Effect of Ascorbic Acid and Polyethylene Plastic Packaging on Browning and Shelf Life of Langsat Fruit (Lansium domesticum)

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Abstract. Langsat (Lansium domesticum) is a tropical fruit classified as a climacteric fruit that can only last 4-6 days after harvesting. Skin colour is easier to brown and black after 4 days of harvesting. This condition does not affect the fruit flesh, but visually, it becomes unappealing. Ascorbic acid and polyethylene plastic packaging could be applied to extend shelf life and slow browning. This study aims to investigate the effect of different concentrations of ascorbic acid treatment and polyethylene plastic (PE) packaging on the browning index and shelf life of langsat fruit. The treatments used in this study involved immersing langsat fruit in different ascorbic acid concentrations: 1.5%, 2%, and 2.5%, respectively. The langsat fruit was then packaged using polyethylene plastic and stored at 15 °C. The results showed that using ascorbic acid could delay browning by up to 14 days, with the lowest browning index found in langsat fruit immersed in 2.5% ascorbic acid concentration and packaged in polyethylene plastic. Polyethylene plastic packaging and ascorbic acid during storage affected the shelf life of langsat fruit, extending it to 14 days.

1 Introduction

Langsat (Lansium domesticum) is a climacteric tropical fruit, meaning that the fruit will continue to ripen even after harvest, followed by deterioration as the fruit continues to respire and produce high ethylene gas. This is an obstacle to maintaining the characteristics of langsat fruit. Damage to langsat fruit can be characterized by changes such as turning the skin blackish and shrinking the weight, which is then followed by softening the texture of the

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fruit. This browning in langsat is known as enzymatic browning. The interaction of oxygen, phenolic chemicals and enzymes causes enzymatic browning [1].

The physical properties and quality of the fruit are very important to maintain after post-harvest. However, farmers and producers still do inappropriate things in handling langsat fruit, such as storing fruit at room temperature and closing spaces so that the physical properties and quality of the fruit can only last 4-6 days. The alternatives that can be used to minimize the occurrence of browning, maintain fruit quality, and not be harmful to consumers are ascorbic acid and polyethylene plastic packaging.

Anti-browning compounds can inhibit browning, which is found in langsat fruit. Applying an ascorbic acid solution to prevent the browning of langsat fruit skin can reduce the activity of the polyphenolase enzyme. Browning reaction is the process of forming yellow pigments that will soon turn into dark brown. As an antioxidant, ascorbic acid can convert o-quinone into o-diphenol again, and enzyme activity can also be limited and inhibit the formation of enzymatic browning processes because ascorbic acid reacts with quinoa components. In addition, fruit packaging is also beneficial in protecting the fruit from any damage, maintaining its freshness, and preventing direct contact with air, thus inhibiting oxidation and increasing the product's shelf life. Physiological changes related to ripening can be slowed down by plastic packaging, which can change the gas in the atmosphere of the packaging, which is different from the ambient atmosphere. Polyethylene (PE) plastic is one of the plastic packaging that is often used in fruit packaging. It is flexible, can be used at low temperatures, and is chemical resistant [2].

Based on this description, this research was conducted to study the effect of ascorbic acid concentration and polyethylene plastic at low temperatures on inhibiting browning and the shelf life of langsat fruit.

2 Research method

2.1 Place and time

This research was conducted from October until November 2023 at the Processing Laboratory, Agricultural Engineering Study Program, Department of Agricultural Technology, Faculty of Agriculture, Hasanuddin University, Makassar.

2.2 Materials and tools

The materials used in this study were langsat fruit (Lansium domesticum) (langsat fruit aged 16 weeks after blossoming) from Palu, ascorbic acid, polyethylene plastic measuring 10 x 30 cm with a thickness of 0.3 mm, flipchart paper, water, and distilled water. The tools used in this research are a measuring cup, digital scale, cup, pestle, penetrometer, colourimeter, refractometer, and refrigerator.

2.3 Research parameters

The observation of research parameters is carried out in the following way:

2.5.1 Color change

The L* value shows the brightness, the a* value shows the difference between red and green, and the b* value shows the difference between yellow and blue. To calculate the ΔE value, we can use the formula [3] below:
\[ \Delta E = \sqrt{((L_0-L_1)^2 + (a_0-a_1)^2 + (b_0-b_1)^2)} \]  

Information \( \Delta E \) Total colour difference, \( L \) Material brightness, the degree of greenness or redness of the material, \( b \) The degree of blueness or yellowness.

### 2.5.2 Index browning

Browning Index (BI) is then calculated using the value obtained. The higher BI value indicates a high browning index [4].

\[ BI = \frac{x^{0.31}}{0.172} \times 100 \]  

Information \( x \) chromaticity coordinate (a) obtained from the colourimeter reading.

### 2.5.3 Percentage weight loss

The weight loss percentage is obtained by weighing the langsat fruit before and after observing the conditions from day 1. Where the percentage of weight loss can be known by using the formula [5] below:

\[ \text{Weight loss} = \frac{W_0 - W_a}{W_0} \times 100\% \]  

Information \( W_0 \) Weight of material at the beginning of storage (g), \( W_a \) Weight of material at the end of storage (g)

### 2.5.4 Hardness level (Kg)

Fruit firmness during storage was measured using a penetrometer. The langsat fruit was placed under the penetrometer needle, and then the penetrometer lever was pressed until the needle entered the fruit sample and read the value that appeared on the tool.

### 2.5.5 Total Soluble Solids (TSS)

The unit reading used in the TSS measurement is °Brix. The greater the °Brix value, the sweeter the langsat fruit is and vice versa.

### 2.4 Data analysis

The Analysis of Variance (ANOVA) method at a significant level of 5% will be used in this study to see whether or not the treatment affects the parameters tested. Furthermore, it is continued with the Duncan Multiple Range Test (DMRT).

### 3 Result and discussion

#### 3.1 Colour

There were 8 treatments in this study, namely without soaking and packaging (control), without soaking and with packaging (0% AS & WP), 1.5% soaking & without packaging (1.5% AS & WOP), 1.5% soaking & with packaging (1.5% AS & WP), 2% soaking & without packaging (1.5% AS & WOP), 2% soaking & with packaging (1.5% AS & WP),
2.5% soaking & without packaging (1.5% AS & WOP) and 2.5% soaking & packaging (1.5% AS & WP).

3.1.1 ∆E value

Colour ∆E refers to the colour difference or distance between two colours in the Lab colour model. The ∆E value describes the extent to which two colours differ from each other in the dimensions of brightness (L*), red-green (a*), and yellow-blue (b*). The larger the ∆E value, the greater the difference between the colours.

![Graph showing ∆E values during storage](image)

**Fig. 1.** ∆E value during storage.

Figure 1 shows that the colour change with an ascorbic acid treatment and polyethylene plastic is lower than without soaking and packaging. This proves the ascorbic acid soaking treatment and polyethylene plastic packaging with low-temperature storage on langsat fruit can inhibit colour changes during storage. The treatment that experienced the highest colour change was without soaking and packaging (control) on day 5 at 3.1. This is because, on day 5, there was a change in yellow to brown colour as a whole. This is following the statement of [2]. Ascorbic acid has high activity as an inhibitor of the browning process because it reduces quinones back into phenol compounds before undergoing further reactions into pigments.

**Table 1.** DMRT (Duncan’s Multiple Range Test) results of ∆E values in each treatment during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Storage Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 3 4 5 6 7 8 9 10 11 12 13 14</td>
</tr>
<tr>
<td>Control</td>
<td>8.00b 3.13b 1.17ab 0.76a 1.51a 1.47a 3.29a</td>
</tr>
<tr>
<td>0% AS &amp; DK</td>
<td>2.90ab 2.28ab 2.36a 1.47a 2.78ab 1.76a 3.60bc 4.09a</td>
</tr>
<tr>
<td>1.5% AS &amp; TK</td>
<td>5.07ab 3.61a 2.39a 1.68a 2.04ab 1.15a 2.43a 3.68a</td>
</tr>
<tr>
<td>1.5% AS &amp; DK</td>
<td>4.07ab 1.38a 2.13a 3.30b 1.50ab 4.24b 4.36cd 4.54a</td>
</tr>
<tr>
<td>2% AS &amp; TK</td>
<td>7.80a 6.83b 2.04a 2.03ab 1.07ab 1.68a 2.97cd 4.10a</td>
</tr>
<tr>
<td>2% AS &amp; DK</td>
<td>3.56b 2.06ab 2.40a 1.30a 1.54ab 2.20a 5.02de 4.80a</td>
</tr>
<tr>
<td>2.5% AS &amp; TK</td>
<td>5.48ab 4.21ab 3.08a 1.52a 2.89b 1.62a 2.90b 5.06a</td>
</tr>
<tr>
<td>2.5% AS &amp; DK</td>
<td>2.51a 1.38ab 3.11a 1.44a 1.83ab 2.38a 5.77e 4.39a</td>
</tr>
<tr>
<td>DMRT sig</td>
<td>0.15 0.18 0.93 0.16 0.15 0.03 0.00 0.63</td>
</tr>
<tr>
<td>Normalitas sig</td>
<td>0.070 0.004 0.086 0.100 0.065 0.200</td>
</tr>
</tbody>
</table>

https://doi.org/10.1051/bioconf/20249602010
Table 1 shows that the results of the ANOVA analysis in Appendix 2 and the DMRT Test (Duncan's Multiple Range Test) show on day 11 and day 13 obtained a P-Value <0.05, meaning there is a real difference between each treatment during storage. The results of the ANOVA data analysis on days 1-9 and day 14 obtained a P-value>0.05, meaning there is no significant difference between the two treatments during the storage of langsat fruit. Langsat. The observation results on day 13 showed that the 2.5% soaking treatment and polyethylene plastic packaging significantly differed from the other treatments.

3.2 Index browning

Browning is a chemical process that occurs when phenolics react with oxygen to produce new compounds that give the langsat peel a brown colour. The following is a graph of the browning index value of langsat fruit peel during storage.

![Graph showing browning index value during storage](image)

**Fig. 2.** Browning index value during storage.

The browning index is a quantitative parameter used to measure or evaluate the degree of browning discoloration of the fruit. The results in Figure 2 show that the browning index value during storage will continue to increase. The browning index value in the 2.5% AS & WP immersion treatment amounted to 7130, 2% AS & WP amounted to 719, and 1.5% AS & WP amounted to 7220, which during storage experienced a slow increase compared to langsat without AS & WOP immersion (control) with a value of 7643. However, the browning index value in the treatment of ascorbic acid soaking and using polyethylene plastic experienced a slower browning index change than in the treatment of ascorbic acid soaking and without polyethylene plastic. The best treatment was 2.5% AS & WP soaking. The langsat treated with ascorbic acid soaking treatment could last for 14 days with the skin color still partially yellow while based on the results of research by [2], that using 2% ascorbic acid and plastic packaging with a storage temperature of 15°C on day 12 showed that the browning index on the langsat fruit was already high. The shelf life only lasted until day 12. This indicates that the higher the concentration, the more effect it will have. The difference in fruit skin colour between the control treatment and 2.5% AS & WP immersion can be seen in Table 3. This is because ascorbic acid works more optimally on plastic langsat skins. After all, plastic can isolate the fruit skin from the outside air to reduce the risk of oxidation of polyphenols enzymes. Plastic also helps inhibit low temperature, which is also one of the methods used to suppress enzyme activity and inactivate enzymes when working. This is following the statement of [6], that water-soluble acid called ascorbic acid dramatically reduces polyphenol oxidase activity. Malic and citric acids are less effective than ascorbic acid in reducing polyphenol oxidase enzyme activity.
Table 2. DMRT (Duncan's Multiple Range Test) results of browning index values in each treatment during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Storage Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Control</td>
<td>5413.43a</td>
</tr>
<tr>
<td>0% AS &amp; DK</td>
<td>4133.07a</td>
</tr>
<tr>
<td>1.5% AS &amp; DK</td>
<td>4234.49a</td>
</tr>
<tr>
<td>1.5% AS &amp; TK</td>
<td>3992.89a</td>
</tr>
<tr>
<td>2% AS &amp; TK</td>
<td>4065.24a</td>
</tr>
<tr>
<td>2% AS &amp; DK</td>
<td>3863.05a</td>
</tr>
<tr>
<td>2.5% AS &amp; TK</td>
<td>3851.42a</td>
</tr>
<tr>
<td>2.5% AS &amp; DK</td>
<td>3840.44a</td>
</tr>
<tr>
<td>DMT sig</td>
<td>0.00</td>
</tr>
<tr>
<td>Normality sig</td>
<td>0.200</td>
</tr>
</tbody>
</table>

Table 2 DMRT Test Results (Duncan's Multiple Range Test) browning index values on each treatment during storage, it can be seen that the results of ANOVA analysis showed on day 1 to day 11 obtained a P-Value <0.05 which means there is a real difference between each treatment during storage. The results of the ANOVA analysis in Appendix 3 on day 14 obtained a P-Value>0.05, meaning there is no significant difference between the two treatments during the storage of langsat fruit. The observation results on day 11 showed that the 2.5% soaking treatment and polyethylene plastic packaging significantly differed from the other treatments.

Table 3. Documentation of langsat fruit treated with control and 2.5% AS & DK.

<table>
<thead>
<tr>
<th>Storage Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>2.5% AS &amp; WP</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>2.5% AS &amp; WP</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td>2.5% AS &amp; WP</td>
</tr>
</tbody>
</table>
3.3 Weight loss

Weight loss in fruit refers to the change in weight or mass due to water loss caused by the ongoing process of respiration and transpiration. The following is a graph of weight loss values on langsat fruit during storage.

Fig. 3. Percentage value of weight loss during storage.

Fig. 4. Percentage value of weight loss in the treatment without packaging.

Fig. 5. Percentage value of weight loss in the treatment with packaging.
Weight loss is one of the indicators of fruit quality during storage. A decrease in weight loss will affect the fruit's selling value, so water loss during storage needs to be maintained. In Figure 3, it can be seen that the percentage value of weight loss during storage continues to increase. Based on Figure 4, the highest increase in weight loss was found in langsat fruit without packaging treatment (WOP), which occurred from day 7 to day 14 and increased to an average of 3.2%. In contrast, Figure 5 shows that langsat fruit given packaging treatment (WP) during storage experienced a slower increase in weight loss; on day 14, it only experienced an average increase of up to 2%. This indicates that the use of polyethylene plastic packaging is more influential than the use of ascorbic acid on the percentage of weight loss during storage. Polyethylene plastic packaging has a low water vapour permeability, which increases the humidity in the packaging and maintains the temperature to reduce water loss due to respiration and transpiration. This follows the statement of [7] that PE plastic has low gas permeability, making it suitable for wrapping or storing foodstuffs and fruits that require protection against oxygen and moisture. PE packaging can slow the fruit ripening process to extend the fruit's shelf life. PE plastic is popular because it is lightweight, strong, resistant to water and chemicals, and easy to recycle.

Table 4. DMRT (Duncan's Multiple Range Test) results in weight loss values in each treatment during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Storage Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Control</td>
<td>0.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>0% AS &amp; DK</td>
<td>0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>1.5% AS &amp; TK</td>
<td>0.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>1.5% AS &amp; DK</td>
<td>0.1&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>2% AS &amp; TK</td>
<td>0.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2% AS &amp; DK</td>
<td>0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2.5% AS &amp; TK</td>
<td>0.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>2.5% AS &amp; DK</td>
<td>0.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>DMRT sig</td>
<td>0.0034</td>
</tr>
<tr>
<td>Normalitas sig</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 4 shows the results of the DMRT (Duncan's Multiple Range Test) test on the value of weight loss in each treatment during storage, showing that the results of ANOVA analysis showed that on day 5 and days 7-14 obtained a P-value <0.05, which means that there is a real difference between each treatment during storage. The results of the ANOVA analysis in Appendix 4 on days 1 and 3 obtained a P-value of > 0.05, meaning there is no significant difference between the two treatments during the storage of langsat fruit. The observation results on day 9 showed that the treatment with polyethylene plastic packaging significantly differed from without plastic packaging.

3.4 Hardness level

Fruit hardness measures the fruit's resistance to pressure or deformation. It reflects the extent to which the fruit's cell structure and cellular components can withstand pressure or other physical forms without suffering significant damage or change. Fruit hardness is often measured with a penetrometer, which gives a resistance value at a certain pressure point. The following is a graph of the hardness value of langsat fruit during storage.
Fruit firmness is one of the objective quality parameters to assess fruit quality and shelf life. The level of fruit hardness is closely related to the level of fruit maturity or fruit decay. Measurement of fruit hardness can be done by using a penetrometer. Based on the results in Figure 6, it can be seen that the hardness of langsat fruit during storage decreased significantly. The highest decrease in hardness was found in langsat fruits that were not treated with packaging (WOP), which occurred from day 8 to day 14 with an average value of 2.82 kg, indicating that the texture of the fruit flesh was still fresh. The langsat fruit treated with packaging (WP) experienced a slower decrease in hardness, which only reached an average decrease of 4.29 kg, indicating that the texture of the pulp was still fresher than the langsat fruit that was not treated with packaging (WOP), while based on the results of research by [2], that using 2% ascorbic acid and plastic packaging with a storage temperature of 15 °C on langsat fruit can only last up to 12 days, indicating that the texture of the pulp is not fresh.

The difference in texture of langsat fruit can be seen in Figure 7. This occurs due to the metabolic process, namely the process of respiration and transpiration, that continues. However, storage at low temperatures and using plastic can prevent the absorption of oxygen from outside, which results in the respiration process being inhibited so that the breakdown of carbohydrates into water-soluble compounds is reduced and the hardness of the fruit can be maintained. This indicates that the use of polyethylene plastic packaging is more influential than the use of ascorbic acid on the level of hardness during storage. This follows the statement of [8] that low-temperature storage will also cause the water content to be frozen so that bacteria and enzymes will experience inactivation, which slows the respiration rate. This is also in line with the statement of [2] that langsat fruit is classified as a fruit that experiences increased respiration after harvest. Lowering the product temperature is the most effective way to reduce the respiration rate process.

Table 5. DMRT (Duncan's Multiple Range Test) test results of the hardness level value in each treatment during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Storage Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Control</td>
<td>7.34a</td>
</tr>
<tr>
<td>0% AS &amp; DK</td>
<td>8.39a</td>
</tr>
<tr>
<td>1.5% AS &amp; TK</td>
<td>7.58a</td>
</tr>
<tr>
<td>1.5% AS &amp; DK</td>
<td>7.92a</td>
</tr>
<tr>
<td>2% AS &amp; TK</td>
<td>7.84a</td>
</tr>
<tr>
<td>2% AS &amp; DK</td>
<td>9.39a</td>
</tr>
</tbody>
</table>
In Table 5, it can be seen the results of the DMRT (Duncan’s Multiple Range Test) tests on the hardness level of each treatment during storage show that the results of ANOVA analysis showed that on day 11 to day 14 obtained a P-value <0.05 means a significant difference between each treatment during storage. The results of the ANOVA analysis in Appendix 5 on day 1 to day 9 obtained a P-value >0.05, meaning there is no significant difference between the two treatments during the storage of langsat fruit. The observation results on day 11 showed that the 2.5% soaking treatment and polyethene plastic packaging significantly differed from the other treatments.

![Langsat Fruit](image)

**Fig. 7.** Langsat fruit (a) fresh (b) rotten.

### 3.5 Total Soluble Solids (TSS)

Total soluble solids in fruit refers to the total amount of solids dissolved in fruit juice. Soluble solids in fruit involve compounds such as sugars, organic acids, vitamins, and minerals that dissolve in water as juice. The following graph shows the value of total soluble solids in langsat fruit during storage.

![Total Soluble Solids Graph](image)

**Fig. 8.** TSS value during storage.

Total soluble solids are one of the indicators of the sweetness of a fruit, which comes from the breakdown of starch and produces a certain amount of sucrose. The increase in total soluble solids is closely related to the level of ripeness, and TSS is often used as an indicator of fruit ripeness. Total soluble solids can be measured using a refractometer. In Figure 8, it can be seen that the value of total soluble solids during 14 days continued to increase.
However, the value of total soluble solids in langsat fruit treated with plastic packaging (WP) with an average value of 18.5 °Brix increased slowly compared to langsat fruit not treated with packaging (WOP) by reaching an average value of 19.3 °Brix. This is because ascorbic acid soaking and polyethylene plastic packaging at low temperatures can maintain the temperature and protect the fruit from outside oxygen so that it can inhibit the process of respiration, which results in the formation of sugar, which will also be inhibited. At the same time, low-temperature storage can also inactivate the work of enzymes to inhibit the work of enzymes in breaking down glucose in the respiration process. This follows the statement of [2] that the soaking treatment will be effective if the fruit that has been soaked with ascorbic acid is then given a packaging treatment. The higher the concentration of ascorbic acid used, the stronger it inhibits the activity of the enzyme pectin methylesterase in the cell wall to work to degrade cellulose and hemi cellulose so that the TSS value tends to stabilize.

**Table 6.** Results of DMRT (Duncan's Multiple Range Test) on the value of total soluble solids in each treatment during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Storage Duration (Days)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15.8a</td>
<td>16.7a</td>
<td>17.2b</td>
<td>17.7a</td>
<td>18.3b</td>
<td>18.6c</td>
<td>18.9a</td>
<td>19.4a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% AS &amp; DK</td>
<td>15.6a</td>
<td>15.6a</td>
<td>16.6ab</td>
<td>16.9a</td>
<td>17.1abc</td>
<td>17.3ab</td>
<td>17.8a</td>
<td>18.3a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>15.4a</td>
<td>16.1a</td>
<td>16.8ab</td>
<td>17.6a</td>
<td>18.2ab</td>
<td>18.5abc</td>
<td>18.8a</td>
<td>19.1a</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1.5% AS &amp; DK</td>
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<td>15.2a</td>
<td>16.5ab</td>
<td>16.9a</td>
<td>17.0ab</td>
<td>17.4abc</td>
<td>17.9a</td>
<td>18.6a</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>2% AS &amp; TK</td>
<td>15.2a</td>
<td>16.3a</td>
<td>16.9ab</td>
<td>17.4a</td>
<td>18.2ab</td>
<td>18.5abc</td>
<td>19.0a</td>
<td>19.3a</td>
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<tr>
<td>2% AS &amp; DK</td>
<td>15.0a</td>
<td>15.5a</td>
<td>16.2ab</td>
<td>16.7a</td>
<td>17.2abc</td>
<td>17.3abc</td>
<td>18.0a</td>
<td>18.3a</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2.5% AS &amp; DK</td>
<td>15.5a</td>
<td>16.3a</td>
<td>16.9ab</td>
<td>17.5a</td>
<td>18.1abc</td>
<td>18.6a</td>
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<tr>
<td>2.5% AS &amp; DK</td>
<td>14.8a</td>
<td>15.0a</td>
<td>16.0a</td>
<td>16.2a</td>
<td>16.8a</td>
<td>17.1a</td>
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<td>DMRT sig</td>
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<td>0.04861</td>
<td>0.026</td>
<td>0.06319</td>
<td>0.003</td>
<td>0.020</td>
<td>0.045</td>
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<td>Normalitas sig</td>
<td>0.13889</td>
<td>0.13889</td>
<td>0.13889</td>
<td>0.032</td>
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</table>

Based on Table 6, the results of the DMRT (Duncan's Multiple Range Test) test on the value of total soluble solids in each treatment during storage show that the results of ANOVA analysis show that on days 9-11 obtained a P-value <0.05, which means that there is a real difference between each treatment during storage. The results of the ANOVA analysis in Appendix 6 on days 1-7 and days 13-14 obtained a P-value >0.05, meaning there is no significant difference between the two treatments during the storage of langsat fruit. The observation results on day 11 showed that the 2.5% soaking treatment and polyethylene plastic packaging significantly differed from the other treatments.

**4 Conclusion**

Based on the results of the research that has been carried out, it can be concluded that:

1. Using ascorbic acid and polyethylene (PE) plastic at a low temperature significantly affects the browning index and shelf life of langsat fruit, which can inhibit the browning index during the 14-day storage period.
2. Polyethylene plastic packaging and ascorbic acid at 15°C during storage can slow down color change, weight loss, hardness and total soluble solids and extend the shelf life up to 14 days.
3. The best concentration used during storage was 2.5% ascorbic acid concentration and polyethylene plastic packaging.
References