Journal of Horticultural Science and Technology 4(1): 1-6 (2021)
ISSN: 2617-3220 (Print), 2664-9489 (Online)
https://doi.org/10.46653/jhst2141001

Original Research

Postharvest Calcium Chloride Application Maintains Shelf Life and Quality of Loquat (*Eriobotrya japonica* L.) Fruit

Shaukat Hussain[a], Zahoor Hussain*[a,b], Faheem Khadija[c], Muhammad Raza Salik[c], Mujahid Ali[a], Akbar Hayat[c] and Ghulam Mustafa[d]

[a] College of Agriculture, University of Sargodha, Pakistan
[b] Department of Horticulture, Ghazi University, Dera Ghazi Khan, Pakistan
[c] Citrus Research Institute, Sargodha, Pakistan
[d] Mango Research Institute, Multan, Pakistan

ABSTRACT

Loquat (*Eriobotrya japonica* L.) is an important sub-tropical fruit with very limited postharvest life. Therefore, in the current study, we investigated the effect of calcium chloride ($CaCl_2$) treatments on the shelf life and quality of loquat fruit. After harvest loquat fruit treated with different concentrations of $CaCl_2$ *viz.* 2%, 4% and 6% for 2 min were kept at room temperature (30±2°C) for 5 and 10 days. Untreated fruit were kept as control. The results showed that fruit treated with 6% $CaCl_2$ exhibited minimum fruit weight loss (9.1%), external browning (8.83%), and internal browning (9.1%) after 10 days shelf period in contrast with control fruit. Lowest total soluble solids contents (9.11%), highest titratable acidity (0.53%) and juice (28%) contents were found in fruit treated with 6% $CalCl_2$ as compared to other treatments. In conclusion, among the tested treatments, application of highest level of $CaCl_2$ (6%) effectively maintained the quality of loquat fruit a room temperature.

Keywords: *Calcium chloride, external browning, internal browning, loquat, total soluble solids.*

Article History: *Received 25 February 2021; Revised 24 March 2021; Accepted 25 March 2021; Published 31 March 2021.*

INTRODUCTION

Loquat is a very famous member of the family Rosaceae (Ghasemnezhad et al., 2010) has been classified as non-climacteric fruit (Blumenfeld, 1980). It was originated from China where its cultivation had been reported about 2000 years back (Lin et al., 1999). At present, it is being cultivated commercially in more than 30 countries of the world (Feng et al., 2007). Being an important fruit of Pakistan, it is cultivated in *Khyber Pakhtunkhwa* and Punjab provinces at commercial scale (Hussain et al., 2007). Loquat fruit contain almost every type of the essential nutrients required for the human health and development. Particularly it is considered as rich source of minerals (phosphorus and calcium), vitamins (A, B and C), salts and carotenoids (Lin et al., 1999).

Loquat exhibits very limited shelf life as fruits start to decay quickly after harvest with substantial reduction in taste, titratable acidity, Juice percentage and increase in internal browning (Lin et al., 1999). Calcium is a vital component of fruit tissues which plays key function in conserving their postharvest quality by maintaining cellular films and suspending senescence. Postharvest use of calcium maintains cell wall, cell turgor, membrane reliability and tissue firmness (Rizk-Alla and Meshreki, 2006). It has been examined that the postharvest treatment of calcium can maintain the fruit quality, inhibit physiological disorders, decrease the rate of respiration, and slow down ripening processes in many fruits especially apple, melons, tomato, and peach (Lester and Grusak, 2004; Burns and Pressey, 1987). Calcium has been found to inhibit postharvest disorders, prevent fruit softening, and cause significant reduction in postharvest fruit weight loss and deterioration (Lara et al., 2004; Lester and Grusak, 2004; Hernandez-Munoz et al., 2006). Similarly, calcium chloride ($CaCl_2$) application reduces physiological processes such as ethylene production, respiration rate and deterioration (Ali et al., 2013; Lester and Grusak, 2004; Mahajan and Sharma, 2000). Babu et al. (2015) found that 3% $CaCl_2$ application significantly extends the shelf-life of loquat by reducing weight loss (%) and maintaining firmness and vitamin C contents.

Use of calcium to improve postharvest quality of perishable horticulture commodities in well documented in literature with varying responses. Particularly it has been reported that calcium (1%) significantly increases the resistance against fungal diseases as well as maintain the cell walls structural integrity in strawberry (Lara et al., 2004) and kiwi fruit (Gerasopoulos and Drogoudi, 2005), custard apple (Jaishankar et al., 2018), pear

* Corresponding author
Email: zahoor.hussain@uos.edu.pk (Z. Hussain)

(Mahajan and Dhatt, 2014) and Loquat (Akhtar et al., 2010) fruits. However, loquat is an important minor fruit of Pakistan and very limited research work has been carried out on its shelf-life extension and quality management. Therefore, it was hypothesized that the application of $CaCl_2$ will maintained firmness, total soluble solids, acidity and reduce browning index and weight loss of loquat fruit kept at ambient conditions.

MATERIALS AND METHODS

The experiment was conducted in the Laboratory of Horticulture Department, University College of Agriculture Sargodha, Punjab, Pakistan. Mature fruits were harvested at commercial maturity (°Brix > 10) with the help of sharp secateurs from the plants grown in the Research Area of the Department. Fruits were dipped in the respective solutions of $CaCl_2$ (0, 2%, 4% and 4%) for 2 min and then kept at room temperature (30±2°C) for 5 and 10 days. Fifteen fruits were used as experimental unit replicated thrice. Following aspects were studied in the experiment.

Weight loss

Fruit weight of each sample was measured (g) by using digital electronic balance (A and D Limited, Tokyo, Japan). Weight loss was calculated by using the following formula: Weight loss (%) = [(A−B)/A] x 100, Where A indicates the fruit weight at the time of harvest and B indicates the fruit weight after shelf period.

Fruit diameter

Fruit diameter (mm) of each sample was measured in mm around the fruit radius by using vernier caliper. Fruit diameter reduction was determined by the following formula: Diameter reduction = Diameter at harvest – diameter after shelf period.

External browning index

External browning index was assessed method described earlier by Wang et al. (2005) after 5 and 10 days of shelf interval. Fruit out skin tissues were assessed on the following scale: 0= no browning; 1=less than ¼ browning; 2= ¼ to ½ browning; 3= ½ to ¾ browning; 4= more than ¾ browning. The browning index was calculated using the following formula:

Browning Index = [(1 x N1 + 2 x N2 + 3 x N3 + 4 x N4) / (4 X N)] x 100

Where N = total number of fruits observed and N1, N2, N3 and N4 were the number of fruits which were scored in each degrees of browning.

Internal browning index

Internal browning index of loquat fruit pulp tissues were noted in the same manner as external browning index.

Firmness

Fruit firmness was determined by means of digital fruit-firmness tester (53205, TR di Turoni, Forli, Italy), equipped with 8 mm plunger tip. Firmness was measured as the maximum force required to penetrate the plunger tip and value was expressed as force (N).

Juice percentage

Juice of each fruit was extracted manually and sieved to get a clear juice. Juice weight was measured (g) by using digital electric balance (A and D Limited, Tokyo, Japan) Juice percentage was determined by the following formula:
Juice % = juice weight / fruit weight x 100

pH of fresh juice

The pH of the juice was measured with the help of digital pH meter (HANA 8520, Italy) using 20 mL clear juice taken in 100 mL beaker.

Total soluble solids

Total soluble solids (TSS) contents of each fruit were measured by using digital refractometer (ATAGO, RX 5000). To calculate the amount of TSS, fruit juice was extracted, and 1-2 drops of juice were placed on refractometer lens. Reading was noted down in percentage (%).

Titratable acidity

Titratable acidity was calculated by using the formula

$$\text{Titratable acidity} = \frac{(\text{meq factor})\times(\text{volume of titrant})\times(\text{volume of NaOH})\times(100)}{(\text{mL of juice}\times\text{volume of aliquot})}$$

Where,
milli-equivalent weight of citric acid = 0.0064
Total volume (mL) = 30
Extract juice sample (mL) = 10
Volume of aliquot (mL) = 5

Juice sample (10 mL) of each replicate taken in a glass beaker was mixed with 20 mL distilled water (DW). Then 5 mL aliquot taken in a conical flask was titrated against NaOH (0.1 N) till end point (permanent light pink) using few drops of phenolphthalein indicator.

Statistical analysis

The experimental design was laid out according to completely randomized design (CRD) with two factors (treatment and shelf period in days). The impacts of different $CaCl_2$ treatments, shelf period in days were evaluated using least significant difference (LSD) test at 5% probability level by using Windows-based software Statistix 8.1.

RESULTS

Weight loss

All the treatments of $CaCl_2$ significantly affected the weight loss of loquat fruit (Table 1). Fruit treated with 6% $CaCl_2$ exhibited minimum fruit weight loss (6.40%) followed by 4% $CaCl_2$

Table 1: Impact of calcium chloride ($CaCl_2$) on weight loss and diameter reduction of loquat fruit during storage.

Treatments	Fruit weight loss (g)			Fruit diameter reduction (mm)		
	Shelf period (Days)			Shelf period (Days)		
	5	10	Mean	5	10	Mean
Control	29.53a	32.49a	31.01A	30.12a	28.01a	29.06A
2% $CaCl_2$	19.94abc	22.39ab	21.17B	23.50ab	20.66bc	22.08B
4% $CaCl_2$	13.00bcd	16.34bcd	14.67BC	18.82bcd	14.15cde	16.49C
6% $CaCl_2$	6.40d	9.08cd	7.74C	11.77de	10.00e	10.89D
Mean	17.22A	20.08A		21.05A	18.20B	
LSD ($P \leq 0.05$)						
Treatments (T)	0.001			0.001		
Shelf period (SP)	NS			0.01		
T x SP	NS			NS		

n = 45 (15 fruits x 3 replicates). Any two means in column or a row followed by different letters are significantly different. NS = not significant, T = Treatment, SP = shelf period.

application (13%) and 2% $CaCl_2$ application (19.94%). However, maximum fruit weight loss was observed (29.53%) in untreated control after day 5 of shelf period. Among other levels, applications of 4% $CaCl_2$ was more effective (13%) than 2% $CaCl_2$ (19.94%) up to day 5 of shelf period. After 10 days of shelf period minimum fruit weight loss (9.08%) was observed in 6% $CaCl_2$ treated loquat fruit, while maximum fruit weight loss (32.49%) was recorded in untreated fruit (Table 1). On an average it was also observed that the loquat fruit exhibited less fruit weight loss up to 5 days of shelf period (17.22%) as compare to kept them for 10 days (20.08%) at ambient conditions.

Fruit diameter reduction

Postharvest $CaCl_2$ application significantly slow down the reduction in diameter of loquat fruit (Table 1). However, minimum loquat fruit diameter reduction was observed (11.76 mm) in 6% $CaCl_2$ treatment, while maximum fruit diameter reduction was observed in control fruit after 5 days of shelf period (Table 1). Similar trend was observed after 10 days of shelf period. In general, the higher reduction in fruit diameter was recorded after 10 days intervals (18.20 mm) compared with 5 days intervals (21.05 mm). The interaction between treatments and shelf period in days was found non-significant ($P \leq 0.05$) for fruit diameter reduction.

External browning Index

Results indicated that among treatments, application of 6% $CaCl_2$ was more efficient in reducing external browning index in loquat fruit than other two levels (2%, and 4% $CaCl_2$) as well as untreated control fruit. However, maximum external browning of loquat fruit was observed (19.21%) in control while minimum fruit level was recorded in fruit (8%) treated with 6% $CaCl_2$ (6%) after 5 days of shelf period. Whereas loquat fruit treated with 2% and 4% $CaCl_2$ exhibited 16.47% and 11.86% external fruit browning after 5 days of shelf period, respectively (Table 2). After 10 days of shelf period minimum external browning (8.83%) was observed in loquat fruit treated with 6% $CaCl_2$ while maximum external browning (16.66%) was observed in control fruit. The interactive effect of treatments with shelf period (days) did not show any significant influence on the changes in the external browning of loquat fruit.

Internal browning Index

Irrespective of shelf period in days postharvest application of various level of $CaCl_2$ significantly reduced the internal browning in loquat fruit (Table 2). Application of 6% $CaCl_2$ was more effective than other two levels (2% and 4% $CaCl_2$), in reduction of internal browning of fruit. After 5 days of shelf period maximum fruit internal browning was observed (17.05%) in untreated control fruit control; while minimum fruit internal browning of loquat was recorded in fruit (7.13%)

Table 2: Impact of calcium chloride ($CaCl_2$) on firmness, external and internal browning of loquat fruit during storage.

Treatments	External browning index (%)			Internal browning index (%)			Fruit firmness (N)		
	Shelf period (Days)			Shelf period (Days)			Shelf period (Days)		
	5	10	Mean	5	10	Mean	5	10	Mean
Control	19.21a	16.66a	17.93A	17.05a	15.13ab	16.09A	1.07c	1.02c	1.05C
2% $CaCl_2$	16.47a	16.86a	16.66AB	14.73ab	15.12ab	14.93A	1.42c	1.36c	1.39C
4% $CaCl_2$	11.86ab	14.11ab	12.99B	10.07bc	11.92abc	10.99B	2.36b	2.15b	2.25B
6% $CaCl_2$	8.00b	8.83b	8.42C	7.13c	9.44bc	8.28B	3.31a	3.20a	3.25A
Mean	13.88A	14.11A		12.24A	12.90 A		2.04 A	1.94A	
LSD ($P \leq 0.05$)									
Treatments (T)	0.001			0.001			0.001		
Shelf period (SP)	NS			NS			NS		
T x SP	NS			NS			NS		

n = 45 (15 fruits x 3 replicates). Any two means in column or a row followed by different letters are significantly different. NS = not significant, T = Treatment, SP = shelf period.

Table 3: Impact of calcium chloride ($CaCl_2$) on total soluble solid and titratable acidity of loquat fruit during storage.

Treatments	Total soluble solids (%)			Titratable acidity (%)		
	Shelf period (Days)			Shelf period (Days)		
	5	10	Mean	5	10	Mean
Control	15.25ab	16.07a	15.66A	0.31c	0.29c	0.30C
2% $CaCl_2$	12.02bcd	13.80abc	12.91B	0.37bc	0.34bc	0.35 BC
4% $CaCl_2$	9.92de	11.07cde	10.50C	0.45abc	0.41abc	0.43B
6% $CaCl_2$	7.77e	9.11de	8.44C	0.59a	0.52ab	0.55A
Mean	11.24B	12.51A		0.43A	0.39A	
LSD ($P \leq 0.05$)						
Treatments (T)	0.00			0.00		
Shelf period (SP)	0.02			NS		
T x SP	NS			NS		

n = 3 replicates. Any two means in column or a row followed by different letters are significantly different. NS = not significant, T = Treatment, SP = shelf period.

treated with 6% $CaCl_2$. Similar results were also observed after 10 days of shelf period, where minimum internal browning (9.44%) of fruit was observed in 6% $CaCl_2$ treatment, while maximum internal browning (15.13%) was observed in control fruit. In general, the higher internal browning of fruit was recorded at 10 day of shelf period (12.90%) compared with 5 days (12.24%) (Table 2). The interaction between treatments and shelf period in days was found non-significant for fruit internal browning index.

Firmness

The results showed that irrespective of shelf period in days, 6% $CaCl_2$ application was more effective among all the treatments to maintain fruit firmness at higher level (Table 2). Maximum fruit firmness (3.31 N) was observed in 6% $CaCl_2$ treatment, while minimum fruit firmness was observed (1.08 N) in untreated control fruit after 5 days of shelf period. Similar results were also observed after 10 days of shelf period, where 6% $CaCl_2$ treated fruit exhibited highest level of fruit firmness as compared to other levels of $CaCl_2$ and untreated control fruit. Independent effect of shelf period and interactive effect of treatments and shelf period showed non-significant differences for changes in fruit firmness.

Total soluble solids

The results showed that after 5 days of shelf period minimum TSS (7.77%) contents were recorded in the juice of loquat fruit treated with 6% $CaCl_2$ followed by the 4% $CaCl_2$ (9.92%) and 2% $CaCl_2$ (12.02%) treatments (Table 3). Similarly, after 10 days of shelf period, minimum TSS (9.11%) of loquat fruit was observed in 6% $CaCl_2$ treated fruit as compared to control fruit (16.07%). In general, the highest TSS of loquat fruit was recorded after 10 days shelf period (12.51%) compared with 5 days shelf intervals (11.24%). The interaction between treatments and intervals as well as storage intervals was found non-significant for changes in TSS.

Acidity

The treatment of $CaCl_2$ has valuable effect on acidity of loquat fruit. The treatment of loquat fruit with highest level of $CaCl_2$ (6%) was more effective than lower levels (2% and 4% $CaCl_2$) and untreated control fruit. After 5 days of shelf period, minimum fruit acidity was observed (0.31%) in control fruit while maximum fruit acidity was recorded (0.59%) in fruit treated with 6% $CaCl_2$ (Table 3). However, 4% $CaCl_2$ treatment was more effective (0.45%) than 2% $CaCl_2$ treatment in which lower acidity was observed (0.37%) at 5-day storage of fruit. Similarly, maximum level of acidity (0.52%) of loquat fruit was observed in $CaCl_2$ (6%) treated fruit, while minimum acidity (0.29%) was observed in control treatment after 10 days of shelf time. In general, as expected, higher level of fruit acidity was observed after 5 day (0.43%) as compared with 10 days (0.39%) of shelf period.

Table 4: Impact of calcium chloride ($CaCl_2$) on juice contents and pH value of loquat fruit juice during storage.

Treatments	Juice contents (%)			pH		
	Shelf period (Days)			Shelf period (Days)		
	5	10	Mean	5	10	Mean
Control	11.77de	10.00e	10.89D	8.8 a	8.4ab	8.6A
2% $CaCl_2$	18.82bcd	14.15cde	16.49C	6.9abcd	7.4abc	7.2AB
4% $CaCl_2$	23.50ab	20.66bc	22.08B	5.9bcd	6.3abcd	6.1BC
6% $CaCl_2$	30.12a	28.01a	29.06A	4.4d	5.2cd	4.8C
Mean	21.05A	18.20B		6.4 A	6.9 A	
LSD ($P \leq 0.05$)						
Treatments (T)	0.00			0.00		
Shelf period (SP)	0.01			NS		
T x SP	NS			NS		

n = 3 replicates. Any two means in column or a row followed by different letters are significantly different. NS = not significant, T = Treatment, SP = shelf period.

Juice content

The highest level of $CaCl_2$ (6%) application to loquat fruit significantly maintained the juice content (%) at higher level as compare to 2% and 4% $CaCl_2$ applications and the control treatment (Table 4). After 5 and 10 days of shelf period minimum fruit Juice contents (%) was observed (11.77% and 10%) in control fruit while maximum fruit Juice (%) was recorded (30.12% and 28%) in 6% $CaCl_2$ application, respectively. The interaction between treatments and shelf period showed non-significant difference with respect to changes in loquat fruit juice contents.

pH of Juice

The results showed that, irrespective of shelf period (Days), $CaCl_2$ treatment significantly decreased pH of loquat fruit juice as compared to control (Table 4). Highest level of $CaCl_2$ (6%) performed better than lower levels (2% and 4% $CaCl_2$), as well as untreated control fruit (Table 4). Maximum fruit pH was observed (8.8 and 8.4) in control fruit, while minimum fruit pH of loquat was observed (4.4 and 5.2) in 6% $CaCl_2$ application after 5 and 10 days of shelf period. It was also found that after 5 days of shelf period loquat fruit showed highest mean decrease in fruit pH (6.4) as compare to 10 days (6.9) shelf period.

DISCUSSION

In the current study the improvement in the fruit physical characteristics such as reduction in weight loss, fruit diameter may be ascribed to the fact that calcium (Ca) is a vital component of fruit tissues that plays a key function in conserving postharvest quality of fruit by maintaining cellular films and suspending senescence. It may be due to application of the $CaCl_2$ as Ca retaining the integrity and functionality of membrane due to abridged loss of proteins and reduction in spoilage which consequently causes the reduction in weight loss. Calcium chloride and salicylic acid have been reported to retain firmness in strawberry fruit with reduction in rotting, weight loss and vitamin C (Shafiee et al., 2010). Similar results were found in the experiments conducted by Hajilou and Fakhimrezaei (2013) and Lester and Grusak, (1999) on apricot and muskmelon, respectively. Akhtar et al. (2010) also observed that $CaCl_2$ application reduced weight loss in loquat fruit. Earlier Ali et al. (2014) and Golomb (1983) observed that in peach and loquat application of Ca improved the fruit physical characteristics.

Postharvest application of Ca to loquat fruit resulted in significant reduction on internal as well as external browning index of loquat fruit. Earlier various studies have reported similar results that overall browning index including external as well as internal browning were reduced in various fruits and vegetables by application of $CaCl_2$ (Poovaiah, 1986) and the application of $CaCl_2$ also maintained the membrane stability (Thompson et al., 1987). High calcium concentrations result in decreased flesh browning symptoms which are directly associated with Ca content in pineapple fruit (Hewajulige et al., 2003). Akhtar et al. (2010) conducted an experiment on loquat cv. Surkh to study the effectiveness of $CaCl_2$ on loquat fruit. They reported valuable improvement in browning index (BI). Similar result about the overall browning index including external as well as internal browning were improved by application of $CaCl_2$ (Poovaiah, 1986). Prevention of browning in treated fruit may be due to the role of calcium to maintains the membrane stability (Thompson et al., 1987). Similar results were also reported by Sohail et al. (2015) who found that application of $CaCl_2$ positively improved firmness of peach fruits as compare to the control. Earlier postharvest application of calcium improved cell wall, cell turgor, membrane reliability, firmness in avocado fruit (Chaplin and Scott, 1980). Similar results have also been reported in strawberry (Lara et al., 2004) and loquat (Akhtar et al., 2010) fruits with calcium treatments. reported that Postharvest application of $CaCl_2$ on the apple also maintained their firmness at higher levels than untreated control fruit (Jan et al., 2013).

After harvest perishable commodities continue their deterioration by break down of energy rich compound into simpler molecules with release of energy to keep themselves alive. Sugars and acids are the main substrates which are consumed during cellular respiration more rapidly after harvest. Application of calcium has been found to slow down these metabolic processes and consequently helped to slowed down the degradation of sugars and acids. Same happened in the current study, all calcium treatments slow down the degradation of sugars and acids. Similarly, earlier Jaishankar et al. (2018) reported that application of $CaCl_2$ improved various biochemical traits of custard apple. Application of calcium has been found to delay senescence process in fruits with no harmful effect on consumer (Lester and Grusak, 2004). Acidity of fruits were reduced more quickly with initiation of senescence process in harvested fruit which may be ascribed to enzymatic action of respiratory enzymes (Hong et al., 2012; El-Anany et al., 2009; Ali et al., 2010). Maintenance of fruit acidity at higher level has also been reported earlier in peach, pomegranate, tomato, and mango fruit (Bakeer et al., 2016; Cheema et al., 2014; He et al., 2016; Manganaris et al., 2005).

CONCLUSION

In conclusion, postharvest application of 6% $CaCl_2$ has showed positive response in maintenance of physical (firmness, external browning, internal browning) and biochemical parameter (TSS, acidity and pH) of loquat fruit kept at ambient conditions for 10 days.

ACKNOWLEDGMENTS

The authors are thankful to Mr. Saleem, University of Sargodha for providing the fruit for current research.

REFERENCES

Akhtar, A., Abbasi, N.A. and Hussain, A. 2010. Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. *Pakistan Journal of Botany*, *42*(1): 181-188.

Ali, I., Abbasi, N.A. and Hafiz, I.A. 2014. Physiological response and quality attributes of peach fruit cv. Florida King as affected by different treatments of calcium chloride, putrescine, and salicylic acid. *Pakistan Journal of Agricultural Sciences*, *51*(1): 33-39.

Ali, S., Masud, T., Abbasi, K.S., Mahmood, T. and Hussain, I. 2013. Influence of $CaCl_2$ on biochemical composition, antioxidant, and enzymatic activity of apricot at ambient storage. *Pakistan Journal of Nutrition*, 12(5): 476-483.

Ali, A., Maqbool, M., Ramachandran, S. and Alderson, P.G. 2010. Gum arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum* L.) fruit. *Postharvest Biology and Technology*, *58*(1): 42-47. https://doi.org/10.1016/j.postharvbio.2010.05.005

Babu, I., Ali, M.A., Shamim, F., Yasmin, Z., Asghar, M. and Khan, A.R. 2015. Effect of calcium chloride application on quality characteristics and post-harvest performance of loquat fruit during storage. *International Journal of Advanced Research,* 1(3): 602-610.

Bakeer, S.M. 2016. Effect of ammonium nitrate fertilizer and calcium chloride foliar spray on fruits cracking and sunburn of Manfalouty pomegranate trees. *Scientia Horticulturae*, 209: 300-308. https://doi.org/10.1016/j.scienta.2016.06.043

Blumenfeld, A. 1980. Fruit growth of loquat. *Journal of the American Society for Horticultural Sciences,* 105: 747-750.

Burns, J.K. and Pressey, R. 1987. Ca_{2+} in the cell walls of ripening tomato and peach. *Journal of the American Society for Horticultural Science,* 112: 783–787.

Chaplin, G.R. and Scott, K.J. 1980. Association of calcium in the chilling injury susceptibility of stored avocados. *Horticulture Science,* 15: 514-515.

Cheema, A., Padmanabhan, P., Subramanian, J., Blom, T. and Paliyath, G. 2014. Improving quality of greenhouse tomato (*Solanum lycopersicum* L.) by pre-and postharvest applications of hexanal-containing formulations. *Postharvest Biology and Technology*, 95: 13-19. https://doi.org/10.1016/j.postharvbio.2014.03.012

Gerasopoulos, D. and Pavlina, D.D. 2005. Summer-pruning and preharvest calcium chloride sprays Affect storability and low temperature breakdown incidence in kiwifruit. *Postharvest Biology and Technology*, 36(3): 303-308. https://doi.org/10.1016/j.postharvbio.2005.01.005

El-Anany, A.M., Hassan, G.F.A. and Ali, F.R. 2009. Effects of edible coatings on the shelf- life and quality of Anna apple (*Malus domestica* Borkh) during cold storage. *Journal of Food Technology*, *7*(1):5-11.

Feng, J.J., Liu, Q., Wang, X.D., Chen J.W., and Ye., J.D. 2007. Characterization of a new loquat cultivar 'Ninghaibai'. *Acta Horticulture,* 750: 117-124. https://doi.org/10.17660/ActaHortic.2007.750.16

Ghasemnezhad, M., Nezhad, M.A. and Gerailoo, Y. 2010. Changes in postharvest quality of loquat fruits influenced by chitosan. *Horticulture Environment and Biotechnology,* 52(1): 40-45.

Golomb, A. 1983. Calcium metabolism in relationship to the occurrence of blemishes in fruit peel. PhD Thesis, Faculty of Agriculture, The Hebrew University of Jerusalem, Israel.

Hajilou, J. and Fakhimrezaei, S. 2013. Effects of post-harvest calcium chloride or salicylic acid treatments on the shelf-life and quality of apricot fruit. *The Journal of Horticultural Science and Biotechnology*, 88(5): 600-604. https://doi.org/10.1080/14620316.2013.11513012

He, J., Ren, Y., Chen, C., Liu, J., Liu, H. and Pei, Y. 2016. Defense responses of salicylic acid in mango fruit against postharvest anthracnose, caused by colletotrichum gloeosporioides and its possible mechanism. *Journal of Food Safety*, 37(1): 1-10. https://doi.org/10.1111/jfs.12294

Hernandez-Munoz, P., Almenar, E., Ocio, M.J. and Gavara, R. 2006. Effect of calcium dips and chitosan coatings on postharvest life of strawberries. *Postharvest Biology and Technology*, *39*(3): 247-253. https://doi.org/10.1016/j.postharvbio.2005.11.006

Hewajulige, I.G.N., Wilson-Wijeratnam, R.S., Wijesundera, R.L.C. and Abeysekere, M. 2003. Fruit calcium concentration and chilling injury during low temperature storage of pineapple. *Journal of the Science of Food and Agriculture*, 83(14): 1451-1454. https://doi.org/10.1002/jsfa.1556

Hussain, A., Abbasi, N.A. and Akhtar, A. 2007. Fruit characteristics of different loquat genotypes cultivated in Pakistan. *Acta Horticulture,* 750: 287-291. https://doi.org/10.17660/ActaHortic.2007.750.45

Hong, K.Q., Xie, J.H., Zhang, L.B., Sun, D.Q. and Gong, D.Q. 2012. Effects of chitosan coating on postharvest life and quality of guava (*Psidium guajava* L.) fruit during cold storage. *Scientia Horticulture*, 144: 172-178. https://doi.org/10.1016/j.scienta.2012.07.002

Jan, I., Rab, A. and Sajjad, M. 2013. Influence of calcium chloride on physical characteristics and soft rot incidence on fruit of apple cultivars. *The Journal of Animal & Plant Sciences*, 23(5): 1353-1359

Jaishankar, H.P., Kukanoor, L., Jholgiker, P., Hipparagi, K., Gorabal, K., Nishani, S. and Karadiguddi, M. 2018. Influence of pre-harvest sprays on physical and physiological parameters of custard apple cv. *Balanagar. International Journal of Chemical Studies,* 6(5): 297-301.

Lara, I., Garcia, P. and Vendrell, M. 2004. Modifications in cell wall composition after cold storage of calcium-treated strawberry fruit. *Postharvest Biology and Technology*, 34(3): 331-339. https://doi.org/10.1016/j.postharvbio.2004.05.018

Lester, G.E. and Grusak, M.A. 2004. Field application of chelated calcium: Post-harvest effects on cantaloupe and honeydew fruit quality. *HortTechnology,* 14*:* 29-38. https://doi.org/10.21273/HORTTECH.14.1.0029

Lester, G E. and Grusak, M.A. 1999. Postharvest application of calcium and magnesium to honeydew and netted muskmelons: effects on tissue ion concentrations, quality, and senescence. *Journal of the American Society for Horticultural Science*, 124(5): 545-552.

Lin, S. Sharpe, R.H. and Janick, J. 1999. Loquat botany and horticulture. *Horticulture Review,* 23: *2*33-276.

Mahajan, B.V.C. and Dhatt, A.S. 2014. 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): 157-159.

Mahajan, B.V.C. and Sharma, R.C. 2000. Effect of postharvest application of growth regulators and calcium chloride on physico-chemical characteristics and storage life of peach cv. Shan-e-Punjab. *Haryana Journal of Horticulture Science,* 29(12): 41-43.

Manganaris, G.A., Vasilakakis, M., Mignani, I., Diamantidis, G. and Tzavella-Klonari, K. 2005. The effect of preharvest calcium sprays on quality attributes, physicochemical aspects of cell wall components and susceptibility to brown rot of peach fruits (*Prunus persica* L. cv. Andross). *Scientia Horticulturae*, 107(1): 43-50. https://doi.org/10.1016/j.scienta.2005.06.005

Poovaiah, B.W. 1986. Role of calcium in prolonging storage life of fruits and vegetables. *Food Technology,* 40: 86-89.

Rizk-Alla, M.S. and Meshreki, A.M. 2006. Effect of pre-harvest application of GA_3, potassium and glucose on fruit quality and storability of Crimson Seedless cultivar. *Egyptian Journal of Basic and Applied Sciences*, 20(6A): 210-238.

Shafiee, M., Taghavi, T.S. and Babalar, M. 2010. Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. *Scientia Horticulturae*, 124(1): 40-45. https://doi.org/10.1016/j.scienta.2009.12.004

Sohail, M., Ayub, M., Khalil, S.A., Zeb, A., Ullah, F., Afridi, S.R. and Ullah, R. 2015. Effect of calcium chloride treatment on post-harvest quality of peach fruit during cold storage. *Food Research Journal, 22*(6): 2225-2229.

Thompson, J.E., Leggee, R.L. and Barber, R.F. 1987. The role of free radicals in senescence and wounding. *New Phytologist*, 105: 317-344. https://doi.org/10.1111/j.1469-8137.1987.tb00871.x

Wang, Y.S., Tian, S.P. and Xu, Y. 2005. Effects of high oxygen concentration on pro- and anti-oxidant enzymes in peach fruits during postharvest periods. *Food Chemistry*, 91(1): 99-104. https://doi.org/10.1016/j.foodchem.2004.05.053