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Research Article

Postharvest Quality of Sein Ta Lone Mango (*Mangifera indica* L.) as Affected by Different Wrapping Materials and Storage Temperature

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Abstract

The experiment was conducted to assess the postharvest quality and storage life of Sein Ta Lone mango affected by wrapping materials and storage temperature. It was carried out at the Laboratory of Department of Horticulture, Yezin Agricultural University during the mango harvest season of May 2018. Treatments were laid out in factorial arrangement, randomized complete block design with four replications. Factor A was the storage at controlled temperature (13˚C) and at room temperature (35 - 38˚C) and factor B was wrapping materials of white net sack, white fruit wrapping paper and without wrapping (control). Sein Ta Lone mangoes were collected from Myanadi mango orchard, Department of Agriculture, Myittha Township, Mandalay Region. The data on physiological weight loss (%), color index, fruit firmness ($kgcm^{-2}$), total soluble solid (TSS%), total titratable acidity (TTA%), respiration rate (mg CO_2 $kg^{-1}h^{-1}$), ethylene production rate (µl $kg^{-1}h^{-1}$) and shelf-life (days) were collected at two days intervals throughout the experiment. Control fruits stored at 13˚C significantly showed the longer shelf-life (14 days) than those under room temperature (7 days). The fruits wrapped with paper showed the longest shelf life of 16 days at 13˚C while the fruits wrapped with net sack maintained the longest shelf-life of 8 days at room temperature. The ethylene production and respiration rates of Sein Ta Lone mango under 13˚C were considerably lower than those of the fruits under room temperature but not significantly different among the treatments. The minimum respiration and ethylene production rate of unwrapped mangoes were 10.84 CO_2 mg $kg^{-1}h^{-1}$ and 0.07ul $kg^{-1}h^{-1}$, respectively. The color value rapidly increased in all treatments stored at room temperature at 4 days after storage. However, the color development of the fruits stored at 13˚C gradually increased with lower value than that of those under room temperature. There were no significant differences in TTA% and TSS% among the treatments at respective temperatures. The results from this study revealed that net sack wrapping should be used at room temperature to protect injury and paper wrapping should be used in low temperature storage of 13˚C to absorb moisture and maintain fruit quality.

Keywords: Ethylene and Respiration Rate; Sein Ta Lone Mango; Postharvest Quality; Shelf-Life; Storage Temperature and Wrapping Materials

Introduction

Mango is an important tropical fruit around the world and it belongs to the family Anacardiaceae. The mango fruit has great economic importance, especially in the developing countries where annual yield is about 10,000 tons or more [1]. The origin of Mango (*Mangifera indica* L.) is Indo-Burma region and it is one of the most important exportable fruits in Myanmar. Myanmar is the sixth largest country in mango production in Asia. The area under mango in Myanmar is over 104,000 hectares with the average yield of 6.83 MT/ha [2]. Major mango production areas in Myanmar are

Mandalay Region, Sagaing Region and Southern Shan State. Twenty kinds of mango species and more than 300 varieties are cultivated throughout Myanmar [3]. Among them, the exportable cultivars are Sein Ta Lone, Mya Kyauk and Shwe Hin Thar. Out of them, Sein Ta Lone is popular in both domestic consumption and export market. The export markets are China, Taiwan, Russia and Singapore. Mango, being one of the most perishable fruits, is facing high postharvest losses in Myanmar, estimated to be in the range of 25 - 40% from harvest to consumption [4].

The shelf-life of mango can vary depending on varieties and storage conditions. At ambient temperature, mango fruits harvested at the mature stage ripen quickly, and have a short postharvest life. It ranges from 4 - 8 days at room temperature and 14 - 21 days in cold storage at 13˚C depending on cultivar [5]. According to Soe [6], the shelf-life of Sein Ta Lone mango is 7 days under ambient condition without any treatment. It is a climacteric fruit and it's ripening can be delayed by retarding respiration, ethylene production rate and minimizing of mechanical damage [7]. The respiration rate of mango depends on cultivar, cultural practice, care and management, environmental factor, location, storage condition and postharvest handling practice [8]. Temperature is one of the most important environmental factors in shelf-life of fruits because of its dramatic effect on physiological changes in fruits including respiration and ethylene production. Low temperature storage is very effective in slowing physiological metabolism, maintaining quality, reducing decay and extending the storage life of fruit.

For export markets, it is necessary to maintain quality and to prolong the shelf-life of mango by mango growers, retailers and wholesalers. Proper packaging and storage temperature increase the storage life and maintain fruit quality. The selection of proper wrapping materials is an essential prerequisite for prolonging the shelf-life of mango. Wrapping materials protect fruits from mechanical injury (e.g. vibration and compression damage) caused by transportation or handling. So, it is necessary to use proper wrapping materials at suitable temperature to get maximum shelf-life. In Myanmar, some academic research papers expressed quality criteria and storage life of mango affected by the use of modified atmosphere packaging (MAP), chemicals and storage temperature. However, there is no academic information on the measurement of ethylene production and respiration rate at different storage temperature of Sein Ta Lone mango fruit affected by the use of wrapping materials. Therefore, the present study was carried out to determine postharvest quality and shelf-life as affected by wrapping materials and storage temperatures.

Materials and Methods

Experimental site and design

The experiment was carried out at the Laboratory of Horticulture Department, Yezin Agricultural University (YAU), Nay-Pyi-Taw, Myanmar during April to May, mango harvest season of 2018. Physiologically mature (115-120 days after flowering) Sein Ta Lone mango fruits were harvested from the Myanadi mango orchard under Department of Agriculture, Myitthar Township, Mandalay Region. It took about 20 hours by car from the harvest to the experimental site.

The experiment was allocated in factorial randomized complete block (RCB) design with four replications. Factor A was storage temperatures - room temperature (35 - 38˚C, 50 - 60% RH) and 13˚C (95% RH). Factor B was wrapping materials: net sack, paper and control.

Data collection

The fruits uniform in size, color and shape with average weight ranging from 320 to 350 grams were selected. The sample fruits were washed manually with clean water to remove latex and dust and to reduce microbial infection. A total of 528 fruits were divided into two groups for storage under ambient condition and at low temperature (13˚C) and each group was further divided into three subgroups each of 40 fruits. From each treatment, for non-destructive analysis ten sample fruits were used to assess physiological weight loss (%), color index, ethylene production, respiration rate and shelf-life. For destructive measurement eight sample fruits from each treatment were evaluated for skin firmness, total soluble solid content (TSS%) and total titratable acidity (TTA%). The data were collected at two-day intervals from the beginning to the unmarketable quality stage of mango fruits.

Changes in peel color of fruit was determined using a Minolta NR-20XE precision colorimeter taking a*, b* and L* values for the determination of color index value. Physiological weight loss was determined as percentage based on the initial weight. From each treatment, eight sample fruits were used to assess fruit firmness ($kgcm^{-2}$), TSS% and TTA%. Measurement of fruit firmness was done by puncturing into the fruit, three places at the equatorial portion by fruit hardness tester. Juice sample was prepared by blending

the pulp of a sample fruit. The juices from two sample fruits were thoroughly mixed and a few drops were evaluated by refractometer and direct reading was recorded. TSS was determined by a hand-held digital pocket refractometer (Atago 3810 PAL-1). TTA of mango juice was determined by using the acid base titration method [9]. The aliquot of 10ml fruit juice was titrated against sodium hydroxide (NaOH) solution (0.1N) using phenolphthalein as an indicator. The respiration (CO_2) and ethylene production rates were measured by using the gas chromatograph (Shimadzu, GC 7100) equipped with thermal conductivity detector (TCD) with Porapack Q column and a flame ionization detector (FID) with the operation column temperature at 60˚C and injection temperature at 100˚C, respectively. Gas sample 5 ml was withdrawn with a gas-tight hypodermic syringe from a sealed gas container and analysed for ethylene production and respiration rate. Ethylene production was expressed in µl $kg^{-1}h^{-1}$ and CO_2 production in mg CO_2 $kg^{-1}h^{-1}$. The standard gas was used at the initial stage before each measurement.

Data analysis

The data were statistically analyzed by using Excel program and Statistix (Version 8). The treatment means were compared by using Least Significant Difference (LSD) at 5% level.

Results and Discussion

Physiological weight loss

Regardless of wrapping materials, the physiological weight loss was highly significant between the storage temperatures; the weight loss of the fruits at room temperature was higher than that of those at 13˚C. However, the physiological weight loss of mango fruits was not significantly different among the treatments at 13˚C (Figure 1). The highest physiological weight loss about 20% was observed in the fruits of paper wrapping treatment under room temperature. This finding was similar to that of Thinh., *et al* [10]. They stated that the weight loss (20%) of mango fruit at room temperature was significantly higher than that of the fruit (5%) at 13˚C. The reason may be due to transpiration of water and other biological changes through respiration [11]. The lower weight loss at 13˚C might be due to the effect of storage temperature leading to reducing water loss and transpiration rate.

Color index

In case of storage temperature, color index of fruits at room temperature was higher than that of fruits at 13˚C. However, there were no significant differences in color index of mango fruits among the treatments at both temperatures. At 13˚C, color index value of paper wrapped fruits was the lowest followed by the fruit of net sack wrapping (Figure 2). The color development gradually increased through the experiment due to the low temperature storage, leading to slower changes in their metabolism, retaining chlorophyll and carotenoid pigments. The loss of green color was the evident change in mango fruits, which was possibly due to the physio-chemical changes by degradation of the chlorophyll structure and increase in carotenoid pigments during storage period [11].

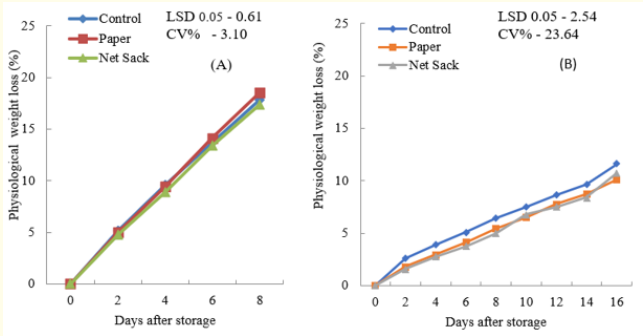

Figure 1: Effects of storage temperature and wrapping materials on physiological weight loss of Sein Ta Lone mango at (A) room temperature (B) 13˚C.

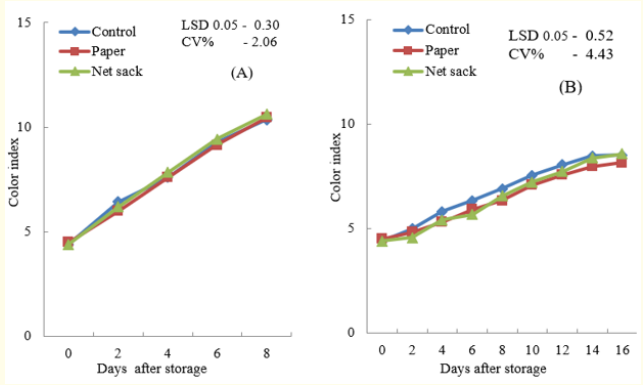

Figure 2: Effects of storage temperature and wrapping materials on color index of SeinTa Lone mango (A) at room temperature (B) at 13˚C.

Fruit firmness

Firmness of fruits in all treatments was higher at 13˚C than at room temperature. The skin firmness of all treatments stored at 13˚C was retained until 14 days after storage but at room tempera-

ture it was retained only up to 8 days after storage. At 13˚C, paper wrapping retained higher fruit firmness than other treatments - net sack wrapping and unwrapped fruits. At room temperature, the highest fruit firmness was observed in the fruits with net sack wrapping followed by paper wrapping treatment (Figure 3).This finding was similar with that of Nasrijal [12], which stated that packaging materials at refrigeration storage can retard mango fruit softening. Tian., *et al*. [13] proved that packaging materials delayed the softening process in mango fruit and retained the desirable fruits.

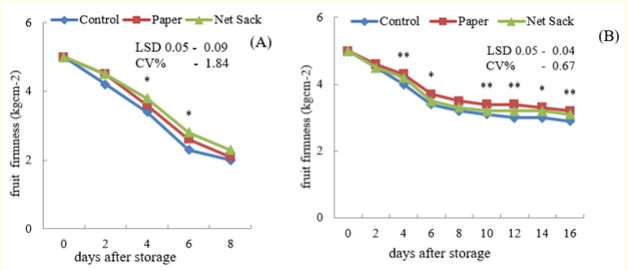

Figure 3: Effects of storage temperature and wrapping materials on fruit firmness of SeinTa Lone mango (A) at room temperature (B) at 13˚C.

Total soluble solid

It was observed that total soluble solid contents increased from 5% to 13% up to 6 days after storage and then gradually decreased at the end of the storage at room temperature. The highest TSS% was observed in the fruits of paper wrapping and control at room temperature. At 13˚C, high TSS% was retained in the fruits of all treatments until 12 days after storage while paper wrapping gave the lowest TSS% among the treatments (Table 1). Storage temperature showed significant effects on total soluble solids content of mango. This fact agreed with Thinh., *et al*. [10], Emongor [15] and Thakur., *et al* [14]. They stated that increase in TSS% was found to be faster in fruits stored at room temperature as compared to low temperature storage. The present study supported the above statement by proving that the TSS% of fruits stored at room temperature rapidly increased than that of those stored at low temperature of 13˚C.

Total titratable acidity

Total titratable acidity (TTA%) affected by storage temperature and wrapping materials is presented in table 2. There was no significant difference in total titratable acidity of fruits among the treatments at each temperature. The fruits stored at 13˚C retained more TTA% than that of fruits at room temperature. The decrease in acidity content was observed to be faster in the fruits stored at room temperature as compared to 13˚C. This finding was similar to that of Thinh., *et al.* [10], who stated that mango fruits decreased more TTA% at room temperature. The reason may be that decrease in acidity is correlated with the advancement of maturity and ripening of the fruits. Decrease of fruit acidity could be attributed to the use of organic acids as respiratory substrate during storage by conversion of acids into sugars [11].

Treatment	2DAS	4DAS	6DAS	8DAS
Wrapping				
Control	13.30 a	13.08	13.09 ab	11.54
Paper	12.96 ab	12.03	14.03 a	11.19
Net sack	11.02 b	12.79	12.48 b	11.26
LSD 0.05	1.97	1.88	1.53	1.49
Storage temperature				
13˚C	10.25 b	11.00	12.27 b	12.02 b
Room temperature	11.58 a	11.38	13.27 a	13.21 a
LSD 0.05	1.61	1.53	1.25	1.21
F-test				
Storage temperature	*	ns	**	**
Wrapping	ns	ns	ns	ns
Storage tem. x wrapping	ns	ns	ns	ns
CV%	14.91	13.99	10.89	12.48

Table 1: Total soluble solid content (TSS %) of Sein Ta Lone mango fruits affected by storage temperature and wrapping materials.

Means in the same column by the same letters are not significantly different at P ≤ 0.05.

** Highly significant at 1% level * Significant at 5% level ns = non-significant

DAS - days after storage

Treatments	2DAS	4DAS	6DAS	8DAS
Wrapping				
Control	0.23	0.14 ab	0.20	0.08
Paper	0.23	0.18 a	0.20	0.12
Net sack	0.18	0.12 b	0.20	0.12
LSD 0.05	0.10	0.04	0.10	0.04
Storage temperature				
13˚C	0.15 b	0.16	0.25 a	0.15 a
Room temperature	0.28 a	0.13	0.15 b	0.07 b
LSD 0.05	0.08	0.03	0.08	0.03
F-test				
Storage temperature	**	ns	*	**
Wrapping	ns	ns	ns	ns
Storage tem. x wrapping	ns	ns	ns	ns
CV%	45.95	27.42	49.89	36.20

Table 2: Total titratable acidity (TTA%) of Sein Ta Lone mango fruits affected by storage temperature and wrapping materials.

Means in the same column by the same letters are not significantly different at P ≤ 0.05.

** Highly significant at 1% level * Significant at 5% level ns = non-significant

DAS - days after storage.

Respiration rate

Data presented in figure 4 reveals the effect of storage temperature and wrapping materials on respiration rate of mango fruits. Respiration rate of the fruit at room temperature was considerably higher than that of those at 13˚C. It was similar to the finding of Kader [16], which stated that mango fruits stored at low temperature showed lower respiration rate than those under high temperature. There was no significant difference in respiration rate of all treatments at room temperature. At 13˚C, paper wrapped fruits showed the lowest respiration rate at 2, 10 and 12 days after storage among the treatments. The highest respiration rate of 77.22 mg CO_2 $kg^{-1}h^{-1}$ was found in the fruits of paper wrapping at room temperature and 58.57 mg CO_2 $kg^{-1}h^{-1}$ was observed in the fruits of net sack wrapping at 13˚C, respectively. The respiratory climacteric peak was found at 6 days after storage in all treatments at both temperatures. According to Lalel., *et al.* [17], mango is a climacteric fruit, exhibiting a climacteric pattern of respiration and an increase in ethylene production during ripening.

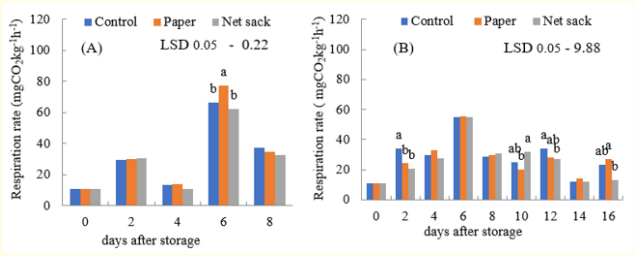

Figure 4: Effects of storage temperature and wrapping materials on respiration rate of Sein Ta Lone mango (A) at room temperature (B) at 13˚C.

Ethylene production rate

The changes in ethylene production rate of mango fruits affected by storage temperature and wrapping materials along the storage periods are shown in figure 5. Ethylene production rate of mango fruits stored at 13˚C was lower than that of those at room temperature. At room temperature, the maximum ethylene production of 2.19µl kg^{-1} h^{-1} was observed in the fruits of paper wrapping and the lowest ethylene production rate of 0.97 µl kg^{-1} h^{-1} was found in the fruit of net sack wrapping at 6 days after storage. At room temperature, the ethylene production peak of control and paper wrapped fruits reached at 6 days after storage but net sack wrapping showed peak at 8 days after storage. Therefore, net sack wrapping reached the ripening stage 2 days later than other treatments and net sack wrapping can prolong the storage life of the fruit. At 13˚C, ethylene production was very little in all treatments until 16 days after storage. The maximum ethylene production rate was 0.69 µl kg^{-1} h^{-1} and the minimum was 0.01 µl kg^{-1} h^{-1}. The peak of ethylene production was found in the fruits of all treatments at 6 days after storage at 13˚C. Therefore, the ethylene production rate was in relation with ripening process of mango and the increase in ethylene production rate from 0.1- 0.2 to 1-3 µl $kg^{-1}h^{-1}$at 20°C was also observed by Ayele., *et al.* [18]. Besides, Hofman., *et al.* [19] stated that temperature was an important factor influencing the ripening processes of mango. Ethylene production rate of mango fruits depends on variety, storage condition and environmental factors.

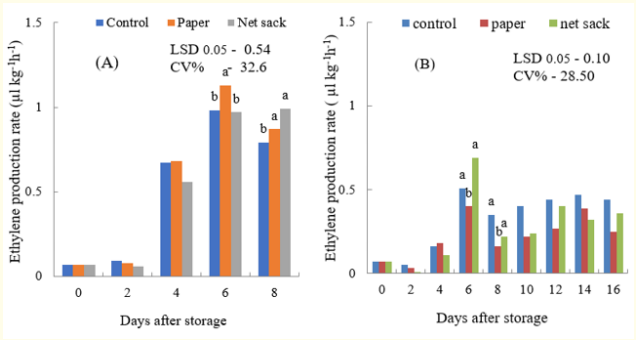

Figure 5: Effects of storage temperature and wrapping materials on ethylene production of Sein Ta Lone mango (A) at room temperature (B) at 13˚C.

Shelf life

There was significant difference in shelf life of fruits between storage temperatures. Control fruits stored at 13˚C significantly showed the longer shelf life of 14 days than those of room temperature with only 7 days. However, there was no significant difference in the shelf life of mango fruit among the treatments in each temperature. The fruits wrapped with paper showed the longest shelf life of 16 days stored at 13˚C and the fruits wrapped with net sack showed the longest shelf-life of 8 days at room temperature. Therefore, the lower the storage temperature, the longer the storage life was observed (Figure 6). The respiration and ethylene production rates of 'Sein Ta Lone' mangoes decreased at low temperature storage of 13˚C which can prolong the shelf life.

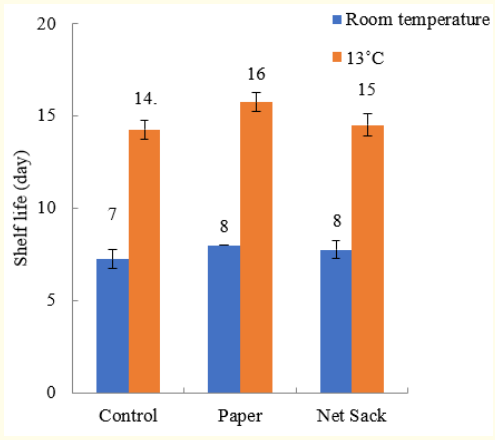

Figure 6: Effect of wrapping materials and storage temperature on shelf life of Sein Ta Lone mango.

Conclusion

The present study reveals that storage temperature and wrapping materials were effective in postharvest quality and shelf life of Sen Ta Lone mango. In comparison of storage temperature, the unwrapped fruits stored at 13˚C significantly showed the longer shelf life of 14 days than that of those under room temperature only 7 days. Therefore, low temperature storage can prolong two times higher in shelf-life of mango fruits than at room temperature. Sein Ta Lone mangoes with wrapping materials can last one day longer than those without wrapping at room temperature. Besides, wrapping materials retained higher skin firmness of fruits. The physiological weight loss, respiration rate and ethylene production rate of Sein Ta Lone mango at room temperature were two times higher than those of the fruits at 13˚C due to faster water loss from skin evaporation and faster physiological changes. Ethylene production peak of fruit at room temperature reached 8 days earlier than that of those at 13˚C. Therefore, it can be concluded that the rate of respiration and ethylene production were reduced with decrease in storage temperature.

According to the results, cold storage of 13˚C should be used to maintain quality and to prolong the shelf-life of Sein Ta Lone mango. At room temperature, net sack wrapping should be used due to lower fruit weight loss and good physical appearance during transportation. At 13˚C, paper wrapping should be used for mango fruit due to higher color development, lower ethylene production and respiration rate than others. Moreover, paper wrapping seems to be able to absorb moisture and water drops due to condensation from low temperature refrigeration and it prevents the fruits from cold injury. Regardless of storage temperature, suitable wrapping material should be used in mango postharvest handling for export market. This study reveals that the use of cold storage and wrapping material is beneficial for mango growers, retailers and wholesalers.

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