J Food Sci Technol (Sept–Oct 2010) 47(5):501–506
DOI 10.1007/s13197-010-0085-2

ORIGINAL ARTICLE

Effect of pre-harvest calcium sprays on post-harvest life of winter guava (*Psidium guajava* L.)

Mandal Goutam · H. S. Dhaliwal · B. V. C. Mahajan

Revised: 17 June 2010 / Accepted: 20 June 2010 / Published online: 22 October 2010
© Association of Food Scientists & Technologists (India) 2010

Abstract Influence of pre-harvest foliar application of calcium nitrate on quality attributes of winter guava cv. 'Sardar' during different interval of cold storage and post cold storage shelf-life under ambient conditions was investigated. Plants were sprayed with calcium nitrate solutions (0.5, 1.0 and 1.5%) at colour break stage of fruit and a fruit with no treatment was control. The fruits were harvested at optimum maturity. Bruise and disease free fruits were packed in corrugated fibre board boxes with newspaper lining and stored at 6–8 °C and 90–95% RH. The fruits were evaluated after 10, 20, 30 and 40 days of storage and during shelf-life at 2 and 4 days interval. Physiological loss in weight and spoilage of fruits increased and firmness, ascorbic acid and acidity decreased continuously during storage. Fruits treated with 1% $Ca(NO_3)_2$ effectively reduced spoilage, maintained higher firmness, total soluble solid and ascorbic acid up to 2 days under ambient conditions after 30 days of cold storage and remained moderately acceptable up to the 40 days of storage.

Keywords Guava · Pre-harvest sprays · Calcium nitrate · Storage · Shelf-life

Guava (*Psidium guajava* L.) is an important fruit crop of India. Due to hardy nature of plant it can withstand adverse climatic conditions and grows under a wide range of soil types from sandy loam to clay loam (Dhaliwal and Singla 2002). It is normally consumed fresh as a dessert fruit, or processed into puree, juice, concentrate, jam, jelly, nectar or syrup (Jagtiani et al. 1988). In India, it is 6th most widely grown fruit, occupying an area of 1.8 lakh ha, with an annual production of 19.8 lakh MT (Anon 2009). There is an increasing demand of fruits for fresh as well as processing purpose in domestic and international markets. The share of the guava fruits, export from India is not enough (0.65%), which can be boosted up with the increasing storability of fruits. Under ambient conditions fruits become overripe and mealy within a week, whereas, in cold storage guava cv. 'Allahabad Safeda' fruits maintained quality up to 15 days at 8–10 °C and 85–90% RH (Tandon et al. 1989). Therefore, it needs immediate marketing and utilization after harvesting. During storage, physico-chemical and biochemical changes affect the final texture and quality of fruits. 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), with calcium having a profound effect on the above changes (Singh and Singh 1999). 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).

Pre-harvest calcium spray is one of the most important practices of new strategies applied in the integrated fruit production systems, improving fruit characteristics and minimizing fungicides sprays towards the end of the harvest period, since they improve fruit resistance to brown rot (Conway et al. 1994). Calcium spray during fruit development provides a safe mode of supplementing endogenous calcium to fresh fruits (Singh et al. 1993; Gerasopoulos et al. 1996; Tzoutzoukou and Bouranis 1997; Raese and Drake 2000).

In guava, there are two crops in a year i.e. rainy and winter crops. The fruits of former have rough fruit surface and are insipid in taste, poor in quality and are infested with

M. Goutam (✉) · H. S. Dhaliwal · B. V. C. Mahajan
Department of Horticulture, Punjab Agricultural University, Ludhiana 141 004, India
e-mail: gouta_2000@yahoo.com

fruit fly. On the other hand, the latter crop fruits are superior in quality, free from fruit fly infestation and fetch higher price as compared to rainy season crops (Lal et al. 2000). Therefore, the present studies were conducted with winter crop to evaluate the influence of pre-harvest foliar application of calcium nitrate on quality attributes of guava fruits during their harvesting and at different intervals of cold storage and post cold storage under ambient conditions.

Materials and methods

Randomly distributed 12 plants of guava cv. 'Sardar' of uniform age, and vigour were selected in the New Orchard of the university (30°55″ N latitude, 75°54″ E longitude and at an altitude of 247 metres msl). The plants were kept under recommended schedule of fertilizer, irrigation and same phytosanitory treatments for insect pest control (Anon 2006).

The selected plants were sprayed with $Ca(NO_3)_2$ solutions at the concentration of 0.5, 1.0 and 1.5% at colour break stage (15 days before harvest) of fruit during first week of December (2006 and 2007) and control (without any treatment). The sprays were conducted until total saturation of foliage. The experimental plants were also sprayed with 0.1% Bavistin to protect the fruits against storage rots. There were 3 plants for each treatment comprising single plant for each replication.

Fruits from experimental plants were harvested during third week of December at the optimum horticultural maturity. The bruised and diseased fruits were sorted out and only healthy and blemish free fruits were selected. The fruits (2 kg) were packed in 5 ply corrugated fibre board (CFB) boxes (5% ventilations) with newspaper lining. The fruits were kept in cold storage (6–8 °C, 90–95% RH). The fruits were taken out from the cold storage at 10, 20, 30 and 40 days after storage and kept under ambient conditions (12–15 °C, 70–75% RH) for shelf-life (post-cold storage) studies and analyses were done after 2 and 4 days.

The physiological loss in weight (PLW) of the fruit was determined with formula given by Srivastava and Tandon (1968) on the basis of initial weight of the fruit and loss in weight that occurred and were expressed in percent. Fruit firmness of flesh was measured on two paired sides of fruits with the help of 'Penetrometer' (Model FT-327, QA Supplies, Norfolk, VA, USA) after removing about 1 cm^2 peel on both sides of the fruits. The pressure required to force a stainless steel probe of 8 mm in diameter into guava flesh was recorded. It was measured in terms of kg/cm^2 force. Palatability rating was determined on the basis of colour and taste of fruits by a panel of 5 judges as per Hedonic scale (1–9 points) as described by Amerine et al. (1965). Spoilage was assayed by counting number of fruits get spoiled and/or display fungal mycelia or sporulation and is expressed as per cent spoilage of fruits. Total soluble solids (TSS) content was determined with the help of an Erma hand refractometer, Japan and expressed in per cent after making the temperature correction at 20 °C. Ascorbic acid and titratable acidity were estimated by the method described by AOAC (2000).

Statistical analysis The experiment was laid out in a completely randomized block design with 3 replications. The data was analysed as per the method of Panse and Sukhatme (1985). Least significant difference at 5% level was used for finding the significant differences among the treatment means.

Results and discussion

PLW The fruits treated with 0.5% $Ca(NO_3)_2$ recorded minimum PLW (0.68%) after 10 days of cold storage, while the highest PLW (5.8%) was found in control on 4 days of shelf-life after 40 days of cold storage (Table 1). The higher PLW in untreated fruits during storage and shelf-life might be due to the upsurge in respiration rate and transpiration processes compared to calcium treated fruits. These results are in agreement with the findings of Chandra et al. (1999), Selvan and Bal (2005) in guava and Singh et al. (2008) in ber fruits.

Firmness Fruits treated with 1.5% $Ca(NO_3)_2$ recorded highest fruit firmness throughout the storage. Control fruits experienced faster loss of firmness during storage thereby leading to excessive softening and shriveling of fruits (Table 1). The maintenance of higher firmness in guava fruits due to calcium compounds might be due to thickening of middle lamella of fruit cells owing to increased formation of deposition of calcium pectate (Gupta et al. 1984). Calcium nitrate has been found to be effective in increasing the firmness of fruits by delaying senescence, preserving cellular organization and retarding respiration rate (Faust and Shear 1972). These results are in agreement with those of Selvan and Bal (2005) in guava and Martinsson et al. (2006) in strawberry.

Palatability rating The palatability rating of guava fruits increased in all calcium treated fruits up to 20 days of cold storage and 2nd day of shelf-life after 10 days of storage, thereafter gradual declined the acceptability (Table 1). The control fruits recorded lowest score throughout the storage except after 10 days of storage. The fruits treated with 1.5%

Table 1 Physical characteristics of guava fruits cv. 'Sardar' in relation to pre-harvest sprays of calcium nitrate and storage periods.

$Ca(NO_3)_2$, %	Storage period, days (cold storage+ shelf-life)												CD (p>0.05)
	10+0	10+2	10+4	20+0	20+2	20+4	30+0	30+2	30+4	40+0	40+2	40+4	
Physiological loss in wt, %													
0.5	0.68	2.2	4.4	1.8	3.4	4.5	2.4	4.0	4.7	3.1	4.2	5.2	A=0.06
1.0	0.73	2.1	4.3	1.9	3.1	4.4	2.1	3.9	4.6	2.8	4.3	5.4	B=0.05
1.5	0.74	2.1	4.3	2.0	3.5	4.5	2.2	3.8	4.9	3.1	4.6	5.4	C=0.06
0	1.0	2.7	4.5	1.9	3.8	5.2	2.9	4.3	5.3	4.7	5.0	5.8	ABC=0.19
Spoilage, %													
0.5	0	0	5.7	5.5	7.4	11.8	10.8	10.4	16.3	12.7	15.9	23.4	A=0.13
1.0	0	0	5.8	5.6	7.2	12.0	10.2	10.3	16.1	13.1	15.6	24.6	B=0.11
1.5	0	0	6.0	5.7	7.5	12.0	11.5	10.6	15.9	13.4	16.5	23.6	C=0.13
0	0	0	6.8	7.7	11.7	15.5	17.6	16.4	20.7	20.0	20.8	29.7	ABC=NS
Firmness, kg/cm^2													
0.5	6.1	4.6	3.3	5.4	4.1	3.3	4.4	4.1	3.3	3.2	2.2	1.3	A=0.25
1.0	6.3	4.8	3.7	5.5	4.3	3.5	4.5	4.3	3.4	3.3	2.4	1.3	B=0.21
1.5	6.5	5.3	4.4	5.7	4.5	3.8	4.8	4.4	3.6	3.5	2.6	1.4	C=0.25
0	5.8	4.0	3.2	4.6	3.1	2.2	3.6	2.5	1.9	2.2	0.9	0.4	ABC=NS
Palatability rating													
0.5	7.2	7.4	7.4	6.8	6.8	5.4	7.2	6.6	5.8	6.0	5.6	4.2	A=0.0.54
1.0	7.6	7.8	6.4	7.4	7.0	5.8	7.4	6.2	6.0	6.0	5.8	3.8	B=0.47
1.5	7.2	8.0	6.4	7.4	6.4	5.8	6.6	6.4	5.8	5.8	5.6	3.6	C=0.54
0	7.4	6.6	5.2	6.6	6.0	4.8	4.6	4.4	4.2	4.4	4.0	2.0	ABC=NS

A = cold storage period, B = Shelf-life, C = Treatment, n=3

$Ca(NO_3)_2$ recorded highest score (8) and rated as very much desirable. Fruits treated with $Ca(NO_3)_2$ were rated as moderately desirable up to 2nd day in shelf-life after 30 days of storage in all the treatments, whereas 1% $Ca(NO_3)_2$ treated fruits maintained the palatability rating up to 40 days of storage. The improvement of palatability rating in fruits during storage might be due to the build up of sugars and acids as a result of hydrolysis of starch and other complex molecules leading to development of flavour in fruits. Singh (1988) and Singh et al. (2007) also found that calcium nitrate treated guava fruits rated higher score and optimum marketable quality for longer period.

Spoilage The spoilage of guava fruits started on 4th day of shelf-life after 10 days of cold storage in all the treatments including control, the lowest spoilage (5.7%) was in fruits treated with 0.5% $Ca(NO_3)_2$ (Table 1). The control fruits showed highest spoilage throughout the storage period. The average lowest spoilage (10%) was recorded up to 4 days in shelf-life after 40 days of cold storage in 0.5% $Ca(NO_3)_2$ treated fruits, which was at par with 1% $Ca(NO_3)_2$ treated fruits. Data revealed an extension of shelf-life for 2 days under ambient conditions after 30 days of cold storage with minimum spoilage (10.3%) by 1% $Ca(NO_3)_2$ treatment which leads to economical and effective for storage of guava fruits. Gupta et al. (1984) reported that calcium compounds significantly thickened the middle lamella of fruit cells owing to increased deposition of calcium pectate and thereby maintained the cell wall, which inhibits the penetration and spread of pathogens in fruits ultimately reducing the spoilage percentage of fruits. Similar observations were made by Hiwale and Singh (2003), and Selvan and Bal (2005) in guava fruits and Singh et al. (2008) in ber fruits.

TSS In all the treatments, TSS content increased slowly and steadily up to 20 days of cold storage and up to 2 days in shelf-life after 10 days of storage, thereafter declined slowly (Table 2). 0.5% $Ca(NO_3)_2$ treated fruits recorded highest TSS (12.7%) after 20 days of storage, while in 1% $Ca(NO_3)_2$ treated fruits the highest TSS (11.9%) was found during shelf-life after 10 days of cold storage, thereafter declined gradually to 10% after 40 days of storage. In control, a sharp decline was noticed in different storage interval and shelf-life indicating rapid metabolic breakdown in these fruits. The increase in TSS

Table 2 Chemical quality attributes of guava fruits cv. 'Sardar' pre-harvest sprayed with calcium nitrate and storage periods

$Ca(NO_3)_2$, %	Storage period, days (cold storage+ shelf-life)												CD ($p>0.05$)
	10+0	10+2	10+4	20+0	20+2	20+4	30+0	30+2	30+4	40+0	40+2	40+4	
Total Soluble Solids, %													
0.5	11.9	12.4	11.3	12.7	10.9	9.8	11.3	10.3	9.9	10.0	9.8	9.3	A=0.13
1.0	11.8	12.5	11.4	12.4	11.0	10.0	11.5	10.6	10.0	10.3	10.2	9.4	B=0.11
1.5	11.7	12.3	11.1	12.6	11.0	9.9	11.4	10.5	9.7	10.2	10.0	9.8	C=0.13
0	11.0	11.4	9.4	12.4	9.5	9.1	9.9	9.3	8.6	9.4	9.2	8.3	ABC=45
Ascorbic acid, mg/100 g													
0.5	225.4	199.2	173.4	203.9	176.0	156.5	196.4	160.9	139.9	164.8	141.6	120.7	A=2.77
1.0	229.8	204.8	178.1	209.3	179.7	158.8	201.9	166.3	140.8	171.8	144.8	124.8	B=2.40
1.5	227.2	203.8	169.6	210.1	174.0	157.6	205.9	163.3	143.4	167.9	147.9	129.1	C=2.77
0	219.9	195.9	189.8	197.3	163.8	142.1	172.3	132.0	122.2	144.5	119.7	107.4	ABC=NS
Titratable acidity, %													
0.5	0.55	0.43	0.34	0.49	0.35	0.32	0.33	0.30	0.29	0.31	0.28	0.28	A=0.012
1.0	0.53	0.44	0.33	0.51	0.34	0.33	0.34	0.32	0.31	0.32	0.30	0.28	B=0.011
1.5	0.55	0.42	0.33	0.53	0.36	0.34	0.36	0.30	0.30	0.34	0.30	0.29	C=0.012
0	0.48	0.36	0.29	0.41	0.32	0.26	0.27	0.27	0.26	0.26	0.26	0.25	ABC=NS

A = cold storage period, B = Shelf-life, C = Treatment, $n=3$

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 TSS is predictable as they along with other organic acids are primarily substrate for respiration (Wills et al. 1980). Higher TSS level was retained by 1.5% $Ca(NO_3)_2$ treated fruits during storage and shelf-life. This was due to the role of $Ca(NO_3)_2$ in maintaining the lowest metabolic activity during storage of fruits. Similar results were reported by Singh and Chauhan (1982), Selvan and Bal (2005) in guava and Mahajan and Dhatt (2004) in pear.

Ascorbic acid Ascorbic acid content of guava fruits decreased during storage period (Table 2). During storage, oxidizing enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase might be causing decrease in ascorbic acid content of fruits (Mapson 1970; Singh et al. 2005). Activities of oxidizing enzymes might be reduced in 1% $Ca(NO_3)_2$ treated fruits resulting in higher ascorbic acid content during the shelf-life and storage of fruits. This finding is in agreement with those of Singh (1988), Ahmed and Singh (2000) and Singh et al. (2008) in guava, mango and ber fruits, respectively.

Titratable acidity A declining trend in titratable acidity during storage was noticed and it was observed that in all the treatments the acidity was higher than the control (Table 2). In 1.5% $Ca(NO_3)_2$ treated fruits, highest average acidity in post cold storage at ambient conditions was recorded (Table 2). The fruits treated with $Ca(NO_3)_2$ maintained higher acidity during storage probably due to delay in ripening process and low respiration rate. The decrease in titratable acids during storage may be due to marked increase in malic enzyme and pyruvate decarboxylation reaction during the climacteric period (Rhodes et al. 1968; Pool et al. 1972), commensurate with an increase in the rate of respiration and other biodegradable metabolic reaction. The calcium treated fruits could maintain a higher acidity during the storage and shelf-life. It might be due to reduced respiration rate. Similar findings have been reported by Singh et al. (2005), (Navjot 2006) and Killadi et al. (2007) in aonla, peach and guava fruits, respectively.

Conclusion

On the basis of spoilage, palatability rating and other quality attributes, it might be concluded that guava fruits treated with 1% $Ca(NO_3)_2$, 15 days before as pre-harvest spray along with 0.1% Bavistin and kept in news paper lined CFB boxes (with 5% ventilation) was most efficient to retain the fruit quality attributes up to 2 days of shelf-life under ambient conditions (12–15 °C, 70–75% RH) after 30 days of cold storage at 6–8 °C and 90–95% RH.

References

Ahmed MS, Singh S (2000) Studies on extension of storage life of 'Amrapali' mango. Orissa J Hort 28:73–76

Amerine MA, Pangborn RM, Roessler EB (1965) Principles of sensory evaluation of food. Academic, London, p 5

Anon (2006) Package of practices for cultivation of fruit crops. Punjab Agricultural University, Ludhiana

Anon (2009) Indian horticulture data base-2008. National Horticulture Board, Gurgaon, India

AOAC (2000) Official methods of analysis, 17th edn. Association of Official Analytical Chemists, Washington DC

Brummell DA, Dal Cin V, Crisosoto CH, Labavitch JM (2004) Cell wall metabolism during maturation, ripening and senescence of peach fruit. J Exp Bot 55:2029–2039

Chandra R, Gupta PN, Rajput CBS (1999) Influence of pre-harvest application of calcium and alar on post-harvest changes in cv. 'Sardar' guava fruits. Trop Agr 76:70–73

Conway WS, Sams CE, Kelman A (1994) Enhancing the natural resistance of plant tissue to post-harvest diseases through calcium applications. HortSci 29:751–754

Dhaliwal GS, Singla R (2002) Studies on the time of anthesis and dehiscence in different genotypes of guava in winter and rainy season crops. Indian J Hort 59:157–161

Faust M, Shear CB (1972) The effect of calcium on respiration of apples. J Am Soc Hort Sci 97:437–439

Fry SC (2004) Primary cell wall metabolism: tracking the carriers of wall polymers in living cells. New Phytol 161:641–675

Gerasopoulos D, Chouliaras V, Lionakis S (1996) Effect of pre-harvest calcium chloride spray on maturity and storability of Hayward kiwifruit. Postharvest Biol Technol 7:65–72

Gupta OP, Singh BP, Singh SP, Chauhan KS (1984) Effect of calcium compounds as pre-harvest spray on the shelf-life of peach cv. 'Sharbati'. Punjab Hort J 24:105–110

Hiwale SS, Singh SP (2003) Prolonging the shelf-life of guava (*Psidium guajava* L.). Indian J Hort 60:1–9

Jagtiani J, Chan HT Jr, Sakai WS (1988) Tropical fruit processing. Academic Press Inc., New York, pp 9–43

Killadi B, Singh MD, Singh BP, Singh RA (2007) Shelf-life evaluation of guava (*Psidium guajava* L.) cultivars. Acta Hort 735:603–607

Lal S, Tiwari JP, Misra KK (2000) Effect of plant spacing and pruning intensity on fruit yield and quality of guava. Prog Hort 32:20–25

Mahajan BVC, Dhatt AS (2004) Studies on post-harvest calcium chloride application on storage behaviour and quality of Asian pear during cold storage. J Food Agric Environ 2:152–159

Mapson CW (1970) Vitamins in fruits: Stability of L-ascorbic acid. In: Biochemistry of fruits and their products. Academic Press, London, pp 376–387

Martinsson M, Kwast A, Cieslinski G, Treder W (2006) Impact of production systems and fertilizer application on yield and quality of strawberries. Acta Hort 708:59–64

Navjot GS (2006) Studies on storage behaviour of peach cv. 'Earli Grande'. Int J Agric Sci 2:541–543

Panse VG, Sukhatme PV (1985) Statistical methods for agricultural workers, 4th edn. Indian Council of Agricultural Research, New Delhi

Pool KM, Weaver RJ, Kliewer KM (1972) The effect of growth regulators on changes in fruits of 'Thompson Seedless' during cold storage. J Am Soc Hort Sci 97:67–70

Raese JT, Drake SR (2000) Effect of calcium sprays, time of harvest, cold storage, and ripeness on fruit quality of 'Anjou' pears. J Plant Nutr 23:843–853

Rhodes MJC, Woodtorton LSC, Gallard T, Hulme AC (1968) Metabolic changes in excised fruit tissue I. Factor affecting the development of a malate decarboxylation system during the ageing of disc of pre-climecteric apples. Phytochem 7:271–276

Selvan MT, Bal JS (2005) Effect of different treatments on the shelf-life of 'Sardar' guava during cold storage. J Res Punjab Agric Univ 42:28–33

Singh G (1988) Effect of calcium nitrate and plant growth regulators on the storage of 'Allahabad Safeda' guava. Indian J Hort 45:45–50

Singh K, Chauhan KS (1982) Effect of pre-harvest application of calcium, potassium and Alar on fruit quality and storage life of guava fruits. Haryana Agric Univ J Res 12:649–654

Singh JP, Singh SP (1999) Effect of pre-harvest spray of calcium nitrate on shelf-life of guava (*Psidium guajava* L.) fruits cv. 'Allahabad Safeda'. J Appl Biol 9:149–152

Singh RP, Tandon DK, Kalra SK (1993) Change in post-harvest quality of mangoes affected by pre-harvest application of calcium salts. Sci Hort 54:211–219

Singh S, Singh AK, Joshi HK (2005) Prolong storability of Indian gooseberry (*Emblica officinalis* Gaertn.) under semiarid eco-system of Gujarat. Indian J Agric Sci 75:647–650

Singh R, Chaturvedi OP, Guar GS, Singh G (2007) Effect of pre-harvest spray of zinc, calcium and boron on the storage behaviour of guava (*Psidium guajava* L.) fruits cv. 'Allahabad Safeda'. Acta Hort 735:633–638

Singh S, Singh AK, Joshi HK, Bagle BG, Dhandar DG (2008) Storability of ber (*Zizyphus mauritiana* Lamk) fruit in semi arid environment. J Food Sci Technol 45:65–69

Srivastava MP, Tandon RN (1968) Influence of temperature on *Botryodiplodia* rot of citrus and sapota. Indian Phytopathol 21:195–207

Tandon DK, Singh BP, Kalra SK (1989) Storage behaviour of specific gravity graded guava fruits. Scientia Hort 41:35–41

Tzoutzoukou CG, Bouranis DI (1997) Effect of pre-harvest application of calcium on apricot fruit. J Plant Nutr 20:295–309

Wills RBH, Bembridge PA, Scott KJ (1980) Use of flesh firmness and other objective tests to determine consumer acceptability of 'Delicious' apples. Aust J Exp Agric Anim 20:252–256