EFFECT OF PRESSURE INFILTRATION OF CALCIUM CHLORIDE ON POSTHARVEST STORAGE LIFE OF AVOCADO (*Persia americana* Mill)

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ABSTRACT

Fruits of avocado var. Pollock, harvested at physiologically matured stage, were pressure infiltrated with four concentrations of aqueous solutions of $CaCl_2$ (0%, 2%, 4% and 6%) at 250 mmHg pressure with a view of improving the shelf-life and quality. Fruits were assessed for firmness, ascorbic acid, and total Ca in peel and flesh. Postharvest pressure infiltration of $CaCl_2$ extended the storage life and slowed down the ripening process of avocado. Ripening of fruits was delayed for 2-3 days with pressure infiltration of $CaCl_2$ compared with untreated fruits, while treated fruits maintained considerable quantity of ascorbic acid at ripened stage. Sensory evaluation revealed that there were no significant differences among treatments for sweetness, color, odor and hardness of fruits.

INTRODUCTION

Avocado (*Persia americana,* Mill) is a very important fruit, not only in nutrient point of view but also play a major role in maintaining human health. The fruit contains unsaturated fatty acids which displace harmful Low Density Lipoproteins from the blood reducing cardiac problems. Postharvest handling is a critical issue in avocado due to the delicate nature of ripened fruits. Postharvest losses may take place at any stage of handling from harvesting, storage, marketing to final delivery to the consumer. The short storage life and perishable nature of the fruit limits long distance delivery from farm to the market and increase wastage.

Calcium chloride treatments have shown in increasing shelf-life of fruits, mainly by making cell wall less accessible to pathogens and softening enzymes. Calcium sprays have been applied on many fruits and vegetables to reduce physiological disorders and postharvest diseases (Sharples and Johnson, 1977; Abeywickrama, 2009). Firming and resistance to softening resulting from addition of calcium have been attributed to the stabilization of membrane systems and the formulation of calcium pectates, which increase the rigidity of measocarp and cell wall of the fruit (Jackman and Stanley, 1998).

Increased Ca^{+2} levels have shown to reduce respiration and rate of ethylene production in variety of fruits. $CaCl_2$ application in fruits can be done in three ways as dipping, vacuum or reduced pressure and pressure infiltration (Senevirathna and Daundasekara, 2010). However, there are some differences in effectiveness of $CaCl_2$ application as a postharvest treatment in crops.

Although uptake of Ca in "Hass" and "Fuerte" avocado were greatly enhanced with vacuum infiltration of 8% $CaCl_2$ solution, higher than 4% $CaCl_2$ did not delay the ripening process (Boonyakiay *et al.*, 1994). Two avocado

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cultivars 'Reed" and "Monoroe" grown in South Florida have short postharvest life, because these varieties ripened within a short time after harvest. Davenport (1984) conducted another calcium infusion experiment with these varieties and his results are in line with Boonyakiats findings, where 4% $CaCl_2$ vacuum infiltration inhibited ripening of avocado and keep good eating qualities. According to Wills and Tirmazi (1982), infiltration with $CaCl_2$ is effective in delaying the ripening of avocado at 20 ^{0}C however, the pressure required for infiltration differs with varieties. Optimum Ca uptake with good eating qualities was assured in variety "Fuerte" at 375 mmHg, while 250 mmHg was required for "Hass" at 4% $CaCl_2$ level.

Keeping in mind the usefulness of $CaCl_2$ treatments in delaying the ripening process of fruits, the present study was undertaken to evaluate the effectiveness of postharvest pressure infiltration of different concentrations of $CaCl_2$ to delay the ripening process of avocado.

MATERIALS AND MATHODS

Mature but green avocado fruits (var. Pollock) harvested from the research field at Regional Agriculture Research and Development Centre, Bandarawela were immediately transferred to the horticulture laboratory of the centre. Fruits of uniform size were selected, washed in running tap water, cleaned, and stems were trimmed out. Then they were separated into four batches, each having three fruits per replicate. Calcium chloride pressure infiltration was performed by slightly modifying the method of Perera and Karunarathne (2002). Fruits were immersed in $CaCl_2$ solutions (2%, 4% and 6% concentrations) and pressure (250 mmHg) was applied for 10 minutes using an autoclave (T.S.I. N.C., England, Thermostat range ± 20^{0}C). Fruits in the control were immersed in distilled water (0% $CaCl_2$) and pressurized in the same manner. Treated fruits allowed draining for 30 minutes upon removal from the immersed solutions. They were stored in clean, dry plastic trays (30cm diameter) at room temperature (23-27^{0}C) and RH of 70-80%. Experiment was arranged in completely randomized design (CRD) with three replicates.

Quality characteristics such as fruit softening, ascorbic acid and Ca content were determined according to standard procedures. Sensory parameters as color, hardiness, sweetness and odor were evaluated by five panelists selected from RARDC, Bandarawela.

Shelf life of fruits

Shelf life of fruits was estimated as numbers of days taken to reach the consumer ripe stage. Fruit softening is the commonly used primary indicator of ripeness. The degree of ripeness was estimated subjectively by softening of the flesh as judged by hand pressure and translated to numerical values as; hard unripe (pressure <12 kg if measured with penetrometer) = 1; starting to soften = 2; medium hard = 3; medium soft = 4; soft = 5. A fruit with a score of 5 was considered consumer ripe (Tirmazi and Wills 1982).

Ascorbic acid (vitamin C) content

Ascorbic acid content in the fruit flesh was determined following the method of Kirk and Sawyer (1991). Ten gram of flesh from each fruit was mixed with 10 ml of metaphosphoric acid and juice was extracted. Extracted juice was titrated with indophenol dye solution till a faint pink color persists for 15 seconds. Indophenol dye solution titrated with vitamin C solution was used as the standard. Calculate the mg of vitamin C equivalent to 1 ml of dye solution. Finally, this factor was used to calculate the vitamin C content in mg per 10 g of the sample.

Determination of Calcium content of avocado flesh and peel tissues

Peel and flesh tissues were removed separately and dried in oven at 60^0C until constant weight. Dry ash method (Barthakur and Baruah, 1997) was used to prepare the tissues for Ca determination. The amount of calcium was obtained by Iron meter (3205, Jenway, UK). Tissue Ca^{+2} contents were expressed as ppm.

Sensory Evaluation

The sensory characters such as color, odor, sweetness and hardiness were judged by a panel of five people. Samples were analyzed using a five-point hedonic scale basis: 1- Extremely dislike, 2-dislike, 3-nor dislike or like, 4-like and 5- Extremely like, (Centinakaya *et al.,* 2006). Data taken from sensory evaluation were subjected to Friedman analysis using MINITAB 14.

RESULTS AND DISCUSSIONS

Calcium chloride pressure infiltration delayed avocado fruit ripening for 2-3 days compared to control (Table 01). However, the results reported here disagree with other workers, who observed up to 50% delayed ripening of "Fuerte" and "Hass" fruits with vacuum infiltration of 4% $CaCl_2$ solution (Wills and Tirmazi, 1982; Boonyakiay *et al.*, 1994). The differences observed in the present experiment may be due to the method used for calcium chloride application. Vacuum infiltration may be a more effective method than pressure infiltration to inject Ca into fruits. Wills *et al.,* (1977) reported that threefold increase of calcium level is required to produce any noticeable retardation of fruit ripening in green tomato cultivar "Rouge de Mamande", at 20^0C. However higher concentrations of calcium chloride stood at par with untreated fruits.

Ascorbic acid (vitamin C) content of fruits

Ascorbic acid content was determined in unripe fruits, and in Ca treated and control fruits after 14 days of treatment (Table 02). Unripe fruits had the highest Vitamin C content (2.00 mg/10 g of fresh weight). Although there was a significant ($P<0.05$) decrease in ascorbic acid content of fruits during ripening, fruits infiltrated with 6% $CaCl_2$ had significantly higher retention of ascorbic acid than in control fruits. Guaglianoni *et al.,* (2009) observed decreased ascorbic acid content during storage of Atemoya fruits. However, Mahumud *et al.,* (2008) reported that papaya fruits treated with higher doses of calcium had highest ascorbic acid content than untreated fruits. The present study agrees with both findings. At consumer-ripe stage, the highest vitamin C content was observed in fruits treated with 6% $CaCl_2$ (Table 01). Ascorbic acid plays an important role in human health (Oguntibeju, 2008) and fruits with high ascorbic acid improve their taste and quality. Therefore treating avocado with $CaCl_2$ not only delays its ripening but also increases the nutritive value.

Table 01: Effect of pressure infiltration of $CaCl_2$ on ripening of "Pollock" avocado

Treatment	Time taken to reach consumer ripe stage (days)
Control	11.333a
2% $CaCl_2$	14.000b
4% $CaCl_2$	14.000b
6% $CaCl_2$	14.000b
CV	10.825

Means with the same letter are not significantly different at 0.05 level according to Duncan's multiple range test

Table 02: Effect of pressure infiltration (250 mmHg) of $CaCl_2$ on ascorbic acid content of "Pollock" avocado.

Treatment	Ascorbic acid content (mg/10 g fresh weight)
Control Fruit at unripe stage	2.00a
Control fruit at ripe stage	0.06c
2% calcium chloride at ripe stage	0.07c
4% calcium chloride at ripe stage	0.06c
6% calcium chloride at ripe stage	0.17b
CV	4.96

Means with the same letter are not significantly different at 0.05 level according to DMRT

Table 03: Uptake of Ca by "Pollock" avocados in $CaCl_2$ solution. Each value is the mean of duplicate on 3 composite samples of 5 fruits.

Treatment	Peel (ppm)	Flesh (ppm)
Control	0.10	0.20
2% $CaCl_2$	0.19	0.38
4% $CaCl_2$	0.21	0.50
6% $CaCl_2$	0.23	0.51

Calcium content of avocado flesh and peel tissues

Calcium uptake of "Pollock" avocado after pressure infiltration of $CaCl_2$ is shown in Table 03. Ca content of the peel and flesh was high in treated fruits compared to untreated fruits. On the other hand, slightly higher level of Ca was detected in avocado flesh. Senevirathna and Daundasekara (2010), in their dye penetration test on tomato, revealed that most of the treatment solutions enter into tomato fruits through the stem end scar. Hence, the large stem end scar of avocado fruits might provide more access for Ca to penetrate more into the flesh. Present study revealed that calcium uptake of the fruit by pressure infiltration was more successful.

Sensory analysis of fruits

Results of sensory analysis are given in Figure 01. There were no significant differences observed between treatments on color, sweetness, odor and hardiness of avocado fruits.

Sensory analysis showed that all treatments were acceptable without significant difference in the overall sweetness, odor, color and hardiness ($P<0.05$). Therefore it can be suggested that $CaCl_2$ pressure infiltration have no effect on the sensory qualities of avocado fruits. Hence $CaCl_2$ pressure infiltration can be used to delay ripening of avocado fruits without any effect of fruit acceptability parameters.

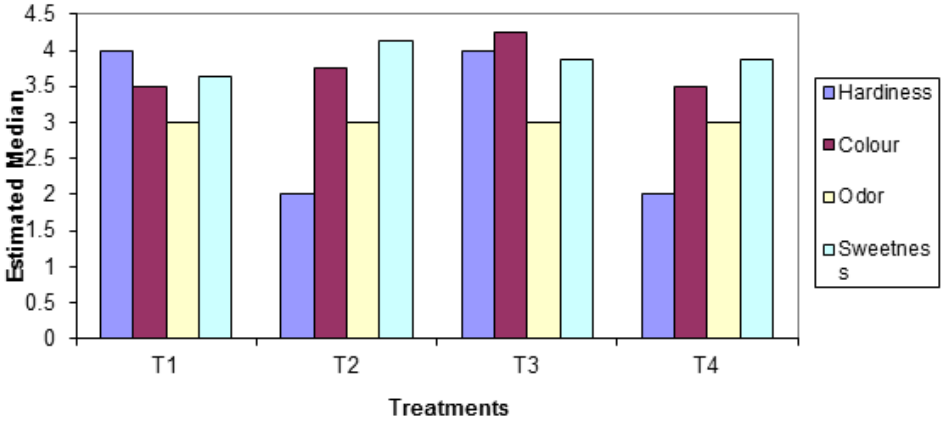

Figure 01. Mean values of sensory parameters of treated avocado (values are means of 5 replicates). T_1= Control, T_2= 2% Calcium chloride, T_3= 4% Calcium chloride, T_4= 6% Calcium chloride

CONCLUSION

Fruits treated with calcium chloride using pressure infiltration delayed fruit ripening for 2-3 days than that of untreated fruits. Further, the calcium treatments maintained considerable level of ascorbic acid in fruits at ripened stage ensuring the nutrition value of the fruit. However, further studies are in need to identify the optimum $CaCl_2$ concentration, pressure level and method of application to delay the ripening process of avocado fruits as different cultivars of fruit could respond differently to the treatments.

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