DOI : 10.5958/0974-0112.2018.00021.X

Indian J. Hort. 75(1), March 2018: 124-129

Effect of gibberellic acid and oxalic acid on colour retention and storage quality of cold stored fruits of *ber* cv. Gola

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ABSTRACT

***Ber* (*Zizyphus mauritiana* Lamk.) fruits are perishable in nature and have poor shelf-life. To extend the shelf-life of *ber* fruits, different post-harvest treatments, like pre-cooling, hot water treatment (HWT) at 55°C for 10 min., HWT (55°C, 10 min.) + 10% oxalic acid for 15 min., GA_3 (30, 60 and 90 ppm) were given to fruits and their effects were studied on the storage life and quality of cv. Gola fruits under cold storage conditions (5 ± 1°C and 85 ± 5% RH). Fruits of uniform size and colour were harvested, from healthy plants and subjected to post harvest dip of different chemicals, before placing in cold storage. The effect of different treatments accessed after 7, 14, 21 and 28 days of storage for physiological loss in weight (PLW), total soluble solids (TSS), marketability and palatability rating. The PLW and TSS increased and marketability decreased during storage under each treatment. The sensory rating increased up to 7 days under all treatments but subsequently decreased during storage. It can be concluded that *ber* cv. Gola fruits can be stored up to 21 days by post-harvest treatment using GA_3 at 90 ppm with acceptable quality.**

Key words: *Zizyphus mauritiana*, browning, cold storage.

INTRODUCTION

Ber (*Zizyphus mauritiana* Lamk.) fruit is very popular among consumers due to its high nutritive value and comparatively low market price. For producing early crop of *ber* under rainfed conditions, cv. Gola is recommended by SDAU (Gujarat) for cultivation in arid and semi-arid regions of Gujarat. However, the poor storage-life and high post-harvest losses are the major constraints in developing *ber*-based industry (Salunkhe and Kadam, 15). After harvest fresh *ber* fruits are usually stored at ambient/room temperature (25-35°C), causing high deterioration and thus, cannot be kept for more than 10 days. The fast fruit ripening and senescence, triggered by the major ripening hormone ethylene, results in a short storage life and poor eating quality, *e.g.* pulp softening, browning and decay. Pareek and Gupta (11) reported that fruits of cv. Gola showed high degree of pathological infection and loss in colour and could be stored for only 7 days. *Ber* fruit quality is highly affected during storage due to high respiration rate, increased metabolic activity and higher activity of cell wall degrading enzymes resulting in deterioration of fleshy organs, which subsequently leads to fruit decay (Looney, 8). However, the post-harvest ripening process can be delayed with the application of fruit ripening hindering hormones. Jawandha *et al*. (7) reported that application of growth regulators like gibberellic acid (GA_3) affects the physico-chemical properties and are known to promote the shelf-life of *ber* fruits. Mehta *et al*. (10) reported that GA_3 at 100 ppm significantly suppresses the succinate activities of malate-dehydrogenase enzyme during post-harvest ripening of papaya thereby retarding the ripening process. Pareek *et al*. (12) reported that postharvest dipping of *ber* fruits cultivars Gola and Umran in 200 ppm of maleic hydrazide increased the marketability percentage and improved the storage life and keeping quality of ripe *ber* fruits for up to 12 days under ambient storage conditions. Physiological loss in weight (PLW) is mainly due to high evaporation of water, high respiration and degradative processes during postharvest handling of fruits (Pareek *et al*., 12). Postharvest dipping of 'Gola' fruits in 500 ppm fungicides (Thiabendazole, Captan and Dithane M-45) improved the shelf-life by reducing rate of respiration and cold water dipping reduced respiration as well as ethylene production and degradating enzymatic activities, whereas, hot water treatment (40°C) hindered the development of pathogens, reduced evaporation water loss and PLW, thereby prolonging the shelf-life and quality of fruits (Gupta and Mehta, 5). For maintaining postharvest fruit quality, fungicide solution dipping (Thiabendazole, Captan and Dithane M-45) and sulphur fumigation (Underhill *et al*., 17) are in common practices. Oxalic acid (OA) is a natural antioxidant and might play an

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important role in the natural and artificial preservation of oxidized materials. The post-harvest fruit treatment with controlled OA is a safe and promising method for maintaining eating quality during postharvest storage. Oxalic acid is the most effective anti-browning agent on litchi (Marboh *et al*., 9), whereas, GA_3 is well known to promote the shelf-life of *ber* fruits as reported by various previous workers (Jawandha *et al*., 7). Growers and consumers of *ber* fruit can be benefited if shelf-life is fruit. Therefore, the present investigation was conducted to examine the effect of post-harvest application of various chemicals on fruit quality of *ber* under during cold storage.

MATERIALS AND METHODS

The experiment was carried out at the ICAR-CAZRI, Regional Research Station, Kukma, Bhuj, Gujarat on *ber* fruits of cv. Gola. Fruits were harvested at optimum maturity in the month of April from the selected trees from an orchard of Arid Horticulture Block and healthy and uniform fruits were used for this study. The treatments consisted of without precooling (control), pre-cooling (T_1), hot water treatment (HWT) at 55°C for 10 min. (T_2), HWT (55°C, 10 min.) + 10% oxalic acid (OA) for 15 min. (T_3), GA_3 (30 ppm) (T_4), GA_3 (60 ppm) (T_5) and GA_3 (90 ppm) (T_6) before packaging. For applying HWT and OA, the air-dried pre-cooled fruits were dipped in hot water kept at 55°C for 10 min., air-dried and finally dipped in 10% OA for 15 min. For GA_3 treatment, fruits were dipped in different concentration of GA_3 solution for 10 min. and air-dried to remove surface moisture. Thereafter, the packed fruits were packed in nylon carriers and kept for observations under cold storage conditions (5 ± 1°C and 85 ± 5% RH). Fruits subjected to pre-cooling, without pre-cooling, HWT were included for comparisons. Each treatment was replicated three times and each replication consists of 50 fruits. Observations on physico-chemical properties, *viz*., PLW, browning index, decay loss, marketability, TSS, fruit colour and taste were carried out periodically at every one week interval.

The PLW was calculated based on initial weight and weight at subsequent intervals. Fruit TSS was determined by a hand refractometer of 0-32°Brix. Three fruits for each treatment were homogenized and the degree brix was measured. Titratable acidity was estimated as per the method suggested by Ranganna (13). Post-harvest decay was assessed on a 1-5 hedonic scale, based on the severity of post-harvest fungal decay : 1 = no decay; 2 = 25%; 3 = 50%; 4 = 75% of the fruit surface affected and 5 = 100% fruit decay and oozing (De Jagger and Korsten, 3). Browning index was assessed using the scale as described by Marboh *et al*. (9): 0 = no browning (excellent quality); 1 = slight browning; 2 = 25% browning; 3 = 25-50% browning; 4 = 50-75% browning and 5 > 75% (very poor quality) and was calculated using the following formula: Browning Index = Σ (browning scale × percentage of corresponding fruit within each class). Fruit marketability was assessed visually using hedonic based on the method suggested by Sivakumar *et al*. (16). Fruit colour and taste were evaluated at 7^{th}, 14^{th} and 28^{th} days of storage, using a semi-trained panel consisting of seven judges, based on the following scale 5 = Excellent; 4 = good; 3 = fair (acceptable); 2 = poor (unacceptable for export); 1 = very poor (totally unacceptable). The data were analyzed statistically through completely randomized design (CRD) method (Gomez and Gomez, 4)

RESULTS AND DISCUSSION

Data presented in Table 1 revealed a significant increase in physiological loss in weight (PLW) with the increase of storage period regardless of various treatments. After one week of storage, the mean 3.80% PLW was noted, which increased upto 8.15%, at the last day of storage. However, treatment that involved a combination of HWT (55°C, 10 min.) and 10% OA dipping for 15 min. record the highest weight loss (10.20%), followed by control (6.98%) treatment which was *at par* with precooling treatment after 4 week of storage, which might be due to a reduction in fruit firmness, indicating structural damage to the cross-linkages in the cell wall (Saengnil *et al.*, 14). The minimum PLW (3.55%) was recorded in GA_3 (90 ppm) treated fruits, followed by (4.96%) in GA_3 (60 ppm) treatment. Similar results were also reported by Jawandha *et al*. (7) in *ber* and Marboh *et al*. (9) in litchi fruit.

The *ber* fruits treated with HWT (T2) and GA_3 60 ppm (T5) gave the highest mean TSS (20.89% each) after 4 week of storage under 5 ± 1°C and 85 ± 5% RH. Whereas, minimum mean TSS (17.30%) was recorded in fruits with pre-cooling, which was statistically at par with fruits treated with GA_3 90 ppm. No significant decline of TSS noted in the fruit treated with GA_3 (60 & 90 ppm) during the experiment period. However, interpretation of the interaction effect between various treatments and storage days divulges that there was a gradual increase in TSS of fruits initially upto 21 days, which then gradually declined later on till the end of experiment except in GA_3 (60 & 90 ppm) treatments. This initial increase might be due to the breakdown of starch and polysaccharides into simple sugars and organic acids and water loss during the subsequent storage, but after 21 days the decline in TSS might be due

Table 1. Effect of various treatments on Total soluble solids (%) of *ber* fruits during cold storage.

Treatment	Total soluble solids (%)					Titratable acidity (%)					Physiological loss in weight %				
	Storage period (day)					Storage period (day)					Storage period (day)				
	0	7	14	21	28	Mean	0	7	14	21	28	Mean	7	14	21	28	Mean
T1	16.17	16.80	17.17	18.43	17.93	17.30	0.20	0.19	0.18	0.18	0.17	0.18	2.47	5.53	8.30	9.63	6.48
T2	19.30	19.97	19.97	22.67	22.57	20.89	0.22	0.21	0.19	0.19	0.18	0.20	2.50	6.13	6.53	9.50	6.17
T3	17.47	18.10	19.23	20.90	19.43	19.03	0.22	0.20	0.19	0.18	0.18	0.19	8.17	11.10	11.13	10.40	10.20
T4	18.70	19.37	19.80	21.20	20.87	19.99	0.20	0.19	0.19	0.18	0.18	0.19	4.17	5.57	6.47	7.20	5.85
T5	19.83	20.43	20.93	21.50	21.73	20.89	0.21	0.20	0.19	0.19	0.19	0.20	3.20	4.47	5.37	6.80	4.96
T6	17.10	17.47	17.77	18.60	19.23	18.03	0.21	0.20	0.20	0.19	0.19	0.20	2.33	4.07	3.45	4.37	3.55
Control	18.53	19.70	20.47	21.43	21.53	20.33	0.21	0.20	0.18	0.18	0.17	0.19	3.77	7.33	7.70	9.13	6.98
Mean	18.16	18.83	19.33	20.68	20.47		0.21	0.20	0.19	0.18	0.18		3.80	6.31	6.99	8.15	
CD at 5%																	
Treatment (A)					1.19						0.01						0.31
Storage period (B)					1.01						0.01						0.24
A × B					2.66						0.01						0.63

to their utilization in evapo-transpiration and other biochemical activities. However, it can be argued that the large declined in TSS due to Hot water treatment might be due to increased senescence of the tissues (Saengnil *et al*., 14), which can be attributed to a decrease in sucrose (Marboh *et al*., 9).

A gradual declining trend in the acidity content of fruit in all the treatment was observed with the advancement of storage period regardless of post-harvest treatments (Table 1). The higher titratable acidity (0.20%) was noted in fruits treated with higher concentration of GA_3 (60 and 90 ppm), fruits treated with GA_3 (60 and 90 ppm) were showing lowest decreasing trend in acidity. While, the highest decrease in acidity from initial day of storage to last day of storage noted in HWT (55°C, 10 min.) and 10% OA dipping for 15 min. and control. It possibly is due to the utilization of organic acids in respiratory process and other biodegradable reactions (Saengnil *et al*., 14). However, under acid treatment, Marboh *et al*. (9) opined that there was a slight penetration of acid into the fruit aril might be responsible for decreasing acidity.

Pericarp browning increased with storage time and use of OA significantly reduced pericarp browning. Minimum browning index was recorded in HWT (55°C, 10 min.) + 10% OA for 15 min. followed by higher concentration of GA_3 (90 ppm) (Fig. 1A). This is due to the effect of HWT prior to an OA dip, in facilitating the penetration of acid (Marboh *et al*., 9) thereby inhibiting polyphenol oxidase (PPO) and peroxidase (POD) activities and resulted in stabilization of anthocyanin's (Saegnil *et al*., 14). However, use of no precooling of fruits and fruit treated with hot water (55°C, 10 min.*),* has been found to accelerate the extent of browning in fruits, which is primarily attributed to enhanced enzymatic activity due to loss of compartmentation of enzymes and substrates as reported by Hu *et al*. (6).

The highest and significant decay index was noted in fruits without precooling followed by fruit treated with hot water (55°C, 12 min.) at the last day of storage. However, under the combined HWT (55°C,12 min.) + 10% OA for 15 min., and higher concentration of GA_3 (90 ppm) treatment, fruit spoilage was minimum (Fig. 1 B). Plant growth regulators (GA_3) applied after harvest delayed ripening and increased shelf-life of fruits as well as reduce the postharvest decay losses of fruits (Abbas, 1). Low spoilage loses under the combined HWT (55°C, 10 min.) + 10% OA for 15 min. might be due to the combined fungistatic effects of the applied treatments (HWT) by killing the organisms on and below the fruit surface (Marboh *et al*., 9) and OA by providing an acidic conditions on the peel surface, that provide an unfavourable conditions

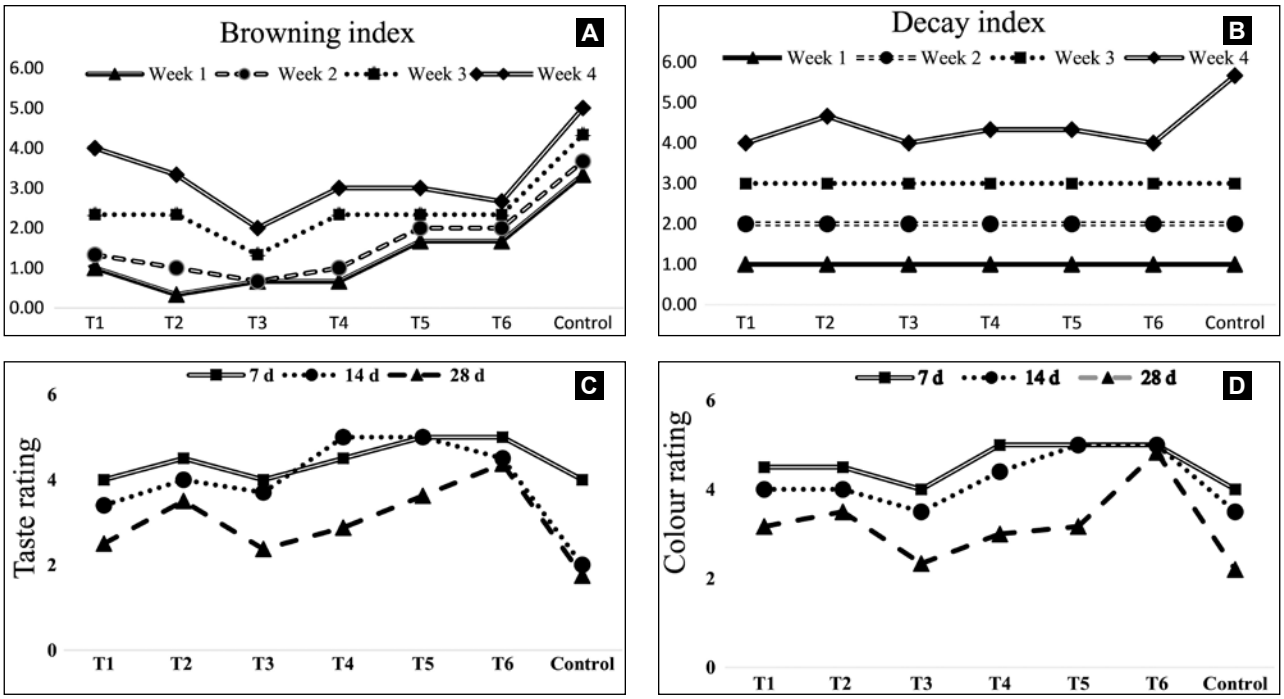

Fig. 1. Effect of different treatments on storage quality of *ber*. T_1 = pre-cooling; T_2 = HWT (55°C, 10 min.); T_3 = HWT (55°C, 10 min.) + 10% OA (15 min.); T_4= GA_3 (30 ppm); T_5= GA_3 (60 ppm); GA_3 (90 ppm); T_6 (control, without pre-cooling;) on (A) Browning index (B) decay index, (C) taste and (D) colour of fruits cv Gola.

for the development of most fungi, as confirmed by Saegnil *et al*. (14) in litchi.

Data presented in Table 2 show the effect of various treatments in influencing the marketable value of Gola *ber*. Highest and significant effect (80.85%) on marketability percentage of fruits was recorded in higher concentration of GA_3 (90 ppm), which was at par (80.27) with GA_3 (60 ppm) treated fruits. Interpretation of the data clearly indicate the role of the combined effects of HWT and OA in reducing browning but due to high shrinkage percentage the marketability of fruit reduced considerably. Significantly, poor marketable

Table 2. Effect of various treatments on fruit shrinkage (%) and marketability (%) of *ber* fruits during cold storage.

Treatment	Shrinkage (%)						Marketability (%)					
	Storage period (day)						Storage period (day)					
	0	7	14	21	28	Mean	0	7	14	21	28	Mean
T1	0.00	17.33	24.67	31.67	40.00	22.73	100	90.89	86.78	74.44	57.50	77.40
T2	0.00	19.67	28.00	31.67	40.00	23.87	100	91.78	86.00	76.11	63.75	79.41
T3	0.00	59.67	67.00	71.67	76.67	55.00	100	78.44	74.33	66.11	55.83	68.68
T4	0.00	21.67	29.00	35.00	36.67	24.47	100	91.11	87.00	73.33	62.33	78.44
T5	0.00	10.00	15.00	20.00	23.33	13.67	100	92.00	83.33	78.33	67.42	80.27
T6	0.00	11.00	16.67	26.67	36.67	18.20	100	91.67	82.78	75.11	73.83	80.85
Control	0.00	44.67	59.67	68.33	73.33	49.20	100	73.44	57.44	43.89	29.67	51.11
Mean	0.00	26.29	34.29	40.71	46.67		100	87.05	79.67	69.62	58.62	
CD at 5%												
Treatment (A)					4.03							
Storage period (B)					3.41							
A × B					9.01							

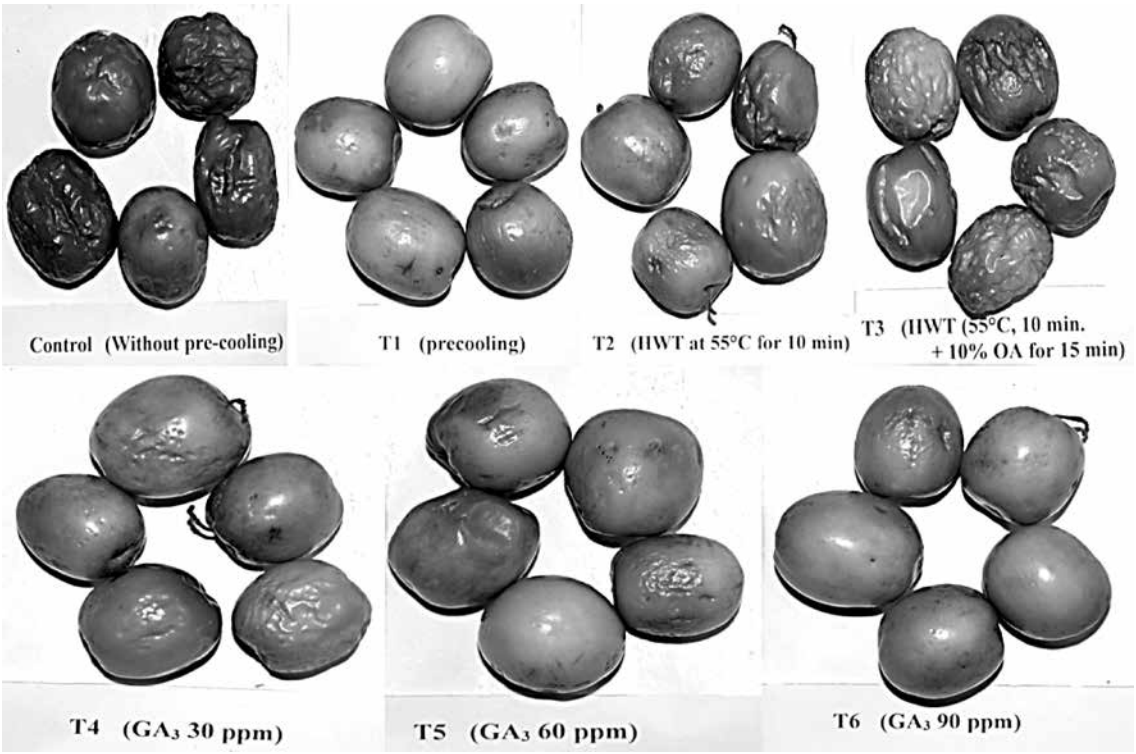

Fig. 2. Effect of different treatments on storage quality of *ber* cv Gola. T_1 = pre-cooling; T_2 = HWT (55°C, 10 min.); T_3 = HWT (55°C, 10 min.) + 10% OA (15 min.); T_4= GA_3 (30 ppm); T_5= GA_3 (60 ppm); GA_3 (90 ppm); T_6 (control, without pre-cooling;) on (A), Browning index (B) decay index, (C) taste and (D) colour of fruits.

fruits (51.11%) were recorded in control followed by HWT at 55°C for 10 min. + 10% OA (68.68%) due to combined effects of extensive shrinkage, browning, spoilage and palatability ratings. Plant growth regulator improves the shelf-life, keeping quality and marketability of fruits for a longer period (Pareek *et al*., 12).

Fruit palatability rating declined during the entire storage period. As illustrated in Fig. 1 (C and D), pronounced effects of the applied treatments on the organoleptic parameters of fruit was observed. Among the treatments, GA_3 (90 ppm) was superior in retaining fruit colour and improving taste of *ber* fruit to after 28 days storage period. The maximum colour (4.8) and taste (4.4) rating were recorded in GA_3 (90 ppm) treated fruits followed by HWT (55°C, 10 min.) + 10% OA (15 min.) in term of fruit colour retention (3.5) and GA_3 (60 ppm) treated fruits in case of fruit taste (3.6). The minimum ratings for colour (1.8) and taste (2.2) at the last day of storage were observed in control fruits. Similar results were also reported by Chahal and Bal (2) in *ber* fruits after 30 days of cold storage. This could be attributed to the low rates of respiration and transpiration in fruits as well as due to the role of the applied treatment maintenance of higher TSS and acidity content of fruits, as reported earlier by many workers (Saegnil *et al*., 14; Marboh *et al*., 9; Jawandha *et al*., 7).

From the study, it could be concluded that ber fruits treated with GA_3 (90 ppm) and stored at low temperature (5±1°C and 85 ± 5% RH) was the most effective treatment. This treatment also gives maximum retention of physico-chemical parameters of *ber* cv. Gola fruit. The fruit remained in acceptable condition up to 21 days of cold storage under this treatment (Fig. 2). After this period the due to higher enzyme activity degradation/senescence process started in fruits that ultimately deteriorated their quality.

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Received : July, 2016; Revised : December, 2017;
Accepted : February, 2018