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EFFECT OF CALCIUM CHLORIDE TREATMENTS ON QUALITY CHARACTERISTICS OF LOQUAT FRUIT DURING STORAGE

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Abstract

In order to study the effectiveness of Calcium chloride treatments on postharvest quality and storage behavior of "Surkh" cultivar of loquat, fruit was dipped in three concentrations (1%, 2% and 3%) of Calcium chloride for two minutes and stored in soft board cartons at 4°C in a cold store for 10 weeks period. The fruit was harvested at mature ripe stage, clipped, sorted and washed before applying the treatments. Changes in weight loss, firmness, total soluble solids (TSS), browning index (BI), ascorbic acid, titratable acidity (TA) and relative electrical conductivity (REC) were studied. One percent $CaCl_2$ did not affect quality parameters of the fruit compared to control treatment, whereas, 2% and 3% $CaCl_2$ retained maximum firmness, TSS, ascorbic acid content reduced browning index (BI) , relative electrical conductivity (REC) and weight loss up to 4-5 weeks.

Introduction

Loquat (*Eriobotrya japonica* Lindl.) is a popular fruit in Pakistan. Generally, 2 local cultivars viz., "Surkh" and "Sufaid" are widely grown in the North Western Frontier Province (NWFP) and Punjab province. The "Surkh" cultivar is nearly pear shaped with orange colored skin and flesh while "Sufaid" cultivar has light yellow skin with creamy white flesh and is less acidic (Hussain *et al*., 2007). Loquat has a short shelf life and its quality deteriorates rapidly after harvest. Though postharvest quality of a produce after harvest cannot be improved, it is possible to reduce the rate of quality loss. The rate of deterioration (physiological decay) of fruit is directly related to the respiration rate (Kader *et al*., 1989). Surface treatments delay physiological decay in fruit tissues, stabilize the fruit surface and prevent degradation that affect the quality of the product. They also rinse the enzymes and substrates released from injured cells during cutting operations from the product surface. Infiltrated calcium in fresh apples has been shown to bind the cell wall and middle lamellae, where major influences on firmness are expected (Glenn & Poovaiah, 1990). Pre- and postharvest application of calcium may delay senescence in fruits with no detrimental effect on consumer acceptance (Lester & Grusak, 2004). Exogenously applied calcium stabilizes the plant cell wall and protects it from cell wall degrading enzymes (White & Broadley, 2003). Studies have shown that the rate of senescence often depends on the calcium status of the tissue and by increasing calcium levels, various parameters of senescence such as respiration, protein, chlorophyll content and membrane fluidity are altered (Poovaiah,1986).

Calcium (Ca_2^+) has been extensively reviewed as both an essential element and its potential role in maintaining postharvest quality of fruit and vegetable crops (Kirkby & Pilbeam, 1984; Bangarth, 1979) by contributing to the linkages between pectic substances within the cell-wall (Demarty *et al*., 1984). The presence of Ca_2^+ ions

increases the cohesion of cell-walls (Demarty *et al*., 1984). It is also involved in reducing the rate of senescence and fruit ripening (Ferguson, 1984). A 1% solution of $CaCl_2$ delayed fruit ripening, improved resistance to fungal attack and maintained structural integrity of cell walls of strawberry during a 10 day storage period at 3°C (Lara *et al*., 2004). Moreover, softening was delayed and storage life was increased by 10–12 weeks in Kiwi fruits stored at 0°C by application of 1% $CaCl_2$ compared with untreated fruit (Dimitrios & Pavlina, 2005). Keeping in view the usefulness of $CaCl_2$ treatments in fruits as revealed by various scientists, the present study was aimed to evaluate the effectiveness of postharvest immersion of different $CaCl_2$ concentrations on the postharvest quality attributes of loquat fruit in refrigerated store.

Materials and Methods

Fruit of "Surkh" cultivar of loquat were harvested at mature ripe stage from the orchard of Hill Fruit Research Station, Tret, Murree, (73° 17' 00"E longitude and 33° 50' 00"N latitude) and transported on the same day to the Post Harvest Laboratory at the Department of Horticulture, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi. The fruit were clipped and washed with distilled water to remove any dirt and dipped for two minutes in the following concentrations of Calcium chloride ($CaCl_2$) solution:

i) 0% $CaCl_2$ (control)
ii) 1 % $CaCl_2$ solution
iii) 2 % $CaCl_2$ solution
iv) 3 % $CaCl_2$ solution

Each treatment included one hundred fruits and was replicated three times. Fruit were placed in corrugated soft board cartons in three layers separated by soft board sheets and stored at 4°C in the cold store for 10 weeks. A sample of randomly selected 10 fruits at day one and weekly intervals was collected from each replication in a treatment during the storage period. Data on the following parameters was recorded.

Weight loss: To evaluate weight loss, separate samples in 3 replicates of each treatments were used. The same samples were evaluated for weight loss each time at weekly intervals until the end of experiment. Weight loss was determined by the following formula:

$$\text{Weight loss (\%)} = [(A-B)/A] \times 100$$

where A indicates the fruit weight at the time of harvest and B indicates the fruit weight after storage intervals.

Fruit firmness: Fruit firmness was determined by peeling the fruit at two equatorial sites and measuring firmness by means of a Wagner® Fruit Firmness Tester, model FT-327, equipped with an 8mm plunger tip, using 10 fruits from each treatment. Values were expressed in ilogram force (kgf).

Total soluble solid: Total soluble solids (TSS) were measured by the method described by Dong *et al*., (2001). One wedge shaped slice of uniform size from ten fruits per replication in all treatments were juiced together for a composite sample. Thirty fruits

were used for each treatment. TSS in Brix% was measured by a hand refractometer (Abbe® model 10450).

Titratable acidity: Loquat pulp (10g) was homogenized in 40 ml distilled water and filtered to extract the juice. Two to five drops of phenolphthalein was added in this juice. A 10 ml aliquot was taken in a titration flask and titrated against 0.1N NaOH till permanent light pink color appeared. Three consecutive readings were taken from each replication of a treatment and percent acidity as malic acid was calculated by using the following formula:

$$\%TA = \frac{\text{(ml NaOH used) (Normality of NaOH) (Equivalent wt. of malic acid)}}{\text{(wt. of sample) (vol. of aliquot taken)}}$$

Ascorbic acid content (Vitamin C): Ascorbic acid was determined by the method described by Hans (1992). Loquat pulp (5g) from 10 fruits was blended with 5 ml 1.0% Hydrochloric acid (w/v) and centrifuged at 10,000 rpm for 10 minutes. The absorbance of the supernatant was measured at 243 nm. For calibration, standard solutions were prepared in the same manner from 100 µg ml^{-1} AA solution in 1% HCl. The Ascorbic acid content was calculated as mg $100g^{-1}$ edible portion.

Browning index: Browning index was assessed weekly by measuring the extent of browning area as described by Wang *et al*., (2005), using 30 fruits on the following scale: 0= no browning; 1=less than ¼ browning; 2= ¼ to ½ browning; 3= ½ to ¾ browning; 4= more than ¾ browning. The browning index was calculated using the following formula:

$$\text{Browning Index} = [(1 \times N_1 + 2 \times N_2 + 3 \times N_3 + 4 \times N_4) / (4 \times N)] \times 100$$

where N = total number of fruits observed and N_1, N_2, N_3 and N_4 will be the number of fruits showing the different degrees of browning.

Relative electrical conductivity: Relative electrical conductivity was measured by the method described by Fan & Sokorai (2005) with a slight modification. Ten discs of flesh tissue were excised from 10 fruits of each replicate in a treatment by a 10mm diameter stainless steel cork borer and washed in distilled water, dried and put into 100ml conical flasks containing 50ml of distilled water. Initial electrolyte leakage was determined at 1 min (C_1) and 60 min (C_{60}) of incubation. The samples were then autoclaved at 121°C for 25 minutes, after cooling the solution was re-adjusted to a volume of 50 ml and total conductivity (CT) was measured. The Relative Electrical Conductivity in percent (REC) was calculated from the following equation:

$$REC\ (\%) = (C_{60} - C_1) / CT \times 100.$$

Statistical analysis: The experiment was a completely randomized design (CRD) with factorial arrangement. Comparison between means was evaluated by Duncan's Multiple Range Test at 5% level of significance. All storage treatments were done with three replications.

Results and Discussion

Maximum weight loss occurred in control and 1% $CaCl_2$ while lowest loss (2.57%) was recorded in 3% $CaCl_2$ (Table 1). Weight loss was highest during the sixth and eighth weeks. Overall highest weight loss occurred in control during the sixth week (Fig. 1). Calcium applications have known to be effective in terms of membrane functionality and integrity maintenance which may be the reason for the lower weight loss found in Calcium treated fruits (Lester & Grusak, 1999). Mahajan & Dhatt (2004) reported that pear fruit treated with $CaCl_2$ proved to be most effective in reducing weight loss compared to non treated fruit during a 75 days storage period. Thus, calcium might have delayed senescence and reduced the rate of respiration and transpiration.

Effect on firmness: Maximum firmness was recorded in 2% & 3% $CaCl_2$ as compared to control and 1% $CaCl_2$. Maximum firmness was recorded in 3% $CaCl_2$ during eight and tenth weeks (Fig. 1). The retention of firmness in calcium treated fruits might be due its accumulation in the cell walls leading to facilitation in the cross linking of the pectic polymers which increases wall strength and cell cohesion (White & Broadly, 2003). These results are also in accordance with those reported by Shuiliang *et al*., (2002) that postharvest dips with $CaCl_2$ maintained firmness and eating quality of loquat.

Effect on total soluble solids: Maximum TSS was observed in 3% $CaCl_2$ (13.1 Brix %) followed by 2% $CaCl_2$. Lowest TSS was recorded in control. Highest TSS in 3% $CaCl_2$ might be due to the fact that more concentration of $CaCl_2$ (3%) formed a thin layer on the surface of fruit which delayed degradation process. The increase in TSS from 2nd week upto 6th week during storage (Fig. 1) was probably due to hydrolysis of polysaccharides and concentrated juice content as a result of dehydration. An initial increase then loss of TSS in loquat has also been reported by (Ding *et al*., 1998).

Effect on titratable acidity: Titratable acidity decreased gradually in all treatments (Fig. 1) and did not seem to be influenced by the postharvest calcium dips. Manganaris *et al*., (2005) has also reported that postharvest calcium chloride dips did not effect TA % in peaches during four weeks of storage. Titratable acidity is directly related to the concentration of organic acids present in the fruit, which are an important parameter in maintaining the quality of fruits. In loquat malic acid is the principal acid contributing 90% of the total organic acid content Ding *et al*., (1998). Ball (1997) suggested that acidity decreases due to fermentation or break up of acids to sugars in fruits during respiration. In the present study it seems that Calcium treatments did not have any significant effect on fermentation process which could delay breakup of acids and maintain TA.

Effect on ascorbic acid (Vit C) content: All three concentrations of Calcium chloride ($CaCl_2$) were similar in effect compared to control. Treatments of 1% and 2% $CaCl_2$ had an ascorbic acid loss of 10.9% and 8.4% compared to 19% loss in control while in 3% this loss was only 2.5% (Fig. 1). Ascorbic acid level decreased gradually during the ten weeks storage period. Ascorbic acid is an important nutrient quality parameter and is very sensitive to degradation due to its oxidation (Veltman *et al*., 2000) compared to other nutrients during food processing and storage. These results show that $CaCl_2$ treatments had a significant effect on retaining ascorbic acid content in loquat fruit. This might be because higher concentrations of $CaCl_2$ delayed the rapid oxidation of ascorbic acid. Ruoyi *et al*., (2005) also stated that AA content of peaches was maintained in a fifty days storage with a postharvest application of 0.5% $CaCl_2$.

Table 1. Effect of calcium chloride on quality attributes of "Surkh" cv. of loquat during ten week storage at 4 ° C.

Treatment	TA (%)	Firmness (kgf)	TSS (brix %)	Ascorbic acid mg 100g $^{-1}$ FW	Weight loss (%)	Browning index (%)	REC (%)
Control	0.40a	1.01c	11.41d	2.59b	3.23a	18.72a	51.26a
CaCl 1%	0.41a	1.11b	12.19c	2.85a	2.98ab	18.15a	48.69b
CaCl 2%	0.38a	1.18a	12.49b	2.93a	2.70bc	15.79b	44.38c
CaCl 3%	0.41a	1.20a	13.10a	3.12a	2.57c	10.58c	43.07c
LSD	0.03	0.05	0.14	0.26	0.29	1.61	2.11

Values for each parameter followed by the same letter within columns are not significantly different at $p<0.05$ (DMRT)

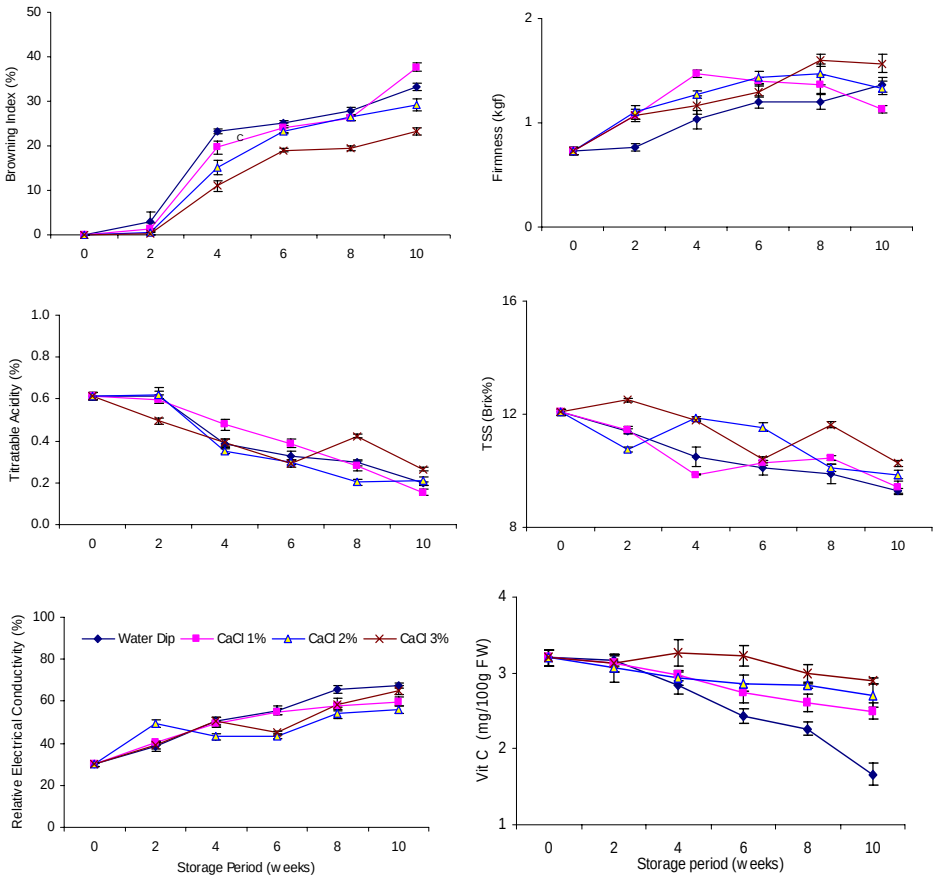

Fig. 1. Effect of calcium chloride agents on quality attributes of "Surkh" cv. of loquat. Vertical bars represent SE of means. LSD for browning index = 2.50, firmness = 0.06, titratable acidity = 0.05, total soluble solids = 0.66, relative electrical conductivity = 5.65, ascorbic acid = 0.32

Effect on browning index (BI): Data in Table 1 reveals significant difference in BI as a result of $CaCl_2$ treatments. Maximum BI (18.72%) was recorded in control while lowest BI (10.58%) was observed in 3% $CaCl_2$. Control and 1% $CaCl_2$ were statistically similar. Overall BI increased during storage (Fig. 1).

Oxidative membrane injury allows the mixing of the normally separated enzyme (PPO) and oxidizable substrates (polyphenols), which lead to browning (Hodges, 2003). High calcium concentrations result in decreased flesh browning symptoms which are directly associated with calcium content in fruits (Hewajulige *et al*., 2003). Therefore, calcium dips raise the possibility of producing fruit less susceptible to flesh browning symptoms. Rosen & Kader (1989) reported that 1% $CaCl_2$ dip reduced softening and browning rates of 'Bartlett' pear slices. This study also indicates that $CaCl_2$ treatments had lower BI compared to control. This could be due to the fact that calcium helps to maintain membrane stability as mentioned by Poovaiah (1988) and Picchioni *et al*., (1995).

Effect on relative electrical conductivity (REC): Highest REC (51.26%) was recorded in control (Table 1). Both the higher concentrations of $CaCl_2$ had lower REC values. In control REC raised upto 67.63% at the end of tenth week (Fig. 1). Research in postharvest physiology suggests that Ca may be involved in control of membrane stability and senescence of plant cells (Leshem, 1992; Torre *et al*., 1999; Rubinstein, 2000). Decreased electrolyte leakage by calcium application increases the cell wall integrity and stability (Mortazavi *et al*., 2007). In this study, 3% $CaCl_2$ had the lowest REC compared to control. The lower REC might be due to less disruption in the plasma lemma membranes as reported by Meng *et al*., (2009) and the increased cohesion of cell membranes (Demarty *et al*., 1984).

Conclusion

This study shows that 1% $CaCl_2$ treatment did not show significant effect on quality parameters and was similar to the control, while 2% $CaCl_2$ had higher firmness and REC. Dipping fruit in 3% $CaCl_2$ retained maximum TSS, firmness and reduced RSA, browning index and weight loss up to 4-5 weeks.

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