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# Physico-microbial investigation of mango (cv. Amrapali) under non-chemical preservation

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## Abstract

Enormous postharvest losses occur in mango at different points of postharvest storage in Bangladesh. Various detrimental chemicals are used in most cases to prevent the postharvest loss. Thus, non-chemical storage strategy has become a crying need to prevent the use of hazardous chemicals. So, this experiment was carried out on mango cv. Amrapalihaving five non-chemical postharvest treatments *viz*., Control, Perforated polyethylene bag, Unperforated polyethylene bag, Chitosan coating & Edible oil (soybean) coating under two storage conditions *viz.*, Ambient condition & Refrigerated condition to point out suitable storage approach through the assessment of physico-microbialattributes. The experiment was laid out in a completely randomized design with three replications. Parameters investigated were total weight loss, peel colour, firmness, visual & other characteristics, disease incidence and disease severity. The results revealed significant influence on all the parameters by both of the factors. At 9 days after storage (DAS), minimum weight loss (1.56%) was recorded at unperforated polyethylene bag under refrigerated condition but maximum weight loss (17.08%) was in control under ambient condition. The perforated polyethylene bag under refrigerated condition showed the lowest peel colour score (1.00) at 9 DAS which give the hint of longer storage. The scores of firmness change were also the lowest in unperforated (1.00) and perforated polyethylene bag (1.05) at 9 DAS, respectively. There was no disease incidence and severity in any of the treatments under refrigerated condition whereas 100% disease incidence was noticed in the control under ambient condition at 9 DAS. At later stages of storage, off-flavor was developed in unperforated polyethylene bag due to anaerobic respiration. The fresh and edible pulp without any off-flavor was recorded up to 27 DAS in perforated polyethylene bag under refrigerated condition. Hence, the perforated polyethylene bag under refrigerated condition could be a promising storage strategy for mango.

**Key words:** Storage, off-flavor, non-chemical, postharvest, mango

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## Introduction

Mango (*Mangifera indica* L.), the 'King of fruits' is one of the most important fruits in Bangladesh. Mango ranks first in terms of total area and production of fruit crops in Bangladesh. It occupied 93 thousand acres of land and total production was 1162 thousand tons during the period of 2015-2016 (BBS, 2016).The regular bearing variety Amrapali mango is being cultivated in Bangladesh for its excellent taste and yield. A range of nutritionally rich and delicious fruits and vegetables are being grown in Bangladesh due to favorable tropical and sub-tropical climates. Unfortunately, a remarkable amount of the produce never reaches the consumers due to enormous postharvest losses. In Bangladesh, 27.4% postharvest

loss was recorded for mango in 2010 (Hassan, 2010). Generally, different hazardous chemicals like fungicides and formalin are used to reduce postharvest loss. So, different non chemical preservations *viz.* storage at low temperature, use of edible oil, polyethylene bag and chitosan are some of the promising methods of reducing postharvest loss of mango. Low temperature storage of 13°C and 94% RH with polyethylene bags retard ripening of mangoes up to 16 days (Illeperuma and Jayasuriya, 2002). Mango fruits stored in chitosan-covered boxes showed an extension of shelf-life of up to 18 days (Srinivasa et al., 2002). The modified atmosphere packaging (MAP) delayed ripening of certain subtropical-tropical fruits, including mango (Kader, 1994). The increased $CO_2$ and decreased $O_2$ levels in various film packaging maintain mango quality through reducing respiration rate and preventing water loss (Chaplin et al., 1982; Miller et al., 1983; Yuen et al., 1993; Rodov et al., 1997). Edible oilcoating improved the postharvest quality of mango through decreased weight loss, disease incidence, disease severity and increased shelf life (Masror, 2010). Hence, this experiment was undertaken to identify the auspicious storage technology and to investigate the changes of physico-microbial traits under different postharvest treatments.

## Materials and Methods

***Experimental materials*:** The mature, disease and insect free Amrapali mangoes were harvested on 21st June 2016 from the Germplasm Centre, Bangladesh Agricultural University (BAU).The experiment was performed at the Post Graduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh.

***Experimental design and treatments*:** The experiment consisted of two storage conditions *viz.* ambient condition (S1) & refrigerated condition (S2) and five postharvest treatments *viz.* control (T1), perforated polyethylene bag (T2), unperforated polyethylene bag (T3), chitosan coating (2% solution) (T4) & edible oil (soybean) coating (T5) and was laid out in a Completely Randomized Design having three replications with eight mangoes in each replication.

***Application of postharvest treatments*:** Disease free two hundred and forty mango fruits were selected randomly from the fruit lot and were placed on brown paper placed on laboratory table and in the refrigerator without applying any treatments, with packing in perforated polyethylene bag, with packing in unperforated polyethylene bag, with coating of 2% chitosan solution and with coating of edible oil (Soybean) for control, perforated polyethylene bag, unperforated polyethylene bag, chitosan coating and edible oil (Soybean) coating treatment, respectively. Each polyethylene bag was characterized by 12.5 cm length and 19 cm width having 12 perforations (each perforation was of 4 mm diameter) for perforated bag and having no perforation for unperforated bag. In case of chitosan and oil treatment, the individual mango was dipped in 2% chitosan solution and soybean oil and kept on another place to drain out the excess solution and oil.

***Parameters investigated*:** The following physical parameters *viz.* total weight loss, peel colour change, firmness, visual & other characteristics and microbial parameters *viz.* disease incidence & disease severity were investigated.

**Methods of studying parameters**

***Total weight loss*:** Five out of 8 fruits of each replication of each treatment were weighed individually and kept under different postharvest treatments for data collection. Weight loss was calculated using the following formula:

$$\text{Percent weight loss (\%WL)} = \frac{\text{IW}-\text{FW}}{\text{IW}} \times 100$$

Where,

WL = Percent total weight loss

IW = Initial weight of fruits (g)

FW = Final weight of fruits (g)

***Peel colour change*:** The changes in colour of mango were determined using a numerical rating scale of 1-6, where 1 = green, 2 = Breaker, 3 = Up to 25% yellow, 4 = 25- <50% yellow, 5 = 50- <75% yellow and 6 = 75-100% yellow. Similar method was followed by Hassan (2006).

***Firmness*:** Firmness of mango was determined by hand feeling using a numerical rating scale of 1-5, where, 1 = mature hard, 2 = sprung, 3 = between sprung and eating ripe, 4 = eating ripe and 5 = over ripe. This method was mentioned by Hassan (2006).

***Disease incidence*:** Diseases incidence means percentage of fruits infected with disease. This is measured by calculating the percentage of fruits infected in each replication of each treatment. The diseased fruits were identified symptomatically. The disease incidence was calculated as follow:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected fruits in each replication}}{\text{Total number of fruits in each replication}} \times 100$$

***Disease severity*:** Disease severity represents the percent diseased portion of the infected mango fruit. The infected fruit of each replication of each treatment were selected to determine percent fruit area infected, and was measured based on eye estimation.

***Visual and other characteristics*:** The external and internal visual changes noticed in the mango were examined and recorded up to 27 DAS. The flavor developed in unperforated polyethylene bag and oil coated mango was examined by nasal sensation.

***Statistical analysis*:** The statistical analysis was done using MSTAT-C statistical package. The means for the treatments were calculated and the analysis of variances (ANOVA) for the parameters was performed by F-test. The significance of the difference between the pair of means was compared by least significant difference (LSD) test at the 5% and 1% levels of probability (Gomez and Gomez, 1984).

## Results and Discussion

***Changes in total weight loss during storage of mango*:** The variations in terms of total weight loss was highly significant between the storage conditions and among the postharvest treatments (Figure 1, Table. 3). Higher total weight loss (11.15%) was recorded at ambient condition while the lower (6.47%) was at refrigerated condition at 9 DAS (Figure 1). Azad (2001) stated higher total weight loss of mango at ambient condition. Weight loss occurs due to the respiration loss of stored starch in mango and increase of respiration is positively correlated with the increase of temperature. As the temperature was low at refrigerated condition so the weight loss was minimum at refrigerated condition. This result is supported by Anwari (2013) who found that total weight loss was lower at low temperature (12°C) storage than all other treatments named LDPE bag storage, hot water (50°C) treatment and control. The highest total weight loss (13.85%) was found in control and lowest (2.60%) was in unperforated polyethylene bag at 9 DAS (Figure 2). Reddy and Haripriya (2002) reported that mango fruits treated with $GA_3$ and stored in polyethylene bags with ethylene absorbent significantly reduced physiological weight loss. Tefera *et al.* (2007) and Fawaz (2006) also reported the lowest total weight loss in polythene wrapped mangoes. The graphs of the total weight loss of the storage conditions and all the treatments showed straight lines in case of both of the storage conditions and treatments which represented the same falling off rate of the total weight during 3 to 9 DAS in each of every storage conditions and treatments (Figure 1).The combined effects showed the lowest (1.56%) total weight loss in unperforated polyethylene bag under refrigerated condition and the highest (17.08%) was in control under ambient condition at 9 DAS (Table 3). It is in agreement with the finding of Zainuri*et al.* (2001) who reported that physiological weight loss was reduced in mango fruits cv. 'Kensington pride' wrapped with polythene bags and stored in 13°C. The cause is the lower respiration rate due to the low concentration of $O_2$ in the unperforated polyethylene bag. Ben

Yehoshua(1985) also suggested the similar phenomenon that packed fruits showed lower weight loss due to checking of the rate of respiration, transpiration and maintaining higher humidity by poly films. This result is similar to the result stated by Rathore *et al.* (2009) who found that physiological weight loss was minimum in fruits packed in polyethylene. Castro *et al.* (2008) also reported that weight loss was reduced in mangoes stored in polyethylene bag under low temperature (12°C) storage.

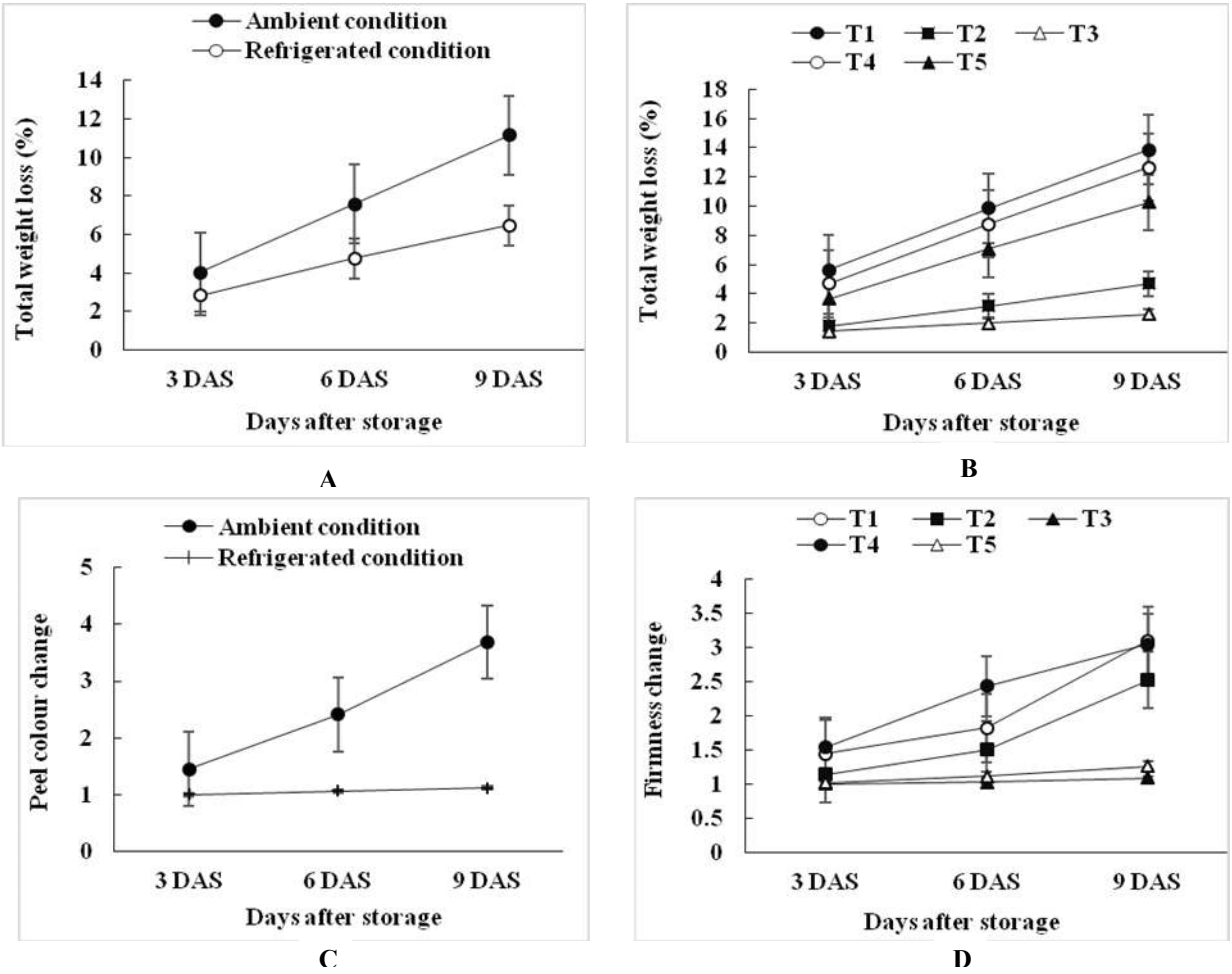



**Figure 1.** Showing different parameters comparison with days after storage**, A.** Effect of storage conditions on total weight loss of mango. Bars represent standard error. **B.** Effect of postharvest treatments on total weight loss content of mango. *(T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating, T5 = Edible oil (Soybean) coating). Bars represent standard error. **C.** Effect of storage conditions on peel colour change of mango. Color score: (1 = green, 2 = breaker, 3 = upto 25 % yellow, 4 = 25 to < 50 % yellow, 5 = 50 to <75 % yellow, and 6 = 75 to 100 % yellow).Bars represent standard error. **D.** Effect of postharvest treatments on firmness change of mango. * &Firmness score: Mature hard (1), Sprung (2), Between sprung and eating ripe (3), Eating ripe (4) and Over ripe (5) where the number in the parenthesis are the numerical rating score for firmness. Bars represent standard error.

***Changes in peel colour during storage of mango*:** Statistically highly significant variation in peel colour change was noticed between the storage conditions and postharvest treatments (Table 2 & 3, Figure 1). During the storage period, the colour of mango changes from green to yellow. From present study we observed that, longer period was required for refrigerated condition than ambient condition to change the colour from green to yellow (Figure 1). This was possibly due to the effect of low temperature which slowed down the activity of enzymes that are responsible for chlorophyll breakdown resulting the colour change. In case of effect of treatments, unperforated polyethylene bag showed the lowest rate of peel colour change, whereas in control treatment, the rate of peel colour change was the fastest (Table 2). This was due to development of yellow colour (an important ripening characteristic) which was depressed in fruits packaged in polyethylene bags, which suggests the failure of chlorophyll breakdown and carotenoid synthesis. This was shown by Medlicott *et al*. (1986), who suggested this as a consequence of accumulation of higher $CO_2$ concentration and depletion of $O_2$ in polyethylene bag. Ullah *et al*. (2012) supported the similar result and revealed that mangoes packed in polyethylene bags ripened slowly as indicated by peel colour change from green to yellow. Considering the combined effects of storage condition and postharvest treatments, unperforated polyethylene bag under refrigerated condition delayed color development of mango and showed the lowest colour score (1.00) at 9 DAS (Figure 1). The rate of change of peel colour was highest (5.83) in control treatment under ambient condition at 9 DAS (Figure 1). This result is also supported by Ullah *et al.* (2012) and Medlicott *et al.* (1986) as described before.

***Changes in fruit firmness of mango during storage*:** The storage condition and postharvest treatments had a highly significant effect on fruit firmness of mango (Table 1 & 3, Figure 1). Refrigerated condition show less firmness score through entire period of storage. Firmness retention capacity was high at refrigerated condition. Refrigerated condition showed the lowest firmness score (1.15) at 9 DAS whereas ambient condition possessed the highest (3.26) (Table 1). The treatment unperforated polyethylene bag showed the lowest firmness score (1.09), whereas in control treatment, the score was highest (3.10) at 9 DAS which represented the delayed ripening in unperforated polyethylene bag and the fastest ripening in the control (Figure 1). For combined effects the highest loss of firmness was in control under ambient condition (firmness score 4.90) and lowest loss was in unperforated polyethylene bag under refrigerated condition (firmness score 1.00) (Table 3). During ripening the pectic substances (protopectin, cellulose, hemicelluloses etc.) are broken down through enzymatic reaction. As a result, the cell wall and the strength of inter cellular bond become weak resulting the softening of the fruit (Mondal, 2000). The firmness of mango decreased remarkably in both refrigerated and unperforated condition (Table 3, Figure 1). This phenomenon is in agreement with the research findings of Boonruang*et al.* (2012) who suggested a decrease in firmnessin various film packaging of mango.

***Changes in disease incidence of mango during storage*:** The disease incidence of mango was significantly influenced by the storage conditions and different postharvest treatments at different DAS (Table 1, 2 & 3). At 9 DAS, the highest disease incidence (61.58%) was found at ambient condition whereas there was no disease incidence at refrigerated condition (Table 1). Anwari (2013) also stated the minimum disease incidence at low temperature storage. There was no disease incidence at refrigerated condition due to the low temperature (13°C) at the storage as the postharvest anthracnose and stem end rot causing fungi *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* need 20-30°Cand 28±2°C for its growth and sporulation (Sharma & Kulshrestha, 2015; Mascarenhas *et al.* 1996). The highest disease incidence (50.00%) was found in control treatment and

**Table 1.** Effect of storage conditions on firmness change, disease incidence and disease severity at different DAS.

| Storage conditions | Firmness change | | | Disease incidence (%) | | | Disease severity (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS |
| Ambient condition | 1.40 | 2.15 | 3.26 | 0.00 (1.01) | 12.40 (14.13) | 61.58 (52.28) | 0.00 | 2.20 | 16.42 |
| Refrigerated condition | 1.05 | 1.01 | 1.15 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| LSD (0.05) | 0.13 | 0.27 | 0.07 | - | 0.68 (0.42) | 1.77 (1.29) | - | 0.09 | 0.54 |
| LSD (0.01) | 0.17 | 0.37 | 0.10 | - | 0.93 (0.57) | 2.41 (1.76) | - | 0.12 | 0.74 |
| Level of significance | ** | ** | ** | NA | ** | ** | NA | ** | ** |

** = Significant at 1% level of probability, NA: Not analyzed, The value in the parenthesis shows disease incidence in Arc sin scale. Firmness score: Mature hard (1), Sprung (2), Between sprung and eating ripe (3), Eating ripe (4) and Over ripe (5), where the number in the parenthesis is the numerical rating score for firmness.

**Table 2.** Effect of postharvest treatments on peel colour change, disease incidence and disease severity at different DAS.

| Postharvest treatments | Peel colour change | | | Disease incidence (%) | | | Disease severity (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS |
| T1 | 1.52 | 2.51 | 3.53 | 0.00 (1.01) | 16.50 (18.02) | 50.00 (44.98) | 0.00 | 2.96 | 17.67 |
| T2 | 1.12 | 1.31 | 2.52 | 0.00 (1.01) | 0.00 (1.01) | 30.68 (26.29) | 0.00 | 0.00 | 5.25 |
| T3 | 1.04 | 1.10 | 1.18 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| T4 | 1.45 | 2.42 | 3.44 | 0.00 (1.01) | 14.50 (16.79) | 44.00 (35.47) | 0.00 | 2.53 | 12.00 |
| T5 | 1.00 | 1.33 | 1.35 | 0.00 (1.01) | 0.00 (1.01) | 29.27 (25.46) | 0.00 | 0.00 | 6.13 |
| LSD (0.05) | 0.09 | 0.26 | 0.33 | - | 1.08 (0.66) | 2.80 (2.04) | - | 0.14 | 0.86 |
| LSD (0.01) | 0.13 | 0.35 | 0.45 | - | 1.47 (0.90) | 3.81 (2.79) | - | 0.19 | 1.17 |
| Level of significance | ** | ** | ** | NA | ** | ** | NA | ** | ** |

** = Significant at 1% level of probability, NA: Not Analyzed, The value in the parenthesis shows disease incidence in Arc sin scale. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4 = Chitosan coating T5 = Edible oil (Soybean) coating). Colour score: Green (1), Breaker (2), 0 to 25 % Yellow (3), 26 to <50 % Yellow (4), 50 to <75 % Yellow (5) and 75 to 100 % Yellow (6), where the number in the parenthesis are the numerical rating score for colour).

**Table 3.** Combined effect of storage conditions and postharvest treatments on total weight loss, peel colour change and firmness change of mango at different DAS.

| Storage conditions | Postharvest treatments | % Total weight loss | | | Peel colour change | | | Firmness change | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS |
| Ambient | T1 | 6.35 | 11.74 | 17.08 | 2.03 | 3.93 | 5.83 | 1.87 | 2.63 | 4.90 |
| | T2 | 2.40 | 4.53 | 6.92 | 1.23 | 1.61 | 4.05 | 1.27 | 2.00 | 4.00 |
| | T3 | 1.70 | 2.71 | 3.64 | 1.07 | 1.12 | 1.25 | 1.01 | 1.07 | 1.18 |
| | T4 | 5.57 | 10.58 | 15.74 | 1.90 | 3.80 | 5.73 | 1.82 | 3.87 | 4.83 |
| | T5 | 4.14 | 8.40 | 12.37 | 1.00 | 1.58 | 1.60 | 1.04 | 1.16 | 1.40 |
| Refrigerated | T1 | 4.87 | 8.00 | 10.63 | 1.00 | 1.09 | 1.22 | 1.00 | 1.00 | 1.29 |
| | T2 | 1.23 | 1.80 | 2.47 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.05 |
| | T3 | 1.17 | 1.32 | 1.56 | 1.00 | 1.07 | 1.11 | 1.00 | 1.00 | 1.00 |
| | T4 | 3.85 | 6.94 | 9.56 | 1.00 | 1.05 | 1.14 | 1.27 | 1.00 | 1.27 |
| | T5 | 3.14 | 5.73 | 8.14 | 1.00 | 1.07 | 1.09 | 1.00 | 1.07 | 1.12 |
| LSD (0.05) | | 0.49 | 0.84 | 1.17 | 0.13 | 0.37 | 0.47 | 0.28 | 0.60 | 0.16 |
| LSD (0.01) | | 0.67 | 1.15 | 1.59 | 0.18 | 0.49 | 0.64 | 0.38 | 0.82 | 0.22 |
| Level of significance | | * | ** | ** | ** | ** | ** | ** | ** | ** |

* =Significant at 5% level of probability, ** = Significant at 1% level of probability, The value in the parenthesis shows disease incidence in Arc sin scale. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4 = Chitosan coating T5 = Edible oil (Soybean) coating). Colour score: Green (1), Breaker (2), 0 to 25 % Yellow (3), 26 to <50 % Yellow (4), 50 to <75 % Yellow (5) and 75 to 100 % Yellow(6), where the number in the parenthesis are the numerical rating score for colour). Firmness score: Mature hard (1), Sprung (2), Between sprung and eating ripe (3), Eating ripe (4) and Over ripe (5), where the number in the parenthesis is the numerical rating score for firmness.

There was no disease incidence in unperforated polyethylene bag at 9 DAS (Table 2). It is in agreement with the findings of Anwari (2013) who stated lower disease incidence in unperforated polyethylene bag than hot water treatment and control. Again, the findings are similar to Islam (2013) and Molla *et al*. (2011) who found maximum disease incidence in control treatment. At 9 DAS, control treatment under ambient condition showed highest disease incidence (100%) but there was no disease incidence in any of the treatments under refrigerated condition (Table 4). The two storage fungi, namely *Colletotrichum gloeosporioides* (causal organism of anthracnose) and *Botryodiplodia theobromae* (causal organism of stem-end rot) are sugar loving fungi. These fungi can infect mango when mango possesses considerable amount of sugar but cannot infect at the condition of high acidity. Green unripe mango contains high amount of different organic acids (Mondal, 2000). For this reason, the fungi cannot infect green unripe mango containing considerable amount of acids. In the present study, the mangoes under the treatment unperforated polyethylene bag and at refrigerated condition possessed high amount of organic acids at 9 DAS. So, there was no disease incidence in unperforated polyethylene bag and at refrigerated condition at 9 DAS whereas disease occurred in control treatment and at ambient condition.

***Changes in disease severity of mango during storage*:** The variations in disease severity due to the difference in the storage conditions and postharvest treatments were statistically highly significant (Table 1 & 2). There was no disease severity at refrigerated condition at 9 DAS, 16.42% disease severity was observed at ambient condition at same DAS (Table 1). Anwari (2013) also found the minimum disease severity at low

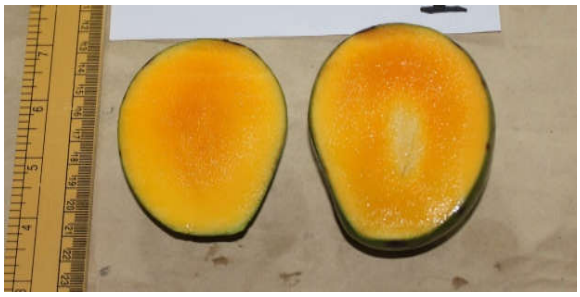
temperature storage. The highest disease severity (17.67%) was found in control and the lowest disease severity (0.00%) was observed in unperforated polyethylene bag at 9 DAS (Table 2). It is in agreement with the statement of Anwari (2013) who stated lower disease severity in unperforated polyethylene bag than hot water treatment and control. Islam (2013) also found highest disease severity in control treatment. The disease severity increased from 0.00% at 3 DAS to 2.96% at 6 DAS in control treatment (Table 2). But, it rose to 17.67% at 9 DAS which exhibited the higher rate of disease severity from 6 to 9 DAS than 3 to 6 DAS (Table 2). The reason was the presence of higher amount of organic acids and lower amount of sugars during the period of 3 to 6 DAS than 6 to 9 DAS. As, there was higher quantity of sugars during the period of 6 to 9 DAS, the sugar loving fungi *Colletotrichum gloeosporioides* and *Botryodiplodia theobromae* cause a remarkable amount of disease severity. At 9 DAS, control treatment under ambient condition showed highest disease severity (35.33%) but there was no disease severity in any of the treatments under refrigerated condition (Table 4).

**Table 4.** Combined effect of storage conditions and postharvest treatments on disease incidence and disease severity.

| **Storage conditions** | **Postharvest treatments** | **Disease incidence (%)** | | | **Disease severity (%)** | | |
|---|---|---|---|---|---|---|---|
| | | 3 DAS | 6 DAS | 9 DAS | 3 DAS | 6 DAS | 9 DAS |
| Ambient | T1 | 0.00 (1.01) | 33.00 (35.03) | 100.00 (88.95) | 0.00 | 5.92 | 35.33 |
| | T2 | 0.00 (1.01) | 0.00 (1.01) | 61.36 (51.57) | 0.00 | 0.00 | 10.50 |
| | T3 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| | T4 | 0.00 (1.01) | 29.00 (32.57) | 88.00 (69.94) | 0.00 | 5.07 | 24.00 |
| | T5 | 0.00 (1.01) | 0.00 (1.01) | 58.55 (49.91) | 0.00 | 0.00 | 12.25 |
| Refrigerated | T1 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| | T2 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| | T3 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| | T4 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| | T5 | 0.00 (1.01) | 0.00 (1.01) | 0.00 (1.01) | 0.00 | 0.00 | 0.00 |
| LSD (0.05) | | - | 1.52 (0.94) | 3.96 (2.89) | - | 0.19 | 1.21 |
| LSD (0.01) | | - | 2.08 (1.28) | 5.39 (3.94) | - | 0.27 | 1.65 |
| Level of significance | | NA | ** | ** | NA | ** | ** |

** = Significant at 1% level of probability, NA: Not Analyzed, The value in the parenthesis shows disease incidence in Arc sin scale.

***Changes in visual and other characteristics during storage*:** The mango fruits belonging to the treatment control and chitosan coating under ambient condition showed anthracnose and stem end rot diseases (Figure 2). The mangoes of the treatment control and chitosan coating under refrigerated condition were showed shriveling of mango due to water loss as suggested by Meng *et al.* (2008) who stated that chitosan film absorbed the water lost from the mango (Figure 2).



**Edible pulp of $S_2T_2$ at 27 DAS**

**$S_2T_2$ at 27 DAS (Surface pitting)**

**$S_2T_1$ at 21 DAS (Shriveled peel)**

**$S_2T_5$ at 24 DAS (Black surface)**

**$S_2T_4$ at 21 DAS ( Shriveled peel)**

**$S_1T_4$ at 9 DAS (Diseased rotten mango)**

**Figure 2.** Pictorial view of mango at different days after storage under different storage conditions and postharvest treatments. (S1 = Ambient condition, S2 = Refrigerated condition, T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating T5 = Edible oil (Soybean) coating).

Surface blackening occurred due to oil coating which also made mango unmarketable (Figure 2). In case of oil coating treatment, oil coating create a thin barrier on the fruit surface performing like polyethylene bag and cause anaerobic respiration. Fruits under oil coating and unperforated polyethylene bag developed off-flavor. This result is supported by Boonruang*et al*. (2012) who stated that limited oxygen levels inside the polyethylene packages caused anaerobic respiration in mangoes, producing ethanol and resulting in off-odor and off-flavor. Again, surface blackening occurred due to oil coating which also made mango unmarketable. In case of oil coating treatment, oil coating creates a thin barrier on the fruit surface performing like polyethylene bag and cause anaerobic respiration. The mango fruits in perforated polyethylene bag under ambient condition exhibited disease incidence (Figure 2). The fruits in perforated polyethylene bag under refrigerated condition manifested chilling injury like surface pitting (Figure 2). The injury might be due to the fluctuation in the temperature of the refrigerator, because temperature below 12°C caused chilling injury (Tasneem, 2004).

## Conclusion

The unperforated and perforated polyethylene bag under refrigerated condition represented the lowest total weight loss, peel colour change, firmness change, disease incidence and disease severity up to 9 DAS. But the unperforated polyethylene bag made mango inedible by developing off-flavor through anaerobic respiration. The perforated polyethylene bag under refrigerated condition kept mango edible up to 27 days without any development of unwanted off-flavor. So, this storage strategy could be anauspicious storage method of mango.

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