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Effect of Post-Harvest Treatments on Physiochemical Properties of Indian Jujube (*Ziziphus mauritiana Lamk*.) during Ambient and Cold Storage Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. Author JSS designed the study and wrote the protocol. Authors LNB, MRC managed the literature searches, performed the statistical analysis. Authors RKJ, AJ and MY managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

The effect of post-harvest application of calcium chloride ($CaCl_2$) and gibberellic acid (GA_3) on physiochemical properties of ber fruits were studied. Mature ber fruits cv. Umran were dipped in aqueous solutions of calcium chloride (0.5, 1.0 and 1.5%) and gibberellic acid (20, 40 and 60 ppm), for 5 minutes and packed in netlon bags for storage under ambient and cold storage conditions. Ber fruits treated with 1.5% $CaCl_2$ could be stored for longer duration in both storage conditions with higher retention of physiochemical quality of the fruits. Results revealed that physiological loss in weight, fruit weight, palatability rating, titratable acidity showed a declining

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trend with advancement of storage period and other parameters *i.e.* total soluble solids, ascorbic acid, reducing sugar, and total sugars showed an increase up to 9 days in ambient storage condition and up to 12 days in cold storage condition, but after 9 days in ambient storage condition and after 12 days in cold storage condition, a decline trend was observed in these parameters respectively. Storage life was extended to 9 days and 15 days of ber fruits treated with 1.5% $CaCl_2$ under ambient and cold storage conditions, respectively.

Keywords: Ber; ambient storage; cold storage; CaCl2.

1. INTRODUCTION

Indian Jujube (*Ziziphus mauritiana* Lamk.) known as ber is a non-climacteric fruit which is delicious, refreshing, rich source of vitamin C (65.8-76.0 mg/100g of fruit pulp), often harvested at full ripening stage and ripened fruits are highly perishable due to thin delicate skin and high water content in pulp. It is also rich in protein (0.8g/100g), minerals like phosphorous (0.148%), iron (0.54%) and various amino acids *i.e.* asparagine, aspartic acid, arginine, glutamic acid, serine, glycine etc. [1]. Due to rapid change in color and poor keeping quality, it cannot be stored for a longer period [2]. Gibberellic acid (GA_3) is growth substances that retard ripening and acts as anti-senescent agent during storage period [3]. GA_3 affects the degradation of complex carbohydrates as well as synthesis of sucrose and delayed ripening in papaya, banana and sapota fruits. Calcium (Ca) compounds extends the shelf-life of several fruits by maintaining firmness, minimizing the rate of respiration, protein breakdown and disease incidence [4]. Ca improves rigidity of cell walls and obstructs enzymes such as polygalacturonae from reaching their active sites, thereby retarding tissue softening and ultimately delaying ripening. Fruit quality parameters like physiological loss in weight (PLW), palatability, fruit weight, total soluble solids (TSS), acidity, ascorbic acid, reducing sugar and total sugars are highly affected during storage. The fruit growers can be highly benefited if its post-harvest life is suitably extended without much deterioration in quality of fruit. Hence, the present investigation was conducted to study the effectiveness of $CaCl_2$ and GA_3 on physiochemical quality of ber fruits.

2. MATERIALS AND METHODS

Uniformly ripe fruits of ber cv. Umran were harvested from university orchard of Krishi Vigyan Kendra, Ajmer, Rajasthan, India. Fruits free from visual symptoms of blemishes and any disease were dipped in aqueous solution of different compounds, viz., as $CaCl_2$ (0.5%. 1.0% and 1.5%) and GA_3 (20ppm, 40ppm and 60ppm) for five minutes then air dried in shade, packed in Netlon bags (1.0 kg) and stored in two different conditions *i.e.* ambient storage (9.8-34.2 and 60-88% RH) and cold storage conditions (4-6^{o}C and 85-95% RH), separately. The experiment was laid out in completely randomized block design with seven treatments and three replications in each storage condition. Each replication comprised of one-kilogram fruit.

The physiological loss in weight (%) was calculated based on initial weight and weight at subsequent intervals and the weight loss calculated [5]. Palatability rating was recorded on the basis of score card *viz*: 0-2.5 poor; 2.5-5.0 good; 5.0-7.5 very good and 7.5-10.0 excellent. Total soluble solids (ºBrix) were determined with the help of hand refractometer from the juice of fruit and the values were corrected at 20°C [6]. Fruit acidity (%) was estimated by titrating the juice against standard 0.1 N sodium hydroxide solution using phenolphthalein as indicator [6]. Ascorbic content (mg 100 g^{-1} fruit weight) content was determined by titrating the juice against 2, 6-dichlorophenol indophenol dye solution to a light pink colour, which persisted for 15 seconds [7]. Reducing sugar and total sugars were determined as per 'Lane and Eynon method' described by [8].

3. RESULTS AND DISCUSSION

3.1 Physiological Loss in Weight (%)

It is evident from the data presented in Table 1, the minimum PLW was found in 1.5% $CaCl_2$ *i.e.* 7.21%, 11.79%, 18.01% and 28.78% at 3rd, 6th, 9th and 12th days under ambient storage condition, respectively. The minimum PLW under 1.5% $CaCl_2$ was 29.97 per cent lower as compared to control. In cold storage condition found that the minimum PLW was observed in 1.5% calcium chloride *i.e.* 2.14%, 5.14%, 9.19%,

15.25%, 20.09%, 25.30% and 31.39% at 3rd, 6th, 9th, 12th, 15th, 18th and 21st respectively. Likewise, minimum PLW was recorded under treatment of 1.5% $CaCl_2$ which was 21.33% less as compared to control. Kiran et al. [9] also reported least PLW in Jamun by application of 1.5% $CaCl_2$.The physiological loss in weight of ber fruits preceded at slow rate during storage at 4-7ºC. This could be attributed to low rates of respiration and metabolic processes in fruits kept at low temperature storage Navjot and Mahajan [10] recorded the minimum PLW in peach during entire 21 day storage period.

3.2 Palatability Rating

A critical analysis of data (Table 3) indicated maximum palatability rating *i.e.* 8.09, 6.89, 4.67 and 2.32 at 3rd, 6th, 9th and 12th days was recorded fruits treated with 1.5% $CaCl_2$, respectively under ambient storage condition. The palatability rating (88.62%) was higher in 1.5% $CaCl_2$ as compared to the control at 12th day of storage. Fruits treated with 1.5% $CaCl_2$ also had the maximum palatability rating under cold storage conditions *i.e.* 8.97, 8.38, 7.66, 7.17, 6.16, 4.95 and 3.10 at 3rd, 6th, 9th, 12th, 15th, 18th and 21st days during storage period, respectively. Application of $CaCl_2$ @ 1.5% maintained 76.14% higher palatability rating over control at 21st day of storage. The consumer acceptability of ber was maintained for longer period when fruits treated with calcium chloride. Use of $CaCl_2$ @ 1.5% significantly increased palatability rating as compared to control. Increase in calcium content of the fruits has been associated with reduced softening. These results are close confirmatory with Kaur et al. [11] in pear, Wasker and Gaikwar [12] in mango.

3.3 Total Soluble Solids (ºBrix)

Data presented in Table 4 clearly reveals that initially TSS increased up to day 9 of storage then thereafter decreased under ambient storage conditions. The maximum TSS was recorded in 1.5% $CaCl_2$ *i.e.* 13.36, 14.56, 14.89 and 13.95 ºBrix at 3rd, 6th, 9th and 12th days of storage respectively, while the minimum was in control. The increase of TSS in 1.5% $CaCl_2$ treatment was registered 45.94% higher over control on 12th day of storage. In cold storage condition, the maximum TSS *i.e.* 15.11, 15.61, 14.90, 14.45 and 13.74 ºBrix was recorded in 1.5% $CaCl_2$ on the 9th, 12th, 15th, 18th and 21st days respectively, TSS content increased up to 12th day of storage before declining. The increase in TSS under the 1.5% $CaCl_2$ was found 43.86% higher as compared to control on 21st day of storage.

Therefore, total soluble solids showed gradual decrease with the advancement of storage period which may be due to increase in senescence process and high respiration rate. Similar rise and fall in total soluble solids was also noticed in guava [13] and loquat [14].

3.4 Titratable Acidity (%)

It is evident from the data presented in Table 5, the maximum acidity *i.e.* 0.25 0.23, 0.22 and 0.17% was recorded in 1.5% $CaCl_2$ on 3rd, 6th, 9th and 12th days of storage period under ambient storage conditions respectively while minimum values were recorded under control. The increased in titratable acidity in treatment 1.5% $CaCl_2$ was 58.33% higher as compared to control on the 12th day of storage. The maximum titratable acidity *i.e.* 0.24, 0.23, 0.21, 0.20, 0.19, 0.18 and 0.174% on the 3rd, 6th, 9th, 12th, 15th, 18th and 21st day of cold storage was recorded under 1.5% $CaCl_2$ which was significantly superior over rest of the treatments. The $CaCl_2$ 1.5% registered increase of 58.18% more titratable acidity over control at 21st day of storage.

In all treatments, the decline in acidity may be attributed to utilization of acids in the process of respiration during ripening in presence of reduced supply of sugar as a substrate of respiration due to lower rate of starch degradation during ripening and which might be due to conversion of acids into salts and sugars by the enzymes particularly invertase. The highest acidity might be due to low respiration rate in ber fruits treated with exogenous application of 1.5% $CaCl_2$. The results are in concurrence with those reported in guava [15] and [16] in ber.

3.5 Ascorbic Acid (mg/100 g Fruit Pulp)

The experimental data (Table 6) showed that the maximum ascorbic acid *i.e.* 119.80, 101.10, 86.10 and 69.10 mg on the 3rd, 6th, 9th and 12th days was recorded under the treatment 1.5% $CaCl_2$ under ambient storage conditions respectively. The increase in the ascorbic acid in 1.5% $CaCl_2$ was 56.69% higher than control. Under cold storage condition, the maximum ascorbic acid content *i.e.* 122.30, 115.40, 107.35, 98.20, 92.17, 83.69 and 72.49 mg/100g at 3rd, 6th, 9th, 12th, 15th, 18th and 21st day was recorded

in 1.5% $CaCl_2$ treatment respectively and the minimum was found in control. $CaCl_2$ at 1.5% had 64.86% higher ascorbic acid compared to control on the 21st day of ambient temperature storage. Significant decrease in ascorbic acid content was noted with advancement of storage period in all the treatments.

Reduction in ascorbic acid content might be attributed to the degradation of enzymes like ascorbic oxidase, peroxidase and catalase into dehydro ascorbic acid during storage. Similar results were also obtained by Hiwale and Singh [15] in guava, Jayachandran et al. [13] in guava and Vijayalaxmi et al. [17] in sapota.

3.6 Reducing Sugar (%)

The data presented in Table 7 revealed that reducing sugar was maximum in fruits treated with $CaCl_2$ at 1.5% *i.e.* 6.39, 6.93, 7.08 and 6.19% on the 3rd, 6th, 9th and 12th days under ambient storage conditions, respectively. This treatment retained 68.60% more reducing sugar over control at 12th day of storage. Data (Table 7) further showed that the maximum reducing sugar *i.e.* 6.20, 6.38, 6.64, 7.16, 6.81, 6.55 and 6.20% on the 3rd, 6th, 9th, 12th, 15th, 18th and 21st days respectively during the cold storage was recorded under treatment $CaCl_2$ @ 1.5%, while minimum reducing sugar was recorded under control. The increase in reducing sugar content under 1.5% $CaCl_2$ treatment was registered by 55.39% higher over control at 21st day of storage.

Ber is a non-climacteric fruit, rich in starch reserves and during post-harvest storage starch is hydrolyzed and liberating reducing sugars with enhancement of storage period. The increase in reducing sugar might be due to less utilization of sugar in respiration and conversion of starch into sugar under 1.5% $CaCl_2$ treatment during both storage conditions. This result is close conformity with findings of Jayachandran et al. [18] in guava and Singh et al. [19] in ber.

Table 1. Effect of different post-harvest treatments on physiological loss in weight of ber fruits

Treatments	Physiological loss in weight (%)						
	Number of days						
A. Ambient storage conditions	**3rd**		**6th**	**9th**	**12th**		
T_1- $CaCl_2$ (0.5%)	7.83		12.26	20.58	32.48		
T_2- $CaCl_2$ (1.0%)	7.69		12.01	19.16	30.01		
T_3- $CaCl_2$ (1.5%)	7.21		11.79	18.01	28.78		
T_4- GA_3 (20ppm)	8.12		13.36	23.09	34.76		
T_5- GA_3 (40ppm)	7.99		13.01	22.21	32.96		
T_6- GA_3 (60ppm)	7.67		12.78	20.96	31.16		
T_7- Untreated	10.14		17.89	25.01	41.10		
SE(m) ±	0.16		0.15	0.29	0.60		
C.D. (p= 0.05)	0.49		0.45	0.89	1.83		
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1- $CaCl_2$ (0.5%)	2.21	5.58	9.79	15.89	20.54	25.89	31.72
T_2- $CaCl_2$ (1.0%)	2.14	5.19	9.21	15.25	20.09	25.30	31.39
T_3- $CaCl_2$ (1.5%)	2.01	4.78	8.79	14.75	19.62	24.95	30.56
T_4- GA_3 (20ppm)	2.53	6.12	10.12	16.21	21.31	26.88	32.65
T_5- GA_3 (40ppm)	2.31	5.81	9.96	16.01	21.05	26.30	32.02
T_6- GA_3 (60ppm)	2.13	5.24	9.69	15.41	20.52	25.83	31.59
T_7- Untreated	4.29	11.78	18.01	24.10	31.29	37.12	44.23
SE(m) ±	0.04	0.12	0.14	0.24	0.38	0.44	0.46
C.D. (p= 0.05)	0.13	0.37	0.41	0.75	1.16	1.34	1.39

Table 2. Effect of different post-harvest treatments on palatability rating of ber fruits

Treatments	Palatability rating (0-10)						
	Number of days						
A. Ambient storage conditions	**3rd**	**6th**	**9th**	**12th**			
T_1- $CaCl_2$ (0.5%)	7.47	6.11	4.10	2.01			
T_2- $CaCl_2$ (1.0%)	7.77	6.41	4.31	2.22			
T_3- $CaCl_2$ (1.5%)	8.09	6.89	4.67	2.32			
T_4- GA_3 (20ppm)	7.10	5.74	3.96	1.81			
T_5- GA_3 (40ppm)	7.53	6.01	4.10	1.93			
T_6- GA_3 (60ppm)	7.98	6.39	4.32	2.09			
T_7- Untreated	6.16	5.07	3.10	0.25			
SE(m) ±	0.13	0.10	0.06	0.03			
C.D. (p= 0.05)	0.39	0.30	0.18	0.09			
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1- $CaCl_2$ (0.5%)	8.83	8.21	7.50	6.90	6.00	4.79	2.94
T_2- $CaCl_2$ (1.0%)	8.91	8.29	7.56	7.01	6.06	4.85	3.00
T_3- $CaCl_2$ (1.5%)	8.97	8.38	7.66	7.17	6.16	4.95	3.10
T_4- GA_3 (20 ppm)	8.47	7.94	7.17	6.59	5.67	4.46	2.61
T_5- GA_3 (40 ppm)	8.53	8.02	7.26	6.75	5.76	4.55	2.70
T_6- GA_3 (60 ppm)	8.59	8.10	7.39	6.91	5.89	4.68	2.83
T_7- Untreated	8.00	7.12	6.32	5.30	4.82	3.61	1.76
SE(m) ±	0.08	0.14	0.13	0.13	0.10	0.07	0.04
C.D. (p= 0.05)	0.25	0.42	0.41	0.38	0.30	0.23	0.13

Table 3. Effect of different post-harvest treatments on total soluble solids of ber fruits

Treatments	Total soluble solids (°Brix)						
	Number of days						
A. Ambient storage conditions	**3rd**	**6th**	**9th**	**12th**			
T_1- $CaCl_2$ (0.5%)	13.20	14.37	14.71	13.11			
T_2- $CaCl_2$ (1.0%)	13.29	14.45	14.79	13.31			
T_3- $CaCl_2$ (1.5%)	13.36	14.56	14.89	13.85			
T_4- GA_3 (20 ppm)	12.30	13.36	13.76	12.35			
T_5- GA_3 (40 ppm)	12.36	13.43	13.84	12.53			
T_6- GA_3 (60 ppm)	12.41	13.54	13.91	12.80			
T_7- Untreated	12.11	12.34	12.50	11.49			
SE(m) ±	0.18	0.19	0.13	0.21			
C.D. (p= 0.05)	0.56	0.57	0.39	0.63			
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1- $CaCl_2$ (0.5%)	13.99	14.27	14.95	15.09	14.51	13.95	13.27
T_2- $CaCl_2$ (1.0%)	14.06	14.30	15.01	15.44	14.65	14.09	13.41
T_3- $CaCl_2$ (1.5%)	14.13	14.37	15.11	15.81	15.14	14.75	13.94
T_4- GA_3 (20 ppm)	13.86	14.20	14.81	15.00	14.49	13.90	13.12
T_5- GA_3 (40 ppm)	13.97	14.26	14.90	15.16	14.59	14.09	13.29
T_6- GA_3 (60 ppm)	14.07	14.32	14.97	15.39	14.73	14.16	13.44
T_7- Untreated	13.96	13.53	12.15	11.81	10.93	10.40	9.69
SE(m) ±	0.25	0.24	0.24	0.21	0.14	0.21	0.16
C.D. (p= 0.05)	NS	NS	0.74	0.64	0.44	0.65	0.49

Table 4. Effect of different post-harvest treatments on titratable acidity of ber fruits

Treatments	Titratable acidity (%)						
	Number of days						
A. Ambient storage conditions	**3rd**		**6th**		**9th**		**12th**
T_1 - $CaCl_2$ (0.5%)	0.22		0.20		0.18		0.14
T_2 - $CaCl_2$ (1.0%)	0.24		0.22		0.20		0.16
T_3 - $CaCl_2$ (1.5%)	0.25		0.23		0.22		0.17
T_4 - GA_3 (20 ppm)	0.20		0.18		0.17		0.13
T_5 - GA_3 (40 ppm)	0.22		0.20		0.18		0.14
T_6 - GA_3 (60 ppm)	0.23		0.21		0.19		0.15
T_7 - Untreated	0.19		0.16		0.14		0.11
SE(m) ±	0.004		0.003		0.003		0.002
C.D. (p= 0.05)	0.013		0.011		0.009		0.006
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1 - $CaCl_2$ (0.5%)	0.21	0.20	0.19	0.18	0.17	0.16	0.14
T_2 - $CaCl_2$ (1.0%)	0.22	0.22	0.20	0.19	0.18	0.17	0.16
T_3 - $CaCl_2$ (1.5%)	0.24	0.23	0.22	0.21	0.19	0.18	0.17
T_4 - GA_3 (20 ppm)	0.21	0.20	0.19	0.18	0.16	0.15	0.13
T_5 - GA_3 (40 ppm)	0.21	0.21	0.20	0.18	0.17	0.16	0.14
T_6 - GA_3 (60 ppm)	0.23	0.22	0.20	0.20	0.18	0.17	0.15
T_7 - Untreated	0.20	0.18	0.15	0.13	0.12	0.11	0.11
SE(m) ±	0.002	0.004	0.003	0.003	0.003	0.002	0.003
C.D. (p= 0.05)	0.006	0.013	0.009	0.010	0.009	0.006	0.008

Table 5. Effect of different post-harvest treatments on ascorbic acid of ber fruits

Treatments	Ascorbic acid (mg/ 100g fruit pulp)						
	Number of days						
A. Ambient storage conditions	**3rd**		**6th**		**9th**		**12th**
T_1 - $CaCl_2$ (0.5%)	106.10		90.70		75.10		59.35
T_2 - $CaCl_2$ (1.0%)	111.60		94.90		80.90		64.90
T_3 - $CaCl_2$ (1.5%)	119.80		101.10		86.10		69.10
T_4 - GA_3 (20 ppm)	97.40		84.70		71.20		54.90
T_5 - GA_3 (40 ppm)	103.15		88.20		76.15		57.25
T_6 - GA_3 (60 ppm)	109.20		94.20		78.20		61.10
T_7 - Untreated	87.20		70.10		60.25		44.10
SE(m) ±	1.38		1.83		1.01		0.82
C.D. (p= 0.05)	4.21		5.60		3.09		2.51
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1 - $CaCl_2$ (0.5%)	119.40	111.12	103.25	90.10	84.71	73.11	61.91
T_2 - $CaCl_2$ (1.0%)	120.29	113.24	105.15	93.70	86.62	77.21	66.01
T_3 - $CaCl_2$ (1.5%)	122.30	115.40	107.35	98.20	92.17	83.69	72.49
T_4 - GA_3 (20 ppm)	111.10	103.10	95.60	86.15	79.21	73.01	61.81
T_5 - GA_3 (40 ppm)	113.20	105.60	97.10	87.65	84.16	77.39	66.19
T_6 - GA_3 (60 ppm)	115.40	109.10	99.90	88.70	86.29	79.98	69.19
T_7 - Untreated	102.50	95.20	89.10	81.10	70.01	55.17	43.97
SE(m) ±	1.99	1.75	0.80	1.37	1.34	1.18	1.04
C.D. (p= 0.05)	6.09	5.36	2.45	4.20	4.12	3.60	3.20

Table 6. Effect of different post harvest treatments on reducing sugar of ber fruits

Treatments	Reducing sugar (%)						
	Number of days						
A. Ambient storage conditions	**3rd**		**6th**		**9th**	**12th**	
T_1 - $CaCl_2$ (0.5%)	6.24		6.74		6.80	5.80	
T_2 - $CaCl_2$ (1.0%)	6.29		6.81		6.89	5.88	
T_3 - $CaCl_2$ (1.5%)	6.39		6.93		7.08	6.19	
T_4 - GA_3 (20 ppm)	5.24		5.42		5.79	4.92	
T_5 - GA_3 (40 ppm)	5.29		5.56		5.99	5.21	
T_6 - GA_3 (60 ppm)	5.34		5.75		6.16	5.48	
T_7 - Untreated	5.09		5.21		4.41	3.79	
SE(m) ±	0.10		0.10		0.09	0.10	
C.D. (p= 0.05)	0.31		0.31		0.27	0.30	
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1 - $CaCl_2$ (0.5%)	6.08	6.19	6.45	6.90	6.56	6.27	5.90
T_2 - $CaCl_2$ (1.0%)	6.14	6.27	6.52	6.99	6.69	6.39	6.04
T_3 - $CaCl_2$ (1.5%)	6.20	6.38	6.64	7.16	6.81	6.55	6.20
T_4 - GA_3 (20 ppm)	5.29	5.49	5.71	6.16	6.00	5.79	5.34
T_5 - GA_3 (40 ppm)	5.35	5.58	5.81	6.27	6.08	5.91	5.51
T_6 - GA_3 (60 ppm)	5.44	5.69	5.93	6.41	6.21	6.15	5.72
T_7 - Untreated	5.27	5.37	5.19	5.01	4.71	4.23	3.99
SE(m) ±	0.07	0.12	0.09	0.09	0.08	0.09	0.08
C.D. (p= 0.05)	0.21	0.37	0.27	0.27	0.24	0.28	0.26

Table 7. Effect of different post-harvest treatments on total sugar of ber fruits

Treatments	Total sugar (%)						
	Number of days						
A. Ambient storage conditions	**3rd**		**6th**		**9th**	**12th**	
T_1 - $CaCl_2$ (0.5%)	10.91		11.85		12.03	10.51	
T_2 - $CaCl_2$ (1.0%)	11.03		12.02		12.29	10.71	
T_3 - $CaCl_2$ (1.5%)	11.24		12.32		12.70	11.29	
T_4 - GA_3 (20 ppm)	9.45		10.08		10.55	9.14	
T_5 - GA_3 (40 ppm)	9.58		10.31		10.82	9.52	
T_6 - GA_3 (60 ppm)	9.73		10.59		11.13	9.93	
T_7 - Untreated	9.29		9.83		8.53	7.23	
SE(m) ±	0.12		0.11		0.19	0.19	
C.D. (p= 0.05)	0.37		0.34		0.59	0.57	
B. Cold storage conditions	**3rd**	**6th**	**9th**	**12th**	**15th**	**18th**	**21st**
T_1 - $CaCl_2$ (0.5%)	10.76	10.95	11.30	11.86	11.37	10.98	10.48
T_2 - $CaCl_2$ (1.0%)	10.86	11.07	11.42	12.08	11.64	11.17	10.71
T_3 - $CaCl_2$ (1.5%)	10.98	11.26	11.63	12.42	12.00	11.53	11.09
T_4 - GA_3 (20 ppm)	9.90	10.14	10.50	11.12	10.76	10.40	9.76
T_5 - GA_3 (40 ppm)	10.01	10.34	10.65	11.27	10.91	10.60	10.02
T_6 - GA_3 (60 ppm)	10.15	10.51	10.86	11.46	11.12	10.93	10.34
T_7 - Untreated	9.88	9.49	9.10	8.79	8.30	7.49	6.85
SE(m) ±	0.16	0.17	0.13	0.18	0.13	0.18	0.16
C.D. (p= 0.05)	0.49	0.51	0.40	0.55	0.40	0.55	0.51

3.7 Total Sugar

It is apparent from the data (Table 7) revealed that application of 1.5% $CaCl_2$ recorded the maximum total sugar content *i.e.* 11.24, 12.32, 12.70 and 11.29% on the 3rd, 6th, 9th and 12th days of storage under ambient storage conditions respectively. This treatment also maintained 69.99% more total sugar over control. The maximum total sugar *i.e.*10.98, 11.26, 11.63, 12.42, 12.00, 11.53 and 11.09% was recorded in 1.5% $CaCl_2$ treatment at 3rd, 6th, 9th, 12th, 15th, 18th and 21st days during storage period under cold storage conditions respectively, while minimum were recorded under control. The increase in total sugar content under 1.5% $CaCl_2$ treatment was noted 61.89% higher over control at 21st day of storage.

The increase in total sugar of ber fruits treated with 1.5% $CaCl_2$ and packed in Netlon bag during initial storage period might be due to water loss from fruits through evapo-transpiration and inhibition of activities of enzymes responsible for degradation of sugars and subsequently a decline may be due to utilization of sugars in respiration. Similar results were also recorded by Torres et al. [20] in atemoya.

4. CONCLUSION

On the basis of results obtained, it may be concluded that ber fruits treated with 1.5% calcium chloride as exogenous post harvest treatment and packed in netlon bags can be stored upto 9th day under ambient storage condition and 18th day under cold storage conditions without any applicable losses. Ber fruits quality was significantly maintained as there was minimum PLW with good palatability rating and appreciable bio chemical properties *i.e.* TSS, titratable acidity, ascorbic acid and sugar. It is concluded that the fruit growers and the fruit merchants may use 1.5% calcium chloride as post-harvest dipping followed by air dried in shade and packed in Netlon bags in order to prolong the storage life of ber fruits up to 9 days in ambient storage conditions and up to 15 days in cold storage conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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