Effects of Washing Materials and Storage Temperature on the Quality of Mango Fruit (Mangifera indica) CV. Gedong

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Abstract. Mango, widely known as the “the best-loved tropical” fruit, is a popular horticultural commodity not only in Indonesia, but also in many foreign countries. Mango in Indonesia is seldom washed after picking, and before marketing and that causes low visual quality due to the sap that sticks to the peel. This condition makes the fruit to be more vulnerable to rapid decay hence, with shorter shelf life. Sapstain on mango fruit skin can be cleaning by washing with slaked lime Ca(OH)₂, detergent, fungicide, and yeast. This study aimed to evaluate the effectiveness of alternative washing material and temperature storage in upgrading the visual quality of mango fruits involved percentage of removed sap stain, dendritic spotting, and fruit textural softness. The result showed the development of washing solution by adding (detergent 1% + slaked lime Ca(OH)₂ 0.5%) added fungicide or yeast, and combining with storage temperature of 12 °C and 15 °C, proved to be highly effective in improving visual quality.

1. Introduction

Mango, widely known as the “the best-loved tropical” fruit, is a popular horticultural commodity not only in Indonesia, but also in many foreign countries. This is attributable to the fact that mango contains eight times more Vitamin A, and nine times more Vitamin C, than apple. In addition, mango also possesses carotenoids and anti-oxidant compounds such as Quercetin-3-galactoside, Quercetin-3-glucoside, Quercetin-3-arabinoside, gallic acid, and mangiferine C-glucoside.

Based on [1] data, Indonesia is among the top five mango-producing countries in the world, yet its mango export volume still ranks comparatively low. One plausible reason for this is the relatively low commercial quality of Indonesian mango, which is primarily brought about by the sapstain adhering on the skin surface of post-harvest mango fruit. Generally, mango in Indonesia is seldom washed after picking, and before marketing, mainly because an efficacious washing solution had yet to be developed. As a result, Indonesian mango fruits being sold in the market appear unattractive and grimy, and tend to rot fast. The sapstain on the mango skin causes sapburn which gives rise to fungal growth, as it contains a basic carbohydrate component. This condition makes the fruit to be more vulnerable to rapid decay hence, with shorter shelf life.
Sapstain from mango fruit skin can be cleaned by washing with slaked lime \( \text{Ca(OH)}_2 \) and detergent, because this method has proved effective to improving visual quality of mango[2,3]. However, this washing solution has not proved effective in preventing anthracnose disease and post-harvest fruit rot. Thus, there is a need to come up with a more effective washing solution for post-harvest mango. The development of washing solution can be constituted by adding a suitable fungicide into the washing Solutions such as Nativo, Gemstar and Carbedazim [4]. Another method that can be used in addition to fungicides is the use of biological control agents, namely yeast [5].

To improve the quality of mango cv Gedong, washing method can be combined with storage at low temperatures. Low temperature level decreases respiration rate in mango fruits so that the fruit can be maintained in longer term. Low temperature storage at a temperature of \( 15^\circ C \) can reduce the rate of respiration and transpiration in mango fruit so that it can inhibit physiological processes such as delaying softening, discoloration, changes in quality, and other chemical processes [6].

2. Methods

This research was conducted at the Postharvest Laboratory of the Department of Agronomy and Horticulture, Bogor Agricultural University, Indonesia during January 2015. Material used in this study was varieties of mango fruit namely Gedong (\textit{Mangifera indica} cv. Gedong), detergent containing 19.5% active ingredient surfactant, slaked lime or calcium hydroxide \( \text{Ca(OH)}_2 \), fungicide with active ingredients \textit{Azoksistrobin} (200 g/l) and Difenokonazol (125 g/l), antagonistic yeast (\textit{Cryptococcus albidus}).

Experimental Design used A split-plot in completely randomized block design (CRBD), with two treatment factors - washing solution application and cold storage temperature was used in this study. Factor 1 (washing solution application) consisted of four combinations of treatment, namely: control or no washing; washing solution (detergent 1% + \( \text{Ca(OH)}_2 \) 0.5%); washing solution + fungicide 0.025%; and washing solution + yeast. Factor 2 (cold storage temperature) was likewise made up of four treatment levels, 12 °C, 15 °C, 18 °C, and room temperature as control.

Mango fruits were gathered in the morning, sorted and then graded. The sap-stained portions of the fruit rind were marked in order to measure the percentage of sap blotch before and after washing. The mango fruits were then subjected to the different washing combinations by immersing them into the four treatment solutions for ± 5 minutes after which they were lifted, rinsed with clean water, and air-dried. For the application of antagonistic yeast, the test mango fruits were first washed with detergent solution and slaked lime \( \text{Ca(OH)}_2 \), were rinsed with clean water and then immersed into the yeast solution. These step were undertaken in order to avoid yeast cell wall lysis (disintegration) due to the presence of enzymes in the wash detergent.

The tested mango fruits were wrapped with paper, and transported in the evening to prevent direct exposure to sunlight which can cause damage. The mango fruits were then stored inside show Chase oven at temperatures of 12 °C, 15 °C, and 18 °C while the control (room temperature) sample was placed on top of a table. Variables that were observed are the percentage of removed sap stain, dendritic spottings (0 nil; 1 not more than 10; 2 not more than 3 cm²; 3 not more than 10%; 4 not more than 25%; 5 more than 25%); fruit softness (1 Hard; 2 Rubbery; 3 Sprung; 4 Firm soft; 5 Soft); fruit peel colour was estimated by visual observations (0-10% yellow; 10-30% yellow; 30-50% yellow; 50-70% yellow; 70-90% yellow; 90-100% yellow). The observation and recording data followed the scoring method [7].

3. Result and Discussion

3.1. Percentage of Removed Sap Stain

In general terms, all washing solution treatments showed capability to remove the sap Stain that had adhered on the rind of the Gedong mango fruit (\textit{Mangifera indica} cv. Gedong). This was clearly
observable from the percentage of the adhering Sap Stain after washing (Figure 1). As it is shown, the mango fruits that had been washed exhibited higher visual quality compared to their appearance before washing.

Two ways which can be used to overcome the adverse effects of mango fruit the sap that stick to the surface of the mango fruit peel are through washing or immersion in a suitable Solutions [2]. Washing may be done with the use of a detergent like slaked lime Ca(OH)$_2$ which neutralizes the sap acidity before it can penetrate the lenticels of the mango fruit peel. In addition, the use of detergent containing a surfactant can bind the oil content and bring down surface tension on the mango fruit peel so that the sticking sap can be released [8].

![Figure 1. Percentage of removed sap stain before and after washing](image)

3.2. Dendritic spots

The results of the research in Table 1 show that dendritic mango spots were significantly lower than those not washed. Dendritic spots that occur in mango usually appear on ripe fruit, its development is quite slow, and does not enter the fruit flesh [8]. States that the number of dendritic spots found on the skin surface of mango fruit can cause mango fruit to be less marketable and cause very high losses in the northern Queensland area in 2006-2007 [9].

| Treatment                  | 3 DAH    | 6 DAH    | 9 DAH    |
|----------------------------|----------|----------|----------|
| Washing Material           |          |          |          |
| No washing                 | 0.75 b   | 0.94 b   | 1.44 b   |
| Detergent + Ca (OH)$_2$    | 0.50 b   | 0.69 b   | 1.00 b   |
| Washing solution + fungicide| 0.00 a   | 0.00 a   | 0.31 a   |
| Washing solution + Yeast   | 0.00 a   | 0.00 a   | 0.00 a   |
| Temperatur storage         |          |          |          |
| room temperature           | 0.50     | 0.50     | 0.81     |
| 18°C                       | 0.38     | 0.38     | 0.69     |
| 15°C                       | 0.38     | 0.38     | 0.69     |
| 12°C                       | 0.19     | 0.19     | 0.56     |

Description: The data displayed is the average score. Statistical processing is carried out on ratings by the Kruskal Wallis test. followed by Dunn test 5%. The number followed by the same letter in the same column means that it is not significantly different in the Dunn test 5%

3.3. Fruit textural softness

Softening of the fruit during ripening is caused by the enzyme pectinesterase, polygalacturonase, and other enzymes that break down the constituent compounds of the cell wall [10]. The results of the research in Figure 2 show that storage at temperatures of 12 °C and 15 °C can suppress the rate of
change in fruit textural softness of the Gedong mangoes during storage while the washing material does not significantly affect the hardness of Gedong manga during storage. Low temperature is able to maintain the quality of hardness well because at low temperatures, the metabolic process and enzyme activity in the process of breaking pectin and hemicellulose become inhibited.

![Figure 2. Level change of fruit textural softness during storage](image1)

### 3.4. Fruit peel colour

During the storage process of gedong mangoes will experience discoloration caused by the presence of chlorophyll disassembly so that the longer the color of the green mango skin will turn yellow during the shelf life. The results of the study in Figure 3 show that storage at 12 °C and 15 °C can slow the rate of change in mango fruit during storage, while the washing material does not significantly affect the color changes in mangoes during storage.

![Figure 3. Level change of fruit peel colour during storage](image2)

Color changes are often used as a criterion by consumers to differentiate between ripe and unripe fruit. Color changes occur with reduced or loss of green color due to degradation of the chlorophyll structure. After the fruit is ripe, chlorophyll is degraded, chloroplast takes the role of chromoplas by starting to synthesize the yellow pigment namely carotene and xanthophyll, causing the fruit skin to turn yellow [11].

The rate of color change at high temperatures is faster than storage conditions at low temperatures. This is also supported by the results that cv Kesar skin color changes that store at 9 oC is slower than...
storage at 12 °C and room temperature, this may be due to the slowing down of the chlorophyll degradation process causing respiration rate and ethylene production are also inhibited [12].

4. Conclusion
The development of washing solution by adding (detergent 1% + slaked lime Ca(OH)\(_2\) 0.5%) added fungicide or yeast, and combining with storage temperature of 12 °C and 15 °C, proved to be highly effective in improving visual quality.

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