Chitosan and Plastic Wrapping Applications to Mangosteen Fruit of Stage III in Lengthening Fruit Shelf-Life and Maintaining High Fruit Qualities

Zulferiyenni[1*], Soesiladi Esti Widodo[2], Muhammad Kamal[2], and Mira Lerizka[3]

[1]Department of Agricultural Product Technology, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia 35145; E-mail: zulferiyenni@gmail.com
[2]Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia 35145; E-mail: sestiwidodo@gmail.com; E-mail: mkamal1961@yahoo.com
[3]Department of Agrotechnology, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia 35145; E-mail: arnurlaily@gmail.com

Abstract

Mangosteen is a climacteric fruit that has a high respiration rate. Farmers commonly harvest the fruits when its rind color changes to reddish pink (stage III). Unfortunately, postharvest efforts on lengthening its fruit shelf-life and maintaining its high fruit qualities by applying fruit coatings are not documented. That is partly because its very thick rind is believed to function as a good physical barrier from water loss leading to fruit desiccation. The purposes of this research were to study the effects of postharvest applications of chitosan and plastic wrapping to mangosteen fruit of stage III in lengthening its fruit shelf-life and maintaining high fruit qualities. Treatment were arranged in a completely randomized design with treatments arranged in a factorial 3 x 2, consisted of chitosan (0, 1.25 and 2.5%) and plastic wrapping (without and with one-layer of the plastic wrapping). The results showed that (1) the application of chitosan significantly lengthened its fruit shelf-life by 4.17-8.50 days longer than the control, while its fruit qualities were mostly well maintained, with the best result was shown by 2.50% chitosan, (2) plastic wrapping significantly lengthened its fruit shelf-life by 4.11 days longer the control, with its fruit qualities were mostly unaffected, (3) the two treatments of chitosan and plastic wrapping were mostly not interacted with their significant individual effects were dominating. The best result was shown by the combination of 2.5% chitosan and one-layer plastic wrapping that was capable of lengthening significantly its fruit shelf-life by 13.34 days longer than the control with its fruit qualities were unaffected.

Keywords: coating, Garciana mangostana, packaging, stadium, storage

1. INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is one of tropical fruits that has high economic value. Mangosteen belongs to climacteric fruit that rapidly suffered postharvest damage, thus shortening the shelf-life and accelerate the decline in fruit qualities. Maturity level of mangosteen fruit is very influential on quality and its self-life. Mangosteen fruits that are harvested too young, although they may have a longer shelf-life, they are usually more acidic, while those harvested too old have short self-life, but taste sweeter (Setyabudi *et al.*, 2015). Mangosteen fruit for export is recomended to be harvested in a reddish pink color of ripening stage III (Palapol *et al*., 2009). In this fruit stage, however, it has a short shelf-life, and therefore, an appropriate postharvest handling is needed in slowing its fruit quality changes.

Chitosan as a fruit coating material has beneficial properties that are non-toxic, cheap, easy to apply, and water soluble. Chitosan coating on fruit can inhibit the entry of O_2 supply from outside the fruit so that the respiratory process will decrease which resulted in prolonging its fruit shelf-life. In addition to using chitosan coating, the shelf-life of fruit can be extended by packaging with a low-density polyethylene plastic wrapping, which is able to maintain fruit quality and freshness. Research by Agustina *et al.* (2016) showed that the application of plastic wrapping on the mangosteen fruit was able to suppress fruit weight loss.

The purposes of this research were to study the effects of postharvest applications of chitosan and plastic wrapping to mangosteen fruit of stage III in lengthening its fruit shelf-life and maintaining high fruit qualities.

2. MATERIALS AND METHODS

A. Materials

The research was conducted at the Horticultural Postharvest Laboratory, Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia on July to August 2017. The main material used in this study was mangosteen fruit of stage III (reddish pink, Palapol *et al*., 2009). The fruits were harvested from the village of Mulang Maya, sub-district of East Kota Agung, Tanggamus district, Lampung

Province, Indonesia, and immediately brought to the laboratory, sorted by size and uniform maturity level, and immediately treated in accordance to the treatments. Other materials used were plastic wrapping (trademark Total' of 300 mm x 500 m x 11 µm) and chitosan (a cosmetic grade).

B. Methods

This study was conducted by using a Completely Randomized Design with six replications of one fruit each, arranged in a factorial 3 × 2. The first factor was chitosan concentration (0%, 1.25%, and 2.5%) and the second factor was plastic wrapping (control/without and with one layer of plastic wrapping). The fruits were quickly dipped into the chitosan solution (1.25 or 2.5%) for ± 10 seconds, until the fruits were completely coated, let them air-dried, and then coated with one-layer plastic wrapping (trademark Total' of 300 mm x 500 m x 11 µm). The untreated fruits were quickly dipped into aquadest. The samples were put into a storage room with room temperature of 27-28 °C.

Observations were made on fruit stage changes based on fruit color changes (observed daily), fruit weight loss, fruit firmness (with a penetrometer typed FHM-5, 5 mm diameter of cylindrical tip; Takemura Electric Work, Ltd., Japan), soluble solids (ºBrix; with an 'Atago' hand refractometer at room temperature, without dilution), and free acid contents (a titration with 0.1 N NaOH and phenolphthalein as indicator). Observation was stopped if the skin color of mangosteen fruit had reached stage VI (purple black; Palapol *et al*., 2009). All data were analyzed with ANOVA, and further tested with Least Significant Difference at 5% (Statistix 9).

3. RESULTS AND DISCUSSION

The results showed that chitosan treatment at various concentrations (1.25% and 2.5%) was able to prolong the shelf-life of mangosteen fruit (Table 1). The chitosan treatments of 1.25% and 2.5% increased the shelf life by 4.17 and 8.50 days longer than the control treatment. Coating of chitosan on mangosteen was able to inhibit air movement between the fruit with the environment around the fruit, so that respiration decreased and delayed the ripening process of mangosteen fruit. The statement was supported by Widodo *et al*. (2017), that the chitosan treatment of the fruit might form a barrier layer capable of modifying the air around the fruit so as to suppress respiration and slow the fruit ripening.

Table 1. Effects of chitosan and plastic wrapping applied to mangosteen fruits harvested at ripening stage III on fruit shelf-life, weight loss, firmness, soluble solid content (°Brix), free acid content, and sweetness level

Treatments	Shelf-life (days)*	Weight loss (%)*	Firmness (kg/cm^2)*	°Brix (%)*	Free acid (g/100 g)*	Sweetness level*
Chitosan (C):						
0% (C0)	11.00 c	10.32 b	8.25 b	15.27 a	0.57 a	28.09 b
1.25% (C1)	15.17 b	15.56 a	16.00 a	15.31 a	0.43 ab	45.63 ab
2.50% (C2)	19.50 a	17.41 a	14.66 a	13.39 a	0.32 b	58.77 a
Plastic Wrapping (W):						
Without (W0)	13.17 b	17.21 a	13.55 a	15.32 a	0.48 a	42.84 a
1 Layer (W1)	17.28 a	11.65 b	12.38 a	13.99 a	0.40 a	45.49 a
Chitosan x Plastic Wrapping:	**P = 0.0405	**P = 0.1590	**P = 0.4218	**P = 0.1994	**P = 0.2193	**P = 0.5851
C0W0	6.83 d	10.26 c	7.50 b	16.05 ab	0.61 a	27.84 b
C0W1	15.17 bc	10.38 c	9.00 b	14.50 abc	0.52 ab	28.33 b
C1W0	13.83 c	19.21 ab	16.33 a	16.80 a	0.52 ab	38.11 ab
C1W1	16.50 abc	11.92 c	15.66 a	13.82 bc	0.33 bc	53.15 ab
C2W0	18.83 ab	22.15 a	16.83 a	13.12 c	0.29 c	62.56 a
C2W1	20.17 a	12.67 bc	12.50 ab	13.67 bc	0.35 bc	54.99 ab

*The values in the same columns followed by the same letter were not significantly different according to 5% LSD test; Sweetness level was ºBrix/free acid content ratio; **Probability values generated with ANOVA test; Fruit firmness, ºBrix, free acid content, and sweetness level at 0 day storage were 7.80 kg/cm^2, 16.52%, 1.30 g/100 g, and 14.21, consecutively

The chitosan ability to inhibit air movement between the fruit with its environment was not in line with its ability to inhibit transpiration. The process of chitosan drying during treatment seemed to speed up rind drying and, consequently, to increase water loss from the rind. Eventually, this rind drying caused increased fruit weight loss and made the rind harder (Table 1). The increased fruit weight loss caused by chitosan drying was also observed by Widodo *et al*. (2013 and 2017).

The single plastic wrapping treatment could prolong the shelf life of the mangosteen fruit (Table 1). Single plastic wrapping treatment could extend the shelf-life, i.e. 4.11 days longer than control treatment (without plastic wrapping) (Table 1). Plastic wrapping treatment could inhibit respiration and transpiration processes by closing the pores of the mangosteen fruit, thus reducing its weight loss and delaying its ripening. This statement was justified by research conducted by Utama *et al*. (2006), which stated that packaging with plastic stretch film (plastic wrapping) could prolong the shelf-life of mangosteen fruits.

Plastic wrapping treatment could suppress the decrease in weight loss of the mangosteen fruit less than the control (Table 1). The application of plastic wrapping had a weight loss of 5.56% lower than that of the control (Table 1). This happened because plastic wrapping had a small permeability to air and water vapor that could suppress transpiration on the fruit thus decreasing the rate of fruit weight loss. This statement was supported by research

conducted by Hasbi *et al*. (2005), which indicated that polyethylene plastic applications were able to produce lower weight loss. This was because plastic packaging could retain the humidity of the storage environment so that the rate of evaporation of water in cells was inhibited.

This ability to retain the rind humidity, however, did not significantly affect the mangosteen fruit firmness (Table 1). The mangosteen rind without plastic coating was even slightly firmer than that receiving plastic coating. This proved that packing of mangosteen fruit using plastic wrapping could inhibit respiration and transpiration so that the hardening of fruit was inhibited. The level of firmness of the mangosteen fruit was caused by the evaporation of water from the skin cells due to the transpiration process (Sihombing, 2015). In general, the treatment combination showed no significant effect in maintaining the firmness of the mangosteen fruit.

In this study, chitosan had no significant effect on dissolved solids (ºBrix) of mangosteen fruit (Table 1). This was in line with research conducted by Widodo *et al*. (2013), which stated that chitosan did not significantly affect the dissolved solids content of the 'Crystal' guava fruit. Becaused the application of 2.50% chitosan decreased significantly free acid content of the mangosteen, therefore, the mangosteen aril was significantly sweeter (Table 1).

The single layer plastic wrapping treatment had no significant effect on the dissolved solids (ºBrix), free acid, and sweetness level (Table 1). This was in line with the results of research conducted by Widodo *et al.* (2016), which stated that plastic wrapping treatment did not affect the sweetness level of the 'Mutiara' guava fruit.

In this study, the combination of plastic wrapping and chitosan (C1W1 and C2W1) was able to prolong the shelf-life of the mangosteen fruit longer than the control (Table 1). This was because of the interaction of the chitosan and plastic wrapping that could extend fruit shelf-life. However, the combination of chitosan and plastic wrapping did not affect the quality of the mangosteen fruit (Table 1).

The combination of 1.25% chitosan and plastic wrapping (C1W1) was able to prolong the shelf life of 9.67 longer than the control but did not affect the quality of the mangosteen fruit (Table 1). However, the result was better when combining 2.5% chitosan and plastic wrapping (C2W1) because it was able to extend the shelf-life of 13.33 longer than the control (Table 1) and did not affect the quality of the mangosteen fruit (Table 1).

4. CONCLUSION

The results showed that (1) the application of chitosan significantly lengthened its fruit shelf-life by 4.17-8.50 days longer than the control, while its fruit qualities were mostly well maintained, with the best result was shown by 2.50% chitosan, (2) plastic wrapping significantly lengthened its fruit shelf-life by 4.11 days longer the control, with its fruit qualities were mostly unaffected, (3) the two treatments of chitosan and plastic wrapping were mostly not interacted with their significant individual effects were dominating. The best result was shown by the combination of 2.5% chitosan and one-layer plastic wrapping that was capable of lengthening significantly its fruit shelf-life by 13.34 days longer than the control with its fruit qualities were unaffected.

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