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INFLUENCE OF POST-HARVEST CALCIUM CHLORIDE TREATMENTS ON PHYSICO-CHEMICAL AND SENSORY ATTRIBUTES OF PEAR cv. 'BARTLETT' UNDER AMBIENT STORAGE CONDITIONS

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ABSTRACT

Freshly harvested pear fruits were treated with different $CaCl_2$ concentrations (1, 2, 3 and 4%) for 10, 20 and 30 min, respectively, for each concentration and dipping time changes in the activity of cell wall degrading pectic enzymes *viz*., pectin methyl esterase (PME), polygalacturonase (PG), quality parameters *viz*., fruit firmness, TSS: acid ratio, respiration rate, physiological loss in weight (PLW) and sensory characteristics *viz*., colour, taste, texture and overall acceptability were studied on different sampling dates (7, 10, 13, 16 and 19th day). PME activity, fruit respiration, PLW and sensory quality of fruits increased in all the treatments up to the climacteric peak of respiration which appeared on 16th day of storage in the fruits treated with 4 % $CaCl_2$ for 30 and 20 min and 3% $CaCl_2$ for 30 min, and decreased thereafter. The activity of PG and TSS: acid ratio increased progressively during ripening of pear fruits. The increase in PG activity closely followed decrease in fruit firmness, while the activity of PG did not exactly match the respiration climacterics.

Key words: $CaCl_2$, enzyme firmness, fruit quality, pear, respiration

INTRODUCTION

Pear (*Pyrus communis*) stands 2nd in ranking after apples as the most important temperate fruit crop, grown throughout the temperate regions of the world. Pear has been under cultivation both in Europe and Asia since pre-historic times. About 72% of all commercially cultivated species of genus *Pyrus* are native to Asia. Pear fruits possess high medicinal properties and are rich in fructose which is the predominant sugar, followed by glucose and sucrose. Various phenolic glucoside compounds and tannins isolated from pear are considered to be beneficial in urinary therapeutics and have anti-inflammatory, antioxidant, antibacterial, analgesic and spasmolytic effect. In India pear is grown in warm humid sub-tropical plains and cold dry temperate regions occupying an area of 44,000 ha with an annual production of 3,23,000 metric tonnes (NHB, 2016). In Himachal Pradesh pear occupies an area of 7106 ha with annual production of 32,039 tonnes (Department of Economics and Statistics. Government of Himachal Pradesh, 2016).

In Himachal Pradesh harvesting of pear starts around 3rd week of July and continues up to September. Generally, this period coincides with heavy rainfall and high temperature which is not conducive for retaining post-harvest quality of fruits and therefore, so have adverse effects on fruit marketability (Dhatt *et al*., 2003). The growers are forced to sell their produce during this period at very low prices. Pear fruit is a typical climacteric fruit that undergoes increase in respiration with a burst of ethylene production during ripening. As ripening process in pears proceeds quickly, the fruit consumption period is limited, and therefore fruits are transported to markets prior to the stage of their optimum eating quality.

The involvement of calcium in the regulation of fruit maturation and ripening is well established (Mahajan and Dhatt, 2004; Bhat *et al*., 2011; Cheour and Souiden, 2015). Calcium application before or after harvest prevents physiological disorders, increases disease resistance, delays ripening and subsequently improves fruit quality (Manganaris *et al.,* 2007). Ca treatment reportedly decreases respiration, reduces ethylene production and delays the onset of ripening in apple, strawberry, avocado, mango, etc. (Manganaris *et al.*, 2007). The success to increase Ca levels in some fruit by pre- and post-harvest $CaCl_2$ treatments is limited as the literature shows great disparity in the concentrations used while absorption behaviour and penetration of $CaCl_2$ into the fruit also varies from fruit to fruit (Joyce *et al.*, 2001). Pear fruits cv. 'Williams Bon Chretien' dipped in $CaCl_2$ solution under reduced pressure (125-375 mm Hg) stored at 20ºC showed delay in ripening by about 40% of the time taken by untreated fruits (Wills *et al.*, 1982).

Ripening of pear fruits is typically characterized by rapid softening which is associated with cell wall disassembly due to the action of pectin methyl esterase (PME), polygalacturonase (PG) which modify pectic substances in cell wall during ripening so cause loss of fruit firmness. PME and PG are prominent fruit softening enzymes that cause striking changes in wall pectin thereby initiate fruit ripening and these activities increase during ripening process (Carvalho *et al.*, 2009). The reports on extension of shelf life and reduction of post-harvest losses of pear by $CaCl_2$ as postharvest treatment are highly inconsistent (Chen *et al*., 1993). Therefore, keeping in view the role of calcium in the extension of fruit shelf life and to exploit market potential for fresh fruits, the present study was aimed to standardize post-harvest $CaCl_2$ treatment of pear fruits for retaining their storage quality.

MATERIALS AND METHODS

Experimental material

Pear cv. 'Bartlett' fruits were harvested from commercial pear orchard located in Kotkahi, Shimla (31° 7' 0'' North, 77° 32' 0'' East) at hard-green stage in the 1st week of August, 2015 and brought immediately to the post-harvest and physiology laboratory of the Department of Food Science and Technology. Healthy fruit were randomly divided into sample lots of 20 fruits each and were rubbed gently with soft cloth, immediately dipped in 1 or 2 or 3 or 4% $CaCl_2$ solution for 10 or 20 or 30 min, subsequently dried in shade and packed in CFB boxes. Each box contained 20 fruits and every treatment was replicated three times in a completely randomized design. The fruit lots were stored at ambient temperature (23.4ºC and 83% RH). The changes in enzyme activities, fruit firmness, respiration rate and sensory quality of fruits were assessed after 7 days of storage and then at successive interval of 3 days until the fruits become unacceptable.

Polygalacturonase activity

Polygalacturonase activity (PG) was determined as per Mahadevan and Sridar (1982). The enzyme reaction mixture consisted of 2 mL enzyme extract (which was prepared by crushing fruit flesh), 4 mL pectin in sodium acetate-acetic acid buffer (pH 5.2) and 1 mL acetate buffer. The mixture was put into an Ostwald-type viscometer [Optech instrumentation, 120 × 1 mm (length × internal diameter)]. Overall height (237 mm) through smaller arm and the initial efflux time of mixture was measured. After 16 h, again the efflux time of mixture was measured and loss in viscosity interpreted as being proportional to the PG activity.

$$\text{Per cent loss in viscosity of substrate, V} = \frac{T_0 - T}{T_0 - TH_2O}$$

Where T_0 = Initial flow time, T = Flow time of the reaction mixture after 16 h; TH_2O = Flow time of distilled water.

Pectin methyl esterase activity

In a 50 mL beaker, 20 mL of 1% pectin solution in 0.5 M sodium chloride was adjusted to pH 7.0. To this, 10 mL enzyme extract was added and pH of enzyme substrate mixture adjusted to 7.0. The mixture was incubated for 24 h at 30ºC and then readjusted with 0.02 N NaOH to pH 7.0 using pH tester. The quantity of NaOH used gives a measure of free carboxyl groups and thus is an indication of enzyme activity (Mazumdar and Mazumdar, 2003).

Fruit firmness and respiration rate

Flesh firmness of fruits was measured by a portable Effigi penetrometer (FT-327, Alfonsine-Italy) which recorded the pressure required to force a plunger of 8 mm dia and 24.4 mm penetration depth into the flesh of fruit samples. Two readings were recorded on opposite sides of each fruit after the removal of peel. The rate of respiration was measured as CO_2 evolved unit^{-1} weight of fruit unit^{-1} time. Known weight of fruits was enclosed in an airtight container of known volume for a known time and the CO_2 evolved due to respiration was measured 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}.

Sensory evaluation

Consumer preferences for experimental fruit samples were assessed through sensory evaluation performed at various intervals during storage by a panel of 10 semi-trained judges. The panelists were given coded samples consisting of whole fruits and slices for giving their views on overall acceptability of fruit on the basis of colour, taste, texture and overall acceptability. The evaluation was done by using the 9-point hedonic scale for each attribute.

Statistical analysis

Results were presented as means of three independent determinations. Statistical evaluation was performed as per two-way analysis of variance using IBM SPSS Statistics Program (Somers, NY, USA). Critical difference between treatments was assessed 5% significance level.

RESULTS AND DISCUSSION

Changes in fruit flesh firmness and TSS/ acid ratio

Flesh firmness of fruits in different treatments showed a progressive linear decline from 10.19 to 1.48 kg cm^{-2} during storage upto 19th day (Table 1). The highest decline in fruit firmness was noticed in untreated fruits which were unacceptable on 16th day of storage. The mean firmness was highest in fruits treated with 4% $CaCl_2$ for 30 min (5.78 kg cm^{-2}) which was at par with the fruits treated with 4% $CaCl_2$ for 20 min (5.7 kg cm^{-2}) and fruits treated with 3% $CaCl_2$ for 30 min (5.64 kg cm^{-2}). The treated fruits were acceptable up to 16 days of storage while untreated could maintain the acceptance level up to 13 days only. The fruits treated with higher concentration of $CaCl_2$ recorded higher firmness values on all the sampling dates as compared to the untreated fruits (Table 1) which might be due to the reduced fruit softening (Bhat *et al.*, 2010). Fruit firmness significantly decreased with advancement in storage period and the progressive softening of flesh during storage might be attributed to the degradation of soluble pectin by high activity of endopolygalacturonase enzyme in fruits (Kaur *et al.,* 2013).

TSS: acid ratio increased during storage with highest value (53.81) observed after 19 days of storage while significantly lower TSS: acid ratio (25.41) was observed in fruits after 7 days of storage kept under ambient conditions. Significantly higher TSS: acid ratio of 46.15 was observed

Table 1: Effect of post-harvest $CaCl_2$ treatments on fruit firmness and TSS/acid ratio of pear cv. Bartlett under ambient conditions

$CaCl_2$ dip	Fruit firmness (kg cm^{-2})						TSS/acid ratio					
	7th day	10th day	13th day	16th day	19th day	Mean	7th day	10th day	13th day	16th day	19th day	Mean
1% for 10 min	7.80	6.83	4.59	2.78	1.29	4.66	27.44	34.09	46.90	60.36	61.93	46.15
1% for 20 min	7.86	6.90	4.69	2.90	1.38	4.74	26.42	32.16	43.90	59.80	64.62	45.38
1% for 30 min	8.00	7.13	4.94	3.15	1.50	4.95	24.99	29.99	41.19	56.77	60.52	42.69
2% for 10 min	7.84	6.94	4.74	2.99	1.47	4.80	26.42	32.51	44.25	59.89	63.77	45.37
2% for 20 min	8.00	7.19	5.07	3.34	1.53	5.03	25.65	30.80	40.76	56.11	50.46	40.76
2% for 30 min	8.20	7.40	5.40	3.71	1.67	5.28	24.16	28.76	39.46	54.46	57.82	40.93
3% for 10 min	8.07	7.18	5.02	3.35	1.51	5.02	25.39	30.72	41.42	57.09	61.39	43.20
3% for 20 min	8.33	7.55	5.44	3.81	1.63	5.35	24.13	28.70	37.20	51.54	59.90	40.29
3% for 30 min	8.51	7.78	5.54	4.56	1.81	5.64	23.39	27.35	34.99	51.26	54.57	38.31
4% for 10 min	8.26	7.52	5.41	3.86	1.73	5.36	23.86	29.37	37.67	50.70	56.25	39.51
4% for 20 min	8.60	8.00	5.46	4.60	1.83	5.70	22.78	26.72	35.18	51.82	53.83	38.07
4% for 30 min	8.70	8.06	5.57	4.63	1.92	5.78	22.24	25.76	33.76	50.63	54.48	37.37
Control, packed in CFB	7.64	5.70	1.55	0.00*	0.00*	2.98	33.48	60.00	83.72	0.00*	0.00*	44.30
Mean	8.14	7.24	4.88	3.36	1.48		25.41	32.07	43.11	50.80	53.81	
Initial value:	10.19 kg cm^{-2}						17.92					
$CD_{0.05}$												
Treatment (T) =	0.14						2.19					
Storage (S) =	0.08						1.76					
Interaction (T× S) =	0.31						6.12					

*The figures represent the control sample which spoiled on sampling date

in fruits treated with 1% $CaCl_2$ for 10 min and it was minimum (37.37) in fruits treated with 4% $CaCl_2$ for 10 min which was closely followed by 3% $CaCl_2$ treatment for 30 min (38.3), 4% $CaCl_2$ for 10 min (39.51) and 4% $CaCl_2$ for 20 min (38.07) as compared to the control fruits which became unacceptable on 16th day. The ratio between TSS and acidity decides the overall acceptability of fruits. During storage many biochemical changes disturb the TSS: acid ratio and ultimately render the fruits unacceptable. An increase in TSS: acid ratio during storage may possibly be due to the continuous decrease in acidity as the acids are converted into sugars and concomitant increase in TSS content which may be attributed to the increase in TSS by breakdown of complex carbohydrates into simpler sugars. The changes were more pronounced in the treatments where $CaCl_2$ was used in lower concentration coupled with low treatment time. Our findings are supported by Bhat *et al*. (2011), Nath *et al*. (2012) and Kaur *et al*. (2013).

Changes in pectin methyl esterase activity

The fruits treated with higher concentration of $CaCl_2$ for longer time exhibited low enzyme activity as compared to the fruits treated with low levels of calcium. PME activity increased in all the treatments up to 13th day of storage, reached a maximum value of 4.16 in untreated control fruits and then followed a linear decline on further sampling days (Table 2). The observed decline in PME activity might be attributed to complete solubilization of pectin by PME (Kaur *et al*., 2014). Similar trend in PME activity in 'Eva apples' have been reported by Thomas *et al*. (2014) and in litchi by Punumong *et al*. (2016). Koslamund *et al*. (2005) reported highest PME activity at green stage when fruit firmness was high. PME activity was higher in more ripe fruits than less ripe fruits and the activity increased only slightly during softening and did not exactly match the climacteric peak of respiration. The fruits treated with 3% $CaCl_2$ dip for 30 min, 4% $CaCl_2$ for 20 or 30 min followed the least increase in PME activity on different sampling dates.

Table 2: Effect of postharvest $CaCl_2$ treatments on pectin methyl esterase (PME) and polygalacturonase (PG) activities in pear cv. Bartlett under ambient conditions

$CaCl_2$ dip	Pectin methylesterase (PME) activity						Polygalacturonase (PG)					
	7th Day	10th day	13th day	16th day	19th day	Mean	7th day	10th day	13th day	16th day	19th day	Mean
1% for 10 min	1.25	2.63	3.68	2.98	1.94	2.50	8.76	11.95	16.11	21.24	23.32	16.28
1% for 20 min	1.20	2.49	3.46	2.95	1.85	2.40	8.44	11.63	16.00	21.02	23.00	16.02
1% for 30 min	1.18	2.40	3.36	2.89	1.81	2.33	8.31	11.60	15.92	20.95	22.76	15.91
2% for 10 min	1.19	2.52	3.45	2.92	1.86	2.39	8.47	11.67	16.02	21.01	23.03	16.04
2% for 20 min	1.13	2.31	3.24	2.79	1.76	2.25	8.21	11.38	15.83	21.17	22.76	15.87
2% for 30 min	1.08	2.20	3.10	2.73	1.73	2.17	8.11	11.22	15.69	20.45	22.15	15.52
3% for 10 min	1.13	2.36	3.28	2.81	1.77	2.27	8.36	11.59	15.87	20.86	22.80	15.90
3% for 20 min	1.07	2.14	2.99	2.69	1.73	2.12	8.13	11.20	15.64	20.57	21.64	15.44
3% for 30 min	0.99	2.03	3.11	2.65	1.70	2.10	8.01	10.89	15.32	20.25	20.98	14.96
4% for 10 min	1.05	2.16	3.22	2.75	1.75	2.19	8.25	11.32	15.63	20.51	22.29	15.60
4% for 20 min	0.97	1.98	3.04	2.67	1.70	2.07	8.03	10.87	15.21	20.04	21.02	15.03
4% for 30 min	0.93	1.92	2.97	2.66	1.55	2.01	7.92	10.75	15.01	19.94	20.13	14.75
Control, packed in CFB	1.68	3.14	4.16	0.00*	0.00*	2.99	9.81	12.94	19.46	0.00*	0.00*	14.07
Mean	1.14	2.33	3.31	2.58	1.63		8.37	11.46	15.98	19.08	20.45	
Initial value:			0.72						6.12			
$CD_{0.05}$												
Treatment (T) =			0.14						0.46			
Storage (S) =			0.09						0.29			
Interaction (T× S) =			0.32						1.03			

*The figures represent the control sample which spoiled on 16th day of storage

The least increase in enzyme activity of calcium-treated fruit may result from calcium interacting directly with cell wall pectic substances, leading to cell wall stiffening. Calcium may also act by reducing the activity of cell wall degrading enzymes. PME has been reported only to act as a precursor of PG, provoking demethylation of pectins and thus facilitating PG activity (Bennet and Labavitch, 2008). Endo-polygalacturonase is the enzyme primarily responsible for softening in 'Asian pear' (Arzani *et al.*, 2011). Bhat *et al.* (2012) reported delay in ripening and slowdown of PG activity in pear by the application of calcium.

Changes in polygalacturonase activity

*P*G activity progressively increased during fruit ripening. The increase in PG activity was observed during the period when the fruit experienced rapid ripening changes between 10 to 16 days of storage which resulted in rapid loss of fruit firmness (Table 2). There was a significant increase in enzyme activity of fruits during storage from 6.12 on first day of sampling to 20.45 on 19th day. Different treatments significantly affected PG activity and with increase in $CaCl_2$ concentration and time of dipping PG activity reduced significantly as compared to control fruits. PG activity was minimum in fruits treated with 4% $CaCl_2$ for 30 min (14.75), closely followed by fruits treated with 4% $CaCl_2$ for 20 min (15.03) and fruits treated with 3% $CaCl_2$ for 30 min (14.96) indicating the importance of calcium in maintaining the cell wall integrity (Table 2). At the climacteric peak a maximum decrease in enzyme activity and least softening was noticed in fruits treated with 4% $CaCl_2$ for 30 min (19.94 flesh firmness 5.94 kg), followed by fruits treated with 4% $CaCl_2$ for 20 min (20.04; flesh firmness 5.78 kg) and fruits treated with 3% $CaCl_2$ for 30 min (20.25; flesh firmness 5.69 kg) on 16th day of storage indicating that the fruits still had consumers acceptability.

Pectic enzymes are most important in softening of fruit tissues during ripening. Pectins are the key substances involved in the mechanical strengthening of primary cell wall (Sirisomboon *et al.*, 2000). As ripening proceeds, pronounced changes in cell wall composition and in the degree of esterification of pectins occurred during fruit ripening. The softening process might be the consequence of pectin de-esterification catalyzed by PME, followed by pectin depolymerization catalyzed by PG (Abu-Bakr *et al.*, 2003). In contrast, Gwanpua *et al.* (2012) reported that the loss of apple fruit firmness is not attributed only to PG activity but to the combined effect of many factors. The series of chemical reactions ultimately lead to the changes in fruit texture and sensory properties which are perceived by consumers to access the proper stage of fruit for a particular use.

Changes in physiological loss in weight

The physiological loss in weight (PLW) of fruits increased significantly with storage, irrespective of the treatments applied (Fig. 1). However, $CaCl_2$ treatment was effective in minimizing PLW as compared to control treatment which exhibited maximum PLW (12.59%) on 13^{th} day and became unacceptable following further storage with a mean PLW of 9.05% after 13 days storage.

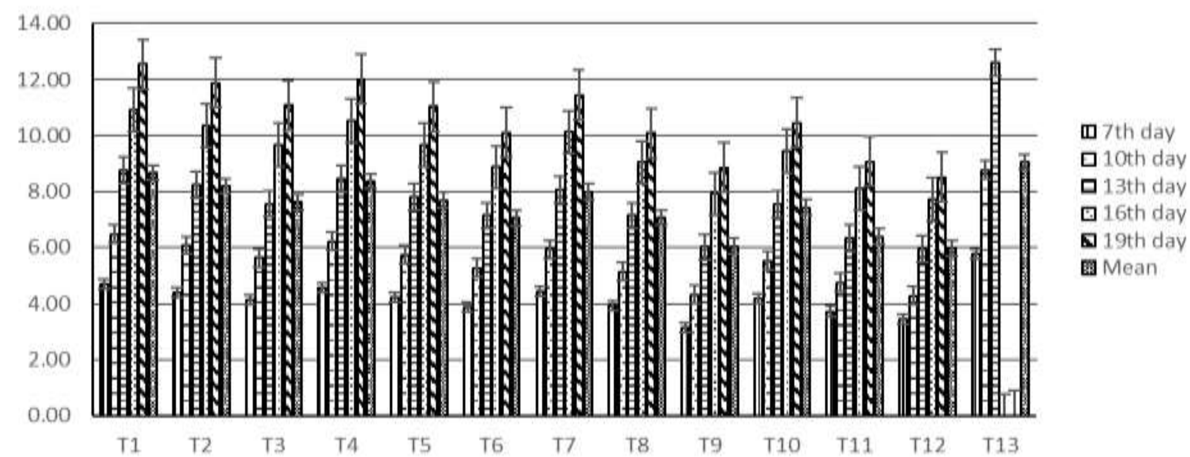

Fig. 1: Effect of postharvest calcium chloride treatments on physiological loss in weight of pear cv. 'Bartlet' under ambient storage conditions: T_1 = 1% $CaCl_2$ dip for 10 min, T_2 = 1% $CaCl_2$ dip for 20 min, T_3 = 1% $CaCl_2$ dip for 30 min, T_4 = 2% $CaCl_2$ dip for 10 min, T_5 = 2% $CaCl_2$ dip for 20 min, T_6 = 2% $CaCl_2$ dip for 30 min, T_7 = 3% $CaCl_2$ dip for 10 min, T_8 = 3% $CaCl_2$ dip for 20 min, T_9 = 3% $CaCl_2$ dip for 30 min, T_{10} = 4% $CaCl_2$ dip for 10 min, T_{11} = 4% $CaCl_2$ dip for 20 min, T_{12} = 4% $CaCl_2$ dip for 30 min, and T_{13} = Control (No $CaCl_2$ dip, packed in CFB)

The fruits treated with 4% $CaCl_2$ for 30 min recorded lowest mean PLW (5.98%) and it was significantly followed by fruits treated with 3% $CaCl_2$ for 30 min 0(6.05%), after 19 days of storage under ambient conditions. The role of calcium in maintaining the structural integrity of membranes and cell walls while regulating the quality and storage life of fruits is well established. Generally, fruits high in calcium remains in good condition for longer duration as calcium decreases respiration rate and directly reduces PLW. $CaCl_2$ treatment have been found to reportedly reduce weight loss in pear fruits earlier also (Mahajan and Dhatt, 2004; Sandhu *et al*., 2004; Ahmad, 2008; Bhatt *et al*., 2011).

Changes in respiration rate

The rate of CO_2 production during respiration (mL CO_2 kg^{-1} h^{-1}) followed a typical climacteric pattern, with respective climacteric peaks attained for best treatments *i.e.* fruits treated with 4 per cent $CaCL_2$ for 30 min (32.48 mL CO_2 kg^{-1} h^{-1}), fruits treated with 4%t $CaCl_2$ for 20 min (32.38 mL CO_2 kg^{-1} h^{-1}) and fruits treated with 3% $CaCl_2$ for 30 min (32.86 mL CO_2 kg^{-1} h^{-1}) on 16^{th} day of storage. The control sample could maintain consumer acceptability only up to 10^{th} days of storage. Significant difference in respiration was noticed in all the treatments at all storage intervals and their interaction showed climacteric peak for fruits treated with 4% $CaCl_2$ for 30 min, 4% $CaCl_2$ for 20 min and 3% $CaCl_2$ for 30 min on 16^{th} day of storage which occurred in other treatments on 13^{th} day

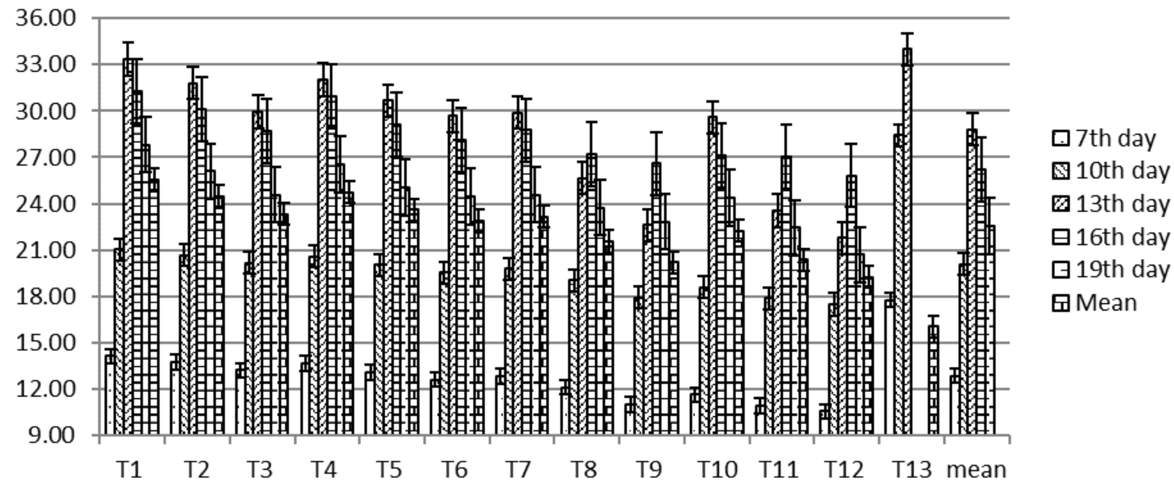

Fig. 2: Effect of postharvest calcium chloride treatments on respiration rate (mL CO_2 kg^{-1} h^{-1}) of pear cv. 'Bartlet' under ambient storage conditions: T_1 = 1% $CaCl_2$ dip for 10 min, T_2 = 1% $CaCl_2$ dip for 20 min, T_3 = 1% $CaCl_2$ dip for 30 min, T_4 = 2% $CaCl_2$ dip for 10 min, T_5 = 2% $CaCl_2$ dip for 20 min, T_6 = 2% $CaCl_2$ dip for 30 min, T_7 = 3% $CaCl_2$ dip for 10 min, T_8 = 3% $CaCl_2$ dip for 20 min, T_9 = 3% $CaCl_2$ dip for 30 min, T_{10} = 4% $CaCl_2$ dip for 10 min, T_{11} = 4% $CaCl_2$ dip for 20 min, T_{12} = 4% $CaCl_2$ dip for 30 min, and T_{13} = Control (No $CaCl_2$ dip, packed in CFB)

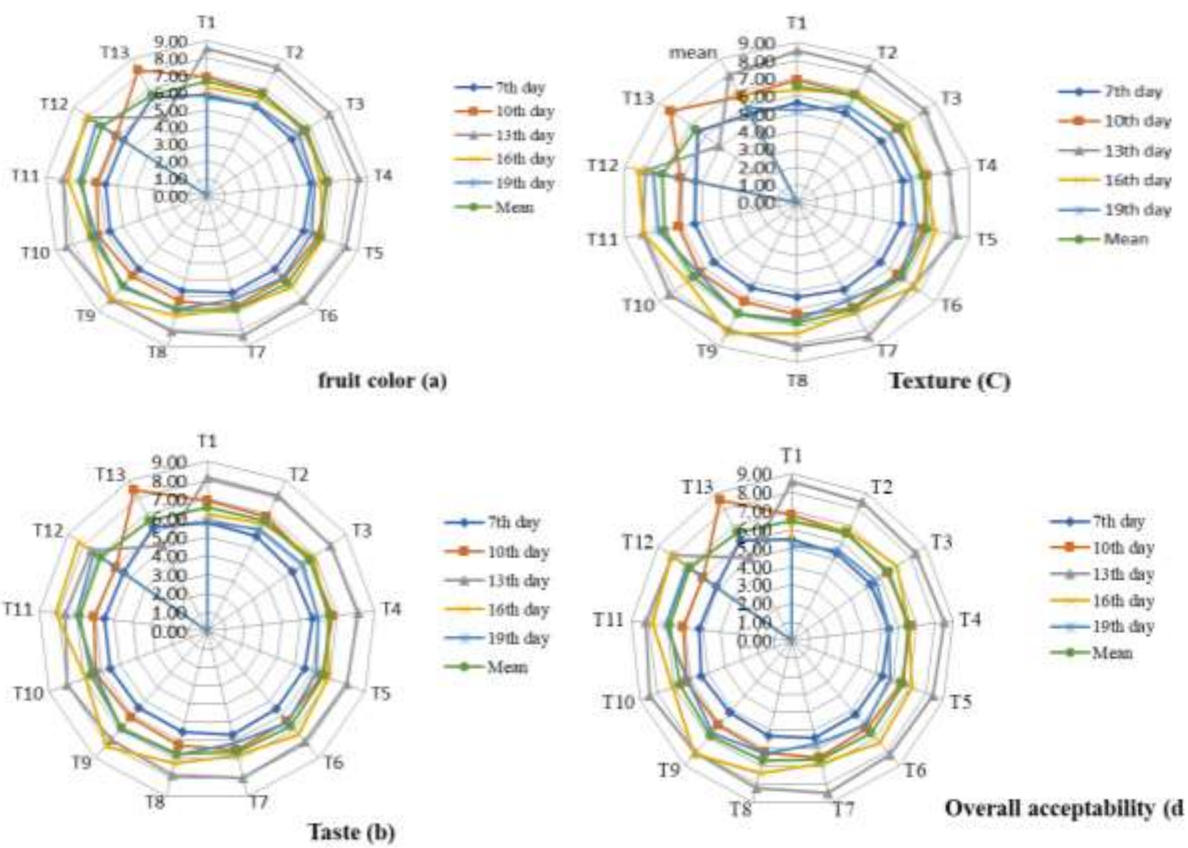

Fig. 2: Effect of post-harvest $CaCl_2$ treatments on sensory attributes of pear cv. Bartlett fruits under ambient conditions

13th day, thus revealing the importance of different concentrations of $CaCl_2$ in maintaining fruit quality. The results of present investigation are in agreement Drake *et al.* (2001), Dou-Shi Juan *et al*. (2002), Ribeiro *et al*. (2003) and Drake *et al*. (2004) in pear fruits.

Changes in sensory attributes

All $CaCl_2$ treatments increased sensory attributes *viz*., colour, taste, texture and overall acceptability scores reaching a maximum value, then followed by a decline (Fig. 2). A rapid increase was observed in control fruit wherein fruit colour (8.25), taste (8.44), texture (8.25) and overall acceptability (8.56) were highest on 10th day of storage; thereafter showed a sharp decline and were non-acceptable on further sampling dates. On the other hand, fruits treated with 4% $CaCl_2$ for 30 min, 4% $CaCl_2$ for 20 min and 3% $CaCl_2$ for 30 min had highest sensory quality on 16th day of storage while other treatments excluding control shown highest consumer acceptability on 13th day of storage after which fruits lost their quality traits at a faster rate. Highest mean values for different sensory attributes after 19 days of storage were recorded in fruits treated with 4% $CaCl_2$ for 30 min i.e. colour (7.05), taste (6.91), texture (7.04) and overall acceptability (6.89) and were significantly followed by fruits treated with 4% $CaCl_2$ for 20 min i.e. taste (6.87), texture (6.96) and overall acceptability (6.86) and fruits treated with 3% $CaCl_2$ for 30 min i.e. colour (7.0), taste (6.88), texture (6.95) and overall acceptability (6.84).

The decrease in sensory rating with the advancement of storage period might be associated with over-ripening, onset of senescence, loss of texture and decrease in acidity. Colour, taste and texture are important for their role in perception of overall acceptability by the consumers. During ripening, transitions of chlorophyll into carotenoids (Kays, 1991), biochemical conversions of starch into sugars (Martinez *et al.*, 1997), loss of organic acids through oxidation (Campestre *et al.*, 2002) are responsible for the changes in sensory attributes. The initial increase in overall scores could be due to the development of appropriate colour, aroma and taste during ripening while decline towards end of storage could be due to the initiation of senescence.

Conclusion: The study revealed that 4% $CaCl_2$ treatment for 20 or 30 min or 3% $CaCl_2$ treatment for 30 min of freshly harvested pear fruits proved equally effective in maintaining the quality and extending the shelf life of 'Bartlett' pear fruits. Dipping the fruits in 3% calcium for 30 min can be used by the pack-houses for retaining the quality attributes and extending shelf life of pear fruits under ambient conditions.

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