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Flower baggings in affecting mangosteen fruit qualities at harvest and during storage

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Abstract. Physiological causes and insect attack are believed to increase yellow latex exudates in mangosteen fruits. To inhibit the causes, flower bagging should be applied. This research was aimed at studying the effects of flower baggings to two different flower developments in affecting mangosteen fruit qualities at harvest and during storage. Three bagging materials (unbagged, paper, and baloon) were applied to flowers of 2 and 4 weeks after anthesis (WAA). The fruits were sampled every 2 weeks during the periods of 8-16 WAA. The results showed that except α -mangosteen content that was slightly decreased during the latest periode of fruit growth by bagging at preharvest, flower baggings of both bagging materials and application periods mostly did not affect mangosteen fruit qualities at harvest, but they affected fruit shelf-life and qualities during storage. Flower baggings resulted in increased fruit shelf-life, with paper bagging applied in 2 WAA was better than that applied in 4 WAA. Paper bagging in 2 WAA resulted in the mangosteen fruit shelf-life of 29 days compared to 4 WAA which resulted in 14 days shelf-life. This research proved also that the occurrence of yellow latex was much more likely affected by physiological causes, not by insect attacks.

Keywords: bagging, fruit quality, harvest, mangosteen, storage

1. Introduction

Among the 20 known species in the genus *Garcinia* [1], mangosteen (*Garcinia mangostana* L.) is the most studied fruit. That is because of its very wide use, from consumption as medicine to table fruit which is consumed fresh or minimally processed [2, 3]. Known as the "Queen of Tropical Fruits", mangosteen is classified as a high-value fruit crop. Increasing the quantity and quality of the fruit must be maintained since it is still in the tree (pre-harvest) until treatment at harvest and post-harvest [4].

Unfortunately, the quality of mangosteen fruit is also known to often experience postharvest damage, due to insect attack, physiological damage, and poor postharvest handling [5]. Physiological causes, insect attack, and improper fruit handling are commonly believed to increase the occurrence of



yellow latex (gamboge) disorder in mangosteen fruits. Gamboge or yellow latex disorder is the type of postharvest damage or physiological disease that is considered to be the most detrimental. This is mostly true if the yellow sap has contaminated the fruit flesh, so it will taste bitter. This type of damage is quite difficult to detect, because although the causes are studied, the method of detection is still unknown. So far, the yellow latex disorder is known to be due to two contributing factors, which are related to water content and Ca deficiency [6–11]. Visual detection is still difficult, because the yellow sap that is seen on the surface of the rind pericarp often does not prove that the fruit flesh has also been contaminated with this bitter yellow gum. Non-destructive detection efforts have been widely tested [12–14], unfortunately the results are generally still felt to be ineffective and economically unbeneficial.

To inhibit physiological causes and insect attack that led to yellow latex disorder, flower bagging should be applied. It is usually done after the flowers are completely open (anthesis) [15]. This is useful in the efficiency of the bagging material which will be wasted if the flowers fall before they develop. The bagging material also affects the physical properties of the fruit, by which bagging with cement paper was reported to be the best [16, 17, 18]. It is known that fruit bagging can affect the intensity of pest attacks, fruit quality, physical and chemical properties of fruit [4, 19, 20], but information about the bagging treatment of mangosteen is difficult to obtain. Therefore, this research was aimed at studying the effects of flower baggings to two different flower developments in affecting mangosteen fruit qualities at harvest and during storage.

2. Materials and Methods

This research that was conducted in July–December 2017, consisted of two consecutive research, namely field research and laboratory postharvest research. The field research was conducted in a farmer's field at Gisting village, Tanggamus district, Lampung Province, Indonesia. The mangosteen crop samples were about 38 years old, and located at $-5^{\circ}27'30''$ NL $104^{\circ}42'8''$ SL, ± 537.1 m above-sea-level. Fruit samples were analyzed in (1) the Laboratory of Horticultural Postharvest, (2) the Laboratory of Plant Insects and Diseases, and (3) Biotechnology Laboratory, Fac. of Agriculture, University of Lampung, Bandar Lampung, Indonesia, (4) the Laboratory of Pharmacy Analysis and Medicinal Chemistry, Fac. of Pharmacy, University of Pajajaran, Bandung, Indonesia, and (5) the Integrated Laboratory and Center for Technology Innovation, University of Lampung, Indonesia. The research was started by tagging mangosteen flower at anthesis.

The field research used Completely Randomized Design (CRD) with three replications in each sampling period of five samplings totally. It was arranged in a 2×3 factorial design. The first factor was bagging date [2 and 4 weeks after anthesis (WAA)], and the second one was bagging material (unbagged or control, banana 'Cavendish'- paper bag, and baloon). The reused banana 'Cavendish'- paper bags were received from Great Giant Foods, Co. Ltd., Terbanggi Besar, Central Lampung through Nusantara Tropical Farm, Co. Ltd., Labuhan Ratu, East Lampung, Indonesia. Three bagging materials (unbagged, banana 'Cavendish'- paper bag, and baloon) were applied to flowers of 2 and 4 WAA. The fruits were then sampled every 2 weeks during the fruit development periods of 8-16 WAA. Observations to fruit variables (fruit diameter, weight, temperature, and α -mangosteen content in the rind, and yellow latex spots on the surface rind pericarp) were conducted in every two weeks sampling in the sampling periods of 8-16 WAA. Fruit surface temperature was taken with an infrared thermometer. The α -mangosteen content was analyzed with HPLC [Dionex-UltiMate® 3000, autosampler, column compartment, Ultimate 3000 pump, UV detector, column Enduro C-18 (250 mm \times 4.6 mm, 5 μ m) with C18 guard] based on [21]. At the end of sampling period of 16 WAA, the fruit variables of °Brix, free acid content, and sweetness level were analyzed. In addition, the data of rainfall, and insects trapped on the yellow-sticky insect trapper were also taken. The insects trapped were then identified based on [22] in the Laboratory of Plant Insects and Diseases, Fac. of Agriculture, University of Lampung, Bandar Lampung, Indonesia.

The laboratory postharvest research used the same 2×3 factorial design as in the field research with three replications. Fruits from the last sampling (121 days; stage 0 yellowish white or yellowish

white with light green)[23] were then brought to the Laboratory of Horticultural Postharvest, Fac. of Agriculture, University of Lampung, Bandar Lampung, Indonesia. The samples were put in a storage room of 27-28 °C, and the observations were terminated when the fruits reached stage 6 (purple black color) [23]. The observed variables were shelf-life, fruit weight, fruit rind color, dissolved solid content (°Brix), free acid content, sweetness level, yellow latex spot, rind weight, rind thickness, fruit diameter, aryl weight, microscopic transverse observation of mangosteen rind. The microscopic transverse observation was analyzed based on [7] in Biotechnology Laboratory, Fac. of Agriculture, and the Integrated Laboratory and Center for Technology Innovation, University of Lampung, Indonesia.

Data were analyzed statistically with an orthogonal polynomial contrast at 5% level (SAS System for Windows V9.1), and then presented into tables and line graphs.

3. Results and Discussion

The results showed that flower baggings mostly did not affect mangosteen fruit development. The fruit grew quickly up to 12 WAA and then slowed down to 16 WAA (figure 1-A), regardless of baggings. This same phenomenon of fruit weight increase (figure 1-A) was noted also with fruit diameter (data were not shown). In general, therefore, flower baggings of both bagging materials and application periods mostly did not affect mangosteen fruit qualities at harvest, such as °Brix, free acid content, and sweetness level (table 1). No differences in fruit surface temperature (figure 1-B) and wet season during fruit sampling (10-20 rainy-days), especially in November 2017 that was classified as higher than normal (301-400 mm), might support fruit growth, regardless of bagging materials and application periods. Similar results of bagging were reported with other fruit [24].

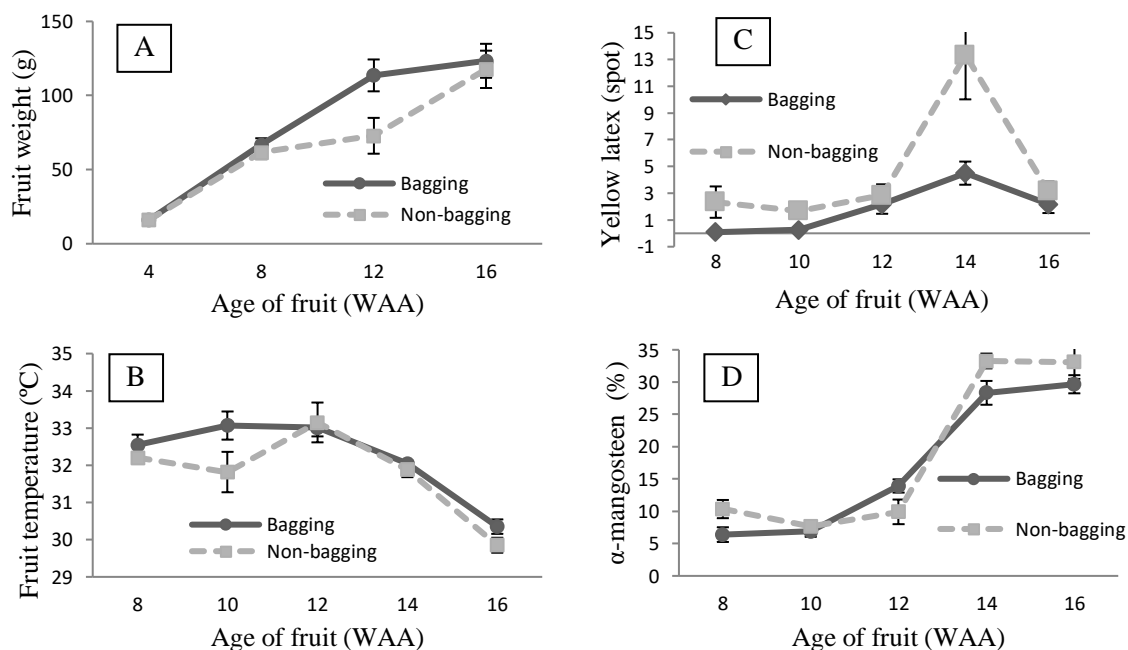


Figure 1. Effect of bagging on fruit weight, yellow latex, fruit temperature, and α -mangosteen of mangosteen fruit.

The yellow latex spots were present throughout fruit growth, irrespective of bagging applications (figure 1-C), even though the bagging fruits experienced lower incidence of yellow latex spots, and fruits bagged with balloon experienced the worst incidence of yellow latex spots. By considering the insects trapped on the yellow-sticky insect trapper, which were dominated by black ants (1.960 *Dolichoderus thoracicus*), compared with *Bactrocera dorsalis* (23) and *Nilaparvata lugens* (4),

yellow latex disorder was much more likely affected by physiological causes, not by insect attacks [25].

Table 1. Effects of bagging materials and dates on soluble solid content ($^{\circ}$ Brix), acid content, and sweetness of mangosteen fruit at harvest based on orthogonal contrast^a.

Contrast	$^{\circ}$ Brix (%)	Acid content (g/100 g)	Sweetness
Control vs Bagging	14.03 vs 13.53 (0.6282)	0.14 vs 0.15 (0.7951)	169.22 vs 135.10 (0.4715)
Baloon vs Paper	13.90 vs 13.16 (0.5397)	0.14 vs 0.15 (0.8807)	113.36 vs 156.86 (0.4280)
Baggings 2 vs 4 WAA	13.50 vs 13.56 (0.9552)	0.11 vs 0.19 (0.1928)	160.76 vs 109.43 (0.3520)
Baloons 2 vs 4 WAA	14.46 vs 13.33 (0.5034)	0.17 vs 0.11 (0.4751)	87.92 vs 138.79 (0.5103)
Papers 2 vs 4 WAA	12.53 vs 13.80 (0.4556)	0.05 vs 0.26 (0.0197)	233.60 vs 80.07 (0.0631)

^aValues inside parentheses are P-contrast values; bagging = banana ‘Cavendish’- paper bag and baloon; paper = banana ‘Cavendish’- paper bag; WAA = week after anthesis; Sweetness = $^{\circ}$ Brix:acid content ratio.

α -Mangosteen content was increased tremendously during 10-14 WAA, and again, regardless of bagging (figure 1-D), bagging materials and application periods (data were not shown). However, bagging slightly decreased α -mangosteen content during the latest periode of fruit growth (figure 1-D), regardless of bagging materials and application periods. Similar results were reported by other researchers [20, 26] and its increase was simply in paralel with anthosianin development [23].

Data in table 2 showed that mangosteen fruits that were bagged at preharvest had longer shelf-life by 6 days than control, and preharvest bagging at 2 WAA produced fruits that had longer shelf-life by 6 days than 4 WAA. Bagging with baloon was better than with banana ‘Cavendish’- paper bag by 7 days storage, regardless of bagging date. However, when bagging was applied with banana ‘Cavendish’- paper bag, bagging at 2 WAA produced fruits that had longer shelf-life by 15 days storage than 4 WAA.

Table 2. Effects of bagging materials and dates on shelf-life, weight loss, and sweetness of mangosteen fruit at storage based on orthogonal contrast^a.

Contrast	Shelf-life (days)	Fruit weight loss (%)	Sweetness
Control vs Bagging	18.5 vs 24.37 (0.0863)	7.42 vs 12.26 (0.1431)	189.30 vs 154.92 (0.4947)
Baloon vs Paper	27.75 vs 21.00 (0.0876)	18.62 vs 5.90 (0.0086)	120.61 vs 189.23 (0.2557)
Baggings 2 vs 4 WAA	27.50 vs 21.25 (0.1079)	12.15 vs 12.36 (0.9516)	200.33 vs 109.52 (0.1474)
Baloons 2 vs 4 WAA	26.50 vs 29.00 (0.6125)	19.91 vs 17.32 (0.6014)	154.01 vs 87.22 (0.4203)
Papers 2 vs 4 WAA	28.50 vs 13.50 (0.0185)	4.39 vs 7.40 (0.5454)	246.64 vs 131.82 (0.1877)

^aValues inside parentheses are P-contrast values; bagging = banana ‘Cavendish’- paper bag and baloon; paper = banana ‘Cavendish’- paper bag; WAA = week after anthesis; Sweetness = $^{\circ}$ Brix:acid content ratio.

A transverse observation of mangosteen mesocarp with SEM revealed that mesocarp cells bagged with baloon (C) were smaller and more compact that those unbagged (A) and bagged with banana ‘Cavendish’- paper bag (figure 2). These smaller and more compact mesocarp cells of the fruits bagged with baloon might inhibit traspiration and resulted in longer shelf-life. Unfortunately, this longer shelf-life resulted in increasing fruit weight loss (table 1).

Fruits of all treatments during postharvest storage developed yellow latex spots on the rind surface. Just like in preharvest applications, this postharvest results suggested that yellow latex disorder was much more likely affected by physiological causes, not by insect attacks [25].

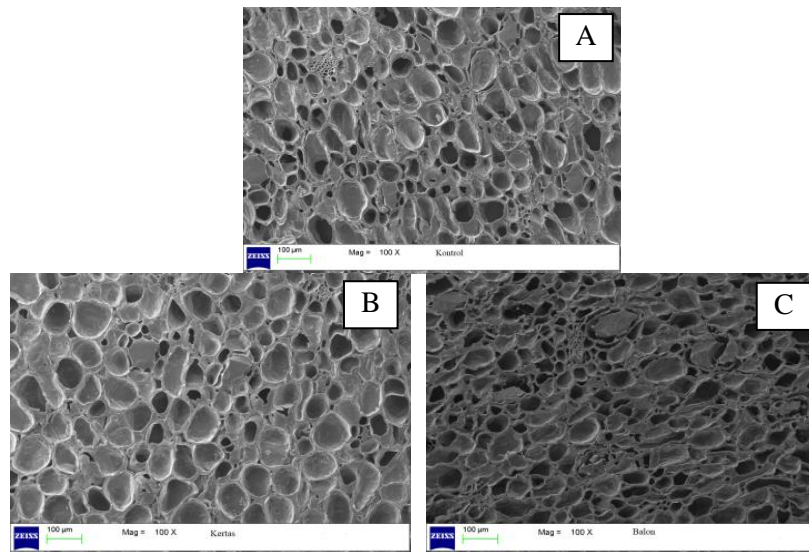


Figure 2. A transverse observation of mangosteen mesocarp unbagged (A), bagged with banana ‘Cavendish’- paper bag (B) and bagged with baloon (C) under *scanning electron microscope* (SEM).

4. Conclusion

The results showed that except α -mangosteen content that was slightly decreased during the latest periode of fruit growth by bagging at preharvest, flower baggings of both bagging materials and application periods mostly did not affect mangosteen fruit qualities at harvest, but they affected fruit shelf-life and qualities during storage. Flower baggings resulted in increased fruit shelf-life, with paper bagging applied in 2 WAA was better than that applied in 4 WAA. Paper bagging in 2 WAA resulted in the mangosteen fruit shelf-life of 29 days compared to 4 WAA which resulted in 14 days shelf-life. This research proved also that the occurrence of yellow latex was much more likely affected by physiological causes, not by insect attacks.

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