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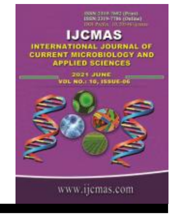

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Effect of Post Harvest Treatments on Storage Quality of Ber (*Ziziphus mauritiana* Lamk.) under Cold Storage Condition cv. Gola

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A B S T R A C T

An experiment was conducted to study the effect of post-harvest treatments on storage quality and shelf life of ber (*Ziziphus mauritiana* Lamk.) under cold storage condition cv. Gola. The experiment was conducted during the *Rabi*-2020 at Horticultural Research Farm and P. G. Laboratory, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. Freshly harvested at physiological maturity of uniform size selected fruits were subject to post harvest treatments *viz*., GA_3 (20, 40 and 60 ppm), $CaCl_2$ (0.5, 1.0 and 2.0 %) along with wax coating (6 %) and without wax coating. Periodic observations at 5th, 10th, 15th and 20th day of storage were taken for evaluation of storage quality. The study results revealed that fruits treated with $CaCl_2$ 2.0 % when coated with wax (6 %) resulted in prolonging shelf life upto15 days with minimizing physiological loss in weight, spoilage, acidity and increased marketable fruits, firmness with maintaining higher level of TSS, ascorbic acid, total sugar, reducing sugar and non reducing sugar as compared to the control (water spray and without wax).

Introduction

Ber (*Ziziphus mauritiana* Lamk.) is one of the most ancient and common fruit of India and it is cultivated practically all over the country. Being a hardy fruit, it can be grown even on inferior and marginal lands. Ber is indigenous to an area stretching from India to China and Malaysia. In view of good returns from ber, its cultivation is becoming increasingly popular in Gujarat and other states of North India, especially in Punjab, Haryana, and Rajasthan. It is nutritive and delicious. Generally, gibberellic acid is known for its anti-senescing properties which results in delaying ripening of fruits. Fruits generally have a considerable amount of Calcium in their tissues. The Ca application makes the middle lamella of fruit cell wall thicker by increased deposition of calcium pectate and so, maintains the firmness of fruit (Sudha *et al.*, 2007). The use of wax emulsion has been found to increase the storage life of guava fruits (Kumar *et al.*, 2012). Wax acts as a barrier of free movement of water, air and oxygen.

Covering with additional layer of wax on the fruit surface by use of wax emulsions like waxol has been reported to have beneficial effect in extending shelf life of several fruits. Therefore, it is needful to subject ber fruits to growth regulator, chemical and wax treatments to evaluate their response on biochemical parameters under cold storage.

Materials and Methods

The research experiment was carried out during *Rabi*-2020at Horticultural Research Farm and P. G. Laboratory, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. Uniform sized fruits of Gola cultivar were selected at physiological maturity. The fruits were dipped for 5 minutes.

Treated fruits were then placed in CFB boxes then after in cold storage (8°C and 85 % RH). The experiment was laid out in Completely Randomized Design with Factorial concept (FCRD) having fourteen treatments combination comprising of $CaCl_2$ (0.5, 1.0 and 2.0 %), GA_3 (20, 40 and 60 ppm), wax (6 %) and with control (water) and three replications.

Fruits samples were analysed for physio-biochemical changes like physiological loss in weight (%), spoilage (%),marketable fruits (%), firmness ($Kgcm^{-2}$), total soluble solids (ºbrix), acidity (%), ascorbic acid (mg/100g pulp), total sugar (%), reducing sugar (%) and non reducing sugar(%). Observations recorded at every five (5) days intervals (i.e., 5th, 10th, 15th and 20th days) up to 20th days during storage.

Results and Discussion

Physiological parameters

Physiological loss in weight (PLW) (%) and Fruit firmness ($Kgcm^{-2}$)

PLW of fruits increased significantly with advancement of storage period regardless of post-harvest treatments. At the end of storage, fruits treated in $CaCl_2$ (2.0 %) with wax coating (6 %) showed minimum PLW (8.44 %) as compared to control (water spray and without wax) (26.84 %). Coating of wax (6 %) to treated fruit with $CaCl_2$ (2.0 %) was effective in creating a physical barrier to moisture loss, hence reduced weight loss observed for the treated fruits (1.37 to 8.44 %) than for non treated fruits (3.2 to 26.84 %). This is might be due to weight loss of fresh fruits is mainly due to water loss because of transpiration while dry matter is lost by respiration. Hence, the lowest PLW of the fruits could be effect of $CaCl_2$ dipping on respiration, which probably lowered the rate of transpiration, water loss and oxidation reactions and related to modified atmosphere created by wax coating. These results were in accordance with the finding of Seleshi *et al.*, (2019) in nectarine, who observed treating nectarine fruits with 3 % BeesWax with 4.5 % $CaCl_2$ kept the PLW low up to the end of shelf life. The similar result on PLW was reported by Gaikwad *et al.*, (2006) in mango and Dhumal *et al.*, (2008) in aonla. Datain Table (1) revealed that all the treatments exhibited non significant effect for fruit firmness upto 15th day of storage. At the end of storage (20th day) it was highest in treatment (C_6W_1) and lowest in control treatment (C_7W_2).

Spoilage (%)

Data in (Table 1) showed that there was no spoilage in all the treatments up to 5th days of storage. Then after fast spoilage observed in all the treatments with advancement of storage regardless of the treatments. The treatment combination of $CaCl_2$ (2.0 %) with wax coating (6 %) showed lowest spoilage over control through the storage. This might be due to combined role of $CaCl_2$, which act as a reducer of fruit softening by strengthening of the cell walls and beeswax by covering cuticle and lenticels of the fruits. Hence, reduction of respiration rate and ripening process by the treatments probably minimized the occurrence of fruit spoilage. Seleshi *et al.*, (2019) reported similar finding where nectarine fruits treated either at 3% BeesWax + 3.0% $CaCl_2$ or 3% BeesWax + 4.5% $CaCl_2$ better reduced the spoilage up to shelf life termination. This might be due to slow release of free water on an effect of reduced metabolism and rate of transpiration in calcium treated fruits. The similar result was reported by Khanvilkar *et al.*, (2018), who reported sapota fruits treated with ($CaCl_2$ 1.0 %) recorded lowest spoilage.

The lowest spoilage fruits in the wax coating might be due to inhibition of sporulation and spore germination of rot causing fungus. These results were in accordance with the finding of Jawadagi *et al.*, (2013) who noticed that the application of the wax emulsion 10 % recorded lowest spoilage of in custard apple.

Marketable fruits (%)

The maximum marketable fruits were found (88.66 %) in treatment (C_6W_1) up to 15th day of storage (Table 1) and minimum recorded in control treatment (45.80 %). Then after decline trend observed. Due to the lowest firmness loss, shrivelling, spoilage occurrence and better appearance had delayed metabolic rates resulted in the highest percentage of marketable fruits. Seleshi *et al.*, (2019) who noticed that 3% Bee Wax + 4.5% $CaCl_2$treatment had consistently kept the highest percentage of marketable fruits up to the last date of storage life of nectarine fruits.

Bio-chemical parameters

Total soluble solids (^{0}Brix)

TSS content of fruits increased up to 15th days of storage in all the treatments except the control (C_7W_2), which recorded increasing TS content only up to 10th days of storage (Table 2). However decline trend was observed for TSS in all the treatments at 20th day of storage. Among the different treatments $CaCl_2$ (2.0 %) with wax coating (6 %) recorded maximum TSS at the end of storage closely followed by $CaCl_2$ (1.0 %) with wax coating (6 %) than other treatments.

This might be due to the calcium helps increase in soluble solids content caused by hydrolysis of polysaccharides like starch, pectin and cellulose substances into simpler substances. The present results is in agreement with Tsomu and Patel (2014), who reported similar finding where sapota fruits treated with $CaCl_2$ 1.0 % recorded highest TSS.

Bee wax coating delayed degradation process of carbohydrates and reduced transpiration from the fruits. Jakhar and Pathak, 2015 who noticed that treatment of HWT+Wax coating also retained the highest TSS followed by wax coating treatment upto 18 days of storage in mango.

Acidity (%)

Data presented in (Table 2) indicated that acidity content was gradually decline in all treatments as storage period progressed. At the end of cold storage, lowest acidity was recorded in $CaCl_2$ (2.0 %) with wax coating (6 %), where as highest acidity observed in control (water spray and without wax). This is might be due to slow metabolic rates. Netravati *et al.*, (2018)reported similar finding where custard apple fruits treated wax (1:10) and $CaCl_2$ (4%) retained least titrable acidity.

Table.1 Effect of different levels of post-harvest treatments of chemical and wax on Physiological loss in weight (%), Spoilage (%), Marketable fruits (%)and Firmness ($Kgcm^{-2}$) of berunder cold storage condition cv. Gola

Treatments	Physiological loss in weight (%)				Spoilage (%)				Marketable fruits (%)				Firmness ($Kgcm^{-2}$)			
	Storage period in days				Storage period in days				Storage period in day				Storage period in days			
	5th	10th	5th	5th	5th	10th	15th	20th	5th	10th	15th	20th	5th	10th	15th	20th
C_1W_1	3.17	5.85	8.76	10.26	0	10.41	35.27	46.58	100	89.59	64.72	53.42	6.79	6.54	6.00	5.90
C_1W_2	2.26	5.99	8.97	10.60	0	15.00	39.20	58.64	100	85.00	60.80	41.35	6.86	6.39	5.87	5.82
C_2W_1	2.22	5.66	7.51	9.45	0	10.00	14.33	29.33	100	90.00	85.66	70.66	7.03	6.44	6.36	5.86
C_2W_2	3.21	6.25	8.88	10.63	0	13.00	34.13	49.62	100	87.00	65.86	50.37	6.86	6.36	6.06	5.90
C_3W_1	2.07	5.44	7.43	9.32	0	8.00	15.33	35.37	100	92.00	84.66	64.62	7.04	6.72	6.40	6.11
C_3W_2	2.21	5.36	8.31	10.04	0	14.20	26.33	56.60	100	85.79	73.66	43.39	6.88	6.46	6.00	5.93
C_4W_1	2.10	5.26	7.66	9.27	0	7.00	15.66	33.29	100	93.00	84.33	66.70	6.83	6.73	6.49	6.09
C_4W_2	2.32	6.50	7.32	10.23	0	11.00	33.66	48.35	100	89.00	66.33	51.65	6.67	6.48	6.27	5.23
C_5W_1	1.87	4.26	6.52	8.65	0	6.00	13.86	30.33	100	94.00	86.13	69.66	7.06	6.63	6.46	6.08
C_5W_2	2.09	5.42	7.44	9.95	0	13.00	31.00	46.61	100	87.00	69.00	53.39	6.95	6.67	6.49	5.30
C_6W_1	1.37	4.15	6.35	8.44	0	3.66	11.33	26.21	100	96.33	88.66	73.78	7.12	6.83	6.64	6.33
C_6W_2	2.05	5.30	7.29	9.85	0	10.66	29.33	35.94	100	89.33	70.66	64.05	6.99	6.79	6.39	5.95
C_7W_1	2.50	6.86	9.67	10.58	0	17.00	34.48	51.99	100	83.00	65.51	48.00	6.56	6.38	6.13	5.46
C_7W_2	3.20	6.75	10.52	26.84	0	25.97	54.19	69.37	100	74.02	45.80	30.62	6.26	6.17	5.68	4.96
S.Em. ±	0.08	0.17	0.15	0.24	-	0.20	0.88	1.70	-	0.54	0.88	1.70	0.11	0.10	0.12	0.10
C.D. at 5 %	0.25	0.51	0.44	0.71	-	0.60	2.57	4.94	-	1.59	2.57	4.94	NS	NS	NS	0.30
C.V. %	6.40	5.48	3.32	3.87	-	8.08	5.55	6.69	-	1.08	2.13	5.29	2.45	2.23	2.73	3.11

C_1- GA_3 20 ppm, C_2- GA_3 40 ppm, C_3- GA_3 60 ppm, C_4- $CaCl_2$ 0.5 %, C_5- $CaCl_2$1.0 %, C_6- $CaCl_2$2.0 %
W_1- With 6 %wax coating and W_2- Without wax coating

Table.2 Effect of different levels of post-harvest treatments of chemical and wax on Total Soluble Solids (°Brix), Acidity (%) and Ascorbic acid (mg/100 g pulp) of ber under cold storage condition cv. Gola

Treatments	Total Soluble Solids (°Brix)				Acidity (%)				Ascorbic acid (mg/100 g pulp)			
	Storage period in days				Storage period in days				Storage period in days			
	5th	10th	15th	20th	5th	10th	15th	20th	5th	10th	15th	20th
C_1W_1	12.24	12.77	12.80	11.94	0.213	0.197	0.182	0.164	76.79	73.32	69.16	58.19
C_1W_2	11.24	12.64	12.85	11.44	0.266	0.234	0.190	0.181	73.54	70.40	67.97	54.57
C_2W_1	11.53	12.43	13.18	12.50	0.210	0.200	0.180	0.179	81.41	81.08	75.86	61.17
C_2W_2	11.47	12.96	13.13	11.14	0.268	0.253	0.240	0.225	74.96	74.18	71.48	57.79
C_3W_1	13.22	13.77	13.92	12.56	0.224	0.192	0.183	0.173	76.72	79.62	75.79	62.83
C_3W_2	11.22	12.96	13.08	11.36	0.272	0.267	0.263	0.255	78.80	75.76	70.81	60.46
C_4W_1	12.41	13.72	14.06	12.30	0.204	0.183	0.178	0.167	82.10	79.90	76.87	63.41
C_4W_2	12.33	13.37	13.55	11.18	0.267	0.264	0.195	0.188	73.95	73.08	68.00	63.14
C_5W_1	13.42	14.17	14.24	13.41	0.204	0.187	0.174	0.159	84.93	77.70	76.61	64.28
C_5W_2	12.57	13.20	13.26	12.39	0.252	0.240	0.235	0.211	71.95	69.27	64.12	61.79
C_6W_1	13.65	14.21	14.32	13.75	0.201	0.178	0.166	0.145	85.08	81.65	78.02	65.58
C_6W_2	12.80	13.27	13.33	11.78	0.285	0.268	0.260	0.256	72.07	78.51	74.41	61.43
C_7W_1	12.22	12.65	12.82	11.26	0.217	0.201	0.185	0.168	71.78	68.17	63.45	56.94
C_7W_2	11.06	11.50	11.13	10.10	0.274	0.269	0.251	0.250	70.55	65.67	59.14	48.19
S.Em. ±	0.27	0.11	0.08	0.18	0.007	0.005	0.004	0.003	0.70	0.77	0.62	0.46
C.D. at 5 %	0.78	0.34	0.25	0.54	NS	0.014	0.010	0.009	2.05	NS	1.82	1.33
C.V. %	3.82	1.56	1.12	2.72	5.150	3.636	3.040	2.647	1.60	2.52	1.54	1.33

C_1- GA_3 20 ppm, C_2- GA_3 40 ppm, C_3- GA_3 60 ppm, C_4- $CaCl_2$ 0.5 %, C_5- $CaCl_2$1.0 %, C_6- $CaCl_2$2.0 %, W_1- With 6 %wax coating and W_2- Without wax coating

Table.3 Effect of different levels of post-harvest treatments of chemical and wax on Total sugar (%), Reducing sugar (%) and Non-reducing sugar (%) of ber under cold storage condition cv. Gola

Treatments	Total sugar (%)				Reducing sugar (%)				Non-reducing sugar (%)			
	Storage period in days				Storage period in days				Storage period in day			
	5th	10th	15th	20th	5th	10th	15th	20th	5th	10th	15th	20th
C_1W_1	8.55	9.34	8.86	8.53	4.36	4.65	4.01	4.27	4.52	4.68	4.85	4.25
C_1W_2	8.70	9.24	8.95	8.80	4.41	4.62	4.72	4.15	4.28	4.62	4.23	4.65
C_2W_1	8.59	9.76	9.59	9.42	4.72	4.81	4.79	4.40	3.87	4.94	4.8	5.02
C_2W_2	8.54	8.95	8.87	8.08	4.42	4.36	4.74	3.94	4.11	4.58	4.12	4.14
C_3W_1	8.51	9.66	10.11	9.37	4.54	4.80	5.52	4.30	3.97	4.85	4.59	5.07
C_3W_2	8.43	9.71	8.84	8.27	4.26	4.41	5.06	4.36	4.16	5.29	3.78	3.90
C_4W_1	8.96	10.09	10.34	9.02	5.53	5.02	5.31	3.66	3.43	5.07	5.03	5.36
C_4W_2	8.35	8.61	9.66	9.32	4.24	4.36	5.55	4.70	4.11	4.25	4.11	4.61
C_5W_1	9.42	10.15	10.56	10.02	5.09	5.20	5.50	4.23	4.33	4.95	5.06	5.78
C_5W_2	8.40	9.67	9.71	9.12	4.46	4.55	4.79	4.22	3.94	5.11	4.91	4.90
C_6W_1	9.85	10.34	11.16	10.15	5.31	4.81	5.81	4.94	4.54	5.52	5.35	5.21
C_6W_2	8.85	9.47	9.78	9.59	4.50	4.62	4.71	4.46	4.35	4.84	5.07	5.12
C_7W_1	8.33	8.80	9.11	8.05	4.27	4.39	4.03	3.62	4.05	4.41	5.08	4.43
C_7W_2	7.47	7.74	7.51	6.74	3.42	3.55	3.83	3.40	4.05	4.19	3.68	3.34
S.Em. ±	0.21	0.23	0.24	0.30	0.19	0.11	0.22	0.19	0.25	0.27	0.25	0.23
C.D. at 5 %	0.63	0.66	0.72	0.87	0.55	0.32	0.64	0.56	NS	NS	NS	0.67
C.V. %	4.39	4.24	4.54	5.88	7.24	4.29	7.90	8.11	8.72	7.98	7.94	8.56

C_1- GA_3 20 ppm, C_2- GA_3 40 ppm, C_3- GA_3 60 ppm, C_4- $CaCl_2$ 0.5 %, C_5- $CaCl_2$1.0 %, C_6- $CaCl_2$2.0 %, W_1- With 6 %wax coating and W_2- Without wax coating

The reduction in acidity during storage might be associated with the conversion of organic acid into sugar and their derivatives or their utilization in respiration. Similar result was also reported by Shrinu *et al.,* (2017) who reported papaya fruits treated with $CaCl_2$ 1.0 % recorded lowest acidity. This might be due to conversions of acids into salts and sugar by the enzymes, particularly invertase. These are in conformity with reported by Shahid and Abbashi (2011) who noticed that the application of the bee wax 5 % recorded lowest acidity in sweet orange.

Ascorbic acid(mg/100g pulp)

Data pertaining to ascorbic acid in the fruit are presented in Table 2. Ascorbic acid content in control treatment C_7W_2 (water spray without wax coating) decreased significantly during storage and this decline was also observed in $CaCl_2$ (2.0 %) with wax coating (6 %) treated fruits. No significance difference in ascorbic acid content was observed at 10^{th} days of storage among the treatments. However, with further progression of storage period, the ascorbic acid content was gradually reduced, though $CaCl_2$ (2.0 %) with wax coating (6 %) treated fruit still maintained higher values of ascorbic acid than the control and other treatments.

These results were in accordance with the finding of Seleshi *et al.,* (2019) in nectarine, who observed higher ascorbic acid content of nectarine fruits was maintained with $CaCl_2$ dipping and beeswax coating, particularly 3 % Bee Wax + 4.5 % $CaCl_2$ treated fruits.

The increase in ascorbic acid content might be due to continued activity of enzymes responsible for synthesis of ascorbic acid. The similar results on ascorbic acid reported by Gupta *et al.,* (1987) who reported ber fruits treated with $CaCl_2$ 2.0 % recorded higher ascorbic acid. This might be due to the degradation of ascorbic acid in the fruits. These results were in accordance with the findings of Singh *et al.,* (2012) who noticed that the application of Bavistin 500 mg/l + Wax emulsion 6 % recorded higher ascorbic acid in mango.

Total sugar (%), Reducing sugar (%) and Non reducing sugar (%)

The effect of treatments on total sugar and reducing sugar was significant. The total sugar showed an increasing trend up to 10^{th} days of storage in all the treatments however decline trend was observed at $15^{th}$and 20^{th}days of storage. The highest TS was recorded in C_6W_1 throughout storage period than control C_7W_2.Reducing sugar had non consistent trend for reducing sugar in all the treatments throughout the storage. However maximum reducing sugar was recorded in C_6W_1at the end of storage (20^{th} day) than control C_7W_2. Non reducing sugar was found non significant at 5^{th}, 10^{th} and 15^{th} day of storage, however, significant at 20^{th} day of storage. This might be due to hydrolysis of starch and accumulation of sugars. These results were in accordance with the findings of Tsomu and Patel (2014) in sapota fruits treated $CaCl_2$ 1.0 % highest total sugar. The slower rate of increase in sugars content in wax coated fruits might be due to the delayed degradation processes and less conversion of starch in to simple sugars. Jakhar and Pathak, 2015 who noticed that treatment of HWT+Wax coating also retained the highest total sugar followed by wax coating treatment upto 18 days of storage in mango. The similar result was reported by Ghadage(2011) in papaya.

On the basis of present findings, the result revealed that ber fruits treated with $CaCl_2$ 2.0 % (dipping 5 minutes) coated with wax (6 %) has prolonging shelf life up to 15 day of storage with improving fruit quality under cold storage (8 ^{0}C and 85 % RH).

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