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POSTHARVEST APPLICATIONS OF KD-112 COATING AND PLASTIC WRAPPING IN AFFECTING FRUIT SHELF-LIFE AND QUALITIES OF MANGOSTEEN FRUITS

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Abstract

Having a very thick rind which is frequently believed as a good physical barrier to fruit deterioration from a high transpiration rate, the mangosteen fruit hardly receives any postharvest technology to lengthen its fruit shelf-life and maintain its high fruit qualities. This research was aimed at studying postharvest applications of sugar-esther blend of KD-112 and plastic wrapping applied to different fruit stages in affecting fruit shelf-life and qualities of mangosteen. This study used a Completely Randomized Design with five replicates arranged in a factorial 4 × 3 × 2. The first factor was mangosteen fruit stage (stage 0, 2, 3, and 4), the second one was KD-112 (0, 7, and 14%), and the third one was plastic wrapping (without and with one layer of plastic wrapping). The results showed that by harvesting mangosteen at younger fruit stages 0 and 2, its fruit shelf-life extended significantly up to 3-5 days longer compared to harvesting at later stages. However, because there might be a risk of misjudge in determining the physiological maturity when the fruits were still at stage 0, stage 2 seemed to be the most appropriate stage for harvest. A single treatment of KD-112 was able to extend fruit shelf-life by 4-6 days longer and to increase fruit firmness by 4-5 kg/cm^2 firmer than the control. A single plastic wrapping treatment was able to extend fruit shelf-life by 5 days longer than the control. By combining both treatments of 14% KD-112 and plastic wrapping, and applied to fruit stage 2, fruit shelf-life of 21 days could be achieved, that was 8 days longer than fruit of the youngest stage receiving no fruit coatings, while its fruit qualities were not affected.

Keywords: Coating, Mangosteen, Postharvest, Storage, Wrapping

Introduction

Mangosteen (*Garcinia mangostana* L.) fruit is much favored due to a good taste and a pleasant flavor. Its maturity index for harvest is mostly judged by skin color [1, 2]. Fruits

at stage 5 (dark purple) or stage 6 (purple black) are harvested for direct consumption and local market, whereas for export, harvesting mangosteen at earlier stages of stage 2 (yellowish green skin color with 51-100% pink spot) and 3 (reddish pink color) is mostly recommended [1-7]. However, stage of mangosteen fruit when harvested by farmers is very diverse. All fruit stages are found [8], such as stage 0 pale yellow or pale yellowish-green color, stage 1 yellowish green skin color with 5-50% pink spot, stage 2 yellowish green skin color with 51-100% pink spot, stage 3 reddish pink color, stage 4 color red to purple skin, stage 5 dark purple skin color, stage 6 purple black color [1].

For export markets, mangosteen fruit needs to have a long shelf-life with no significant change in fruit quality. Consequently good and proper postharvest handling should be applied. However, having a very thick rind which is frequently believed as a good physical barrier to fruit deterioration from a high transpiration rate, mangosteen fruit hardly receives any postharvest technology to lengthen its fruit shelf-life and maintain its high fruit qualities. Few researchers have been noted to apply postharvest technologies to mangosteen fruits, such as low temperature storage and film coatings [8, 9, 10].

A sugar-ester blend of KD-112 is one of several common fruit coatings applied to pineapple in pineapple agroindustries. It is derived from enzymatic reactions which are the latest manufacturing methods for applications in food, cosmetics, detergents and pharmaceutical industries [11]. In addition to plastic wrapping which is one of the most widely used, easy, effective and economical packaging tool [12], KD-112 has been applied to papaya as a postharvest application and proven to be effective [13]. However, no one has tried to applied KD-112 to mangosteen fruits. This research was aimed at studying postharvest applications of sugar-esther blend of KD-112 and plastic wrapping applied to different fruit stages in affecting fruit shelf-life and qualities of mangosteen.

Materials and Methods

This research was conducted from July to August 2017 in the Horticultural Postharvest Laboratory, Faculty of Agriculture, University of Lampung. Fresh harvest of mangosteen fruits of stages 0, 2, 3, and 4 [1] were obtained from the village of Mulang Maya, Kota

Agung, Tanggamus district, Lampung Province, Indonesia. Fruits of stage 0 (S0) were yellowish white or yellowish white with light green, those of stage 2 (S2) were light greenish yellow with 51-100% scattered pink spots, those of stage 3 (S3) were reddish pink, and those of stage 4 (S4) were red to reddish purple [1]. The mangosteen fruit samples were then sorted to obtain a relatively homogeneous sample based on size, color, shape and maturity level, and treated on the same day of harvest..

This research used Completely Randomized Design (CRD) with five replications arranged factorially 4 × 3 × 2. The first factor was the stages of mangosteen fruit [stage 0 (S0), stage 2 (S2), stage 3 (S3), and stage 4 (S4)], the second factor was KD-112 concentrations [without KD-112 (KD0), 7% KD-112 (KD1), and 14% KD-112 (KD2)] and the third factor was plastic wrapping [without (W0) and with one-layer of plastic wrapping (W1) (trademark 'Total' of 300 mm x 500 m x 11 μm)].

The KD-112 solution was prepared by adding aquadest into KD-112 concentrated solution to get the concentrations applied (7 and 14%). Then the mangosteen fruits were dipped into the solution, air-dried, then wrapped using one-layer plastic wrapping. Untreated mangosteen fruits were simply dipped into aquadest and air-dried. All samples of mangosteen fruits were then stored in a room temperature of 27-28 °C.

Observations were made to changes in fruit stages, fruit weight, fruit firmness (using FHM-5 type penetrometer, 5 mm in diameter, Takemura Electric Work, Co. Ltd., Japan) , soluble solid content (°Brix, using an Atago 'N-1E' hand-refractometer), and free acid content (a titration with 0.1N NaOH and phenolphthalein as an indicator). Observations were terminated when the fruits reached stage 6 (purple black color) [1]. Data were analyzed with analysis of variance, followed by Least Significant Different (LSD) test with 5% level.

Results and Discussion

Similar to the result of our other research [8], data in Table 1 showed also that the fruits of earlier stages tended to have a longer shelf-life. By harvesting mangosteen fruit at younger fruit stages of stage 0 and 2, its fruit shelf-life extended significantly up to 3-5

days longer compared to harvesting at later stages. Fruits of stage 0 had the longest shelf-life compared to other maturity stages or 5 days longer than the fruits of stage 4, and its fruit qualities were unaffected significantly. Other researchers [14] had reported a similar conclusion that the later the mangosteen fruit was harvested, the shorter its shelf-life to be.

The data in Table 1 also revealed the facts that the mangosteen fruits of all stages were ripened to their full ripening stage of stage 6 with no significant differences in fruit qualities, such as in physical qualities of weight loss and firmness (Table 1), and chemical qualities of soluble solid content, free acid content, and sweetness level (Table 2).

Table 1. Effects of fruit stages, sugar-esther blend KD-112, plastic wrapping on fruit shelf-life, weight loss, and firmness of mangosteen fruits

Treatment	Shelf-life (days)*	Weight loss (%)*	Firmness (kg/cm^2)*
Stage (S):			
Stage 0 (S0)	17.60 a	11.06 b	12.16 a
Stage 2 (S2)	16.58 ab	14.46 a	14.50 a
Stage 3 (S3)	14.58 bc	12.53 ab	12.91 a
Stage 4 (S4)	12.87 c	11.24 b	13.17 a
KD-112 (K):			
KD-112 0% (K0)	12.02 b	11.79 a	10.46 b
KD-112 7% (K1)	16.22 a	12.45 a	14.05 a
KD-112 14% (K2)	17.98 a	12.73 a	15.04 a
Plastic wrapping (W):			
Without (W0)	13.13 b	13.25 a	12.98 a
1 Layer (W1)	17.69 a	11.40 b	13.39 a
Stage x KD-112:	NS	NS	NS
Stage x Plastic Wrapping	NS	NS	NS
KD-112 x Plastic Wrapping	NS	NS	NS
Stage x KD-112 x Plastic Wrapping	NS	NS	NS

*The values in the same columns followed by the same letters were not significantly different according to the 5% LSD test; NS non significant; Fruit firmness at 0 days storage of stage 0 was 22.85 kg/cm^2, while at stage 2 was 15.85 kg/cm^2, at stage 3 was 14.20 kg/cm^2, at stage 4 was 12.19 kg/cm^2. Fruit shelf-lifes of S0K2W1, S2K2W1, and S3K2W1 were 22.60, 20.83, 20.50 days storage, consecutively, while that of control was 12.40 days storage.

Table 2. Effects of fruit stages, sugar-esther blend KD-112, plastic wrapping on fruit soluble solid content, free acid content, and sweetness level of mangosteen fruits

Treatments	Soluble solid content (%)*	Free acid content (g/100 g)*	Sweetness level*
Stage (S):			
Stage 0 (S0)	14.48 a	0.44 a	43.15 a
Stage 2 (S2)	14.90 a	0.48 a	36.77 a
Stage 3 (S3)	15.11 a	0.52 a	34.51 a
Stage 4 (S4)	14.73 a	0.48 a	35.61 a
KD-112 (KD):			
KD-112 0% (KD0)	15.31 a	0.50 a	37.34 a
KD-112 7% (KD1)	14.24 a	0.45 a	38.73 a
KD-112 14% (KD2)	14.86 a	0.49 a	36.45 a
Plastic wrapping (W):			
Without (W0)	14.85 a	0.54 a	32.10 b
1 Layer (W1)	14.75 a	0.42 b	42.92 a
Stage x KD-112:	NS	NS	NS
Stage x Plastic Wrapping	NS	NS	NS
KD-112 x Plastic Wrapping	NS	NS	NS
Stage x KD-112 x Plastic Wrapping	NS	NS	NS

* The values in the same columns followed by the same letters were not significantly different according to the 5% LSD test; NS non significant; Sweetness level was soluble solid:free acid content ratio; The values of soluble solid content (°Brix), free acid, and sweetness level at 0 days storage were stage 0 (S0): 15.48%, 0.39 g/100 g, and 39.69%; stage 2 (S2): 16.16%, 0.43 g/100 g, and 37.76%; stage 3 (S3): 16.52%, 0.48 g/100 g, and 34.11%; stage 4 (S4): 16.52%, 0.50 g/100 g, and 33.04%, consecutively.

The question is raised on what stages the mangosteen fruits should be harvested? Mangosteen fruits are commonly perceived as climacteric fruits [2]. That means that, as a common knowledge, the fruit can be harvested at its physiological maturity (or at its full maturity stage, that is just before ripening process begins), and then the fruit will naturally reach its full ripening stage during its storage period. Our data in Table 1 showed that even the fruits of stage 0 (yellowish white or yellowish white with light green) reached stage 6 (purple black) [1] during storage. That told us that the fruits had reached their physiological maturity. However, using stage 0 as a harvest maturity index should be avoided because determination of physiological maturity on stage 0 could be easily misjudged during harvest in the field as other fruit physical parameters. That is due

to fruits with similar physical parameters might have different physiological development [15].

As an alternative to stage 0, stage 2 (light greenish yellow with 51-100% scattered pink spots) [1] seemed to be the most appropriate stage for harvest because the stage developed fruit shelf-life as long as stage 0 (Table 1) and was technically easier to be executed due to clear pink spots. In facts, stage 2 was the stage that was mostly recomended [1-4; 6-7]. However, during a situation in which the fruits harvested in a diverse stages are present in the field, fruits of stage 0 should not be discarded because they will reach full ripening stage 6 (Table 1), with the qualities are as good as the later stages (Table 2).

The single treatment of KD-112 also had a significant effect on fruit shelf-life and firmness (Table 1). The single treatment of KD-112 was able to extend the fruit shelf-life and firmness by 4-6 days longer and 4-5 kg/cm^2 firmer than the control, consecutively. This indicated that the coating of fruit using sucrose polyester of KD-112 slowed the rate of respiration and inhibited the ripening process of the fruit [16], thus extended the shelf-life and inhibited the softening of the mangosteen fruit [17]. However, single treatment of KD-112 had no effect on fruit weight loss (Table 1) and the chemical qualities of the mangosteen fruit (Table 2).

The single plastic wrapping treatment had a significant effect on the duration of shelf-life (Table 1). The single plastic wrapping treatment was able to extend the shelf-life by 5 days longer than the control. This was because plastic wrapping suppressed the rate of respiration of the fruit due to having a smaller permeability to water vapor and air compared to uncoated fruit [12], so that it decreased the level of O_2 and increased that of CO_2 in the fruits, thus slowing the ripening process of the mangosteen fruits.

The single plastic wrapping treatment had also a significant effect on decreasing the fruit weight loss by 2% smaller than the control (Table 1). Plastic wrapping had a smaller permeability to water vapor and air, and therefore, it inhibited the transpiration process more effectively [12, 18].

In general, the treatments applied to the mangosteen fruit did not affect the chemical qualities of the fruit (Table 2), just as our other research report [8]. However, data in Table 2 showed that the single plastic wrapping treatment decreased free acid content by 0.12% lower than the control, and consequently, it increased the sweetness level of the fruit by 33.71% higher than the control.

There were no interactions effects of two and three factor combinations on the fruit shelf-life and qualities of the mangosteen (Tables 1 and 2). Their effects on the fruit shelf-life and qualities of the mangosteen were simply due to the combination of their significant effects from individual treatments. Therefore, the most significant effect was noted on the three combination treatments of S0K2W1, S2K2W1, and S3K2W1 that prolonged significantly the fruit shelf-life by 8-10 days longer than the control (see notes in Table 1). However, because there might be a risk of misjudge in determining the physiological maturity when the fruits were still at stage 0 [8], and KD-112 did not have a biopesticide effect [19], therefore, applying 14% KD-112 and one-layer plastic wrapping to mangosteen fruits of stage 2 (S2K2W1) seemed to be more reasonable. The combined treatment made the fruit shelf-life up to 21 days, that was 8 days longer than fruit of the youngest stage receiving no fruit coatings, while its fruit qualities were unaffected significantly. In addition, when postharvest diseases are at risk, then a biopesticide might be applied [19, 20].

Conclusion

The results showed that by harvesting mangosteen at younger fruit stages of stage 0 and 2, its fruit shelf-life extended significantly up to 3-5 days longer compared to harvesting at later stages. However, because there might be a risk of misjudge in determining the physiological maturity when the fruits were still at stage 0, stage 2 seemed to be the most appropriate stage for harvest. A single treatment of KD-112 was able to extend fruit shelf-life by 4-6 days longer and to increase fruit firmness by 4-5 kg/cm^2 firmer than the control. A single plastic wrapping treatment was able to extend fruit shelf-life by 5 days longer than the control. By combining both treatments of 14% KD-112 and plastic wrapping, and applied to fruit stage 2, fruit shelf-life of 21 days could be achieved, that

was 8 days longer than fruit of the youngest stage receiving no fruit coatings, while its fruit qualities were unaffected.

Conflict of Interest

The authors declaired that there were no conflict of interest regarding this article on financial, personal or other relationships with other people or organizations.

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