Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 3955-3959
Received: 04-03-2019
Accepted: 06-04-2019

RN Kanpure
Department of Fruit Science
KNK College of Horticulture
Mandsaur, Madhya Pradesh, India

R Tiwari
RVSKVV, Gwalior,
Madhya Pradesh, India

AK Barholia
RVSKVV, Gwalior,
Madhya Pradesh, India

SS Kushwah
Department of Vegetable Science
KNK College of Horticulture
Mandsaur, Madhya Pradesh, India

SN Mishra
Department of Soil Science & Agril. Chemistry, KNK College of Horticulture Mandsaur, Madhya Pradesh, India

R Lekhi
Department of Horticulture,
College of Agriculture Gwalior,
Madhya Pradesh, India

Correspondence
RN Kanpure
Department of Fruit Science
KNK College of Horticulture
Mandsaur, Madhya Pradesh, India

Effect of pre harvest spray of gibberellic acid, calcium nitrate and potassium sulphate on post harvest behaviour of winter guava (*Psidium guajava* L.) fruits

RN Kanpure, R Tiwari, AK Barholia, SS Kushwah, SN Mishra and R Lekhi

Abstract
The present investigation was carried out in Instructional cum research fruit orchard and laboratory of Department of fruit science, College of Horticulture Mandsaur (M.P.) during 2015-16 and 2016-17 two successive years. Results of two year pooled data revealed that the minimum physiological loss in weight (PLW) (4.68%), (7.44%) and (12.16%) was recorded in variety Chittidar on 3, 6 and 9 days storage. The maximum fruit length (7.30cm), (7.10cm), (6.66cm) and (6.04cm) was recorded in guava variety Chittidar and maximum fruit diameter (7.80cm), (7.50cm), (7.12cm) and (6.52cm) was recorded in guava variety of Dharidar on 0, 3, 6 & 9 days storage, maximum specific gravity (0.96), (0.94) & (0.91) was recorded in Chittitar on 0, 3 & 6 days storage, however on 9th day at storage specific gravity was found non significant. At 9 days storage, the maximum marketable fruits (47.72%) were obtained in Chittidar.
As regards to plant growth regulator (GA_3) and nutrients (Ca (NO_3)2) & (K_2SO_4), the minimum physiological weight loss (2.97%), (5.20%), (10.04%) was recorded in T_{12} which was followed by T_7 (3.70%), (5.46%) & (10.67%) on 3, 6 & 9 days at storage condition respectively. Maximum fruit length and diameter (7.29cm), (7.15cm), (6.83cm) & (6.27cm) and (7.49cm), (7.19cm), (6.87cm) & (6.30cm), maximum specific gravity (1.01), (0.99), (0.97) & (0.95), maximum marketable fruits (72.13%) was obtained in T_{12} which was followed by T_7 (71.23%) on 9th days at storage. Interaction study revealed that significant variation was noticed for physiological loss in weight in both years of experiment. The minimum physiological loss in weight (PLW) was recorded in (2.96%), (5.09%) & (9.96%) in V_2T_{12} on 3, 6 and 9 days at storage. Maximum marketable fruits (72.81%) were obtained in V_2T_{12} on 9th days at storage. However, non significant variations were noticed in fruit size (length & diameter) and specific gravity under the present investigation.

Keywords: Pre harvest spray, gibberellic acid, calcium nitrate, potassium sulphate, *Psidium guajava* L.

Introduction
Guava (*Psidium guajava* L.) is an important fruit crop of India. It is normally consumed fresh as a dessert fruit, of processed into, juice, concentrate, jam, jelly, nector or syrup (Jagtiani *et al.*, 1988) [17]. There is an increasing demand of fruits for fresh as well as processing purpose in domestic and international markets.
Physico-chemical and biochemical changes affect the final texture and quality of fruits during the storage. The effect of elucidating the maintenance of fruit quality has been based on the modifications taking place in the cell wall (Brummell *et al*., 2004) [5]. Calcium, as a constituent of the cell wall, plays an important role in forming cross-bridges, which influence cell wall strength and regarded as the last barrier before cell separation (Fry 2004) [11].
In recent years plant growth regulators have been used for improving the quality, delaying deterioration in storage and thereby increase the shelf life of various fruit crops including guava. Some chemicals like calcium, potassium and plant growth regulator have been reported to prolong shelf life and improve the quality by affecting the wide range of physiological processes in plants and also inhibit specific aspect of abnormal senescence in numerous fruits (Farag and Kassem, 2000) [12]. Calcium compound have shown promise in the quality retention of fruit also (Huber, 1983) [15]. The choice of different calcium compounds to supply the required calcium is quite confusing, due to mixed report from scientific community about the superiority of one calcium compound of other.
Nutrients and plant growth regulators like GA_3 have been extensively used for improving quality, delaying degradation in storage and thereby, increasing the shelf life of various fruits (Kher *et al.*, 2005) [20]. GA_3 on fruits and plants acts as an anti-senescence agent (Ahmed *et al.* 2001) [1]. Potassium is a unique mineral element in plant biology. It has a pertinent role in

many metabolic processes, like carbohydrate synthesis and development of meristematic tissues, as well as encourages lignifications and regulates water absorption and transpiration. Guava is a perishable fruit and highly prone to bruising and mechanical injuries. Due to such perishability, control of fruit ripening is fundamental and this generates the necessity to search for new technologies to increase shelf life, reach distant markets and thus improve the marketing process (Mitra *et al*., 2012) [23]. A very little information is available, particular response of plant growth regulator (GA_3) and nutrients {Ca $(NO_3)_2$} & K_2SO_4). Keeping these points in mind, the present investigation was, therefore, undertaken to study the effect of pre harvest spray of GA_3, calcium nitrate and potassium sulphate on post harvest behaviour of guava (*Psidium guajava* L.) fruits of Dharidar and Chittidar.

Material and methods

The present experiment was carried out at the Instructional cum research fruit orchards Department of Fruit Science KNK College of Horticulture Mandsaur (M.P.), during the two successive years i.e. 2015-16 and 2016-17. Randomly distributed plants of guava fruits cv. Dharidar and Chittidar of uniform age and vigour were selected. The experiment consisted of three replications and 26 treatments with randomized block design in factorial concept. The investigation consisted of treatments *viz*., T_1- GA_3 @ 50 ppm, T_2 - GA_3 @ 100 ppm, T_3- Calcium nitrate @ 1%, T_4- Calcium nitrate @ 2%, T_5- Potassium sulphate @ 1%, T_6- Potassium sulphate @ 2%, T_7- GA_3 @ 100 ppm+ Calcium nitrate @ 2%,T_8- GA_3 @ 100 ppm+ Potassium sulphate @ 2%, T_9- GA_3 @ 50 ppm+ Calcium nitrate @ 1%+ Potassium sulphate @ 1%, T_{10}- GA_3 @ 50 ppm+ Calcium nitrate @ 2%+ Potassium sulphate @ 2%, T_{11}- GA_3 @ 100 ppm+ Calcium nitrate @ 1%+ Potassium sulphate @ 1%, T_{12}- GA_3 @ 100 ppm+ Calcium nitrate @ 2%+ Potassium sulphate @ 2% including control treatment i.e. water spray with two varieties i.e. Dharidar and Chittidar. All treatments were applied as foliar spray. At the optimum horticultural maturity, uniform sized fruits harvested after 20 days of foliar spray and stored up to 9 days.

These fruits were analysed for various physico-chemical characters like physiological loss in weight (PLW), fruit size (length &diameter), specific gravity, marketable fruits (%). Physiological loss in weight (PLW) of fruit was determined with formula given by Srivastava and Tandon (1968) [30] on the basis of initial weight of the fruit and loss in weight that occurred and were expressed in per cent. Fruit size was measured with the help of vernier callipers. Water replacement method was advocated for specific gravity and marketable fruits were calculated by number of fruits retained after decay loss on per cent basis.

Results and Discussion

Physiological loss in weight

A perusal of data in Table 1 shows that per cent PLW was influenced significantly by varieties, plant growth regulator & nutrients and their interactions under the ambient storage conditions at 3 days intervals up to 9th day storage. The weight loss increased gradually and progressively with advancement in storage period. The minimum loss in physiological weight (4.68%), (7.44%) and (12.16%) was recorded on 3rd, 6th and 9th days respectively in guava variety of Chittidar fruits stored at ambient condition. Plant growth regulator and nutrients (GA_3, calcium nitrate and potassium sulphate) had significantly increased the loss in physiological weight as the storage period advanced irrespective of any treatments. T_{12} (GA_3 @100ppm + calcium nitrate @ 2% + potassium sulphate @ 2%) recorded the minimum loss in physiological weight (2.97%, 5.20% & 10.04%) which was followed by T_7 (3.70%, 5.46% & 10.67%) and T_{10} (3.89%, 5.73% & 11.01%) on 3rd, 6th and 9th days at storage respectively. However, maximum loss in physiological weight was recorded in control treatment. As regards to interaction study of gibberellic acid (GA_3), calcium nitrate {Ca $(NO_3)_2$} & potassium sulphate (K_2SO_4)) with Dharidar & Chittidar varieties of guava fruits revealed that significant variation was noticed for physiological loss in weight, treatment V_2T_{12} recorded minimum loss in physiological weight (2.96%, 5.09% & 9.69) on 3rd, 6th and 9th days storage respectively which was followed by V_1T_{12} (2.98%, 5.31% and 10.12%) and V_2T_7 (3.56%, 5.37% & 10.16%) on 3rd, 6rd & 9th days of storage respectively. However, maximum losses in physiological weight (8.50%, 15.69% and 24.06%) were recorded in V_1T_0. Higher concentration, Ca $(NO_3)2$ showed lowest weight loss this might be due to role of calcium on altering the membrane permeability of cell wall and thereby limiting the rate of respiration (Bengerth, 1979) [3]. Prolongation of fruit life due to growth regulators is probably due to effectiveness of these chemical in retardation of ripening and senescence and reduction in weight loss (Huang, 1974) [14]. Effectiveness of GA_3 in maintaining fruit firmness may be due to the reason that might reduce various physiological activities related with softening of fruits (Rees 1975) [25]. Many workers, Singh (1998) [27], Aly and Ismail (2000) [2], Mahajan *et al*. (2011) [22] in guava, Jakhar and Pathak (2016) [16] in mango, Deepthi *el al*. (2016) [9] in guava and Singh *et al*. (2014) [28] in aonla also reported calcium nitrate and GA_3 had effectively reduce the weight loss during storage.

Fruit Size (length and diameter)

The fruit size (diameter and length) decreases with the increase in storage period as given in Table 2. However, the treated fruits maintained higher values of fruit size as compared to control. The reduction in fruit size during storage period may be due to shrinking of fruits caused by transpiration. Application of chemicals might have decreased the rate of transpiration and physiological loss in weight resulting in retention of better size fruits during storage.

At the end of the storage the minimum reduction in fruit size i.e. length was recorded in variety Chittidar & diameter in variety Dharidar. Application of plant growth regulator (GA_3) and nutrients alone & in conjunction had influenced the length and diameter of the fruits. The maximum fruit length (6.27 cm) and maximum diameter (6.30 cm) was recorded in T_{12} (GA_3 @ 100ppm + calcium nitrate @ 2% + potassium sulphate @ 2%). It might be due to the ant senescent action of GA_3 and cell degradation was prevented by Ca $(NO_3)_2$ which in turn facilitated the reduced moisture loss and lesser respiratory gas exchange, hence delay in ripening and lower the shrinkage percentage. The effect of higher concentration of calcium compound and GA_3 on guava fruits was also supported by Lal *et al*. (2011) [21] in Apricot cv. Harcot, Bisen *et* al. (2014) [4] in guava, Kirmani *et al*. (2013) [18] in Plum and Manivannan *et al*. (2015) [24] in guava cv. L-49.

Specific gravity

Specific gravity of guava varieties was significantly influenced by plant growth regulator & nutrients during both year of experiment. Chittidar variety had recorded maximum

specific gravity (0.91) on 6th day of storage. Specific gravity on 9th day of guava fruits storage was found non significant. As regards to gibberellic acid (GA_3), calcium nitrate {Ca $(NO_3)_2$} & potassium sulphate (K_2SO_4)) alone and in combination T_{12} (GA_3 @100ppm + calcium nitrate @ 2% + potassium sulphate @ 2%) treatment recorded maximum specific gravity (0.97) and (0.95) on 6th days and 9th day at storage condition which was followed by T_7 (0.95) & (0.93) on 6th days and 9th day at storage condition. The gradual decrease in specific gravity in both years of calcium treated fruits could possibly be due to slow reduction in weight and volume of the fruit because of the retarding effect of calcium on ripening process, such findings also been reported by Chundawat *et al* . (1978) [6], Singh (1980) [26], kher *et al*. (2005) [20] in guava, Kazemi *et al.* (2011) [19] in Kiwifruit, Bisen, *et al.* (2014) [4] in guava and Desai *et al*. (2017) [10] in sapota.

Marketable fruits

Among two variety of guava, Dharidar variety of guava had obtained maximum marketable fruits (47.72%) on 9th days at storage condition. Application of plant growth regulator and nutrients revealed that significant variations were noticed for marketable fruit percentage in two year experiments. Maximum marketable fruits (72.13%) were obtained in T_{12} which was the statistically superior compare to other treatments. As regards to interaction study of gibberellic acid (GA_3), calcium nitrate {Ca $(NO_3)_2$} & potassium sulphate (K_2SO_4) with Dharidar & Chittidar varieties of guava fruits, maximum marketable fruits (73.19%) were obtained under V_2T_7 followed by V_2T_{12} (72.81%) and V_1T_{12} (71.44%) on 9th days storage. However, the minimum marketable fruits (8.78%) were obtained in V_2T_0. The increase in fruit marketability might be due to decrease in production of ethylene which is responsible for the fast ripening of fruits, improved fruit colour development and appearance (Cheour *et al*., 1990) [7]. Singh (1998) [27] and Singh *et al.* (2007) [29] also found that calcium treated guava fruits rated higher score and optimum marketable quality for longer period. Almost similar results were also obtained by Goutam *et al*. (2010) [13] in guava, Chouhan *et al.* (2015) [8] in Mango cv. Dashehari and Vishwakarma *et al.* (2017) [31] in mango cv. Amrapali.

Table 1: Effect of pre harvest spray of GA_3, calcium nitrate and potassium sulphate on physiological loss in weight (%) and marketable fruits (%) at 3 days intervals up to 9 days storage

Treatments	Physiological loss in weight (%)				Marketable fruits (%)			
	0 day	3 days	6 days	9 days	0 day	3 days	6 days	9 days
Varieties								
V_1	0.00	5.05	7.90	13.25	100	100	83.28	46.39
V_2	0.00	4.68	7.44	12.16	100	100	84.62	47.72
S. Em. ±	0.00	0.009	0.006	0.006	0.00	0.00	0.011	0.017
CD (at 5%)	0.00	0.026	0.015	0.016	0.00	0.00	0.030	0.048
Plant growth regulator and nutrients								
T_0	0.00	8.03	14.52	21.43	100	100	35.31	9.10
T_1	0.00	5.23	8.32	13.08	100	100	80.47	40.31
T_2	0.00	5.10	8.09	12.44	100	100	85.95	43.50
T_3	0.00	4.90	7.62	11.86	100	100	89.49	49.17
T_4	0.00	4.59	6.88	11.65	100	100	96.26	55.89
T_5	0.00	5.86	8.95	14.11	100	100	58.34	17.62
T_6	0.00	5.66	8.86	14.01	100	100	59.04	18.17
T_7	0.00	3.70	5.46	10.67	100	100	100.00	71.23
T_8	0.00	4.97	7.88	12.27	100	100	86.51	47.01
T_9	0.00	4.21	6.18	11.31	100	100	100.00	59.37
T_{10}	0.00	3.89	5.73	11.01	100	100	100.00	66.56
T_{11}	0.00	4.15	6.01	11.25	100	100	100.00	61.63
T_{12}	0.00	2.97	5.20	10.04	100	100	100.00	72.13
S.Em.±	0.00	0.024	0.014	0.014	0.00	0.00	0.03	0.04
CD (at 5%)	0.00	0.067	0.039	0.040	0.00	0.00	0.08	0.12
Interactions								
V_1T_0	0.00	8.50	15.69	24.06	100	100	34.29	9.42
V_1T_1	0.00	5.46	8.36	13.26	100	100	79.27	39.17
V_1T_2	0.00	5.25	8.16	12.68	100	100	83.91	43.69
V_1T_3	0.00	4.96	7.93	12.10	100	100	88.73	48.33
V_1T_4	0.00	4.82	6.73	12.02	100	100	95.53	55.03
V_1T_5	0.00	6.42	9.13	15.00	100	100	58.05	17.16
V_1T_6	0.00	6.09	9.05	14.95	100	100	58.71	17.83
V_1T_7	0.00	3.84	5.55	11.17	100	100	100.00	69.26
V_1T_8	0.00	5.01	7.90	12.47	100	100	84.21	46.92
V_1T_9	0.00	4.20	6.48	11.60	100	100	100.00	59.85
V_1T_{10}	0.00	3.93	6.03	11.22	100	100	100.00	64.24
V_1T_{11}	0.00	4.15	6.34	11.54	100	100	100.00	60.69
V_1T_{12}	0.00	2.98	5.31	10.12	100	100	100.00	71.44
V_2T_0	0.00	7.57	13.36	18.79	100	100	36.33	8.78
V_2T_1	0.00	5.00	8.29	12.90	100	100	81.67	41.46
V_2T_2	0.00	4.95	8.02	12.20	100	100	87.99	43.30
V_2T_3	0.00	4.83	7.31	11.62	100	100	90.25	50.01
V_2T_4	0.00	4.35	7.03	11.29	100	100	96.98	56.75
V_2T_5	0.00	5.31	8.78	13.22	100	100	58.64	18.09

V_2T_6	0.00	5.23	8.68	13.08	100	100	59.37	18.51
V_2T_7	0.00	3.56	5.37	10.16	100	100	100.00	73.19
V_2T_8	0.00	4.93	7.86	12.08	100	100	88.78	47.09
V_2T_9	0.00	4.22	5.88	11.01	100	100	100.00	58.89
V_2T_{10}	0.00	3.84	5.44	10.79	100	100	100.00	68.88
V_2T_{11}	0.00	4.16	5.68	10.95	100	100	100.00	62.57
V_2T_{12}	0.00	2.96	5.09	9.96	100	100	100.00	72.81
S.Em. ±	0.00	0.03	0.01	0.02	0.00	0.00	0.04	0.06
CD (at 5%)	0.00	0.09	0.05	0.05	0.00	0.00	0.11	0.17

Table 2: Effect of pre harvest spray of GA_3, calcium nitrate and potassium sulphate on fruit diameter (cm) and fruit length (cm) at 3 days intervals up to 9 days storage

Treatments	Fruit diameter (cm)				Fruit length (cm)			
	0 day	3 days	6 days	9 days	0 day	3 days	6 days	9 days
Varieties								
V_1	7.80	7.50	7.12	6.52	6.94	6.77	6.36	5.72
V_2	6.86	6.57	6.19	5.53	7.30	7.10	6.66	6.04
S.Em. ±	0.006	0.004	0.006	0.005	0.007	0.004	0.005	0.003
CD (at 5%)	0.017	0.012	0.016	0.015	0.020	0.012	0.015	0.009
Plant growth regulator and nutrients								
T_0	7.19	6.89	6.36	5.66	6.93	6.69	6.18	5.44
T_1	7.27	6.97	6.59	5.92	7.04	6.86	6.37	5.71
T_2	7.27	6.98	6.62	5.97	7.06	6.87	6.41	5.77
T_3	7.31	7.02	6.66	6.05	7.10	6.92	6.50	5.87
T_4	7.34	7.04	6.69	6.09	7.13	6.96	6.55	5.94
T_5	7.21	6.93	6.45	5.76	7.00	6.76	6.26	5.57
T_6	7.23	6.94	6.47	5.77	7.02	6.78	6.30	5.59
T_7	7.46	7.17	6.85	6.27	7.29	7.11	6.78	6.21
T_8	7.29	6.99	6.63	5.98	7.09	6.89	6.44	5.80
T_9	7.38	7.09	6.75	6.15	7.17	7.01	6.62	6.04
T_{10}	7.43	7.15	6.82	6.22	7.23	7.10	6.73	6.15
T_{11}	7.41	7.12	6.78	6.19	7.21	7.05	6.68	6.09
T_{12}	7.49	7.19	6.87	6.30	7.29	7.15	6.83	6.27
S.Em.±	0.015	0.011	0.014	0.013	0.018	0.011	0.01	0.008
CD (at 5%)	0.043	0.031	0.040	0.037	0.050	0.031	0.04	0.024

Table 3: Effect of pre harvest spray of GA_3, calcium nitrate and potassium sulphate on specific gravity at 3 days intervals up to 9 days storage

Treatments	Specific gravity			
	0 day	3 days	6 days	9 days
Varieties				
V_1	0.92	0.91	0.90	0.88
V_2	0.96	0.94	0.91	0.88
S.Em. ±	0.003	0.003	0.003	0.004
CD (at 5%)	0.009	0.009	0.008	NS
Plant growth regulator and nutrients				
T_0	0.91	0.87	0.86	0.82
T_1	0.92	0.90	0.87	0.85
T_2	0.92	0.91	0.89	0.86
T_3	0.93	0.92	0.89	0.87
T_4	0.95	0.93	0.90	0.88
T_5	0.89	0.88	0.86	0.84
T_6	0.90	0.88	0.86	0.84
T_7	0.99	0.97	0.95	0.93
T_8	0.92	0.91	0.89	0.87
T_9	0.96	0.94	0.93	0.90
T_{10}	0.97	0.96	0.95	0.92
T_{11}	0.97	0.95	0.94	0.91
T_{12}	1.01	0.99	0.97	0.95
S.Em.±	0.008	0.008	0.008	0.009
CD (at 5%)	0.023	0.87	0.022	0.025

Conclusion

The results obtained from present two years investigation concluded that the guava variety Chittidar performed well in relation to physiological weight in loss, fruit length, specific gravity and marketable fruits; however variety Dharidar performed well in relation to fruit diameter. As regards to plant growth regulator (GA_3 @ 100 ppm) & nutrients Ca $(NO_3)_2$ @ 2%) & K_2SO_4 @ 2%), the minimum physiological weight in loss, maximum fruit size, specific gravity and marketable fruits were recorded in T_{12}. In interaction study, minimum physiological weight in loss & maximum marketable fruits was obtained in V_2T_{12}. However, in interaction study non significant variations were noticed with fruit size (length & diameter) and specific gravity under the present investigation.

References

1. Ahmed FF, Morsy MH. Response of 'canino' apricot trees grown in the new reclaimed land to application of some nutrients and ascorbic acid. The fifth Arabian Hort. Conf. Ismalia, Egypt. 2001, 27-34.
2. Aly EZ, Ismail HA. Effect of pre-harvest GA_3, $CaCl_2$ and boron treatments on quality and enzymatic browning in Balady guava fruits. Annals of Agricultural Science, Moshtohor. 2000; 38(2):1101-1108.
3. Bengerth F. Calcium regulated physiological disorder in plants. Ann. Rev. Phytopathology. 1979; 17:97-99.
4. Bisen Sarad, Thakur RS, Tembhare Dharna. Effect of calcium nitrate and gibberellic acid application on growth, fruit quality and post-harvest behaviour of guava fruit. The ecoscan. 2014; 14:55-62.
5. Brummell DA, Dal Cin V, Crisosoto CH, Labavitch JM. Cell wall metabolism during maturation, ripening and senescence of peach fruit. J Exp Bot. 2004; 55:2029-2039.
6. Chundawat BS, Gupta AK, Singh BP. Storage behaviour of different grades of kinnow fruits. Punjab Hort. J. 1978; 18:156-160.
7. Cheour F, Willemot C, Arul J, Desjardins Y, Makhlouf J, Charent PM, Gosselin A. Foliar application of calcium chloride delay post harvest ripening of strawberry. J Amerc. Soc. Hort. Sci. 1990; 115:789-792.
8. Chouhan P, Singh JP, Kaushik Himanshu, Singh RK, Rajbeer. Effect of pre-harvest foliar spray of nutrients and plant bio-regulators on shelf-life and quality of fruit of mango cv. Dashehari. The Asian Journal of Horticulture. 2015; 10(2):246-250.
9. Deepthi Phani V, Sekhar Chandra R, Srihari D, Sankar Siva A. Guava fruit quality and storability as influenced by harvest maturity and postharvest application of calcium salts**.** Plant Archives. 2015; 16(1):174-182.
10. Desai VN, Satodiya BN, Khatana KJ. Influence of pre-harvest spraying treatments of chemicals and plant growth regulators on physical parameters, post-harvest losses and shelf life of sapota [*Manilkara achras* (Mill.) Forsberg] fruits cv. Kalipatti. Journal of Pharmacognosy and Phytochemistry. 2017; 6(5):576-578.
11. Fry SC. Primary cell wall metabolism: tracking the carriers of wall polymers in living cells. New Phytol. 2004; 161:641-675.
12. Farag KM, Kassem HA. Effect of naphthalene acetic acid, calcium, phosphorus, or potassium on fruit quality, abscission and the shelf life of guava fruits. Emir. J Agric. Sci. 2000; 12:01-19.
13. Goutam Mandal, Dhaliwal HS, Mahajan BVC. Effect of pre-harvest calcium sprays on post-harvest life of winter guava (*Psidium guajava* L.**)**. J Food Sci Technol 2010; 47**(**5):501-506.
14. Huang CC. Maintaining freshness of pineapple fruits for export. *Taiwan* Agril. Quarterly 1974; 10:103-11.
15. Huber DJ. Role of cell wall hydrolases in fruit softening. Horti. Rev. 1983; 5:169-171.
16. Jakhar MS, Pathak S. Effect of pre-harvest nutrients application and bagging on quality and shelf life of mango (*Mangifera indica* L.) fruits cv. Amrapali. Journal of Agricultural Science & Technology 2016**;** 18(3):717-729.
17. Jagtiani J, Chan HT Jr, Sakai WS. Tropical fruit processing. Academic Press Inc., New York. 1988, 9-43.
18. Kirmani SN, Wani GM, Wani MS, Ghani MY, Abid M, Mujamil S, Raja H, Malik, AR. Effect of pre-harvest application of calcium chloride ($CaCl_2$), gibberlic acid (GA_3) and napthelenic acetic acid (NAA) on storage of plum (*Prunus salicina* L.) cv. Santa Rosa under ambient storage conditions. African J Agril. Research 2013; 8(9):812-818.
19. Kazemi M, Aran M, Zamani S. Effect of calcium chloride and salicylic acid treatment and quality characteristics of kiwifruit (*Actinida deliciosa*) cv. Hayward during storage. American J Plant Physiol. 2011; 6:183-89.
20. Kher R, Bhat S, Wali VK. Effect of foliar application of GA_3, NAA and CCC on physic-chemical characteristics of guava cv. Sardar. Haryana Journal of Horticultural Sciences. 2005; 34:31-32.
21. Lal S, Kumar D, Singh D, Ahmed N, Kumar R, Dar G. Effect of pre-harvest application of calcium chloride and gibberellic acid on shelf-life and post-harvest quality of apricot (*Prunus Armeniaca* L.) cv. Harcot. J Horti. Sci. 2011; 6(1):46-51.
22. Mahajan BVC, Ghuman BS, Harsimrat KB. Effect of post harvest treatments of calcium chloride and Gibberellic acid on storage behavior and quality of guava fruits. J. Horticultural Science and Ornamental Plants. 2011; 3(1):38-42.
23. Mitra SK, Devi HL, Chakraborty I, Pathak, PK. Recent development in post harvest physiology and storage of guava. Acta Hort. 2012; 959:89-95.
24. Manivannan MI, Irulandi S, Shoba Thingalmaniyan K. Studies on the effect of pre-harvest application of plant growth regulators and chemicals on yield and quality of guava (*Psidium guajava* L.) cv. L.-49. International Journal of Agricultural Sciences. 2015; 11(1):138-140.
25. Rees DA. Steriochemistry and binding behaviour of carbohydrate chains. In Biochemistry of Carbohydrates. MTP I (Ed. W.J. Whelan), Butterworths, London, Unv. Park Press, Baltimore, Inst. Rev. Sci. Biochem. Ser. 1975, 5.
26. Singh K. Effect of various chemicals as pre and post harvest application on shelf life of guava at various temperatures. Ph.D. Thesis, Haryana Agric. Univ. Hisar, India, 1980.
27. Singh Gorakh. Effect of calcium nitrate and plant growth regulators on the storage of Allahabad Safeda guava. Ind. J of Hort. 1998; 45(1/2):45-50.
28. Singh Amit Kumar, Shukla HS, Kumar Harit, Singh Vaibhav, Singh RR. Effect of gibberelic acid and calcium nitrate on the physiological and physico-chemical changes and shelf-life of aonla (*Emblica officinalis* Gaertn) fruits. International Journal of Farm Sciences. 2014; 5(2):140-145.
29. Singh R, Chaturvedi OP, Guar GS, Singh G. Effect of preharvest spray of zinc, calcium and boron on the storage behaviour of guava (*Psidium guajava* L.) fruits cv. Allahabad Safeda. Acta Hort. 2007; 735:633-638.
30. Srivastava MP, Tandon RN. Influence of temperature on Botryodiplodia rot of citrus and sapota. Indian Phytopathol. 1968; 21:195-207.
31. Vishwakarma Pradeep Kumar, Masu MM, Singh Sumit. Effect of preharvest application of different chemicals and plant growth regulators on physical parameters and shelf life of fruits of mango (*Mangifera indica* L.) cv. Amrapali. International Journal of Chemical Studies. 2017; 5(4):350-354.