Effect of Hormone Treatment, Coating Material and Ethylene Absorber on the Shelf Life of Mangosteen

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Abstract. Several factors affect the shelf life of mangosteen fruit, such as the low quality of fruit at harvest time or less precise storage and transportation conditions before the fruit is consumed. Cause of poor quality of mangosteen fruit for export due to hardening of fruit skin after harvest and harvesting through matures caused by the lack of proper handling of harvest and postharvest. The objective of the research was to study the effect of hormone treatment, coating material and ethylene absorber to the shelf life of mangosteen. Treatments were implemented by coating process using a combination of GA3 hormone treatment and coating material type (chitosan and wax). The other treatments used were combination of plastic and teabag packaging containing KMNO₄. The study was designed using a completely randomized design. Observations included external visuals, internal visuals, weight loss, color, texture, and skin structure. The data analysis was performed using SPSS 2.1 software. At first week, the condition of treated mangosteen fruit were still resembles with fruit on day-0. This was due to the cooling factor, assisting in the process of maintaining the freshness of the mangosteen fruit.

1. Introduction
Mangosteen known as the queen of tropical fruit [1]. Several factors affect the shelf life of mangosteen fruit, such as the low quality of fruit at harvest time or less precise storage and transportation conditions before the fruit is consumed. Cause of poor quality of mangosteen fruit for export due to hardening of fruit skin after harvest and harvesting through matures caused by the lack of proper handling of harvest and postharvest. In this research, some postharvest treatments were done to prolong the shelf life of mangosteen fruit.

Harvesting is generally done after the 104-day-old fruit is counted from the flower bloom, when the mangosteen fruit skin surface is still green with slight purple streaks. Six days after harvesting the fruit skin color changes into dark purple [2, 3]. Mangosteen fruit is generally harvested at stage 5 (dark purple) or stage 6 (purple black) [4, 5].

Mangosteen is a climacteric fruit so that the fruit can mature during its storage period. Climatic peak was reached after 10 days of storage at room temperature. Mangosteen fruit damage is also characterized by small puncture marks or scratches [6]. The quality of fresh mangosteen fruit is largely determined by its postharvest handling, from the selection of fruit aging, packaging to storage [7].

Treatments were implemented by coating process using a combination of GA3 treatment and coating material type (chitosan and wax). The other treatment was using a combination of plastic and teabag packaging containing KMNO₄. The objective of the research was to study the effect of hormone treatment, coating material and ethylene absorber on the shelf life of mangosteen.
2. Methods
In this research activity, materials were used included mangosteen fruit, hormone GA3, wax, chitosan, zeolite-KMnO₄ and other supporting materials. The equipment used included crates, sprayers, cool rooms, chromameter, scales and SEM (Scanning Electron Microscope).

The stages of the activity included cleaning the mangosteen fruit from ants and other impurities, treatment of hormone, and a combination with coating materials according to the designed treatment below (Table 1). Two control treatments were used, namely without using plastic packaging and using plastic packaging, without coating treatment. The overall treatment of this study is shown in the Table 1.

Table 1. Code for Storage of Mangosteen

| Code | Treatment | Code | Treatment |
|------|-----------|------|-----------|
| K    | Control   | CG   | Chitosan, GA3, Plastic |
| C    | Chitosan  | CGW  | Chitosan, GA3, Wax, Plastic |
| CGTP | Citosan, GA3, Without Plastic | KT   | Control Teabag KMnO₄ |
| CGWT | Chitosan, GA3, Wax, Without Plastic | CT   | Chitosan Teabag KMnO₄ |
| KP   | Control Plastic | CGT  | Chitosan, GA3, Teabag KMnO₄ |
| CP   | Chitosan Plastic | CGWT | Chitosan, GA3, Wax, Teabag KMnO₄ |

The study was designed using a completely randomized design. Observations included external visuals, internal visuals, weight loss, color, texture, and skin structure. Some external visual parameters observed included the level of freshness, skin color, fruit stalk, sepal, number of insects and dirt levels. The data analysis was performed using SPSS 2.1 software. Observations in the first week was compared to that of on day-0.

3. Result and Discussion

3.1. Color Analysis
Some parameters that show the quality of mangosteen fruit, can be determined by conducting several types of analysis. One important parameter of quality that shows the freshness of the mangosteen fruit is the color change during storage. It can be analyzed by observing the changes in the color of the mangosteen fruit during storage using a chromameter. The results of the color of mangosteen is stated in Table 2.

Table 2. Mangosteen Color on First and Fifth Weeks

| Code | First Week | Fifth Week |
|------|------------|------------|
|      | L          | a          | b          | L          | a          | b          |
| K    | 25.473bc   | 24.540a    | 14.444ab   | 27.997bc   | 14.830ab   | 10.921ab   |
| C    | 28.573b    | 20.342abc  | 10.913abc  | 36.522a    | 9.379b     | 4.918d     |
| CGTP | 24.692c    | 20.465abc  | 10.464abc  | 31.598ab   | 11.337b    | 6.433cd    |
| CGWT | 26.763bc   | 24.253a    | 12.900abc  | 30.984ab   | 14.228ab   | 5.782d     |
| KP   | 26.176bc   | 16.110c    | 8.297bc    | 27.723bc   | 24.064a    | 11.600a    |
| CP   | 32.575a    | 17.685bc   | 7.666bc    | 25.704bc   | 18.331ab   | 10.168abc  |
| CG   | 28.588b    | 20.895abc  | 9.985abc   | 31.341ab   | 13.012b    | 6.609cd    |
| CGW  | 27.455bc   | 20.669abc  | 17.388a    | 31.158ab   | 16.032ab   | 7.220bcd   |
Based on the observations, different treatments showed significant differences between the treatment of hormone use, coating matrix and the use of zeolite teabag - KMnO₄. This showed that the treatments affected the quality of the color, namely the value of L, a and b of mangosteen fruit during storage. The use of coating material also allegedly affected the color of mangosteen fruit during the storage process. Decreasing the value of b and a is faster at room temperature compared to 15°C, due to the degradation of chlorophyll so that the colors of other pigments appear [8]. This process causes the green color to change to other colors, namely yellow, pink, red, purple to black. Skin discoloration becomes reddish yellow due to the presence of anthocyanin pigments which depend on their concentration.

Another factor that influences is due to the presence of other pigments and temperature (low temperature, the anthocyanin increases). The red color of mangosteen besides being influenced by anthocyanins is also influenced by lycopene. Temperature affects the formation of lycopene, if the temperature rises, its formation will also increase. Changes in lycopene pigment to carotene cause the skin color to become purple [9].

To determine the level of damage to the mangosteen fruit, visual observations was made. The storage period of the mangosteen fruit will experience a pericarp fruit color change, which is one of the parameters of fruit maturity [10]. The pericarp moisture content of mangosteen fruit in general during storage has decreased along with the length of storage life [11]. Mangosteen fruit quality standards based on SNI limit the super class namely mangosteen with a reddish green skin color, the color of the pure white fruit flesh typical of mangosteen, the green sepal color [12].

Mangosteen fruit coating using 6% Britex USA wax emulsion at a storage temperature of 15°C can reduce the degree of damage [7]. To avoid discoloration from green to brown on the part of the fruit sepals, during the senecent process it is endeavored that the fruit sepals are not exposed to dye solution [12]. The color of purplish red mangosteen fruit is due to the betalain pigment content which is easily damaged (discolored) because it is unstable and can dissolve in water and is sensitive to sunlight, oxygen and hot water [13].

3.2. Weight Loss

Other indication of damage of mangosteen fruits is through observations of the decrease in weight during the storage process. Fruit shrinkage shows one of the parameters for the level of damage to the mangosteen fruit. Increasing storage time will affect the degradation of the freshness of the mangosteen fruit. Fruit shrinkage identifies the destruction of the components of the stalk, sepals, skin and mangosteen fruit. The rate of destruction will ultimately increase the percentage of mangosteen shrinkage. Based on observations, the shrinkage of mangosteen fruit increased from the first week of storage to the fifth week of storage, as shown in the following table.

Table 3: Weight losses in mangosteen in the first and fifth weeks

| Code   | Weight Losses in First Week (%) | Weight Losses in Fifth Week (%) |
|--------|---------------------------------|---------------------------------|
| K      | 2.369⁶  | 17.668⁶  |
| C      | 2.171⁶  | 8.666⁶   |
| CGTP   | 2.270⁶  | 9.626⁶   |
| CGWTP  | 1.856⁶  | 8.566⁶   |

Remarks: numbers followed by the same letter show significantly different levels of 95% confidence interval.
| Code | Weight Losses in First Week (%) | Weight Losses in Fifth Week (%) |
|------|--------------------------------|--------------------------------|
| KP   | 0.224b                         | 0.982c                         |
| CP   | 0.096b                         | 0.926c                         |
| CG   | 0.278b                         | 0.554c                         |
| CGW  | 0.129b                         | 1.216c                         |
| KT   | 0.262b                         | 1.103c                         |
| CT   | 0.210b                         | 1.529c                         |
| CGT  | 0.447b                         | 1.581c                         |
| CGWT | 0.148b                         | 1.218c                         |

Remarks: numbers followed by the same letter show significantly different levels of 95% confidence interval

Control had a greater percentage of shrinkage compared to other treatments. The presence of a coating and the use of packaging, automatically affected the pattern of mangosteen respiration, which in turn reduced the weight loss of fruit during storage compared to controls. The use of surface coating and wrapping fruits in polyethylene film bags [14] reduces weight loss [15]. Furthermore, a too low temperature can cause fruit damage due to cold temperatures (chilling injury) [15]. Storage at a temperature of 12-14°C can extend fruit retention up to 20 days without chilling injury. Chilling injury occurs if the storage temperature is less than 10°C.

3.3. Total Soluble Solid
Total dissolved solid shows the concentration of solids contained in a solution. The relationship between the TSS (Total soluble Solid) and the level of freshness, including the increasing number of TSS, the more components that are deconstructed and the fruit decreases in quality. The results of observations of TSS is listed in the following table.

**Table 4. Mangosteen Fruit Total Soluble Solid on the First and Fourth Weeks**

| No | Code | TSS First Week (°Brix) | TSS Fourth Weeks (°Brix) |
|----|------|------------------------|--------------------------|
| 1  | K    | 17.175b                | 15.350a                  |
| 2  | C    | 19.825a                | 16.250a                  |
| 3  | CGTP | 17.075b                | 14.600a                  |
| 4  | CGWTP| 17.400b                | 15.400a                  |
| 5  | KP   | 18.100b                | 15.650a                  |
| 6  | CP   | 17.450b                | 16.800a                  |
| 7  | CG   | 17.140b                | 17.300a                  |
| 8  | CGW  | 17.750b                | 16.700a                  |
| 9  | KT   | 17.900b                | 17.000a                  |
| 10 | CT   | 17.425b                | 17.300a                  |
| 11 | CGT  | 17.600b                | 16.700a                  |
| 12 | CGWT | 17.175b                | 17.350a                  |

Remarks: numbers followed by the same letter show significantly different levels of 95% confidence interval

Based on observations, TSS of mangosteen was significantly different for treatment using chitosan. Whereas in the fourth week observations, the results were not significantly different. The value of TSS broadly decreased after the fourth week. This is possible, because the fruit had begun to decay and contained a lot of water.

The results of research by [2] showed that the increase in TSS content only occurs in mangosteen fruit harvested at a level of age with a purple spot. The increase in the content of TSS in mangosteen with the level of age of the fruit with green pericarp with purple spots caused by the degradation of starch to glucose.
3.4. Acidity (pH)

Changes in the acidity of the fruit during storage can vary according to the level of fruit maturity and high storage temperature. Green fruits that are old and changing color increase the amount of acidity, and the increase occurs along with the climacteric pattern [16]. The results of observations of fruit acidity levels can be identified by the rise and fall of pH. The results of observation of the pH of mangosteen pulp during storage is shown in the following table.

**Table 5. Mangosteen pH on the First and Fourth Week**

| No | Code  | pH First Week | pH Fourth Weeks |
|----|-------|---------------|-----------------|
| 1  | K     | 3.003<sup>b</sup> | 3.300<sup>ab</sup> |
| 2  | C     | 3.305<sup>a</sup>  | 3.245<sup>ab</sup> |
| 3  | CGTP  | 2.968<sup>b</sup>  | 3.375<sup>a</sup>  |
| 4  | CGWTP | 3.128<sup>ab</sup> | 3.100<sup>ab</sup> |
| 5  | KP    | 3.183<sup>ab</sup> | 3.110<sup>ab</sup> |
| 6  | CP    | 3.143<sup>ab</sup> | 3.135<sup>ab</sup> |
| 7  | CG    | 3.060<sup>ab</sup> | 3.005<sup>b</sup>  |
| 8  | CGW   | 3.078<sup>ab</sup> | 3.090<sup>ab</sup> |
| 9  | KT    | 3.180<sup>ab</sup> | 3.160<sup>ab</sup> |
| 10 | CT    | 3.160<sup>ab</sup> | 3.285<sup>ab</sup> |
| 11 | CGT   | 3.058<sup>ab</sup> | 3.160<sup>ab</sup> |
| 12 | CGWT  | 3.008<sup>ab</sup> | 3.170<sup>ab</sup> |

Remarks: numbers followed by the same letter show significantly different levels of 95% confidence interval.

The pH of mangosteen fruit was significantly different for all treatments, both in the first week and in the fourth week. Suryanti et al. [2] suggested that the pattern of changes in acid content in mangosteen is the higher the acid content as the fruit gets older. However, in this study there was no tendency to increase or decrease pH for all treatments.

3.5. Microstructure Profile

To determine the performance of the hardening of fresh mangosteen rind compared to the hard mangosteen fruit, an observation was performed using SEM (Scanning Electrone Microscope). SEM performance results in fresh and hard mangosteen rind is shown in the Figure 1.

**Figure 1.** Microstructure Profile of Fresh Mangosteen Skin Section (1a, 1b, 1c) And Hard Textured Mangosteen After 5 Days (2a, 2b, 2c)
Based on the results of the appearance of the mangosteen peel microstructure above, it showed that the storage time for 5 days produced fruit peels with tissue that begins to break down and wrinkle compared to before storage. Important identification is related to texture, which correlates with the quality of the mangosteen fruit which is the level of violence. Sartika and Poerwanto [17], stated that the problems that arise in storing mangosteen fruit at room temperature one of which is the hardening of the fruit skin if stored for more than two weeks. Storage at low temperatures aims to slow respiration and transpiration, so that it can extend the shelf life with minimal weight loss, quality is still good and market prices remain high.

Mangosteen fruit resistance on all maturity stages stored at 15°C and room temperature showed a decrease (softened fruit) and then increased (hardening) during storage. This was because the fruit maturation process occurs hydrolysis of pectin and hemicellulose which are the components that form the structure of the cell wall so that this change causes the fruit to become soft when ripe [18].

The hardening of the mangosteen fruit during storage is due to the pericarp hardening of the mangosteen fruit associated with the perikarp water content. The fruit that has transpired some of the water will harden. Hardening occurs because the pericarp cells that initially round become somewhat flattened due to loss of turgor. This cell turgor causes the cells to shrink so that the space between cells becomes narrower and pectin binds to each other, which causes pericarp integrity to become more resistant to pressure, making it difficult to open [19].

4. Conclusion
Based on observations in the first week, the condition of mangosteen fruit still resembled visual conditions on day-0. This was due to the cooling factor, assisting in the process of maintaining the freshness of the mangosteen fruit. Different treatments showed significant differences between the treatment of hormone use, coating matrix and the use of zeolite teabag - KMnO₄. This showed that the treatment affected the quality of the color, namely the value of L, a and b on mangosteen fruit during storage. The use of coating material also allegedly affects the quality of mangosteen fruit during the storage process. Control had a greater percentage of weight loss compared to other treatments. The presence of a coating process and the use of packaging, automatically affect the pattern of mangosteen respiration, which in turn reduced the weight loss of fruit during storage compared to controls. Changes in the acidity of the fruit during storage varied according to the level of fruit maturity and high storage temperature. Some of the influence of these characteristics can be used as a reference for handling and storing the mangosteen fruit in the future.

5. References

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