Original Research Article

Preharvest Foliar Applied Salicylic Acid and Calcium Chloride Affects Postharvest Storability and Bio-chemical Quality of Pear (*Pyrus communis* L.) cv. Carmen Fruits

ABSTRACT

An investigation was carried out to examine the storage behaviour and bio-chemical quality of pear fruits cv. Carmen on Quince C rootstock as affected by pre-harvest pre-harvest foliar application of salicylic acid and calcium chloride treatments. The treatments consisted of four levels each of salicylic acid (0, 100, 150 and 200 ppm) and Calcium chloride (0, 0.20, 0.25 and 0.30 %) constituting total 16 treatment combinations. The experiment was laid out in Randomized Complete Block Design in factorial arrangements with three replications. The treatments were applied as a foliar spray at 3, 6 and 9 weeks after the petal fall. After harvest, fruits were stored under ambient conditions for 7 14 and 21 days. Postharvest physiological loss in weight, rotting percentage, total soluble solids, total sugars and reducing sugars in fruits was increased. In contrast, fruit firmness, titratable acidity and ascorbic acid content decreased with an increase over storage periods. Salicylic acid @ 200 ppm and calcium chloride @ 0.30 % resulted in a minimum physiological loss in weight and rotting percentage at 21 days of storage. Also, salicylic acid @ 200 ppm and calcium chloride @ 0.30 % were effective in minimizing the loss of fruit firmness, titratable acidity and ascorbic acid content. In conclusion, the salicylic acid @ 200 ppm and calcium chloride @ 0.30 % were found to be effective in improving pear cv. Carmen fruits storability by reducing physiological loss in weight and fruit rotting; and maintaining the bio-chemical quality.

Keywords: Bio-chemical quality, Calcium chloride, Pear, Preharvest, Postharvest, Salicylic acid, Storability.

1. INTRODUCTION

Pears important member of the *Pyrus* genus of the Family Rosaceae sub family Maloidae [1], native to Europe and Asia [2] and widely cultivated in the temperate regions of the world [3]. Pears broadly grouped in two major types, the 'European' pears; *P. communis,* and the 'Asian' pears; *P. pyrifolia* [4]. Pears have wide range of agro-climatic adaptation, hence plantations can be found from subtropical plains to temperate highland regions of India [5]. It is grown in more than eleven states, primarily in the temperate zones of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, and even in the subtropical area of Punjab, Haryana, Jharkhand, the North Eastern region (Manipur, Mizoram, and Nagaland), and Tamil Nadu [6]. The agro-climatic conditions of Kashmir valley are highly favourable for excellent pear fruit growing, herby Jammu and Kashmir is leading producer in India with 88523 MT productions from an area of 13991 ha [7]. Currently, a substantial number of pear cultivars are grown, the majority of which are introductions, some of important cultivars are Kings Pear, Vicar of Winkfield, Beurre-de-Amanlis, Bartlett, Monarch, Devoe, Flemish Beauty, Red Bartlett, China Pear and Fertility [8]. Recently, SKUAST-Kashmir has introduced a new red-coloured European pear variety 'Carmen' grafted on Quince-C rootstocks from Italy. The fruits of Carnem pear are quite appealing, being elongated, medium to large in size, and with a scarlet blush covering part of the skin [9]. In Kashmir valley, Carmen pear started bearing only one year after planting and fruits mature about 15 days earlier than the most common variety Williams Bartlett of the valley.

Growth hormones and nutrients are considered vital for several processes in the plant life cycle and play an important role in productivity and quality of fruits. Among growth hormones, salicylic acid is one of the naturally occurring phyto-chemical considered to be a potent plant hormone because of its diverse regulatory role in plant metabolism. It plays an important role in the regulation of plant growth, development, ripening, flowering, and responses to abiotic stresses [10]. Salicylic acid and its derivatives are also useful in enhancing the postharvest quality of several fruits [11, 12]. Calcium is an important role in fruit production and quality and is considered to be deficit in highest rainfall areas and is less mobile in soils [13]. Amiri *et al*. [14] claimed that foliar application of nutrients is more efficient to improve quality of pear, as foliar sprays can supply essential elements directly to the foliage and fruits; however it is very difficult to achieve the goal because of the restricted uptake and penetration of calcium into the fruit and its movement within fruit tissue [15]. Keeping in view the above facts, the present investigation was carried to explore the role of salicylic acid and calcium chloride, out on the storage behaviour and bio-chemical quality of pear cv. Carmen.

2. MATERIAL AND METHODS

The present study was conducted at Experimental Farm of Division of Fruit Science, SKUAST-Kashmir, Shalimar campus, Srinagar (J&K) on Carmen cv. Pear grafted on Quince C rootstock planted at a spacing of 3 x 3 m. The experimental site is located at an elevation of 1685 m amsl and is characterized by very cold temperature (falls upto -7 ^{o}C) during December to March and moderately hot (upto 35 ^{o}C) during summer months. April and May are cold and mild, June to August comparatively warm and September is mild. October and November are cold and generally dry.

The treatments comprised of four levels of salicylic acid (S_0: control, S_1: 100 ppm, S_2: 150 ppm and S_3: 200 ppm) with four levels calcium chloride (C_0: control, C_1: 0.20 %, C_2: 0.25 % and C_3: 0.30 %). Forty eight uniform trees were used for trial. The corresponding doses of salicylic acid and calcium chloride ($CaCl_2$) were applied as per the treatment combinations. The chemical treatments were applied as foliar spray to the trees through Knapsack Sprayer at 3, 6 and 9 weeks after petal fall till slight run off of the spray liquid from the leaves. Randomized Complete Block Design with three replications of each treatment was used for laying out the experiment.

Initial weight of 10 fruits from each treatment was recorded at harvest and at subsequent storage of 7, 14 and 21 days and thus physiological loss in weight (PLW) at different storage period under study was worked out as per given formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Weight at 'x' day of storage}}{\text{Initial weight}} \times 100$$

Rotting per cent of stored fruits was calculated on the basis of number of fruits that had rotted out of total stored fruits at 7, 14, and 21 days of storage using following formula:

$$\text{Rotting (\%)} = \frac{\text{Number of rotten fruits at 'x' day of storage}}{\text{Total number of stored fruits}} \times 100$$

Fruit firmness was determined with the help of a digital Effegi Pressure Tester Plunger and expressed in kg cm^{-2}. Total soluble solids of fruit were determined with the help of Digital Hand Refractometer and the values were expressed in ^{o}Brix. The bio-chemical characteristics of fruit (reducing sugar, total sugar, titrable acidity and ascorbic acid) were determined as per the standard procedures [16].

Data generated from investigations were appropriately computed, tabulated and statistically analysed, and means were compared at 5 per cent level of significance as per the procedure given by **[17]**.

3. RESULTS AND DISCUSSION

Foliar application of salicylic acid and calcium chloride resulted in significant reduction in physiological loss in weight of Carmen pear fruits during ambient storage period (Fig. 1). Minimum physiological loss in weight (2.38 %, 4.24 % and 6.46 %) was recorded with salicylic acid @ 200 ppm after 7, 14 and 21 days of storage, respectively which was statistically at par with the results observed with the application of salicylic acid @ 150 ppm. After 21 days of storage studies, salicylic acid @ 200 ppm was significantly superior over rest of the treatments. Maximum physiological loss in weight of fruit after 7, 14 and 21 days of storage was observed under control (3.46, 5.98, and 8.86 %, respectively). Calcium chloride @ 0.30 per cent registered minimum weight loss (2.43 %, 4.33 % and 6.91 % after 7, 14 and 21 days of storage, respectively) which was statistically at par with calcium chloride @ 0.25 % after 7 days of storage (2.71 %), whereas after 14 and 21 days of storage, calcium chloride @ 0.30 % was significantly superior over rest of the treatments. Maximum physiological loss in weight (3.16, 5.81, and 8.66 % at 7, 14 and 21 days of storage, respectively) was recorded in control. Salicylic acid maintains lower rate of respiration by inhibiting ethylene levels during storage which in turn decreases the activity of cell wall degrading enzymes and prevent softening and weight loss**.** Low physiological loss in weight of fruits in present study is attributed to the facts that calcium also delays natural physiological processes like respiration, onset of the climacteric, ripening process and senescence [18]. Similar results were reported in apricot [19] pear Bhat [20], strawberry [21] and plum [22].

Increased rotting percentage of fruits was observed with the advancement of storage period; however foliar application of salicylic acid and calcium chloride had significant effect on reducing the rotting percentage (Fig. 1). Minimum rotting of fruits (5.00, 11.67 and 20.00 % at 7, 14 and 21 days of storage, respectively) was noted with salicylic acid @ 200 ppm that was significantly the highest than treatments. Also, foliar application of calcium chloride @ 0.30 per cent registered

minimum rotting of fruits (5.00, 11.67 and 21.25 % at 7, 14 and 21 days of storage, respectively) and was found superior among all the treatments. Lower values of rotting of fruits in present study is due to the ability salicylic acid in induced defensive enzymes chitinase, POD and PAL [11, 23] that reduces the fungal and bacterial infections causing rotting of fruits. Calcium chloride application was found beneficial in reducing the rotting of fruits to a great extent during storage. Reduced rooting per cent of fruit due to calcium chloride application in present study might be attributed to high calcium concentrations in fruits that decreased flesh browning which are directly associated with calcium content in fruits [24].

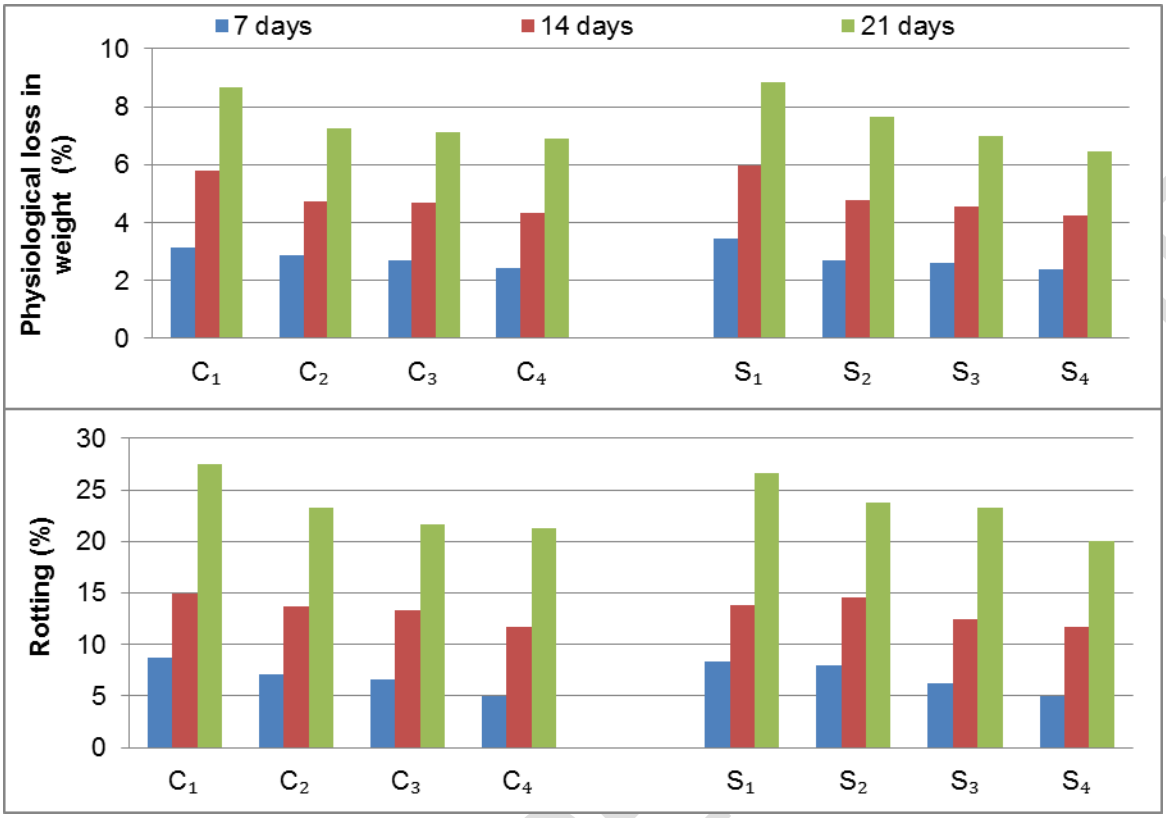

Fig.1. Effect of salicylic acid and calcium chloride sprays on physiological loss in weight and rotting percentage of pear fruits cv. Carmen on 7, 14 and 21 days ambient storage conditions.

Fruit firmness was decreased with increase in storage duration as observed at 7, 14 and 21 days of storage studies (Fig. 2). Foliar application of salicylic acid and calcium chloride showed a significant role in maintaining the fruit firmness during storage (Fig. 2). Salicylic acid @ 200 ppm resulted maximum fruit firmness of 9.39, 8.30 and 7.62 kg/cm at 7, 14 and 21 days of storage studies, respectively though it was at par with salicylic acid @ 150 ppm (9.35, 8.26 and 6.99 kg/cm at 7, 14 and 21 days of storage, respectively) whereas minimum fruit firmness (8.59, 7.40 and 5.37 kg/cm at 7, 14 and 21 days of storage, respectively) was recorded in control. Application of calcium chloride @ 0.30 % resulted maximum firmness (9.61, 8.54 and 7.06 kg/cm) which was statistically at par with calcium chloride @ 0.25 % (9.32, 8.24 and 6.70 kg/cm) at 7 and 14 days only whereas at 21 days of storage calcium chloride @ 0.30 % was superior over rest of the treatments. Minimum fruit firmness of 8.63, 7.46 and 5.98 kg/cm at 7, 14 and 21 days of storage, respectively was recorded in control. Maintenance of higher fruit firmness by salicylic acid could be via its efficacy in decreasing ethylene production. Moreover cell swelling is affected by salicylic acid which leads to higher firmness of fruits [23, 25]. Calcium chloride was effective in retaining the fruit firmness during storage as calcium plays an important role in maintaining cell wall structure by interaction with pectic acids in the cell walls to form calcium pectate [26]. Earlier Val and Fernandez [27] also reported that firmness was improved with calcium sprays on late season Calrico peaches.

Total soluble solids (TSS) in fruits were increased with the foliar applications of salicylic acid (Fig. 2). At 7 days of storage, highest total soluble solid content (14.43 ^{o}Brix) was recorded with the salicylic acid @ 200 ppm which was at par with the application of 150 and 100 ppm salicylic acid (14.30 and 14.16 ^{o}Brix, respectively) whereas lowest TSS (14.01 ^{o}Brix) was recorded in control. at 14 and 21 days of storage, maximum TSS was recorded in control (16.35 and 18.82 ^{o}Brix, respectively) which was superior among all other treatments whereas minimum total soluble solids after 14 days (15.21 ^{o}Brix) and 21 days (16.49 ^{o}Brix) of storage were observed with salicylic acid @ 200 ppm. Foliar application of calcium chloride exhibited significant influence on total soluble solid content of fruits during storage and after 7, 14 and 21 days of storage highest total soluble solid (14.87, 16.80 and 18.7 ^{o}Brix, respectively) was recorded in control while it was

significantly lowest i.e. 13.56, 14.94 and 16.50 ^{o}Brix at 7, 14 and 21 days of storage, respectively with calcium chloride @ 0.30 %.

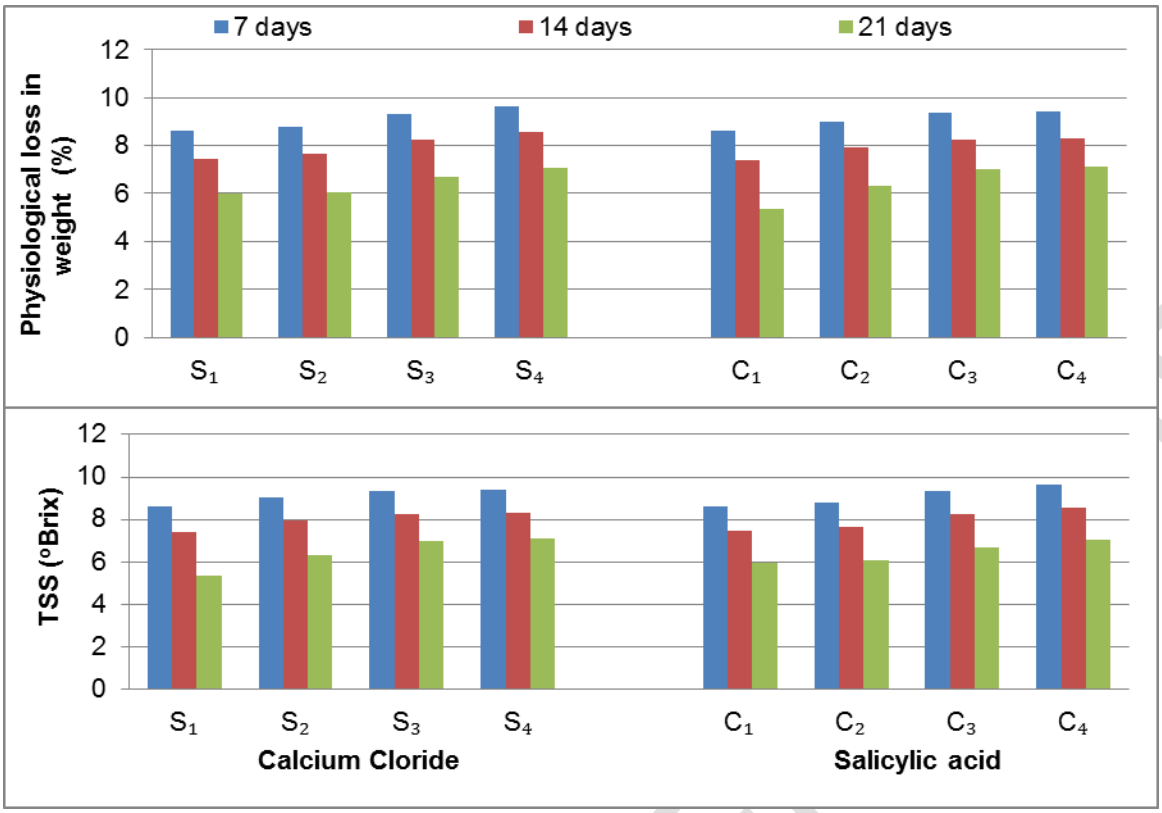

Fig. 2. Effect of salicylic acid and calcium chloride sprays on firmness and total soluble solids of pear fruits cv. Carmen on 7, 14 and 21 days ambient storage conditions.

Significant effect of foliar application of salicylic acid and calcium chloride on reducing sugars of fruits was observed during the storage period (Table 1). Rate of increase in reducing sugars in fruit under salicylic acid treatments was slow as compared to control; and after 7 days of storage, maximum total sugars content (11.32 %) was recorded with salicylic acid @ 200 ppm, which was statistically at par with the application of 150 ppm (11.26 %) and 100 ppm (11.21 %) salicylic acid whereas minimum reducing sugar was recorded under control (10.54 %). At 14 and 21 days of storage, maximum reducing sugar (12.52 and 13.62 %, respectively) was recorded in control which was significant higher among all other treatments. Minimum reducing sugars content after 14 and 21 days of storage (11.69 and 12.42 %, respectively) were determined with salicylic acid @ 200 ppm. Maximum reducing sugars content i.e. 11.55, 12.29 and 13.62 % at 7, 14 and 21 days of storage, respectively was recorded under control. which was statistically at par with the application of calcium chloride treatment @ 0.20 % (11.40, 12.20 and 12.32 %, respectively). After 7, 14 and 21 days of storage, minimum reducing sugars (10.46, 11.60 and 12.62 %, respectively) were recorded with calcium chloride @ 0.30 per cent.

Total sugars content in fruits were increased during storage period with the pre-harvest foliar application of salicylic acid and the rate of increase in total sugars content under salicylic acid treatments was slow as compared to control (Table 1). After 7 days of storage, maximum total sugars content (12.99 %) was recorded with salicylic acid @ 200 ppm which was statistically at par with 150 ppm (12.81 %) and 100 ppm (12.62 %) salicylic acid treatments whereas minimum was recorded under control (12.48 %). After 14 and 21 days of storage, maximum total sugars were recorded under control i.e. 14.57 and 15.57 per cent, respectively which was significant over other salicylic acid treatments whereas minimum total sugars content were observed with salicylic acid @ 200 ppm i.e. 14.53 and 15.67 per cent, respectively. Foliar application of calcium chloride application significantly influenced total sugar content during storage and after 7, 14 and 21 days of storage, maximum total sugars content in fruits i.e. 13.27, 14.47 and 15.43 per cent, respectively was recorded in control which were statistically at par with the results obtained under calcium chloride treatment @ 0.20 per cent (13.03, 14.37 and 15.37 %, respectively). Minimum total sugars i.e. 12.20, 13.43 and 14.50 per cent were recorded with calcium chloride @ 0.30 per cent after 7, 14 and 21 days of storage, respectively.

Table 1: Effect of salicylic acid and calcium chloride sprays on sugars content of Carmen pear fruits fruit during ambient storage

Treatment	Reducing sugars (%)			Total sugars (%)		
	7 days	7 days	14 days	21 days	14 days	21 days
Salicylic acid						
S_1- Control	10.54	12.48	14.57	15.57	12.52	13.62
S_2- 100 ppm	11.21	12.62	13.89	15.04	12.10	13.01
S_3- 150 ppm	11.26	12.81	13.81	14.95	11.79	12.58
S_4- 200 ppm	11.32	12.99	13.71	14.51	11.69	12.42
SEm±	0.10	0.12	0.12	0.15	0.21	0.12
$CD_{0.05}$	0.26	0.30	0.30	0.37	0.53	0.31
$CaCl_2$						
C_1- Control	11.55	13.27	14.47	15.53	12.38	13.62
C_2- 0.20 %	11.40	13.03	14.37	15.40	12.20	13.32
C_3- 0.25 %	10.93	12.42	13.60	14.65	11.93	12.59
C_4- 0.30 %	10.46	12.20	13.43	14.50	11.60	12.10
SEm±	0.10	0.12	0.12	0.15	0.21	0.12
$CD_{0.05}$	0.26	0.30	0.30	0.37	0.53	0.31

Total sugars and reducing sugars of fruits increased over the period of storage but the rate of increase was slow in fruits harvested from trees sprayed with salicylic acid and calcium chloride treatments. Salicylic acid is an ethylene inhibitor which makes it effective in reducing respiration rates and metabolic activities thereby slowing down the ripening process [28, 29] and thus might resulted lower values of total soluble solids and sugars during storage. The present results are in agreement with the findings of Salari *et al.* [30] and Srivastava and Drivedi [31] those also reported that the rate of respiration gets retarded due to application of salicylic acid and thereby delaying the increase in SSC content in strawberry and banana fruits respectively. According to Minh [32] CaCl2 treatment would be an effective approach to extend shelf life of banana fruit in commercial distribution..

Titrable acidity in fruits was decreased with the increase in storage period and the foliar applications of salicylic acid and calcium chloride had significant effect on titrable acidity fruits during storage (Table 2). Maximum titrable acidity after 7, 14 and 21 days of storage (0.52, 0.48 and 0.42 %, respectively) was recorded with salicylic acid @ 200 ppm which was statistically superior over other treatments whereas minimum titrable acidity after 7, 14 and 21 days of storage were recorded in control i.e. 0.40, 0.35 and 0.30 per cent, respectively. Calcium chloride @ 0.30 per cent resulted maximum titrable acidity in fruits i.e. 0.50, 0.46 and 0.40 per cent after 7, 14 and 21 days of storage, respectively, although at 21 days of storage it was at par with 0.25 % (0.37 %). Minimum titrable acidity in fruits i.e. 0.42, 0.37 and 0.30 per cent at 7, 14 and 21 days of storage, respectively was recorded in control. Kirinus *et al*. [33] in peaches and Srivastava and Dwivedi [31] in banana also recorded that salicylic acid maintain higher acid content at the end of storage period. Attri *et al.* [34] in pear and Ibadullah *et al* [35] in apple revealed that acidity reduced faster in control fruits as compared to calcium treated fruits during storage.

Table 2: Effect of salicylic acid and calcium chloride sprays on titrable acidity and ascorbic acid content of Carmen pear fruits fruit during ambient storage

Treatment	Titrable acidity (%)			Ascorbic acid (mg 100 g^{-1})		
	7 days	14 days	21 days	7 days	14 days	21 days
Salicylic acid						
S_1- Control	0.40	0.35	0.30	8.30	7.89	6.88
S_2- 100 ppm	0.44	0.39	0.33	8.90	8.22	7.32
S_3- 150 ppm	0.48	0.44	0.38	9.09	8.64	7.98
S_4- 200 ppm	0.52	0.48	0.42	9.19	8.83	8.04
SEm±	0.01	0.01	0.01	0.11	0.11	0.12
$CD_{0.05}$	0.02	0.02	0.03	0.27	0.27	0.29
$CaCl_2$						
C_1- Control	0.42	0.37	0.30	8.61	8.09	7.36
C_2- 0.20 %	0.45	0.41	0.36	8.73	8.25	7.41
C_3- 0.25 %	0.47	0.43	0.37	8.95	8.56	7.67

C_4- 0.30 %	0.50	0.46	0.40	9.18	8.69	7.78
SEm±	0.01	0.01	0.01	0.11	0.11	0.12
$CD_{0.05}$	0.02	0.02	0.03	0.27	0.27	0.29

Foliar application of salicylic acid and calcium chloride showed significant results for ascorbic acid content which was decreased with increased storage period of fruits (Table 2). Highest ascorbic acid content (9.19, 8.83 and 8.04 mg/100) was recorded with the application of salicylic acid @ 200 ppm after 7, 14 and 21 days of storage, respectively which was statistically superior among all other treatments. Lowest ascorbic acid content (8.30, 7.89 and 6.88 mg/100 g) after 7, 14 and 21 days of storage, respectively were recorded in control. Calcium chloride @ 0.30 per cent resulted the maximum ascorbic acid content (9.18, 8.69 and 7.78 mg/100 g) after 7, 14 and 21 days of storage, respectively although it was statistically at par with calcium chloride 0.25 per cent (8.95, 8.56, 7.67 mg/100 g), whereas minimum ascorbic acid content (8.61, 8.09 and 7.36 mg/100 g) was registered under control after 7, 14 and 21 days of storage, respectively (Table 2). Ascorbic acid content in fruits was decreased with the advancement of storage period. It has been reported that the salicylic acid has a potential role in minimizing fruit decay and maintaining fruit quality [36]. Awad *et al.* [37] reported that changes in fruit ascorbic acid content during storage increased gradually with increasing salicylic acid rates at all periods of storage while, decreased sharply with increasing the time of storage. Attri *et al* [34] also found that maximum ascorbic acid content of pear treated with salicylic acid and calcium was retained during storage.

4. CONCLUSION

Foliar application of salicylic acid and calcium chloride were promising in minimizing physiological loss in weight and rotting percentage of fruit besides maintaining biochemical quality of fruits during 21 days storage at ambient conditions. Fruit firmness, titratable acidity and ascorbic acid content decreased with increased storage duration while total soluble solids, total sugars and reducing sugars content of fruits were increased with increase in days of storage. Salicylic acid @ 200 ppm and calcium chloride @ 0.30 % was helpful in minimizing physiological loss in weight, rotting per cent and maintaining the fruit firmness, titratable acidity and ascorbic acid content. In conclusion, salicylic acid @ 200 ppm and calcium chloride @ 0.30 % can be an effective tool for improving storability and enhancing the biochemical quality of Carmen pear fruits at ambient storage.

REFERENCES

1. Potter D, Eriksson T, Evans RC, Oh S, Smedmark J, EE, Morgan DR, Kerr M, Robertson KR, Arsenault M, Dickinson TA, Campbell CS. Phylogeny and classification of Rosaceae. Plant Syst Evol. 2007;266:5-43. https://doi.org/10.1007/s00606-007-0539-9.
2. da Silva, GJ, Villa F, Grimaldi F, da Silva PS, Welter JF. Pear (*Pyrus* spp.) breeding. In: Al-Khayri J, Jain S, Johnson D. Eds.; Advances in plant breeding strategies: fruits. Springer, Cham., 2018. DOI: https://doi.org/10.1007/978-3-319-91944-7_4.
3. Hummer KE, Janick J. Rosaceae: taxonomy, economic importance, genomics. In: Folta KM, Gardiner SE. Eds.; Genetics and genomics of Rosaceae. Plant genetics and genomics: crops and models. Springer, New York, 2009. Doi: https://doi.org/10.1007/978-0-387-77491-6_1.
4. James-Martin G, Williams G, Stonehouse W, O''Callaghan N, Noakes M. Health and nutritional properties of pears (*Pyrus*): A literature review. 2015. Available: www.csiro.au.
5. Kumar N, Sengupta BN. Pears In**:** Chattopadhyay, T.K. Ed., A Text book of Pomology, 2nd ed. (Vol. IV), New Delhi: Kalyani Publishers, 2009.
6. NHB, Indian Horticulture Database. National Horticulture Board, Ministry of Agriculture, Gurugram, India; 2019. Available: http://www.nhb.gov.in/
7. Anonymous. Area and production of major horticultural crops in Jammu and Kashmir for year 2018-19. Directorate of Horticulture, Kashmir, J&K, India, 2019. Available: http://hortikashmir.gov.in/
8. Farooqui KD, Bhat KM, Mehmood A. Effect of different levels of fertigation on quality and production of apple cultivars. Prog. Hort. 2004;36-216-220.
9. Rivalta L, Dradi M. 'Turandot', 'Norma' and 'Carmen': three new early pear cultivars for high-quality production. Acta Hortic. 2002;596:275-277. DOI: https://doi.org/10.17660/ActaHortic.2002.596.42.
10. Hara M, Furukawa J, Sato A, Mizoguchi T, Miura K. Abiotic stress and role of Salicylic acid in plants. In: Ahmad P, Prasad MNV, Eds.; Abiotic Stress Responses in Plants: Metabolism, Productivity and Sustainability. New York: Springer-Verlag, 2012. DOI: https://doi.org/10.1007/978-1-4614-0634-1_13.
11. Hayat Q, Hayat H, Irfan M, Ahmad A. Effect of exogenous salicylic acid under changing environment: A review. Environ. Exp. Bot. 2010;68(1):14-25. DOI: https://doi.org/10.1016/j.envexpbot.2009.08.005.

12. Kazemi M, Aran M, Zamani S Effect of salicylic acid treatments on quality characteristics of apple fruits during storage*. Amer. J. Plant Physiol.* 2011;6:113-119. DOI: DOI: https://doi.org/10.3923/ajpp.2011.113.119.
13. Zatylnyl AM, St-Pierre, RG. Development of standard concentrations of foliar nutrients for Saskatoon. J. Plant Nutr. 2006;29:195-207. DOI: https://doi.org/10.1080/01904160500468662.
14. Amiri ME, Fallahi E, Golchin A. Influence of foliar and ground fertilization on yield, fruit quality, and soil, leaf and fruit mineral nutrients in apple. J. Plant Nutr. 2008;31:515-525. DOI: https://doi.org/10.1080/01904160801895035.
15. Schlegel TK, Schonherr J. Stage of development affects penetration of calcium chloride into apple fruits. J. Plant Nutr. Soil Sci. 2002;165(6):738-745. DOI: https://doi.org/10.1002/jpln.200290012.
16. AOAC. Official Methods of Analysis, 15th Edn. Association of Official Analytical Chemists, Washington, DC, USA.
17. Snedecor GW, Cochran WG. Statistical methods. 1ST Edn.; New Delhi: East-West Press; 1994.
18. Hussain PR, Meena RS, Dar MA Wani AM. Effect of post-harvest calcium chloride dip treatment and gamma irradiation on storage quality and shelf-life extension of Red Delicious apple. *J. Food Sci. Technol.* 2012;**49**:415-426.DOI: https://doi.org/10.1007/s13197-011-0289-0.
19. Lal S, Kumar D, Singh DB, Ahmed N, Kumar R Dar GA. 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. Hortic. Sci. 2011;6(1):46-51.
20. Bhat MY. Effect of preharvest calcium sprays on harvest maturity, quality and storage of pear (*Pyrus communis* L.) cv. Bartlett. PhD thesis submitted to SKUAST-Kashmir, Srinagar, India; 2006.
21. Davarynejad GH, Zarei M, Nasrabadi ME, Ardakani E. Effect of salicylic acid and putrescine on storability, quality attributes and antioxidant activity of plum cv. Santa Rosa. J. Food Sci. Technol. 2015;52(4):2053-2062. DOI: https://doi.org/10.1007/s13197-013-1232-3.
22. Mahsa G, Sadegh S, Vahid A. Extending postharvest longevity and improving quality of strawberry (*Fragaria ananasa* Duch. cv. 'Gaviota') fruit by postharvest salicylic acid treatment. J. Agric. Studies, 2015;3(2):17-36. DOI: https://doi.org/10.5296/jas.v3i2.7274.
23. Zhang Y, Chen K, Zhang S, Ferguson I. The role of salicylic acid in postharvest ripening of kiwifruit. Postharvest Biol. Technol. 2003;28:67-74.DOI: https://doi.org/10.1016/S0925-5214(02)00172-2.
24. Hewajulige IGN, Wilson-Wijeratnam RS, Wijesundera RLC, Abeysekere M. Fruit calcium concentration and chilling injury during low temperature storage of pineapple. J. Sci. Food Agric. 2003;83:1451-1454. DOI: https://doi.org/10.1002/jsfa.1556.
25. Shafiee M, Taghavi TS, Babalar M. 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 Hortic*.* 2010;124:40-45. DOI: https://doi.org/10.1016/j.scienta.2009.12.004.
26. Conway WS, Sams CE. The effect of post-harvest infiltration of calcium, magnesium or strontium on decay, firmness, respiration and ethylene production in apples. J. Amer. Society Hortic. Sci. 1987;112:300-303.
27. Val J, Fernandez V. In-season calcium-spray formulations improve calcium balance and fruit quality traits of peach. J. Plant Nutr. Soil Sci. 2011;174(3):465-472. DOI: https://doi.org/10.1002/jpln.201000181.
28. Pila N, Gol NB Rao TVR. Effect of postharvest treatments on physic-chemical. Amer-Eur. J. Agric. Environ. Sci. 2010;9(5):470-479.
29. Rademacher W. Effects on gibberellin biosynthesis and other metabolic pathways. Annu. Rev. Plant Physiol. Plant Mol. Biol. 2000;512:501-531. DOI: https://doi.org/10.1146/annurev.arplant.51.1.501.
30. Salari N, Bahraminejad A, Afsharmanesh G, Khajehpour G. Effect of salicylic acid on postharvest quantitative and qualitative traits of strawberry cultivars. Adv. Environ. Biol. 2013;7:94-99.
31. Srivastava MK, Dwivedi UN. Delayed ripening of banana fruit by salicylic acid. *Plant Sci.* 2000;158:87-96. DOI: https://doi.org/10.1016/S0168-9452(00)00304-6.
32. Minh, NP. Effectiveness of CaCl2 treatment on quality attributes of banana fruit during storage. Plant Sci. Today, 2022;9(1):206-214. DOI: https://doi.org/10.14719/pst.1458.
33. Kirinus MBM, Barreto CF, da Silva PS, Farias PCM, Malgarim MB. Salicylic acid (SA) addition influences postharvest quality of 'Jubileu' peaches (*Prunus persica*). Aus. J. Crop Sci. 2018;12(05):788-793. DOI: https://doi.org/10.21475/ajcs.18.12.05.PNE932.
34. Attri BL, Krishna H, Ahmed N Kumar A. Physiochemical characters of different cultivars of pear affected by bio-regulators during storage. J. Hill Agric*.* 2011;2(2):141-147.
35. Ibadullah J, Abdur R, Muhammad S. Influence of calcium chloride on storability and quality of apple fruits. Pakistan J. Agric. Sci. 2015;52:115-122.
36. Ali A, Kumar A, Ganai NA, Dar KR, Wani AH. Salicylic Acid Alleviates Postharvest Fruit Decay of Strawberry (*Fragaria* x *ananassa* Duch.) -A Review. *Intl. J. Plant Soil Sci.* 2021;33(20):20-27. https://doi.org/10.9734/ijpss/2021/v33i2030625.
37. Awad RM. Effect of post-harvest salicylic acid treatments on fruit quality of peach cv. Flordaprince during cold storage. Aus. J. Basic Appl. Sci. 2013;7(7):920-927.