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Effect of post-harvest treatments on shelf life of ber CV. Gola under cold storage conditions

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Abstract

An experiment was carried out to determine the response of ber (*Ziziphus mauritiana* L.) cv. Gola to different post-harvest treatments under cold storage conditions. Fruits were treated with lemongrass oil (0.1%), til oil (2%), *Aloe vera* gel (100%), salicylic acid (1mM), calcium chloride (2%), citric acid (0.5%) and sodium nitroprusside (1mM), and stored at 5 ± 2 °C with 80-85% relative humidity. Storage behaviour was assessed in terms of physiological loss in weight, decay incidence, firmness, colour, sensory quality and biochemical characteristics. Refrigerated storage markedly reduced metabolic activity and quality degradation of fruits. Among the treatments, calcium chloride, salicylic acid and sodium nitroprusside were most effective in minimizing decay and maintaining firmness and acidity, while *Aloe vera* gel improved colour retention and acceptability. The combined use of post-harvest treatments with cold storage significantly extended the shelf life and improved the quality of ber fruits.

Keywords: Cold storage, *Ziziphus mauritiana*, sodium nitroprusside, salicylic acid, fruit firmness, quality retention

Introduction

Ber (*Ziziphus mauritiana* L.) is an important cultivated fruit of arid and semi-arid regions. In Northern India, harvesting time of ber is February to March and Gola is early to ripen than others. Ber fruits are very nutritious and are usually eaten fresh. It contains good quantities of vitamins, minerals, and sugar. Ber fruits are good source of vitamin C (19.54 to 99.49 mg/100g) (Koley *et al.*, 2011) [9]. These are used for making several delicious products like ber jam, dehydrated ber, ber murraba, ber candy and ready to serve beverages. Due to increased metabolic activity of some enzymes, fruit quality is highly affected during storage resulting in deterioration of fleshy organs. Higher activity of cell wall degrading enzymes results in fruit softening, which subsequently leads to fruit decay. To enhance the storage quality of ber, post-harvest treatments can be alternatives to overcome post-harvest losses. Exogenous treatments inhibit the physiological degradation process, which curbs the fruit quality and also help in maintaining storage life. Calcium compounds extend the shelf life of several fruits by maintaining firmness, minimizing the rate of respiration, protein breakdown, and disease incidence (Jawandha *et al.*, 2008) [6]. Calcium treatment also increases chlorophyll content in ber by maintaining integrity of chloroplast membrane and retarding the activities of chlorophyll oxidase and chlorophyllase (Singh *et al.*, 2010) [17]. To enhance the shelf life of ber, *Aloe vera* gel proved to be an effective edible coating owing to its great antifungal and antibacterial property (Mani *et al.*, 2018) [11]. Lemongrass oil is mainly comprised of functional components like limonene, citronellal, monoterpenes, olefins *etc.* It is widely recognised for its antimicrobial, insecticidal and therapeutic properties (Murmu and Mishra, 2017) [12]. Sodium nitroprusside helps in maintaining low ethylene production which enhances storage potential, improve resistance to decay organisms (Sis *et al.*, 2012). Exogenous application of nitric oxide enhances the shelf life of fruit crops such as strawberry, peach, and kiwifruit *etc.* (Zhu and Zhou, 2007) [19]. Salicylic acid is considered to be a plant hormone that plays a key role in plant growth, development, inhibition of ethylene biosynthesis, delaying the fruit senescence, and defence responses (Ding *et al.*, 2002 and Khademi and Ershadi, 2013) [8, 1]. Salicylic acid prevents softening of fruits and helps in stimulation of antioxidant enzymes. To prevent decay, ber fruits should be kept in cold storage, as after harvest the entire crop cannot be put for use suddenly.

Due to surplus of fruits in the local market during peak season, a substantial quantity goes waste, resulting in 6.70-15.88% post-harvest loss in fruits, which is not only loss to the growers but also a net loss of human nutrition (Goyal, 2017) [12]. The colossal post-harvest losses are the serious bottleneck in the way of establishing fruit industry on a commercial-scale in India. Thus, the reduction of these losses becomes quite essential. Most horticultural produce is classed as perishables. Therefore, the long-term storage is necessary not only to extend shelf life but also to have the availability of fresh fruits throughout the year. Therefore, to fetch better prices and make it available in off-season, there is a need for storing produce under low temperatures, which help to lower down the metabolic activities of fruits.

Material and methods

The experiment was conducted at PG Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar (Haryana 125004) situated at 215.2 m (705 ft) above mean sea level with co-ordinates of 29°10' N latitude and 75°46' E longitudes. Hisar falls under the semi-tropical region of Western Zone of India. For experimental study, the fruits of ber cv. 'Gola' were procured from university orchard. Uniform and healthy fruits were selected for harvesting. After imposing treatments, Fruits were stored at (5° ± 2°C) and 80-85% relative humidity under cold storage conditions with 3 replications. Treatments used for the experiment were Lemongrass oil (0.1%), Til oil (2%),

Aloe vera (100%), Salicylic acid (1mM), Calcium chloride (2%), Citric acid (0.5%), Sodium nitro prusside (1mM). Various parameters like decay loss, fruit firmness, ascorbic acid, colour, organoleptic quality, Sugars, total chlorophyll content and free radical scavenging activity were measured upto 15 days.

Result and discussions

Loss in weight: In table-1 depicted that the minimum (1.96%) loss in weight was recorded in *Aloe vera* 100% followed by calcium chloride 2% (2.16%) as shown in table. All the treatments were effective in checking the loss in weight over control. The maximum (3.76%) loss in weight was recorded in control fruits after 15 days during cold storage. The reduction in weight loss was probably due to the effect of *Aloe vera*, which served as a semipermeable barrier against oxygen, carbon dioxide and moisture thus helps in reducing respiration, oxidation reactions and water loss, thus increasing shelf life of ber (Parven *et al.*, 2020) [15]. The less weight loss during cold storage was due to maintenance of the maximum moisture content around the surface of fruit along with storage having high humidity and cold storage conditions. The loss in weight increased with prolongation of storage period, this might be due to increase in transpiration and respiration process during storage. Similar findings were also reported by Naik and Rokhade (1997) [13] in ber and Gupta *et al.* (2011) [3] in peach.

Table 1: Effect of post-harvest treatments on loss in weight (%) of ber under cold storage conditions

Sr. No.	Treatments	Storage period (days)					Mean
		3	6	9	12	15	
T ₁	Lemongrass oil (0.1%)	0.97	1.50	1.97	4.60	9.12	3.03
T ₂	Til oil (2%)	0.60	1.17	1.87	4.57	8.48	2.78
T ₃	<i>Aloe vera</i> (100%)	0.48	0.87	1.38	2.53	6.47	1.96
T ₄	Salicylic acid (1mM)	0.57	0.85	1.52	4.55	8.40	2.65
T ₅	Calcium chloride (2%)	0.62	1.00	1.47	2.67	7.20	2.16
T ₆	Citric acid (0.5%)	0.77	1.28	1.85	3.63	8.43	2.66
T ₇	SNP (1mM)	0.72	1.32	2.90	6.35	10.28	3.59
T ₈	Control	0.95	1.45	2.57	6.12	11.50	3.76
Mean		0.71	1.18	1.94	4.38	8.74	
CD at 5% level of significance		Treatment (T)= 0.21 Storage period (S)= 0.18 T×S= 0.50					

Decay loss: Data depicted in table-2 shows that the lowest (1.44%) decay loss was observed in *Aloe vera* 100%. This is because *Aloe vera* inhibits the growth of pathogens as well as it slows down the respiration and ripening process which is the basic cause of spoilage of fruits. Thus it helps in maintaining the shelf life of fruits for longer period under cold storage conditions. There was no decay loss recorded

up to 6 days of storage. The softening of fruits occurs due to chemical changes in fruits during storage. These changes can be retarded to some extent under cold storage conditions (Kaur and Bal, 2014) [7]. Decay loss increased as storage period increased. Similar findings were reported by Jain *et al.* (2017) [4] in ber and Gupta *et al.* (2011) [3] in peach.

Table 2: Effect of post-harvest treatments on decay loss (%) of ber under cold storage conditions

Sr. No	Treatments	Storage period (days)					Mean
		3	6	9	12	15	
T ₁	Lemongrass oil (0.1%)	0.00	0.00	3.83	5.53	7.65	3.29
T ₂	Til oil (2%)	0.00	0.00	2.52	3.22	5.02	1.79
T ₃	<i>Aloe vera</i> (100%)	0.00	0.00	1.25	2.88	4.50	1.44
T ₄	Salicylic acid (1mM)	0.00	0.00	1.87	3.32	5.12	1.72
T ₅	Calcium chloride (2%)	0.00	0.00	1.88	3.35	4.98	1.70
T ₆	Citric acid (0.5%)	0.00	0.00	3.50	5.33	7.52	2.73
T ₇	SNP (1mM)	0.00	0.00	3.47	5.32	7.68	3.17
T ₈	Control	0.00	0.00	4.65	6.53	8.70	3.74
Mean		0.00	0.00	2.87	4.44	6.40	
CD at 5% level of significance		Treatment (T)= 0.22 Storage period (S)= 0.19 T×S= 0.54					

TSS to acid ratio

The findings presented in table showed that the highest TSS to acid ratio was recorded in calcium chloride 2% treated fruits which were statistically at par with *Aloe vera* 100% (57.19), salicylic acid 1mM (57.82), sodium nitroprusside

1mM (57.01) during cold storage. In present studies, it was observed that with the advancement of storage period, there was an increase in the TSS to acid ratio. These results are in close accordance with the results of Navjot (2005) ^[14] in peach.

Table 3: Effect of post-harvest treatments on TSS to acid ratio of ber under cold storage conditions

Sr. No	Treatments	Storage period (days)						Mean
		0	3	6	9	12	15	
T ₁	Lemongrass oil (0.1%)	36.16	36.79	41.71	47.16	64.73	95.11	53.61
T ₂	Til oil (2%)	36.16	39.00	43.88	57.12	63.81	80.08	53.34
T ₃	<i>Aloe vera</i> (100%)	36.16	39.94	48.39	61.19	70.04	87.43	57.19
T ₄	Salicylic acid (1mM)	36.16	39.39	46.45	58.23	67.77	92.99	57.82
T ₅	Calcium chloride (2%)	36.07	39.64	47.40	62.96	74.09	93.05	57.89
T ₆	Citric acid (0.5%)	36.16	36.65	38.41	50.08	62.86	78.29	50.41
T ₇	SNP (1mM)	36.16	37.32	42.17	52.44	72.51	101.4	57.01
T ₈	Control	36.16	38.12	42.06	48.42	66.33	84.66	52.63
Mean		36.15	38.36	43.81	54.70	67.77	89.13	
CD at 5% level of significance		Treatment (T)= 4.50 Storage period (S)= 3.90 T×S= NS						

Total sugars

Table-4 depicted that among the treatments, the highest (9.60%) total sugar was maintained by calcium chloride (10.65%) and least (9.34%) was observed in lemongrass oil 0.1%. It might be due to delayed senescence and low respiration rate in calcium treated fruits. Stated that calcium

compounds thickened the middle lamella of fruit, thereby maintaining the cell wall and cell wall material. In present study, total sugar increased initially up to 12th day and declined thereafter under cold storage. Similar findings were also reported by Singh *et al.* 2010, ^[17] Jain *et al.* (2017) ^[4] and Kaur and Bal (2014) ^[7] in ber fruit.

Table 4: Effect of post-harvest treatments on total sugar (%) of ber under cold storage conditions

Sr. No.	Treatments	Storage period (days)						Mean
		0	3	6	9	12	15	
T ₁	Lemongrass oil (0.1%)	8.16	8.85	9.20	9.62	10.48	9.73	9.34
T ₂	Til oil (2%)	8.16	8.92	9.22	9.56	10.68	10.12	9.44
T ₃	<i>Aloe vera</i> (100%)	8.16	8.92	9.28	9.59	10.79	10.19	9.49
T ₄	Salicylic acid (1mM)	8.16	8.83	9.28	9.64	10.88	10.38	9.53
T ₅	Calcium chloride (2%)	8.16	8.92	9.36	9.75	10.97	10.47	9.60
T ₆	Citric acid (0.5%)	8.16	8.88	9.28	9.68	10.65	10.24	9.48
T ₇	SNP (1mM)	8.16	8.86	9.20	9.58	10.46	10.10	9.39
T ₈	Control	8.16	8.85	9.26	9.65	10.63	10.17	9.45
Mean		8.16	8.88	9.26	9.63	10.69	10.18	
CD at 5% level of significance		Treatment (T)= 0.06 Storage period (S)= 0.06 T×S= 0.16						

Reducing sugars (%)

Table-5 depicted that the effect of calcium chloride was seen effective in retaining the higher reducing sugar content during cold storage. The maximum (4.39%) reducing sugar was found in calcium chloride 2% and the minimum (4.28%) was observed in lemongrass oil 0.1%. Similar

results were obtained by Jain *et al.* (2017) ^[4] in ber fruit with application of calcium chloride. It was also observed that with the passage of storage duration, reducing sugar was first to be increased up to 12th day and decreased on the 15th day under cold storage. Similar results were obtained by Kumar *et al.* (2012) and Singh *et al.* (2010) ^[17] in ber.

Table 5: Effect of post-harvest treatments on reducing sugar (%) of ber under cold storage conditions

Sr. No.	Treatments	Storage period (days)						Mean
		0	3	6	9	12	15	
T ₁	Lemongrass oil (0.1%)	3.77	3.79	4.27	4.50	4.77	4.55	4.28
T ₂	Til oil (2%)	3.77	3.77	4.29	4.50	4.74	4.62	4.28
T ₃	<i>Aloe vera</i> (100%)	3.77	3.82	4.30	4.57	4.77	4.74	4.33
T ₄	Salicylic acid (1mM)	3.77	3.85	4.26	4.56	4.81	4.77	4.34
T ₅	Calcium chloride (2%)	3.77	3.91	4.34	4.61	4.89	4.82	4.39
T ₆	Citric acid (0.5%)	3.77	3.82	4.27	4.54	4.84	4.79	4.34
T ₇	SNP (1mM)	3.77	3.82	4.25	4.48	4.78	4.75	4.31
T ₈	Control	3.77	3.82	4.26	4.53	4.83	4.75	4.33
Mean		3.77	3.82	4.28	4.54	4.80	4.72	
CD at 5% level of significance		Treatment (T)= 0.03 Storage period (S)= 0.02 T×S= 0.07						

Non- reducing sugars (%): In table-6 result showed that the maximum non-reducing sugar (5.21%) was maintained under calcium chloride 2%. It was found that non-reducing sugar first increased up to 12th day while decreased on 15th

day under cold storage. Similar data were also obtained by Jain *et al.* (2017) ^[4] in ber and Singh *et al.* (2019) ^[16] in guava fruit.

Table 6: Effect of post-harvest treatments on non- reducing sugar (%) of ber under cold storage conditions

Sr. No.	Treatments	Storage period (days)						Mean
		0	3	6	9	12	15	
T ₁	Lemongrass oil (0.1%)	4.39	5.06	4.93	5.11	5.71	5.18	5.07
T ₂	Til oil (2%)	4.39	5.15	4.93	5.05	5.94	5.50	5.16
T ₃	<i>Aloe vera</i> (100%)	4.39	5.11	4.99	5.03	6.02	5.45	5.16
T ₄	Salicylic acid (1mM)	4.39	4.98	5.02	5.08	6.07	5.61	5.19
T ₅	Calcium chloride (2%)	4.39	5.00	5.02	5.14	6.08	5.65	5.21
T ₆	Citric acid (0.5%)	4.39	5.05	5.01	5.13	5.81	5.45	5.14
T ₇	SNP (1mM)	4.39	5.04	4.95	5.10	5.68	5.35	5.09
T ₈	Control	4.39	5.04	4.99	5.13	5.80	5.42	5.13
Mean		4.39	5.06	4.98	5.10	5.89	5.45	
CD at 5% level of significance		Treatment (T)= 0.06 Storage period (S)= 0.06 T×S= 0.16						

Conclusion

From the present experiment, it is concluded that *Aloe vera* (pure juice) treatment possessing antifungal and antibacterial properties proved better in reducing weight and decay loss and retaining higher fruit firmness, specific gravity, colour, organoleptic quality, acceptable marketable value and good keeping quality up to 15 days under cold storage conditions, however, highest TSS to Acid ratio, total soluble solids, reducing sugars and non- reducing sugars were observed in calcium chloride (2%). Salicylic acid 1mM treatment exhibited maximum free radical scavenging activity by maintaining high phenol content

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