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Evaluation of postharvest quality and shelf life of rose apple (*Syzygium jambos* L.) during storage

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ABSTRACT

Three rose apple accessions and five postharvest bagging treatments viz., Control (non-bag), unperforated low density polyethylene (LDPE) bag, perforated LDPE bag, unperforated brown paper bag, and perforated brown paper bag were evaluated for storage quality and shelf life of rose apple. Results showed that different postharvest treatments significantly influenced fruit quality and shelf life of rose apple. Changes in skin colour, weight loss, moisture, dry matter, vitamin C and pH of LDPE bagged fruits irrespective of perforation were slower than non-bagged control fruits during storage at ambient condition. The shelf life of fruit was counted until two weeks of storage. It was found that fruits stored in unperforated LDPE bag exhibited the longest shelf life (14.40 days) as compared to other treatments. The overall results expressed that rose apple quality can be maintained effectively at least six days using various bagging materials. However, it may conclude that unperforated LDPE bag could be used for extending storage life with maintaining external and internal qualities of rose apple.

***Keywords*: Minor fruit, packaging, postharvest, rose apple, shelf life, storage**

INTRODUCTION

Rose apple (*Syzyzium jambos* L.) locally known as *Golapjam*, is a non-climacteric tropical fruit belongs to the family Myrtaceae. It is an underutilized and neglected minor fruit in Bangladesh. It is an excellent fruit and appeals everybody for its nice rosy fragrance, good and spongy texture which is neither very soft nor very hard and very low acerbity. It is also known as plum rose, Malaya apple, Malabar plum, Yambo (Kishore *et al.*, 2016). It is native to Eastern India and a popular subtropical minor fruit which is not fully exploited. In Bangladesh, rose apple is found to grow all over the country due to its attractive fruits liked by the children or planted as an ornamental tree because of its sensational foliage and flowers. Rose apple fruit is rich sources of fat, vitamins and minerals. It contains plenty of sugars, total soluble solids, carotene and anthocyanin. Ripe fruit can be used to make rosewater. Rose apple fruit also contained different volatiles compounds (Guedes *et al.*, 2004) which are used in the cosmetic industry. The fruits are used to make jam, jelly with lemon juice added or more frequently used as flavouring agent. It is also made into syrup for use as flavour in cold drinks. However, this fruit is mostly consumed as a table purpose fruit.

Since rose apple is a non-climacteric fruit (Das *et al.*, 2011), therefore this fruit is harvested after ripen on the tree. It is very critical to retain freshness after harvest as its skin is very thin and soft textured flesh therefore moisture is quickly lost from fruits and rapidly deteriorates the quality (Plainsirichai *et al.*, 2010; Das *et al.,* 2011). As a result, growers are bond to compulsorily market this fruits on the day of harvest, but long distance marketing is a great problem due to loss of freshness. Therefore, technologies towards postharvest loss reduction are necessary in form of extending shelf-life of rose apple fruit. Reducing moisture loss from fruit surface may assist in extending postharvest life of any fruit. Vapour pressure deficit between the fruit and its surrounding atmosphere should be reduced to prevent transpiration water loss from fruit surface thus preventing weight loss and delaying shrinking. In this case modified atmosphere packaging (MAP) can be used to handle this condition to extent the storage life of rose apple. A number of researches on MAP for extending shelf life and postharvest qualities of fruits and vegetables have been done (Hassan *et al.*, 2005, Soltani *et al.*, 2015). Although low temperature storage can extend the shelf life horticultural commodities but this process is costly.

Therefore, low cost modified atmosphere packaging storage in an ambient condition could be a useful technology for extension of shelf life of rose apple by maintaining physical and biochemical traits of fruits and it may help to long time marketing. The aim of this study was to evaluate the postharvest quality and shelf life of rose apple under different packaging materials in ambient storage condition

MATERIALS AND METHODS

Experimental materials

This study was conducted during February to May 2019. Ripe fruits of three rose apple accessions were harvested from Bangladesh Agricultural University Germplasm Centre (BAU-GPC). After harvest, fruits were immediately transferred to the Postgraduate laboratory of the Department of Horticulture, BAU.

Experimental design and treatments

The two-factor experiment was carried out following completely randomized design with three replications. The study comprised of three rose apple accessions namely ACS SJ_1, ACS SJ_2, ACS SJ_3 and five postharvest packaging treatments *viz.*, T_o: Control (Non-bag), T_1: Fruit stored in unperforated low density polyethylene (LDPE) bag, T_2: Perforated LDPE bag, T_3: Unperforated brown paper bag, and T_4: Perforated brown paper bag. The perforation size was 2 cm in diameter. After application of treatments, fruits were kept on a brown paper in the laboratory floor at ambient condition. Physio-chemical changes and shelf life of fruits were investigated at different days after storage (DAS).

Fruit skin colour changes during storage was determined using numerical rating scale of 1-5, where 1= Light yellowish green, 2= Light yellow, 3=Yellow, 4= Light yellow brown, 5= Yellow brown.

Percent weight loss of fruits of each treatment was measured by using electric weighing balance. Percent total weight loss was calculated by using the following formula:

$$\%\ \text{weight loss} = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}} \times 100$$

Determination of moisture and dry matter contents

Ten grams of fruit pulp was weighed in a porcelain crucible (which was previously cleaned, dried and weighed) from each treatment and replications. The crucible was kept in electric oven at 65°C for 72 hours until the weight became constant. It was then cooled in desiccators and weighed again. Percent moisture and dry matter contents were calculated by using the formula:

$$\%\ \text{moisture content} = \frac{\text{Fresh weight of sample (g)} - \text{Dry weight of sample (g)}}{\text{Fresh weight of sample (g)}} \times 100$$

$$\%\ \text{dry matter content} = \frac{\text{Dry weight of sample (g)}}{\text{Fresh weight of sample (g)}} \times 100$$

Total Soluble Solids (TSS)

TSS content of rose apple pulp was estimated by using Abbe's refractometer (ATAGO Company Ltd., Japan). A drop of rose apple juice squeezed from the fruit pulp on the prism of the refractometer. Percent TSS was obtained from direct reading of the instrument. Temperature corrections were made by using the methods described by Ranganna (1995).

Vitamin C (Ascorbic acid)

Ascorbic acid content was determined according to the method of Plummer (1971). In brief, ten grams of fresh fruits and 70 ml 6% meta phosphoric acid solution was taken in a blender and homogenized for 2 minutes. Thereafter, it was filtered and centrifuged at about 2000 rpm for 5 minutes. The supernatant was transferred to a 100 ml volumetric flask and made up to the volume with 6% meta phosphoric acid. Five ml of the aliquot was taken in a conical flask and titrated with dye solution. Ascorbic acid content was calculated by using the following formula.

$$\text{Ascorbic acid content } (\text{mg/100g}) = \frac{\text{Titer} \times \text{Dye factor} \times \text{Volumn made up (ml)}}{\text{Volumn of extract (ml)} \times \text{Weight of sample (g)}} \times 100$$

Fruit pH

Fruit pH was determined by using a glass electrode pH meter (Senso Direct pH 110, UK).

Shelf life

Shelf life is the period of time which started from harvesting and extends up to the start of rotting of fruits. Shelf life of rose apple fruits was estimated by counting the days required to storages to retaining, optimum marketing and eating qualities.

Statistical analysis

Data obtained from this study were analyzed to find out the significance of difference among the treatments. Data on different parameters were statistically analyzed using MSTAT C Statistical Package Program. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was performed by *F*-test. The significance of difference between the pair of means was compared by least significant difference (LSD) test at the 1% and 5 % levels of probability.

RESULTS AND DISCUSSION

Changes of skin colour

Fruit skin colour is one of the important criteria to determine the quality of fruits as well as consumer acceptance. Skin colour of fruits significantly changed up to 4 days after storage (DAS) due to the influence of different rose apple accessions. It was found that fruit skin colour changed from light yellow green to yellow colour after six days of storage (Table 1). This trait is also influenced by different postharvest packaging treatments. It was noticed that the changes of skin colour were quicker in fruits under non-bag control treatment while colour changes were slower in fruits stored at unperforated brown paper bag (Table 2). In combination of rose apple accessions and packaging treatments it was observed that rapid colour change exhibited when ACS SJ_2 stored non-bag control treatment and the minimum colour change found in treatment combination of ACS SJ_1 stored in unperforated brown paper bag (Table 3). Charoenchongsuk *et al.* (2015) reported that skin colour changes during ripening of fruits due to alteration of chlorophyll. Chlorophyll degradation is a key factor of changes in pigment compassion that typically occur in fruit peel at the onset of ripening.

Weight loss

The variation in percentage of total weight loss was highly significant due to the effects of different accessions of rose apple at different days of storage. It was observed that fruit weight loss was faster in ACS SJ_2 while it was slower in ACS JS_1 during the entire storage period (Fig. 1a). Postharvest packaging treatments exerted significant effects on weight loss of fruits. Results showed that percent weight loss of fruits was steady during storage period under perforated and unperforated LDPE bag treatments. Fruit weight loss was accelerated in non-bag control treatment followed by perforated brown paper bag (Fig. 2b). The combined effects showed significant influence on total weight loss of fruits during storage. The rate of weight of loss was the fastest in ACS SJ_2 when stored in non-bag control treatment. In contrast, the changes were the slowest in ACS SJ_1 held in unperforated LDPE bag (Table 4). Plainsirichai *et al.* (2014) reported that coating the fruits of rose apple cv. Tabtim Chan with 2% chitosan and stored at an ambient temperature of 30°C resulted in significantly less weight loss, disease incidence and significantly higher fruit firmness compared to the control at day 5 of storage. In this study, we noticed that weight loss of rose apple fruits was the slowest from unperforated LDPE bagged fruits. Hagenmaier (2000) and Rojas *et al.* (2002) reported that texture and strength of citrus improved when fruit was coated, while uncoated fruits turn soft with the passage of storage duration. While Tefera *et al.* (2007) stated that the minimum weight losses occurred in unperforated LDPE bag wrapping fruits. They reported that polythene bag significantly reduced weight loss due to the inhibition of transpiration.

Table 1: Effects of different accessions on changes of skin colour at different days after storage

Accessions	Fruit skin colour change at different DAS			
	0	2	4	6
ACS SJ_1	1.00	1.62	2.22	3.02
ACS SJ_2	1.00	1.70	2.24	3.04
ACS SJ_3	1.00	1.70	2.18	3.03
$LSD_{0.05}$	-	0.03	0.04	0.05
$LSD_{0.01}$	-	0.04	0.05	0.07
Level of significance	ND	**	*	NS

** & * indicates significant at 1% & 5% levels of probability, NS = Not significant, ND= Statistical analysis not done

Table 2: Effects of postharvest packaging treatments on changes of skin colour at different days after storage

Postharvest treatments	Fruit skin colour change at different DAS			
	0	2	4	6
T_0:Control (Non-bag)	1.00	2.13	3.40	5.00
T_1:Unperforated LDPE bag	1.00	2.08	2.59	3.28
T_2:Perforated LDPE bag	1.00	2.15	2.36	2.57
T_3:Unperforated brown paper bag	1.00	1.00	1.50	2.13
T_4:Perforated brown paper bag	1.00	1.00	1.21	2.15
$LSD_{0.05}$	-	0.04	0.05	0.06
$LSD_{0.01}$	-	0.05	0.07	0.09
Level of significance	ND	**	**	**

** indicates significant at 1% level of probability, ND= Statistical analysis not done

Table 3: Combined effects of postharvest packaging treatments and accessions on changes of skin colour at different days after storage

Treatment combinations		Fruit skin colour change at different DAS			
		0	2	4	6
T_0: Control(Non-bag)	ACS SJ_1	1.00	2.00	3.25	5.00
	ACS SJ_2	1.00	2.21	3.58	5.00
	ACS SJ_3	1.00	2.17	3.38	5.00
T_1: Unperforated LDPE bag	ACS SJ_1	1.00	2.00	2.66	3.21
	ACS SJ_2	1.00	2.08	2.56	3.25
	ACS SJ_3	1.00	2.17	2.54	3.38
T_2: Perforated LDPE bag	ACS SJ_1	1.00	2.12	2.50	2.66
	ACS SJ_2	1.00	2.19	2.21	2.56
	ACS SJ_3	1.00	2.15	2.37	2.50
T_3: Unperforated brown paper bag	ACS SJ_1	1.00	1.00	1.17	2.00
	ACS SJ_2	1.00	1.00	1.50	2.21
	ACS SJ_3	1.00	1.00	1.40	2.17
T_4:Perforated brown paper bag	ACS SJ_1	1.00	1.00	1.60	2.21
	ACS SJ_2	1.00	1.00	1.25	2.17
	ACS SJ_3	1.00	1.00	1.20	2.08
$LSD_{0.05}$		-	0.07	0.09	0.11
$LSD_{0.01}$		-	0.10	0.12	0.15
Level of significance		ND	**	**	**

** indicates significant at 1% level of probability, ND= Statistical analysis not done

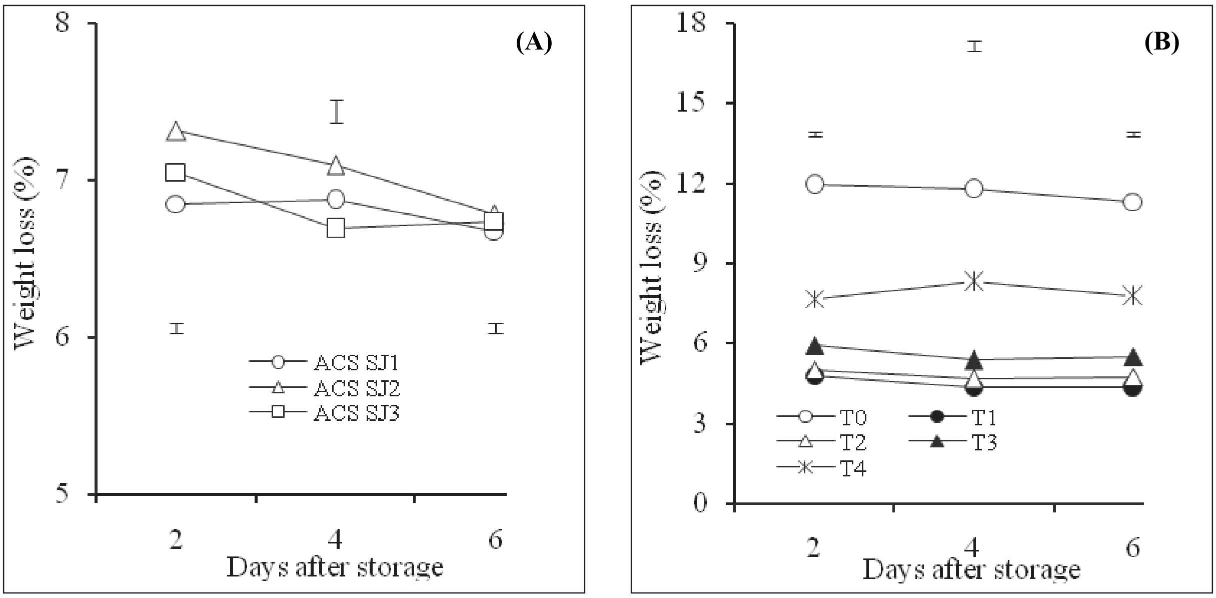

Fig. 1: Effects of rose apple accessions (A) and postharvest treatments (B) on weight loss at different days after storage. Vertical bars represent LSD at 1% level of significance. T_0: Control (Non-bag), T_1: Unperforated LDPE bag, T_2: Perforated LDPE bag, T_3: Unperforated brown paper bag, T_4: Perforated brown paper bag.

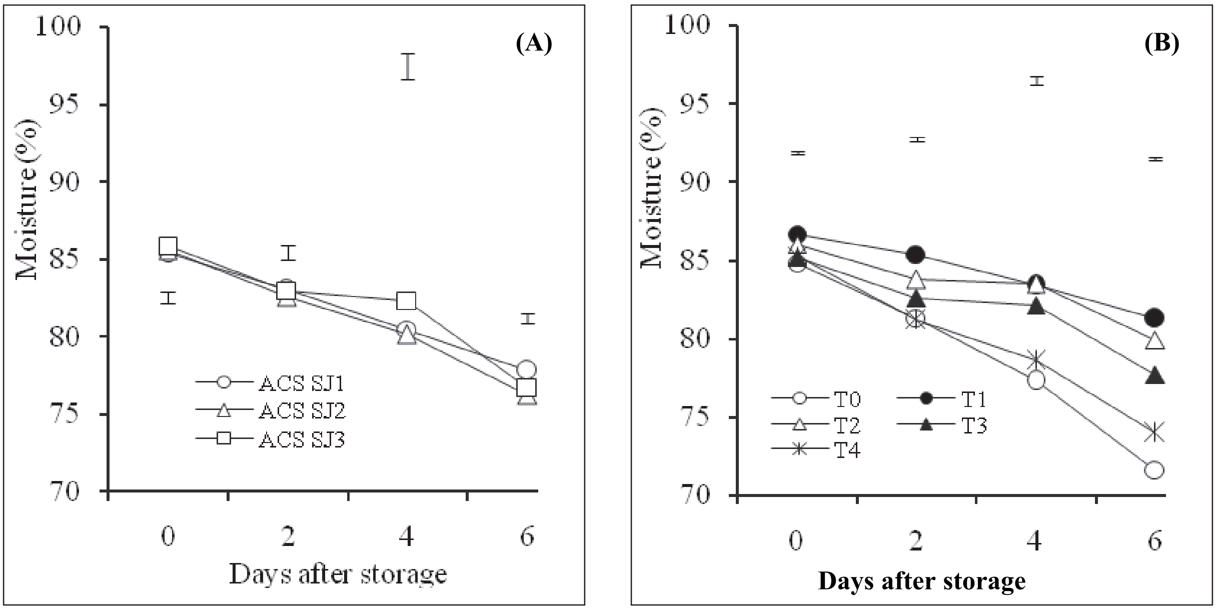

Fig. 2: Main effects of rose apple accessions (A) and postharvest treatments (B) on moisture content at different days after storage. Vertical bars represent LSD at 1% level of significance. T_0: Control (Non-bag), T_1: Unperforated LDPE bag, T_2: Perforated LDPE bag, T_3: Unperforated brown paper bag, T_4: Perforated brown paper bag.

Moisture content

Reduction of moisture content of rose apple during storage varied significantly due to the influence of different accessions. It was found that, all of the accessions lost moisture content during storage and this trend was faster in case of ACS SJ_2 fruits which lost 9.31% moisture while ACS SJ_1 lost 7.61% (Fig. 2a). Postharvest packaging treatments exerted significant effects on depletion of percentage of moisture content in fruits during storage. It is noticed that moisture content in fruits sharply declined when it was stored in non-bag

Table 4: Combined effects of postharvest packaging treatments and accessions on percent of weight loss and moisture content at different days after storage

Treatment combinations		Initial weight (gm)	Weight loss (%) at different DAS			Moisture (%) at different DAS			
			2	4	6	0	2	4	6
T_0: Control (Non-bag)	ACS SJ_1	16.90	11.30	12.01	11.43	82.99	80.70	76.38	72.06
	ACS SJ_2	18.25	11.49	12.98	12.51	86.00	81.25	77.52	71.25
	ACS SJ_3	17.98	10.98	10.32	11.98	85.48	82.05	77.98	71.56
T_1: Unperforated LDPE bag	ACS SJ_1	19.08	4.08	4.12	4.43	87.49	85.98	83.58	81.86
	ACS SJ_2	18.50	4.38	4.57	4.97	87.01	86.02	83.87	80.92
	ACS SJ_3	20.03	4.56	4.38	4.98	85.46	84.15	82.79	81.06
T_2: Perforated LDPE bag	ACS SJ_1	21.02	4.51	4.32	5.13	85.46	83.25	81.83	80.48
	ACS SJ_2	18.02	4.65	4.71	4.93	86.68	83.86	79.62	79.36
	ACS SJ_3	19.00	5.04	4.92	5.02	85.88	84.17	89.00	80.02
T_3: Unperforated brown paper bag	ACS SJ_1	17.89	6.01	5.43	6.14	86.14	84.25	82.68	79.83
	ACS SJ_2	18.50	5.38	5.16	5.43	84.34	81.23	81.69	76.32
	ACS SJ_3	21.00	5.12	5.46	6.23	85.13	82.38	82.05	77.08
T_4:Perforated brown paper bag	ACS SJ_1	19.50	6.73	7.06	6.95	84.86	80.92	77.83	74.68
	ACS SJ_2	18.90	8.35	9.47	9.25	83.65	80.48	78.02	73.28
	ACS SJ_3	19.75	7.02	8.35	7.98	87.43	82.17	79.88	74.05
$LSD_{0.05}$		-	0.19	0.45	0.19	0.56	0.69	1.23	0.50
$LSD_{0.01}$		-	0.26	0.61	0.26	0.76	0.93	1.66	0.67
Level of significance		ND	**	**	**	**	**	**	**

** indicates significant at 1% level of probability, ND= Statistical analysis not done

control (13.21%) and perforated brown paper bag (11.31%), respectively. The retention of moisture content was higher when fruits were stored in LDPE bag and unperforated brown paper bag (Fig. 2b). The loss of moisture content from fruits was higher when ACS SJ_2 stored in non-bag condition (14.75%) and the retention of moisture was higher when ACS SJ_3 fruits stored in unperforated LDPE bag which lost only 4.4% moisture during storage (Table 4). Naik *et al.* (1993) reported that polythene bag plays an important role in quality maintenance by slowing down the biochemical changes and reducing the moisture loss in fresh produces.

Dry matter content

Percentage of dry matter content of rose apple varied significantly among the accessions. It was observed that dry matter content increased as storage duration progressed. At 6th day of storage, fruits of ACS SJ_2 had the highest dry matter content (23.77%), while it was the lowest (22.22%) in ACS SJ_1 (Fig. 3a).

Different postharvest packaging treatments exerted significant influences on percentage of dry matter content in fruits during storage. At 6th day of storage, results revealed that dry matter content was the highest (28.38 %) in rose apple held in non-bag control treatment. On the other hand, it was the lowest (18.72%) in unperforated LDPE bag treatment (Fig. 3b). The combined effects of packaging treatments and accessions was also significant on dry matter content of rose apple. The maximum dry matter content (28.75%) was estimated in ACS SJ_2 under non-bag control treatment and the minimum (18.14%) recorded in ACS SJ_1under unperforated LDPE bag treatment (Table 5).

Vitamin C (Ascorbic acid)

Vitamin C content of different accessions of rose apple declined with storage duration. However, at 6th day of storage, ACS SJ_3 contained highest vitamin C (17.30mg/100g) while ACS SJ_2 contained the lowest (14.86mg/100g) (Fig. 4a). Postharvest packaging treatments showed significant influences on vitamin C contents of rose apple during storage. Vitamin C content was reduced as storage period progressed in case of all packaging treatments. The reduction trend of vitamin C was faster in non-bagged control fruits

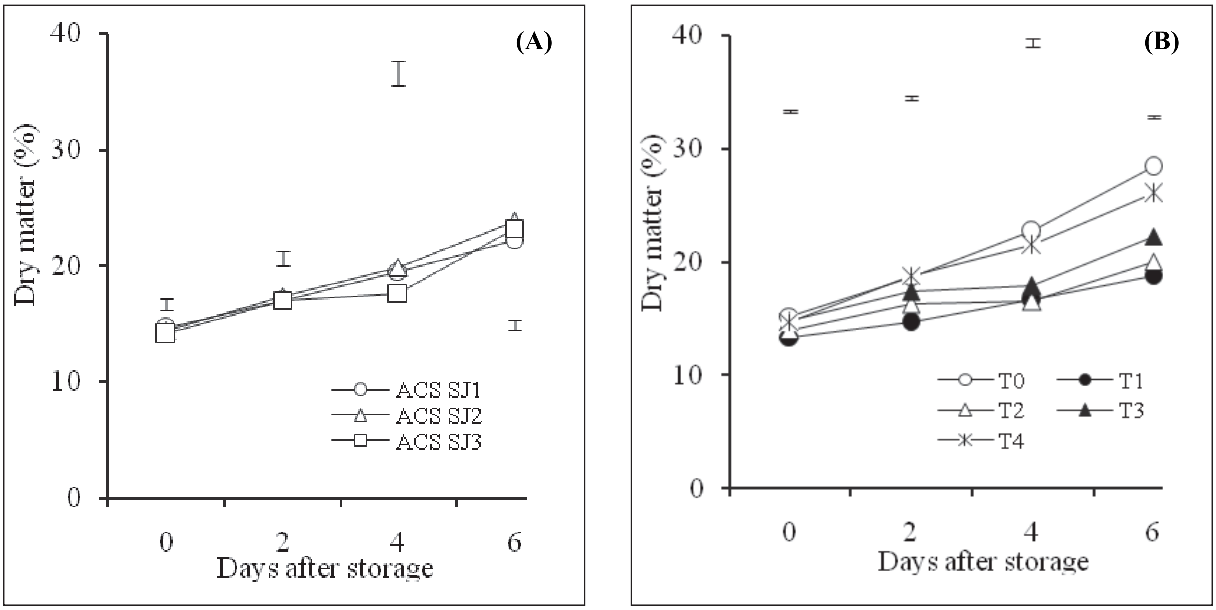

Fig. 3: Main effect of rose apple accessions (A) and postharvest treatments (B) on dry matter contents at different days after storage. Vertical bars represent LSD at 1% level of significance. T_0: Control (Non-bag), T_1: Unperforated LDPE bag, T_2: Perforated LDPE bag, T_3: Unperforated brown paper bag, T_4: Perforated brown paper bag.

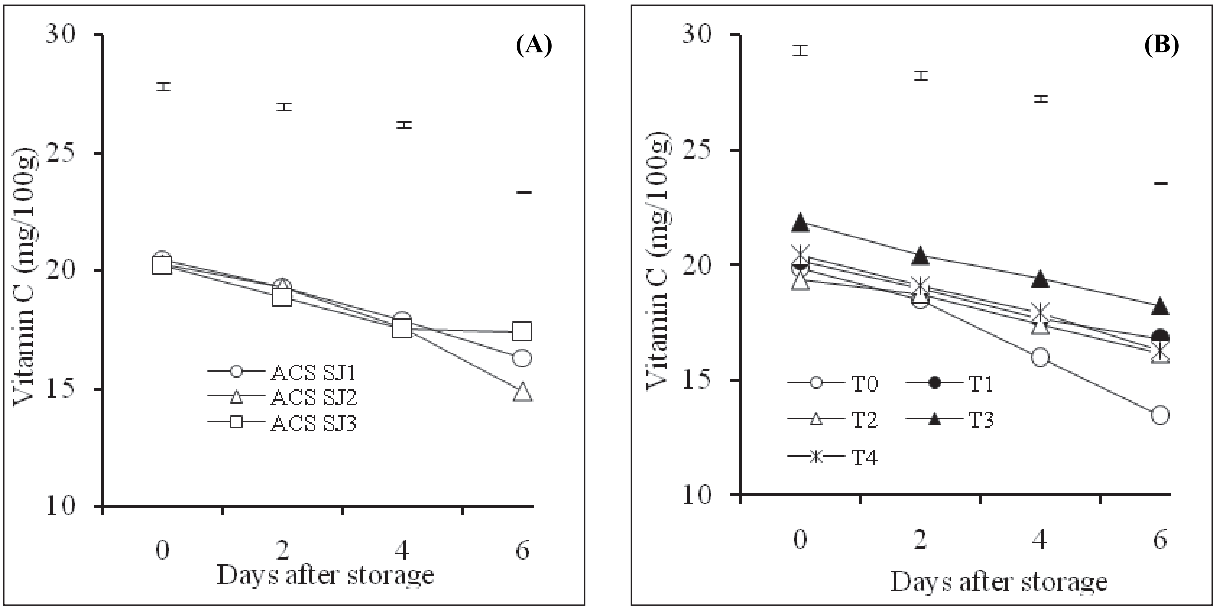

Fig. 4: Main effects of rose apple accessions (A) and postharvest treatments (B) on vitamin C contents at different days after storage. Vertical bars represent LSD at 1% level of significance. T_0: Control (Non-bag), T_1: Unperforated LDPE bag, T_2: Perforated LDPE bag, T_3: Unperforated brown paper bag, T_4: Perforated brown paper bag.

while it was slower in unperforated brown paper bagged fruits (Fig. 4b). The combined effects were also significant in relation to vitamin C contents. At 6^{th} day of storage, the highest vitamin C (19.73 mg/100 g) was found in ACS SJ_3 treated with unperforated brown paper bag. In contrast, the amount of vitamin C (12.18 mg/100 g) was the lowest in ACS SJ_2 held in non-bag control condition (Table 5). Das *et al.* (2011) reported that ascorbic acid contents in rose apple increase up to two months after fruit set thereafter decreased as fruit become mature and start ripening.

Table 5: Combined effects of postharvest packaging treatments and accessions on dry matter and vitamin C contents at different days after storage

Treatment combinations		Dry matter (%)				Vitamin C (mg/100g)			
		at different DAS							
		0	2	4	6	0	2	4	6
T_0: Control(Non-bag)	ACS SJ_1	17.01	19.30	23.62	27.94	21.80	20.75	18.02	13.57
	ACS SJ_2	14.00	18.75	22.48	28.75	20.00	18.39	15.19	12.18
	ACS SJ_3	14.52	17.95	22.02	28.44	17.70	16.32	14.65	14.59
T_1: Unperforated LDPE bag	ACS SJ_1	12.51	14.02	16.42	18.14	19.50	18.02	16.28	17.25
	ACS SJ_2	12.99	13.98	16.13	19.08	20.00	19.13	18.29	15.05
	ACS SJ_3	14.54	15.85	17.21	18.94	21.00	19.85	18.35	17.95
T_2: Perforated LDPE bag	ACS SJ_1	14.54	16.75	18.17	19.52	18.00	17.57	16.00	16.45
	ACS SJ_2	13.32	16.14	20.38	20.64	20.50	20.02	18.85	15.02
	ACS SJ_3	14.12	15.83	11.00	19.98	19.50	18.59	17.32	16.95
T_3: Unperforated brown paper bag	ACS SJ_1	13.86	15.75	17.32	20.17	21.00	20.05	19.89	18.05
	ACS SJ_2	15.66	18.77	18.31	23.68	20.50	19.25	18.25	16.95
	ACS SJ_3	14.87	17.62	17.95	22.92	24.01	21.93	20.15	19.73
T_4:Perforated brown paper bag	ACS SJ_1	15.14	19.08	22.17	25.32	22.10	20.13	19.25	16.12
	ACS SJ_2	16.35	19.52	21.98	26.72	20.22	19.63	17.39	15.08
	ACS SJ_3	12.57	17.83	20.12	25.95	18.90	17.59	17.02	17.65
$LSD_{0.05}$		0.56	0.69	1.23	0.50	0.48	0.39	0.33	0.75
$LSD_{0.01}$		0.76	0.93	1.66	0.67	0.64	0.54	0.44	1.00
Level of significance		**	**	**	**	**	**	**	**

** indicates significant at 1% level of probability

Total soluble solids (TSS)

The difference in respect of TSS was found to be statistically significant during storage period of different accessions of rose apple. At 6th day of storage, ACS SJ_2 showed the highest TSS (11.87%) and ACS SJ_3 retain the lowest TSS (11.60 %) (Table 6). Postharvest packaging treatments also exerted significant effects on TSS content of rose apple during storage. Results showed that the TSS content was the maximum in unperforated LDPE bag. On the other hand, the value was the minimum in unperforated brown paper bag (Table 7). The combined effects were significant in relation to TSS content of fruit. The amount of TSS of rose apple fruit was higher (12.41%) in ACS SJ_2 when stored in unperforated LDPE bag. In contrast, the amount of TSS was lower (10.64%) in both ACS SJ_2 and ACS SJ_3 under unperforated brown paper bag (Table 8). TSS of fruits is increased as acidity decrease throughout the maturity of rose apple fruit (Das *et al*., 2011). Although internal quality of non-climacteric fruit did not change much but in our study we observed that at 6th day of storage, rose apple of ACS SJ_2 stored in unperforated LDPE bag showed higher level of TSS (12.41%) and ACS SJ_2 and ACS SJ_3 under unperforated brown paper bag showed lower TSS (10.64%). Caner *et al.* (2008) noticed that fruit TSS did not changed much during storage under modified atmosphere packaging.

Fruit pH

Fruit pH was slightly decreased during storage. Different accessions of rose apple exhibited significant effects on pH content of fruit during storage. Among the accessions, the reduction of pH was higher in ACS SJ_1 and lower in ACS SJ_2 (Table 6). Postharvest packaging treatments exerted significant effects on reduction pH of rose apple during storage. The reduction trend was higher in non-bag control treatment as compared to bagged fruits. The minimum pH was reduced in perforated LDPE and unperforated brown paper bagged fruits (Table 7). The combined effects of rose apple accessions and postharvest treatments were significant in relation to pH content of fruit. At 6th day of storage, pH was the higher in ACS SJ_1 held in unperforated brown paper bag (5.62). In contrast, the amount of pH was lower in ACS SJ_3 treated with the control treatment (5.21) (Table 8). Caner *et al*. (2008) reported that fruit pH did not change during storage under different bagging treatments rather reduced reading recorded at the end of day 6 of storage. They also stated that fruit pH did not changed much during storage under modified atmosphere packaging.

Shelf life

Rose apple accessions performed slightly different in respect of shelf life. The longest shelf life was observed in ACS SJ_3 (10.46 days) followed by ACS SJ_2 (10.18 days) and the shortest shelf life was observed in ACS SJ_1 (10.00 days) (Table 6). Postharvest packaging treatments significantly influenced shelf life of rose apple. The longest shelf life (14.20 day) was found in fruits stored in unperforated LDPE bag followed by perforated LDPE bag (12.17 days), un perforated brown paper bag (10.23 days), perforated brown paper bag (8.23 days) and the lowest (6.23 day) in non-bag control treatments (Table 7). The combined effects of accessions and postharvest packaging treatments showed highly significant variations in respect of shelf life of fruits. The highest shelf life (14.40 days) was recorded in ACS SJ_3 stored in unperforated LDPE bag followed by the different accessions stored in perforated LDPE bag, unperforated brown paper bag, perforated brown paper bag, respectively and the lowest shelf life (6.00 days) was observed in ACS SJ_1 stored in non-bag control treatment (Table 8). LDPE bag restrict water loss from fruit which maintained internal and external qualities of fruit compared to control. Plainsirichai *et al.* (2010) reported that fruits treated with 1-MCP extended shelf life of rose apple. Fruit coating with 2% chitosan also increased shelf life of rose apple (Plainsirichai *et al*., 2014).

Table 6: Main effect of rose apple accessions on TSS, pH and shelf life at different days after storage

Accessions	TSS (%)				pH				Shelf life
	at different DAS								(days)
	0	2	4	6	0	2	4	6	
ACS SJ_1	11.37	11.27	11.60	11.71	5.58	5.51	5.47	5.43	10.00
ACS SJ_2	11.24	11.51	11.59	11.87	5.45	5.42	5.41	5.40	10.18
ACS SJ_3	11.07	11.35	11.51	11.60	5.45	5.41	5.40	5.38	10.46
$LSD_{0.05}$	0.17	0.14	0.05	0.07	0.04	0.05	0.05	0.04	0.03
$LSD_{0.01}$	0.23	0.19	0.07	0.10	0.05	0.07	0.07	0.06	0.05
Level of significance	**	**	**	**	**	**	**	**	**

** indicates significant at 1% level of probability

Table 7: Main effect of postharvest treatments on TSS, pH and shelf life at different days after storage

Postharvest treatments	TSS (%)				pH				Shelf life
	at different DAS								(days)
	0	2	4	6	0	2	4	6	
T_0:Control (Non-bag)	11.42	11.39	11.92	11.78	5.60	5.41	5.47	5.34	6.23
T_1:Unperforated LDPE bag	11.68	11.74	11.92	11.88	5.51	5.45	5.41	5.38	14.20
T_2:Perforated LDPE bag	10.11	10.60	10.81	11.65	5.46	5.43	5.40	5.38	12.17
T_3:Unperforated brown paper bag	11.19	11.36	11.40	11.50	5.50	5.48	5.45	5.42	10.23
T_4:Perforated brown paper bag	11.73	11.78	11.78	11.81	5.38	5.41	5.37	5.43	8.23
$LSD_{0.05}$	0.22	0.18	0.07	0.10	0.05	0.06	0.06	0.06	0.04
$LSD_{0.01}$	0.30	0.24	0.10	0.13	0.07	0.09	0.09	0.08	0.06
Level of significance	**	**	**	**	**	**	*	*	**

** and * indicates significant at 1% and 5% levels of probability

Table 8: Combined effects of postharvest treatments and accessions on TSS, pH and shelf life at different days after storage

Treatment combinations		TSS (%) at different DAS				pH at different DAS				Shelf life (days)
		0	2	4	6	0	2	4	6	
T_0: Control (Non-bag)	ACS SJ_1	11.25	10.12	11.50	11.45	5.83	5.75	5.62	5.56	6.0
	ACS SJ_2	12.00	12.16	12.24	12.09	5.65	5.58	5.54	5.49	6.2
	ACS SJ_3	11.00	11.90	12.01	11.80	5.32	5.28	5.25	5.21	6.5
T_1: Unperforated LDPE bag	ACS SJ_1	11.40	11.47	11.68	11.52	5.49	5.35	5.31	5.29	14.0
	ACS SJ_2	12.40	12.42	12.38	12.41	5.34	5.31	5.29	5.27	14.2
	ACS SJ_3	11.25	11.32	11.69	11.72	5.71	5.69	5.63	5.59	14.4
T_2: Perforated LDPE bag	ACS SJ_1	10.80	10.98	11.06	11.56	5.35	5.31	5.29	5.26	12.0
	ACS SJ_2	8.96	9.98	10.32	11.82	5.39	5.35	5.31	5.30	12.0
	ACS SJ_3	10.56	10.83	11.06	11.58	5.65	5.62	5.61	5.59	12.5
T_3: Unperforated brown paper bag	ACS SJ_1	11.00	11.34	11.38	11.63	5.67	5.65	5.64	5.62	10.0
	ACS SJ_2	12.11	10.58	12.21	10.64	5.43	5.41	5.38	5.35	10.2
	ACS SJ_3	10.56	12.17	10.62	10.64	5.39	5.38	5.33	5.31	10.5
T_4:Perforated brown paper bag	ACS SJ_1	12.40	12.43	12.40	12.37	5.54	5.51	5.48	5.42	8.0
	ACS SJ_2	12.38	12.39	12.37	12.39	5.42	5.38	5.32	5.30	8.3
	ACS SJ_3	10.41	10.51	10.58	10.66	5.18	5.35	5.31	5.29	8.4
$LSD_{0.05}$		0.39	0.32	0.12	0.17	0.09	0.11	0.11	0.10	0.07
$LSD_{0.01}$		0.52	0.43	0.17	0.23	0.12	0.15	0.15	0.14	0.10
Level of significance		**	**	**	**	**	**	**	**	**

** indicates significant at 1% level of probability

Conclusion

This study suggests that fruit quality and shelf life can be improved significantly by bagging fruits in unperforated LDPE bag compared to non-bag control fruits. From the above results it was found that the postharvest treatments caused significant effects on colour, weight loss, moisture, dry matter, vitamin C, TSS, pH and shelf life of rose apple. LDPE bag treated fruits gave the superior result in relation to the reduction of weight loss, vitamin C compared to other treatments, and which ultimately resulted in prolonged shelf life of rose apple. Therefore, it can be summarized that LDPE bag could be useful for storage of rose apple for at least two weeks after harvesting.

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