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HORTICULTURE

Efficacy of edible coatings on the shelf life of ber (*Zizyphus mauritiana* Lamk.) fruits at ambient condition

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Abstract

The present study explored the use of some post harvest treatments to extend the shelf life of ber. Matured ber fruits were treated with Chitosan (0.5%, 1%, 2%), Guar gum (1%, 1.5%, 2%), Gum tragacanth (1%, 1.5%, 2%) for 16 days of storage. All treated fruits showed lower loss in fruit weight, less spoilage and long marketable life in comparison to untreated fruits. Guar gum (1.5%) proved very useful for reducing loss in weight, shriveling even after 12 days of storage. At the end of the storage maximum TSS, acidity, ascorbic acid, total sugar, reducing sugar were observed in Guar gum(1.5%) treated fruits followed by Gum tragacanth(2%).

Highlights

Guar gum (1.5%) was recorded lowest physiological loss in weight (7.45%) at the end of storage life and maintained overall consumer acceptability.

Keywords: Edible coatings, shelf life, Ber.

Ber (Zizyphus mauritiana Lamk.) is one of the important minor fruit crop in arid and semi-arid regions belongs to the family Rhamnaceae. It is generally eaten as fresh fruit but several types of processed products can also be made from it. It is a good source of minerals, promising source of natural antioxidants and antimicrobials. It is a climacteric fruit and ripening, senescence of is triggered by the ethylene, resulting a short storage life and prone to softening, browning, decay. The ber fruit is highly perishable in nature, its shelf life is very poor (hardly 2-4 days) at ambient condition (Meena *et al.* 2009). Cultivation of ber is popular in present days with the introduction of ber cv. Apple Ber ('Apple kul' is an improved ber variety, which actually a hybrid of the delicious plum or 'Kul boroi' Afroz *et al.* 2014) in the sub-Himalayan Terai region of West Bengal, and the area and production of ber has been increased many folds in present days. Due to the surplus of fruits in the local markets during peak season, a substantial quantity goes to waste, resulting in heavy postharvest losses. Several techniques such as refrigeration, modified atmosphere storage, chemical preservatives and packaging are being used to minimize deleterious effects (Zhang and Quantick,1997), however the edible coatings might be a cheaper alternative for both extending post-harvest life and keeping production costs low (Baldwin *et al.* 1995). Among different types of edible coating, Chitosan, Guar gum and Gum tragacanth are known to extend the shelf life of guava (Hong *et al.* 2012), star fruit (Nurul-Hanani *et al.* 2012), tomato

(Ghosh *et al.* 2014) and mushroom (Mohebbi *et al.* 2012). However, a little information in this regard is available in ber in sub-Himalayan terai region of West Bengal. In view of the above facts and as the ber is now an emerging important fruit crop in this area, this experiment was carried out to determine the effect of these edible coatings for increasing the shelf life as well as maintaining the physico-chemical properties of the fruit.

Materials and Methods

Fully matured, uniform size ber cv. Apple Kul fruits were collected from a private orchard at Cooch Behar, West Bengal in 2014 and immediately brought to the laboratory of the Department of Pomology and Post-harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal for storage after necessary treatments. The fruits after washing in running tap water, were dried in the shade for few minutes. Then the fruits were subjected to edible coating of following treatments: T_1- Chitosan 0.5%, T_2- Chitosan 1%, T_3- Chitosan 2%, T_4- Guar gum 1%, T_5- Guar gum 1.5%, T_6- Guar gum 2%, T_7- Gum tragacanth 1%, T_8- Gum tragacanth 1.5%, T_9- Gum tragacanth 2% and T_{10}- Control. Chitosan (purchased from HIMEDIA, Mumbai, India) solutions was done according to the method of Jiang and Li (2001). To prepare 500 ml of 0.5%, 1.0% and 2% (w/v) chitosan solution, accurate weight of 2.5 g, 5.0 g and 10g of chitosan were dispersed in 50 ml of glacial acetic acid, respectively. The pH of the solution was adjusted to pH 6.0 with 1 M NaOH and the solutions were made up to 500 ml. Guar gum (purchased from HIMEDIA, Mumbai, India) coating solution was prepared on the percentage of weight basis with distilled water. 1gm, 1.5gm and 2gm guar gum powder was mixed with 100 ml of water for the preparation of 1%, 1.5% and 2% solutions, respectively. Solutions were heated in oven, cooled in air followed by Wijewardane *et al.* 2013. Gum tragacanth powder (purchased from HIMEDIA,Mumbai, India) was used in ratio of 10 to 100 ml (w/w) and was mixed in water (pH was 1.70), stirred vigorously with a magnetic stirrer on a hotplate for 40 min and were kept in the refrigerator for 24 h (Mohebbi *et al.* 2012) for using as coating of ber fruit. Fruit samples were analysed for physico-chemical properties at an interval of 3 days after treatments. The percentage of weight loss was calculated based on initial weight and weight at subsequent intervals. The length and breadth (millimeter scale) of ber fruits were measured as an index for shrinkage and it was measured by digital vernier callipers at zero time of storage (beginning) and 3 days interval during the storage period. The fruit colour was recorded with the help of Royal Horticulture Society mini colour chart (Fifth edition, 2007). Total soluble solids (TSS), total sugar and reducing sugar were estimated by the method described by Mazumdar and Majumder, 2003. The acidity and ascorbic acid were estimated by the method described by Rangana (1977). Analysis of variance (one way classified data) for each parameter was performed using ProcGlm of Statistical Analysis System (SAS) software (version 9.3). Mean separation for different treatment under different parameter were performed using Least Significant Different (LSD) test ($P \leq 0.05$). Normality of residuals under the assumption of ANOVA was tested using Kolmogrov-Smirnov, Shapiro-Wilk, Cramer-Von Mises and Anderson Darling procedure using Proc-Univariate procedure of SAS, (version 9.3). Data transformation was done following the method of Gomez and Gomez (1983).

Results and Discussion

Physiological loss in weight

Observation during storage of ber fruit revealed that among several coating treatments T_5 gives better result (Table 1) as compared to others. On 3rd day after treatment the physiological loss in weight was statistically was found minimum (8.89%) in T_5 followed by T_6 (9.04%) where as it was maximum (15.15%) in the fruits under control (T_{10}). The reduction in weight loss was probably due to the effects of these coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss

Table 1: Effect of edible coatings on physiological loss in weight (percent)

Treatments	Days after storage				
	3	6	9	12	Cumulative
T_1 (Chitosan-0.5%)	11.63a	21.4a	17.98ab	14.18bc	51.29ab
T_2 (Chitosan-1%)	13.67a	21.48a	10.24c	13.38bc	48.59abc
T_3 (Chitosan-2%)	10.01a	16.95a	13bc	12.48bc	43.1cb
T_4 (Guar gum1%)	9.08a	16.6a	12.34bc	16.62abc	47.05abc
T_5 (Guar gum-1.5%)	8.89a	11.88a	6.83c	7.45c	29.12d
T_6 (Guar gum-2%)	9.04a	18.02a	11.36bc	15.9abc	44.58bc
T_7 (Gum tragacanth-1%)	14.65a	15.35a	9.86c	16.82ab	45.54abc
T_8 (Gum tragacanth-1.5%)	10.27a	16.96a	12.31bc	14.91bc	44.72bc
T_9 (Gum tragacanth-2%)	8.61a	13.5a	7.93c	9.22bc	34.12cd
T_{10} (Control-Untreated)	15.15a	25.73a	21.3a	24.46a	60.58a
LSD ($P \leq 0.05$)	NS	NS	7.60	9.21	15.35
SEM (±)	1.98	2.65	1.41	1.71	2.85

Means with the same letter are not significantly different.

Table 2: Effect of some post-harvest treatments on colour of fruits

Treatments	Days after storage			
	3	6	9	12
T_1 (Chitosan-0.5%)	YGGN144D	YGG144B	GBGN199C	GBG199B
T_2 (Chitosan-1%)	YGG144D	YGG144D	GBGN199C	GBG199B
T_3 (Chitosan-2%)	YGGN144D	YGGN144C	GBGN199C	GBG199B
T_4 (Guar gum1%)	YGGN144D	YGG144D	YGG145A	YGG144B
T_5 (Guar gum-1.5%)	YGGN144D	YGG144C	YGG145B	YGG144A
T_6 (Guar gum-2%)	YGGN144D	YGG144C	YGG144B	YGG144B
T_7 (Gum tragacanth-1%)	YGG144B	YGG144D	YGG144B	BG200D
T_8 (Gum tragacanth-1.5%)	YGGN144C	YGG144D	YGG145A	BG200D
T_9 (Gum tragacanth-2%)	YGGN144C	YGG144D	YGG144B	BG200D
T_{10} (Control-Untreated)	YGG144B	BG200D	BG200C	GBGN199A

Gbg-Grey Brown Group,Ygg-Yellow Green Group,Bg-Brown Group.

and oxidation reaction rates (Baldwin *et al.* 1999). At the end of storage on 12th day, T_5 showed the minimum change in weight (7.45%) followed by T_9 (9.22%) and T_{10} gives maximum loss in weight (24.46%). The basic mechanism of weight loss from fresh fruit and vegetables is by vapour pressure at different locations (Yaman and Bayoindirli 2002), although respiration also causes a weight reduction. A significant delay in change of weight in tomato fruits by using guar gum as an edible coating was also found by Ghosh *et al.* 2014. The physiological loss of weight of ber fruits were recorded in this present experiment. Similar observation was reported by Kaur *et al* 2014 in guava fruits during the storage period.

Fruit Colour

Colour is an important criterion of quality, especially with respect to consumer acceptability in ber fruits. At the time of the harvesting fruits were yellowish green (YGGN144D) in colour, which is ultimately changed in to brown (BG200D) or grayish brown (GBG199B) in colour at the end of the storage except fruits coated with guar gum (Table 2). A quicker senescence was observed in fruits under control from 6th day of storage. On 12th days of storage, a significant delay in colour change was observed in T_5(Guar gum 1.5%). It was probably due to an increase in CO_2 and decrease in O_2 levels, which decrease ethylene synthesis followed by delay in colour changes (Buescher 1979). Castricini *et al.* (2012) observed that papaya coated with cassava starch and carboxy methyle starch helped to maintain the colour during storage. Generally the yellowness increased with storage time due to ripening of fruits Ruzaina *et al.* (2013).

Fruit length and breadth

T_5 (Guar gum 1.5%) showed a lower percentage of shrinkage compared to other treatments and control fruits. The shrinkage percentage of T_5 was 3.12% (from 30.3 cm to 27.18 cm) for fruit length and 2.18% (from 26.01 cm. to 23.83 cm.) for fruit breadth. All the treatments have no effects on length but statistically at par on 6th and 12th days af er storage for breadth (Table 3). It might be due to the anti-senescent action of coatings which had an inhibitory effect on ethylene biosynthesis and retard the activity of enzymes responsible for ripening, cell degradation was prevented which in turn facilitated reduced moisture loss and lesser respiratory gas exchange, hence delay in senescence and lower the shrinkage percentage (Sudha *et al.* 2007). Jawandha et al, 2014 reported that percent spoilage of Baramasi lemon fruits was increased with the extension in storage period due to the weakening of the defense system against fungal at ack.

Table 3: Effect of some post-harvest treatments on length(mm.) and breadth(mm.) of fruits

Treatments	Days after treatments									
	3		6		9		12		Shrinkage (%)	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
T_1 (Chitosan-0.5%)	30.35a	26.09ab	28.45a	25.12a	26.13a	23.83b	23.77a	22.51a	6.58%	3.58%
T_2 (Chitosan-1%)	30.26a	26.26ab	29.06a	25.19a	27.79a	24.85ab	25.75a	23.34a	4.51%	2.92%
T_3 (Chitosan-2%)	31.06a	26.16ab	29.69a	25.38a	28.39a	24.96ab	26.96a	23.55a	4.10%	2.61%
T_4 (Guar gum1%)	30.59a	25.78b	29.22a	25.03a	27.15a	24.27ab	25.69a	23.18a	4.90%	2.60%
T_5 (Guar gum-1.5%)	30.3a	26.01ab	30.36a	25.90a	28.93a	25.44a	27.18a	23.83a	3.12%	2.18%
T_6 (Guar gum-2%)	30.67a	26.09ab	29.43a	25.51a	28.23a	24.57ab	26.73a	23.26a	3.94%	2.83%
T_7 (Gum tragacanth-1%)	31.4a	26.57a	29.44a	24.99a	27.82a	24.14ab	28.1a	24.27a	3.30%	2.30%
T_8 (Gum tragacanth-1.5%)	29.5a	25.94ab	28.43a	25.54a	26.93a	25.23ab	25.73a	23.26a	3.77%	2.68%
T_9 (Gum tragacanth-2%)	31a	26.28ab	29.98a	25.63a	28.93a	25.26a	27.2a	23.96a	3.8%	2.32%
T_{10} (Control-Untreated)	29.37a	25.9ab	27.75a	24.97a	26.59a	24.34ab	25.27a	23.3a	4.10%	2.60%
LSD(P≤0.05)	NS	0.71	NS	NS	NS	1.42	NS	NS	-	-
SEM (±)	0.94	0.13	0.93	0.20	0.92	0.26	0.94	0.37	-	-

Means with the same letter are not significantly different.

Total soluble solids

Observation during storage of ber fruits revealed that the TSS content of fruit was decreased in all the treatments as the storage period progressed (Table No. 4). On 3 days after treatment, the TSS content was found highest (9.3° brix) in T_5 followed by T_9 (9.23° brix), whereas, it was lowest (8.8° brix) in control (T_{10}). However, on 12 days after treatment, the TSS content was also found maximum (7.73° brix) in T_5 followed by T_4 (7.4° brix) and was minimum (6.33° brix) in T_{10} i.e in control. Decreased respiration rates also slow down the synthesis and use of metabolites resulting in lower TSS (Yaman and Bayoindrili 2002). Oluwaseun *et al.* (2013) observed that, coated cucumber showed higher TSS compared to uncoated ones.

Table 4: Effect of some post-harvest treatments on TSS (°Brix) of fruits

Treatments	Days after storage			
	3	6	9	12
T_1 (Chitosan-0.5%)	9.2a	8.37a	8.09ab	7.17abc
T_2 (Chitosan-1%)	9.17a	8.5a	7.6ab	7abc
T_3 (Chitosan-2%)	8.93a	8.67a	8.2ab	7.2abc
T_4 (Guar gum1%)	9a	8.33a	7.87ab	7.4ab
T_5 (Guar gum-1.5%)	9.3a	8.87a	8.47a	7.73a
T_6 (Guar gum-2%)	9a	7.93a	7.2b	6.63bc
T_7 (Gum tragacanth-1%)	8.93a	8.67a	8.33ab	7.13abc
T_8 (Gum tragacanth-1.5%)	9.2a	8.7a	8ab	7.3abc
T_9 (Gum tragacanth-2%)	9.23a	8.53a	8.43a	7.33ab
T_{10} (Control-Untreated)	8.8a	8.3a	7.8ab	6.33c
LSD(P≤0.05)	1.34	1.20	1.14	0.97
SEM (±)	0.25	0.22	0.21	0.18

Means with the same letter are not significantly different.

Titrable acidity

The titrable acidity values of coated and uncoated fruit during storage decreased with storage time (Table 5). The value was highest (0.11%) in T_5 on 12th days after treatment and the lowest (0.07%) in control ($T_{10)}$. However, the data of all the treated fruits were statistically at par. The coating has no effect on titrable acidity during storage of ber fruits. The low level of titrable acidity in control fruit compared to coated fruit suggests that the guar gum coating delayed ripening by providing a transparent coating around the fruit. It is also considered that coatings reduce the rate of respiration and may therefore delay the utilization of organic acids. Retention of titrable acidity has been reported previously for various fruit treated with edible coatings and films (Yaman and Bayoindirli 2002).

Table 5: Effect of some post-harvest treatments on acidity percentage of fruits

Treatments	Days after storage			
	3	6	9	12
T_1 (Chitosan-0.5%)	0.18a	0.16a	0.12a	0.08a
T_2 (Chitosan-1%)	0.16a	0.15a	0.12a	0.08a
T_3 (Chitosan-2%)	0.17a	0.13a	0.11a	0.08a
T_4 (Guar gum1%)	0.19a	0.16a	0.13a	0.09a
T_5 (Guar gum-1.5%)	0.19a	0.16a	0.13a	0.11a
T_6 (Guar gum-2%)	0.19a	0.13a	0.09a	0.05a
T_7 (Gum tragacanth-1%)	0.18a	0.16a	0.13a	0.1a
T_8 (Gum tragacanth-1.5%)	0.17a	0.15a	0.13a	0.08a
T_9 (Gum tragacanth-2%)	0.19a	0.16a	0.13a	0.09a
T_{10} (Control-Untreated)	0.18a	0.14a	0.1a	0.07a
LSD(P≤0.05)	NS	NS	NS	NS
SEM (±)	0.02	0.02	0.02	0.01

Means with the same letter are not significantly different.

Reducing sugar

It can be observed from Table 6, that in general reducing sugar content showed a decreasing trend with the storage time (Table 7). The reducing sugar content was found highest (4.37%) in T_5 on 3rd days of storage whereas the lowest content (4.2%) was found in untreated fruits. On 12th day of storage, T_5 showed highest (3.99%) result and the lowest (3.07%) result was observed in control. However, the data of all the treated fruits were statistically at par. The change of reducing sugar content is occurred due to utilization of sugar as a respiratory substrate (Nandane and Jain 2011).

Table 6: Effect of some post-harvest treatments on reducing sugar percentage of fruits

Treatments	Days after storage			
	3	6	9	12
T_1 (Chitosan-0.5%)	4.27a	4.19a	3.77a	3.63a
T_2 (Chitosan-1%)	4.31a	3.93a	3.7a	3.47a
T_3 (Chitosan-2%)	4.29a	3.8a	3.43a	3.53a
T_4 (Guar gum1%)	4.33a	4.16a	4.1a	3.83a
T_5 (Guar gum-1.5%)	4.37a	4.25a	4.11a	3.99a
T_6 (Guar gum-2%)	4.27a	4.04a	3.92a	3.69a
T_7 (Gum tragacanth-1%)	4.33a	4.1a	4.09a	3.86a
T_8 (Gum tragacanth-1.5%)	4.32a	4.18a	4.1a	3.63a
T_9 (Gum tragacanth-2%)	4.35a	4.23a	4.11a	3.94a
T_{10} (Control-Untreated)	4.2a	4.02a	3.83a	3.07a
LSD(P≤0.05)	NS	NS	NS	NS
SEM (±)	0.19	0.21	0.20	0.19

Means with the same letter are not significantly different.

Total sugar

Total sugar percentage is an important factor for determining the quality of ber fruits. The flavour depends on total sugar percentage (Nandane and Jain 2011). It was decreased in all the treatments as the storage period advanced (Table 7). On 3rd days after treatment of sample, the total sugar content was found highest (7.47%) in T_5, where as it was lowest (7.03%) in the uncoated fruit. On 9th days after treatment, total sugar content was found maximum (6.87%) in T_5 where as it was minimum (6%) in T_7 (control). However all the treatments were statistically at par except 12th day. The change of sugar content is occurred due to utilization of sugar as a respiratory substrate (Nandane and Jain 2011).

Table 7: Effect of some post-harvest treatments on total sugar percentage of fruits

Treatments	Days after storage			
	3	6	9	12
T_1 (Chitosan-0.5%)	7.27a	6.83a	5.9a	5.19bc
T_2 (Chitosan-1%)	7.3a	6.83a	6.11a	5.33abc
T_3 (Chitosan-2%)	7.3a	6.63a	6.03a	5.31abc
T_4 (Guar gum1%)	7.13a	7a	6.6a	5.05cd
T_5 (Guar gum-1.5%)	7.47a	7.5a	6.87a	5.8ab
T_6 (Guar gum-2%)	7.3a	6.9a	6.57a	6a
T_7 (Gum tragacanth-1%)	7.1a	6.6a	6.2a	5.2bc
T_8 (Gum tragacanth-1.5%)	7.3a	6.5a	5.8a	5.8ab
T_9 (Gum tragacanth-2%)	7.43a	7.1a	6.7a	5.8ab
T_{10} (Control-Untreated)	7.03a	6.6a	6a	4.42d
LSD(P≤0.05)	NS	NS	NS	0.74
SEM (±)	0.22	0.20	0.23	0.14

Means with the same letter are not significantly different.

Ascorbic acid

The highest level of ascorbic acid (91.45 mg/100g pulp) was observed in T_5, closely followed by fruits in T_9 (91.17 mg/100g pulp) and the lowest level (86.15 mg/100g pulp) in control fruit on 3rd days after storage. On 12thdays of storage, it was observed maximum (86.22 mg/100g pulp) and minimum (80.76 mg/100 g pulp) in T_5 and untreated fruits, respectively (Table 9). From the experimental result it is clear that coated fruits retained more amount of ascorbic acid. This was probably because guar gum coating acted as a gas barrier, inhibiting oxygen from entering the fruit, thus reducing the oxidation of ascorbic acid. Ascorbic acid is lost at later stage due to the activities of phenol oxidase and ascorbic acid oxidase enzymes during storage (Salunkhe *et al.* 1991).

Table 8: Effect of some post-harvest treatments on ascorbic acid (mg/100g fruit sample) of fruits

Treatments	Days after storage			
	3	6	9	12
T_1 (Chitosan-0.5%)	86.43cd	84.65bc	83.3bc	81.38b
T_2 (Chitosan-1%)	88.54abcd	82.37c	81.55c	80.85b
T_3 (Chitosan-2%)	90.19abc	87.92ab	86.48ab	83.45ab
T_4 (Guar gum1%)	88.17abcd	86.21ab	84.23abc	83.29ab
T_5 (Guar gum-1.5%)	91.45a	88.97a	87.81a	86.22a
T_6 (Guar gum-2%)	89.66abcd	87.83ab	85.16abc	83.15ab

T_7 (Gum tragacanth-1%)	88.55abcd	87.65ab	86.12ab	85.67a
T_8 (Gum tragacanth-1.5%)	87.29bcd	84.53bc	81.8c	83.55ab
T_9 (Gum tragacanth-2%)	91.17ab	88.41a	86.77ab	86.04a
T_{10} (Control-Untreated)	86.15d	86.03ab	84.77abc	80.76b
LSD(P≤0.05)	3.99	3.62	3.90	4.08
SEM (±)	0.74	0.67	0.72	0.76

Means with the same letter are not significantly different.

Conclusion

It can be concluded from the present experiment that the edible coating affects positively on the physico-chemical parameters of ber fruits. Among all the coating materials fruit coated with guar gum 1.5% (T_5) showed a significant delay in change of weight, length and breadth, total soluble solids, titrable acidity, total and reducing sugar, ascorbic acid content and colour during storage as compared to uncoated control fruit. This suggests that guar gum not only extends the shelf life but also preserves the ascorbic acid content which is associated with antioxidant capacity during storage and also suggests that guar gum is promising as an edible coating to be used in commercial postharvest applications for prolonging the storage life.

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