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Selection of efficient storage approach through chemical investigation of mango cv. 'Amrapali'

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ABSTRACT

Purpose: Ineffective storage technology is the major concern for the high level of postharvest loss in Bangladesh. So, aiming to pick out the promising storage strategy of mango, this study was conducted. **Research method:** The mangoes cv. Amrapali were kept under two storage conditions *viz.*, ambient and refrigerated (13 ± 2 °C and 15-20% RH) storage having five postharvest treatments including untreated control, perforated polyethylene bag, unperforated polyethylene bag, chitosan coating and edible oil (soybean) coating. **Findings:** The effect of storage conditions and postharvest treatments were found highly significant on the chemical parameters. Unperforated polyethylene bag and oil coating showed the highest titratable acidity (0.51 and 0.50%), the highest vitamin C (22.43 and 22.63 mg/100 g), and the lowest TSS (8.90 and 10.00%) under refrigerated condition and control showed the lowest titratable acidity (0.10%), the lowest vitamin C (12.50 mg/100 g), and the highest TSS (27.03%) under ambient condition at 9 days after storage. Unperforated polyethylene bag and oil coating under refrigerated conditions kept mangoes edible up to 9 days after storage. But after certain days of storage, unperforated polyethylene bag and oil coating developed off-flavor making mangoes inedible. **Research limitations:** More research should be conducted using other mango cultivars. **Originality/Value:** The perforated polyethylene bag under refrigerated condition showed a slower change of chemical parameters, simultaneously resulting in the longest shelf life (27 days) without producing any unwanted flavor and taste indicating efficient postharvest storage.

INTRODUCTION

Mango (*Mangifera indica* L.) is a popular fleshy stone fruit belonging to the genus *Mangifera*, under the botanical family Anacardiaceae. In Bangladesh, in terms of total area and production of fruit crops, mango ranks second. During the period of 2013-2014 it occupied 34632 hectares of land and total production was 992296 metric tons (BBS, 2014). The Amrapali mango is a dwarf, high yielding, regular bearing variety having pleasant flavour and sweetness (Mondal, 2000). Now it is being cultivated in Bangladesh due to its high yield and excellent taste.

Due to favorable climates, huge quantities of mangoes are produced each year in Bangladesh. However, a considerable proportion of mango fruit is spoiled each year due to postharvest losses. The postharvest losses of mango in Bangladesh were 27.4% in 2010, especially due to the lack of proper storage technologies and facilities (Hassan, 2010). So, necessary measures should be taken to prolong the shelf life and to reduce the postharvest losses of mango. Storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distances. Normally fungicides are used to control storage fungi and formalin is used to prolong the shelf life of mango, which are very much detrimental to human health (Hassan, 2010). So, non-chemical preservations *viz*. use of chitosan, edible oil, polyethylene bag and storage at low temperature are some of the efficient methods to protect chemical hazards and to extend the shelf life of mango. Low-temperature storage was found effective in relation to the slower decrease in weight loss, vitamin C and to prolong shelf life in mango (Anwari, 2013; Tefera et al., 2007). Polyethylene bag was effective in prolonging the shelf life of mango fruits by delaying the ripening process (Singh et al., 2016). Mature 'Karuthacolomban' mangoes were sealed in low-density polyethylene (LDPE) bags and stored at 13 °C and 94% RH which was effective in delaying ripening of mangoes up to 16 days (Illeperuma & Jayasuriya, 2002). Chitosan coating having antifungal activity could effectively delay ripening, reduce decay and extend the storage life of mango fruits (Zhu et al., 2008). Edible oil coating was found suitable in improving the postharvest quality of mango as the weight loss, disease incidence, and disease severity were lower and shelf life was higher in oil coated mango during storage (Masror, 2010). Hence the present experiment was undertaken to find out the suitable postharvest storage condition for reducing postharvest losses and prolonging the shelf life of mango and to observe the chemical changes due to different postharvest treatments during storage of mango.

MATERIALS AND METHODS

The experiment was conducted at the Post Graduate Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh and Postharvest Technology Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the period from June to August, 2016.

Experimental materials

The experimental materials were mature firm fruits of the mango variety Amrapali, which were free of any visible defects, disease symptoms and insect infestations and collected from Germplasm Centre, Bangladesh Agricultural University (BAU), Mymensingh on 21st June 2016.

Experimental treatments and design

Five postharvest treatments *viz.* Control (T1), Perforated polyethylene bag (T2), Unperforated polyethylene bag (T3), Chitosan coating (2% solution) (T4) and Edible oil (Soybean) coating (T5) under two storage conditions *viz.* Ambient condition (S1) and Refrigerated condition (13 ± 2°C and 15-20% RH) (S2) were used to observe the performance of mango. The two-factor experiment was laid out in a Completely Randomized Design with three replications having eight fruits in each replication.

Application of postharvest treatments

Two hundred and forty fruits were selected from the experimental fruit lot and were subjected to different treatments. The mango fruits were not subjected to any treatments for control. The selected mangoes were packed in perforated plastic bag (Thickness: 25 µm, Independent Export (BD) Ltd., Dhaka, Bangladesh) measured 12.5 × 19 cm having 12 perforations (each perforation is of 4 mm diameter) for perforated polyethylene bag. The mango fruits were packed in unperforated plastic bag (Thickness: 25 µm, Independent Export (BD) Ltd., Dhaka, Bangladesh) measured 12.5 × 19 cm for unperforated polyethylene bag. In case of chitosan coating, the individual mango fruit was dipped into 2% chitosan solution in a beaker and then placed outside of the beaker to air dry. For oil coating, the mango fruits were individually dipped in oil and placed on another place to drain out the excess oil and to air dry. Finally, all the untreated and treated mango fruits were placed on brown paper previously placed on laboratory table and in the refrigerator for further supervision.

Parameters studied and methods of studying parameters

The total soluble solids (TSS), titratable acidity (TA), pulp pH, vitamin C content, reducing sugar content, non-reducing sugar content, total sugar content and shelf life were studied up to 27 days at three days interval in the present experiment. Total soluble solids content of mango pulp was estimated using a digital refractometer (NR 151 Digital Refractometer, Selecta group, Spain). The titratable acidity of mango pulp was determined by titration with 0.1N NaOH solution (AOAC, 1990). The pH of fruit juice was recorded by using an electric pH meter (Mettler Toledo Delta 320 pH Meter, Ohio, USA). Ascorbic acid (vitamin C) content was determined by titration with standardized 2, 6- dichlorophenol indophenol dye (Ranganna, 2008). The sugar content of fruit pulp was determined by the method of Lane and Eynon. At first, Fehling's solution was standardized with a standard sugar solution. Twenty gram of fresh mango fruit pulp was taken. The pulp sample was further prepared by mixing with 45% neutral lead acetate solution and 22% potassium oxalate solution and finally filtered. Then filtrated pulp solution was taken in a burette and titrated by Fehling's solution with the presence of methylene blue indicator to measure reducing sugar. Then fifty milliliter (ml) filtrate was taken, citric acid was added for inversion of sucrose and was neutralized by 1N NaOH using phenolphthalein indicator. The volume was then titrated by the Fehling's solution to measure total invert sugar. The non-reducing sugar was calculated by deducting the amount of reducing sugar from total invert sugar (Ranganna, 2008). The shelf life was calculated by counting the number of days required to ripen fully with retained optimum marketing and eating qualities. During observation, the flavor of the treated mango was evaluated by nasal sensation.

Statistical analysis

The collected data on various parameters were statistically analyzed using Mstatc statistical package. The means for all the treatments were calculated and the analysis of variance

(ANOVA) for all 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 soluble solids (TSS) of mango

The storage condition and postharvest treatments had a significant effect on total soluble solids of mango (Table 1). The rate of change of TSS was higher at ambient condition than the refrigerated condition. Ambient condition attained 19.69% at 9 DAS (days after storage) whereas refrigerated condition attained only 11.76% (Fig 1. A). This was similar to the finding of Anwari (2013) who reported the lowest TSS content at low temperature (12°C) storage. Azad (2001) found higher TSS content of mango at ambient condition. The maximum value of TSS (19.85%) was observed at 9 DAS in control whereas minimum value of TSS (9.83%) was observed in the unperforated polyethylene bag (Table 5). Rathore et al. (2009) also found the similar outcome that the lower TSS content was in the fruits packed in polyethylene bag. At 9 DAS, the maximum value of TSS (27.03%) was found in control under ambient condition and the minimum value (8.90%) was observed in unperforated polyethylene bag under refrigerated condition (Table 1). It was similar to the statement of Thanaa and Rehab (2011) who stated the high amount of TSS in control treatment. Anwari (2013) reported the lower TSS content in the fruits stored in polyethylene bag and at low temperature (12°C). The increase in TSS content is due to the conversion of complex carbohydrates into simple sugars (mainly glucose and fructose) (Baloch & Bibi, 2012; Mondal, 2000). As the rate of conversion reactions decrease sharply at low temperature, it reduces the TSS content at the refrigerated condition.

Changes in titratable acidity of mango

The difference between storage conditions and among postharvest treatments in terms of titratable acidity was statistically highly significant (Table 1). The rate of degradation of titratable acidity was higher at ambient condition than the refrigerated condition. At 9 DAS, the % total acid was 0.22 at ambient condition whereas it was 0.45 at refrigerated condition (Table 3). The result was in agreement with the findings of Azad (2001) and Peter et al. (2007) who stated that titratable acidity decreased at ambient condition during storage of mango. In a study OHare (1995) reported that titratable acidity declined slowly when mango fruits were stored at 13 ^{o}C temperature. The rate of degradation of titratable acidity was maximum in control and perforated polyethylene bag whereas it was minimum in oil coating and unperforated polyethylene bag. At 9 DAS, control showed 0.30% and unperforated polyethylene bag showed 0.42% (Table 5). Rathore et al. (2009) studied the effect of polyethylene packaging and stated higher retention of acidity in the fruits during the storage period. At 9 DAS, the highest titratable acidity (0.51%) was recorded in unperforated polyethylene bag under the refrigerated condition and the lowest (0.10%) was in control under ambient condition (Table 1). As the ripening process proceeds different organic acids are converted into sugars making mangoes sweeter (Doreyappy-Gowda & Huddar, 2001; Srinivasa et al., 2002). But due to the low concentration of O_2 in unperforated polyethylene bag these acid to sugar conversion reactions are hampered resulting a high percentage of acids than sugars. Similarly, at low temperature, the speed of the conversion reactions abruptly fall causing high acid to sugar ratio in mango. This was correlated with the finding of Anwari

(2013) who showed higher titratable acidity in polyethylene bag and at low temperature than hot water (50 °C) treatment and control.

Changes in pulp pH of mango

Statistically highly significant variation in pulp pH was noticed between the storage conditions and postharvest treatments (Table 1). The higher pulp pH was found (5.09) at ambient condition and the lower (4.30) was found at refrigerated condition (Table 3). The highest pulp pH (4.87) was found in control and the lowest (4.48) was in unperforated polyethylene bag at 12 DAS (Table 5). It was in agreement with the finding of Rathore et al. (2009) who suggested the slower increase of pH in the fruits packed in polyethylene bag. From the combined effect of storage conditions and postharvest treatments, at 9 DAS the highest pulp pH (5.44) was observed in control under ambient condition and the lowest pulp pH (4.08) was in perforated polyethylene bag under refrigerated condition (Table 1). Islam (2013) also found the highest pulp pH in control fruits than treated ones. When the ripening process goes onward, the different acids prevailing in mango are converted to sugar cause the decrease in acidity and increase in the alkaline environment resulting in higher pH in fruit pulp (Doreyappy-Gowda & Huddar, 2001; Mondal, 2000; Srinivasa et al., 2002).

Table 1. The combined effect of storage conditions and postharvest treatments on chemical traits of mango

Storage conditions	Postharvest treatments	TSS (% Brix)			Titratable Acidity (%)		
		Days after storage					
		3	6	9	3	6	9
Ambient	T1	14.37	22.07	27.03	0.61	0.14	0.10
	T2	14.13	20.07	23.50	0.64	0.18	0.13
	T3	8.10	8.77	10.77	0.65	0.55	0.49
	T4	14.17	21.97	26.27	0.65	0.18	0.15
	T5	8.97	9.13	10.87	0.67	0.58	0.49
Refrigerated	T1	8.60	9.63	12.67	0.65	0.49	0.42
	T2	9.20	13.13	14.90	0.65	0.44	0.35
	T3	7.87	8.30	8.90	0.69	0.59	0.51
	T4	8.44	9.47	12.33	0.68	0.51	0.44
	T5	7.87	8.37	10.00	0.68	0.58	0.50
LSD (0.05)		0.43	0.37	0.82	0.012	0.011	0.009
LSD (0.01)		0.58	0.50	1.12	0.016	0.015	0.013
Level of significance		**	**	**	**	**	**

Storage conditions	Postharvest treatments	Pulp pH			Vitamin C content (mg/100g)		
		Days after storage					
		3	6	9	3	6	9
Ambient	T1	4.21	4.90	5.44	16.63	13.17	12.50
	T2	4.15	5.28	5.32	18.60	17.07	14.30
	T3	4.31	4.44	4.55	24.17	22.00	20.47
	T4	4.07	4.76	5.41	19.13	14.07	13.90
	T5	4.18	4.25	4.72	24.23	23.00	21.43
Refrigerated	T1	4.11	4.21	4.30	21.13	18.70	17.67
	T2	3.98	4.02	4.08	23.20	20.10	19.80
	T3	4.24	4.32	4.40	26.10	24.00	22.43
	T4	4.09	4.20	4.28	23.57	20.57	18.30
	T5	4.13	4.19	4.43	24.00	23.03	22.63
LSD (0.05)		0.05	0.12	0.05	0.28	0.51	0.84
LSD (0.01)		0.07	0.16	0.073	0.38	0.69	1.14
Level of significance		**	**	**	**	**	**

** Significant at 1% level of probability. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating, T5 = Edible oil (Soybean) coating).

In unperforated polyethylene bag, this attainment of the alkaline environment is very slow due to low O_2 concentration within the bag. As the low temperature reduces all metabolic reactions, so the change of acidic to alkaline medium also decreases resulting lower pulp pH.

Changes in vitamin C content

The vitamin C content of mango pulp was significantly influenced by the storage conditions and different postharvest treatments at different DAS (Table 1). There was a decreasing trend in vitamin C during storage. The higher vitamin C content (20.17 mg/100 g) was found at the refrigerated condition and the lower vitamin C content (16.52 mg/100 g) was found at the ambient condition at 9 DAS (Table 3). The outcome of ambient condition was supported by previous studies of Azad (2001), Jain et al. (2001), Mondal (2000) and Mondal et al. (1998) who reported decreased vitamin C content at ambient condition and increased ascorbic acid content in cool chamber. In case of the effect of treatments, there was also a decreasing trend in relation to vitamin C content of fruit pulp during storage. The highest vitamin C content (22.03 mg/100 g) followed by 21.45 mg/100 g were recorded in oil coating and unperforated polyethylene bag and the lowest (15.08 mg/100 g) was recorded in control at 9 DAS (Fig 1. B).

Table 2. The combined effect of storage conditions and postharvest treatments on chemical traits and shelf life of mango

Storage conditions	Postharvest treatments	Reducing sugar content (%)			Non- reducing sugar content (%)		
		Days after storage					
		3	6	9	3	6	9
Ambient	T1	2.03	3.13	3.90	1.94	2.77	4.17
	T2	2.11	2.95	3.80	1.56	2.22	3.60
	T3	1.03	1.16	1.38	1.98	2.44	2.85
	T4	2.58	3.00	3.40	1.05	2.70	4.50
	T5	1.26	1.35	1.49	1.82	2.01	2.63
Refrigerated	T1	1.25	1.43	1.76	1.90	2.53	3.30
	T2	1.11	1.98	2.10	2.37	2.15	3.11
	T3	1.07	1.17	1.21	1.74	1.74	1.82
	T4	0.91	1.40	1.74	2.21	2.52	3.21
	T5	1.19	1.32	1.43	1.91	2.23	2.54
LSD (0.05)		0.32	0.11	0.08	0.33	0.19	0.16
LSD (0.01)		0.44	0.15	0.10	0.45	0.25	0.22
Level of significance		**	**	**	**	**	**

Storage conditions	Postharvest treatments	Total sugar content (%)			Shelf Life (days)
		Days after storage			
		3	6	9	
Ambient	T1	3.97	5.90	8.07	8.00
	T2	3.67	5.17	7.40	11.67
	T3	3.01	3.60	4.23	11.67
	T4	3.63	5.70	7.90	8.67
	T5	3.08	3.36	4.12	14.67
Refrigerated	T1	3.15	3.96	5.06	20.33
	T2	3.48	4.13	5.21	26.67
	T3	2.81	2.91	3.03	23.67
	T4	3.12	3.92	4.95	20.67
	T5	3.10	3.55	3.97	23.67
LSD (0.05)		0.17	0.14	0.12	1.08
LSD (0.01)		0.23	0.19	0.16	1.47
Level of significance		**	**	**	**

** Significant at 1% level of probability. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating, T5 = Edible oil (Soybean) coating).

Table 3. Effect of different storage conditions on titratable acidity, pulp pH and vitamin C content of mango

Storage conditions	Titratable Acidity (%)			Pulp pH			Vitamin C content (mg/100g)		
	Days after storage								
	3	6	9	3	6	9	3	6	9
Ambient condition	0.64	0.26	0.22	4.19	4.73	5.09	20.55	17.86	16.52
Refrigerated condition	0.68	0.53	0.45	4.11	4.19	4.30	23.60	21.28	20.17
LSD (0.05)	0.005	0.005	0.004	0.02	0.05	0.02	0.13	0.23	0.37
LSD (0.01)	0.007	0.007	0.006	0.03	0.07	0.03	0.17	0.31	0.51
Level of significance	**	**	**	**	**	**	**	**	**

** Significant at 1% level of probability.

The lowest vitamin C content (12.50 mg/100 g) was observed in control treatment under ambient condition and the highest (22.63 mg/100 g) was in oil coating under refrigerated condition followed by 22.43 mg/100g in unperforated polyethylene bag under refrigerated condition at 9 DAS (Table 1). The result was similar to Ramayya et al. (2012) who showed the least average decrease (3.1 mg/100g) in the unperforated film compared to perforated film (4.3 mg/100g).

Anwari (2013) stated the similar result that the vitamin C content was higher in polyethylene bag and at low temperature (12 °C) storage than hot water treatment and control. Shahjahan et al. (1994) also stated that the green fruits stored at 10-12 °C temperature for 7 weeks had little change in vitamin C content. The decrease in vitamin C content with storage duration is attributed to the oxidation of ascorbic acid in to dehydro ascorbic acid by enzyme ascorbic acid oxidase (Shimada & Ko, 2008). The oxidation process cannot take place properly in oil coated fruits. Because of the oil coating acts as a barrier to the gases. The outside O_2 cannot enter into the fruits and respired CO_2 cannot come outside from the fruits in case of oil coated and unperforated polyethylene bag. So, the oxidation of ascorbic acid is very low in oil coated and unperforated polyethylene bagged fruit resulting in the minimum loss of vitamin C. Again, as the rate of physiological reaction slows down at low temperature, the oxidation of ascorbic acid is very low resulting in higher vitamin C content at the refrigerated condition.

Changes in reducing sugar content

The variations in reducing sugar content of fruits due to the difference in the storage conditions and postharvest treatments were statistically significant (Table 2). Reducing sugar content was observed higher (2.80%) at ambient condition and lower (1.65%) at the refrigerated condition at 9 DAS (Table 4). Azad (2001) stated the increase in reducing sugar at ambient condition during storage of mango. Conversion of different organic acids into sugars as well as polymeric carbohydrate to sugar (mainly glucose and fructose), take place during storage resulting in the higher concentration of reducing sugars (Mondal, 2000; Doreyappy-Gowda & Huddar, 2001; Srinivasa et al., 2002). For this reason, reducing sugar was high at ambient condition. The maximum reducing sugar content (2.95%) was recorded in perforated polyethylene bag followed by control while minimum reducing sugar content (1.30%) was found in unperforated polyethylene bag at 9 DAS (Table 5). A similar result was found by Islam (2013). He stated that maximum reducing sugar was in perforated polythene bag and control. The highest reducing sugar content (3.90%) was observed in control treatment under ambient condition, while the lowest (1.21%) was observed in unperforated polyethylene bag under refrigerated condition at 9 DAS (Table 2). It was in agreement with

Table 4. Effect of different storage conditions on reducing and non-reducing sugar content of mango

Storage conditions	Reducing sugar content (%)			Non- reducing sugar content (%)		
	Days after storage					
	3	6	9	3	6	9
Ambient condition	1.80	2.32	2.80	1.67	2.43	3.55
Refrigerated condition	1.11	1.46	1.65	2.03	2.24	2.80
LSD (0.05)	0.14	0.05	0.03	0.15	0.08	0.07
LSD (0.01)	0.20	0.07	0.05	0.20	0.11	0.10
Level of significance	**	**	**	**	**	**

** Significant at 1% level of probability.

the result of Thanaa and Rehab (2011) who stated the high amount of reducing sugar in control treatment.

Changes in non-reducing sugar content of mango

The effect of storage conditions and postharvest treatments were found to be statistically highly significant on changes in non-reducing sugar content of fruit during storage (Table 2). Non-reducing sugar content was observed higher (3.55%) at ambient condition and lower (2.80%) at the refrigerated condition at 9 DAS (Table 4). It was similar to the findings of Mondal (2000) and Srinivasa et al. (2002) who stated that organic acids and polymeric carbohydrate are converted to sugar (mainly glucose and fructose) during storage resulting in the higher concentration of non-reducing sugar. Azad (2001) also suggested that non-reducing sugar increases at ambient condition during storage of mango. At 9 DAS, the higher non-reducing sugar content (3.86% and 3.73%) were observed in chitosan coating and control fruits respectively while the lowest (2.33%) was found in fruits stored in unperforated polyethylene bag (Table 5). Islam (2013) stated the similar finding that control fruits showed the highest non-reducing sugar content at 12 DAS than all other treatments. The highest non-reducing sugar content (4.50%) was found in chitosan coating followed by control (4.17%) under ambient condition while the lowest (1.82%) was found in unperforated polyethylene bag under refrigerated condition at 9 DAS (Table 2). The reason for the decrease of non-reducing sugar in unperforated polyethylene bag and at refrigerated condition is similar as described before in reducing sugar.

Changes in the total sugar content of mango

The variations in respect of total sugar content were found highly significant between storage conditions and among different postharvest treatments during storage (Table 2). Total sugar content was observed higher (6.34%) at ambient condition and lower (4.45%) at the refrigerated condition at 9 DAS (Fig 1. C). Azad (2001) found that total sugar increased at ambient condition during storage of mango. Mondal et al. (1995) also reported an increasing trend of total sugar of 8.1% and 23.08% on the 3rd and 12th day of storage. The increase of total sugar is due to conversion of different organic acids (Baloch & Bibi, 2012; Srinivasa et al., 2002). The total sugar content was the highest (6.56%) in control treatment and the lowest (3.63) was in unperforated polyethylene bag (Table 5). This finding was in agreement with Islam (2013) who found maximum total sugar content in control treatment. The highest total sugar content (8.07%) was found in control under ambient condition while the lowest (3.03%) was found in unperforated polyethylene bag under refrigerated condition at 9 DAS (Table 2). Thanaa and Rehab (2011) also found a high amount of total sugar in control treatment. The reason for the decrease of total sugar in unperforated polyethylene bag and at refrigerated condition is similar as described before in reducing sugar.

Table 5. Effect of different postharvest treatments on chemical traits of mango

Postharvest treatments	TSS (% Brix)			Titratable Acidity (%)			Pulp pH		
	Days after storage								
	3	6	9	3	6	9	3	6	9
T1	11.48	15.85	19.85	0.64	0.36	0.30	4.16	4.56	4.87
T2	11.67	16.60	19.20	0.65	0.33	0.27	4.07	4.65	4.70
T3	7.98	8.53	9.83	0.65	0.50	0.42	4.27	4.38	4.48
T4	11.30	15.72	19.30	0.67	0.39	0.33	4.08	4.48	4.85
T5	8.42	8.75	10.43	0.66	0.39	0.33	4.16	4.22	4.57
LSD (0.05)	0.30	0.26	0.58	0.009	0.008	0.007	0.04	0.09	0.04
LSD (0.01)	0.41	0.36	0.79	0.012	0.010	0.009	0.05	0.12	0.05
Level of significance	**	**	**	**	**	**	**	**	**

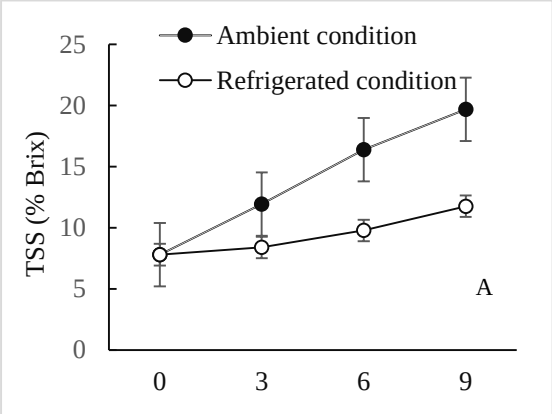
Postharvest treatments	Reducing sugar content (%)			Non-reducing sugar content (%)			Total sugar content (%)		
	Days after storage								
	3	6	9	3	6	9	3	6	9
T1	1.64	2.28	2.83	1.92	2.65	3.73	3.56	4.93	6.56
T2	1.61	2.46	2.95	1.97	2.18	3.36	3.57	4.65	6.31
T3	1.05	1.17	1.30	1.86	2.09	2.33	2.91	3.26	3.63
T4	1.75	2.20	2.57	1.63	2.61	3.86	3.38	4.81	6.43
T5	1.23	1.34	1.46	1.87	2.12	2.59	3.09	3.46	4.05
LSD (0.05)	0.23	0.08	0.05	0.23	0.13	0.11	0.12	0.10	0.09
LSD (0.01)	0.31	0.10	0.07	0.32	0.18	0.16	0.16	0.14	0.12
Level of significance	**	**	**	**	**	**	**	**	**

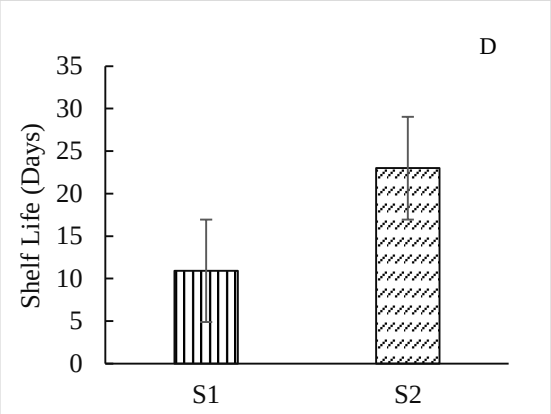
** Significant at 1% level of probability. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating, T5 = Edible oil (Soybean) coating).

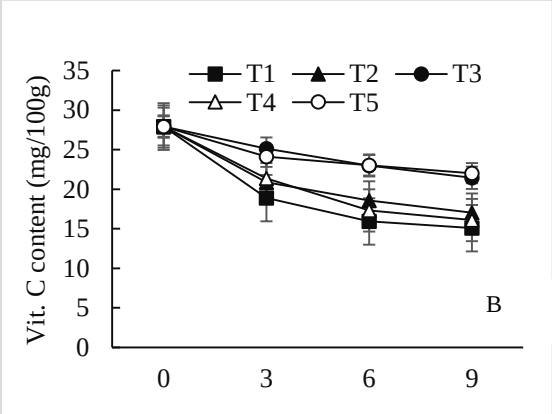
Shelf life of mango

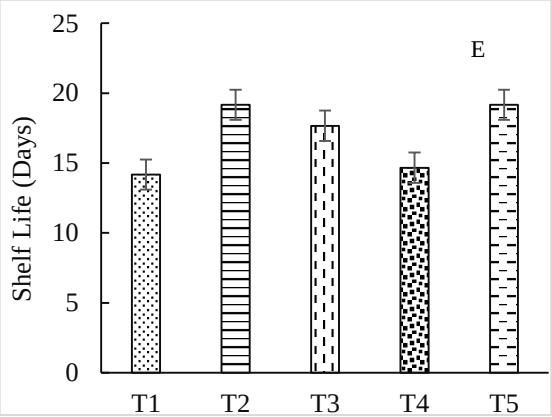
The storage conditions and postharvest treatments had a highly significant effect on shelf life extension of mango (Table 2). Refrigerated condition showed the longest shelf life (23.00 days) (Fig 1. D). The result was similar to the statement of Mondal (2000) who stated that the shelf life of mango could be increased by (4-7) weeks by storing at 13 °C. Anwari (2013) also found the longest shelf life at low temperature (12 °C) storage. Oosthuyse et al. (2000) also suggested the increase of shelf life at low-temperature storage. The longest shelf life (19.17 days) was observed in mango belonging to the treatments perforated polyethylene bag and edible oil coating whereas the shortest shelf life (14.17 days) was recorded in control fruits (Fig 1. E). Islam (2013) also stated the shortest shelf life in the control treatment. The longest shelf life (26.67 days) was observed in perforated polyethylene bag under refrigerated condition whereas the shortest shelf life (8.00 days) was recorded in control under ambient condition (Table 2). It was similar to the findings of Islam (2013) who recorded longer shelf life in perforated polyethylene bag. Barua (2003) reported the longest shelf life at low temperature (15 °C) storage.

Illeperuma et al. (2002) also stated the shelf life extension of mango stored in polyethylene bag at low temperature (13 °C). Fruits under oil coating and unperforated polyethylene bag were discarded due to development of off-flavor. This result was 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.









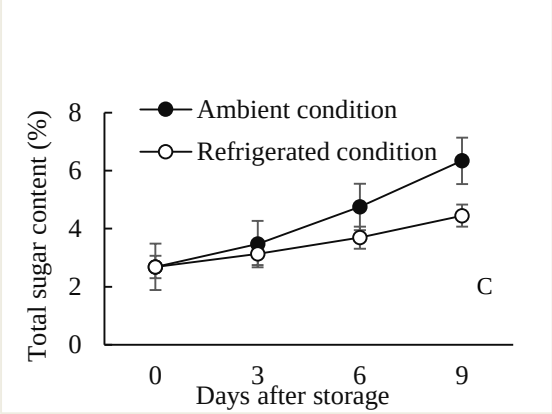


Fig. 1D: Effect of storage conditions on shelf life of mango. Bars indicate standard error. (S1 = Ambient condition, S2 = Refrigerated condition)

Fig. 1E: Effect of postharvest treatments on shelf life of mango. Bars indicate standard error. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating T5 = Edible oil (Soybean) coating).

Fig. 1A: Effect of storage conditions on total soluble solids (% Brix) of mango. Bars indicate standard error.

Fig. 1B: Effect of postharvest treatments on vitamin C content of mango. Bars indicate standard error. (T1 = Control, T2 = Perforated polyethylene bag, T3 = Unperforated polyethylene bag, T4= Chitosan coating, T5 = Edible oil (Soybean) coating).

Fig. 1C: Effect of storage conditions on total sugar content of mango. Bars indicate standard error.

Fig. 2. Pictorial view of mango under different treatments. **A:** Untreated control at ambient condition **B:** Chitosan coated mango at ambient condition **C:** Oil coated mango at ambient condition **D:** Unperforated polyethylene bag at ambient condition **E:** Perforated polyethylene bag at refrigerated condition **F:** Unperforated polyethylene bag at refrigerated condition **G:** Chitosan coated mango at refrigerated condition **H:** Oil coated mango at refrigerated condition.

CONCLUSION

Considering the findings, it might be concluded that significant variation existed due to the effect of storage conditions and postharvest treatments. The unperforated polyethylene bag under refrigerated condition mostly showed the lowest result on the basis of the data obtained from chemical analysis up to 9 DAS. But after certain days of storage, it produced off-flavor making the mangoes inedible. So, this treatment should not be recommended for storage of mango. The another propitious treatment combination, perforated polyethylene bag under refrigerated condition showed the slower change of chemical parameters resulting longest shelf life (27 days) without producing any unwanted flavor and taste. So, this treatment combination could be recommended for storage of mango.

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CONFLICT OF INTEREST

The authors have no conflict of interest to report.

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انتخاب رویکرد انبارداری کارآمد از طریق بررسی شیمیایی انبه رقم آمراپالی

مهدی حسن حافظ و موکتر حسین

چکیده:

نگرانی عمده در خصوص میزان ضایعات زیاد پس از برداشت در بنگلادش فناوری غیر موثر انبارداری است. بنابراین، با هدف بهینه سازی استراتژی انبارداری انبه این مطالعه انجام شد. انبه رقم Amrapali تحت دو شرایط نگهداری، دمای محیط و یخچال (۲ ± ۱۳ °C و ۲۰-۱۵٪ RH)، پس از پنج تیمار پس از برداشت شامل شاهد تیمار نشده، کیسه های پلی اتیلن منفذدار، کیسه های پلی اتیلن بدون منفذ، پوشش کیتوزان و روغن خوراکی (سویا) پوشش و نگهداری شدند. اثر تیمارهای پس از برداشت و شرایط انبارداری بر صفات شیمیایی بسیار معنی‌دار بود. کیسه‌های پلی اتیلنی بدون منفذ و پوشش روغن بیشترین میزان اسیدیته قابل تیتر را داشتند. بیشترین ویتامین ث (۲۲/۴۳ و ۲۲/۶۳ میلی گرم در ۱۰۰ گرم) و کمترین میزان مواد جامد محلول (۸/۹ و ۱۰ درصد) تحت شرایط یخچال حاصل شد در حالی که شاهد کمترین میزان اسیدیته قابل تیتر (۰/۱ درصد)، کمترین میزان ویتامین ث (۱۲/۵ میلی گرم در ۱۰۰ گرم) و بیشترین مواد جامد محلول (۲۷/۰۳ درصد) تحت شرایط دمای محیط در ۹ روز پس از نگهداری در انبار حاصل شد. کیسه های پلی اتیلن منفذدار و پوشش روغن نگهداری شده در شرایط یخچال موجب حفظ کیفیت خوراکی انبه تا ۹ روز پس از انبارداری شد. اما پس از تعداد روز مشخص انبارداری، کیسه‌های پلی اتیلن بدون منفذ و پوشش روغن موجب طعم نامطبوع و غیرقابل مصرف شدن انبه شد. تحقیق بیشتری با استفاده از ارقام انبه بایستی انجام شود. کیسه‌های پلی اتیلن منفذدار در شرایط یخچال موجب تغییرات کندتر در پارامترهای شیمیایی شد و به طور همزمان بیشترین ماندگاری (۲۷ روز) را بدون تولید طعم و مزه نامطلوب را موجب شد، این نشان دهنده کارایی انبار پس از برداشت بود.

کلمات کلیدی: انبار پس از برداشت کارآمد، طعم نامطبوع، ضایعات پس از برداشت، ماندگاری، ویتامین ث