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Effect of Preharvest Spray on Textural Property of Pomegranate (*Punica granatum* L.) Fruit cv. Bhagwa during Storage

Mohamad Tayeebulla H.[1*], Sreenivas K. N.[2], Sadananda G. K.[3], Sudhakar Rao D. V.[4], Shivashankara K. S.[5] and Guruprasad T. R.[6]

[1]Ph.D Scholar, Department of Postharvest Technology, College of Horticulture, Bengaluru, Karnataka, India

[2]Retired Dean, College of Horticulture, Tamaka, Kolar, Karnataka, India

[3]Assistant Professor, Department of Postharvest Technology, College of Horticulture, Bengaluru, Karnataka, India

[4]Principal Scientist, Division of Postharvest Technology,

[5]Principal Scientist, Division of Plant Physiology & Biochemistry, IIHR, Hesaraghatta, Bengaluru, Karnataka, India

[6]Retired Associate Director of Research & Extension, RHREC, UHS Campus, Bangalore-65

*Corresponding Author E-mail: tayeebmd@gmail.com

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ABSTRACT

Pomegranate has been grown since ancient times for its delicious fruits pomegranate (Punica granatum L.) belongs to the Lythraceae family. In spite of the known nutraceutical benefits and great global demand for potentially pomegranate derived products; the pomegranate processing industry is not developed due to lack of technological developments. Quality after harvest can greatly be altered during supply chain, have a considerable effect on changes in fruits quality and mechanical properties, decrease in firmness during storage period will decrease the marketability of fruits. Therefore, mechanical properties such as compression and puncture resistance is an important quality indicators of pomegranate. In this context, novel compounds were pretreated, among different chemical GA_3(100ppm) with Benzyl adenine (75 ppm) (T_5) sprayed in combination had maintained higher rind moisture with minimum rind firmness (1841.52 g/mm^2), similarly in aril firmness was *minimum was recorded in T_5 (767.66 g/mm^2), which had delayed rind case hardening and browning in pomegranate fruit during the 16days of storage at ambient storage condition.*

Key word: *Pre-harvest, Pomegranate, Texture, Rind and Aril firmness*

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the oldest known edible fruits and is capable of growing in different agro-climatic conditions ranging from the tropical to sub- tropical[13,9]. It is a commercially important fruit grown throughout the world.

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India ranks first in the pomegranate production (1346000 MT) in the world, in an area of 130770 hectares with productivity of 10.30 t ha^{-1}. Maharashtra, a pomegranate basket of India, covers 0.90 lakh ha area (70.2%) with the production of 9.45 lakh tones[2]. More than 90 per cent of the fresh produce is utilized for domestic fresh consumption and export[2].

The edible part (aril) of the fruit is consumed as fresh arils or as processed products such as jams, jellies, wine, and beverages[1,17,20]. It is an important source of anthocyanins, phenolic compounds, vitamins and minerals[8,15,19]. Scientific evidence has linked increasing consumption of pomegranate fruit to improved human health as a result of active phenolic compounds which have potent pharmacological activities, including, antioxidant, anti-mutagenic, anti-hypertension, anti-inflammatory activities[7,12,4,24,6].

Quality after harvest can greatly be altered during supply chain, storage temperature, humidity and duration have a considerable effect on changes in fruits quality and mechanical properties[5], decrease in firmness during storage period will decrease the marketability of fruits[14]. Therefore, mechanical properties such as compression and puncture resistance is an important quality indicators of pomegranate. However, there is limited understanding of the effects of temperature on surface quality attributes like firmness, rind moisture, peel colour of pomegranate fruit[10]. The occurrence of physiological disorders such as husk scalds, splitting, and chilling injury are challengers which reduce marketability and consumer's acceptance[3,22]. Hence, textural observation are the indicator of fruit quality.

In this context, novel compounds such as Calcium chloride, Gibberellic acid (GA_3), Benzyl adenine (BA), Methyl Jasmonate (MeJa), salicylic acid (SA) and Potassium nitrate, etc., have emerged as a ray of hope for extending the shelf life and quality of some fruits at ambient conditions. These compounds can be used either as preharvest sprays in several fruits wherein they exhibit differential responses in the treated commodity.

Among different elite horticultural practices, growth regulators have been advantageously used in the recent time to increase the fruit production and to improve the quality of several fruit crops. Plant growth regulators or phytohormones are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute amounts. Pomegranate trees applied with growth regulators have potent to increased fruit size, aril development and were highly effective in improving, nutritional status yield and fruit quality of pomegranate trees.

However, scientific knowledge on physico-chemical changes, mechanical properties during handling and storage of pomegranate fruits is lacking, especially during postharvest storage. Hence, in view of the above an attempt has been made to study the effect of various preharvest treatments on mechanical changes of pomegranate fruit during storage is present in this study.

MATERIAL AND METHODS

The experiment was carried out in at farmers field, Hiriyur (T), Chitradurga (D), Karnataka located at an altitude of 693 meters above mean sea level and has latitude of 13° 58'10.7" North and longitude of 76° 38' 02.9" East. The soil at the experimental station was red loam. The postharvest studies were carried out at Department of Postharvest Technology, College of Horticulture, UHS Campus, Bengaluru located at an altitude of 890 meters above mean sea level and has latitude of 13° 58′ North and longitude of 77° 37′ East during 2016-17.

Preharvest operations

The experiment consisted of 12 treatments with three replications in randomized block design. Three years old pomegranate trees cv. Bhagwa with uniform vigour and size, planted at a spacing of 6 x 8m were selected for the study. The spray were applied at 30 days interval after bud burst and repeated till harvest (135 days after flowering).

Spray solution for preharvest treatments solution were prepared according to concentration required, calcium chloride (5gm or 10gm in 1 litre of distilled water was homogenized for 0.5 % and 1% concentration respectively), GA_3 (to prepare 100 ppm of GA_3, 100 gm of GA_3 was homogenized in 1 litre of distilled water), Benzyl adenine (BA) (75 ppm of BA, 75 gm of BA was homogenized in 1 litre of distilled water), Salicylic acid (The molar mass of salicylic acid (SA) is 138.121 g/mol, hence, 1.38121 g or 138.121 mg and small amount of ethanol to dissolve SA then volume was makeup to 1 liter with distilled water and homogenized for 1mM SA). Potassium nitrate (solution was prepared by adding 250 and 350mg of potassium nitrate in 1 liter of distilled water each and homogenized using magnetic stirrer). Prepared solution were dissolved them in distilled water directly with the desired solution, before spraying 1.0 ml of sticking agent (Triton-X @ 1%) per litre of solution was added as surfactant to reduce surface tension and to facilitate the absorption of solution. The treatments were applied with a hand sprayer and spraying was done in a clear and calm day during the morning hours to increase efficiency. On each tree, about 35-40 flowers were tagged after flowering and selected trees were sprayed with respective spray solutions at 30 days interval, total 5 sprays were given before the harvest and spray was carried on all sides of the plants and fruits as well as to the foliage surrounding the fruit. Preharvest treated fruits were harvested using secateurs after 135 days of flowering and brought to the laboratory.

Fruit firmness (g/mm^2)

The firmness of pomegranate fruit, at equatorial region, was measured as the force required for puncturing the fruits using a texture analyzer (Model: TA + Di, Stable Microsystems, UK). A probe of 2 mm diameter was used, set at a cross head speed of 0.5 mm sec^{-1} using a 500 kg load cell. The firmness was defined in terms of maximum force (g f) during the compression, which was expressed in grams of force per millimetre (g/mm^2). The first peak in the force deformation curve was taken as firmness of the aril firmness (g/mm^2) and rind firmness(g/mm^2) was recorded and tabulated.

Statistical analyses

All statistical analyses were performed with SAS version 9.4v available at ICAR-Indian Agricultural Statistical Research Institute, New Delhi. A factorial design was employed defining treatments (12 levels) and storage time (5 levels) as factors for all studies. Data were analysed and if factorial effects were found significant, then they were subjected to Duncan's Multiple Range Test (DMRT)[21]. All comparisons were carried out at a significant level of $P < 0.05$.

RESULTS

Rind firmness (Texture Bio yield g/mm^2)

The pomegranate fruit rind firmness has shown a significant increasing trend with the progressive increase in storage period and lower increase in firmness was reported in fruits received chemical spray is presented in Table 1. Irrespective of the storage period, fruit rind firmness (bio-yield) of pomegranate fruits was highest at the end of storage period (2769.80 g/mm^2) and lowest on the day of harvest (1693.55 g/mm^2). Similarly, irrespective of the treatment, the maximum fruit rind firmness was observed in control fruits (2436.64 g/mm^2) which was followed by potassium nitrate (250ppm) sprayed fruits and minimum was recorded in the pomegranate fruits treated with GA_3(100ppm) with Benzyl adenine (75 ppm) received fruits (1841.52 g/mm^2). The interaction, treatment x storage period (T x S) was also significant as the highest fruit rind firmness was observed in $T_{12}S_5$ (3095.15 g/mm^2) which was followed by T_1S_5 and T_2S_1 and the lowest rind firmness was recorded in T_1S_1 (1453.69 g/mm^2) and T_5S_1 (1498.97 g/mm^2).

Aril firmness (Texture Flesh Firmness g/mm^2)

The pomegranate fruit aril firmness has shown a significantly increasing trend with the gradually increased during storage which was reported in fruits received chemical spray as compared to untreated is presented in Table 2. Irrespective of the storage period, fruit aril firmness of pomegranate fruits was lowest in S_1 (751.75 g/mm^2) and highest was on S_5 (1123.82 g/mm^2). Similarly, irrespective of the treatment, the maximum fruit firmness was observed in T_{12} (1070.51 g/mm^2) and minimum was recorded in T_5 (767.66 g/mm^2). The interaction, treatment x storage period (T x S) was also significant as the highest aril firmness was observed in $T_{12}S_5$ (1332.53 g/mm^2) and the lowest aril firmness was recorded in T_5S_1 (652.40 g/mm^2) and T_1S_1 (663.40 g/mm^2) it was followed by $T_{11}S_1$ and T_2S_1.

DISCUSSION

The fruit firmness is one of the most crucial factors in determining the postharvest quality of fruits[23], studies have shown that textural properties of pomegranate fruit changed depending on storage conditions. Loss of moisture from the fruit through the peel of pomegranate fruit might have resulted in decreased firmness and result in hardening of husk, mechanical strength of fruit peel during storage. Although the peel appears to be thick, it has numerous minute openings that permit free movement of water vapour, making the fruit highly susceptible to water loss[11].

In the present experiment as depicted in Table. 1 and 2 resulted in preharvest treatment with gibberellic acid and benzyl adenine sprayed fruits had minimum rind and aril firmness compared to the untreated during storage of pomegranate fruits. The greater increase in firmness during storage could be due to moisture loss from the fruit resulting to hardening and increase in mechanical strength of fruit peel[5] while the lower firmness was resulted may be due to GA_3 and BA application result in elongation of cell and cell size which had maintained the rind cells texture leading to lower moisture loss as compared to control. The results are in confirmation with Mansouri *et al*.[14] in Hondos-e-Yalabad' and 'Malas-e-Saveh' cultivars. On contrary Nanda *et al*.[18] reported that there is in decreases in fruit firmness after 5 weeks of storage; Mirdehghan *et al*., 2006 in Mollar de Elche' fruit decreases firmness after 90 days of storage.

Table 1. Effect of different preharvest treatments on rind firmness (bioyield g/mm^2) of pomegranate (*Punica granatum* L) cv. Bhagwa during storage

Treatments/ Storage	S_1 (Initial)	S_2 (4DAS)	S_3 (8DAS)	S_4 (12DAS)	S_5 (16DAS)	Mean (T)
T_1	1453.69 (14.25 N)	1637.26 (16.05 N)	2017.6 (19.79 N)	2810.59 (27.56 N)	2994.25 (29.36 N)	**2182.68^{dc} (21.4 N)**
T_2	1591.65 (15.61 N)	1826.05 (17.9 N)	2214.39 (21.71 N)	2558.84 (25.09 N)	2974.75 (29.17 N)	**2233.14^{bc} (21.9 N)**
T_3	1681.27 (16.49 N)	1855.5 (18.19 N)	1970.3 (19.32 N)	2209.77 (21.67 N)	2315.84 (22.71 N)	**2006.53^{f} (19.67 N)**
T_4	1651.77 (16.2 N)	1890.87 (18.54 N)	2045.39 (20.06 N)	2387.22 (23.41 N)	2590.4 (25.4 N)	**2113.13^{de} (20.72 N)**
T_5	1498.97 (14.7 N)	1700.64 (16.67 N)	1878.79 (18.42 N)	1935.29 (18.98 N)	2193.93 (21.51 N)	**1841.52^{g} (18.06 N)**
T_6	1685.53 (16.53 N)	1800.48 (17.65 N)	1874.23 (18.38 N)	2200.16 (21.58 N)	2689.65 (26.37 N)	**2050.01^{ef} (20.1 N)**
T_7	1873.92 (18.38 N)	1939.78 (19.02 N)	2135.34 (20.94 N)	2409.1 (23.62 N)	2951.74 (28.94 N)	**2261.97^{bc} (22.18 N)**
T_8	1885.1 (18.49 N)	2045.08 (20.05 N)	2178.81 (21.36 N)	2538.14 (24.89 N)	2812.18 (27.58 N)	**2291.86^{bc} (22.47 N)**
T_9	1638.47 (16.07 N)	1709.46 (16.76 N)	2152.41 (21.1 N)	2478.5 (24.3 N)	2940.25 (28.83 N)	**2183.82^{dc} (21.41 N)**
T_{10}	1823.01 (17.87 N)	1957.36 (19.19 N)	2258.6 (22.14 N)	2679.94 (26.28 N)	2884.36 (28.28 N)	**2320.65^{b} (22.75 N)**
T_{11}	1671.77 (16.39 N)	1900.9 (18.64 N)	2059.53 (20.19 N)	2694.28 (26.42 N)	2795.15 (27.41 N)	**2224.32^{bc} (21.81 N)**
T_{12}	1867.46 (18.31 N)	1988.87 (19.5 N)	2318.74 (22.74 N)	2913 (28.57 N)	3095.15 (30.35 N)	**2436.64^{a} (23.89 N)**
Mean (S)	**1693.55^{e} (16.6 N)**	**1854.35d (18.18 N)**	**2092.01^{c} (20.51 N)**	**2484.57^{b} (24.36 N)**	**2769.8^{a} (27.16 N)**	

	C.D.	**F-test**	**S.Em±**
Factor(T)	98.525	*	35.142
Factor(S)	63.598	*	22.684
Factor (T x S)	220.309	*	78.58

N-Newton, C.D. :Critical Difference, NS- Non Significant, * - significant, S.Em± : Standard Error (Mean)

T_1	Calcium chloride – 0.5%	T_5	GA_3 (100ppm) + BA (75ppm)	T_9	Methyl Jasmonate - 0.5mM
T_2	Calcium chloride - 1.0%	T_6	Salicylic acid- 1mM	T_{10}	Potassium Nitrate - 250ppm
T_3	Gibberellic acid (GA_3)– 100ppm	T_7	Salicylic acid- 2mM	T_{11}	Potassium Nitrate - 350ppm
T_4	Benzyl adenine (BA) – 75ppm	T_8	Methyl Jasmonate - 0.25mM	T_{12}	Control (Distilled Water)

For each attribute and storage intervals, values in columns with the same letter, and for each attribute and treatment, values in rows with the same letter, are not significantly different according to DMRT test ($p \leq 0.05$).

Table 2. Effect of different preharvest treatments on aril firmness (g/mm^2) of pomegranate (*Punica granatum* L) cv. Bhagwa during storage

Treatments/ Storage	S_1 (Initial)	S_2 (4DAS)	S_3 (8DAS)	S_4 (12DAS)	S_5 (16DAS)	Mean (T)
T_1	663.4 (6.50 N)	747.17 (7.32 N)	838.58 (8.22 N)	1083.86 (10.63 N)	1154.68 (11.32 N)	**897.54^d (8.8 N)**
T_2	731.93 (7.18 N)	839.72 (8.23 N)	921.15 (9.03 N)	987.67 (9.68 N)	1118.46 (10.97 N)	**919.78^{cd} (9.01 N)**
T_3	770.56 (7.55 N)	850.42 (8.33 N)	819.3 (8.03 N)	874.69 (8.57 N)	963 (9.44 N)	**855.59^e (8.39 N)**
T_4	759.52 (7.45 N)	869.46 (8.52 N)	850.84 (8.34 N)	921.42 (9.04 N)	1077.55 (10.56 N)	**895.76^d (8.78 N)**
T_5	652.4 (6.39 N)	740.17 (7.26 N)	776.92 (7.62 N)	761.58 (7.46 N)	907.23 (8.89 N)	**767.66^f (7.52 N)**
T_6	762.86 (7.48 N)	814.89 (7.99 N)	759.54 (7.45 N)	847.63 (8.31 N)	1090.00 (10.69 N)	**854.98^e (8.38 N)**
T_7	780.03 (7.64 N)	846.24 (8.3 N)	888.85 (8.71 N)	930.53 (9.12 N)	1228.68 (12.05 N)	**934.86^c (9.16 N)**
T_8	780.39 (7.65 N)	846.62 (8.3 N)	901.98 (8.84 N)	1025.35 (10.05 N)	1119.97 (10.98 N)	**934.86^c (9.16 N)**
T_9	781.31 (7.66 N)	815.16 (7.99 N)	877.5 (8.6 N)	1010.44 (9.91 N)	1198.69 (11.75 N)	**936.62^c (9.18 N)**
T_{10}	776.57 (7.61 N)	846.75 (8.3 N)	924.35 (9.06 N)	1096.78 (10.75 N)	1180.44 (11.57 N)	**964.98^b (9.46 N)**
T_{11}	708.13 (6.94 N)	805.18 (7.89 N)	828.66 (8.12 N)	1084.06 (10.63 N)	1124.65 (11.03 N)	**910.13^{cd} (8.92 N)**
T_{12}	853.97 (8.37 N)	940.6 (9.22 N)	990.78 (9.72 N)	1244.7 (12.2 N)	1322.53 (12.97 N)	**1070.51^a (10.49 N)**
Mean (S)	**751.75^e (7.37 N)**	**830.2^d (8.14 N)**	**864.87^c (8.48 N)**	**989.06^b (9.69 N)**	**1123.82^a (11.02 N)**	

	C.D.	F-test	S.Em±
Factor (T)	25.829	*	9.213
Factor (S)	16.673	*	5.947
Factor (T x S)	57.756	*	20.601

D. :Critical Difference, NS- Non Significant * - significant S.Em± : Standard Error (Mean)

T_1	Calcium chloride – 0.5%	T_5	GA_3 (100ppm) + BA (75ppm)	T_9	Methyl Jasmonate - 0.5mM
T_2	Calcium chloride - 1.0%	T_6	Salicylic acid- 1mM	T_{10}	Potassium Nitrate - 250ppm
T_3	Gibberellic acid (GA_3)– 100ppm	T_7	Salicylic acid- 2mM	T_{11}	Potassium Nitrate - 350ppm
T_4	Benzyl adenine (BA) – 75ppm	T_8	Methyl Jasmonate - 0.25mM	T_{12}	Control (Distilled Water)

For each attribute and storage intervals, values in columns with the same letter, and for each attribute and treatment, values in rows with the same letter, are not significantly different according to DMRT test ($p \leq 0.05$).

CONCLUSION

In conclusion, GA_3 and BA sprayed fruits had maintained higher rind moisture content their by maintaining better firmness and their by delayed rind case hardening and browning in pomegranate fruit during the 16days of storage at ambient storage condition. The mechanism by which GA_3 and BA accomplished this may be through the maintaining rind cells integrity and cell structure had resulted in better textural property of pomegranate fruits.

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