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INFLUENCE OF CALCIUM CHLORIDE ($CaCl_2$) ON FRUIT QUALITY OF PEAR (*Pyrus communis)* CV. LE CONTE DURING STORAGE

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An experiment was conducted at Postharvest laboratory, Department of Horticulture, The University of Agriculture Peshawar, during 2010 to evaluate the "Influence of calcium chloride ($CaCl_2$) on fruit quality of pear (*Pyrus communis*) cv. Le-conte". The experiment was laid out in Randomized Complete Block Design (RCBD) with three factors i.e. $CaCl_2$ concentration (0, 3, 6 and 9%), dipping time (5, 10 and 15 minutes) and storage durations (0, 10, 20, 30 and 40 days). The maximum ascorbic acid (7.93 mg/100 g), reducing sugar (5.86%), while the least percent weight loss (4.52%), pH of fruit juice (4.42), total soluble solids (TSS) (19.83%) and percent disease incidence (2.56%) were observed in fruits treated with 9% $CaCl_2$ solution. The dipping time also significantly influenced the quality attributes of pear fruits during storage. The more ascorbic acid (6.88 mg/100 g) and reducing sugar (5.44%) were recorded in the pear fruits dipped for 15 minutes. Storage duration significantly affected the fruit quality during 40 days storage. The highest reducing sugar recorded in fresh pear fruits while the highest ascorbic acid (7.83 mg/100 g) were observed in pear fruit stored for 10 days storage duration, while more non-reducing sugar (7.03%) recorded in the fruits stored for 30 days. In the interaction of $CaCl_2$ concentration × dipping time, the highest total soluble solid (31.88%) noted in the fruits stored for 40 days and dipped for 5 minutes in $CaCl_2$ solution. It is concluded that pear fruit perform best in the postharvest life when treated with 9% $CaCl_2$ solution and dipped for 15 minutes. It retained most of the quality attributes up to 10 days storage at ambient temperature while a significant decline was recorded in fruit quality when extended the storage duration from 20 to 40 days.
Keywords: Calcium chloride, fruit quality, pear, fruit firmness, ascorbic acid and storage

INTRODUCTION

Pear (*Pyrus communis)* cv. Le Conte belongs to the family Rosaceae. In Pakistan pear orchard are found on the terraces or in the hills and in the plan areas of Khyber Pakhtunkhwa (Mardan, Peshawar and Hazara) (Muhammad, 2009). Total area under pear cultivation in Pakistan is 2130 hectares with production 24376 tons, while in Khyber Pakhtunkhwa pear is cultivated on an area 1949 hectares with the total production 23472 tons (MINFAL, 2008-09). Calcium in the form of pectic substances it is founded first in the middle lamella and in the primary cell walls of all plant tissues. It acts as cell binding or cementing materials. Calcium plays important role in the stability of cell wall structure, especially in fruits that are stored for relatively long time such as pears (Pooviah, 1988). The gradual infiltration of calcium to cell wall results in increasing level of this ion in the cell wall and thus stabilizes it and protects the fruit against fungal and other microbial attack or contamination (Pooviah *et al*., 1991). Postharvest treatment of pear fruit with 2% of $CaCl_2$ solution followed by cold storage (2°C & 90% RH) and ripening after storage for one week at 20°C not only prevented cell wall and membrane from degradation, but it also decreased ethylene production and delayed its ripening process (Lara and Vendrell, 1998). The firmness of "Red Delicious" apple is directly related to the calcium concentration in post-harvest hydro cooling treatment (Conway and Sams, 1984). High levels of calcium in plant tissues delays ethylene production, ripening and senescence, improve fruit quality and increase fruit resistance to disease (Carl and William, 1984). Pear is moderately perishable fruit which can be stored from 4 to 8 weeks. Many post harvest physiological disorder are reduced by increasing the calcium level in fruit tissues (Masson, 1974). Bitter pit and softening in apple, blossom end rot in tomato, tip burn in lettuce, hollow heart in potato and pear are related to low calcium content in the fruit tissues. Increasing calcium by pre-harvest or post-harvest applications may decrease the occurrence of these disorders (Lougheed *et al*., 1979). Calcium (such as Calcium Chloride) conserved the qualities of fruits, prevented physiological disorders, reduced the rate of respiration, lessens the solubilization of pectic substance, maintaining the firmness and slows down the ripening process (Magee *et al*., 2002). Shelf-life and fruit quality of Ca-sprayed fruit was improved due to higher Ca concentrations in fruit peel and cortex resulting in overall enhancement of fruit appearance, and in improvement in the control of the incidences of cork spot, scald, brown core, external and internal rots, and in amelioration of fruit juiciness and fruit

color (Raese *et al*., 2000). Due to the mishandling, inadequate storage or lack of post harvest technical knowledge producers and traders have to face about 20-30% or even up to 40% losses of fruits in Pakistan that is estimated to a value of more than 3 billion rupees loss in the country (Rathore *et al*., 2007). Keeping in view the importance of postharvest management, an experiment was conducted to study the influence of calcium chloride on fruit quality of pear (*Pyrus communis)* cv. Le-Conte during storage.

MATERIALS AND METHODS

To study the "Influence of calcium chloride ($CaCl_2$) on fruit quality of pear (*Pyrus communis)* cv. Le-Conte during storage" an experiment was conducted at Postharvest laboratory, Department of Horticulture The University of Agriculuture Peshawar during July 2010. The experiment was laid out in Randomized Complete Block Design (RCBD) with three factors i.e. calcium chloride concentration (0, 3, 6 and 9%), dipping time (5, 10 and 15 minutes) and storage durations (0, 10, 20, 30 and 40 days).

The healthy pear fruits cv. Le-Conte were collected from pear orchard Malakandher fruits farm during the months of July 2010, at physiological maturity stage. The healthy fruits were selected and discarded the bruised and injured ones. The pear fruits were carefully transported to postharvest laboratory, Department of Horticulture, Agricultural University Peshawar and stored for 40 days at ambient temperature (20°C) and recitative humidity (65-70 RH).

The data were recorded on the following physical and chemical attributes of pear fruits during storage duration.

***Percent weight loss (PWL)*:** The percent weight loss was determined for all treatment in each replication. Five fruits were selected and marked with black permanent marker properly to avoid mixing with other fruits. All the marked pear fruits were randomly selected. The weight of the selected fruits was taken with the help of electrical balance and the mean were recorded. At the end the percent weight loss was calculated with help of the following formula.

$$\text{Percent weigh loss} = \frac{\text{Weight of fresh fruit - weight after duration}}{\text{Weight of fresh fruit}} \times 100$$

***pH of fruit juice*:** The pH of the randomly selected pear fruits was determined for all treatment in each replication with the help of pH meter (Model No. INOLAB. pH 720). Before the use of pH meter it was standardized with standard buffer solution. Juice was extracted from randomly selected pear fruit through juicer and the sample of juice was taken in a beaker for the pH determination purpose. Then pH meter electrode was dipped in it. At the same time the temperature dial was set to juice sample and the pH was carefully noted on the pH meter scale.

***Total soluble solids (%)*:** The total soluble solids of the pear fruits were determined with the help of hand refractometer of the randomly selected fruit for all treatment in each replication. A drop of the representative pear fruit juice was placed on the absolutely clean and dry prism of the hand refractometer and the reading was recorded. For the each sample the prism was washed with distilled water and cleans with tissue paper.

***Ascorbic acid (mg/100 g)*:** Ascorbic acid of the fruits will be determined by dye method as prescribed in AOAC(1990) of randomly selected fruit for all treatment in each replication with the help of following formula.

$$\text{Percent Ascorbic Acid} = \frac{F \times T \times 100}{D \times S} \times 100$$

Where $F = \text{Factor for standardization} = \frac{\text{ml of ascorbic acid}}{\text{ml of dye}}$

T = ml of dye solution used

D = ml of diluted sample take for titration.

S = g of pear juice taken for dilution.

***Reducing sugar (%)*:** For the determination of reducing sugar (%) we used the following reagents.

Fehling - A: Dissolve 34.65 gm of $CuSO_4.5H_2O$ in 500 ml distilled water.

Fehling - B: Dissolve 173 gm sodium Potassium titrate + 50 gm of NaOH in 500 ml distilled water.

Indicator: Methylene blue 0.2 gram in 100 ml distilled water. 100 ml of H_2O was added and dissolved the chemicals by striking. The solution was transferred to 500 ml flask and volume was mad up to the mark with distilled water.

***Non-reducing sugar (%)*:** For the determination of non reducing sugar we use the following reagents.

Fehling - A: Dissolve 34.65 gm of $CuSO_4$. 5 H_2O in 500 ml distilled water.

Fehling - B: Dissolve 173 gm sodium Potassium titrate + 50 gm of NaOH in 500 ml distilled water.

Indicator: Methlylene blue.

***Percent disease incidence*:** The disease incidence in each replication and treatment was visually examined on the daily basis and recorded the data in percentage for the fruits that was showing the symptoms of diseases incidence for all treatment after each duration in each replication with the help of following formula.

$$\text{Percent disease incidence} = \frac{\text{No. of disease fruits}}{\text{Total no. of fruits}} \times 100$$

The data calculated on different parameters were subjected to Analysis of Variance (ANOVA) technique to observe the differences between the different treatment as well as their interactions. In cases where the differences were significant, the means were further assessed for differences through Least Significant Difference (LSD) test. Statistical computer software, MSTATC (Michigan State University, USA), was applied for computing both the ANOVA and LSD (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

***Percent weight loss (PWL)*:** The statistical analysis of the data showed that $CaCl_2$ concentrations and storage duration had significant effect on the percent weight loss of pear fruits, while dipping time had non significant effect on percent weight loss. The interaction of $CaCl_2$ concentration x storage duration had significantly influenced percent weight loss of the pear fruits (Fig. 1), whereas, the remaining interactions had non significant response.

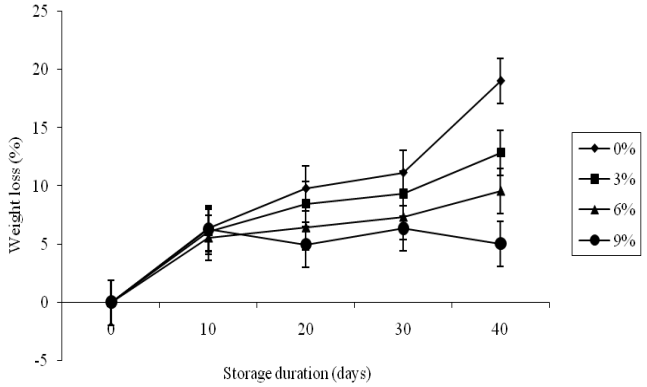

Figure 1. Effect of $CaCl_2$ Conc. (%) and storage duration (days) on percent weight loss

The percent weight loss significantly decreased with increasing the $CaCl_2$ concentration. The mean values of the data indicated that more weight loss (9.27 %) was recorded in untreated pear fruits, followed by 7.35% when fruits were treated with 3% $CaCl_2$ solution as compare to the fruit treated with 9% $CaCl_2$ solution having the least weight loss (4.52%). The percent weight loss significantly increased with increasing the storage duration. The highest percent weight loss (11.63%) recorded in fruit stored for 40 days as compared to (6.07%) in fruits stored for 10 days. The interaction of $CaCl_2$ concentration x storage duration showed that the highest percent weight loss (19.03%) was recorded in untreated fruits stored for 40 days. It is found that the high concentration of $CaCl_2$ declined the weight loss in pear fruit. The minimum percent weight loss of pear fruits may be due to optimum level of $CaCl_2$ served as semi permeable membrane and cell wall is integrated which slow down the evapo-transpiration and rate of respiration in fruits. Therefore, the $CaCl_2$ solution at an optimum level of 9% reduced the percent weight loss in pear fruits during storage. Excessive weight loss may causes shrivel (visible wrinkling) in the fruits during storage. In this experiment more weight loss (%) has been observed in the untreated pear fruit (Tabatabaie and Malakouti, 1998). Hayat *et al.* (2003) recorded more weight loss in untreated fruit stored for longer period of time. The findings of the current investigation are also in agreement with the findings of Bidabe (1970) who reported that the increase in weight loss in apple fruits was recorded as the storage period was further extended. The results are in relation with Sajid *et al.* (2012) who stated that increased weight loss of citrus was observed by increasing storage duration.

Table 1. Effect of $CaCl_2$ concentrations (%), dipping time (minutes) and storage durations on percent weight loss, pH, TSS and ascorbic acid (mg/100 g) of pear fruit Cv.Le-Conte.

Treatments	Treatments levels	Weight loss (%)	pH	Total soluble solid (0brix)	Ascorbic acid mg/100 g
$CaCl_2$ concentration (C) (%)	0	9.27 a	4.67 a	21.40 a	5.16 c
	3	7.35 b	4.48 b	21.54 a	6.25 b
	6	5.78 c	4.47 b	20.67 b	6.56 b
	9	4.52 d	4.42 b	19.83 c	7.93 a
	LSD at 5%	0.86	0.07	0.45	0.63
Dipping time (D) (minutes)	5	7.12	4.50	21.11	6.21 b
	10	6.82	4.53	20.80	6.35 ab
	15	6.27	4.49	20.68	6.88 a
	LSD at 5%	NS	NS	NS	0.55
Storage duration (S) (days)	0	0.00 e	3.83 e	14.25 d	7.51 ab
	10	6.07 d	4.18 d	14.15 d	7.83 a
	20	7.42 c	4.36 c	17.76 c	7.10 b
	30	8.55b	5.00 b	26.83 b	5.91 c
	40	11.63 a	5.19 a	31.31 a	4.04 d
	LSD at 5%	0.96	0.07	0.51	0.70
Interactions	C ×D	NS	NS	* (Fig 3)	* (Fig 6)
	C×S	* (Fig.1)	* (Fig 2)	* (Fig 4)	NS
	D ×S	NS	NS	* (Fig 5)	NS
	C ×D×S	NS	NS	NS	NS

* = significant at 5 %; NS = non significant; C = $CaCl_2$ Concentration, D = Dipping time and S = Storage duration

***pH of fruit juice*:** The data pertaining to the pH of pear fruit juice showed in the Table 1. The statistical analysis of the data showed that $CaCl_2$ concentrations and storage durations had significant effect on pH of the pear fruits. A non-significant response was observed for the dipping time on pH of fruit juice. The pH of fruit juice was significantly influenced by the interaction of $CaCl_2$ concentration and storage durations, whereas, all other interactions showed non-significant response on pH of fruit juice during 40 days storage. A significant difference was observed when the fruits were treated with different concentration of $CaCl_2$ solution. The mean value of the data showed that highest pH (4.67) value was recorded in untreated fruits i-e in control treatment. A non-significant variation was recorded in fruits treated with 3, 6 and 9% $CaCl_2$ solution, which are at par with each other. However the lowest pH value of 4.42 was noted in fruits treated 9% $CaCl_2$ solution. The pH value of fruit juice significantly increased with increase in storage durations from 0 to 40 days at ambient condition. The highest pH value of 5.19 was recorded in fruits when stored for maximum storage duration of 40 days, followed by fruit (5.00) stored for 30 days. The lowest pH value of 3.83 was noted in fresh fruit at 0 day storage. The interaction of $CaCl_2$ concentration and storage duration had significantly influenced the pH of fruit juice during storage. The highest pH value (5.54) was noted in untreated fruit when stored for 40 days, closely followed by the fruit having pH (5.19) treated with 3% $CaCl_2$ solution and stored for 30 days at ambient condition. Whereas, the lowest pH (3.82) was recorded in the untreated and fresh fruit stored for 0 days (Fig. 2).

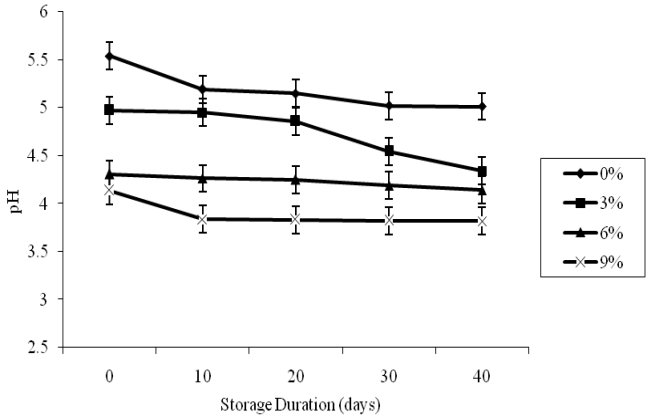

Figure 2. Effect of $CaCl_2$ Conc. (%) and storage duration (days) on pH

The possible reason might be due to the fact that lower strengths of both calcium chloride and dipping times were proved less effective to prevent the conversion of acids into sugars. But high concentration of calcium chloride prevented a decline in the acidity of the fruits and the biochemical changes which results in less increase in the pH of fruit juice (Hayat *et al.,* 2003). The pH value of apple fruit increased with increasing the storage duration (Khalid, 1974). On other side the treatment of $CaCl_2$ concentration of strawberry fruit significantly reduced the fruit pH during storage (Andrea *et al.,* 1999).

***Total soluble solid (%)*:** The data concerning to total soluble solid (%) are showed in the Table 1. The analysis of the data showed that the total soluble solids (%) of pear fruit were significantly influenced different concentration of $CaCl_2$ solution and the storage durations at an ambient temperature of 20-28°C. The dipping time had non-significant effect on TSS of fruit juice during 40 days storage. The interactions of $CaCl_2$ concentration x dipping time, $CaCl_2$ concentration x storage duration and dipping time x storage duration also had a significant effect on total soluble solid of the pear fruits. The interaction of $CaCl_2$ concentration × dipping time × storage duration showed a non-significant response on total soluble solid (%) of the pear fruits during 40 days storage (Table 1). The total soluble solids decreased significantly with increase in $CaCl_2$ concentrations. The highest total soluble solid (21.54%) was recorded in the pear fruits treated with 3% $CaCl_2$ concentration, followed by untreated fruit (21.40%) with non-significant difference between 0 and 3% $CaCl_2$ concentration. The least total soluble solids (19.83%) recorded with 9% $CaCl_2$ concentration. The total soluble solids (TSS) increased with increase in storage duration of pear fruit from 0 day to 40 days storage. The total soluble solids increased significantly from 14.25 recorded with 0 day storage to 31.31 for fruit after 40 days storage. The interactions of $CaCl_2$ conc. x dipping time had significant response on total soluble solids (TSS) of pear fruit. The interaction of $CaCl_2$ conc. and dipping time showed that the highest value of total soluble solids (21.8%) retained in untreated fruits, dipped for 15 minutes. The lowest total soluble solids (TSS) value of (19.12%) recorded in fruits treated with concentration of 9% $CaCl_2$ solution dipped for 15 minutes (Fig. 3).

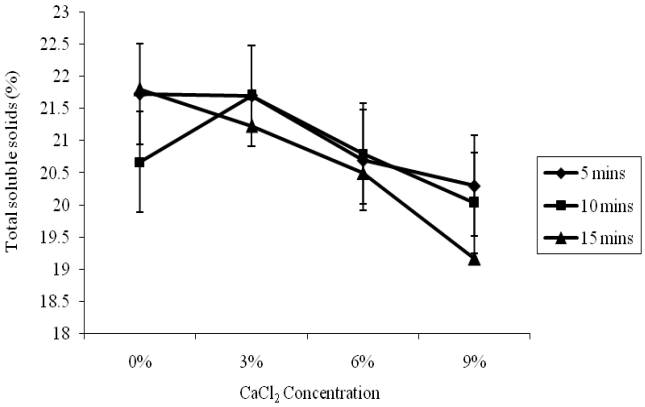

Figure 3. Effect of $CaCl_2$ Conc. (%) and dipping (minutes) on total soluble solid

The interactions of $CaCl_2$ conc. x storage duration and dipping time x storage duration significantly influenced the total soluble solid (TSS) of the pear fruits during 40 days storage. The highest total soluble solid (32.83%) observed in the fruits treated with 0% $CaCl_2$ solution stored for 40 days, while the least total soluble solid (13.39%) recorded in fruits treated with 0% $CaCl_2$ solution stored for 10 days (Fig. 4). The interaction of storage duration and dipping time showed that more total soluble solid (31.88%) noted in the fruits stored for 40 days and dipped for 5 minutes in $CaCl_2$ conc. The lowest TSS (13.33%) recorded in the pear fruits stored for 10 days and dipped for 10 minutes in solution of $CaCl_2$ (Fig. 5).

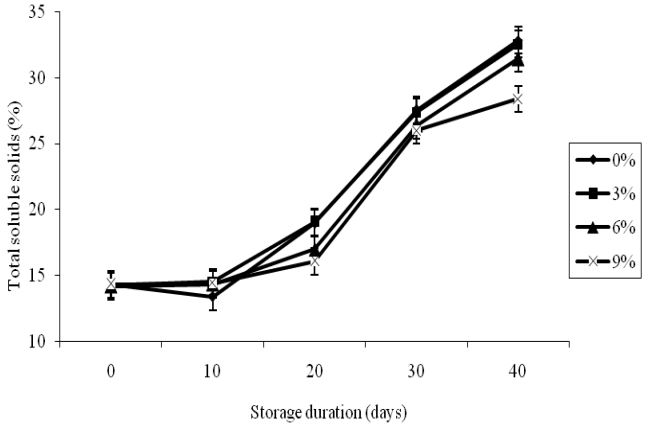

Figure 4. Effect of $CaCl_2$ Conc. (%) and storage duration (days) on total soluble solid

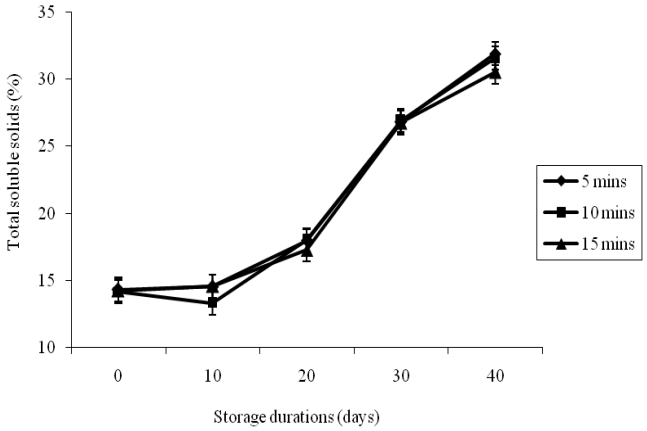

Figure 5. Effect of dipping time (min.) and storage duration (days) on total soluble solid

The possible reasons for increasing the total soluble solid in untreated pear fruits or treated with low concentration of $CaCl_2$ might be due to the reason that some content of starch present in the fruits during picking slowly and gradually converted into sugar during storage period (Bhartiya *et al.,* 1998). The high concentration of calcium chloride application increased the metabolic activities which ultimately decreased the TSS of the apple fruits, while more TSS noted in untreated apple fruit during storage (Alam *et al.,* 2003). The results of the experiment are also in line with Arthey and Philip (2005), who reported that higher retention of total soluble solid, is due to slower alteration in cell wall structure which breakdown into simple sugars. It might be due to carbon is stored largely in the form of starch in most climacteric fruit and these starch will sweeten under post-harvest conditions because of starch degradation and conversion to soluble sugars depending upon storage temperature (Beaudry *et al*., 1989). The present results also confirmed the results of Jan *et al.* (2012), who concluded that increasing storage duration increased the total soluble content in apple. Furthermore, an increased trend in TSS in sweet orange was observed from 0 to 30 days which then decreased as the storage life is increased to 60 days (Khan *et al.,* 2007)

***Ascorbic acid (mg/100 g)*:** The ascorbic acid of pear fruit was significantly influenced by $CaCl_2$ concentrations, storage durations, dipping time and the interaction of $CaCl_2$ concentration x dipping time (Table 1). The ascorbic acid was significantly retained at highest level with the application of higher $CaCl_2$ concentration. The highest level of ascorbic acid (13.87 mg/100 g) recorded in fruits treated with 9% $CaCl_2$ concentration, followed by 6 and 3% $CaCl_2$ concentrations with ascorbic acid of 6.56 and 6.25 mg/100 g, respectively. The difference in 3 and 6% was, however, non significant. The lowest ascorbic acid value (5.16 mg/100 g) was observed in fruits treated with 0% $CaCl_2$ concentration. The dipping time significantly influenced the content of ascorbic acids in fruit. The mean value of the data showed that least ascorbic acid (6.21 mg/100 g) was recorded in the pear fruits dipped for 5 which is at par with the fruit dipped for 10 minutes in $CaCl_2$ solution. The more ascorbic acid (6.88 mg/100 g) was recorded in the pear fruits dipped for 15 minutes in $CaCl_2$ solution. The ascorbic acid decreased with increase in storage duration. It is evident from the mean value that the more ascorbic acid (7.51 mg/100 g) and (7.83 mg/100 g) were recorded in the pear fruits stored for 0 and 10 days. Whereas, the least ascorbic acid (4.04 mg/100 g) was recorded in the pear fruits stored for 40 days. The mean value regarding the interaction of $CaCl_2$ concentration x dipping time interpreted that the high ascorbic acid values (9.1 mg/100 g) and (8.81 mg/100 g) were recorded in fruits treated with 9% $CaCl_2$ stored for 10 & 20 days, respectively. Similarly the lowest ascorbic value (2.8 mg/100 g) was noted in the untreated pear fruits stored for 40 days (Fig.6). The percent ascorbic acid was found to retain for longer period of time with the application of calcium chloride and dipping time. The content of ascorbic acid start to reduce when become matured (Lazan *et al*., 1990; Selvaraj *et al*., 1982). The highest ascorbic acid recorded in apple fruits

Table 2. Effect of $CaCl_2$ concentrations (%), dipping time (minutes) and storage durations on ascorbic acid (mg/100 g), reducing sugar (%), non-reducing sugar and percent disease incidence of pear fruit Cv. Le-Conte.

Treatments	Treatments levels	Reducing sugar (%)	Non-reducing sugar (%)	Percent disease incidence
$CaCl_2$ Concentration	0	4.92 d	3.32	6.56 a
(C)	3	5.13 c	3.25	4.44 b
(%)	6	5.36 b	3.21	3.00 c
	9	5.86 a	3.21	2.56 c
	LSD at 5 %	0.12	NS	1.22
Dipping time (D)	5	5.21 b	3.25	4.67
(minutes)	10	5.31 b	3.25	4.33
	15	5.44 a	3.24	3.42
	LSD at 5 %	0.11	NS	NS
Storage duration	0	7.28 a	1.23 c	ND
(S)	10	7.18 a	0.73 d	4.31 b
(Days)	20	4.83 b	3.70 b	4.03 b
	30	3.99 c	7.03 a	5.00 b
	40	3.31 d	3.55 b	7.36 a
	LSD at 5 %	0.14	0.24	1.37
Interactions	C × D	* (Fig 7)	NS	NS
		* (Fig 8)	NS	* (Fig 9)
	D × S	NS	NS	NS
	C × D × S	NS	NS	NS

*=Significant, NS=Non-significant, ND=Not detected; C=$CaCl_2$ Concentration, D=Dipping time and S=Storage duration

treated with $CaCl_2$ solution as compared to control (Laufmann and Sams, 1989). The apple fruits were more firm and retained highest content of ascorbic acid when treated with $CaCl_2$ solutions (Sams *et al,*. 1993). Similarly, the present results are in line with Jan *et al.* (2012), who noted that increasing storage duration decreased the ascorbic acid content in apple. The application of $CaCl_2$ at high concentration significantly retained the ascorbic acid content in Papaya fruits during storage (Mahmud *et al*., 2008).

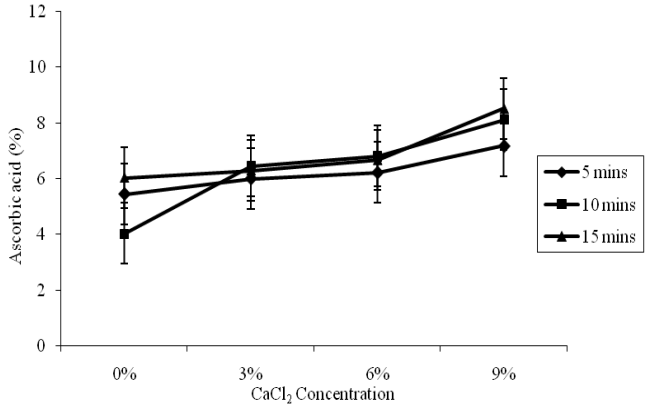

Figure 6. Effect of $CaCl_2$ Conc. (%) and storage duration (days) on ascorbic acid

***Reducing sugar (%)*:** The data presenting in the Table 2 are related with reducing sugar of pear fruit. The statistical results of the data showed that $CaCl_2$ concentration, dipping time and storage duration significantly influenced the reducing sugar (%) of the pear fruit. Similarly, there was a significant difference in the interaction of $CaCl_2$ concentration x dipping time and $CaCl_2$ concentration x storage duration, while a non-significant difference was recorded in all other interaction for reducing sugar (%) of pear fruit during storage (Table 2). The application of $CaCl_2$ solution significantly influenced the percent reducing sugar of pear fruit. The mean values of the data showed that high reducing sugar (5.86%) was recorded in pear fruits treated with 9% $CaCl_2$ concentration followed by 5.36% treated with 6% $CaCl_2$, whereas, the untreated pear fruits (control) showed the lowest reducing sugar (4.92%). The magnitude of percent reducing sugar significantly affected by increasing the dipping time (minutes). The pear fruit dipped for 15 minutes showed the highest percent reducing sugar (5.44%) as compare to the fruits dipped for 5 minutes (5.21%). A significant variation was recorded for the reducing sugar (%) of pear fruit. The percent reducing sugar decreased with increasing the storage durations. The highest reducing sugar (7.28%) was recorded in fresh fruit which was at par with the fruit stored for 10 days (7.18%). The pear fruit stored for 40 days at ambient temperature (20-28°C) had the lowest reducing sugar (3.31%). The interaction of $CaCl_2$ concentration x dipping time showed that highest reducing sugar (6.2%) was observed in the pear

fruits treated with 9% $CaCl_2$ solution dipped for 10 minutes. On other side the lowest reducing sugar (4.9%) recorded in fruit un-treated fruit, dipped for 5 minutes (Fig. 7). The interaction of $CaCl_2$ concentration x storage duration indicated that more reducing sugar (7.5%) was recorded in pear fruits treated with 9% $CaCl_2$ conc. stored for 10 days, while less reducing sugar (2.79%) recorded in un-treated, stored for 40 days (Fig. 8). It is evident from the current study that calcium chloride treatment had retained the reducing sugar (Glucose and Fructose) for longer period of time. The application of calcium chloride solution controlled the respiration process because glucose is the main substrate in respiration (Alam *et al*., 2003) which retained the percent reducing sugar.

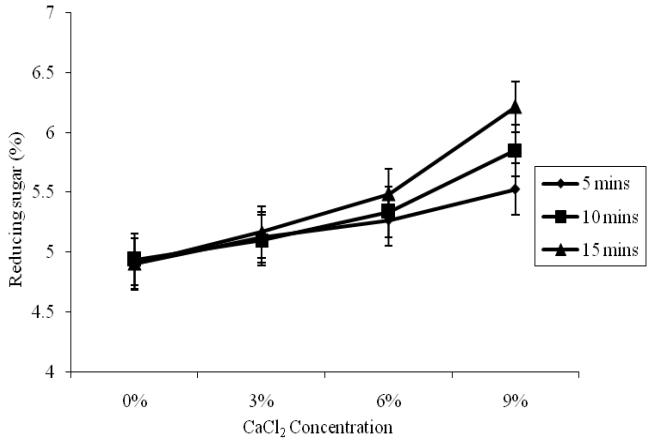

Figure 7. Effect of $CaCl_2$ Conc. (%) and dipping time (minutes) on reducing sugar

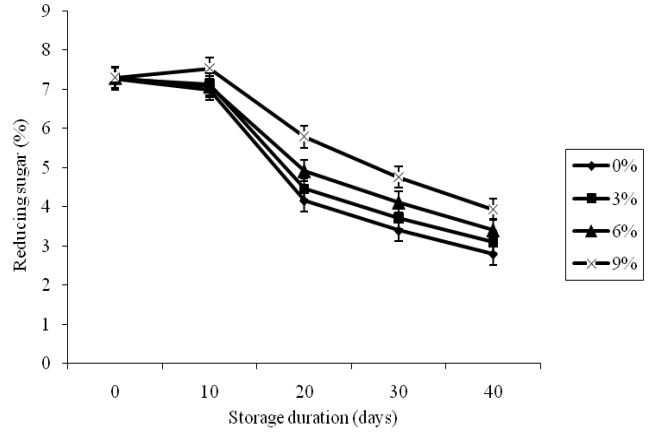

Figure 8. Effect of $CaCl_2$ Conc. (%) and storage duration (days) on reducing sugar

***Non reducing sugar (%)*:** The data pertaining to non-reducing sugar (%) are showed in the Table 2. The statistical analysis of the data revealed that only storage duration had significant effect on percent non-reducing sugar. The $CaCl_2$ concentration and dipping time showed non-significant response on non-reducing sugar. The percent non-reducing sugar was non-significantly influenced by all interactions (Table 2). A non consistent response was recorded for non-reducing sugar during storage. The data concerned to the storage duration indicating that highest non-reducing sugar (7.03%) was recorded in the pear fruits stored for 30 day, while lowest non-reducing sugar (0.73 %) was noiced in the pear fruits stored for 10 days. The sugar content of apple fruit contributes to the fruit sweetness and thus, is a major fruit quality characteristic. The starch accumulation at the early stages of maturation, which is hydrolyzed to sugars at edible maturity (Magein and Leurquin, 2000) and during storage (Beaudry *et al*., 1989), results in increase total sugar with increased storage duration (Bidabe *et al*., 1970; Crouch 2003). Since the application of Ca delays the changes associated with ripening and senescence in apple fruit such as increased in total sugars (Wills *et al*., 1977), its application resulted in lower total sugars with increasing $CaCl_2$ concentration probably by retarding the general senescence or decreasing the water loss (Hayat *et al*., 2003).

***Percent disease incidence*:** The data regarding percent disease incidence are shown in the Table 2. The statistical analysis of the data revealed that there was a significant difference for $CaCl_2$ concentration and storage duration on percent disease incidence. The interaction of the $CaCl_2$ concentration x storage duration was also significantly affected the disease incidence (%) of the pear fruits, whereas, dipping time and all other interaction were non-significantly affected the percent disease incidence of the pear fruits during storage (Table.2). The percent disease incidence of pear fruit significantly declined with increasing the $CaCl_2$ concentration. The mean values of data indicated that more disease incidence (6.56%) was observed in untreated pear, closely followed by (4.44%) treated with 3% $CaCl_2$, while the less disease incidence recorded (2.56%) in pear fruits treated with 9% $CaCl_2$ concentration. As concerned to the storage duration, percent disease incidence increased with increasing the storage duration of the pear fruits. The mean value of the data interpreting that highest percent disease incidence (7.36%) and (5.00%) were noted in the pear fruits stored for 40 and 30 days respectively, while the lowest percent disease incidence (4.31%) was recorded in the pear fruits after 10 days storage. The mean value of the data concerned to the interaction of $CaCl_2$ concentration x storage duration showed that least percent disease incidence (0.00%) was recorded in the untreated and fresh fruits, while more percent disease incidence (11.67%) observed in untreated pear fruits stored for 40 days (Fig. 9). Regarding the $CaCl_2$ treatment and dipping time, the highest concentration of $CaCl_2$ (9%) and the more dipping time (15 minutes) delayed the metabolic activity of the fruits and minimized the percent fruit decay. Post harvest calcium application decreased the disease incidence in apple fruit

(Crisosto and Michailides, 1991; Sabry, 1998). The post harvest application of $CaCl_2$ to apple fruit protect the apple fruit from the physiological disorders and also help in reducing percent disease incidence (%), by strengthening the cell wall and regulating the metabolic activity in the fruit. The application of $CaCl_2$ enhanced the fruit quality by controlling the metabolic activity and also extended the shelf life of the fruits (Shear and Faust, 1975).

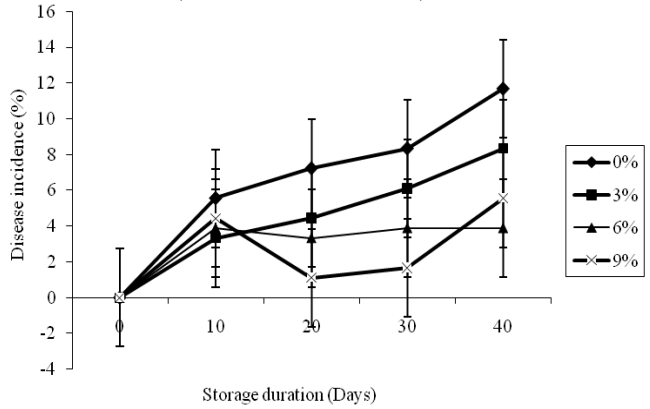

Figure 9. Effect of $CaCl_2$ Conc. (%) and storage durations (days) on disease incidence

***Conclusions*:** It is concluded from the findings of this experiment that pear fruits dipped in 9% $CaCl_2$ solution for 15 minutes retained most of the quality attributes and fruit firmness up to 10 days storage at ambient temperature while a significant declined was recorded in quality of fruit when extended the storage duration from 20 to 40 days.

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