

Effect of Calcium Chloride and Hot Water Treatment on Physiology and Biochemical Quality of Green Papaya Flesh Shreds cv. 'Kaek Noul'

Kasama Chareekhot¹ Phanida Renumarn² and Sirichai Kanlayanarat³

Abstract

The effects of calcium chloride (CaCl₂) and hot water treatments on quality of green papaya flesh shreds stored at 7 °C for 8 days were investigated. Calcium chloride was used to maintain the firmness of green papaya flesh shreds. Treating with 0.5% CaCl₂ showed the highest firmness of green papaya flesh shreds during storage for 8 days. Respiration rate was suppressed by calcium and hot water treatment, whereas control (dipped in distill water at ambient temperature) showed the highest rate of respiration from day 2 - 8 during refrigerated storage (10.95 – 34.00 mg CO₂ kg⁻¹ hr⁻¹). Control at 50 °C had the highest loss of fresh weight during 5 - 8 days of storage. Moreover, cellulose activity of the green papaya flesh shreds were suppressed by 0.5% CaCl₂ at 50 °C and showed the lowest level for 4 days (0.40 μg D-glucose mg⁻¹ protein) whereas the increases in the enzymes activities were found in the control at 50 °C. Results suggested that the loss of firmness could be the key factor affecting quality of green papaya flesh shreds and the application of calcium treatments maintained the quality and inhibited the loss of firmness by retarding cellulase activity. However, hot water treatment combined with CaCl₂ retarded the respiration rate.

Keywords: calcium chloride, hot water treatment, quality of green papaya

¹ Faculty of Technology, Department of Food Science and Technology, Udon Thani Rajabhat University, 64 Thaharn Road, Muang, Udon Thani 41000, Thailand.

² Department of Innovation and Product Development Technology, Faculty of Agro-Industry, King Mongkut's University of Technology North Bangkok, Thailand

³ Postharvest Technology Program, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Bangkok 10140 Thailand.

1. Introduction

Fresh-cut green papaya or green papaya flesh shreds is susceptible to softening during storage. Fresh cut firmness can be increased by the addition of calcium due to stabilization of membrane systems and formation of Ca pectates increasing the rigidity of the middle lamella and cell walls. High calcium levels in fruit delay softening, physiological disorders and senescence in fresh cut cantaloupe (Luna-Guzman and Barret, 2000). Calcium can be applied by fertilization or direct application before or after harvest, and directly on fruit by spray applications or calcium dips. Izumi and Watada (1994) obtained high texture values when shredded carrot was dipped for 2 min in 0.5% and 1% CaCl_2 .

Heat treatment may have caused a reduction in the activity of enzymes such as cellulase, polygalacturonase, and pectin methylesterase that involved in fruit softening (Lagunes, 2007). Heat treatments also modify the solubility of pectins and hemicelluloses and ethylene biosynthesis, thus affecting fruit firmness (Ali et al., 2004 and Vicente et al., 2005)

The level of calcium penetrated in fresh cut fruit depends on calcium concentration, dipping time and temperature of dip solution and the sizes of pieces (Qui et al., 1995; Siddiqui and Bangerth, 1995; Aguayo et al., 2008). The application of heat shock at 50°C in combination with 1.5% Ca lactate was maintained better texture in fresh-cut lettuce and carrots (Martin-Diana et al., 2007 and Rico et al., 2007). Additionally, hot water dip at 60°C for has 1 min been reported as a good temperature to maintain the texture of Cantaloupe cylinders (Luna-Guzman et al., 1999). The aim of this study was to investigate the effect of calcium chloride treatments and hot water treatment in combined with CaCl_2

dips on the quality of green green papaya flesh shreds during storage.

2. Material and Methods

2.1 Plant materials

Green papaya fruits were harvested 60-70 days after anthesis according to their size, and maturity without damaged. Papayas with were transported to laboratory within 1 hr. Minimal processing was began by washing the fruits with tap water, draining and cutting top and stem-ends. The seeds were properly removed from the pulp. Subsequently, the pulp was sliced cut into shreds (0.2 wide, 10.0 cm length) by a disinfected knife. Green papaya flesh shreds were dip in control and 0.5% Calcium chloride solution and the combination treatments as hot-water at 50°C in combination with control and 0.5% CaCl_2 for 1 min. Each sample were cooled in ice-cold potable water (4°C) for 1 min, then dried by a manual spinner and shreds at 100 g were packed in clamshell boxes, then stored at 7°C for 8 days. Measurements were performed every day.

2.2 Weight loss

Three replicate of green papaya flesh shreds per treatment were taken every other day for the measurement of weight loss. Weight loss in the green papaya flesh shreds was determined as the difference in weight of the sample before and after storage and expressed as percentage of weight loss.

2.3 Texture measurement

Fifteen samples of green papaya flesh shreds per treatment were taken every other day for the measurement of flesh firmness. A texture analyzer (Texture Analyzer TA.XT2, Stable Micro Systems Ltd., UK) fitted with a steel blade probe and a standard Kramer shear-compression cell was used. Sample size placed in the cell was 1shred time^{-1} . Pre-test speed was

set at 5.0 mm s^{-1} , test speed at 2 mm s^{-1} and post-test speed at 5 mm s^{-1} . Maximum peak force (Newton) was calculated by the exponent software, version 3 analyzer (Texture Analyzer TA.XT2, Stable Micro Systems Ltd., UK).

2.4 Respiration rates

Green papaya flesh shreds (100 g each), taken from each treatment listed above every other day, each a plastic box for respiration rate measurement in close condition. The box was held for 1 h at 7°C storage temperature. Each 1 ml gas sample was withdrawn from the headspace with a syringe for carbon dioxide. The gas samples were analyzed by gas chromatography using Shimadzu Model GC-8A for carbon dioxide and a Shimadzu Model GC-14B for ethylene concentration. The Shimadzu Model GC-8A were fitted with 80/100 mesh Propak Q column and a thermal conductivity detector 24 (TCD). The data were recorded as $\text{ml CO}_2 \text{ kg}^{-1} \text{ h}^{-1}$ for respiration rate.

2.5 Cellulase Activity

A pulp homogenate was prepared by homogenizing 5 g of pulp tissue sample in 10 mL sodium citrate buffer (0.1 M, pH 5) containing NaCl (1 M), PVPP (1%) in an Ultra shear homogenizer and placed in ice water bath at 4°C for 1 min. The homogenate was centrifuged at $12,000 \times g$ for 20 min at 4°C . The supernatant was used for enzymatic assays. The protein content was determined using bovine serum albumin (BSA) as the standard (Bradford, 1976). Cellulase activity was assayed as described by Pressey and Avants (1973) and Chang and Ming (1998). The reaction mixture contained 1 ml sodium citrate (0.1 M, pH 5), 0.8 ml carboxymethyl cellulose and 0.2 ml enzyme extract. The mixture reaction incubated at 37°C for 1 h, then 1 ml DNS (dinitrosalicylic acid) was added. The mixture was incubated at 40°C for 5 min. The reducing group formed was measured

at A_{520} . Cellulase activity is expressed as μg glucose mg^{-1} protein.

2.6 Statistical analysis

All data were expressed as mean \pm standard errors (SE) of at least three replications. Significant difference among the mean values were calculated using paired t tests with a significance level of $P \leq 0.05$ and correlation test were performed on data using the statistic software SPSS.

3. Results and Discussion

Firmness

The green papaya flesh shreds softened during storage and the initial firmness (6.93-9.01 N) of green papaya flesh shreds was reduced throughout storage at 7°C , the treatment with 0.5 % CaCl_2 being the most effective throughout storage while the combination 0.5 % with 50°C treatments was quite effective only 3 days of storage after that reduced values until the end of storage (Figure. 1).

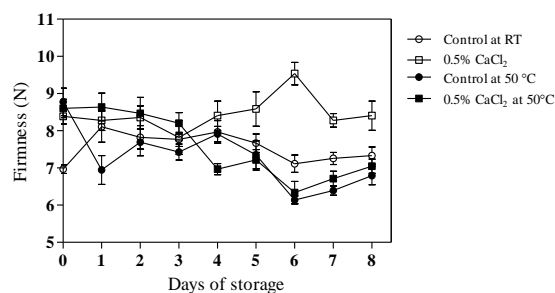


Figure 1 Changes in the firmness of green papaya flesh shreds subjected to different treatments during storages at 7°C . Values represent the means of replicate measurements; error bars represent the standard deviations of the mean ($n=15$).

The CaCl_2 dip was the treatment was found, and it improved the firmness of the green papaya flesh shreds. In our study the CaCl_2 combined with hot water treatments dips may

be were too hot and long to slightly damage the membrane of green papaya flesh shreds. However, our study had only CaCl_2 treatments could maintain the firmness of green papaya flesh shreds. In the same way, Izumi and Watada (1994) maintained the firmness in fresh-cut kiwifruit, strawberry and mango slices dipped in Calcium chloride solution. The firmness can be increased by calcium solution by the formation of Calcium pectates increasing the rigidity of the middle lamella and cell walls (Poovaiah, 1986). In contrast results, Rico et al. (2007) in fresh-cut carrot and Luna-Guzmán et al. (1999) in cylinders of cantaloupe obtained better results when calcium salts were combined with a heat shock.

Weight loss

The moisture content of hot water and CaCl_2 treatments affected the flesh weight loss (Figure 2). All treatment increased constant over storage and they did not have difference in each treatment. Due to we use plastic box packaging (clamshell boxes), may be could be protection the water loss of green papaya flesh shreds in all treatment. However, the heat treatments have been shown to promote postharvest weight loss in many fruits and vegetables (Siomos et al., 2012 and Bassal et al., 2011).

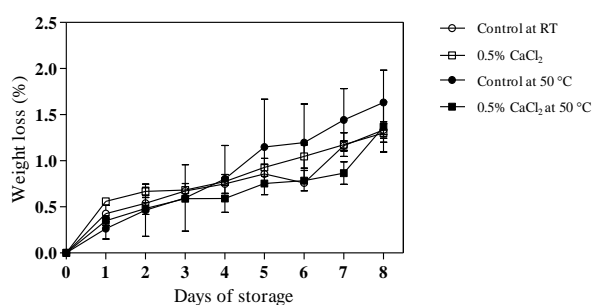


Figure 2 Changes in the weight loss of green papaya flesh shreds subjected to different treatments during storages at 7°C. Values represent the means of replicate measurements;

error bars represent the standard deviations of the mean ($n=3$).

Respiration rate

In green papaya flesh shreds, the initial respiration ($3.42\text{--}7.22 \text{ mg CO}_2 \text{ kg}^{-1} \text{ h}^{-1}$) were detected (Figure 3). On day 3, the respiration rates of the control at room temperature treatment were increased to $10.94 \text{ mg CO}_2 \text{ kg}^{-1} \text{ h}^{-1}$, respectively. Reduced respiration rates as a result of heat treatments have also been reported by other authors in shredded iceberg lettuce ($47^\circ\text{C}/30\text{--}180 \text{ s}$) (Odumeru, et al., 2003) and Ca treatment also delay physiological disorders and senescence in fresh cut cantaloupe (Fallahi, et al., 1997, Luna-Guzman and Barret, 2000).

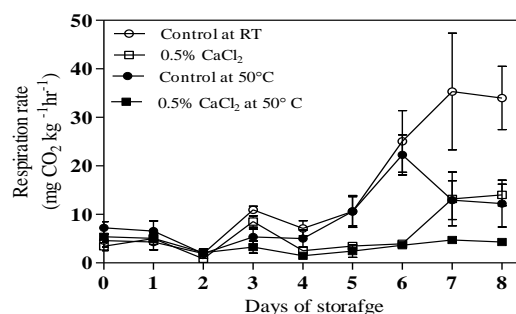


Figure 3 Changes in carbon dioxide production of green papaya flesh shreds subjected to different treatments during storage at 7 °C. Values represent the means of the replicates; error bars represent the standard deviations of the mean ($n=3$).

In addition, for each temperature of dipping, the hot water combined with CaCl_2 solution had an effect on reducing the metabolic activity when compared with the control treatments. Accordingly, Luna-Guzmán et al., (1999) also found that respiration was reduced in cut cantaloupe melon dipped at 1% or 5% CaCl_2 for 1 min and stored at 5°C compared to the control samples. Faust and Shear (1972) and Saftner et al., (1998) found that

calcium dips delayed respiration and ethylene production and consequently the maturation process and calcium dips increased membrane rigidity and blocked gas exchange.

Cellulase activity

Cellulase activity of all hot water dip at 50°C treatments could suppress the activity cellulase on the first day when compared with calcium treatments.(Figure 4) On day 2, the control dip at room temperature and 50°C was increased after first day of storage. However, after day 4, cellulase of all treatments was increased and did not difference in each treatment. Heat treatment may have caused a reduction in the activity of enzymes such as cellulase, polygalacturonase and pectin methylesterase that are involved in fruit softening (Lagunes, 2007). Heat treatment also modify the solubility of pectins and hemicelluloses and ethylene biosynthesis, thus affecting fruit firmness (Ali et al., 2004 and Vicente et al., 2005)

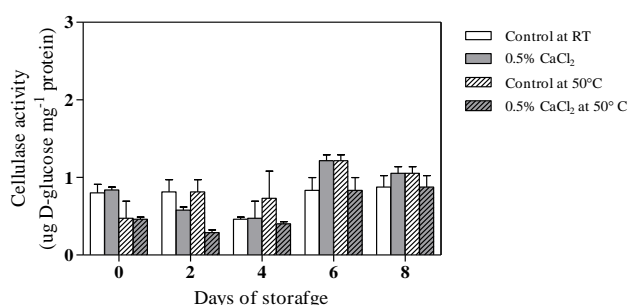


Figure 4 Changes in the cellulase activity of green papaya flesh shreds subjected to different treatments during storages at 7°C. Values represent the means of replicate measurements; error bars represent the standard deviations of the mean ($n=3$).

Conclusion

Calcium chloride solution of 0.5% maintained the firmness of green papaya flesh shreds and reduces activity of cellulase within 4

days of storage. While, hot water treatment and the combination treatment with CaCl₂ had only delay respiration rate during storage. However, the hot water treatment could not maintain the firmness of green papaya flesh shreds when compared with CaCl₂ treatments in this our study.

Reference

- Aguayo, E., V.H. Escalona and F. Artés. 2008. Effect of hot water treatment and various calcium salts on quality of fresh-cut 'Amarillo' melon. *Postharvest Biology and Technology*. 47(3), 397-406.
- Ali, Z.M., L.H. Chin and H. Lazan. 2004. A comparative study on wall degrading enzymes, pectin modifications and softening during ripening of selected tropical fruits. *Plant Science*. 167(2), 317-327.
- Bassal, M., and M. El-Hamahmy. 2011. Hot water dip and preconditioning treatments to reduce chilling injury and maintain postharvest quality of Navel and Valencia oranges during cold quarantine. *Postharvest Biology and Technology*. 60(3), 186-191.
- Bradford, M.M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding *Analytical biochemistry*. 72(1-2), 248-254.
- Chang, W.M. and T.L. Ming. 1998. Activity of softening enzymes during storage of sugar apple (*Annona squamosa* L.) at different temperatures. *Food Preservation Science*. 24(5), 319-323.
- Faust, M., and C.B. Shear. 1972. Effect of calcium on respiration of apples. *Journal of the American Society for Horticultural Science* 47,437-439.

- Izumi, H., and A.E. Watada. 1994. Calcium treatments affect storage quality of shredded carrots. *Journal of Food Science*. 59(1), 106-109.
- Lagunes, L., B. Tovar, M. Mata, J.C. Vinay-Vadillo, J. De La Cruz, and H.S. Garcia. 2007. Effect of exogenous ethylene on ACC content and ACC oxidase activity during ripening of Manila mangoes subjected to hot water treatment. *Plant foods for human nutrition*. 62(4), 157-163.
- Luna-Guzmán, I., and D.M. Barrett. 2000. Comparison of calcium chloride and calcium lactate effectiveness in maintaining shelf stability and quality of fresh-cut cantaloupes. *Postharvest Biology and Technology*. 19(1), 61-72.
- Luna-Guzmán, I., M. Cantwell, and D.M. Barrett. 1999. Fresh-cut cantaloupe: effects of CaCl₂ dips and heat treatments on firmness and metabolic activity. *Postharvest Biology and Technology*. 17(3), 201-213.
- Martin-Diana, A.B., D. Rico, J. Frias, G.T.M. Henehan, J. Mulcahy, J.M. Barat, and C. Barry-Ryan. 2006. Effect of calcium lactate and heat-shock on texture in fresh-cut lettuce during storage. *Journal of Food Engineering*. 77(4), 1069-1077.
- Odumeru, J.A., J. Boulter, K. Knight, X. Lu, and R. McKellar. 2003. Assessment of a wash treatment with warm chlorinated water to extend the shelf-life of ready-to-use lettuce. *Journal of food quality*. 26(3), 197-209.
- Poovaiah, B.W., 1986. Role of calcium in prolonging storage life of fruits and vegetables. *Food Technol*. 40(5), 86-89.
- Pressey, R. and J.K. Avants. 1973. Separation and characterization of endopolygalacturonase and exopolygalacturonase from peaches. *Plant Physiology*. 52(3), 252-256.
- Qiu, Y., M.S. Nishina, and R.E. Paull. 1995. Papaya fruit growth, calcium uptake, and fruit ripening. *Journal of the American Society for Horticultural Science*. 120(2), 246-253.
- Rico, D., A.B. Martin-Diana, J.M. Frias, J.M. Barat, G.T.M. Henehan, and C. Barry-Ryan. 2007. Improvement in texture using calcium lactate and heat-shock treatments for stored ready-to-eat carrots. *Journal of Food Engineering*. 79(4), 1196-1206.
- Saftner, R.A., W.S. Conway, and C.E. Sams. 1998. Effects of postharvest calcium and fruit coating treatments on postharvest life, quality maintenance, and fruit-surface injury in 'Golden Delicious' apples. *Journal of the American Society for Horticultural Science*. 123(2), 294-298.
- Siddiqui, S., and F. Bangerth. 1995. Effect of pre-harvest application of calcium on flesh firmness and cell-wall composition of apples influence of fruit size. *Journal of Horticultural Science*. 70(2), 263-269.
- Siomos, A.S., D. Gerasopoulos, P. Tsouvaltzis, and A. Koukounaras. 2010. Effects of heat treatment on atmospheric composition and color of peeled white asparagus in modified atmosphere packaging. *Innovative food science & emerging technologies*. 11(1), 118-122.
- Vicente, A.R., M.L. Costa, G.A. Martínez, A.R. Chaves, and P.M. Civello. 2005. Effect of heat treatments on cell wall degradation and softening in strawberry fruit. *Postharvest Biology and Technology*. 38(3), 213-222.