Fresh Produce ©2011 Global Science Books

Effect of Pre-Storage Treatments of Calcium Chloride and Gibberellic Acid on Storage Behaviour and Quality of Guava Fruits

Bal Vipan Chandar Mahajan* • Kulbir Singh Brar • Birinder Singh Ghuman • Rajbir Singh Boora

Punjab Horticultural Postharvest Technology Centre, Punjab Agricultural University, Ludhiana, Punjab, 141 004 India

Corresponding author: * bvc_mahajan@rediffmail.com

ABSTRACT

Guava fruits of cultivar 'Allahabad Safeda' were harvested at the green mature stage. The fruits were given postharvest treatments of calcium chloride ($CaCl_2$: 1, 2, 3%), gibberelic acid (GA_3: 25, 50, 75 ppm) each for 5 min. The fruits were air dried and packed in corrugated fibre board boxes and stored in a walk-in cold-room maintained at 6 ± 1°C and 90-95% relative humidity. A control lot of fruit (without any treatment) was also stored under same conditions. The fruits were analysed for various quality attributes at different storage intervals until 4 weeks. The postharvest application of $CaCl_2$ (2%) extended the storage life of guava fruits up to 4 weeks with minimum weight loss, desirable firmness and highly acceptable quality.

Keywords: firmness, postharvest, quality, storage

Abbreviations: $CaCl_2$, calcium chloride; **GA_3**, gibberellic acid; **RH**, relative humidity

INTRODUCTION

Guava (*Psidium guajava* L.) is believed to have been introduced to India since the early 17th century (Anonymous 2011). In India, it is the 5th most widely grown fruit, occupying an area of 220,000 ha, with an annual production of 2.27 million MT (Anonymous 2008). Guava is a climacteric fruit (Akamine and Goo 1979), ripens rapidly after harvest and therefore has a short shelf-life. It is a highly perishable fruit and loses its texture and quality in 3-4 days at ambient temperature. Therefore, guava fruits are required to be managed appropriately in order to get a regulated market supply through judicious use of post-harvest treatments followed by storage at appropriate temperature and relative humidity. Calcium retards tissue softening and delays ripening (Goncalves *et al.* 2000; Serrano *et al.* 2004). Similarly, the application of gibberellic acid (GA_3) has been reported to delay senescence in fruits and vegetables (Osman and Abu-Goukh 2008; Pila *et al.* 2010). This study was thus conducted to determine the most suitable post-harvest treatment for improving the storage life and quality of guava fruits cv. 'Allahabad Safeda', which is known for its excellent size, appearance and pleasant flavour and is grown commercially by fruit growers in the Northern parts of India.

MATERIALS AND METHODS

Uniform, medium-sized (60-80 mm) fruits, apparently free from diseases and bruises, were harvested at the physiological mature stage and divided into lots for further handling.

Postharvest treatments, packaging and storage

The fruits were dip treated with an aqueous solution of different concentrations of $CaCl_2$ (1, 2 and 3%) and GA_3 (25, 50 and 75 ppm) separately each for 5 min. Control fruits were dipped in tap water for 5 min. The surface of fruits was air dried and thereafter packed in corrugated fibre board boxes. The fruits were stored in a walk-in cold-room maintained at 6 ± 1°C and 90-95% relative humidity.

Analytical methods

The physiological loss in weight (PLW) of fruit was calculated on an initial weight basis and expressed in per cent. The fruit firmness was measured with the help of a penetrometer (Model FT- 327, USA) using an 8-mm stainless steel probe and expressed in pounds force (lb force). The overall organoleptic rating of the fruits was performed by a panel of 10 judges on the basis of a 9-point Hedonic scale (Amerine *et al.* 1965). The total soluble solids (TSS) of the fruit juice were determined using a hand refractometer and expressed as TSS% after correcting the temperature at 20°C. The total sugars, titratable acidity and ascorbic acid content of fruits were estimated according to AOAC (1990).

Statistical analysis

There were three replications for each treatment and each replication comprised of 20 fruits. The experiment was laid out in a completely randomized design (Snedecor and Cochran 1987).

RESULTS AND DISCUSSION

Physiological loss in weight

PLW, in general, increased as the storage period advanced, rather slowly initially but more rapidly as the storage period advanced (**Table 1**). The lowest mean PLW (1.98%) was observed in fruits treated with 2% $CaCl_2$ closely followed by 3% $CaCl_2$. On the other hand, the highest mean PLW (3.32%) was observed in control fruits. During different storage intervals, $CaCl_2$ (2%)-treated fruits showed lowest weight loss, which ranged between 0.66 to 2.66% from 7 days to 28 days of cold storage, respectively compared to control fruits in which PLW ranged between 0.96 to 5.16% during the same interval. The application of calcium has been reported to be effective in terms of membrane functionality and integrity maintenance with lower losses of phospholipids and proteins and reduced ion leakage which could be responsible for the lower weight loss in plums (Lester and Grusak 1999). Favourable effects of $CaCl_2$ (4–

Received: 23 November, 2010. Accepted: 19 March, 2011.

Original Research Paper

Table 1 Effect of $CaCl_2$ and GA_3 on the physiological loss in weight (PLW) and firmness of guava fruits during storage.

Treatment	PLW, %					Firmness, lb force				
	7	14	21	28	Mean	7	14	21	28	Mean
$CaCl_2$ 1%	0.83	1.66	2.83	3.45	2.19	17.10	16.10	13.10	10.20	14.12
$CaCl_2$ 2%	0.66	2.11	2.50	2.66	1.98	17.40	16.20	13.50	11.10	14.55
$CaCl_2$ 3%	0.83	1.83	2.66	2.87	2.04	17.84	16.80	13.60	10.50	14.68
GA_3 25 ppm	0.83	2.22	2.83	3.44	2.33	16.10	12.10	8.40	6.70	10.82
GA_3 50 ppm	0.66	2.33	2.41	3.54	2.24	16.20	13.10	10.50	7.80	11.90
GA_3 75 ppm	0.66	2.50	3.16	3.66	2.49	16.30	12.10	9.50	6.40	11.07
Control	0.96	2.33	4.83	5.16	3.32	15.30	11.30	7.80	5.50	9.97
Mean	0.78	2.14	3.03	3.54		16.61	13.96	10.91	8.31	
					C.D. (0.05)					
		Treatments = 0.10				0.22				
		Storage = 0.40				0.70				
		Interaction = 0.56				1.26				

Table 2 Effect of $CaCl_2$ and GA_3 on the physiological loss in weight (PLW) and firmness of guava fruits during storage.

Treatment	Spoilage, %					Sensory quality				
	7	14	21	28	Mean	7	14	21	28	Mean
$CaCl_2$ 1%	0.00	7.06	9.10	10.45	6.65	6.13	7.51	7.62	6.24	6.88
$CaCl_2$ 2%	0.00	4.16	7.40	8.71	5.07	6.33	7.52	7.73	6.90	7.12
$CaCl_2$ 3%	0.00	4.16	7.50	8.89	5.14	6.25	7.56	7.86	6.80	7.11
GA_3 25 ppm	0.00	9.01	12.71	18.30	10.00	7.39	7.86	5.53	5.17	6.48
GA_3 50 ppm	0.00	8.33	10.83	19.11	9.57	7.66	7.40	7.32	5.43	6.95
GA_3 75 ppm	0.00	3.71	8.33	18.14	7.54	7.51	7.43	7.30	5.73	6.99
Control	0.00	15.14	22.14	30.41	16.92	7.60	7.95	5.06	3.14	5.94
Mean	0.00	7.37	11.14	16.29		6.98	7.60	6.92	5.63	
					C.D. (0.05)					
		Treatments = 0.12				0.18				
		Storage = 0.49				0.39				
		Interaction = 0.76				0.60				

6%) in reducing PLW has been reported in mango (Mootoo 1991).

Firmness

Fruit firmness, in general, followed a declining trend commensurate with the advancement in storage period (**Table 1**). Fruits treated with $CaCl_2$ maintained higher firmness compared to GA_3 and control at all storage intervals. $CaCl_2$ (2 and 3%)-treated fruits maintained best fruit firmness than control fruits. The fruit treated with $CaCl_2$ (2 and 3%) maintained higher fruit firmness throughout the stipulated storage period of 4 weeks which ranged between 17.40 to 11.10 lb and 17.84 to 10.50 lb, respectively compared to other treatments. On the other hand, control fruits experienced a faster loss of firmness during storage, ranging between 15.30 and 5.50 lb, thereby leading to excessive softening and shrivelling of fruits. Softening of fruits is caused either by a breakdown of insoluble protopectins into soluble pectin or by hydrolysis of starch (Mattoo *et al.* 1975). The desired effect of calcium on maintaining fruit firmness may be due to the binding of calcium to free carboxyl groups of polygalacturonate polymer, stabilizing and strengthening the cell wall (Conway and Sams 1983).The maintenance of higher firmness as a result of $CaCl_2$ may be due to their ability to prevent the physiological weight loss during storage and to inhibit/delay ethylene production and/ or action in different fruits (Mahajan and Dhatt 2004).

Spoilage percentage

The different post-harvest treatments showed wide variation in spoilage percentage during cold storage (**Table 2**). There was no spoilage of fruits till 7 days of storage in any treatment, including the control. The lowest mean cumulative spoilage was recorded in fruits treated with $CaCl_2$ (2%) which was followed by fruits treated with $CaCl_2$ (3%). However, the cumulative spoilage remained at higher levels (16.92%) in control fruits than other treatments. In control fruits the level of spoilage increased from the 2^{nd} week (15.14%) to the 4^{th} week of storage (30.41%) followed by GA_3 treatments. However, the level of spoilage was considerably low in $CaCl_2$ treatments. In general, fruit spoilage decreased with an increase in $CaCl_2$ concentration. The current study demonstrates that the application of $CaCl_2$ has merit in reducing spoilage in guava fruits which may be due to their positive role in delaying the senescence of fruits by maintaining cell wall integrity and thus lowering the spoilage. Beneficial effects of calcium against postharvest decay have been shown for various fruit species (Cheour *et al.* 1990).

Sensory quality

The mean sensory quality score was significantly the highest in fruits treated with $CaCl_2$ (2%) which was closely followed in $CaCl_2$ at 3% (**Table 2**). Control fruits had the lowest score (5.94/9). Initially, the fruits treated with $CaCl_2$ were rated as slightly desirable on the 7^{th} day, thereafter, the organoleptic quality, gradually increased up to 3 weeks and fruits were rated as very to moderately desirable. The fruits remained moderately desirable up to 28 days of storage in $CaCl_2$ (2 and 3%) compared to GA_3 and control treatments. However, control fruits maintained the best organoleptic score (7.95/9) after 14 days of storage and were rated as much desirable; thereafter, a sharp decline in organoleptic score was noticed in the control resulting in fair to poor acceptability of fruits. Calcium chloride (1.0%) was most effective in enhancing the storage life of tomato fruits (Bhattarai and Gautam 2006).

Total soluble solids and total sugars

In $CaCl_2$ treatments the TSS and total sugar content of guava fruits increased slowly and steadily up to 3 weeks of storage and thereafter declined gradually (**Table 3**). On the other hand, in control and GA_3 treatments the TSS and total sugars content increased up to 2 weeks and thereafter a sharp decline was noticed indicating rapid metabolic breakdown in these fruits. The fruit treated with $CaCl_2$ (2%) registered maximum average TSS content (9.99%) and total sugars (6.15%) and this treatment was significantly better

Table 3 Effect of $CaCl_2$ and GA_3 on TSS and total sugars of guava fruits during storage.

Treatment	TSS, %					Total sugars, %				
	7	14	21	28	Mean	7	14	21	28	Mean
$CaCl_2$ 1%	9.14	9.17	10.01	9.89	9.55	5.63	5.91	5.86	5.71	5.78
$CaCl_2$ 2%	9.36	10.13	10.45	10.01	9.99	5.60	5.85	6.93	6.22	6.15
$CaCl_2$ 3%	9.46	9.91	10.66	9.43	9.87	5.66	5.70	6.90	6.30	6.14
GA_3 25 ppm	9.21	10.11	9.11	9.01	9.36	5.40	5.90	5.60	5.45	5.59
GA_3 50 ppm	10.11	11.12	9.11	8.72	9.77	5.40	5.92	5.70	5.50	5.63
GA_3 75 ppm	9.47	10.11	9.55	9.11	9.56	5.46	6.00	5.72	5.60	5.70
Control	10.00	11.05	8.45	7.51	9.25	5.72	6.20	5.20	4.80	5.48
Mean	9.54	10.23	9.62	9.10		5.55	5.93	5.99	5.65	
				C.D. (0.05)						
		Treatments = 0.15				0.09				
		Storage = 0.26				0.16				
		Interaction = 0.52				0.32				

Table 4 Effect of $CaCl_2$ and GA_3 on titratable acidity and ascorbic acid content of guava fruits during storage.

Treatment	Acidity, %					Ascorbic acid, mg/100 g				
	7	14	21	28	Mean	7	14	21	28	Mean
$CaCl_2$ 1%	0.39	0.36	0.33	0.31	0.35	140.10	129.40	121.12	119.14	127.44
$CaCl_2$ 2%	0.41	0.39	0.38	0.36	0.39	142.10	130.20	122.14	119.55	128.50
$CaCl_2$ 3%	0.42	0.40	0.32	0.31	0.36	143.10	128.40	121.14	118.14	127.69
GA_3 25 ppm	0.39	0.32	0.26	0.21	0.30	135.10	124.10	117.14	109.14	121.37
GA_3 50 ppm	0.41	0.37	0.30	0.22	0.33	136.10	127.10	119.15	110.13	123.12
GA_3 75 ppm	0.39	0.35	0.28	0.20	0.31	136.90	126.10	118.13	110.12	122.81
Control	0.36	0.24	0.23	0.20	0.26	126.43	123.30	115.12	106.14	117.75
Mean	0.40	0.35	0.30	0.26		137.12	126.94	119.13	113.19	
				C.D. (0.05)						
		Treatments = 0.04				0.50				
		Storage = 0.07				0.68				
		Interaction = 0.15				0.92				

than other treatments. However, the second best treatment was found to be $CaCl_2$ (3%). The control fruits recorded the lowest average TSS content (9.25%) and total sugars (5.48%). The increase in TSS and sugars during storage may possibly be due to hydrolysis of starch into sugars as on complete hydrolysis of starch no further increase occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al.* 1980). In $CaCl_2$ treated fruits, the increase in TSS and total sugars up to 21 days and gradual declined thereafter compared to GA_3 and control fruits where an increase in TSS and total sugars was noticed up to 14 days and a sharp decline thereafter, indicating the possible role of calcium in delaying the metabolic activity of fruits during storage (Sams and Conway 1984).

Titratable acidity

The acidity of guava fruits experienced a linear decline during the storage period (**Table 4**). However, the loss of acidity during storage was more rapid and faster in control and GA_3-treated fruits, but it was gradual in $CaCl_2$-treated fruits. The lowest mean acid content (0.26%) was noticed in the control whereas the highest mean acid content (0.39%) was observed in fruits treated with $CaCl_2$ (2%) and these treatments were at par with $CaCl_2$ (1 and 3%). The decrease in titratable acids during ripening and storage may be attributed to an increase in malic enzyme and pyruvate decarboxylation reaction during the climacteric period (Rhodes *et al.* 1968). The fruits treated with $CaCl_2$ maintained higher acidity during storage, probably due to a delay in the ripening process (Mahmud *et al.* 2008).

Ascorbic acid

The ascorbic acid content of fruits decreased with the advancement of storage period (**Table 4**). The ascorbic acid content in different treatments varied significantly at all storage intervals. The highest mean ascorbic acid content (128.50 mg/100 g) was recorded in fruits treated with $CaCl_2$ (2%) and the lowest (117.75 mg/100 g) in control fruits. However, in $CaCl_2$ treatments a slower and steadier loss of ascorbic acid content was noticed. Calcium-treated apple has been reported to maintain higher ascorbic acid than the control (Laufmann and Sams 1989).

CONCLUSIONS

Freshly harvested green mature guava fruits treated with calcium chloride (2%) can be stored at 6 ± 1°C and 90-95% RH for 4 weeks with acceptable quality.

REFERENCES

Akamine EK, Goo T (1979) Respiration and ethylene production in fruits of species and cultivars of *Psidium* and species of *Eugenia*. *Journal of the American Society of Horticultural Science* **104**, 632-635

Amerine MA, Pangborn RM, Roessler EB (1965) *Principles of Sensory Evaluation of Food*, Academic Press, London, 5 pp

Anonymous (2008) *Area and Production of Different Fruits in India*, National Horticulture Board, India, www.nhb.gov.in

Anonymous (2011) *Commodity Bulletin for Fruits*, National Horticulture Board, India. Available online: www.nhb.gov.in

AOAC (1990) *Official Methods of Analysis* (12th Edn), Washington, DC, USA

Bhattarai DR, Gautam DM (2006) Effect of harvesting method and calcium on post harvest physiology of tomato. *Nepal Agriculture Research Journal* **7**, 37-41

Cheour F, Wilemot CJ, Arul Y, Desjardins J, Makhlouf PM, Gosselin A (1990) Effects of foliar application of $CaCl_2$ on postharvest strawberry ripening. *Journal of the American Society of Horticultural Science* **115**, 789-792

Conway WS, Sams CE (1983) Calcium infiltration of Golden Delicious apples and its effect on decay. *Phytopathology* **73**, 1068-1071

Gonçalves NB, de Carvalho VD, de Gonçalves JRA (2000) Effect of calcium chloride and hot water treatment on enzyme activity and content of phenolic compounds in pineapple. *Pesquisa Agropecuária Brasileira* **35**, 2075-2081

Laufmann JE, Sams CE (1989) The effect of postharvest calcium treatment on polyphenol oxidase and peroxidases activity in golden delicious apples. *Horticultural Science* **24**, 753-754

Lester GE, Grusak MA (1999) Postharvest application of calcium and magnesium to honeydrew and netter muskmelons: Effects on tissue ion concentrations, quality and senescence. *Journal of American Society of Horticultural Science* **124**, 545-552

Mahajan BVC, Dhatt AS (2004) Studies on postharvest calcium chloride application on storage behaviour and quality of Asian pear during cold storage. *Journal of Food Agriculture* and *Environment* **2 (3-4)**, 152-159

Mahmud TMM, Eryysni-Raqeeb AAl, Sayed Omar SR, Mohmad Zaki AR, Al Eryani AR (2008) Effect of different concentration and application of calcium on storage life and physicochemical characteristics of papaya. *American Journal of Agricultural and Biological Science* **3**, 526-533

Mattoo AK, Murata T, Pantastico EB, Chachiss K, Ogata K, Phan CT (1975) Chemical changes during ripening and senescence. In: Pantastico EB (Ed) *Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables*, The Avi Pub. Co. Inc., pp 103-127

Mootoo A (1991) Effect of postharvest calcium chloride dips on ripening changes in 'Tulie' mangoes. *Tropical Science* **31**, 243-248

Osman HE, Abu-Goukh ABA (2008) Effect of polyethylene film lining and gibberellic acid on quality and shelf-life of banana fruits. *University of Khartoum Journal of Agricultural Sciences* **16 (2)**, 242-261

Pila N, Gol NB, Rao TVR (2010) Effect of post harvest treatments on physicochemical characteristics and shelf life of tomato (*Lycopersicon esculentum* Mill.) fruits during storage. *American-Eurasian Journal of Agricultural and Environmental Sciences* **9 (5)**, 470-479

Rhodes MJC, Woodtorton LSC, Gallard T, Hulme AC (1968) Metabolic changes in excised fruit tissue I. Factors affecting the development of a melate decarboxylation system during the ageing of disc of pre-climacteric apples. *Phytochemistry* **7**, 439

Sams CE, Conway WS (1984) Effect of calcium infiltration on ethylene production, respiration and quality of Golden Delicious apple fruit. *Journal of the American Society of Horticultural Science* **109**, 53-57

Snedecor GW, Cochran WG (1987) *Statistical Methods* (7th Edn), The Iowa State University Press, Ames, IA, USA, pp 221-222

Serrano M, Romero DM, Zuzunaga M, Riquelme F, Valero D (2004) Calcium, polyamine and gibberellin treatments to improve postharvest fruit quality. *Production Practices and Quality Assessment of Food Crops* **4**, 55-58

Wills RBH, Bembridge PA, Scott KJ (1980) Use of flesh firmness and other objective tests to determine consumer acceptability of Delicious apples. *Australian Journal of Experimental Agriculture and Animal Husbandry* **20**, 252-256