ISSN:0971-1260
Vol-22-Issue-34-December -2019

Effect of post harvest calcium chloride treatment and refrigerated storage conditions on keeping quality of Bartlett pear

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Abstract

Theaim of the study was to evaluate the efficacy of different calcium chloride ($CaCl_2$)treatmentsand refrigerated storage conditionson quality and storability of pear fruit cv. Bartlett. Freshly harvested pear fruits weretested for harvest maturity and quality on farm and then were treated $CaCl_2$ (1, 2, 3 and 4 per cent) for different time intervals(10, 20 and 30 min.). The effects of postharvest $CaCl_2$ applications on quality and storability were recorded as changes in asphysical parameters viz. physiological loss in weight (PLW), firmness (Kg/cm^2),total soluble solids (ºB), chemical parameters viz. ascorbic acid content (mg/100g), total and reducing sugars (%), total phenols (mg/100g), calcium content (ppm), enzyme activity (PME and PG activity) and physiological changes in respiration rate (mL of CO^2/Kg/h).The fruits treated withcalcium chloride resulted in improved firmness and fruit calcium content with significant reduction in physiological loss in weight, respiration rate and retained higher total phenols, TSS, ascorbic acid and sugars (total and reducing)after stimulated refrigeration cycles.Present investigation suggested that 4% calcium chloride dip for 20, 30 min. and 3% for 30 min.retained highest physico-chemical characteristics and maintained storage quality of fruits up to 90 days of refrigeration and thus, can maintain storability and highest edible quality of fruits for relatively longer time.

Key words: *Pear, post harvest quality, calcium treatment, quality changes, shelf life extension*

Introduction

Pear is occupies an important place among temperate fruit crops after apple both in terms of acreage, production and varietal diversity and is grown under both temperate and subtropical conditions.In India, pear occupies an area of 42.30 thousand ha with an annual production of 317 thousand MT (NHB 2013).Particularly, in Himachal Pradesh area under pear cultivation is 7,283 ha with an annual production of 35 thousand ton (Anon 2014). It is a

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major contributor in horticulture driven economy of some states like Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, some parts of Nilgiri Hills and North Eastern states. Among the varietal diversity Bartlett is an important cultivar due to its high yield and good market value. Harvesting season of pear starts in the third week of July which continues up to September depending on regional climatic variations. Though, the fruits are firm at the harvest but do not keep well for long particularly during ambient holdings. Pear is a typical climacteric fruit which experience a robust increase in rate of respiration with a burst of ethylene production immediately after the harvest. The ripening processproceedsquickly and thus renders the fruit consumption period very limited.Further, to add on the harvest season coincides with heavy rainfall, high temperature and variable humidity whichhave an adverse effect on the marketability of the fruits with significant reduction in post-harvest quality of fruit (Dhatt et al. 2003). The growers are therefore, forced to sell their produce at very low pricesparticularly due to limited shelf life of fruits.

Various attempts have been made historically for retaining the storability of different horticultural produce by using various chemicals and growth regulators with variable success rate in different fruit. $CaCl_2$is well recognised as the commercial fruit firming agent and its post-harvest application has been reported toenhance storability of different fruit via complexed formation with pectic substanceslike calcium pectate which acts as a cementing material to hold the cellular network together (Ahmad 2008, Dhatt et al.2004, Sandhu et al. 2004,Bhat et al. 2011). The major portion of calcium is located in the cell wall middle lamella and plasma membrane, where its major role is in lowering down the senescence and ripening of the fruits (Chardonnet *et al.*2003).

However, there had been disparities in commercial recommendations of a specific concentration of calcium chloride ($CaCl_2$) appropriate to retain the quality and storability of the fruit. Sometimes concentration as low as 1.5%$CaCl_2$or as high as 6% $CaCl_2$have been reported as most significant formulations keeping the producers and the storage house operators in confusion for adoption of a particular concentration (Senevirathna and Daundasekera 2010). Besides,verylittleinformation is available on appropriate dipping time for the fruit at a given concentration which have a greater role to define the success of a treatment. Thus, there is the need to investigateeffect of different calcium chloride concentrations and dipping time on the quality and physiological response of the fruit. In the

ISSN:0971-1260
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present study an attempt has been made to standardize the calcium treatment with respect to concentration and time to retain the storage quality of the fruits.

Materials and methods:

Pear (*Pyruscommunis* L.) cv. 'Bartlett' fruit were harvestedat hard-green stage in first week of August with a starch iodine rating index of 3.56 from commercial pear fruit orchard from Kotkhai, Shimla (31° 7' 0" North, 77° 32' 0" East). The fruit were immediately brought to postharvest physiology laboratory of the department where healthy, disease freesamples were randomly shorted and distributed into different lots of fruits each containing a load of about 20 fruits each. The fruit were given a dip of 1, 2, 3 and 4% $CaCl_2$ solution for 10, 20 and 30 min.respectively,subsequently dried in shade and then packed in corrugated fibre board boxes (CFB) with a load of about 5 kg in each box.Control fruits were dipped in distilled water for the same period and then air dried before packaging in CFB boxes. The fruit lots were stored under refrigerated storage conditions at 2±1ºC temperature and 90±5 % RH. The physical, biochemical, physiological and enzymatic parameters were evaluated at a monthly interval of 30 days to record the effect of different $CaCl_2$concentrations and dipping time on quality and storability of the fruits. Flesh firmness was measured with the help of digital fruit hardness tester equipped with a pressure head 8 mm in diameter (Lutron fruit hardness tester, FR-5120).Acidity was measuredin terms of % malic acid. Ascorbic acid, phenolics and sugars (total and reducing)were estimated by standard methods (AOAC, 2000). Calcium content in fruit flesh was determined using flame photometer.The rate of respiration was measured as CO_2 evolved unit^{-1} weight of fruit unit^{-1} time with the help of Gas Data Analyzer (GFM series 30 - 1/2/3, Gas Data Ltd., Coventry, UK) and expressed as mL CO_2 kg^{-1} h^{-1}. Pectin methylesterase (PME) activity was measured by mixing 20 ml of 1.0 % pectin solution in 0.5 M sodium chloride (pH 7.0). To this, 10 ml of enzyme extract was added and the pH was adjusted to 7.0. The mixture was incubated for 24 hours at 30 ºC and then readjusted with 0.02 N NaOH to pH 7.0 PME units were recorded as milli equivalents of esters hydrolyzed per min per ml of juice and expressed as units/ml juice (Balaban et al., 2003).

$$\text{PME (units/ml)} = \frac{\text{ml of NaOH} \times \text{normality of NaOH} \times 1000}{\text{time} \times \text{ml of sample}}$$

To measure polygalacturonase (EC 3.2.1.15) activity (PG) 2 mL of enzyme extract, 4 ml of

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pectin in sodium acetate-acetic acid buffer (pH 5.2) and 1ml of acetate buffer were mixed in a vortex mixture for 2 min and the loss in viscosity of the substrate was recorded by ostwald-type viscometer (Mahadevan and Sridhar, 1982).

$$\% \text{ loss in viscosity of substrate} = \frac{T_0 - T}{T_0 - T_{H_2O}} \times 100$$

Where;

T_0 = Initial flow time

T = Flow time of the reaction mixture after 16 hours

T_{H_2O} = Flow time of distilled water

Consumerpreferencesforexperimentalfruitsampleswerefoundoutthroughsensoryevaluationperformedatmonthlyintervalsonthebasisofappearance,texture,flavour andtexture. Theevaluationwasdonebyusingthe9- pointhedonicscale(Amerine*etal*.1965). Results are presented as means of at least three independent determinations in the form of pooled data of two consecutive years using two-way analysis of variance (ANOVA) of the IBM SPSS Statistics program (Somers, NY, USA) with a significance level $\alpha = 0.05$. To evaluate the effect of different storage atmospheres and treatments on shelf life and quality of fruitTukey's HSD (honestly significant difference at $P < 0.05$) was used for significant mean separation (ranking sample means, largest to smallest) during cold storage.

Results and discussion

With progression in storage from 30 to 90 days there was an increase in PLW (Table 1) of whole fruit samples stored under refrigeration. The maximum PLW was reported after 90 days of storage in the untreated control fruit samples (14.52%) whereas,the minimum values were recorded in the treated fruit samples particularly, lowest PLW (4.79%) was recorded in fruit samples treated with 4 % $CaCl_2$ for 30 minwith statistically non significant variations recorded in fruits treated with 4 % $CaCl_2$ for 20 min (5.24%) and thosetreated with 3 % $CaCl_2$ for 30 min (5.34%) respectively. The continuous linear increase in PLW of the fruit was mainly attributed to transpiration and respiration losses.The reduced weight loss of the samples treated with higher concentrations of $CaCl_2$ might have resulted from the reported effectsof calcium on membrane functionality and integrity maintenance (Lester and Grusak1999) in calcium treated fruits. Similar findings on reduced weight loss of pear

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fruits treated with $CaCl_2$ have also been reported earlier by Mahajan and Dhatt (2004) during 75 days of refrigerated storage.

Flesh firmness continuously declined with periodic increase in storage intervals under refrigerated conditions. The fruits treated with 4 % $CaCl_2$ for 30 min and 20 min and 3 % $CaCl_2$ for 30 min were quite firm after 90 days of refrigeration and were acceptable for fresh consumption. A slow and more gradual decrease in firmness was recorded in the fruits under these treatments as a result the fruits treated with 4% calcium for 30 min.and exhibited the highest firmness values (5.15 kg/cm^2)were in close linearity with4 % $CaCl_2$ dipping for 20 min (4.91 kg/cm^2) and 3 % $CaCl_2$ for 30 min (4.92 kg/cm^2) treatments.Minimum firmness values (3.19 kg) on the other hand was recorded in control fruits. Fruit softeningis a result of breakdown of insoluble complex biomolecules like protopectins into soluble pectin or due to the hydrolysis of polysaccharides like starch. The retention of higher firmnessis attributes to accumulation of $CaCl_2$ in the middle lamella of cell walls which facilitates in the cross linking of the pectic polymers to increases cell wall strength and cell cohesion (White, 2002). Further, calcium salts have been well recognised to reduce activity of cell wall degrading enzymes like pectin methyle esterase (PME) and polygalacturonase (PG).PGis primarily responsible for softening in many fruits including pear cv. Conference(Bartley et al. 1982) and Bartlett (Ahmed1980, Bhat et al. 2011) during ripening. Polygalacturonase activation is a prerequisite and essential for the activation of PME as they collectively are responsible for fruit softening. Reducedactivity of PGby$CaCl_2$treatment have been well recognized in pear fruit earlier (Mahajan et al. 2013).

Changes in fruit TSS, total sugar and reducing sugar as affected by different treatments are highly correlated and are presented in Table 1 and 2.TSS content of the fruit increased initially with progression in storageperiod under refrigerated storage under all treatments reached a maximum value at the climacteric maxima and then to decline. Highest TSS of 14.44 °B, 14.21°B and 14.01 were recorded in fruits treated with 4 % $CaCl_2$ for 30 min and 20 min and 3 % $CaCl_2$ for 30 min after 90 days of refrigerated storage which followed a close linearity. Following a similar trend total sugar content of the fruit increased with increase in storage interval and then started to decline. The mean maximum total sugar were recorded in fruits treated with 4 % $CaCl_2$ for 30 min(9.28 %) closely followed by 4 % $CaCl_2$ for 20 min (8.78 %) and 3 % $CaCl_2$ for 30 min (9.25 %). Following the same trend maximum reducing sugar content was recorded in in fruits treated with 4 % $CaCl_2$ for 30

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min(6.35 %) which was significantly followed by 4 % $CaCl_2$ treatment for 20 min(5.41 %) and closely followed by 3 % $CaCl_2$ for 30 min(5.56 %). While, on the other hand minimum reducing sugar content was recorded in the untreated fruit sample.The fruit samples experienced rise in TSS, total andreducing sugars till they reachesclimacteric maxima followed by a gradual decline an indicative of onset of senescence irrespective of post-harvest treatments and storage conditions. The results of the present study pertaining to changes in TSS and fruit sugars (total and reducing) are in agreement with the findings of Sandhu and Singh, 2000, Wills et al. 1980 and Hayat et al. 2013.

Changes in ascorbic acid content of the fruits as affected by different $CaCl_2$ treatments during refrigerated storage after 30, 60 and 90 days indicated a continuous decrease in ascorbic acid content of fruits during refrigerated storage. The decrease was maximum in control fruits which recorded the lowest mean ascorbic acid content of (….mg/100)after 90 days of refrigerated storage. $CaCl_2$ treatments on the other hand were found to be effective in retaining higher ascorbic acid contentand the fruits treated with 4.0 per cent $CaCl_2$ for 30 min retained highest mean ascorbic acid content (11.54 mg/100g) after 30 days of refrigerated storage. and was followed by its lower concentrations.

Initial ascorbic acid content of pear fruit was found to be 16.63 mg/100g. Results for changes in ascorbic acid content of fruit with progressive increase in storage from 30 to 90 days under refrigerated storage are depicted in Table 2. The data revealed that there was a continuous and steep decline in the ascorbic acid content of the fruits under all the treatments. The maximum ascorbic acid (11.01 mg/100g) was recorded in fruits treated with 4 % $CaCl_2$ for 30 min which had statistically non significant differences with 4 % $CaCl_2$ dipping for 20 min (10.55 mg/100g) and 3 % $CaCl_2$ dipping for 30 min (10.92 mg/100g). The minimum ascorbic acid (6.12 mg/100g) was recorded in untreated control fruits after 90 days of refrigerated storage. The findings of present investigation are in agreement with those reported earlier by Soliva and Martin (2003) and Nath et al. (2013) in pear. $CaCl_2$ treatment might have resulted in reduction in activity of oxidizing enzymes which might have resulted in slow degradation and higher retention of ascorbic acid in such fruits. During storage, oxidizing enzymes like ascorbic acid oxidase, peroxidise, catalase and polyphenol oxidase facilitates the reduction of ascorbic acid of the fruit Nath et al. (2013).

Retention of total phenols was higher in the fruits treated with different concentrations of $CaCl_2$ on all sampling dates compared to control (Table 2). It was also noticed that the

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fruits dipped in 4 % $CaCl_2$ solution for 30 min exhibited significantly highest total phenols (32.95 mg/100g) which was also in close linearity with total phenolic content of the fruits treated with 4 per cent $CaCl_2$ for 20 min (32.88 mg/100g).The minimum phenolic content corresponds to the control fruits (24.86 mg/100g) which exhibited a rapid decrease in total phenols and spoiled on 90th day of storage.The continuous decline in phenolics during storage was attributed to activity of polyphenol oxidase (PPO). These results are in conformity with the findings of Randhawa (1982) in patharnakh pear. The slower rate of degradation of phenolics apparently indicates that calcium play an important role in delaying the activity of polyphenol oxidase enzyme due to delay in respiratory activity of the fruits (Tomas et al. 1997).

The calcium content of the fruitsamplesincreasedsignificantly during refrigeratedstorageupto90 days (Table 2). The highest amount of calcium (1438.91 ppm) was recorded in fruits treated with 4% $CaCl_2$for 30 min as compared to893.56ppm registered in untreated fruits after 90 days of refrigerated storage. The higher calcium content of the fruits treated with different concentrations of $CaCl_2$is associated to slow cellular degeneration and higher absorption of calcium by the fruits (Mahanty and Finerman 1975).Results of the present work are in line with those reported by Tobias et al.(1993)who found that calcium applied to fruit penetrates primarily through lenticels and increase Ca^+ content of the tissues, mainly in the middle lamella region. Also, Chardonnet et al.(2003) reported similar findings where the calcium content of Golden Delicious apple increased significantly after 6 months of refrigerated storage.

The activity of pectinmethylesterase (PME) exhibited a notable ‘up-down’ trend during storage (Figure 1) and PME activity of the control fruit increased sharply during the initial 2 months before declining during the remaining sampling and recorded the highest mean PME activity. While, a relatively slower and gradual increase in PME activity was observed in fruit samples treated with 4 % $CaCl_2$ for 30 minandresulted in lowest PME activity with non-significant differences in PME activity of the fruit samples treated with 4 % $CaCl_2$ for 20 min and 3% $CaCl_2$ for 30 min. PG activity, on the other hand, continued to rise with progression in storage (Figure 2). This behavior suggests that enzymes (PME and PG) actively participate in mid- and late-stage softening which ultimately leads to the onset of senescence. There was a sharp increase in PG activity of control fruit during storage, reaching peak values after the 3rd month of storage. However, fruit treated with different

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concentrations of $CaCl_2$ recorded a more gradual increase in PG activity.

Pectin methyl esterase (PME) de-esterifies galacturonic acid units in the pectin molecule and makes it susceptible to the action of polygalacturonase (PG) (Carpita and Gibeaut 1993). Polygalacturonase (PG) catalyses the hydrolytic cleavage of galacturonide linkages and is responsible for the major cell wall disassembly during ripening. The decrease in fruit firmness which generally occurs with a progressive increase in storage duration may be ascribed to an increase in the PG activity during ripening of the fruits. Similar observations on changes in the enzyme activity (PME and PG) have been reported earlier in cherimoya (Sanchez *et al.* 1998), Asian pear (Arzani *et al.* 2011), tomato (Ali and Abu-Goukh 2005), Rocha pears (Galvis Snchez *et al.* 2002) and prickly pear (Carrillo-Loapez *et al.* 2002).

Respiration rate of pear fruit, under different treatments, during refrigerated storage exhibited an initial increase before declining towards the end of storage (Fig. 1). Such changes were relatively faster in control fruits which recorded highest respiration after 90 days of refrigerated storage. Treatment of the fruits with different $CaCl_2$concentrations effectively reduced respiration rate of the fruits and the fruits treated with 4.0 % $CaCl_2$ for 30 min recorded the lowest respiration with statistically non-significant differencewith treatment of the fruits with 30 % $CaCl_2$ for 30 min. following 90 days of refrigerated storage.$CaCl_2$ has been reported to control ethylene action by strengthening the pectin framework and making fruit less susceptible to the action of ethylene. A delay in fruit ripening and decrease in rate of respiration of fruits upon calcium treatments has been reported during storage of peach (Manganaris *et al.* 2016), loquat (Babu *et al.* 2015), persimmon (Bagheri *et al.* 2015) and tomato (Arthur *et al.* 2015).

The effect of various treatments on sensory scores of pear fruits during refrigerated storage are presented in Fig. 2. It was observed that various $CaCl_2$ treatments were effective in influencing color, flavor, texture and overall acceptability rating of pear fruits, during refrigerated storage for 90 days. The color, texture, flavor and overall acceptability ratings were reported to be the highest for the fruit samples treated with 4.0 % $CaCl_2$ for 30 min. At the same time the fruits treated with 4 % $CaCl_2$ for 20 min and those treated with 3 % $CaCl_2$ for 30 min were also found equally effective in retaining the storage quality and sensory properties for up to 90 days of refrigerated storage. The control fruiton the other hand recorded the lowest overall acceptability score.

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Sensory quality scores were usually highest in fruits treated with different combinations of $CaCl_2$ whereas the control fruits exhibited rapid deterioration in quality during storage and were least acceptable. During ripening, degradation of chlorophyll results in exposer of the underlying carotenoids which is also accompanied by the conversion of starch into sugars and a decrease in acidity resulting in fruits becoming more acceptable. Such changes occurred rapidly in control fruits. While, changes in the sensory scores were more gradual under different $CaCl_2$ treatments and thus the initial increase in sensory scores of the fruits could be due to development of appropriate colour, taste, flavor and the most appreciated melting texture of fruits while the decline towards the end of storage could be due to the completion of ripening and initiation of senescence marked by the occurrence of undesirable changes. The findings of present study where higher sensory scores in pear fruits treated with $CaCl_2$ have been observed are congruous to the results obtained by Gorny *et al.* 2002 in pear and Conway *et al.* (2002) in apple fruits.

Conclusion

Use of calcium chloride to extend shelf life of pear fruits may be considered as an economic and alternative method for storage of pear fruits under ambient condition. Calcium treatment overall has shown that besides reducing PLW, it also effectively retained firmness, titratable acidity, ascorbic acid and total phenols while, at the same time maintained the highest level of TSS and sugars in the treated fruits. Amongst different treatments, 4% $CaCl_2$dip for 30 min. proved to be most effective which was statistically at par with treatment of 4% $CaCl_2$for 20 min. and 3% $CaCl_2$ for 30 min. It was concluded that 3% $CaCl_2$dip for 30 min has a beneficial effect on shelf-life parameters of pear fruits, by maintaining the quality parameters close to those of fresh fruits.

Acknowledgements

The present studies have been carried out in post harvest physiology (PHP) laboratory Dept. Of Food Science and Technology UHF, Nauni- Solan (HP) and the financial assistance provided by the institution for the study is fully acknowledged

References

Ahmad, F. (2008). Calcium therapy for prolongation of storage life of pear cv.‘Bartlett’. *Applied Biological Research*, *10*(1and2), 17-21.

ISSN:0971-1260
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Ali, M.B.,& Abu-Goukh, A.B.A. (2005). Changes in pectic substance and cell wall degrading enzymes during tomato fruit ripening. *Journal of Agricultural Sciences,*13(2), 202-223.

Amerine, M. A., Pangborn, R. M., & Roessler, E. B. (1965). Physical and chemical tests related to sensory properties of foods. *Principles of Sensory Evaluation of Food*.

Anonymous. (2014).Statistical Outline of Himachal Pradesh. Department of Economics and Statistics, Shimla (HP).

AOAC. (2000) Official methods of analysis, 15thed. Association of Official Analytical Chemists, Benjamin Franklin Station, Washington DC

Eric, A., Oduro, I., & Kumah, P. (2015). Postharvest quality response of tomato (Lycopersicon esculentum, Mill) fruits to different concentrations of calcium chloride at different dip-times.

Arzani, K., Khoshghalb, H., Malakouti, M. J., & Barzegar, M. (2011). Total oxalate-soluble pectin concentration in Asian pear (Pyrus serotina Rehd) fruit in relation to ripening, storage and Internal Browning disorder.

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

Bagheri, M., Esna-Ashari, M., & Ershadi, A. (2015). Effect of postharvest calcium chloride treatment on the storage life and quality of persimmon fruits (Diospyros kaki Thunb.) cv.'Karaj'. *International Journal of Horticultural Science and Technology*, *2*(1), 15-26.

Balaban, M.O., Arreola, A.G., Marshall, M., Peplow, A., Wei, C.I., Cornel, J., 1991. Inactivation of pectinesterase in orange juice by supercritical carbon dioxide. *Journal of Food Science* 56:743–746

Bangerth, F., Dilley, D. R., & Dewey, D. H. (1972). Effect of postharvest calcium treatments on internal breakdown and respiration of apple fruits. *Amer Soc Hort Sci J.*

Bangerth, F. (1979). Calcium-related physiological disorders of plants. *Annual review of phytopathology*, *17*(1), 97-122.

Bartley, I. M., Knee, M., & Casimir, M. A. (1982). Fruit softening I. Changes in cell wall composition and endo-polygalacturonase in ripening pears. *Journal of Experimental Botany, 33*(6), 1248-1255.

Błaszczyk, J., & Łysiak, G. (2001). Storage properties of Czech pear cultivars 'Erica'and 'Dicolor'. *Journal of Fruit and Ornamental Plant Research", IX (1-4),* 71-76.

ISSN:0971-1260
Vol-22-Issue-34-December -2019

Bhat, M. Y., Ahsan, H., Banday, F. A., Dar, M. A., Wani, A. I., & Hassan, G. I. (2012). Effect of harvest dates, pre harvest calcium sprays and storage period on physico-chemical characteristics of pear cv. Bartlett. *Journal of Agricultural Research and Development*, *2*(4), 101-106.

Carrillo-López, A., Cruz-Hernández, A., Cárabez-Trejo, A., Guevara-Lara, F., & Paredes-López, O. (2002). Hydrolytic activity and ultrastructural changes in fruit skins from two prickly pear (Opuntia sp.) varieties during storage. *Journal of agricultural and food chemistry*, *50*(6), 1681-1685.

Chardonnet, C. O., Charron, C. S., Sams, C. E., & Conway, W. S. (2003). Chemical changes in the cortical tissue and cell walls of calcium-infiltrated 'Golden Delicious' apples during storage. *Postharvest Biology and Technology*, *28*(1), 97-111.

Conway, W. S., Sams, C. E., & Hickey, K. D. (2002). Pre-and postharvest calcium treatment of apple fruit and its effect on quality. In *International Symposium on Foliar Nutrition of Perennial Fruit Plants 594* (pp. 413-419).

Dey, P.M., & Brinson, K.(1984). Pant cell wall. *Advances in CarbohydrateChemistry and Biochemistry*, 42.265-382

Dhatt, A. S., Bhatt, A. R., & Mahajan, B. V. C. (2003). Effect of postharvest calcium dips on uptake and fruit firmness in Asian pear. *Indian J Plant Physiol*, *8*, 475-479.

Dhatt, A.S., Mahajan, B.V.C.,& Dhatt, A.R.(2004). Effect of pre and post-harvest calcium treatments on the storage life of Asian Pear. *Acta Horticulturae*,696, 497-501.

Elgar, H. J., Watkins, C. B., Murray, S. H., & Gunson, F. A. (1997). Quality of 'Buerre Bosc'and 'Doyenne du Comice'pears in relation to harvest date and storage period. *Postharvest Biology and Technology*, *10*(1), 29-37.

Galvis Sánchez, A. C., & Morais, A. M. M. B. (2002). Effects of controlled atmosphere (CA) storage on pectinmethylesterase (PME) activity and texture of 'Rocha'pears. *Journal of the Science of Food and Agriculture*, *82*(1), 143-145.

Gomez, K.A.,Gomez, A.A.(1984). Statistical Procedures for Agricultural Research, John Wiley and sons, Singapore.

Gorny, J. R., Hess-Pierce, B., Cifuentes, R. A., & Kader, A. A. (2002). Quality changes in fresh-cut pear slices as affected by controlled atmospheres and chemical preservatives. *Postharvest biology and Technology*, *24*(3), 271-278.

ISSN:0971-1260
Vol-22-Issue-34-December -2019

Shazia, H., Mir, M. A., Singh, D. B., Hayat, N., & Khan, F. U. (2013). Effect of post-harvest treatment and storage conditions on quality of plum cv. Santa Rosa. *Progressive Horticulture*, *45*(1), 89-94.

Jones, R.G.W.,& Lunt, O.R.(1967). The function of calcium in plants. *Botanical Review* 33, 407-426

Joyce, D.C., Shorter, A.J.,& Hockings, P.D.(2001). Mango fruit calcium levels and the effect on postharvest calcium infiltration at different maturities. *Scientia Horticulture*, 91, 81-99

Lester, G.E., &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, 545-552

Mahadevan,A.,& Sridhar,R.(1982).Methodsin physiologicalplantpathology. SivaKamiPublishers,Madras.1112p.

Mahajan, B.V.C., &Dhatt, A.S.(2004). Studies on postharvest calcium chloride application on storage behaviour and quality of Asian pear during cold storage. *InternationalJournal* of *Food*, *Agriculture and Environment*,2(3-4), 157-159

Mahajan,B.V.C., Kumar, D., Dhillon,W.S.(2013). Effect of different polymeric films on shelf-life and quality of pear fruits under supermarket conditions. *Indian Journal of Horticulture*,70(2)-309-312

Mahanty, H.K., &Finerman, B.A.(1975). The effect of calcium on the ultra-structure of Cox's Orange apples with reference to bitter pit disorder. *Australian Journal of Botany*, 2355-65

Manganaris, G. A., Vasilakakis, M., Diamantidis, G., & Mignani, I. (2007). The effect of postharvest calcium application on tissue calcium concentration, quality attributes, incidence of flesh browning and cell wall physicochemical aspects of peach fruits. *Food Chemistry*, *100*(4), 1385-1392.

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

Nath, A., Deka, B. C., Singh, A., Patel, R. K., Paul, D., Misra, L. K., & Ojha, H. (2012). Extension of shelf life of pear fruits using different packaging materials. *Journal of food science and technology*, *49*(5), 556-563.

N.H.B.(2013). http://nhb.gov.in/area_production.html

Park, Y. M. (2002). Relationship between instrumental and sensory analysis of quality factors in apple and pear fruits. *Korean J Hortic Sci Technol*, *20*, 394-398.

ISSN:0971-1260
Vol-22-Issue-34-December -2019

Randhawa, J.S. (1982). Ripening and storage behavior of 'Patharnakh' pear (*Pyruspyrifolia*, Burm, Nakai). PhD Dissertation, PAU, Ludhiana, India

Sanchez, J. A., Zamorano, J. P., & Alique, R. (1998). Polygalacturonase, cellulase and invertase activities during cherimoya fruit ripening. *The Journal of Horticultural Science and Biotechnology*, *73*(1), 87-92.

Sandhu, A. S., Paul, S., & Dhillon, W. S. (2004). Studies on storage behaviour and shelf-life of semi-soft subtropical pear cv. Punjab beauty. In *VII International Symposium on Temperate Zone Fruits in the Tropics and Subtropics 662* (pp. 385-390).

Sandhu, S. S., & Singh, A. P. (2000). Effect of harvesting dates and individual seal packaging on the pear fruit cv. Le Conte during cold storage. *Haryana Journal of Horticultural Sciences*, *29*(1/2), 48-52.

Soliva-Fortuny, R. C., & Martín-Belloso, O. (2003). Microbiological and biochemical changes in minimally processed fresh-cut Conference pears. *European Food Research and Technology*, *217*(1), 4-9.

Tobias, R. B., Conway, W. S., Sams, C. E., Gross, K. C., & Whitaker, B. D. (1992). Cell wall composition of calcium-treated apples inoculated with Botrytis cinerea. *Phytochemistry*, *32*(1), 35-39.

Tomás-Barberán, F. A., Gil, M. I., Castaner, M., Artés, F., & Saltveit, M. E. (1997). Effect of selected browning inhibitors on phenolic metabolism in stem tissue of harvested lettuce. *Journal of Agricultural and Food Chemistry*, *45*(3), 583-589.

White, P. J. (2002). Recent advances in fruit development and ripening: an overview. *Journal of Experimental Botany*, *53*(377), 1995-2000.

White, P.J., &Broadley, M.R.(2003). Calcium in plants. *Annals of Botany*92, 487-511

Wills, R. B. H., Bambridge, P. A., & Scott, K. J. (1980). Use of flesh firmness and other objective tests to determine consumer acceptability of Delicious apples. *Australian Journal of Experimental Agriculture*, *20*(103), 252-256.

Wills, R. B. H., Tirmazi, S. I. H., & Scott, K. J. (1982). Effect of postharvest application of calcium on ripening rates of pears and bananas. *Journal of Horticultural Science*, *57*(4), 431-435.

Zerbini, P.E.(2002). The quality of pear fruit. *Acta Horticulturae,* 596, 805-810

ISSN:0971-1260
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Table 1:Effect of $CaCl_2$ treatments on changes on physiological loss in weight (%), firmness (kg/cm^2) total soluble solids (ºB) and reducing sugars content (%) of Bartlett pear fruits during cold storage

	Physiological loss in weight (%)			Firmness (Kg/cm^2)			Total soluble solids (˚B)			Reducing sugar (%)		
	30d	**60d**	**90d**	**30d**	**60d**	**90d**	**30d**	**60d**	**90d**	**30d**	**60d**	**90d**
1.0 % $CaCl_2$ + 10 min	2.58±0.11^{b}	5.32±0.16^{b}	8.02±0.11^{b}	8.67±0.11^{e}	7.09±0.01^{ed}	3.37±0.03g	11.36±0.13^{b}	14.16±0.12^{b}	10.17±0.03^{i}	4.02±0.09^{ba}	6.38±0.01^{a}	3.48±0.11^{b}
1.0 % $CaCl_2$ +20 min	2.29±0.12^{c}	5.00±0.05^{c}	7.58±0.14^{dc}	8.69±0.12^{e}	7.13±0.02^{d}	3.42±0.09g	11.17±0.08^{c}	14.13±0.08^{b}	10.87±0.08^{h}	3.98±0.02^{b}	6.16±0.05^{c}	3.84±0.14^{dc}
1.0 % $CaCl_2$ + 30 min	2.02±0.07^{d}	4.67±0.10^{f}	7.22±0.03^{e}	8.71±0.03^{de}	7.24±0.09^{c}	3.66±0.17fe	10.99±0.26^{c}	14.12±0.06^{b}	11.21±0.05^{g}	3.96±0.07^{b}	5.93±0.10^{e}	4.18±0.03^{e}
2.0 % $CaCl_2$ + 10 min	2.47±0.12^{bc}	5.11±0.15^{c}	7.74±0.05^{c}	8.72±0.05^{de}	7.18±0.07^{c}	3.51±0.10f	11.11±0.09^{c}	14.04±0.09^{cb}	10.88±0.06^{h}	3.98±0.02^{b}	6.36±0.05^{b}	3.68±0.05^{c}
2.0 % $CaCl_2$ + 20 min	2.25±0.21^{c}	4.71±0.01^{ef}	7.11±0.11^{fe}	8.88±0.12^{dc}	7.32±0.10^{c}	3.72±0.05e	11.07±0.10^{dc}	13.45±0.10^{d}	12.13±0.08^{ef}	3.92±0.01^{cd}	5.98±0.01^{d}	4.23±0.11^{fe}
2.0 % $CaCl_2$ + 30 min	1.78±0.13^{e}	4.32±0.12^{g}	6.34±0.13^{h}	9.08±0.09^{b}	7.65±0.11^{b}	4.29±0.06c	10.66±0.09^{e}	13.04±0.10^{f}	13.18±0.09^{b}	3.89±0.13^{d}	5.43±0.02^{g}	4.85±0.13^{h}
3.0 % $CaCl_2$ + 10 min	2.31±0.17^{c}	4.91±0.06^{d}	7.25±0.07^{e}	8.82±0.17^{dc}	7.31±0.17^{c}	4.06±0.11d	11.00±0.03^{d}	13.17±0.06^{e}	12.02±0.13^{f}	3.94±0.05^{b}	5.94±0.04^{ed}	4.17±0.07^{e}
3.0 % $CaCl_2$ + 20 min	1.80±0.16^{e}	4.12±0.09^{h}	6.33±0.16^{h}	8.97±0.06^{c}	7.46±0.11^{cb}	4.43±0.06c	10.58±0.11^{e}	13.06±0.04^{fe}	13.32±0.17^{b}	3.88±0.06^{d}	5.62±0.09^{f}	4.72±0.16^{h}
3.0 % $CaCl_2$ + 30 min	1.02±0.16^{g}	3.24±0.15^{i}	5.34±0.16^{i}	9.49±0.06^{a}	8.19±0.06^{a}	4.92±0.06b	10.35±0.04^{g}	12.82±0.05^{g}	14.01±0.10^{c}	3.76±0.06^{e}	5.42±0.05^{g}	5.56±0.16^{i}
4.0 % $CaCl_2$ + 10 min	2.08±0.05^{d}	4.28±0.14^{g}	6.86±0.05^{g}	9.03±0.15^{b}	7.53±0.05^{b}	4.36±0.15c	10.47±0.12^{f}	13.13±0.02^{e}	13.35±0.12^{ba}	3.87±0.05^{d}	5.48±0.06^{g}	4.99±0.05^{g}
4.0 % $CaCl_2$ + 20 min	1.61±0.11^{f}	3.12±0.11^{i}	5.24±0.0^{1i}	9.50±0.11^{a}	8.07±0.01^{a}	4.91±0.11b	10.37±0.01^{gf}	12.76±0.11^{hgi}	14.21±0.01^{a}	3.75±0.13^{ed}	5.31±0.01^{h}	5.41±0.01^{i}
4.0 % $CaCl_2$ + 30 min	1.33±0.01^{h}	2.71±0.06^{j}	4.79±0.01^{j}	9.53±0.10^{a}	8.20±0.11^{a}	5.15±0.13a	10.49±0.06^{f}	12.68±0.10^{i}	14.44±0.11^{a}	3.70±0.01^{e}	4.86±0.05^{i}	6.35±0.01^{j}
Control	5.46±0.12^{a}	8.67±0.15^{a}	10.01±0.09^{a}	7.41±0.22^{f}	4.68±0.12^{f}	1.38±0.04h	12.05±0.01^{a}	14.55±0.08^{a}	8.02±0.12^{i}	4.11±0.02^{a}	6.45±0.06^{a}	3.01±0.09^{a}

conditions.

Data presented in table is the average pooled values (mean ± SE) of two consecutive years

Measurements were made at harvest and after 30, 60, 90 and 120 days of cold storage

The values followed by the same lower case letter, in the same column and parameter are not significantly different at 95% confidence level. (Tukey's HSD test)

Table 1:Effect of $CaCl_2$ treatments on changes in total sugars (%), ascorbic acid (mg/100g), total phenols (mg/100g) and calcium content (ppm) of Bartlett pear fruits during cold storage conditions.

	Total sugar (%)			Ascorbic acid (mg/100g)			Total phenol (mg/100g)			Calcium content (ppm)		
	30d	**60d**	**90d**	**30d**	**60d**	**90d**	**30d**	**60d**	**90d**	**30d**	**60d**	**90d**
1.0 % CaCl2 + 10 min	5.45±0.08^{b}	9.11±0.11^{a}	5.97±0.15^{h}	13.45±0.02^{e}	11.14±0.09^{f}	8.46±0.06^{i}	77.71±0.01^{h}	56.42±0.12^{i}	30.68±0.08^{f}	747.00±0.36^{j}	1028.86±0.51^{k}	1168.82±0.56^{l}
1.0 % CaCl2 +20 min	5.41±0.02^{bc}	9.07±0.04^{b}	6.15±0.05^{g}	13.51±0.08^{e}	11.20±0.02^{e}	8.64±0.09^{h}	78.06±0.05^{g}	56.83±0.09^{h}	30.76±0.12^{f}	767.80±0.55^{i}	1040.77±0.52^{i}	1171.00±0.34^{k}
1.0 % CaCl2 + 30 min	5.23±0.03^{c}	8.99±0.02^{c}	6.67±0.12^{e}	13.54±0.06^{e}	11.34±0.12^{ed}	9.11±0.06^{g}	78.19±0.06^{f}	57.01±0.14^{e}	31.01±0.02^{g}	794.82±0.16^{g}	1062.34±0.63^{k}	1183.86±0.51^{j}
2.0 % CaCl2 + 10 min	5.32±0.11^{c}	9.05±0.03^{b}	6.38±0.03^{f}	13.48±0.09^{e}	11.17±0.05^{f}	8.76±0.15^{h}	77.89±0.13^{h}	56.72±0.07^{g}	30.73±0.13^{f}	762.45±0.65^{j}	1058.23±0.30^{j}	1187.12±0.35^{i}
2.0 % CaCl2 + 20 min	5.21±0.01^{c}	8.14±0.07^{d}	7.88±0.05^{c}	13.52±0.09^{e}	11.27±0.08^{e}	9.87±0.08^{f}	78.22±0.11^{f}	57.09±0.06^{e}	30.91±0.12^{e}	796.08±0.17^{f}	1080.37±0.33^{h}	1210.64±0.31^{h}
2.0 % CaCl2 + 30 min	5.10±0.09^{d}	7.71±0.07^{d}	8.84±0.19^{b}	13.90±0.05^{c}	11.49±0.09^{d}	10.23±0.02^{d}	78.43±0.15^{e}	57.35±0.18^{dc}	31.23±0.15^{d}	811.60±0.42^{d}	1088.83±0.20^{g}	1345.18±0.43^{f}
3.0 % CaCl2 + 10 min	5.20±0.09^{c}	8.82±0.16^{dc}	7.01±0.03^{d}	13.62±0.03^{c}	11.31±0.03^{e}	9.94±0.06^{f}	78.12±0.03^{f}	56.98±0.11^{f}	31.18±0.21^{d}	790.76±0.16^{h}	1091.77±0.36^{f}	1335.69±0.60^{g}
3.0 % CaCl2 + 20 min	5.02±0.06^{d}	7.62±0.04^{g}	8.77±0.04^{b}	13.81±0.14^{d}	11.57±0.04^{c}	10.24±0.07^{d}	78.64±0.06^{c}	57.62±0.14^{b}	31.46±0.09^{c}	809.23±0.22^{e}	1126.64±0.31^{e}	1369.38±0.71^{d}
3.0 % CaCl2 + 30 min	4.97±0.06^{ed}	7.48±0.06^{h}	9.25±0.06^{a}	14.18±0.04^{b}	11.94±0.04^{b}	10.92±0.05^{b}	79.02±0.10^{b}	58.07±0.16^{bc}	32.08±0.10^{b}	840.03±0.25^{c}	1221.87±0.43^{c}	1432.80±0.21^{c}
4.0 % CaCl2 + 10 min	5.11±0.11^{d}	8.21±0.08^{d}	7.86±0.04^{c}	13.74±0.01^{d}	11.54±0.08^{c}	10.06±0.06^{e}	78.56±0.15^{dc}	57.44±0.17^{cb}	31.51±0.24^{c}	800.53±0.44^{f}	1144.37±0.26^{d}	1341.17±0.54^{e}
4.0 % CaCl2 + 20 min	4.93±0.01^{f}	7.78±0.09^{e}	8.78±0.09^{b}	14.06±0.05^{c}	11.99±0.08^{b}	10.55±0.21^{c}	79.05±0.10^{b}	58.18±0.09^{a}	32.88±0.12^{a}	855.14±0.51^{b}	1244.30±0.21^{b}	1430.09±0.21^{b}
4.0 % CaCl2 + 30 min	4.87±0.01^{g}	7.69±0.11^{h}	9.28±0.22^{a}	14.29±0.07^{a}	12.08±0.08^{a}	11.01±0.08^{a}	79.12±0.06^{a}	58.33±0.19^{a}	32.95±0.16^{a}	868.02±0.41^{a}	1255.49±0.44^{a}	1438.91±0.60^{a}
Control	7.41±0.01^{a}	4.68±0.09^{i}	1.38±0.10^{i}	11.63±0.08^{f}	9.04±0.03^{g}	6.12±0.07^{j}	71.12±0.9^{i}	50.55±0.10^{j}	24.86±0.09^{g}	701.11±0.61^{k}	805.09±0.31^{l}	893.56±0.40^{m}

ISSN:0971-1260
Vol-22-Issue-34-December -2019

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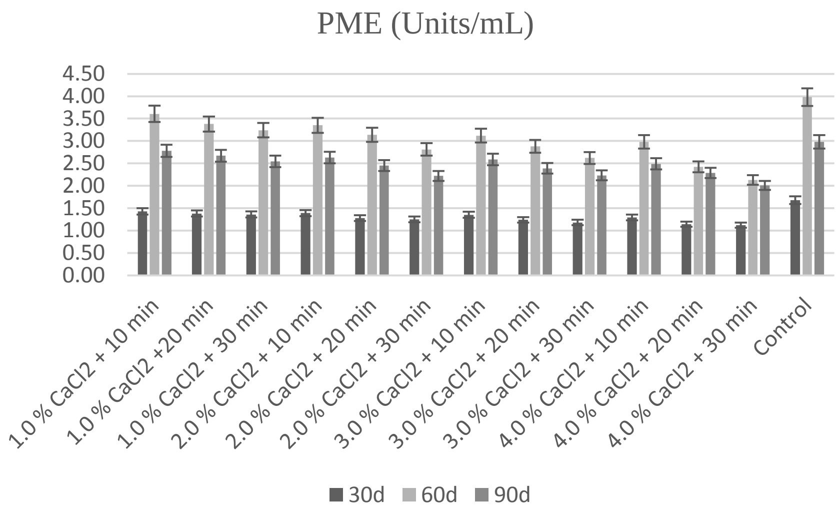

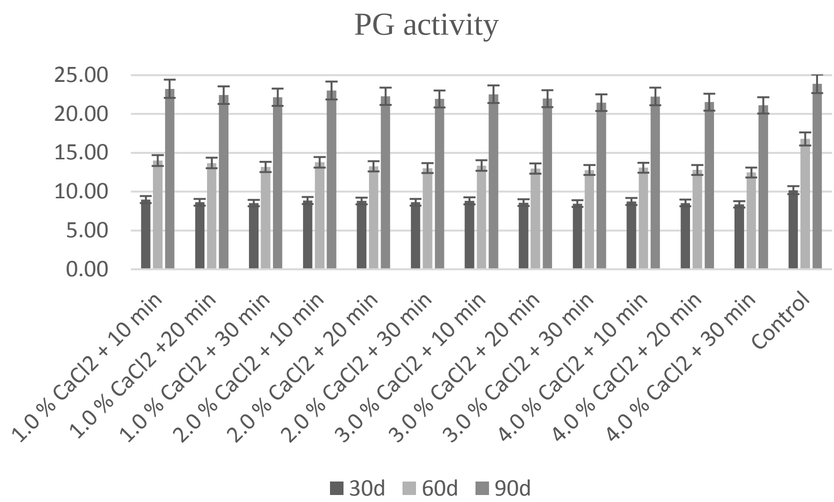

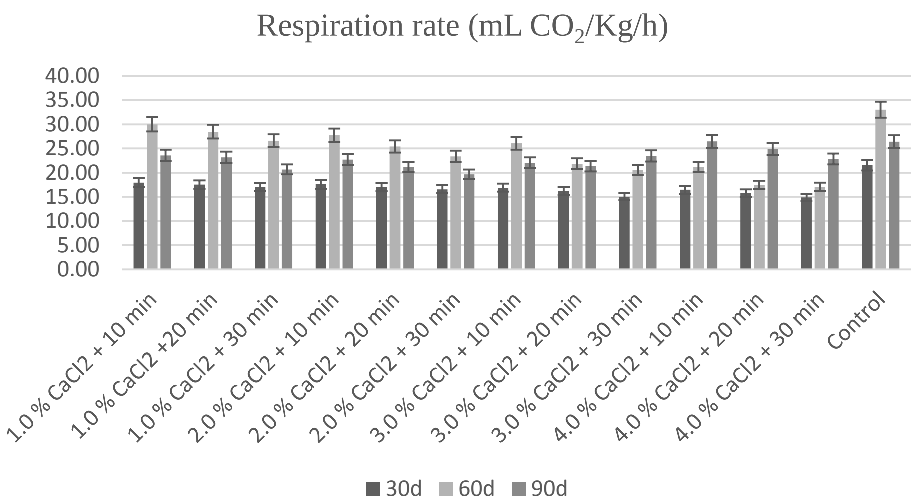

Fig 1. Effect of different post harvest $CaCl_2$ treatments on pectin methyl esterase (PME), polygalacturonase (PG) and respiration rate of fruit storedfor 90 days under 2±1°C temperature and 90±5% RH

ISSN:0971-1260
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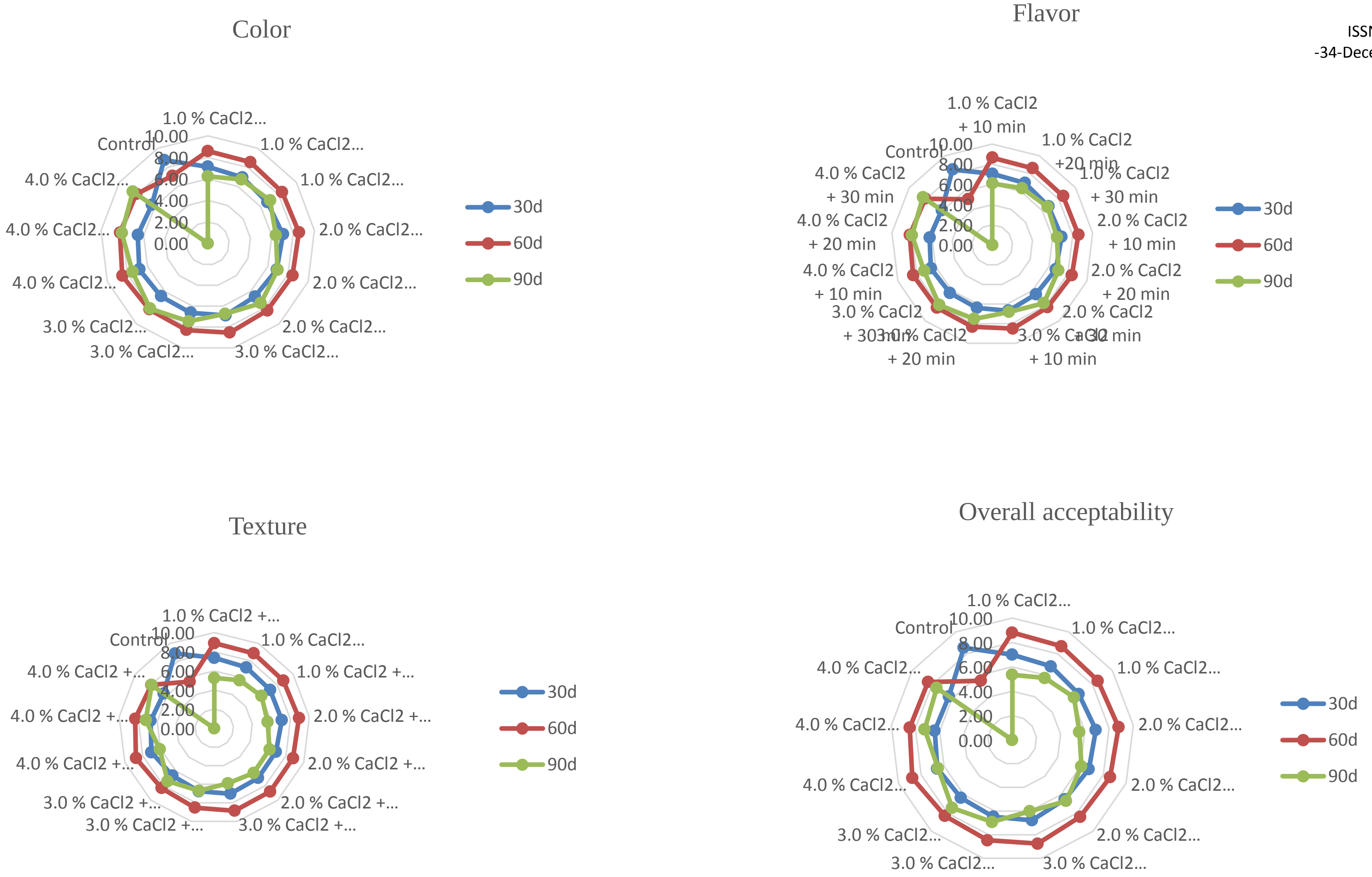

Figure 2: Effect of $CaCl_2$ treatments on colour, Flavor, texture and overall acceptability of pear fruit cv. Bartlett during refrigerated storage.