Title of Paper: EFFECTS OF CALCIUM CHLORIDE DIPS ON QUALITY AND SHELF LIFE OF FRESH-CUT MANGO CV. ‘NAMDOKMAI’

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ABSTRACT

Ripe mango fruit slices cv. ‘Namdokmai’ were dipped in 1% or 2% calcium chloride for 1 or 3 min before storage at 1°C with 90-95% RH. Slices dipped in water served as control. Calcium chloride at 2% remarkably inhibited firmness loss and prevented undesirable surface color changes indicated by the absence of corresponding changes in L* and b* values. As a result, shelf life increased to 14 days from about 3 days without calcium chloride treatment. At 1%, calcium chloride was ineffective in preventing firmness loss and consequently in improving shelf life. 1% and 2% calcium chloride had comparable inhibitory effect on ethylene production but had no clear effect on respiration rate. The effect of calcium chloride was dependent on concentration rather than on duration of treatment. The 1-min and 3-min dipping time had comparable effect on shelf life of the fruit slices.

Key words: Mango; Mangifera indica L.; minimal processing; fruit slices; calcium treatment; cold storage; postharvest life

INTRODUCTION

Mango (Mangifera indica L.) fruit slices are a common feature in the fresh-cut produce market which is a rapidly expanding segment of Thailand’s fresh horticultural produce industry. This is brought about by the increasing consumer demand and consumption of ready-to-eat, convenience food. Operations involved in preparing fresh-cut mango include washing, peeling, slicing and packing in film packages or containers with film
overwrap before distribution or retail display in ambient or refrigerated shelves. Because of the wounded nature of the fresh-cut produce which is devoid of the protective skin, shelf life particularly of ripe fruit slices is very short, only one day at ambient and 2-3 days at refrigerated temperature. Shelf life is limited by rapid firmness loss, surface discoloration, overripening and microbial contamination or decay. Suitable methods to prevent or minimize these detrimental effects on quality and shelf life of fresh-cut product would be beneficial not only to producers but also to consumers to meet their expectations of product quality and safety. Invariably, this will build confidence and competitive advantage in the fresh-cut produce industry necessary for a sustained increase in trade in the domestic and export markets.

Calcium chloride dip has been used as a firming agent for whole and fresh-cut fruits. In melon cylinders stored at 5°C, 1-5% calcium chloride increased firmness, with the higher concentration giving better improvement in firmness (Luna-Guzman et al., 1999). Firmness response to calcium chloride did not vary with dipping time of 1-5 minutes at the same concentration which was attributed to the possibility that calcium uptake is limited by rates of mass transfer. Calcium chloride dips at 0.5% concentration were also found to have a beneficial effect on retaining or improving the texture of zucchini squash slices stored at 0°C and 10°C (Izumi and Watada, 1995). Calcium chloride at 0.5 or 1% for 2 min likewise maintained firmness of shredded carrot stored at 0, 5 or 10°C (Izumi and Watada, 1994). The treatments increased the calcium content of the tissues. Other studies also showed that calcium treatment retarded firmness loss consequently extending shelf life of apple (Garcia et al., 1996) and improving post-processing quality of tomatoes (Floros et al., 1992) and blueberries (Camire et al., 1994). Calcium-induced firming and resistance to softening have been attributed to the stabilization of membrane systems and the formation of calcium
pectinates which increase rigidity of the middle lamella and cell wall, increased resistance to polygalacturonase attack on or inhibition of degradation of pectic substance of the middle lamella and cell wall, and improved turgor pressure (Barnes and Patchet, 1976; Buescher and Hobson, 1982; Bourne, 1989; Jackman and Stanley, 1995). A more crosslinked pectin network due to the crosslinking between the carboxyl groups of adjacent polyuronide chains and divalent calcium could improve water holding capacity of the tissue hence increased turgor (Luna-Guzman and Barrett, 2000).

Other effects of calcium chloride dip include reduced respiration indicating retarded ripening process and/or microbial contamination and improved visual quality indicated by improved tissue integrity and reduced mushiness and watery appearance, although ethylene production increased (Luna-Guzman et al., 1999). Calcium chloride treated at 2.5% for 1 min in melon fruit pieces also decreased the total plate counts and yeast and mold counts at 25°C (Luna-Guzman and Barrett, 2000) and at 1%, reduced the microbial growth rate in carrot shreds stored at 5°C (Izumi and Watada, 1994). Calcium could enhance tissue resistance to fungal or bacterial attack by stabilizing or strengthening cell walls (Conway et al., 1994). In apple slices, calcium chloride dips at 0.2% was found to reduce enzymatic browning (Sapers et al., 1990). However, the inhibitory effect was diminished with storage duration and differed with apple cultivars. Due to its residual effect, calcium chloride could impart bitterness to fresh-cut produce as found in melons (Luna-Guzman and Barrett, 2000).

This study investigated the effects of different rates of application of calcium chloride dip on quality changes and shelf life of ripe fruit slices of ‘Namdokmai’ mango, Thailand’s leading and most popular variety.
MATERIALS AND METHODS

Experimental Treatments

Ripe fruits of ‘Namdokmai’ mango were procured from a local market, sorted for uniformity in size and shape and freedom from defects, washed in tap water and air-dried. The fruits were peeled using a very sharp stainless steel knife. The pulp or flesh from both sides of the fruit was sliced and the pulp from each side was further divided into 6 equal slices. The slices were then dipped for 1-3 minutes in water (control), 1.0 or 2.0% calcium chloride. After air-drying, the slices were placed in foam trays and stored at 1°C with 90-95% relative humidity. The study was done following completely randomized design experiments using four replications with 6 slices per replicate per observation period. Observation of responses was done at 3-day interval.

Measurement of Responses

Firmness. Firmness was measured using TA-TX2 texture analyzer equipped with a 500 kg load cell and 2mm-diameter plunger set to pierce 5 mm deep from the fruit surface. Cross head and chart speed were 100 mm/min and 300 mm/min, respectively.

Color changes. Changes in surface color were determined using a Minolta DP-301 colorimeter taking the b* value as a measure of degree of yellowing and L* value as a measure of surface lightness.

Respiration and ethylene production. Respiration and ethylene production were determined by gas chromatography. The 6 fruit slices were sealed in a respiration jar for 3 hours at 20°C. One ml gas samples were taken using gas-tight hypodermic syringe and injected into the Shimadzu GC-8A gas chromatograph with thermal conductivity detector and molecular sieve 5A column at 50°C for CO₂ analysis and Shimadzu GC-14B with flame ionization detector and Porapak Q column at 50°C for ethylene analysis.
Storage life. Storage life was estimated as the number of days the fruits slices remained edible and visually marketable.

Results were analyzed by conducting analysis of variance using the general linear models procedure by SAS (SAS Institute, Cary, N.C.) for completely randomized design experiments and Duncan’s multiple range test (DMRT) or LSD analysis for mean comparison.

RESULTS

Firmness

Calcium chloride dip at 2% concentration remarkably inhibited firmness loss and softening of fruit slices (Figure 1). After 3 days of storage at 1C when the untreated control showed dramatic decrease in firmness, slices treated with 2% calcium chloride had a firmness similar to or slightly higher than that at the start of storage (day 0). One-minute dip was sufficient to elicit the effect since increasing the dipping time to 3 minutes did not correspondingly improve firmness retention. As the storage period advanced when only the 2% calcium chloride-treated slices remained visually acceptable, firmness of the slices did not decrease and was even higher than that measured at day 0. Calcium chloride at 1% did not result to firmness changes that differed greatly with that of the untreated control. Slices from these treatments reached the end of their shelf life after 3 days of storage due to firmness loss.

Surface Color Changes

Except for 2% calcium chloride as 3-min dip, all calcium chloride treatments resulted to lower L* than the control after 3 days of storage (Figure 1). This decrease in L* was not due to darkening of the yellow color associated with advancing stage of ripening since the b* values correspondingly decreased (Figure 1). After 7-14 days when slices treated with 2%
calcium chloride were left in storage, color changes, particularly L*, showed an erratic trend. However, the b* values generally increased before decreasing at the end of storage. This occurred earlier in 3 minute-dipped slices than in 1 minute-dipped ones.

**Respiration Rate**

Respiration rates decreased after 3 days of storage (Figure 2). At this period, slices treated with 2% calcium chloride for 1 minute had the highest rate of respiration while those treated with 1% calcium chloride for 3 minutes, the lowest among treatments. The other calcium chloride-treated slices had slightly higher rates of respiration than the untreated control. After 7-10 days of storage, the slices treated with 2% calcium chloride showed comparable respiration rates regardless of dipping time. At the end of the 14-day storage period, slices treated with 2% calcium chloride for 1 min had higher rates of respiration than those treated for 3 min.

**Ethylene Production**

Ethylene production rates of untreated slices markedly increased from about 0.018 nl/kg.h at day 0 to about 0.042 nl/kg.h after 3 days of storage (Figure 2). Such increase in ethylene production was absent in calcium chloride-dipped slices. Ethylene production was either similar to or slightly lower than that obtained at day 0. The rates differed only slightly among calcium chloride-treated slices. Ethylene production rates of slices treated with 2% calcium chloride for 1 or 3 min remained essentially unchanged for the next 3-7 days of storage before increasing on the fourteenth and last day of storage. At this period, the increase in ethylene production was higher in slices treated for 3 min than that treated for 1 min.

**Shelf Life**

Fruit slices without calcium chloride treatment had a shelf life of 3 days (Figure 3). Quality deterioration was due to firmness loss and surface color degradation. Calcium chloride dip at 1% for 1-3 min did not significantly influence these changes. Consequently,
shelf life of the slices was not improved and was similar to that of untreated slices. With 2% calcium chloride application as 1 or 3-min dip, firmness loss was remarkably inhibited. This contributed mainly to the appreciable increase in shelf life of the treated slices to 14 days.

CONCLUSION

Calcium chloride at 2% could markedly improve the storage life of ripe mango fruit slices by effectively maintaining firmness. Other senescent changes could be inhibited also, partly evidenced in the present study by the inhibition of ethylene production. At lower concentration of 1%, calcium chloride is ineffective in influencing shelf life. The effect of calcium chloride appears to be determined by concentration rather than by the duration of treatment. There was no marked differences in responses of the slices to 1-min and 3-min dipping.

LITERATURE CITED


Fig. 1 Lightness L, b and firmness of “Namdokmai” mango slices treated with 1-2 % of CaCl$_2$ for 1-3 min before storage at 1 °C.
Fig 2. Respiration and ethylene production of “Namdokmai” mango slice storage treated with 1-2 % of CaCl₂
Fig. 3 Shelf life of “Namdokmai” mango slices treated with 1-2 % of CaCl$_2$ for 1-3 min before storage at 1°C.