

Effects of wax coating applications and storage temperatures on the quality of tangerine citrus (*Citrus reticulata*) var. Siam Banjar

¹Hassan, Z. H., ²Lesmayati, S., ²Qomariah, R. and ²Hasbianto, A.

¹Indonesian Center for Agricultural Post Harvest Research and Development, Jl. Tentara Pelajar No. 12
Bogor 16114 West Java, Indonesia

²South Kalimantan Assessment Institute for Agricultural Technology, Jl. Panglima Batur Barat No. 4
Banjarbaru 70711 South Kalimantan, Indonesia

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Abstract

The objective of this study is to assess the effects of wax coating concentrations and storage temperatures on the quality changes, both physically and nutritionally, of tangerine citrus (*Citrus reticulata*) var. Siam Banjar. Tangerine citrus var. Siam Banjar were coated with three different concentrations of wax emulsion (10, 12, and 15%) and stored at two different temperatures (5 and 25°C) at 85-90% RH. The observation in respect of the percentage weight loss, percentage decay incidence, fruit quality characteristics (titratable acidity, total soluble solids, and ascorbic acid), and sensory evaluation (colour, texture, odor, freshness, appearance, fruit firmness, taste, and overall acceptability) were recorded and evaluated at intervals of 5 days for 35 days of storage. The results showed that the combination of 12% wax coating and storage at 5°C was the most effective treatment in maintaining the quality of tangerine citrus var. Siam Banjar, which was significantly ($p < 0.05$) indicated by the lowest percentage weight loss (16.88%) and percentage incidence of fruit rot (17.67%). There are no significant changes ($p > 0.05$) in term of quality attributes of the fruits (titratable acidity, total soluble solids, ascorbic acid), although physio-chemical analysis revealed that this treatment had higher level of titratable acidity (0.53 citric acid/100 ml), lower level of TSS (9°Brix), and the higher level of ascorbic acid (38.2 mg ascorbic acid/100 g) compared to the other treatments. Additionally, the organoleptic evaluation found that the highest score of overall acceptability value was observed in 12 % wax coated fruits stored at 5°C.

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Introduction

Among the various types of tangerine citrus (*Citrus reticulata*) ("Jeruk Siam") known and found in Indonesian, the most popular ones are Siam Banjar, Siam Pontianak and Siam Madu. Tangerine citrus (*Citrus reticulata*) var. Siam Banjar is mostly grown in South Kalimantan province, Indonesia. The trees are grown throughout South Kalimantan and are generally planted in the lowland or swampy land. Most of the tangerines produced are mainly propagated by grafting, with Japanese citroen (JC) being the rootstock cultivar. Fruit production starts in 3 to 4 years after planting. Growing tangerines from the seeds may take longer, as usually seven or eight years are required before the first fruit. The fruits are usually between 5 to 7 cm in diameter, with 6-9 seeds (Antarlina, 2006a; Antarlina, 2006b). A thin soft peel that can be as thin as 0.13 cm envelops the flesh, which ranges in hue from green to yellowish green, and usually easy-to-peel. Tangerine citrus var. Siam Banjar are mature and ready for harvest when 10-30% of the peel surface has started to turn yellow in colour. Flesh is bright orange, very juicy, and sweet flavor,

without bitterness. Most of the tangerines produced in South Kalimantan are sold as fresh fruit in the domestic market. A study on the consumer preference local consumer prefers to choose tangerine citrus var. Siam Banjar which has small size from the grade C and D in spite of grade A or B. The smallest Siam Banjar fruit size, the thinnest fruit skin can be easily peeled, tasted more sweet with tend to have small number of fruit sands (Supriyanto *et al.*, 2005).

Initial assessments in current domestic markets as well as visits to the producers in Barito Kuala district, the largest production centre of tangerine citrus var. Siam Banjar in South Kalimantan, have shown that the quality of fresh tangerine citrus var. Siam Banjar currently produced is in good quality. However, these fruits have a short shelf-life compared to other types of citrus. Although only within 3 to 7 days after harvesting fruit already reaches the market, it is often found already a development of postharvest decay. It is estimated that the magnitude of post harvest losses during the transportation is about 25-80%, depends on the initial condition of the fruit as well as the post harvest handling.

One of the major problems faced by the traders

*Corresponding author.

Email: hikmah_f@yahoo.com

during the transport and distribution of the fruits over long distances from the production areas to the market is maintaining the quality of the fruits. Low temperature or cold storage is known as one of the most effective method of prolonging the postharvest life of fresh produce and reducing the quality losses of the fruits. Temperature of 5°C was reported to be effective in maintaining the shelf life of mandarin oranges (*Citrus reticulata* Blanco cv. 'Sai Nam Peung') compared to those stored at room temperature (Shein *et al.*, 2008). However, due to the lack of cold storage facilities during the transport at farmer level as well as at local trader level as a result of high costs of low temperature or cold storage, most of the produced fresh fruit is distributed in non-refrigerated trucks. These conditions enhance the local traders to find another cheaper method to prolong the self-life of fresh produce. Fruit waxing was considered as a cheaper alternative to cope with this problem.

The application of surface coating on fruits is considered as one of several treatments developed to reduce post harvest losses and to prolong self-life of fruits. Surface coating has been used as preservation technique for fruits as well as for vegetables for decades (Baldwin, 1995). The main objectives of the application of surface coating on fruits are to reduce the water evaporation from the fruits, and thereby slow of weight loss, which ultimately extend the shelf-life of the fruits. It is reported that surface coating can reduce fruit weight loss by up to 50%, depending upon coating type and concentration. Furthermore, surface coating can maintain the freshness of the products and improve the appearance of them (Baldwin, 1994). Although many fruits develop waxy coat on their epidermis, this natural waxy coat is not adequate to offer protection against water loss and high respiration rate. Hence, by applying surface coating on fruit, it can maintain the quality of products and reduce the post harvest decay. The common compounds used as surface coating is wax (Park, 1999).

Many studies have been conducted focusing on the application of wax coating on various kinds of fruit (Joyce *et al.*, 1995; Baldwin *et al.*, 1998; Saftner, 1999; Sabir *et al.*, 2004; Navarro *et al.*, 2005; Cong *et al.*, 2007; El-Anany *et al.*, 2009), including the wax coating treatment in citrus species (Sadasivan *et al.*, 1974; Gilfillan and Piner, 1985; Hamid *et al.*, 1987; Bayindirli *et al.*, 1995; Shein *et al.*, 2008). However, to our knowledge, the effects of wax coating on the tangerine citrus var. Siam Banjar have not been yet investigated. The aim of this study is to characterize the effects of diverse wax coating applications and the on the quality changes, both physically and

nutritionally on tangerine citrus var. Siam Banjar, stored at different temperatures.

Materials and Methods

Fruit samples

All the fruits samples used in this study were fresh tangerine citrus (*Citrus reticulata*) var. Siam Banjar obtained from a single orchard in Sungai Kambat village, Barito Kuala district, South Kalimantan Province, Indonesia, harvested in June-August 2010. Fruits were selected for uniformity in maturity, shape, size (6.0-6.5 cm in diameter), and weight (130-140 g). Fruits used were free of physical damage and infection.

Preparation of wax emulsion

The wax emulsion was prepared by dissolving bees wax (100, 120, and 150 g, depends on the concentration) into 100 ml water phase. The water phase was heated to the temperature of 90°C (being sure that all wax becomes completely hydrated). Subsequently, a volume of 20 ml of oleic acid and 60 ml of TEA (triethanolamine) were added to the molten wax. Finally, add water until it reaches the volume of 1000 ml. The emulsifier is the soap produced by the in situ reaction of oleic acid and TEA. The oleic acid is dissolved in the wax phase, and the TEA is dissolved in the water phase. This formulation produces a very fine emulsion; but, obviously, it does not have good acid stability. In place of oleic acid, stearic acid could be used, and morpholine, sodium hydroxide or potassium hydroxide could be used in place of TEA. The pH of this emulsion would be about 8 to 10.

Pre-treatment

Tangerine citrus var. Siam Banjar were washed by scrubbing gently the fruit surface in warm water (40-45°C) containing hypochlorous acid (150 ppm), fungicide of benomyl (500 ppm) and a small amount of detergent for 3-4 minutes. Fruits were then dried with muslin cloth, and ready to be used for the experiments.

Treatment

Fruits were divided into 8 groups (200 fruits/group). Each group was treated by different treatments including: 1) fruits were coated with 10% bees wax emulsion, stored at 25°C (T1), 2) fruits were coated with 12% bees wax emulsion, stored at 25°C (T2), 3) fruits were coated with 15% bees wax emulsion, stored at 25°C (T3), 4) uncoated fruits, stored at 25°C (T4), 5) fruits were coated with 10% bees wax emulsion, stored at 5°C (T5), 6) fruits were coated

with 12% bees wax emulsion, stored at 5°C (T6), 7) fruits were coated with 15% bees wax emulsion, stored at 5°C (T7), 8) uncoated fruits, stored at 5°C (T8). Coatings were performed by hand with muslin cloth and the fruits were then air dried. The experiments were undertaken in three replications. The treated fruits were sampled at a certain period of time (5, 10, 15, 20, 25, 30, and 35 days) and analyzed for the quality characteristics.

Quality analysis

Weight loss was expressed as percentage decrease in fruit weight, using the following formula $(W_t/W_0) \times 100$, with W_0 being the initial weight and W_t being the fruit weight after an indicated period of storage. Incidence of fruit rot was determined as percentage of the number of decayed fruits from the initial number after an indicated period of storage.

The characteristics quality of the treated fruits was measured from the sample juice taken from each treatment. The quality attributes such as titratable acidity, total soluble solids, ascorbic acid were determined by using standard procedures according to AOAC (2006). Titratable acidity (TA) were measured by titration with 0.1 M NaOH, and expressed as percentage of citric acid/100 ml of juice. Total soluble solids (TSS) were measured by direct reading of fruit juice drop in a refractometer (Kenko RHB-32ATC) and the results were expressed as °Brix. Ascorbic acid was measured by 2,6-dichlorophenol indophenol titration solution to a pink end-point, and expressed as mg ascorbic acid/100 g of juice. Sensory properties (colour, texture, odor, freshness, appearance, firmness, taste, and overall acceptability) were evaluated by 20 experienced panelists using the nine point hedonic scale as described by Bai (Bai *et al.*, 2003); 1 for extremely poor, 2 for very poor, 3 for poor, 4 for fair, 5 for very fair, 6 for very fair to good, 7 for good, 8 for very good, and 9 for extremely good.

Statistical analysis

The data on physical and chemical properties were statistically analyzed by two ways ANOVA, while sensory data were subjected to analysis by Kruskal-Wallis Test. Both using SPSS version 19.0 (SPSS, Inc., Chicago, IL, USA). A value of $P < 0.05$ was considered statistically significant for comparison.

Results and Discussion

This study was conducted as an effort to address the challenges faced by the farmers and local traders of tangerine citrus var. Siam Banjar in South Kalimantan, Indonesia in maintaining the quality

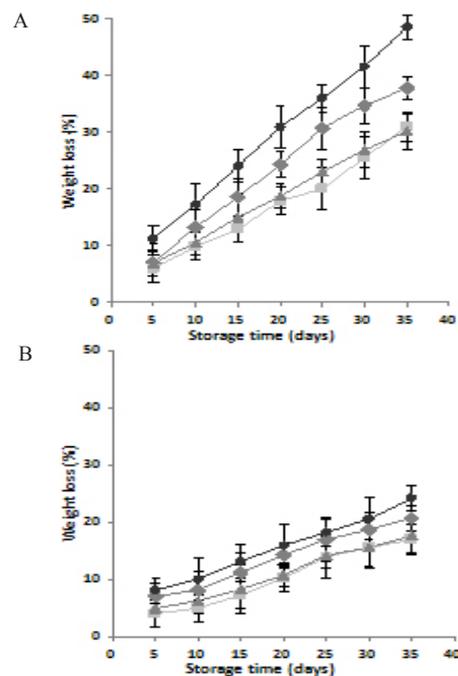


Figure 1. Effect of wax coating on the weight loss percentages of tangerine citrus var. Siam Banjar during storage at room temperature, 25°C (A) and cold storage, 5°C (B). Fruits were coated with bees wax emulsion at 0 (●), 10 (◐), 12 (■), and 15 (▲) %. Each point represents the mean \pm SE of three replications.

of the fruits during the transport. Referring to some previous studies (Sadasivan *et al.*, 1974; Gilfillan and Piner, 1985; Hamid *et al.*, 1987; Bayindirli *et al.*, 1995; Shein *et al.*, 2008), it has been reported that fruit waxing was considered as a cheaper alternative to maintain the shelf life of citrus species. However, to our knowledge the study of application of fruit waxing treatment on tangerine citrus var. Siam Banjar are not yet studied. This is the first experimental evidence about the proper formulation of wax emulsion produced from bees wax applied on tangerine citrus var. Siam Banjar, as well as the changes of the physicochemical properties of the fruits treated with this wax emulsion.

Percentage weight loss

Figure 1 shows the changes in percentage weight loss of the coated and uncoated tangerine citrus var. Siam Banjar stored at two different temperatures, 25°C and 5°C. The results revealed that as the storage period progressed, the percentage weight loss increased. Storage at 5°C had lower percentage weight loss than storage at 25°C. Also, coated fruits had lower percentage weight loss compared to those uncoated ones. After 35 days of storage, the weight loss of the fruits stored at 5°C ranges from 17.62 to 24.1%. These values were far below compared to the weight loss of the fruits stored at 25°C, which ranges from 30.14 to 48.48%. Regarding the weight loss of the coated fruits, the variation in the reduction of the

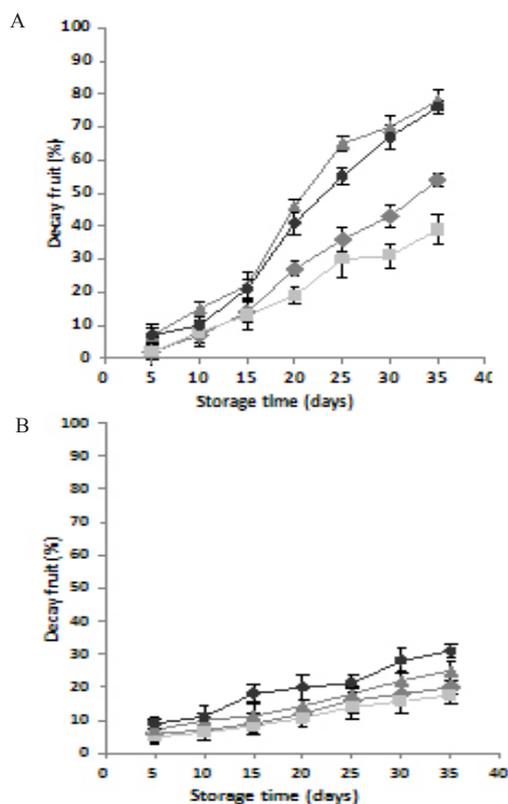


Figure 2. Effect of wax coating on the decay incidence of tangerine citrus var. Siam Banjar during storage at room temperature, 25°C (A) and cold storage, 5°C (B). Fruits were coated with bees wax emulsion at 0 (●), 10 (◐), 12 (■), and 15 (▲) %. Each point represents the mean \pm SE of three replications.

fruit weight depends on the concentration of the wax emulsion. For the coated fruits, both stored at 5°C and 25°C, the highest percentage weight loss was observed in 10% wax coated fruits, followed by 15% wax coated fruits, and 12% wax coated fruits. Overall, the highest percentage weight loss was observed in the 10% wax coated fruits stored at 25°C (17.62%), while the lowest percentage weight loss was found in the 12% wax coated fruits stored at 5°C (48.48 %).

These results indicated that the application of wax coating in combination with low temperature storage proven effective in reducing the percentage weight loss of the tangerine citrus var. Siam Banjar. Similar observations were recorded for some fruits in the previous studies. Ni Shein *et al.* (2008) reported that the use of 18% teva wax coating in combination with cold storage can reduce the % weight loss of 'Sai Nam Peung' mandarin orange (*Citrus reticulata* Blanco) up to 30%. Study by Sakhale and Kapse (2012) noted a significant improvement ($P < 0.05$) in reduction of percentage weight loss in coated sweet orange. Other studies (Sabir *et al.*, 2004; El-Anany *et al.*, 2009) noted that during the storage period, wax coated apples had lower percentage weight loss compared to the uncoated ones.

The loss of water from fresh fruit after harvest is a serious problem, causing shrinkage and weight loss (Wills *et al.*, 1981). Surface coatings have been used widely in fruits to reduce dehydration in fruits, reduce water loss, retain the shriveling of the fruit skin, delay the fruit ripening, and thereby delay the decline in fruit quality. The loss of fruit weight indicated the tendency to lose water in fruits, which occurs during the fruits storage. The fruit weight decrease due to its respiratory process, the transference of humidity and some processes of oxidation, and the evaporation of moisture inside the fruits during ripening process. During the process of waxing a tightly adhering thin film of the coating substance is applied to the surface of the fruit. These coatings can act as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movements. Hence they can reduce the rates of the respiration, water loss and oxidation reaction (Baldwin *et al.*, 1999; Park, 1999). The time needed for water loss or evaporation depends on the temperature, the length of time the fruit is to be stored, and the thickness of the fruit skin. If the temperatures are low, fruits need a longer period for water loss. They also need a longer period for water loss if they have a thick peel or if they are to be stored for a short time. On average, it takes from three to seven days to reduce the citrus fruit weight by about 3%.

Decay incidence /incidence of fruit rot

Figure 2 presents the decay incidence of the coated and uncoated tangerine citrus var. Siam Banjar stored at two different temperatures, 25°C and 5°C. The results show that at the end of storage period at the low temperature storage (5°C), the decay percentage of coated fruits was lower compared to the uncoated ones. Whereas at the room temperature storage (25°C), the 15% wax coated fruits had highest decay percentage. Overall, lowering the storage temperature from 25°C to 5°C reduced the incidence of fruit rot. For the coated fruits, both stored at 5°C and 25°C, the highest % decay incidence was observed in 15% wax coated fruits, followed by 10% wax coated fruits, and 12% wax coated fruits. Study by El-Anany *et al.* (2009) noted that the application of edible coating in combination with cold storage (0°C, 90-95% RH) on Anna apple can reduce the % decay incidence of approximately 1.6 to 3.2 times compared to the uncoated ones.

The application of edible coating will partially restrict gas exchange through the fruit peel and inhibit the action of ethylene. This inhibitory action can provide better protection against postharvest decay in fruits. Furthermore, the water loss may cure minor wounds on the peel of the fruits and thereby reduce

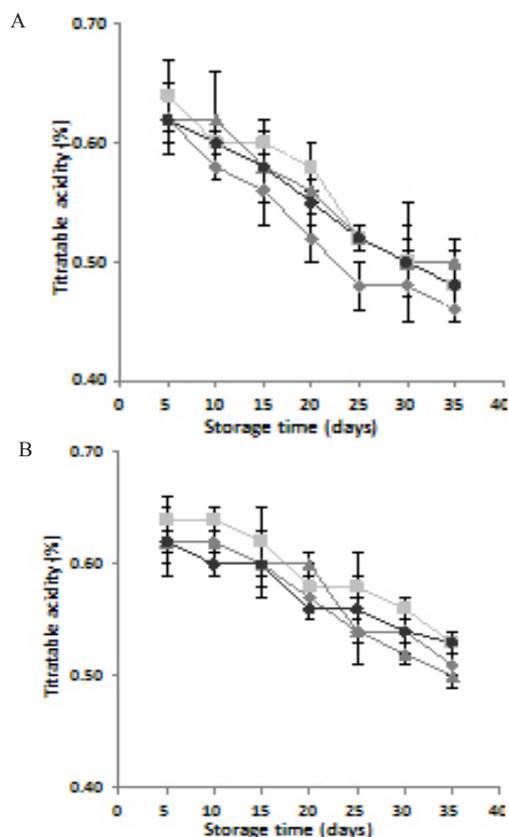


Figure 3. Effect of wax coating on the titratable acidity of tangerine citrus var. Siam Banjar during storage at room temperature, 25°C (A) and cold storage, 5°C (B). Fruits were coated with bees wax emulsion at 0 (●), 10 (○), 12 (■), and 15 (▲) %. Each point represents the mean \pm SE of three replications.

the incidence of rot during storage. It was suggested that a wax emulsions contain wax levels equal to 12% might be the best concentration for retain the incidence of rot in tangerine citrus var. Siam Banjar. Exceeding that amount of wax greatly increase the viscosity of the emulsion from a free-flowing emulsion to a thick, slow flowing emulsion, and thereby create an environment that causes anaerobic respiration. If a thicker layer of wax is applied to the fruit surface, it becomes an undesirable barrier between the external and internal atmosphere and restricts exchange of respiratory gases (CO_2 and O_2). This may result in anaerobic respiration, resulting in fermentation and development of an off flavor. Similar results were also reported by (Tietel *et al.*, 2010) who observed the development of off flavor in 'Mor' mandarin fruits coated with higher concentration of wax during storage at 20°C. Waxing can be detrimental to tangerines if it is applied too thick, making this treatment unsuitable for this fruits. Hence, the critical point of the coating application is the concentration of the wax emulsion. In other words, too thin wax emulsion might not work effectively in retaining the decay incidence, while too thick wax emulsion might

cause fruit rot which resulting in the development of off-flavour. It is therefore necessary to adjust the thickness of the wax coat according to the variety and storage and marketing.

Titratable acidity

Figure 3 shows the changes in titratable acidity (TA) of the coated and uncoated tangerine citrus var. Siam Banjar during the storage period at two different temperatures, 25°C and 5°C. As shown in Figure 3, the titratable acidity values were gradually decreased with increasing storage period. All fruits stored at 5°C had higher concentration of titratable acidity compared to those stored at 25°C. However, there was no statistically significant difference ($p \geq 0.05$) in the values of titratable acidity between the coated and uncoated fruits, either stored at 25°C or at 5°C. Relatively higher values of titratable acidity were observed in the 12% wax coated fruits. The decline in titratable acidity in the treated fruits as what was observed in this study is also reported for other citrus varieties, such as in satsuma mandarin (Bayindirli *et al.*, 1995), *Citrus grandis* var. Nambangan (Siahaan, 1998), and baladi mandarin (Yagi, 1980), 'Mor' mandarins (Tietel *et al.*, 2010).

Tangerines contain significant amounts of organic acids. The major organic acids in the must are oxalic, tartaric, malic, lactic, citric, ascorbic. Of these six acids, citric acids account for the most abundant acid of the total acid constituents of the juice followed by malic acid (Karadeniz, 2004). As the ripening of the fruits develops, a reduction in titratable acidity is observed. The decrease in acid content is caused by the use of acids in the fruit as a source of energy and the conversion of organic acids to form sugar (Burton, 1985; Willis *et al.*, 1998).

Total soluble solids (TSS)

Figure 4 shows the results of total soluble solid (TSS) of the coated and uncoated tangerine citrus var. Siam Banjar during the storage period at two different temperatures, 25°C and 5°C. The results indicate that total soluble solid (TSS) in tangerine citrus increased gradually as storage time progressed. The values of TSS of the uncoated fruits, both stored at 25°C and 5°C, were higher than those of coated ones. At the end of the storage period, the highest TSS was recorded in uncoated fruits stored at 25°C (11.10°Brix), while the lowest TSS was found in 12% coated fruits stored at 5°C (9.76°Brix). Similar findings were observed in some fruits treated with edible coatings, as those reported previously for other varieties of orange (Baldwin *et al.*, 1995; Gosh and Sen, 1984; Shahid and Abbasi, 2011), guava (Bashir and Abu-Goukh,

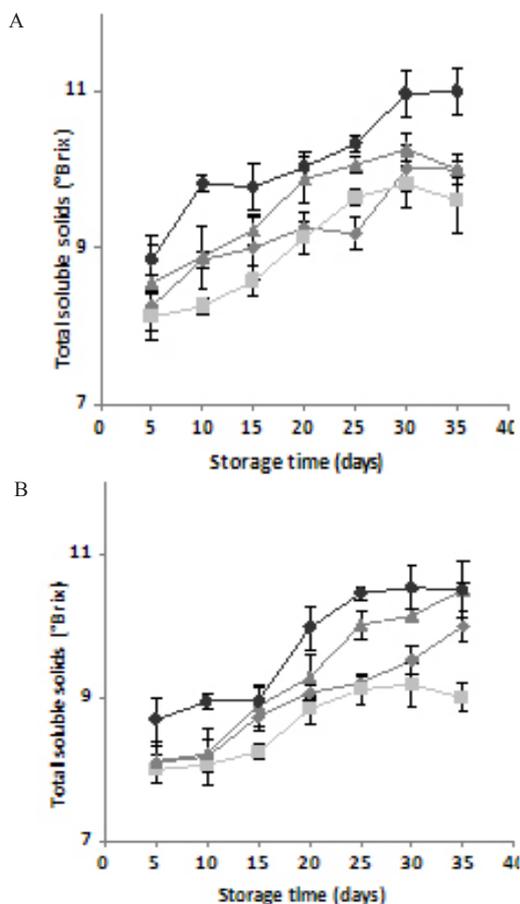


Figure 4. Effect of wax coating on the total soluble solids of tangerine citrus var. Siam Banjar during storage at room temperature, 25°C (A) and cold storage, 5°C (B). Fruits were coated with bees wax emulsion at 0 (●), 10 (◐), 12 (◑), and 15 (▲) %. Each point represents the mean \pm SE of three replications.

2003), sweet peppers (Tadesse *et al.*, 2002), and apples (Sabir *et al.*, 2004; El-Anany *et al.*, 2009).

The increase in total soluble solids in fruits is directly correlated to the hydrolytic activities in starch, the increased activity of enzymes responsible for the hydrolysis of starch to soluble sugars, and the conversion of starch to sugar, which indicates that the fruits are at the ripening process.

Ascorbic acid

Figure 5 shows the ascorbic acid content of the coated and uncoated tangerine citrus var. Siam Banjar during storage at 25°C and 5°C. The ascorbic acid content in both coated and uncoated fruits decreased gradually as storage period was prolonged. However, these differences were not statistically significant ($p \geq 0.05$). The results show that at the end of the storage period, treatment 10 and 12% wax coating, stored either at 25°C or 5°C had relatively higher value of ascorbic acid compared to the control. However, treatment 15% wax coating had lower value of ascorbic acid compared to the control. After 35 day of storage, it was observed that the combination of 12%

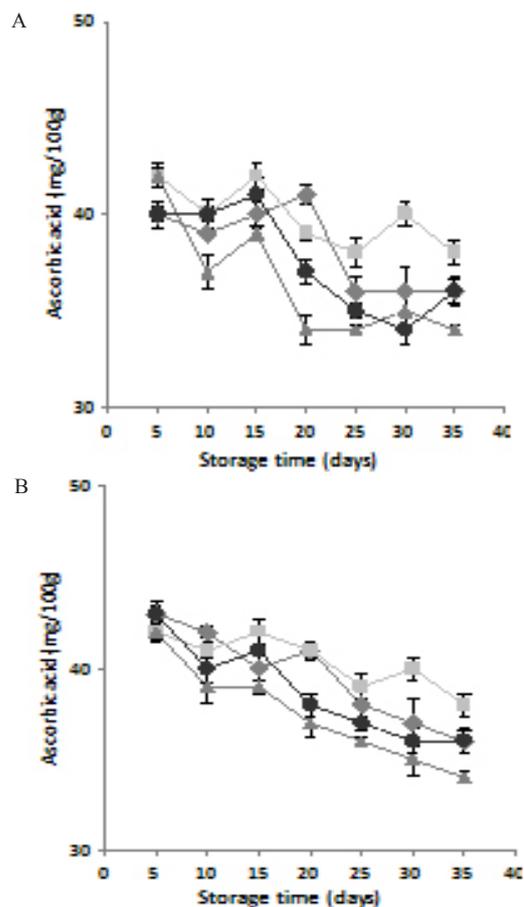


Figure 5. Effect of wax coating on the ascorbic acid of tangerine citrus var. Siam Banjar during storage at room temperature, 25°C (A) and cold storage, 5°C (B). Fruits were coated with bees wax emulsion at 0 (●), 10 (◐), 12 (◑), and 15 (▲) %. Each point represents the mean \pm SE of three replications.

wax coating and storage at 5°C is the most effective in preventing ascorbic acid losses from fruits, which had the highest value of ascorbic acid (38.64 mg/100 ml). The same trend was also observed in the previous study by Ahmed *et al.* (2007) who reported that orange fruit coated with 30% jojoba oil can reduce the loss of ascorbic acid in Valencia orange fruits compared to those uncoated ones.

This retention of ascorbic acid might be due to the lowering of respiration of fruits or oxidation of ascorbic acid content from the fruits. Lower level of ascorbic acid in control might be due to increased respiration causing loss of ascorbic acid. Ascorbic acid is susceptible to oxidative deterioration as well as mild oxidation of ascorbic acid results in the formation of dehydroascorbic acid (Willis *et al.*, 1981).

Sensory evaluation (colour, texture, odor, freshness, appearance, fruit firmness, taste, and overall acceptability)

Table 1 presents the results on the sensory evaluation. As shown in the Table, tangerine citrus

Table 1. Sensory evaluation of tangerine citrus var. Siam Banjar coated with bees wax emulsion at 0, 10, 12, and 15 %, stored at room temperature 25°C and cold storage 5°C, at the end of storage.

Parameters	Treatments							
	T1 (10%, 25°C)	T2 (12%, 25°C)	T3 (15%, 25°C)	T4 (0%, 25°C)	T5 (10%, 5°C)	T6 (12%, 5°C)	T7 (15%, 5°C)	T8 (0%, 5°C)
Colour	6,65 ^a	6,72 ^a	5,75 ^b	5,65 ^b	6,84 ^a	6,95 ^a	5,75 ^b	5,60 ^b
Texture	4,45 ^{ab}	4,42 ^{ab}	3,51 ^c	4,45 ^{ab}	5,42 ^a	5,51 ^a	4,05 ^b	4,45 ^{ab}
Odor	3,25 ^c	4,22 ^b	2,08 ^d	3,25 ^c	4,02 ^b	5,78 ^a	3,34 ^c	3,75 ^{bc}
Freshness	4,67 ^c	5,12 ^b	2,52 ^e	2,61 ^e	5,42 ^b	6,75 ^a	3,88 ^d	3,82 ^d
Appearance	5,11 ^{ab}	5,45 ^b	3,05 ^c	4,01 ^b	6,21 ^b	6,85 ^a	4,85 ^{ab}	5,21 ^{ab}
Firmness	5,34 ^c	5,42 ^c	3,86 ^e	4,74 ^{cd}	6,12 ^b	6,80 ^a	4,16 ^d	4,14 ^d
Taste	4,48 ^c	5,17 ^b	2,48 ^e	2,66 ^e	4,78 ^c	6,40 ^a	3,12 ^a	3,98 ^d
Overall acceptability	4,85 ^{bc}	5,22 ^b	3,32 ^e	3,91 ^d	5,54 ^b	6,43 ^a	4,16 ^c	4,42 ^c

* Values followed by the same letter are not significantly different at (p < 0.05).

var. Siam Banjar coated with 10 and 12% bees wax emulsion, either stored at 25°C or 5°C, had higher colour score compared to 15% coated and uncoated ones. The highest texture score was indicated in 10 and 12% wax coated fruits stored at 5°C, while the lowest one was noted in 15% wax coated fruits stored at 25°C. The maximum odor score was indicated in 12% wax coated fruits stored at 5°C, followed by 12% wax coated fruits stored at 25°C and 10% wax coated fruits stored at 5°C; uncoated fruits stored at 5°C; 10% wax coated and uncoated fruits stored at 25°C; and the minimum odor score was observed in 15% wax coated fruits stored at 25°C. Maximum freshness score was observed in 12% wax coated fruits stored at 5°C, whereas the minimum was noted in 15% wax coated and uncoated fruits stored at 25°C. Similar to the results of the freshness score, maximum taste score was also observed in 12% wax coated fruits stored at 5°C, whereas the minimum was noted in 15% wax coated and uncoated fruits stored at 25°C. The highest appearance score was indicated in 12% wax coated fruits stored at 5°C, while the lowest one was noted in 15% wax coated fruits stored at 25°C. The highest firmness score was observed in 12% wax coated fruits stored at 5°C, whereas the lowest one was noted in 15% wax coated fruits stored at 25°C. The overall acceptability score in Table 1 revealed that the highest score of overall acceptability value was observed in 12% wax coated fruits stored at 5°C.

Conclusion

Comparative analysis on the effects of several coating concentration and storage condition on the quality and the shelf-life of tangerine citrus var. Siam Banjar, as observed in the present study, reveals that the combination of 12% wax coating and storage at 5°C was the best treatment for maintaining the quality and extending the shelf-life of tangerine citrus var. Siam Banjar over other treatments or control, which

was exhibited by the least weight loss percentages and decay incidence, higher titratable acidity, lower total soluble solids, higher ascorbic acid, and also had higher overall sensory acceptability, over other treatment or control. On the basis of these results, it can be concluded that the combination of 12% wax coating and storage at 5°C was the most effective method in maintaining the quality and extending the shelf-life of tangerine citrus var. Siam Banjar.

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