Studying the Effects Of Inhibitor Solution Soaking Time On Guava (*Psidium guajava* L.) Storability

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Abstract. This research is conducted to study the effects of the concentration and soaking time of inhibitor solution on the storability of guava using various concentrations (0, 10, 30, and 50 ppm) and soaking time (4, 8, and 12 hours). The estimation of guava storability uses simple linear regression. Results show that an AgNO₃ 10 ppm solution with 4 to 12 hours of soaking time can reduce the effect of storability with the following parameters: weight decrease, hardness level, vitamin C content, and total dissolved solids (TDS). Guava that is stored at room temperature is expected to have a storability that lasts for 29 days for the responses of weight decrease, hardness level, vitamin C, and TPI or it can reach around 2.5 to 3 times longer compared to the controls only stored for 9 days at room temperature. The treatment using AgNO₃ solution for 4 hours can suppress the effect of storage on the response parameters; the hardness level with storability reaching 28 days, and vitamin C content with storability reaching 12 days. Meanwhile, the treatment using the AgNO₃ solution for 12 hours can suppress the effects of storage on the response parameters; weight decrease with storability that reaches 12 days, TDS with storability that reaches 63 days.

Keywords: guava, storability, inhibitor solution, soaking time

1. Introduction

Fruits generally have a certain season and time to distribute, so it is necessary to extend a fruit’s storability. Changes in quality during the time of storage occur because the fruits still do respiration, ripening, and then followed by the process of withering and decaying. According to Kader (1992) cited in [3], the range of loss after harvesting fresh fruits and vegetables is estimated at 5-25% in developed countries and 20-50% in developing countries.

Guava is one of the climacteric fruit groups which has a respiration rate that will continue to increase as the fruit grows. The decrease in weight and other changes might occur, especially when the fruit reaches its climatic peak. Changes occur due to external factors such as ethylene, O₂, CO₂ and temperature, and mechanical damage as well as microbiological damage resulting in a shorter shelf life [20]
Inhibition of the most important biological factors in fruits is the formation of ethylene, respiration, transpiration, and morphological factors [6]. Ethylene is a compound that functions to stimulate fruit ripening, a flower blooming, and leaf and flower shedding. Ethylene formation in the tissue, from ACC (1-aminocyclopropane-1-carboxylic acid), is converted to ethylene with the ACC oxidase catalyst. According to [10], silver nitrate (AgNO₃) can function as an anti-ethylene. In silver nitrate solutions, Ag⁺ ions may inhibit ethylene formation in tissues and negative feedback from endogenous ethylene.

Based on the explanation above, it is necessary to study the storability of Guava (Psidium guajava L.) to inhibit ripening to fruit by soaking in inhibitors. The purpose and objective of this research are to study the effects of soaking treatment using an inhibitor solution on the shelf life of fresh guava (Psidium guajava L.) stored at room temperature.

2. Materials and Methodology

2.1 Materials and Tools

The main material is Citayam variety grade guavas (Psidium guajava L.) with 6-9 fruits/kg, fruit age at 4 months and ripeness level at 60% in Garut Regency. The research materials include solid AgNO₃, 1% acetate acid from PT Bratachem, Citric acid 1% and glacial acetate from PT. Bratachem and solid chitosan obtained via Tokopedia. The analysis material for vitamin C is iodine 0.01 N and 1% starch, sodium thiosulfate 0.01 N, and solid potassium iodate from PT. Merck.

The volume measuring include plastic measuring (200 mL, 1000 mL), and 2000 mL glass measuring, 100 mL and 1000 mL measuring flask, and tool such as stirring rod, watch glass, glass funnel, spatula, 10 mL volumetric pipette, 25 mL burette, 250 mL Iwaki Pyrex Erlenmeyer, and a 500 mL spray bottle.

The tools used to assist analysis (physical, chemical, and physicochemical) are heaters, magnetic stirrers, Quattro Macs series digital balance, Mettler Toledo AL 204 digital analytical balance, Memmert VO200 vacuum oven, Penetrometer, and Atago PAL 1 digital refractometer.

2.2 Research Method

The estimation of storability uses the experimental design is a simple linear regression with the regression equation model [17] and the research stages are: The first stage of research to determine the concentration and soaking time of the inhibitor solution (AgNO₃) with a variety of concentrations (0, 10, 30, and 50 ppm) and soaking time (4, 8, 12 hours). The experimental design as follows: Y = a + bX, Y = dependent variable (response X), X = independent variable, a = intercept, b = regression coefficient (slope). The values of a and b for linear regression are calculated by the following formula:

\[
a = \frac{\sum Y_i (\sum X_i^2) - (\sum X_i)(\sum X_i Y_i)}{n \sum X_i^2 - (\sum X_i)^2} \]

\[
b = \frac{n \sum X_i Y_i - (\sum X_i)(\sum Y_i)}{n \sum X_i^2 - (\sum X_i)^2}
\]

The response design/parameter(y) consists of: (1) physical response; weight decrease and hardness level. (2) Chemical response; water and vitamin C levels [16], and (3) physicochemical response; total dissolved solids [7].

3. Results and Discussion

Results of the analysis of the effect of soaking treatment using inhibitor solution on the response or parameters for the change of guava characteristics are as follows:

3.1 Weight Decrease

According to Royana (2012) quoted in [8], the increase of respiration rate will cause changes in the compounds and the release of water (transpiration) so that the fruit shrinks in weight. The results of the correlation of storage time with the percentage of weight decrease in the guava fruit can be seen in Figure 1 and Table 1.
Figure 1. The curve of the correlation of storability (x) with fruit weight decrease (y) on the treatment of AgNO₃ 50 ppm and soaking time of 4, 8, and 12 hours

Based on Figure 1 and Table 1, the soaking of the fruit stem in the AgNO₃ 50 ppm solution for 4 hours can suppress the effect of storability (x) on the weight decrease percentage with a coefficient of determination that is the lowest among the other treatments. This treatment has a formula of $y = 2.0593x + 1.194$ with $r^2 = 0.9227$, which shows that the storability has affected about 92.27% of the weight decrease with an estimation of storability reaching 12.29 days. The second treatment is the soaking using AgNO₃ 10 ppm solution for 12 hours, resulting in the storability effect of 97.33%. The treatment uses a formula of $y = 2.139x + 0.912$ with $r^2 = 0.9733$ and a storability estimation of 11.96 days. The third treatment uses AgNO₃ 10 ppm for 4 hours which resulted in a 97.66% in weight decrease. The treatment uses a formula of $y = 2.403x + 0.3$ with $r^2 = 0.9766$ % and an estimation of storability reaching 10.90 days.

Table 1. Correlation of storability(x) with fruit weight decrease (y) from the AgNO₃ soaking treatment on the concentration and soaking time and the coefficient of determination from the lowest value

| AgNO₃ Treatment | Formula            | Coef. of Determination ($r^2$) | Effect of X on Y (%) | Storability Estimation (days) |
|-----------------|--------------------|-------------------------------|----------------------|------------------------------|
| 50 ppm, 4 hours | $y = 2.0593x + 1.194$ | 0.9227 (1) *                 | 92.27%               | 12.29                        |
| 10 ppm, 12 hours| $y = 2.139x + 0.912$ | 0.9733 (2)                   | 97.33%               | 11.96                        |
| 10 ppm, 4 hours | $y = 2.403x + 0.3$   | 0.9766 (3)                   | 97.66%               | 10.90                        |

*) Selected starting from the smallest $r^2$ value from the effect of x (storage) on the response parameters

Soaking the pieces of tomato pericarp for 2 minutes into 0.3 to 5 millimolar (mM) AgNO₃ solution which is equivalent to 51 ppm to 850 ppm can inhibit ethylene and significant work and reduce endogenous ethylene production [10]. Silver metal (Ag⁺) can also inhibit the ripening of whole tomatoes when silver thiosulfate enters the fruit’s vascular system through a cut fruit stem. Tomatoes treated with soaking in a solution containing silver ions had a smaller amount of 1-aminocyclopropane-1-carboxylic acid (ACC) than the fruit that did not receive the treatment with solutions containing silver ions. The fruit treated with silver ion solutions had an ACC content of 1.8 nmol/g of fresh weight. Meanwhile, the fruit that was not soaked into a solution containing Ag⁺ ions had an ACC content of 2.6 nmol/g fresh weight.

3.2. Hardness Level

Measuring the hardness level of fruit is one way to find out the characteristics of fruit ripeness, the fruit hardness will decrease or become soft. Fruit softness that occurs during the ripening process will result in a
decrease in the quality of the fruit. According to Nasution (2012) quoted in [8], the value of fruit hardness shows the freshness level of fruit. The hardness level is considered good not when the value is too high or too low, but depending on the physical condition of the fruit. Fruit stored for a certain period will experience a decrease in the level of hardness. The results of the observation of the correlation of storability on the hardness level of guava can be seen in Figure 2 and Table 2.

\[ y = 1.6267x + 2.994 \quad R^2 = 0.7235 \]

Based on Figure 2 and Table 2, the treatment of soaking the fruit stem in \( \text{AgNO}_3 \) 10 ppm solution for 4 hours have the formula of \( y = 1.6267x + 2.994 \) with \( R^2 = 0.7235 \). The second treatment is the soaking using \( \text{AgNO}_3 \) 50 ppm solution for 12 hours which shows a storability effect of 72.77% on the level of hardness. The treatment uses a formula of \( y = 1.6033x + 2.692 \), with \( R^2 = 0.7277 \) and a storability estimation of 28.50 days. The third treatment uses \( \text{AgNO}_3 \) 30 ppm for 4 hours using a formula of \( y = 1.64x + 1.972 \) with \( R^2 = 0.7495 \) and an estimated storability of 28.30 days.

\( \text{Table 2.} \) Correlation of storability (x) with hardness level (y) from the \( \text{AgNO}_3 \) soaking treatment on the concentration and soaking time and the coefficient of determination from the lowest value

| Inhibitor Treatment | Formula          | Coef.of Determination \((R^2)\) | Effects of X on Y(%) | Storability Estimation (days) |
|--------------------|------------------|---------------------------------|---------------------|------------------------------|
| 10 ppm, 4 hours    | \( y = 1.6267x + 2.994 \) | 0.7235 (1)                      | 72.35%              | 27.91                        |
| 50 ppm, 12 hours   | \( y = 1.6033x + 2.692 \) | 0.7277 (2)                      | 72.77%              | 28.50                        |
| 30 ppm, 4 hours    | \( y = 1.64x + 1.972 \)   | 0.7495 (3)                      | 74.95%              | 28.30                        |

*) Selected starting from the smallest \( R^2 \) value from the effect of x (storage) on the response parameters.

Sampebatu (2006) cited in [11] states that there is a change in the composition of the cell wall constituent due to the breakdown of insoluble protopectin into soluble pectin so that softening occurs. Afrazak (2014) cited in [4] states that during the fruit ripening process, pectin compounds resulting from protopectin degradation increase. The increase of pectin will reduce the cell wall cohesion power that binds cells to one another. As a result, the fruit’s hardness will decrease, and the fruit becomes soft. According to [4] hardness is an important indicator in determining the ripeness level of an agricultural product, especially fruits. Fruits that experience the ripening process tend to have a low level of hardness than before the ripening process.

The guava fruit has increased the value of hardness (getting softer) in each treatment, because the respiration that occurs is suspected to run normally, given the respiration process needs simple organic
compounds and oxygen from the air. Ag⁺ ions from AgNO₃ solution which inhibits the formation of ACC will inhibit the formation of ethylene. Respiration of guava fruit runs normally, but the ethylene hormone which can accelerate the ripening process is inhibited. When the ripening process is inhibited, then the degradation of protopectin into pectin which dissolves in water will also be inhibited so that the increase in the hardness value will be more stable where the r² value is near 0%. The soaking treatment of guava stalks into AgNO₃ 10 ppm solution for 4 hours can reduce the effect of storage time (lower r² value) on the response of the parameters of the hardness level that is greater than other treatments. The r² value of the soaking treatment of AgNO₃ solution was more than 10 ppm and more than 4 hours compared to the selected treatment; this could be due to a surge in the increase or decrease in the level of hardness on the guava.

3.3. Vitamin C Content
Vitamin C or ascorbic acid has the molecular formula C₆H₈O₆. Vitamin C is soluble in water and slightly soluble in acetone or alcohol which has a low molecular weight. Vitamin C is easily oxidized and even more so if there is a Cu, Fe catalyst, ascorbate oxidase enzyme, light, and high temperature [16]. The content of vitamin C in guava increases after being harvested. According to Purwatiningsih (2012) cited in [14], the increase of vitamin C in the handling of post-harvest fruits during storage for a certain period of time is due to the enzymes that work actively to convert simple sugars into vitamin C. Results from the observation of the correlation of storage time for vitamin C content of guava can be seen in Figure 3, and Table 3.

![Figure 3](image-url)

**Figure 3.** The Curve of the correlation of storability (x) with vitamin C level (y) on a treatment of AgNO₃ 10 ppm and soaking time of 4, 8, and 12 hours

Based on Figure 3 and Table 3, the treatment of soaking the fruit stem in AgNO₃ 10 ppm solution for 8 hours can suppress the effect of storability on the level of vitamin C in guava better than the other treatments. This treatment use the formula of y = 8.526x + 18.408 with r² = 0.5949. The r² = 0.5949 value shows that the storage time has an effect of 59.49% on the level of vitamin C with an estimated storability of 12.26 days. The second treatment is the soaking using AgNO₃ 10 ppm solution for 4 hours which shows a storability effect of 64.38% on the level of vitamin C. The treatment uses a formula of y = 7.807x + 18.408 with r² = 0.6438 and a storability estimation of 11.25 days. The third treatment uses AgNO₃ 50 ppm for 12 hours using a formula of y = 4.7367x + 20.21 with r² = 0.6507 and an estimated storability of 19.86 days.

In each treatment, the content of vitamin C tends to increase until the 9th day and then decrease on the 12th day. This increase in vitamin C will reach its peak when the fruit is ripe. The synthesis of vitamin C will be followed by a decrease in the content of vitamin C. According to, the decrease occurs of vitamin C because of the enzyme formation of vitamin C is no longer active due to lack of supply of nutrients and
minerals as the fruit has been picked from the tree [14]. In addition, it can also be caused by oxidation with air which causes vitamin C to decrease. Storage of guava at room temperature can also cause damage to vitamin C in the fruit. The oxidation of vitamin C will produce L-dehydroascorbic acid which is highly labile and changes to L-diketogulonic acid which no longer has the activity as vitamin C.

Table 3. Correlation of storability (x) with vitamin C level (y) from the AgNO\textsubscript{3} soaking treatment on the concentration and soaking time and the coefficient of determination from the lowest value

| Inhibitor Treatment | Formula                | Coef. of Determination (\(r^2\)) * | Effects of X on Y (%) | Storability Estimation (days) |
|---------------------|------------------------|-------------------------------------|-----------------------|-------------------------------|
| 10 ppm, 8 hours     | \(y = 8.526x + 18.408\) | 0.5949 (1)                          | 59.49%               | 12.26                         |
| 10 ppm, 4 hours     | \(y = 7.807x + 18.538\) | 0.6438 (2)                          | 64.38%               | 11.25                         |
| 50 ppm, 12 hours    | \(y = 4.736x + 20.21\)  | 0.6507 (3)                          | 65.07%               | 19.86                         |

*) Selected starting from the smallest \(r^2\) value from the effect of x (storage) on the response parameters

When the ripening process is inhibited, vitamin C synthesis can also be inhibited. When Ag\textsuperscript{+} ion from AgNO\textsubscript{3} solution inhibits ACC synthase enzyme work, the resulting ethylene product will be reduced to a smaller amount. ACC compounds are intermediate compounds in ethylene production, so ripening hormones can be inhibited. Thus, the ripening process is inhibited and the synthesis of vitamin C will be suppressed.

Based on the explanation above, the AgNO\textsubscript{3} 10 ppm concentration with 8 hours soaking time can withstand the effect of storage time on the value of the increase in vitamin C content of guava up to 40.51\% (100\%-59.49\%). Soaking time for more than 8 hours in AgNO\textsubscript{3} 10 ppm concentration did not affect because the 12-hour soaking time had a greater \(r^2\) value than the 8-hour soaking time.

3.4. Total Dissolved Solids (TDS) Contents

Total dissolved solids are compounds in fruit that dissolve in water. In most fruits, the total dissolved solids contained are sugar. This means that the TDS can be used as a parameter of sugar content in fruit. The sugar found in fruit is sucrose, glucose, and fructose [18].

![Figure 4. Curve of the correlation of storability (x) with TDS (y) on treatment of AgNO\textsubscript{3} 30 ppm and soaking time of 4, 8, and 12 hours](image)

Based on Figure 4 and Table 4, the treatment of soaking the fruit stem in AgNO\textsubscript{3} 30 ppm solution for 4 hours can suppress the effects of storability on the TDS in guava better than the other treatments. This treatment uses the formula of \(y = -0.0037x + 6.532\) with \(r^2 = 0.0005\). The \(r^2 = 0.0005\) value shows that the
storage time has an effect of 0.05% on the TDS with an estimated storability of 58.01 days. The second treatment is the soaking using AgNO\textsubscript{3} 10 ppm solution for 12 hours which uses a formula of \( y = 0.0407x + 6.638 \) with \( r^2 = 0.0830 \). This \( r^2 \) value shows an effect of 8.30% towards the TDS and an estimated storability of 63.69 days. The third treatment uses AgNO\textsubscript{3} 10 ppm for 8 hours using a formula of \( y = 0.031x + 6.33 \) with \( r^2 = 0.1237 \) and an estimated storability of 93.55 days.

**Table 4.** Correlation of storability (x) with TDS (y) from the AgNO\textsubscript{3} soaking treatment on the concentration and soaking time and the coefficient of determination from the lowest value

| Inhibitor Treatment | Formula                  | Coef. of Determination (\( r^2 \)) | Effects of X on Y (%) | Storability Estimation (days) |
|---------------------|--------------------------|-------------------------------------|-----------------------|-------------------------------|
| 30 ppm, 4 hours     | \( y = -0.0037x + 6.532 \) | 0.0005 (1)                          | 0.05%                 | 58.01                         |
| 10 ppm, 12 hours    | \( y = 0.0407x + 6.638 \) | 0.0830 (2)                          | 8.30%                 | 63.69                         |
| 10 ppm, 8 hours     | \( y = 0.031x + 6.33 \)   | 0.1237 (3)                          | 12.37%                | 93.55                         |

*) Selected starting from the smallest \( r^2 \) value from the effect of x (storage)on the response parameters

The TDS content of guava in each treatment tends to rise to a certain point and then decrease. This change is in accordance with the statement of Hakim, et al. (2012) quoted in [4] that the total sugar during storage tends to increase due to organic acids being converted into sugar. According to Wills, et al. (1981) cited in [4], the increase in total dissolved solids that occur at room temperature is caused by the accelerated reaction due to high temperatures resulting in carbohydrate breakdown by enzyme activity. This can be used as an indicator of the process of ripening and respiration.

The soaking treatment of guava fruit stalks into AgNO\textsubscript{3} solution can reduce the effect of storage time on total dissolved solids due to the Ag\textsuperscript{+} ions from AgNO\textsubscript{3} solution which can optimally inhibit intermediate compounds (ACC) in the formation of ethylene hormone. The results of the ANOVA analysis of the response parameters from the effect of soaking treatment of AgNO\textsubscript{3} inhibitor solution and storage factor with estimated storability are recapitulated in Table 5.

**Table 5.** Results of ANOVA Analysis of the Effect of inhibitor solution and storage factor of Guava (at trust 95%)

| No | Parameter | Inhibitor Factor (A) | Storage Factor (B) | AB Interaction | Explanation |
|----|-----------|----------------------|--------------------|----------------|-------------|
| 1  | Weight decrease | significant | significant | Significant | significant |
| 2  | Hardness | not significant | significant | not significant | not significant |
| 3  | Vitamin C | significant | significant | Significant | significant |
| 4  | Water content | not significant | significant | not significant | not significant |
| 5  | TDS | not significant | significant | Significant | significant |

**Table 6.** Conclusions from the ANOVA analysis results of the response parameters and storability from the effects of soaking in AgNO\textsubscript{3} inhibitor solution

| No | Response / Parameter | Concentration and Soaking Time of AgNO\textsubscript{3} | Coefficient of Determination (%) | Storability Estimation (days) |
|----|----------------------|---------------------------------------------------------|---------------------------------|-------------------------------|
| 1  | Weight decrease | 10 ppm 12 hours | 97.33 % | 11.96 |
| 2  | Hardness | 10 ppm 4 hours | 72.35 % | 27.91 |
| 3  | Vitamin C | 10 ppm 4 hours | 64.38 % | 11.26 |
| 4  | TDS | 10 ppm 12 hours | 8.30 % | 63.69 |

\( \bar{x} = 29 \)

Based on Table 5 and Table 6, it can be concluded in general that the soaking of guava stems AgNO\textsubscript{3} 10 ppm solution with soaking time of 4 to 12 hours can reduce the effect of storage time on the response of the analyzed parameters; weight loss, level of hardness, vitamin C content, and total dissolved solids (TDS) with an estimated shelf life reaching an average of 29 days (Table 6). Soaking treatment in AgNO\textsubscript{3} solution
with a concentration of 10 ppm and a soaking time of 4 hours can reduce the effect of storage time on the response/parameters; the level of hardness with an estimated storability of 28 days, and vitamin C with an estimated storability of 12 days. Meanwhile, the soaking treatment of AgNO₃ solution with a concentration of 10 ppm and a soaking time of 12 hours can reduce the effect of storage time on the response/parameters; weight decrease with an estimated storability of up to 12 days, and TDS with an estimated storability of 63 days.

The estimation of storability/shelf life based on simple linear regression method shows that the effect of soaking in an AgNO₃ inhibitor solution can increase the average storability of 29 days compared to control without AgNO₃ soaking, which only has a storability of up to 9 days stored at room temperature or around 2.5-3 times. The AgNO₃ 10 ppm soaking treatment for 4 hours on the guava fruit stem can increase the fruit's storability up to 2.5 times when stored at room temperature. The AgNO₃ 10 ppm concentration is based on the calculation of $r^2$ values of linear regression where the AgNO₃ 10 ppm solution can suppress the effect of storage time on response parameters analyzed.

An increase in the concentration of AgNO₃ solution can inhibit the formation of ACC compounds, but an increase in the concentration of AgNO₃ solution can trigger the production of ethylene in tomatoes [10]. This is why the AgNO₃ with a 10 ppm concentration was chosen.

4. Conclusion

Based on the research, it can be concluded that increasing the concentration of inhibitor solution (AgNO₃) can reduce the effect of storage time on the responses; weight decrease, Vitamin C content, and total dissolved solids (TDS) of the guava. The soaking treatment of inhibitor solutions(AgNO₃) and the concentration, as well as time, can suppress the effects of storability (low value of $r^2$) of the guava. The soaking treatment of AgNO₃ 10 ppm solution for 4 hours can reduce the storage effects (low value of $r^2$) on the response parameters; the level of hardness with a storability estimation of 28 days and vitamin C with an estimation of 12 days. Meanwhile, the treatment using AgNO₃ 10 ppm solution for 12 hours can reduce the storage effects (low value of $r^2$) on the weight decrease parameter with an estimated storability of 12 days and TDS with an estimated storability of 63 days.

Based on the results of the evaluation of the research that has been carried out, the researcher submits several suggestions including an analysis on silver metal residues on the skin and flesh of the guava fruit should be done. Further research is needed on coating the seed of guava with chitosan to suppress the effect of exogeneous factors combined with the soaking of fruit stem into the AgNO₃ to suppress the influence of endogenous during storage at room temperature.

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6. References

[1] Amiarsi and Pudji KU 2011 Peranan Larutan Pengawet terhadap Mutu Bunga Potong Alpinia selama Peragaan. *J. Hortikultura* 21 2 185-190 Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian Bogor and Balai Penelitian Tanaman Hias Cianjur

[2] Desrosier and Norman W 1988 Teknologi Pengawetan Pangan UI Press Jakarta

[3] Fitrianti and Junita 2006 Kajian Teknik Penyimpanan dan Pengemasan Jambu Biji (Psidium guajava.L.) dalam Kemasan Transportasi Skripsi Departemen Teknik Pertanian Fakultas Teknologi Pertanian Institut Pertanian Bogor

[4] Ifmalinda 2017 Pengaruh Jenis Kemasan Pada Penyimpanan Atmosfir Termodifikasi Buah Tomat. *J Teknologi Pertanian* Andalas 21 no 1 Program Studi Teknik Pertanian Fakultas Teknologi Pertanian, Universitas Andalas
[5] Indriani and Nidahanifah 2012 Pengaruh Komposisi Larutan Pulsing dan Chitosan sebagai Anti Transpiran dalam Meningkatkan Vase Life Mawar Potong (Rosa hybridavar ‘Grand Gala’) Skripsi Departemen Agronomi dan Hortikultura Fakultas Pertanian Institut Pertanian Bogor.

[6] Kristianingrum and Susila 2007 Beberapa Metode Pengawetan Buah-buahan Jurusan Pendidikan Kimia Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Negeri Yogyakarta

[7] Muchtadi, Tien R, Sugiyono and Fitriyono A 2015 Ilmu Pengetahuan Bahan Pangan Penerbit Alfabeta Bandung

[8] Mudawamah and Nur 2014 Pengaruh Konsentrasi dan Lama Perendaman dalam Kalsium Klorida (CaCl₂) terhadap Kualitas dan Kuantitas Pascapanen Buah Jambu Biji Merah (Psidiumguajava Linn) Skripsi Jurusan Biologi Fakultas Sains dan Teknologi Universitas Islam Negeri Maulana Malik Ibrahim Malang

[9] Mukdisari and Yurisqi 2015 Penggunaan Kitosan dan Lilin Lebah sebagai Bahan Pelapis untuk Meningkatkan Masa Simpan dan Mempertahankan Kualitas Buah Pepaya Skripsi Departemen Agronomi dan Hortikultura Fakultas Pertanian Institut Pertanian Bogor

[10] Atta-Aly MA, Saltveit ME and Hobson GE 1987 Effect of Silver Ions on Ethylene Biosynthesis by Tomato Fruit Tissue Plant Physiol 83 Department of Horticulture Ain Shams University Cairo Egypt

[11] Naibaho J, Elisa J and Era Y 2013 Penyimpanan Buah Terung Belanda dengan Kemasan Aktif Menggunakan Bahan Penjerap Oksigen, Karbondioksida, Uap Air dan Etilen J Rekayasa Pangan dan Pertanian 1 No 3 Program Studi Ilmu dan Teknologi Pangan Fakultas Pertanian Universitas Sumatera Utara Medan

[12] Nur’aini, Hesti and Siska A 2015 Penggunaan Kitosan untuk Memperpanjang Umur Simpan Buah Duku (Lansium Domesticum Corr) AGRITEPA (ISSN: 2407-1315) 1 No 2 Program Studi Teknologi Pertanian dan Program Studi Teknologi Pangan Fakultas Pertanian Universitas Dehasen Bengkulu

[13] Rezeki and Trisma 2016 Pelapisan Lilin Karnau badan Kitosan untuk Mempertahankan Mutu Wortel Kupas Tesis Program Studi Teknologi Pascapanen Institut Pertanian Bogor

[14] Rohim A, Alimuddin and Erwin 2016 Analisis Kandungan Asam Askorbat dalam Buah Naga Merah (Hylocereuspolyrhizus) dengan Iodometri J Kimia Mulawarman 14 No. 1 Jurusan Kimia FMIPA Universitas Mulawarman Samarinda

[15] Sitorus RF, Karo-Karo T and Lubis Z 2014 Pengaruh Konsentrasi Kitosan sebagai Edible Coating dan Lama Penyimpanan terhadap Mutu Buah Jambu Biji Merah J. Rekayasa Pangan dan Pertanian 2 No.1 Program Studi Ilmu dan Teknologi Pangan, Fakultas Pertanian, Universitas Sumatera Utara

[16] Sudarmadji S 2010 Analisa Bahan Makanan dan Pertanian Penerbit Liberty Yogyakarta

[17] Sudjana 2005 Metode Statistika Tarsito Bandung

[18] Syaefullah and Enrico 2008 Optimasi Keadaan Penyimpanan Buah Pepaya Sebelum Pemeraman Dengan Algoritma Genetika. Disertasi. Program Studi Ilmu Keteknikan Pertanian, Sekolah Pascasarjana, Institut Petanian Bogor

[19] Triyanto and Cahya I 2000 Pengaruh Penggunaan Germisida Perak Nitrat dan Tetrasiklin, dan Lama Perendaman Larutan Pulsing Terhadap Mutu Bunga Mawar Potong (Rosa hybrida) Skripsi Jurusan Teknologi Industri Pertanian Fakultas Teknologi Pertanian Institut Petanian Bogor

[20] Wardhani HK, Santoso S, Rahmawati W 2013 Pengaruh Penggunaan Modified Atmosphere Storage (MAS) dalam Kemasan Polietilen Suhu Ruang dan Suhu Chiller terhadap Kadar Vitamin C dan Kadar β Karoten pada Jambu Biji J. Mahasiswa Program Studi Ilmu Gizi Fakultas Kedokteran Universitas Brawijaya

[21] Winarno FG 1992 Kimia Pangan dan Gizi PT Gramedia