruang (26.18 ± 0.71°C) menunjukkan kehilangan ascorbic acid sebesar 60.34%. Perlakuan kombinasi suhu pengolahan sirup jambu biji sebelum dilakukan penyimpanan tidak berpengaruh terhadap kandungan ascorbic acid dan nilai pH selama penyimpanan. Nilai pH sirup jambu biji cenderung konstan sampai akhir penyimpanan. Dengan hasil yang diperoleh, dapat membantu dalam menentukan kondisi sirup selama penyimpanan khususnya untuk meminimalisir kehilangan faktor penting seperti kandungan ascorbic acid.

Kata kunci: Ascorbic acid, penurunan, penyimpanan, pH.

1. Introduction
1.1. Background

Guava (Psidium guajava) is a popular fruit in the tropics. Guava, which belongs to the Myrtaceae family, is originated in an area extending from Southern Mexico through Central America and is widespread throughout the tropical and subtropical areas (Shigeura and Bullock, 1983). In Indonesia production of guava fruit was increasing with fluctuate condition, it was recorded that the production of guava in Indonesia in 2006 reached about 192,180 tons (Indonesian Central Bureau of Statistic, 2008). Moreover, guava fruit has a potentially high value for export purposes. This fruit has been exported to Singapore, Taiwan, Hongkong, Malaysia, and Thailand (Parimin, 2005). The development of a prospective fruit production is very important in order to increase the competence in responding to the demand for local and export markets. To promote intensive guava production and to assure the good handling after harvesting of guava fruit, a better knowledge on pre- and postharvest technology was required.

Guava fruit is high in nutritional value; its ascorbic acid content is higher than in other fruits such as: mango, orange, papaya, strawberry, and pineapple (Salunkhe and Kadam, 1995). In their study ascorbic acid content in guava fruit can reach about 11-1160 mg 100g-1. Determinations of ascorbic acid degradation during guava post harvest handling have hardly been reported, particularly in relation to the destruction of ascorbic acid during storage. Jawaheer et al. (2003) evaluated the ascorbic acid concentration during processing and storage of jam and juice, where jam has lower ascorbic acid content than juice. Sato (2006) studied the addition of calcium to the guava fruits in syrup for the improvement of the texture and lowering the negative effects of temperature on the mechanical
properties. Uddin et al. (2002) evaluated ascorbic acid loss in dried guava during storage. However, the research particularly related to degradation of ascorbic acid storage of guava syrup has not yet been conducted. The objective of this work was to determine ascorbic acid degradation and pH value during storage of guava syrup.

1.2. Guava fruit (Psidium guajava)

Guava fruit belong to a member of the dicotyledon family Myrtaceae. Genus of Psidium is divided into five different species, Psidium guianense, P. chinense, P. friedrichsthalianum, P. cattleianum, and P. guajava. The guajava species is the most cultivated one (Sidhu, 2006). The whole fruit is edible, from seeds to rind, but many people prefer to cut out the seeds and the middle part of guava. The guava flesh is sweet, however the middle part with seeds is the sweetest one; the rind is slightly bitter.

There are some varieties of guava fruits which are commonly found in Indonesia such as: jambu pasar minggu, jambu Australia, jambu sukun, and jambu Bangkok. Cv. jambu pasar minggu consist two types that are white flesh guava called “white milk” and red flesh guava. White flesh guava cv. pasar minggu is more preferred because it is sweeter with quite dense flesh and also has softer flesh. Cv. jambu Australia was introduced from Australia to Indonesia and has specific raw materials for commercial plant processing in tropical countries. It is a good source of ascorbic acid, pectin, carotenoids, dietary fiber and antioxidant compounds (Sidhu, 2006). Because of its unique and strong flavor, guava fruit lends itself to the production of a number of processed products such as juice, clarified juice, nectar, jam, jelly, guava cheese, canned, concentrate, dehydrated powder, puree, and syrup.

1.3. Ascorbic acid

Vitamin C commonly found in food as L-ascorbic acid or dehydroascorbic acid. Vitamin C is important in the
Vitamin C is required in the human body for the collagen production which is important to provide the structure of connective tissues particularly teeth, bones, tendons, arteries, skin, and cartilage. Vitamin C is also known to have many biological functions in reducing the risk of coronary heart diseases, cancer, cataracts, and high lead levels (Blake, 2008).

Losses of ascorbic acid are enhanced by extended storage, higher temperatures, low relative humidity, physical damage, and chilling injury. L-ascorbic acid is easily oxidized, especially in aqueous solutions, and also at the presence of oxygen, heavy metal ions, especially Cu2+, Ag+, and Fe3+, and by alkaline pH and high temperature. L-dehydroascorbic acid (DHA) can be decreased to ascorbic acid by reducing agents and can also be irreversibly oxidized to diketogulonic acid, which has no ascorbic acid activity (Parviainen and Nyyssonen, 1992).

Changes in degradation of ascorbic acid are influenced by pH value. Low pH conditions contribute to the formation of furfural, 2-furoic acid, and 3-hydroxy-2-pyrone. However, high pH value leads to formation of very small amounts of furfural and 3-hydroxy-2-pyrone and no 2-furoic acid (Yuan and Chen, 1998). Roig et al (1995) described that accelerate of ascorbic acid loss is influenced by changes of pH value between 1.5 and 7.

2. Materials and Methods

2.1. Materials

The material, guava fruit cv. Jambu Bangkok, was collected fresh from North Sumatra, Indonesia. All fruit samples were collected about 112 days from the onset of guava flowering. The guava fruits used for study were observed with length of 100-117 mm, diameter of 85-97 mm and weight of 420-465 g, randomly. The flesh color of guava fruit that used in this study is white, and has light green skin color.
in the Erlenmeyer flask and titrated with 2, 6 DIP solutions until the color change to the light pink occur. The content of ascorbic acid (mg 100ml-1 guava syrup) was calculated according to formula below:

\[ AA = (V \text{ (ml)} \times \text{Ae} \times \frac{(100 \text{ ml/Sa-Vo ml})}{(\text{Ex-Vol/Titr-Vol})}) \]

Where:
- \( V \) is the volume of DIP-dye solution in ml,
- \( \text{Ae} \) is ascorbic acid equivalent of dye solution expressed as mg/ml of dye determined before with standardized ascorbic acid solution (1 mg in 1 ml) (three times).
- \( \text{Sa-Vo} \) as a sample volume in ml = 5 ml,
- \( \text{Ex-Vol} \) is extraction volume in ml = 50 ml, and
- \( \text{Titr-Vol} \) is aliquot volume in ml used for titration = 10 ml.

### 2.4. Measurement of pH value

The pH meter was calibrated using pH 2 and 7 as buffer solutions. After calibration, the stable result as shown in pH meter display (HM-60V, Toa Electronics Ltd., Japan) was recorded by putting the electrode in each sample. This was done in order to know the pH value of guava syrup during storage periods.

### 2.5. Statistical methods

Analysis of variance and Bonferroni test (p<0.05) were performed in order to evaluate the ascorbic acid loss and the stability of pH value during storage. Pasteurization effect was analyzed using paired t-test.

### 3. Results and Discussions

#### 3.1. Heat treatment of Guava syrup

The rate of ascorbic acid loss is influenced by time and temperature which are categorized as critical factors that are involved in this destruction. During the guava syrup processing (heating for 10 minutes), the percentage degradation of ascorbic acid was 0%, 0.82%, 2.91%, 3.34%, 3.40% for heating temperature at 60, 70, 80, 90, 100°C, respectively. Jawaheer et al. (2000) processed guava to juice at 88°C for 10 minutes, the percentage of ascorbic acid loss was 4.5%. Lima et al. (1999) found that degradation of ascorbic acid in orange juice at 80°C for 40 minutes reaches ascorbic acid loss of 12.3%.

#### 3.2. Pasteurization

Pasteurization is necessary to avoid pathogenic bacteria, infestation of diseases, and also to prevent spoilage bacteria of food products that can maintain its quality aspects (Lewis, 2006). It can...
also inactivate enzymes activities which leading to a decreasing cloud formation in orange juices and to avoid bitter taste due to microorganism attack (Farnworth et al. 2001). Reduced microbial population of the product results in better food safety and prolong the shelf life of product. However, the pasteurization affects the loss of nutrients, particularly ascorbic acid. Figure 2 below shows the ascorbic acid content before and after pasteurization of guava syrup 33.65±2.069 mg 100 ml-1 and 33.21±1.860 mg 100 ml-1, respectively. After heating of guava syrup at 90°C for 30 seconds the retention of ascorbic acid was 98.69% ± 0.515.

By using paired t-test (parametric test), there was no indication that pasteurization had a significant effect (p < 0.05) on ascorbic acid loss. Another study confirmed the retention of ascorbic acid after pasteurization of orange juice at 90°C for 30 seconds about 97.6% up to 98.2% (Roig et al. 1995).

3.3. Storage

Ascorbic acid content in guava syrup decreased during storage at ambient temperature (26.18 ± 0.71 °C) (Figure 3). The loss of ascorbic acid was started in the second days about 2.70% ± 3.030, and it was continued until sixty fourth days about 60.34% ± 4.709. This loss might be cause by many factors, which can affect the stability of ascorbic acid for instance: ambient temperature, the incidence of light, and the availability of oxygen in headspace and others. The presence of oxygen will destroy ascorbic acid due to oxidation by residual oxygen level in headspace. The oxygen will dissolve in syrup and ascorbic acid would be oxidized and converted into dehydroascorbic acid which then will be transformed to 2,3-diketogulonic acid (Rojas and Gerschenson, 1997). 

Figure 2. Effects of pasteurization on ascorbic acid degradation at 90°C for 30 seconds
over, loss of ascorbic acid also occurs under anaerobic conditions when as soon as the free oxygen in headspace has been depleted by certain chemical reactions and then ascorbic acid is degraded via several steps to form furfural instead of dehydroascorbic acid (Smoot and Nagy, 1980).

Ascorbic acid loss during storage period might be accelerated by the presence of light. Sattar et al., (1989) observed the greatest losses of ascorbic acid in a HTST pasteurized orange drink packaged in clear or green glass; tetrapack and amber glass had lower losses when exposed to fluorescent light over a 30 day storage period at temperatures between 25-30°C. According to Solomon et al. (1995) sunlight had a minimal influence on ascorbic acid content of orange juice which is stored at 8°C in glass containers, covered on the sides with aluminum foil. Mottar, J. (1989) also recorded that the influence of light was minimal on ascorbic acid content in orange juice which was stored for three months at 5 or

![Figure 3. Ascorbic acid loss in guava syrup during storage period at ambient temperature](image)

Table 2. The effect of storage time of guava syrup on ascorbic acid content (mg 100 ml⁻¹) during storage

<table>
<thead>
<tr>
<th>Day</th>
<th>60°C</th>
<th>70°C</th>
<th>80°C</th>
<th>90°C</th>
<th>100°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>35.22±1.441&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.277±0.545&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33.333±1.441&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.076±0.943&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.132±1.634&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>33.962±0.943&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>34.603±2.397&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.746±1.455&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>32.064±1.455&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.245±0.943&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>29.206±1.100&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.731±1.504&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>30.380±0.980&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>27.767±2.829&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>27.937±1.100&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>8</td>
<td>29.932±1.559&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.460±1.697&lt;sup&gt;b&lt;/sup&gt;</td>
<td>26.787±2.040&lt;sup&gt;b&lt;/sup&gt;</td>
<td>24.827±0.566&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.510±1.020&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>16</td>
<td>26.740±1.634&lt;sup&gt;c&lt;/sup&gt;</td>
<td>25.643±1.020&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.847±1.132&lt;sup&gt;c&lt;/sup&gt;</td>
<td>22.213±1.132&lt;sup&gt;c&lt;/sup&gt;</td>
<td>22.34±1.679&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>32</td>
<td>18.315±1.269&lt;sup&gt;d&lt;/sup&gt;</td>
<td>21.769±1.559&lt;sup&gt;c&lt;/sup&gt;</td>
<td>18.707±0.589&lt;sup&gt;d&lt;/sup&gt;</td>
<td>18.367±1.767&lt;sup&gt;d&lt;/sup&gt;</td>
<td>19.780±1.099&lt;sup&gt;ed&lt;/sup&gt;</td>
</tr>
<tr>
<td>64</td>
<td>12.821±0.634&lt;sup&gt;d&lt;/sup&gt;</td>
<td>13.265±1.020&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12.925±3.863&lt;sup&gt;e&lt;/sup&gt;</td>
<td>11.735±4.050&lt;sup&gt;e&lt;/sup&gt;</td>
<td>14.894±1.064&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are presented as mean ± standard deviation. Mean values in the same column with the same superscripts are not significantly different (p < 0.05 using Bonferroni test).
20°C in polypropylene packaging.

As shown in Table 2, the degradation of ascorbic acid content at 60°C from first day until eighth days was not statistically significant different. Starting at sixteenth days until sixty fourth days of storage the content of ascorbic acid was found significant different. The ascorbic acid loss trend at 70-100°C of heat treatment before storage was tends to be the same with temperature at 60°C during storage period.

Table 3 shows ascorbic acid rate constants of guava syrup stored at ambient temperature (26.18 ± 0.71 °C). During storage the degradation of ascorbic acid was followed by first order reaction due to both coefficient determination and standard error correspondent to first order reaction higher than zero order reaction. Lin and Agalloco (1979) reported first order rate equation of ascorbic acid degradation is used when oxygen is available in abundance (for aerobic degradation) or not at all (for anaerobic degradation). Riemer and Karel (1978) studied the rate of destruction of ascorbic acid dehydrated tomato juice during storage which is affected by water activity, oxygen, and temperature. In their study the rate of destruction was described by first-order reaction kinetics.

Rate constant (Table 3) for first order reaction at different heating levels before storage tend to be relatively constant. In this case the data did not reveal significant difference among heating temperature treatment. This is because the similar condition in syrup which was placed in the same room temperature (26.18 ± 0.71 °C) during storage. Moreover, heat treatment of guava syrup at 60, 70, 80, 90, and 100°C respectively for 10 minutes before storage have small effect on ascorbic acid degradation rate during storage.

<table>
<thead>
<tr>
<th>Heating before storage (°C)</th>
<th>Zero Order</th>
<th></th>
<th>First Order</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rate (k) (days⁻¹)</td>
<td>R²</td>
<td>SE</td>
<td>Rate (k) (days⁻¹)</td>
</tr>
<tr>
<td>60</td>
<td>0.972</td>
<td>0.911</td>
<td>6.841</td>
<td>0.0158</td>
</tr>
<tr>
<td>70</td>
<td>0.903</td>
<td>0.885</td>
<td>7.298</td>
<td>0.0141</td>
</tr>
<tr>
<td>80</td>
<td>0.933</td>
<td>0.881</td>
<td>7.679</td>
<td>0.0150</td>
</tr>
<tr>
<td>90</td>
<td>0.952</td>
<td>0.846</td>
<td>9.103</td>
<td>0.0159</td>
</tr>
<tr>
<td>100</td>
<td>0.762</td>
<td>0.873</td>
<td>6.531</td>
<td>0.0110</td>
</tr>
</tbody>
</table>

R² is coefficient determination; SE is standard error of estimation

Effect of pH value during storage

Table 4 describes the effect of time on pH value during guava syrup storage. Guava syrup was stored in ambient temperature (26.18 ± 0.71 °C) for 64 days. The mean value and standard deviation of pH value was measured along 0, 2, 4, 8, 16, 32, and 64 of day’s storage. The pH value was remained constant for all considered samples until the end of storage. These results above are supported by Robertson and Samaniego (1990) who found no significant difference during storage of lemon juice on pH value. Kaanane et al. (1988) added that the pH value of orange juice did not significantly changes during storage. Based on Table 4, the pH value that always lower than ascorbic acid pKa (4.2) was not expected
to affect the kinetics of ascorbic acid loss (Baiano et al., 2004).

Different temperature of guava syrup processing also did not perform different results on pH value during storage (Table 5). This is because the pH value was not influenced by temperature during processing of guava syrup (0 day). As stated by Kim and Tadini (1999) that temperature and holding time did not affect on pH value, Brix value, density and viscosity of orange juice during pasteurization. This reason also the answer why the pH value was remained constant for all considered temperatures started from 2nd until 64th days of storage.

4. Conclusions

The results of the study on the degradation of ascorbic acid during storage of guava syrup can be concluded as follows:
1. There was no indication that pasteurization of guava syrup at 90°C for 30 seconds had a significant effect (p<0.05) on ascorbic acid degradation.
2. Storage of guava syrup for 64 days at an ambient temperature (26.18 ± 0.71°C) cause ascorbic acid losses up to 60.34% ± 4.709. The reason for these losses could be the effects of temperature, light, aerobic, and anaerobic conditions.
3. The effect of combination temperature processing of guava syrup on both ascorbic acid content and pH value did not found to be different during storage periods.
4. The pH value was relatively constant until the end of guava syrup storage.

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CTAHR, University of Hawaii.


