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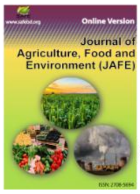

Original Article

Postharvest quality and shelf life of dragon fruit (*Hylocereus* spp.) as influenced by preharvest fruit bagging materials

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Dry matter content, flesh-peel ratio, peel thickness, pH, TSS, dragon fruit

A B S T R A C T

This research was conducted at the Bangladesh Agricultural University Germplasm Centre (BAU-GPC), Mymensingh during the period from May 2018 to September 2019 with a view to determine the effect of preharvest fruit bagging materials as well as variety on the yield, postharvest qualities and shelf life of dragon fruit. The two-factor experiment was comprised of two varieties *viz.*, V_1: BAU dragon fruit-1 (White flesh) and V_2: BAU dragon fruit-2 (Red flesh) and five bagging materials *viz.*, T_0: non-bag (Control), T_{CB}: cloth bag, T_{BB}: brown paper bag, T_{BP}: black polythene bag and T_{WP}: white polythene bag. The experiment was laid out in a randomized complete block design with three replications. Results showed that fruit bagging with black polythene bag significantly improved fruit fresh weight (287.47 g), fruit diameter (7.91 cm), peel-flesh ratio (5.97), total dry weight (61.33 g/fruit), reduced days to maturity (22 days) and peel weight (48.11 g) of BAU dragon fruit-1 while black polythene bag extended shelf life (12.05 days), increased total soluble solids (TSS) (14.40%) and reduced peel thickness (0.21 cm) of BAU dragon fruit-2. From the findings of this study, it can be stated that preharvest fruit bagging with black polythene bag would be the best option as bagging material to improve the yield, postharvest quality and shelf life of dragon fruit.

Introduction

Dragon fruit is considered as one of the most beautiful fruits of Cactaceae family with its light red skin stubbed with green scales and white, pink as well as red flesh with tiny black seeds. Dragon fruit (*Hylocereus* spp.) is a sprawling or vine, terrestrial or epiphytic cactus which has received worldwide recognition, first as an ornamental plant and then a fruit crop (Britton *et al.*, 1963). The common names of dragon in english included pitahaya, night blooming cereus, strawberry pear, Belle of the night, Cinderella plant and Jesus in the Cradle (Martin *et al.*, 1987). The flower is so beautiful that it is nick named as Nobel women, Queen of the night or the Moonflower. The creamy pulp with edible seeds has a very delicate aroma.

Dragon fruit is one of the most nutritious fruits that increase the digesting power. Besides, it has the ability to control obesity, cancer, diabetes, high cholesterol as well as high blood pressure. Dragon fruit contains substances that regulate and maintain the blood sugar level within the body. High antioxidant levels in the fruit prevent free radicals from attacking the body. Harmful cancer cells are eliminated in a natural way without any side effects. Regular consumption of the dragon fruit has been known to alleviate asthma and chronic cough in both children and adults. Dragon fruit may help to maintain eye health as well (Barbeau, 1993).

Although dragon fruit is a heat loving crop, it can be damaged by long periods of intense sun and heat, resulting in sunscald. Bagging is the best option for protecting dragon fruit from sunburn and fruit cracking. Dragon fruit may also attract ants, beetles and fruit flies. These insects can also hamper the production of this fruit. Dragon fruits are also damaged by birds severely when it's getting mature. Due to various fungi, insects and birds attack, the superior fruit size as well as skin color is not possible get properly thus infested fruits are not generally sold in the market.

Bagging is a physical protection technique, commonly applied to many fruits, which not only improves their visual quality by promoting peel coloration and reducing the incidence of fruit cracking and rusting, but can also change the micro environment for fruit development, which can have multiple effects on internal fruit quality (Son and Lee, 2008). Bagging has been extensively used in several fruit crops to improve skin color (Amarante *et al.*, 2002) and to reduce the incidence of disease (Kitagawa *et al.*, 1992), insect pests (Bentley *et al.*, 1992), mechanical damage, sunburn of the skin and bird damage to increase market value (Hofman *et al.*, 1997).

Due to its many beneficial effects, fruit bagging has become an integral part of different fruits cultivation in many countries of the world. Now-a-days, fruit bagging has been an eco-friendly practice in many kind of fruits in Bangladesh such as mango (Hossain *et al.*, 2020; Islam *et al.*, 2020; Akter *et al.*, 2020), guava (Rahman *et al.*, 2018), banana (Rubel *et al.*, 2019), papaya, citrus etc. However, very limited information is available on the effect of different bagging materials on dragon fruit production in Bangladesh. Therefore, this study was undertaken to investigate the effect of preharvest fruit bagging materials on the yield, postharvest quality and shelf life of dragon fruit.

Materials and Methods

Experimental site and plant materials

The experiment was conducted at the Bangladesh Agricultural University Germplasm Centre (BAU-GPC), Mymensingh, during the period from May 2018 - September 2019. The experimental site is situated between 24.46°N latitude and 90.24°E longitude and having altitude of 18m from sea level. The soil of the experimental area is sandy loam type and belonging to the old Brahmaputra Flood Plain Alluvial Tract of AEZ 9 having non calcareous dark grey flood plain soil. The selected area was a medium high land. The land was well drained, fertile and slightly acidic with p^H ranges from 5.4 to 6.7. During the study period the average maximum and minimum temperature as well as relative humidity were 34.01°C, 25.30°C and 85.61%, respectively.

Experimental design and treatments

The two-factor experiment was conducted following Randomized Complete Block Design (RCBD) with three replications. The experimental treatments were comprised of two varieties dragon fruit *viz.*, V_1: BAU dragon fruit-1 (White flesh) and V_2: BAU dragon fruit-2 (Red flesh) and five different types of bagging materials *viz.*, T_0: non-bag (Control), T_{CB}: cloth bag, T_{BB}: brown paper bag, T_{BP}: black polythene bag and T_{WP}: white polythene bag.

Ten fruits for each treatment and variety were properly covered with bagging materials and ten similar aged fruits were kept open as control. Fruit bagging was executed at 15 days after fruit setting (DAFS) with different bagging materials. A small portion of two corners of each bag was cut off in order to prevent water deposition inside the bag. Bags were firmly fixed with the help of rope so that water and insects could not enter in it. Fruits were harvested at full mature stages. Five fruits were randomly selected from each replication of each treatment and analyzed to determine days to maturity (days), fruit length (cm), diameter (cm), fresh weight (cm), flesh weight (g), peel weight (g), thickness of peel (cm), flesh-peel ratio, edible rate (%).

Determination of moisture and dry matter content

Fifty grams (50 g) of fresh fruit sample from each treatment was taken and cut into small pieces on an aluminum foil and oven dried at 70^0C until the constant weight was attained. Percent moisture content was calculated according to the following formula:

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

% dry matter content was calculated as % dry matter content =100 - %moisture content

Determination of fruit pH

The pH of dragon fruit was determined by using an electric pH meter. The pH meter was calibrated with the help of a buffer solutions (pH: 4.0, pH: 7.0) according to the method described by Ranganna (1994). Samples of 10 g fresh flesh was homogenized in 10 ml de-ionized water pH 7.0 and the flesh of homogenate was measured with the pH meter.

Determination of Total Soluble Solids (%)

Total soluble solids (TSS) content of dragon fruit was estimated by using Abbe's Refractometer (ATAGO Company Ltd., Japan). A drop of dragon fruit juice was squeezed from the fruit flesh and taken into the prism of refractometer and % TSS was recorded from the direct reading of the instrument. Temperature correction was made using the temperature correction chart.

Shelf life (days)

After recording morphological and other traits of fruits for each bagging treatment and variety, fruits were stored in the postgraduate laboratory of the Department of Horticulture at ambient condition (30±2^{0}C) to observed the storage duration. The shelf life of fruits was counted from the date of harvesting to the last edible stage.

Statistical analysis

The collected data on various parameters were statistically analyzed using MSTATC statistical package program. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was compared by least significant difference (LSD) test at 5% and 1% levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Days to fruit maturity: The duration from fruit setting to maturity is a critical criterion for any fleshy fruit. Early maturity allows early harvesting of fruits which expedite early marketing. In this study we applied various bagging materials for bagging fruits at half-way of fruit development. Result showed that there was no significant difference on days required to fruit maturity of both the varieties (Table 1). Tran *et al.* (2015) noticed that ripening duration was not significantly different among the dragon fruit varieties. But different fruit bagging materials exhibited significant role on the duration of fruit maturity. The shortest duration (22.1 days) was required to fruit mature under black polythene bagged fruits while the longest time (27.16 days) required to fruit mature in cloth bag and brown paper bag (Table 2).

The combined effect of variety and bagging materials had a significant impact on days required to fruit maturity of dragon fruit. The shortest days to maturity (22.00 days) was found when BAU dragon fruit-1 was bagged with black polythene bag followed by BAU dragon fruit-2 bagged with black polythene bag (22.33 days) (Table 3). This earliest maturity might be due to the increased temperature and as a result the early enzymatic activity in fruit inside the black polythene bag (Mallik *et al.*, 2018). The longest days to maturity (27.66 days) was obtained from BAU Dragon fruit-1 bagged with cloth bag preceded by BAU Dragon fruit-1 bagged with brown paper bag (27.33 days) (Table 3). Slow ripening due to aeration in cloth bag and improper light and temperature in brown paper bag delayed maturity (Yang *et al.*, 2009). In another report, Amarante *et al.* (2002) noticed that preharvest fruit bagging in pear fruit did not affect the duration of fruit maturity. Johns and Scott (1989) claimed that bagging reduced the time to maturity in bananas significantly. In contrast, Ju (1998) noticed that bagging did not affect time to fruit maturity for Delicious apples.

Fruit length: It was observed that fruit length of two varieties was significantly different (Table 1). The higher fruit length (10.62 cm) was obtained from BAU Dragon fruit-1 while BAU dragon fruit-2 produced the lower fruit length (9.08 cm) (Table 1). Fruit length of dragon fruit was also significantly influenced by different bagging materials (Table 2). The maximum fruit length (10.90 cm) obtained from black polythene bagged while the minimum fruit length (8.50 cm) was recorded from brown paper bagged fruit. There was a significant influence observed due to combined effects of variety and bagging materials on fruit length. The highest fruit length (11.60 cm) was found when BAU dragon fruit-1 was under bagging with black polythene bag followed by same fruit variety bagging with white polythene bag (11.40 cm) (Table 3). The lowest fruit length (7.80 cm) was achieved from the combination of BAU dragon fruit-2 and brown paper bag, preceded by same fruit variety with non-bag control treatment (8.10 cm) (Table 3). The longest fruits were obtained from bagging with black polythene bag which is supported by Tran *et al.* (2015). They mentioned that the temperature inside the bag may promoted fruit development. Xu *et al. (*2010) noticed that the reason for short fruit length might be the presence of carbon layer inside the brown paper bag that hampers the growth.

Fruit diameter: There was no varietal difference on fruit diameter (Table 1). But bagging materials significantly affected this trait during fruit growth and development. The highest fruit diameter (7.76 cm) was obtained from black polythene bagged fruit and the brown paper bagged fruits gave the lowest fruit diameter (6.37cm) (Table 2). It was observed that the interaction between variety and bagging materials had a significant impact on fruit diameter. The highest fruit diameter (7.91 cm) was found when BAU dragon fruit-1 was bagged with black polythene bag followed by BAU Dragon fruit-2 with black polythene bag (7.61 cm). The lowest fruit length (6.33cm) was achieved from the combination of BAU dragon fruit-2 and brown paper bag, preceded by BAU dragon fruit-1 with brown paper bag (6.41 cm) (Table 3). The current finding was also supported by Yang *et al.* (2009). They reported that bagging with black polythene bag increase inside air humidity as well as tends to increase temperature inside the bag resulting in larger fruit size of longan. Hossain *et al.* (2020) reported that breadth of mango cv. Amrapali increased under bagged fruits as compared to non-bagged control fruits.

Table 1. Effect of variety on days to maturity and other traits of dragon fruit

Variety	Days to maturity (days)	Fruit length (cm)	Diameter (cm)	Fruit fresh weight (g)	Flesh weight (g)	Peel weight (g)	Thickness of peel (cm)
V_1(BAU Dragon fruit-1)	25.73	10.62	7.05	290.65	230.52	64.37	0.25
V_2(BAU Dragon fruit-2)	25.40	9.08	7.02	254.36	192.96	65.64	0.23
$LSD_{(0.05)}$	0.67	0.05	0.07	0.76	0.81	0.55	0.01
Level of significance	NS	**	NS	**	**	**	**

** indicates LSD at 1% level of probability, NS: Non-significant

Table 2. Effect of bagging materials on days to maturity and other traits of Dragon fruit

Treatment	Days to maturity (days)	Fruit length (cm)	Diameter (cm)	Fruit fresh weight (g)	Flesh weight (g)	Peel weight (g)	Thickness of peal (cm)
T_{CB} (Cloth bag)	27.16	10.10	7.09	264.61	208.55	60.30	0.23
T_{BB} (Brown paper bag)	27.16	8.50	6.37	229.57	182.03	80.22	0.27
T_{BP} (Black polythene bag)	22.16	10.90	7.76	327.48	251.49	51.78	0.21
T_{WP} (White polythene bag)	24.83	10.55	7.35	296.22	228.04	72.42	0.26
T_0 (Non-bag, Control)	26.50	9.20	6.62	244.66	188.60	60.30	0.23
$LSD_{(0.05)}$	1.06	0.08	0.11	1.20	1.28	0.87	0.01
Level of significance	**	**	**	**	**	**	**

** indicates LSD at 1% level of probability. T_{CB}=Cloth bag; T_{BB}=Brown paper bag; T_{BP}=Black polythene bag; T_{WP}=White polythene bag; T_0 = Non-bag (Control)

Table 3. Combined effects of variety and bagging materials on days to maturity and other traits of dragon fruit

Variety and Treatments		Days to maturity (days)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Flesh weight (g)	Peel weight (g)	Thickness of peel (cm)
V_1 (BAU dragon fruit-1)	T_{CB}	27.66	10.61	7.00	269.57	221.54	52.27	0.24
	T_{BB}	27.33	9.20	6.41	232.41	188.54	85.16	0.29
	T_{BP}	22.00	11.60	7.91	368.40	287.47	48.11	0.22
	T_{WP}	25.00	11.40	7.30	332.27	262.48	74.03	0.26
	T_0	26.66	10.30	6.65	250.62	192.59	62.27	0.23
V_2 (BAU dragon fruit-2)	T_{CB}	26.66	9.60	7.19	259.64	195.55	68.33	0.22
	T_{BB}	27.00	7.80	6.33	226.74	175.52	75.29	0.26
	T_{BP}	22.33	10.20	7.61	286.56	215.51	55.46	0.21
	T_{WP}	24.66	9.70	7.40	260.17	193.60	70.81	0.26
	T_0	26.33	8.10	6.58	238.70	184.62	58.32	0.23
$LSD_{(0.05)}$		1.50	0.11	0.15	1.69	1.81	1.23	0.03
Level of significance		**	**	**	**	**	**	**

** indicates LSD at 1% level of probability, T_{CB}=Cloth bag; T_{BB}=Brown paper bag; T_{BP}=Black polythene bag; T_{WP}=White polythene bag; T_0 = Non-bag (Control)

Fruit weight: There was a significant variation found in terms of fruit fresh weight of two varieties of Dragon fruit (Table 1). The average fruit fresh weight of BAU Dragon fruit-1 (290.65 g) was highest as compared to BAU Dragon fruit-2 (254.36 g). Fruit subjected to different bagging treatments showed significant variation in fruit fresh weight. The fresh weight of black polythene bagged fruits was significantly higher than that of all other treatments with the maximum fresh weight (327.48 g). The lowest fresh weight (229.57 g) was recorded in brown paper bagged fruits preceded by control treatment (244.66 g) (Table 2). It was found that about 25.29% increment in fruit fresh weight due to application of fruit bagging with black polythene bag compared to non-bagged control fruit. Similar increment in fruit fresh weight due to bagging of guava reported by Rahman *et al.,* 2018; Rahman *et al.,* 2017. They explained that bagging protect fruits from UV rays and increase cell division as well as cell expansion enhanced accumulation of photosynthats thus improved fruit weight.

The combine effect of variety and bagging materials had a significant impact on fresh weight of fruit. The highest fruit fresh weight (368.40 g) was found when BAU Dragon fruit-1 was under black polythene bag followed by same fruit variety with white polythene bag (332.27 g), which might be due to its genetic quality to produce more fresh weight and was supported by Jacobs (1999). The lowest fruit fresh weight was obtained from BAU Dragon fruit-2 with brown paper bag (226.74 g) (Table 3). The reason for the result might be due to the respiration loss of starch, different sunlight intensity and temperature inside the bag that accelerated the growth of the fruit which is supported by Yang *et al.* (2009). The use of bagging materials improved fruit weight by increasing humidity and reduced fruit water loss (Dutta and Majumder, 2012).

Fruit flesh weight: Fruit flesh weight was also varied between two varieties of dragon fruit (Table 1). The average fruit flesh weight of BAU Dragon fruit-1 (230.52 g) was higher as compared to BAU Dragon fruit-2 (192.96 g). Different bagging materials significantly influenced the fruit flesh weight. Black polythene bagged fruit produced the highest flesh weight (251.49 g) and non-bagged control fruit gave the lowest flesh weight (188.60 g) (Table 2). It was observed that the combined effect between variety and bagging materials had a significant impact on flesh weight. The highest fruit flesh weight (287.47 g) was found when BAU Dragon fruit-1 was under bagging with black polythene bag followed by the same fruit with white polythene bag (262.48 g). The lowest fruit flesh weight was obtained (184.62 g) from BAU Dragon fruit-2 with non-bag control, preceded by BAU Dragon fruit-1 with brown paper bag (188.54 g) (Table 3).

Peel weight and thickness: Fruit peel weight and peel thickness was also varied significantly between two varieties with the highest peel weight (65.64 g) and lowest peel thickness (0.23 cm) from BAU Dragon fruit-2. The lowest peel weight (64.37g) and highest peel thickness from BAU Dragon fruit-1 (Table 1). The result showed a significant impact of variety on peel weight and thickness of dragon fruit, which might be due to the genotypic difference in the both varieties to get matured at equal duration (Ding *et al.*, 2004). Different bagging materials significantly influenced the peel weight and thickness of dragon fruit. The highest peel weight (80.22 g) and thickness (0.27 cm) was recorded from brown paper bagged fruits while the lowest peel weight (51.78 g) and thickness (0.21 cm) was noticed in black polythene bagged fruits (Table 2). Tran *et al.* (2015) noticed that fruit bagging significantly reduced peel thickness of dragon fruit.

The combine effect of variety and bagging materials had a significant impact on peel weight and thickness. The lowest peel weight and thickness (48.11 g and 0.21 cm) was achieved from the combination of BAU dragon fruit-1 and black polythene bag. The highest peel weight and thickness (85.16 g and 0.29 cm) was found when BAU dragon fruit-1 bagged with brown paper bag (Table 3). It may be due to the varietal character and bag helped the fruit surface from light and insect-pest attack that leads to thin peel which is supported by Ding *et al.* (2004).

Flesh-peel ratio and edible rate of dragon fruit: The ratio of flesh to peel and edible rate of dragon fruit significantly varied between two varieties. The highest ratio (3.81) and edible rate (79.43%) obtained from BAU dragon fruit-1, while the lowest flesh-peel ratio (2.99) and edible rate (75.93%) recorded from BAU dragon fruit-2 (Fig. 1a, Table 4). Fruit bagging materials significantly influenced the flesh-peel ratio and edible rate of dragon fruit. The maximum ration (4.93) and the minimum edible rate (76.62%) obtained from black polythene bagged fruits, while the minimum ratio (2.27) and the maximum (79.26%) edible rate noticed in brown paper bagged fruits (Fig. 1b, Table 5).

Significant variations found in fruit flesh-peel ratio and edible rate due to the combined effects of variety and bagging materials. The highest flesh-peel ratio (5.97) was found when BAU dragon fruit-1 bagged with black polythene bag. The lowest flesh-peel ratio (2.21) was achieved from the combination of BAU Dragon fruit-1 and brown paper bag (Fig. 2). The maximum edible rate (82.18%) obtained from cloth bagged BAU dragon fruit-1 and white polythene bagged BAU Dragon fruit-2 produced the minimum edible rate (74.41%) (Table 6). Tran *et al.* (2015) reported that fruit bagging could not increase the edible rate of fruit.

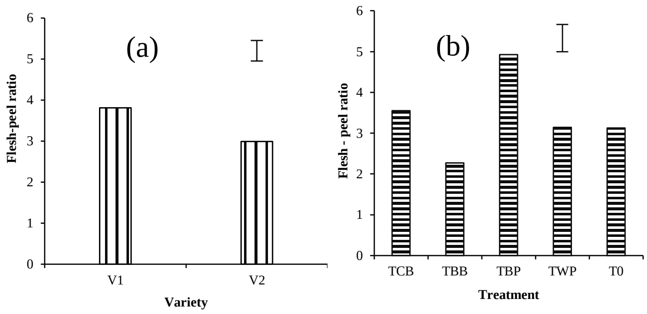

Fig. 1. Effect of variety (a) and bagging materials (b) on flesh-peel ratio of dragon fruit. Vertical bars indicate LSD at 0.05 level of significance; V_1: BAU Dragon fruit-1, V_2: BAU Dragon fruit-2, T_{CB}: Cloth bag; T_{BB}: Brown paper bag; T_{BP}: Black polythene bag; T_{WP}: White polythene bag; T_0: Non-bag (Control).

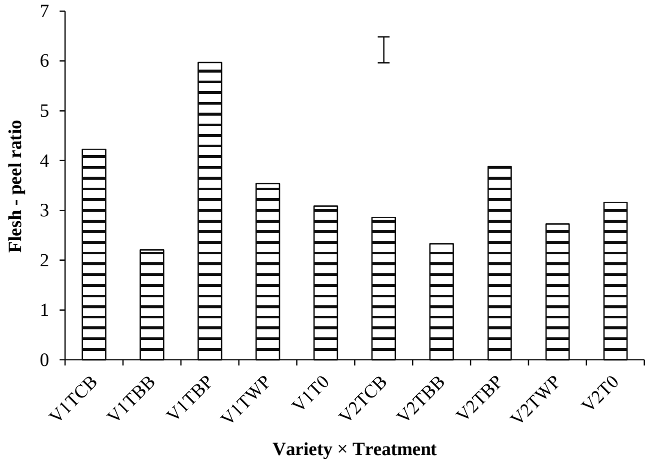

Fig. 2. Combine effects of variety and bagging materials on flesh-peel ratio of dragon fruit. Vertical bar indicates LSD at 0.05 level of significance; V_1: BAU Dragon fruit-1, V_2: BAU Dragon fruit-2, T_{CB}: Cloth bag; T_{BB}: Brown paper bag; T_{BP}: Black polythene bag; T_{WP}: White polythene bag; T_0: Non-bag (Control).

Moisture content: Significant variation was observed between two varieties of dragon fruit. The highest moisture content was obtained from BAU Dragon fruit-2 (83.26%) and the lowest moisture content was recorded from BAU Dragon fruit-1 (82.70%) (Table 4). Moisture content of dragon fruits varied significantly due to the use of different bagging materials. The highest moisture content was obtained from brown paper bagged fruits (85.29%) and the lowest moisture content (81.71%) attained from fruits bagged with black polythene bag (Table 5). It was observed that the combined effect between variety and bagging materials significantly impact on moisture content of fruit. The highest fruit moisture content (85.56%) was found when BAU Dragon fruit-1 was under bagging with brown paper bag and the lowest moisture content was obtained (80.84%) from BAU Dragon fruit-1 with cloth bag (Table 6). Bagging assist to retain moisture content in fruits by inhibiting water loss from surface thus increase percent moisture content in fruits (Dutta and Majumder, 2012).

Table 4. Effect of variety on quality traits dragon fruit

Variety	Edible rate (%)	Moisture content (%)	Dry matter content (%)	pH	TSS (%)
V_1(BAU Dragon fruit-1)	79.43	82.70	17.29	4.37	10.17
V_2(BAU Dragon fruit-2)	75.93	83.26	16.74	4.50	13.01
$LSD_{(0.05)}$	0.22	0.27	0.27	0.07	0.16
Level of significance	**	**	**	**	**

** indicates LSD at 1% level of probability.

Table 5. Effect of bagging materials on quality traits of dragon fruit

Treatment	Edible rate (%)	Moisture content (%)	Dry matter content (%)	pH	TSS (%)
T_{CB} (Cloth bag)	78.75	82.58	17.41	4.34	11.51
T_{BB} (Brown paper bag)	79.26	85.29	14.70	4.32	10.32
T_{BP} (Black polythene bag)	76.62	81.71	18.28	4.57	12.71
T_{WP} (White polythene bag)	76.70	82.98	17.01	4.44	12.22
T_0 (Non-bag, Control)	77.09	82.33	17.66	4.51	11.17
$LSD_{(0.05)}$	0.34	0.42	0.42	0.12	0.25
Level of significance	**	**	**	**	**

** indicates LSD at 1% level of probability, T_{CB}=Cloth bag; T_{BB}=Brown paper bag; T_{BP}=Black polythene bag; T_{WP}=White polythene bag; T_0 = Non-bag (Control).

Table 6. Combined effects of variety and bagging quality traits of dragon fruit

Variety and Treatments		Edible rate (%)	Moisture content (%)	Dry matter content (%)	pH	TSS (%)
V_1 (BAU Dragon fruit-1)	T_{CB}	82.18	80.84	19.15	4.24	10.00
	T_{BB}	81.12	85.56	14.43	4.22	9.53
	T_{BP}	78.03	81.72	18.27	4.59	11.03
	T_{WP}	79.00	83.21	16.78	4.24	10.45
	T_0	76.84	82.19	17.81	4.57	9.83
V_2 (BAU Dragon fruit-2)	T_{CB}	75.32	84.33	15.67	4.44	13.02
	T_{BB}	77.41	85.02	14.98	4.42	11.12
	T_{BP}	75.20	81.71	18.28	4.55	14.40
	T_{WP}	74.41	82.75	17.25	4.63	14.00
	T_0	77.34	82.48	17.51	4.44	12.51
$LSD_{(0.05)}$		0.48	0.60	0.60	0.16	0.30
Level of significance		**	**	**	**	**

** indicates LSD at 1% level of probability, T_{CB}=Cloth bag; T_{BB}=Brown paper bag; T_{BP}=Black polythene bag; T_{WP}=White polythene bag; T_0 = Non-bag (Control).

Dry matter content: There was a significant variation noticed in percent dry matter contents between the varieties. Higher dry matter content was recorded from BAU Dragon fruit-1 (17.29%) while BAU Dragon fruit-2 (16.74%) produced the lower dry matter content (Table 4). Statistically significant variation was observed among the bagging materials on dry matter contents of fruits. The higher dry matter content (18.28%) was found in the bagging with black polythene bag and the lowest dry matter content (14.70%) was found in the bagging with brown paper bag (Table 5). It was observed that the combined effect of variety and bagging materials had a significant impact on percent dry matter content**.** The highest fruit dry matter (19.15%) was found when BAU Dragon fruit-1 was under bagging with cloth bag and the lowest fruit dry matter (14.43%) was obtained from similar variety with brown paper bag (Table 6).

Fruit pH: There was a significant difference observed between two varieties on fruit pH. The highest pH (4.50) was recorded from BAU Dragon fruit-2 while the lowest pH (4.37) was recorded from BAU Dragon fruit-1 (Table 4). The effect of different bagging materials on fruit pH value was significant. The maximum pH value (4.57) was recorded from black polythene bagged fruits and the minimum pH value (4.32) was noticed in brown paper bagged fruits (Table 5). The combined effect of variety and treatments in relation to fruit pH was highly significant. The highest pH (4.63) was recorded when BAU Dragon fruit-2 bagged with white polythene bag. The lowest pH (4.22) was found when BAU Dragon fruit-1 was bagged with the brown paper bagged fruits (4.24) (Table 6). Possible light passing through white polythene bag might enhance the improvement of fruit pH in this study. Costa *et al.* (2017) noticed that fruit pH and titratable acidity of Pitaya did not varied significantly due to bagging with newspaper, kraft paper, waxed paper, Non-oven bag and non-bag control.

Total Soluble Solids (TSS): It was observed that the variation in TSS content of fruits was significant. The higher TSS (13.01%) was recorded from BAU dragon fruit-2 while BAU dragon fruit-1 produce the lower TSS (10.170%) (Table 4). TSS contents of dragon fruits under different bagging treatments were significantly varied. Fruits bagged in black polythene bag contained the highest TSS (12.71%) and brown paper bagged fruits contained the lowest TSS (10.320%) (Table 5). There were significant variations found in fruit TSS content due to combined effects of variety and bagging materials. The highest TSS (14.40%) was found when BAU dragon fruit-2 was under black polythene bag and the lowest TSS (9.53%) was obtained from BAU dragon fruit-1 with brown paper bag (Table 6). These results partially supported by the findings of Meena *et al.* (2016). However, Huang *et al.* (2009) claimed that bagging treatments did not affect the contents of total soluble sugars but decreased organic acids contents in fruit. Fruit bagging significantly increased fruit TSS contents as compared to control fruit (Tuan *et al.*, 2017; Rahman *et al.*, 2018; Hossain *et al.*, 2020)

Shelf life: There was a significant variation observed in respect of shelf life of dragon fruit. The longest shelf life was obtained in BAU Dragon fruit-2 (8.80 days) and the shortest shelf life recorded in BAU Dragon fruit-1 (8.61 days) (Fig. 3a). Different bagging materials resulted in a significant variation on shelf life of dragon fruit. The maximum shelf life (11.06 days) was recorded under black polythene bag treatment and the minimum shelf life (7.73 days) was recorded from non-bagged control fruits followed by cloth bag treatment (7.75 days) (Fig. 3b).

The combined effect of variety and bagging materials showed a significant impact on shelf life. The longest shelf life (12.05 days) was obtained when BAU Dragon fruit-2 bagged with black ploythene bag followed by BAU Dragon fruit-1 with black polythene bag ((10.07 days). The shortest shelf life (7.46 days) was found when BAU Dragon fruit-2 was under bagging with white polythene bag and the same result found in BAU Dragon fruit-1 bagging with cloth bag (7.46 days) (Fig. 4). Islam *et al.* (2017) reported that bagging influenced growth and development of mango fruit by the reduction of disease and insect-pest attack and also increases shelf life of mango. Bagging remarkably increased shelf life of fruits by protecting fruits from any physical injuries, insect-pest infestations, sun burn and bird attack, which assisted to extended storage life (Rubel *et al.,* 2019; Hossain *et al.,* 2020).

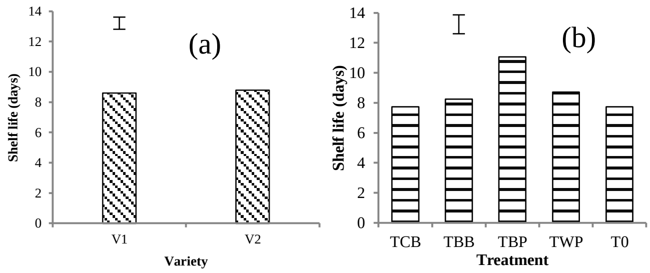

Fig. 3. Effect of variety (a) and bagging materials (b) on shelf life of dragon fruit. Vertical bars indicate LSD at 0.05 level of significance; V_1: BAU Dragon fruit-1, V_2: BAU Dragon fruit-2, T_{CB}: Cloth bag; T_{BB}: Brown paper bag; T_{BP}: Black polythene bag; T_{WP}: White polythene bag; T_0: Non-bag (Control).

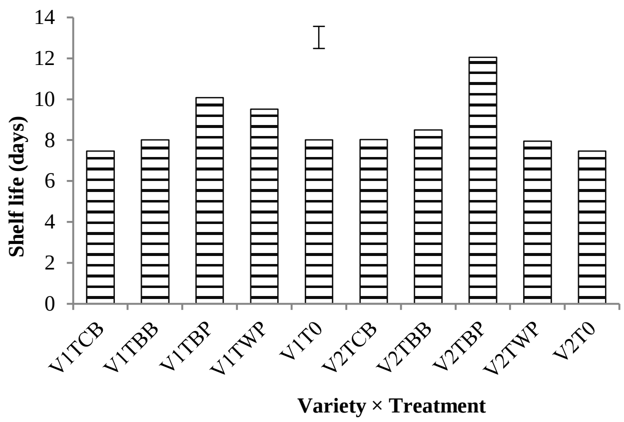

Fig. 4. Combine effects of variety and bagging materials on shelf life of Dragon fruit. Vertical bar indicates LSD at 0.05 level of significance; V_1: BAU Dragon fruit-1, V_2: BAU Dragon fruit-2, T_{CB}: Cloth bag; T_{BB}: Brown paper bag; T_{BP}: Black polythene bag; T_{WP}: White polythene bag; T_0: Non-bag (Control).

Conclusion

It can be concluded that both the varieties of dragon fruit showed superior performances in respect of most of the parameters studied. On the other hand, black polythene bag enhanced days to maturity, improved length diameter fruit flesh weight, edible rate, length, diameter, lower peel thickness, higher dry matter content as well as TSS content. Hence, black polythene bag could be recommended as a suitable bagging material for improving quality and shelf life of dragon fruit at Mymensingh condition.

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