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EVALUATION OF COATINGS FOR SHELF LIFE ENHANCEMENT AND QUALITY RETENTION IN BER (*ZIZYPHUS MAURITIANA* LAMK.)

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ABSTRACT

Ber, a climacteric fruit crop, is liable to spoilage during storage. This study aims to evaluate the effect of coatings on shelf life and quality retention in ber under ambient storage conditions. Coated and uncoated ber fruits were stored at ambient storage temperatures (±25ºC) for 10 days and accessed every 2 days for analysis. Ber fruits reported minimum weight loss (2.68g), PLW (14.35%) and TSS (9.52%) with the application of petroleum jelly coating. Minimum total sugars (8.98%), minimum reducing sugar content (3.96%), maximum non-reducing sugars (5.69%) and maximum antioxidant activity (63.83%) was recorded in fruits with petroleum jelly coating. This study highlights the importance of coating of fruits for enhanced shelf life and quality retention under ambient storage conditions.

Keywords: Ber, coating, quality, shelf life, antioxidant

INTRODUCTION

Ber (*Zizyphus mauritiana* Lamk.), a member of family Rhamnaceae consisting of about 170 species, is one of the hardy minor fruit crop appropriate for cultivation in tropical and subtropical regions (Jackson *et al.,* 2011). Ber cultivation is a low cost input enterprise and plant is highly tolerant to drought with wide adaptability and gives high economic value to the farmers. Under ambient storage conditions, the shelf life of ber is about 3-4 days. This can be attributed to the climacteric nature of the fruit as well as thin exocarp layer that makes it hard for the fruit to retain moisture. All these factors contribute to the short shelf-life of ber fruits. Postharvest storage under ambient conditions is a challenge for most of the food technologists and researchers. Coating of fruits with some edible layer to minimize the moisture loss is practised in fruit crops. Coatings enhance shelf-life of fruit by making a barrier between fruit and external environment which is helpful for long time storage under ambient conditions. In this context, various coating materials were evaluated for shelf life enhancement and quality retention in ber fruits which are otherwise having a short storage period under ambient conditions of storage.

MATERIAL AND METHODS

Preparation of coating material

Chitosan coating

5.0g of chitosan in 400ml of distilled water was dispersed in which glacial acetic acid (25ml) was added to dissolve the chitosan. The pH value of chitosan solution was adjusted to 5.0 with 1.0 mol/l NaOH. After dipping, fruits were allowed to dry for 4 hrs at 25 ̊C (Jiang and Li., 2001).

Calcium Chloride coating

Dissolve 20g of calcium chloride in 1000 ml of deionized water to prepare 2 percent solution of calcium chloride. The fruits were immersed in the calcium chloride solution for 15 min at room temperature and then dried for 24 hours at room temperature (Kou *et al.,* 2014).

Aloe vera coating

For preparation of aloe vera coating material, aloe vera gel matrix was separated from the outer cortex of the aloe vera leaf and the colourless hydroparenchyma was blended in a mixer. The resultant matrix was filtered to remove fibers. The liquid obtained contained fresh aloe vera gel. The gel matrix was pasteurized at 70º C for 45 min. For stabilizing, the gel was cooled immediately at room temperature and ascorbic acid (1.9 to 2g per litre) was added; then citric acid (4.5 to 4.6g per litre) was added to maintain the pH at 4.00. 50 g of this aloe vera gel was added to 100 ml of distilled water to get 50% aloe vera coating solution. The viscosity of the stabilized aloe gel and its coating efficiency was improved by using 1% commercial gelling agent and was used as aloe gel (AG) coating. The fruits were immersed in the aloe vera solution prepared for 15 min at room temperature and then dried for 24 hours at room temperature (Adetunji *et al,* 2012).

Bee wax coating

Wax coating was prepared by dissolving 120 g of bees wax into 10ml water by using heat treatment of 90º C and be sure that every part of bees wax becomes absolutely hydrated. After this 20 ml of oleic acid and 60 ml of triethanolamine (TEA) were further added to the molten bees wax solution. At the end water was added until solution reached the

Table 1: Effect of coating treatments on physiological weight loss (%) during storage of ber cv. Umran.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	7.69^{cd}	14.57^{cd}	20.09^{d}	25.61^{de}	32.16^{d}
T_2	5.77^{cd}	9.25^{b}	13.29^{bc}	17.69^{bc}	20.97^{bc}
T_3	6.97^{cd}	11.47^{bc}	16.20^{c}	22.30^{cd}	28.37^{d}
T_4	2.38^{ab}	4.91^{a}	10.23^{ab}	11.61^{a}	16.07^{ab}
T_5	5.06^{bc}	8.91^{b}	11.89^{b}	15.50^{ab}	18.79^{abc}
T_6	6.05^{cd}	9.89^{b}	14.27^{bc}	19.81^{bc}	22.43^{c}
T_7	1.43^{a}	3.53^{a}	7.26^{a}	11.38^{a}	14.35^{a}
T_8	8.80^{d}	16.16^{d}	22.11^{d}	28.04e	33.85^{d}

T_1: Chitosan 1%, T_2: CaCl2 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 2: Average value of bio-chemical parameters of ber fruit before application of coating treatment.

S. No.	Bio-chemical parameter	Average Value
1.	TSS (Brix)	8.13
2.	Acidity (%)	0.22
3.	TSS: acidity ratio	37.54
4.	Total sugar (%)	6.72
5.	Reducing sugars (%)	3.25
6.	Non-reducing sugars (%)	3.29
7.	Vitamin C	105.03
8.	Antioxidant activity (%)	45.61

Table 3: Effect of different coating treatments on TSS (oBrix) in ber under ambient storage conditions.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	8.81^{de}	9.21^{e}	9.72^{d}	10.07^{d}	10.41^{ef}
T_2	8.56^{abc}	8.95^{cd}	9.38^{c}	9.74^{c}	10.14^{d}
T_3	8.76^{cde}	9.24^{e}	9.70^{d}	10.04^{d}	10.53^{f}
T_4	8.42^{a}	8.74^{ab}	9.06^{b}	9.37^{b}	9.76^{b}
T_5	8.47^{ab}	8.86^{bc}	9.24^{c}	9.51^{b}	9.92^{c}
T_6	8.67^{bc}	9.08^{de}	9.57^{d}	9.93^{d}	10.31^{e}
T_7	8.36^{a}	8.61^{a}	8.89^{a}	9.19^{a}	9.52^{a}
T_8	8.94^{e}	9.45^{f}	9.96^{e}	10.47^{e}	11.02^{g}

T_1: Chitosan 1%, T_2: CaCl2 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 4: Effect of different coating treatments on acidity (%) in ber under ambient storage conditions.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	0.20^{ab}	0.19^{a}	0.19^{b}	0.17^{ab}	0.16^{b}
T_2	0.21^{ab}	0.20^{a}	0.20^{bc}	0.19^{c}	0.17^{bc}
T_3	0.20^{ab}	0.20^{a}	0.19^{b}	0.18^{bc}	0.17^{bc}
T_4	0.21^{ab}	0.21^{a}	0.20^{bc}	0.19^{c}	0.18^{cd}
T_5	0.21^{ab}	0.21^{a}	0.20^{bc}	0.19^{c}	0.18^{cd}
T_6	0.21^{ab}	0.20^{a}	0.19^{b}	0.18^{bc}	0.17^{bc}
T_7	0.22^{b}	0.21^{a}	0.21^{c}	0.20^{d}	0.19^{d}
T_8	0.19^{a}	0.19^{a}	0.17^{a}	0.16^{a}	0.15^{a}

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

volume of 1 litre. The emulsifier is the soap produced by the *in situ* reaction of oleic acid and TEA. The oleic acid is dissolved in the wax phase, and the TEA is dissolved in the water phase (Hassan, 2013).

Pectin coating

For preparing pectin coating solution, 30g of commercial grade pectin was dissolved in 1000 ml of mild warm water to prepare 3 % solution of pectin and stirring with a magnetic stirrer and allowed to homogenize with moderate stirring until complete dissolution (Felix and Mahendran, 2009).

Guar Gum coating

Guar gum 6% coating was prepared by using 6g weight of guar gum powder mixed in 100 ml distilled water for preparing 6% guar gum solution. After mixing solution was heated in oven and air cooling was done. After cooling ber fruits dipped in this solution. Then all the treated fruits were kept under ambient temperature for air drying (Ghosh *et al,* 2014).

Petroleum jelly coating

For application of petroleum jelly coatings, the fruits were first washed with deionized water and dried at room temperature. Food grade petroleum jelly was applied uniformly as a thin coating all over the fruits and fruits were then stored at room temperature.

Plant Material

Uniform and healthy fruits of ber cv. Umran were procured from the Department of Fruit Science, Punjab Agriculture University, Ludhiana for the purpose of the study and brought to the post-harvest laboratory at Lovely Professional University. The fruits were harvested at mature stage.

Treatments

Before the application of the treatments, the fruits were thoroughly washed and dried. The experiment was carried out with 8 different treatments including control *viz.* T_1: Chitosan (1%), T_2: $CaCl_2$ (2%), T_3: Aloe vera (50%), T_4: Bee Wax (12%), T_5: Pectin (3%), T_6: Guar Gum (6%), T_7: Petroleum Jelly and T_8: untreated control.

Experimental Design

The experimental unit consisted of fifteen fruits per treatment. The experiment was laid out in completely randomized design with three replications per treatment totalling to 360 fruits.

Physical and chemical analysis

The fruits in different treatments were accessed for physical and chemical analysis at 2 days intervals starting from the day of storage. Fruit weight of accessed using an electronic weigh balance and the data was presented as physiological loss in weight (PLW) by subtracting the final fruit weight from the initial fruit weight divided by the initial fruit weight and expressed as percentage. Total soluble solids were estimated using Hand Refractometer. Titratable acidity and total sugars in fresh fruits was determined by the method as suggested in A.O.A.C (1995). Ascorbic acid was estimated by standard method using 2, 6-Dichlorophenol indophenols (Ruck, 1969) and antioxidant activity was estimated using DPPH method as suggested by Parejo *et al.,* (2000).

Statistical analysis

Statistical analysis was performed using SPSS v.21 to identify the homogenous subsets among the data generated.

RESULTS AND DISCUSSION

Loss of fruit weight differed significantly between the coated and uncoated (control) as well as within the coated fruits. Data presented in Fig. 1 reveals minimum physiological weight loss (14.35%) up to 10th day of ambient storage was recorded under treatment T_7 (petroleum jelly coating) followed by 16.07% recorded in the treatment where fruits were treated with bee wax @12%. However, maximum weight loss percentage (33.85%) was observed in treatment T_8 (untreated control). Loss of weight of fruits is primarily due to the loss of moisture from the fruit surface. Coatings help to prevent this loss by forming a barrier between the fruit surface and the immediate environment of the fruit. The most effective coatings can judged on the basis of the decreased physiological loss in weight of the fruit as compared to control treatment. Similar findings have been already reported by Bhowmick *et al.,* (2015) and Shahid and Abbasi (2011). On 10th day, minimum increase in TSS in T_7 (petroleum jelly coating) whereas untreated control (T_8) recorded maximum TSS (11.02 ºBrix) (Table 3). TSS includes amino acids, carbohydrates and organic acids. Coating provides a semi permeable layer on fruit upper surface by which there is a barrier which modify the inner atmosphere of fruit by which gaseous activity goes to its minimum level which reducing the rate of respiration, evaporation and metabolic activity of fruit (Hossain, 2016). Petroleum jelly coated fruits showed maximum acidity content (0.19%) as against 0.15% recorded in T_8 (untreated control) showed in table 4. A decreasing trend in the level of acidity in fruits was observed in all the treatments. This might be attributed to the fact that during the process of ripening, organic acids are used in metabolic processes and respiration of fruits which leads to gradual decline in fruit acidity. Rapid increase in TSS/Acid ratio was recorded in the coating treatment included untreated control (Table 5). On 10th day maximum increase of TSS/Acid ratio was recorded in T_8 (73.49) and minimum increase was recorded in T_7 (49.24). TSS: acid ratio increasing during the storage period. It might be due to water loss from the fruits which leads to more concentration of juice resulting in high sugars content (Hazarika *et al.,* (2017).

The data presented in Table 6 shows that the total sugars present in fruit continuously increased during storage. Minimum total sugars on 10th day of storage were recorded under treatment T_7 (8.98%) whereas maximum total sugars 10.37% were observed in treatment T_8 (untreated control). Maximum value for total sugars on 10th day of storage under the control treatment is a testimony of the

Table 5: Effect of coating treatments on TSS: acidity ratio during storage of ber cv. Umran.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	44.05^{bc}	47.64^{de}	52.05^{d}	58.10^{d}	63.73^{d}
T_2	40.75^{ab}	44.75^{bcd}	47.71^{bc}	52.18^{bc}	58.50^{c}
T_3	43.78^{bc}	46.20^{de}	51.05^{cd}	54.75^{c}	60.73^{cd}
T_4	40.11^{a}	42.29^{ab}	45.28^{b}	49.32^{b}	53.24^{ab}
T_5	40.35^{a}	42.85^{abc}	46.18^{b}	50.05^{b}	54.11^{b}
T_6	41.95^{ab}	45.42^{cd}	50.39^{cd}	54.16^{c}	60.63^{cd}
T_7	38.58^{a}	40.98^{a}	41.67^{a}	45.21^{a}	49.24^{a}
T_8	46.24^{c}	48.86^{e}	58.59^{e}	64.08^{e}	73.49^{e}

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 6: Effect of different coating treatments on total sugar (%) in ber under ambient storage conditions.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	7.26^{d}	8.03^{f}	8.69^{d}	9.50^{f}	10.08^{f}
T_2	7.08^{ab}	7.68^{c}	8.22^{b}	8.77^{c}	9.52^{cd}
T_3	7.19^{cd}	7.93^{e}	8.58^{d}	9.10^{e}	9.80^{e}
T_4	7.01^{a}	7.57^{ab}	8.08^{ab}	8.55^{ab}	9.12^{ab}
T_5	7.04^{ab}	7.63^{bc}	8.14^{ab}	8.62^{bc}	9.32^{bc}
T_6	7.13^{bc}	7.82^{d}	8.38^{c}	8.95^{d}	9.72^{de}
T_7	6.98^{a}	7.52^{a}	8.02^{a}	8.47^{a}	8.98^{a}
T_8	7.37^{e}	8.12^{f}	8.87^{e}	9.75^{g}	10.37^{g}

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 7: Effect of different coating treatments on reducing sugars (%) in ber under ambient storage conditions.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	3.48^{ef}	3.78^{f}	3.97^{e}	4.13^{f}	4.29^{d}
T_2	3.41^{bc}	3.66^{c}	3.83^{c}	4.00^{cd}	4.16^{c}
T_3	3.45^{de}	3.74^{e}	3.94^{e}	4.08^{ef}	4.24^{d}
T_4	3.38^{ab}	3.60^{b}	3.76^{ab}	3.93^{ab}	3.99^{a}
T_5	3.39^{abc}	3.62^{b}	3.81^{b}	3.97^{bc}	4.08^{b}
T_6	3.42^{cd}	3.70^{d}	3.87^{d}	4.04^{de}	4.19^{c}
T_7	3.36^{a}	3.56^{a}	3.74^{a}	3.89^{a}	3.96^{a}
T_8	3.51^{f}	3.81^{g}	4.03^{f}	4.20^{g}	4.37^{e}

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 8: Effect of different coating treatments on non-reducing sugars (%) in ber cv. Umran under ambient storage conditions.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	3.59^{d}	4.04^{e}	4.49^{c}	5.10^{f}	5.50^{d}
T_2	3.49^{abc}	3.82^{a}	4.17^{a}	4.47^{c}	5.09^{bc}
T_3	3.56^{cd}	3.99^{c}	4.41^{c}	4.77^{e}	5.28^{c}
T_4	3.45^{a}	3.78^{a}	4.10^{a}	4.39^{ab}	4.87^{a}
T_5	3.46^{ab}	3.81^{a}	4.12^{a}	4.42^{bc}	4.97^{ab}
T_6	3.52^{bcd}	3.91^{b}	4.28^{b}	4.66^{d}	5.25^{c}
T_7	3.44^{a}	3.77^{a}	4.07^{a}	4.35^{a}	4.77^{a}
T_8	3.66^{e}	4.09^{e}	4.60^{d}	5.27^{g}	5.69^{d}

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 9: Effect of different coating treatments on vitamin C content (mg per 100 g pulp) in ber cv. Umran under ambient storage conditions.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	99.37[a]	88.07[ab]	77.67[ab]	71.70[ab]	64.97ab
T_2	100.21[a]	91.99[cd]	82.10[bcde]	74.33[b]	68.53[abcd]
T_3	99.68[a]	88.79[b]	79.23[bc]	72.57[ab]	65.93[abc]
T_4	101.08[ab]	94.74[e]	84.70[de]	77.13[ab]	71.02[cd]
T_5	100.47[a]	92.92[d]	83.48[cde]	75.49[ab]	70.06[bcd]
T_6	99.83[a]	90.49[c]	80.39[bcd]	73.52[ab]	67.63[abcd]
T_7	102.62[b]	97.38[f]	86.92[e]	78.86[b]	72.73[d]
T_8	98.97[a]	86.57[a]	74.27[a]	70.01[a]	63.22[a]

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

Table 10: Effect of coating treatments on Antioxidant activity (%) during storage of ber cv. Umran.

Treatment	2nd day	4th day	6th day	8th day	10th day
T_1	64.67[g]	70.67[d]	68.73[c]	48.77[b]	39.40[b]
T_2	54.03[d]	64.27[b]	74.93[e]	65.97[e]	56.07[e]
T_3	63.43[f]	68.00[cd]	68.90[c]	53.50[c]	43.47[c]
T_4	48.93[b]	56.83[b]	68.20[c]	73.73[g]	61.73[f]
T_5	52.77[c]	63.63[b]	72.73[d]	69.17[f]	58.13[e]
T_6	58.87[e]	66.13[bc]	72.50[d]	58.97[d]	52.40[d]
T_7	47.80[a]	54.07[a]	64.03[a]	75.93[h]	63.83[f]
T_8	69.67[h]	77.40[e]	65.97[b]	46.40[a]	32.80[a]

T_1: Chitosan 1%, T_2: $CaCl_2$ 2%, T_3: Aloe vera gel 50%, T_4: Bee wax 12%, T_5: Pectin 3%, T_6: Guar gum 6%, T_7: Petroleum jelly, T_8: Control

*Value with same alphabets are non-significant among themselves.

fact that under normal conditions of storage without any protective coating, there is tremendous gaseous exchange between the fruit and the external environment that might have led to increased total sugar levels. Increasing in total sugar attributed to the increase the enzymatic activity for starch hydrolysis and reduces the rate of sugar breakdown during respiration (Mani *et al.,* 2017).

There was a significant increase in reducing sugar content throughout the storage period (Table 7). On the 10th day of treatment, T_7 (petroleum jelly coating) showed both minimum reducing sugar content as well as low rate of increase in reducing sugars wherein the reducing sugar content of 3.96 % on 10th day of storage was recorded and maximum reducing sugar content of 4.37 % was recorded under treatment T_8 (untreated control). Similar increased total sugar content and reducing sugar content was recorded due to higher rate of ripening in untreated fruits as compared to other coated treatments which trigger the starch into sugar during storage period (Mani *et al.,* 2017).

Non-reducing sugars increased continuously in all the treatments (Table 8). An inquisition of the data presented in the table reveals that during most of the storage period, the level of non-reducing sugars in ber fruits under different coating treatments was almost similar and there were no significant differences observed at a large scale.

Minimum loss of vitamin C (72.73 mg) was recorded in fruits coated with petroleum jelly and maximum loss of vitamin C was found in T_8 (63.22 mg) on 10th day which was higher as compare to other treatments (Table 9). Coating not only increases the shelf life but it also protects the vitamin C present in ber fruit which is linked with antioxidant capacity at the time of storage (Bhowmick *et al.,* 2015). Table 10 reveals the effect of coating on antioxidant activity of fruits. On 10th day of treatment minimum antioxidant activity found in T_8 (untreated control) 32.80% and maximum antioxidant activity (63.83%) was recorded in petroleum jelly coated fruits (T_7).

CONCLUSION

The present study revealed the importance of post-harvest coatings on increasing the shelf life and quality retention in ber. It was concluded on the basis of the results obtained during the course of this study that application of petroleum jelly coating to ber fruits stored under ambient storage conditions can significantly improve the shelf life duration and retention of quality parameters for longer duration of time as compared to untreated fruits. Overall, all the coating applications used were helpful in extending shelf life of the fruits. Use of coatings can surely bring down the post-harvest losses and can serve as a tool for nutritional security of the nation.

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