OPTIMUM STORAGE TEMPERATURE OF MATURE DROP DURIAN (*DURIO ZIBETHINUS* CV. MUSANG KING)

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ABSTRACT

Durian cv. Musang King is one of the popular cultivars due its thick flesh and strong sweet taste. However, the fully matured drop Musang King durian easily crack and often results in high water loss. To prolong shelf life of Malaysian durian, cold storage was applied. However, the main problems using cold storage are chilling injury, decay and water loss with the latter reducing in freshness and unmarketable. Mature drop durian fruit were randomly divided into five groups and stored at temperatures of 13, 10, 7, 4 or 1 °C. Fruit samples from each treatment were analyzed weekly at day 0, 7, 14, 21. At each analysis, the fruits were transferred to 25°C for 24 hours to allow for development of chilling injury symptoms. The results showed that no chilling injury symptoms were observed in fruits at all temperatures up to 2 weeks storage except at 4 and 1°C with symptoms of red lesions area along the internal core. Fruits at 10 and 13°C had severe fungal infection at week 1 (28%) and week 2 (40%), respectively. Storage at 7°C had marketable quality up to 2 weeks with no chilling injury symptoms and suppressed fungal infection.

Key words: Cold storage, chilling injury, fruit quality, dehiscence, drop fruit

INTRODUCTION

Durian (*Durio zibethinus)* is a climacteric tropical fruit, and available during its season through out of South East Asia. Durian is famous for its strong and unique taste and aroma as well as nutritional content (Ho & Bhat, 2015). It is rich in carbohydrate, calcium, phosphorus, thiamin, riboflavin, niacin, and ascorbic acid. Ripe pulp is usually eaten raw, right after opening the fruit or as a frozen commodity. It is also further processed to sweet delicacies such as jams, candies, tarts, or used as a flavoring ingredient in ice cream and other product (Tagubase & Ueno, 2016). The fruit typically has five locular units and each contain 1-5 pulps. The pulp consists of seed, which covered by a white, yellow or orange aril, the edible portion of the fruit (Voon et al., 2006). Due to its popularity, durian is now having demand all over the world.

LITERATURE REVIEW

Production and export market

There are several countries that have been exporting durian such as Thailand, Hong Kong, China, Malaysia and Spain. Thailand is the largest producer of durian due to their abundance resources and high economic demands (Narong C. et al., 2008), followed by Indonesia and Malaysia. The total hectares covered in Malaysia were about 72,391.34 hectares with production of 210,873.99 metric tonnes (DOA, 2017). The value of production was estimated about RM 2,794,080.33 in 2017. There are more than 200 durian clones registered by the Department of Agriculture Malaysia.

According to Yuhuan L. (2015), Malaysian durians varieties is gradually getting more of warm welcome by the locals in China in recent years as compared to Thailand's. Musang King Durian (D197) is one of the popular variety due it thick flesh, small core and sweet taste although their price is very expensive and can go up as high as over 120 USD/kg (Durian Global Market Report, 2018).

Maturity and storage

It is well known that when an immature durian is harvested, it will not ripen properly, or else will ripen with substantially less flavor and taste, leading to a poor eating experience. Conversely, an over-ripe one will decay rapidly after harvest. The maturity of Thailand's durian is different from Malaysian durian. Thailand's durian is harvested by cutting them at the stage when fruits are of physiologically mature before drop. The fruit of the commercial varieties in Thailand take about 90 to 135 days from anthesis to physiological maturity, depending on varieties, position of fruit on a tree, cultural techniques and environmental conditions. Several criteria are used for judging durian fruit maturity, such as the number of days from full bloom, the color of the spine tip, the elasticity and disposition of the spines, the intensity of the odor emitted, changes in the fruit stalk, the percentage of dry matter of fruit, and especially the sound of the fruit when tapped (Siriphanich, 2011).

Differently, Malaysian durian are allowed to full mature until drop. Thus, they are tend to dehiscence and their short postharvest life affect their market distribution. As durian ripens, abscission area naturally develops at the centre of each locule that weakens and allows the fruit to easily opened.

Cold storage has plenty of benefits in prolonging shelf life of fresh produce after harvest by reducing respiration and water loss as well as controlling decay. However, fruits like durian are susceptible to chilling injury when exposed to temperatures lower than their optimum temperatures (Kader, 2002). Studies on optimum temperature for durian mostly focus on cut durian in Thailand. This cut durian has extended shelf-life when stored at 15 °C with relative humidity of 85-95% (Booncherm & Siriphanich, 1991). However, the optimum temperature for mature drop durian still under study. Previous study by Abdullah et al. (1992) mentioned that the optimum storage temperature for durian cultivar D24 was 10 °C. Recent study by Nur Azlin et al. (2019) on cultivar D197 (Musang King) identified there were a lot of changes in physicochemical properties of durian when stored at cold temperature. As the fruit more mature during harvest, it can survive lower temperature than the proposed temperature from Thailand's durian. So, the objective of this study was to identify the optimum temperature of Malaysian durian, in this study was the cultivar D197 (Musang King), by determining the lowest safe temperature that does not induce chilling injury and prolong the postharvest storage life.

MATERIALS AND METHODS

Sample Preparation

Musang King durian were purchased from Top Fruit Sdn. Bhd. in Batu Pahat, Malaysia and fruit were kept in 13 °C after arrived in Postharvest Complex, MARDI Serdang. Fruit were sorted for sound and without any dehiscence fruit as well as free of visual defects. Fruit were randomized into five groups for storage at 13 °C, 10 °C, 7 °C, 4°C or 1 °C with 85% relative humidity (RH). Fruit (n=3) were analyzed initially and each seven days during 21 days' storage. At each analysis, fruit were transferred to 25 ºC for 24 hours to allow for development of any chilling injury symptoms.

Quality Analysis

Each evaluation, individual fruit were subjectively rated for external chilling injury symptoms, red lesions area, dehiscence incidence and overall acceptability rating. The percentage of weight loss was obtained by measuring the difference in weight before and after storage. The pH value was measured using an Origon digital pH meter (model SA 520) and total titratable acidity was measured by titrating the known volume of homogenates solution with 0.1 N NaOH to an end point of pH 8.1 using digital burette. The total soluble solids (TSS) were determined by a digital refractometer (ATAGO RX-5000, ATAGO, Japan).

Respiration rate and ethylene production

The respiration rate and ethylene production were measured weekly. The gas samples (CO_2 and C_2H_4) were drawn by a syringe through a septum in the package. For ethylene measurement, 1 ml of the gas sample was injected into a Perkin Elmer Auto System XL gas chromatography fitted with flame ionization detector (FID) and a stainless-steel column packed with Porapak T of 100/120-mesh size. Simultaneously, CO_2 was detected using a different detector (thermal conductivity detector; TCD) with a stainless-steel column packed with Porapak R of 80/100-mesh size. The flow rate of the purified helium gas was 30mL/min and the column oven were operated at 50ºC and 100ºC for CO_2 and ethylene gases, respectively. Three replications were used for each treatment.

Statistical Analysis

The experimental setup was a completely randomized design and performed for each variable. For this purpose, a one-way ANOVA test was used to evaluate the effects of the treatments on each measurement day. The Duncan Multiple Range Test was used for means difference testing. A 95% confidence interval was used for all calculations ($p \leq 0.05$). SAS statistical software version 9.4 was used to perform the statistical analyses.

RESULTS AND DISCUSSION

Chilling injury occurs when commodities are held at temperature below their optimum temperature but above their freezing points. Commonly, chilling injury symptom are discoloration, pitting, water-soaked appearance, failure to ripen, internal breakdown, off flavor and decay (Wang, 2010). According to Siriphanich (1994), chilling injury in durian shows symptom like dark color development along the groove between spines, and later the whole rind turns black. The aril may remain hard or ripen abnormally. In this study, visual appearances of the rind after expose 24 hours in ambient temperature showed that there were no chilling injury symptoms occur as describe above among treatments during 21 days' storage (Table 1).

Other than symptoms describe above, we observed chilling injury symptoms as red lesions along the suture (core) at the centre of the fruit (Figure 1). During 7 days storage, fruit stored in 4 and 1 °C started developed red lesions area at the core near the stem-end (Table 1). After 14 days storage, fruit stored at 7 °C also developed red lesions area. No red lesions observed in fruit stored at 10 °C after 14 days storage, however fruit are not acceptable due to dehiscence (Figure 2). Thus, the storage temperature of durian can be lowered as low as 7 °C without any chilling injury symptoms.

For disease incidence, fruit stored at 13 °C had highest incidence of fungal infection after 7 days storage compared to fruit stored at 10, 7, 4 and 1 °C (Table 1). When the storage was extended to 14 days, fruit stored at 10 °C had higher fungal infection at stem compared to other temperatures. This can be concluded that storage in low temperature helps in retarding fungal growth.

Husk dehiscence or cracking is a primary problem limiting the shelf life of durian (Khurnpoon, Siriphanich, & Labavitch, 2008). Table 1 showed that, at day 7 most of the durian stored at 13 °C already dehisced. On day 14, most durian at treatment 10, 4 and 1 °C also already dehisced while durian stored at 7 °C still remain good. On day 21, durian at 7 °C were then dehisced. This showed that 7°C is suitable temperature to stored durian up to 14 days. According to Sriyook (1994), water loss and ethylene production are the two main factors that cause the mature durian fruit to dehisce. Water losses cause the husk to shrink and pull the carpel from each other along the suture at the middle of each locule. Ethylene weakens the cells in the dehiscence region that consists of parenchyma cell without chlorophyll.

For overall acceptability, after 7 days storage, durian at 7, 4 and 1 °C scored as excellent compared to durian at 10 °C only scored as good (Table 1). The fruit at 13 °C were rated as poor and then been discarded due to fungal infection and most of them were already dehisced. At day 14, fruit stored at 10, 4 and 1 °C were scored poor while fruit at 7 °C were still acceptable. Thus, the storage temperature of durian can be lowered as low as 7 °C and it is still acceptable to be marketed.

Table 1: Effect of different storage temperature on external chilling injury symptoms, red lesions area, disease at stem, dehiscence incidence and overall acceptability rating (score 1-5) for mature-drop fresh durian during 21 days' storage.

Characteristics	Day	13°C	10°C	7°C	4°C	1°C
External chilling injury	0	-	-	-	-	-
	7	-	-	-	-	-
	14	n.a.	-	-	-	-
	21	n.a.	n.a.	-	-	-
Red Lesions	0	-	-	-	-	-
	7	-	-	-	+	+
	14	n.a.	-	+	++	++
	21	n.a.	n.a.	+	+++	+++
Disease at stem-end	0	-	-	-	-	-
	7	+++	+	+	+	-
	14	n.a.	+++	++	++	+
	21	n.a.	n.a.	+++	++	+
Dehiscence incidence	0	-	-	-	-	-
	7	+	-	-	-	-
	14	n.a.	+	-	+	+
	21	n.a.	n.a.	+	+	+
Overall acceptability ratings	0	5.0	5.0	5.0	5.0	5.0
	7	2.0	4.0	5.0	5.0	5.0
	14	n.a.	2.5	3.3	2.5	2.5
	21	n.a.	n.a.	2.7	2.5	2.3

Abbreviations: Score of symptoms based on each fruit (n=3): negative=no trace; +=slightly affected; ++=moderately affected; +++=badly affected; n.a.=not available.
Overall acceptability ratings: 5=Excellent, 4=Good, 3=Accepatable, 2=Poor, 1=Very poor

Figure 1. Red lesion area; inside near the stem end of durian fruit.

Figure 2. Appearance of durian during 3 weeks storage at 13, 10, 7, 4 and 1 °C followed by 1 day holding at 25 °C.

The data of pH, soluble solids content, total titratable acidity and soluble solids content/ total titratable acidity were observed as no significant difference ($p<0.05$) among treatments. Thus, temperature does not affect the chemical parameters of the durian (Table 2).

Table 2 also shows the percentage of weight loss during 21 days storage for different storage temperature. The percentage of weight loss of fruit stored at 13 °C was highest (4.1%) after 7 days storage followed by 4 °C (3.7%), 7 °C (2.3%), 10 °C (2.2%) and 1 °C (1.6%). This can be concluded that percentage of weight loss is correlated with storage temperature. Increase of storage temperature will increase the percentage of weight loss of the fruit. After 2 weeks of storage, the fruit stored at 10 °C lost 6.61% of its weight while fruit at 7 °C lost 4.86%.This weight loss might be due to loss of water in the fruits resulted the loss of firmness of the rind, the latter, contribute to dehiscence of durian fruit.

Table 2. Changes in pH, soluble solids content, total titratable acidity and sugar:acid ratio of different storage temperature.

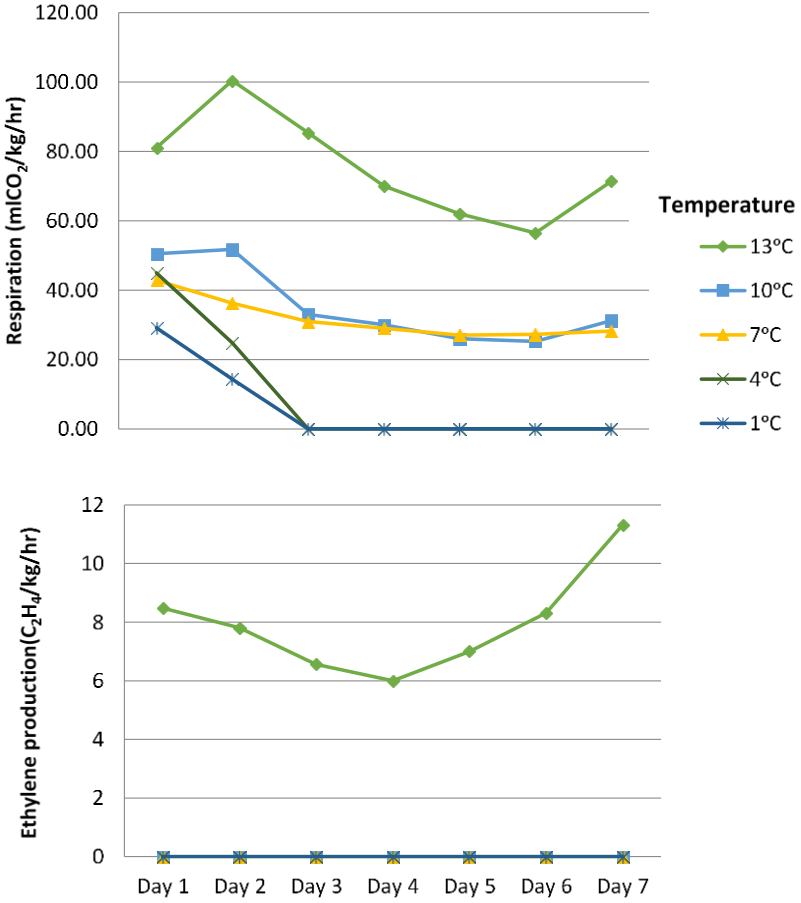
Parameters	Day	13°C	10°C	7°C	4°C	1°C
pH	0	7.00±0.27aA	7.00±0.27aAB	7.00±0.27aAB	7.00±0.27aA	7.00±0.27aA
	7	7.14±0.07aA	6.75±0.14bB	7.13±0.17aA	7.11±0.09aA	7.19±0.27aA
	14	n.a.	7.24±0.08aA	7.01±0.04bAB	7.10±0.06abA	7.00±0.19bA
	21	n.a.	n.a.	6.75±0.16bB	7.11a±0.10A	7.04±0.04aA
Soluble solids content (%)	0	41.83±0.64aA	41.83±0.64aA	41.83±0.64aA	41.83±0.64aA	41.83±0.64aA
	7	42.77±0.64aA	40.43±2.47aA	43.00±0.56aA	42.30±0.36aA	39.43±3.87aAB
	14	n.a.	39.93±0.21aA	39.20±1.76aB	38.47±1.27aB	38.40±2.79aAB
	21	n.a.	n.a.	35.57±1.67bC	39.20±1.39aB	34.57±1.44bB
Total titratible acidity (%)	0	0.11±0.02aA	0.11±0.02aA	0.11±0.02aA	0.11±0.02aA	0.11±0.02aA
	7	0.08±0.01bcA	0.11±0.01aA	0.09±0.01abA	0.10±0.03abA	0.07±0.00cB
	14	n.a.	0.09±0.01aA	0.07±0.01bA	0.06±0.01cB	0.07±0.01bB
	21	n.a.	n.a.	0.09±0.03aA	0.05±0.00bB	0.06±0.01bB
Sugar:Acid ratio	0	403.10±68.36aA	403.10±68.36aA	403.10±68.36aA	403.10±68.36aB	403.10±68.36aB
	7	555.86±88.35abA	359.20±12.89cA	462.04±31.09aA	434.00±121.75bcB	574.31±45.68aA
	14	n.a.	439.73±38.77bA	515.51±47.93bA	654.79±63.88aA	534.72±59.25bAB
	21	n.a.	n.a.	394.08±111.32cA	784.84±48.66aA	584.57±106.00bA
Weight loss	0	0.00±0.00aB	0.00aC	0.00aD	0.00aD	0.00aD
	7	4.07±0.30aA	3.68±0.96aB	2.49±0.02bC	2.15±0.19bC	1.64±0.18bC
	14	n.a.	6.61±0.83aA	4.86±0.09bB	4.28±0.69bcB	3.25±0.21cB
	21	n.a.	n.a.	6.99±0.02aA	6.27±1.05aA	4.22±0.00aA

Each value in the table represents the meanSD from triplicate analyses. Means within each column with different superscripts are significantly (P<0.05) different. Means within each row with different subscripts are significantly (P<0.05) different. Day 0, initial data before storage; day 7 to day 21, data at each subsequent days of storage. n.a.=not available

Rates of respiration and ethylene production showed different results with different storage temperature. Fruit stored at 13°C had highest respiration rate while fruit at 10°C and 7°C had almost same respiration rate (Figure 3). The respiration rate of 4°C and 1°C were decreased from day 1 to day 3 and maintained 0 mlCO2/kg/hr until day 7. The respiration was completely stopped or might be the concentration was very low to be detected after day 3 at 4°C and 1°C. The decrease of storage temperature will decrease the metabolism rate of the product.

Ethylene production showed changes with different storage temperature from day 1 to day 7 (Figure 3). The durian stored at the temperature of 13°C had higher ethylene production than other temperatures. Durian stored at temperature of 10°C, 7°C, 4°C and 1°C showed no ethylene production detected. The result defines the decrease of ethylene production with decrease of storage temperature.

Figure 3. Respiration rate and ethylene production of durian in different storage temperatures.



CONCLUSION

Cold storage at 13°C is not suitable for Musang King durian because of the short storage life (less than 7 days), easily infected by fungus and has highest weight loss while storage at 10°C only gives extra several days. So, by determining the lowest safe temperature that does not induce chilling injury and prolong the postharvest storage life, the optimum temperature of mature drop fresh Musang King durian is 7°C. Cold storage at 7°C can delays the dehiscence of the fruit up to 14 days, prevent the infection of diseases, slow down the development of red lesion and controlled the percentage of weight loss, respiration rate and ethylene production of mature drop fresh durian. This storage life extension of Malaysian durian will lead to market expansion in Malaysia region as well as for export market.

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