

## Some compositional changes in *Kent* mango (*Mangifera indica*) slices during storage

Beatriz Tovar<sup>1,2</sup>, Lilia I. Ibarra<sup>1</sup>, Hugo S. García<sup>2</sup>, and Miguel Mata<sup>1</sup>

<sup>1</sup>Instituto Tecnológico de Tepic. Apdo. Postal 634. Tepic, Nay. 63000, México. Email: mmata@homonet.com.mx

<sup>2</sup>Instituto Tecnológico de Veracruz. Apdo. Postal 1420, Veracruz, Ver. 91897, México.

### Abstract

*Kent* mango slices at two different stages of ripening: 4 days (S1) and 6 days (S2) after harvest were kept under aseptic conditions at 13 and 23°C to determine if normal ripening could proceed after slicing. Whole mangoes stored at 23°C and 65% R.H. were used as control. Soluble solids of slices from all treatments did not show the same trend as whole fruits and remained unchanged at their initial values. Titratable acidity increased and pH decreased in all the slices and were in turn, different from the control fruit. Color parameters indicated loss of yellow pigments and browning. Decay occurred between days 5 and 7 of storage in slices that were stored at 23°C. Slices from S1 mangoes kept at 13°C suffered minimal changes due to cutting; however, the slices did not show the same compositional changes as the naturally-ripened whole fruit.

**Keywords:** Postharvest, precut fruits, minimal processing, ripening, mango, *Mangifera indica*

### Introduction

There is a growing demand for safe and high quality minimally processed fruits and vegetables (Yildiz, 1994); however, little attention has been paid to tropical fruits such as mangoes. Rolle and Chism (1987) stated that minimally processed products are living respiring tissues. Labuza and Breene (1989) shared the concept and found necessary to define the shelf life period of highest quality for each fruit or vegetable. Additionally, both cultivar and stage of ripening play important roles in determining the high quality of a minimally processed product for commercial use. Cutting or slicing of a fresh product exposes living respiring tissue to considerable mechanical damages and increases its susceptibility to spoilage (Reyes, 1996). However, we have observed that peeling of firm green bananas did not cause any spoilage nor interference with normal ripening process when the fruits were kept inside an auto-modified atmosphere (Tovar *et al.*, 2000).

In the present research, the changes of compositional parameters of 'Kent' mango slices made at two different stages of ripening and two storage temperatures were monitored to determine if normal ripening continued after slicing.

### Materials and methods

Physiologically mature *Kent* mangoes (outgrown shoulders, pit formation with ridged edges at the stem-end, firm and green; according to Seymour *et al.*, 1990) were collected from a local grower. Fruits were sorted by size and washed with 1 g/l Benlate®. Slices were made from mangoes that were kept for 4 days (S1) and 6 days (S2) at 23°C and 65 % R.H. Two slices of 7.5 x 40 x 30 mm (T x L x W) were cut from every fruit, from the middle portion of each side. The slices were washed with 300 ppm chlorine, for removal of cellular contents from the cut surfaces and as sanitizing agent (Ahvenainen, 1996; Brecht, 1995), immediately immersed in 20 g/l citric acid, then in 300 mg/l sodium metabisulfite (each for

30 seconds) to prevent oxidative browning (Bolin and Huxsoll, 1989); and finally in 20 g/l sodium benzoate (2 minutes) to prevent yeast and mould proliferation, as well as free radical inhibition (Yang and Hoffman, 1984). The treated slices were transferred into 10 x 32 x 20 cm (H x L x W) acrylic chambers that were previously disinfected with 300 ppm chlorine for 18 hours. Sterile air at 500 ml/min and 98% R.H. was passed through the chambers for the duration of the experiments and the chambers were placed inside incubators at 13 and 23°C, respectively. Whole mangoes (W) were kept at 23°C and 65% R.H. and were used as control.

Soluble solids were measured with an Abbe refractometer. Titratable acidity (TA) expressed as % citric acid and pH, were determined according to standard methods (AOAC, 1984). Colour determinations were performed with a Minolta CR300 colorimeter, using the Hunter scale (L, a, b). Three measurements were made on the peel (P) and seed (S) sides of each slice. From the colour values, chroma (C) and hue (h) were calculated using equations described by McGuire (1992). Mean values and 95% confidence intervals were calculated for each storage day using the statistical software package StatView®.

### Results and discussion

The soluble solids trends of the S1 and S2 slices at 13 and 23°C were statistically similar (Fig. 1); however, both were different from the ripening pattern of the whole fruit (W), that reached 14.3°Brix after 7 days of storage. Sugars and organic acids are the main substrates for the respiration process in plants (Tucker and Grierson, 1987).

Since respiration in injured tissues is stimulated by ethylene produced by the lesion (Brecht, 1995), a decrease in soluble solids in the slices should have been observed; however, Fig. 1 presents no evidence of such trend. This could be attributed to a combined effect of starch hydrolysis and sucrose synthesis as reported for whole mangoes (Castrillo *et al.*, 1992).

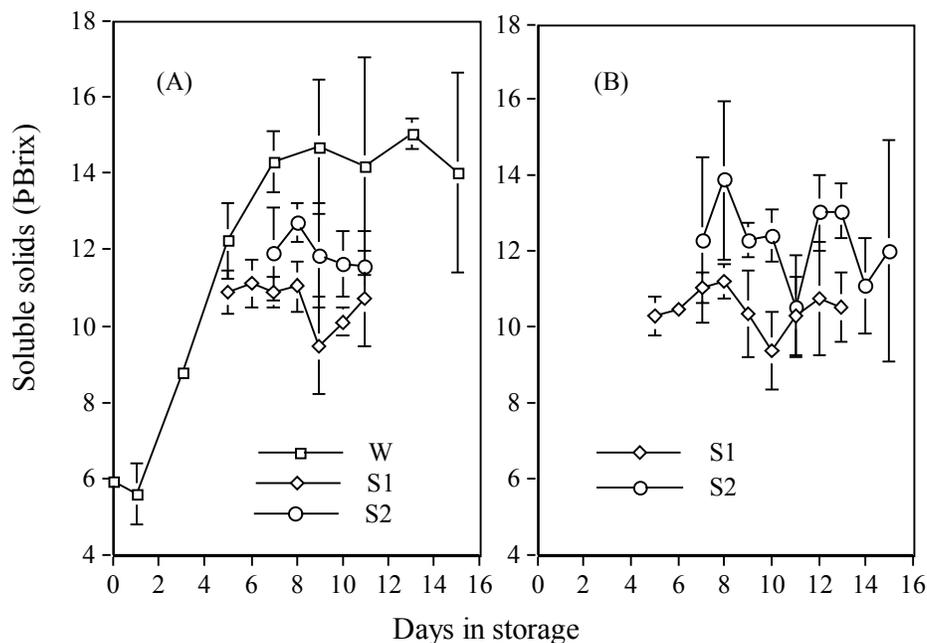


Fig. 1. Evolution in soluble solids (°Brix) of whole (W), and sliced (S1, 4 days and S2, 6 days after harvest and ripening at 23 °C and 65 % R.H.) Kent mango fruit during storage at A) 23 °C and B) 13 °C. Each value represents the mean and 95% confidence interval of at least 4 independent determinations.

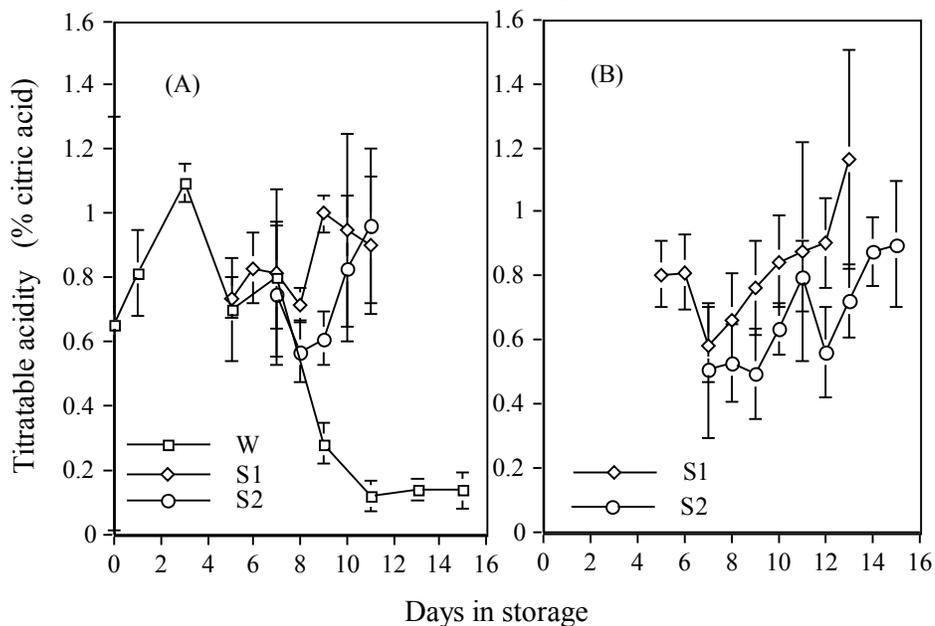


Fig. 2. Changes in titratable acidity (as % citric acid) of whole (W) and sliced (S1, 4 days and S2, 6 days after harvest and ripening at 23 °C and 65 % R.H.) Kent mango fruit during storage at A) 23 °C and B) 13 °C. Conditions and replicates were same as for Fig. 1.

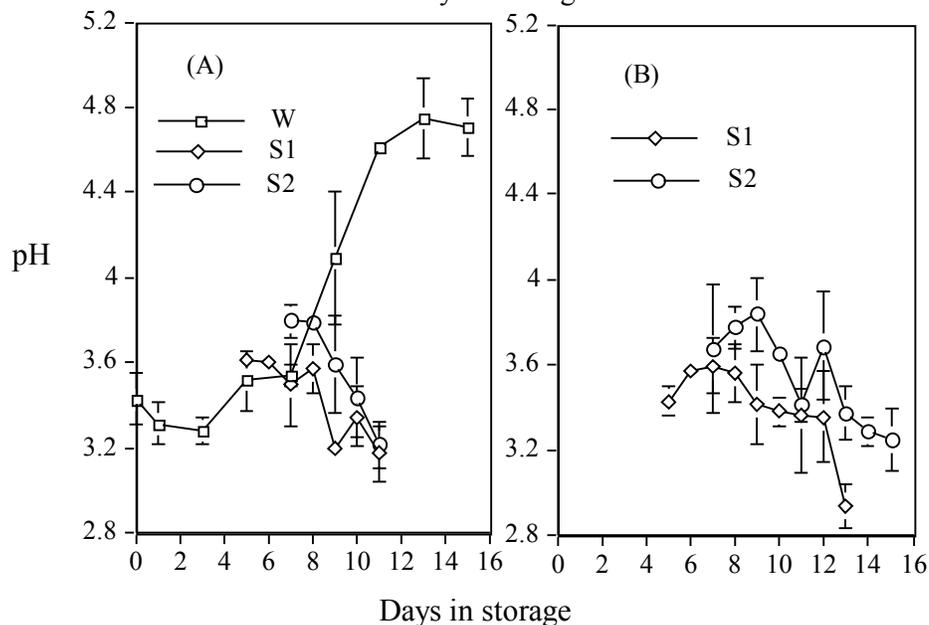


Fig. 3. Changes in pH of whole (W) and sliced (S1, 4 days and S2, 6 days after harvest and ripening at 23 °C and 65 % R.H.) Kent mango fruit during storage at A) 23 °C and B) 13 °C. Conditions and replicates were same as for Fig. 1.

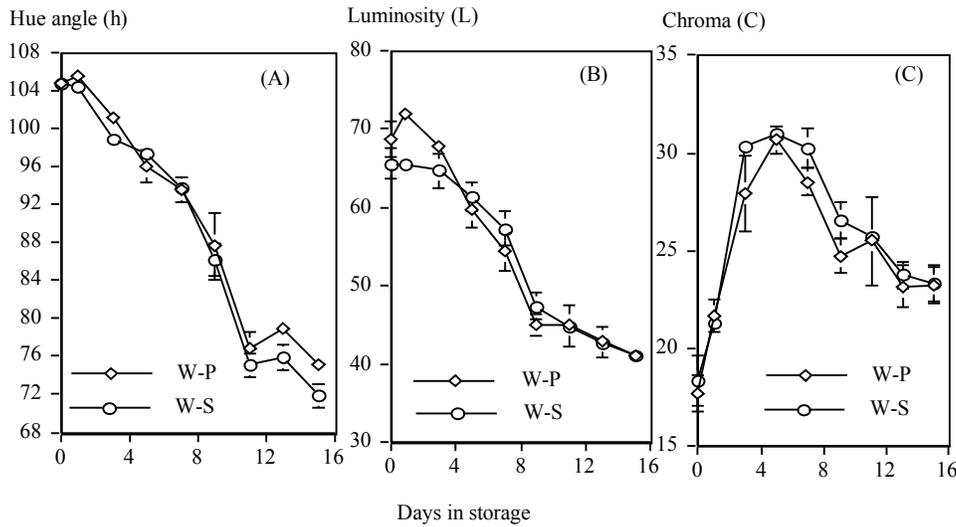


Fig. 4. Changes in A) hue angle (h), B) luminosity (L) and C) chroma (C) of whole (W) on the peel “P” and seed “S” sides of each slice of whole mango fruit during storage at 23 °C and 65 % R.H. Each value is the mean and 95% confidence interval of at least 6 independent determinations.

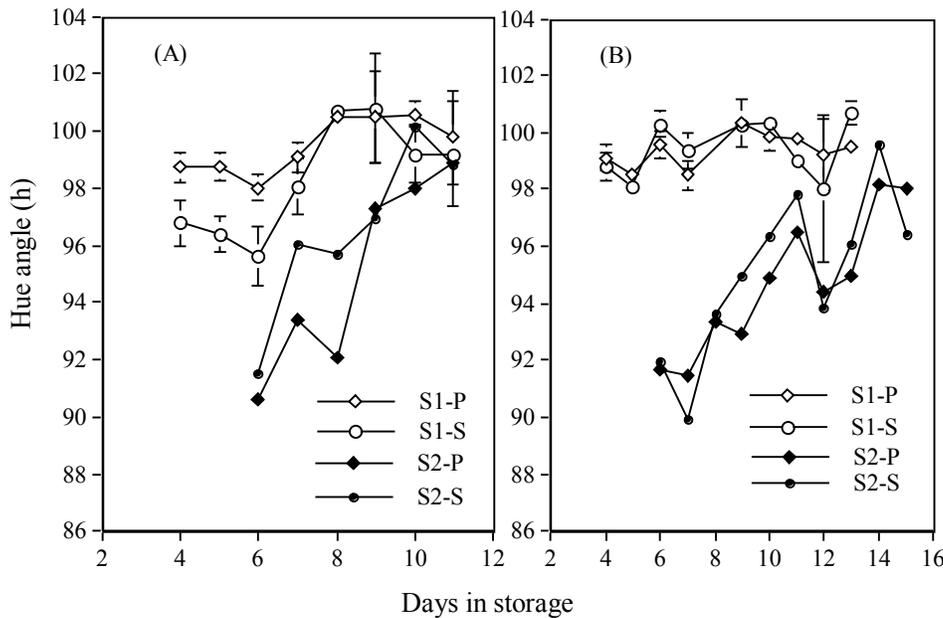


Fig. 5. Changes in hue angle (h) of sliced (S1, 4 days and S2, 6 days after harvest and ripening at 23 °C and 65 % R.H.) mango fruit on the peel “P” and seed “S” sides of each slice during storage at A) 23 °C and B) 13 °C. Each value is the mean and 95% confidence interval of at least 6 independent determinations.

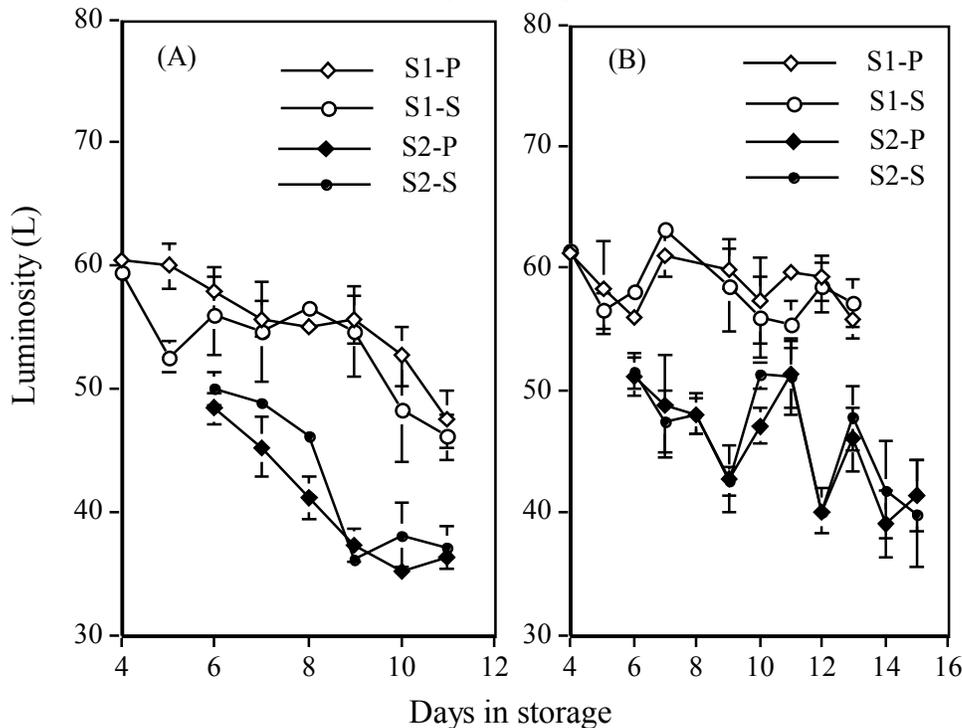


Fig. 6. Changes in luminosity (L) of sliced (S1, 4 days and S2, 6 days after harvest and ripening at 23 °C and 65 % R.H.) mango fruit at the same conditions as those described in Fig. 5.7

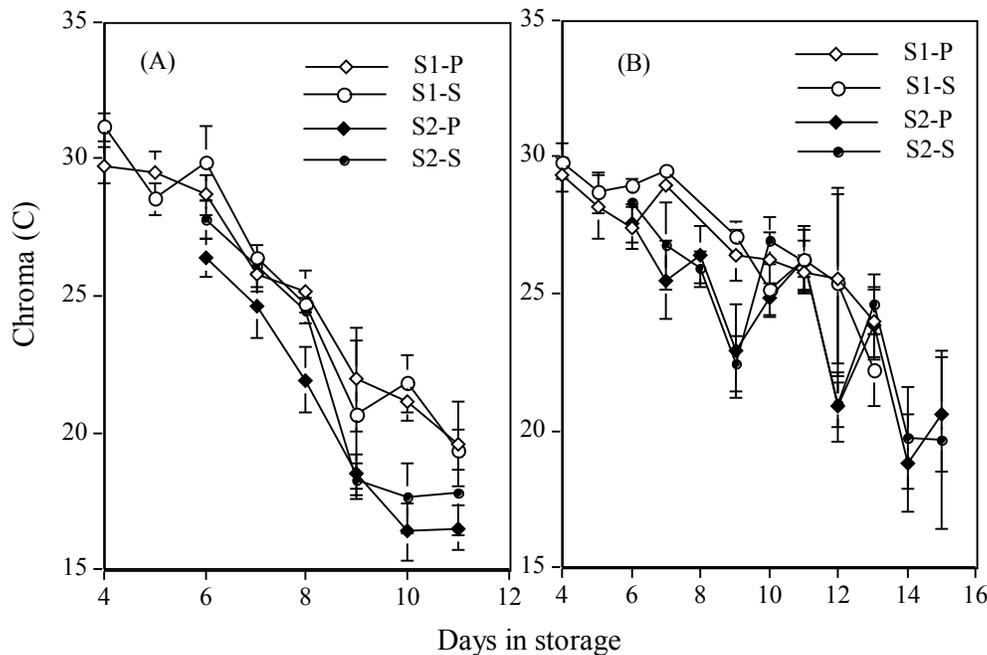


Fig. 7. Changes in chroma (C) of sliced (S1, 4 days and S2, 6 days after harvest and ripening at 23 °C and 65 % R.H.) mango fruit at the same conditions as those described in Fig. 5.

Titrateable acidity (TA) of slices increased during storage at both temperatures tested (Fig. 2). Slices at S1 and 13°C maintained TA near 0.8% for the first 8 days of storage (5 to 12 days postharvest). Whole fruit displayed a typical decrease in TA to 0.1% when the fruit was fully ripe. Kato-Noguchi and Watada (1997) found that application of a citric acid solution 1 mM or greater to the cut surface of carrots at 25°C depressed respiration and consequently organic acids produced at the cytosol by glycolysis and the pentose-phosphate pathway were not oxidized at the mitochondria (Day and Copeland, 1993). In this study, mango slices were immersed in 2% citrate, and later in sodium metabisulfite and sodium benzoate. This treatment and the storage temperature may have caused accumulation of organic acids in the mango tissues and increased their acidity considerably.

An increase in TA is associated to decreased pH. The pH values of S1 mangoes stored at 13°C fluctuated between 3.2 and 3.6 for the first 8 days of storage (5 to 12 days postharvest), which was not different from the pH of whole mangoes at the initial stages of the experiment (Fig. 3). It has been suggested that pH may be used as a 'fine' control for glycolysis (Plaxton, 1996). In our experiments, the drop in pH values observed when mangoes were cut may affect glycolysis as well as stimulate pyruvate decarboxylase. In Fig. 3, the typical behaviour of pH during ripening is observed for whole mangoes, in which pH increased to ca. 4.8.

The colour parameter *h* in whole mangoes (P-side and S-side) changed from 104.6 (off-white, greenish) at day zero, to 75.0 (yellow-orange) at day 15 (Fig. 4). Values for *h* of S1 at 23°C were different at either side of the slice (P-side, 96.8 and S-side, 98.7) for the first three days and then increased to values close to 100, that were statistically similar and indicated the loss of yellow pigments (Fig. 5). In S2 (Fig. 5) the latter behaviour was more pronounced due to the more advanced state of ripeness of the mangoes. These S2 samples started with *h* values of 90-92 (yellow) and reached *h* values of ca. 100 at the end of the storage

and similar trend was observed for S2 mangoes at 13°C. S1 mangoes held at 13°C maintained *h* values unchanged for the first 8 days, suggesting better stability in hue. Loss of yellow colour in the slices may be attributed to carotenoid degradation, which undergo co-oxidation by reacting with hydroperoxides formed by lipoxygenase-mediated oxidation of polyunsaturated fatty acids. These oxidases are activated after the mechanical damage caused to the tissues by the cutting operation (Rolle and Chism, 1987; Gardner, 1980).

The luminosity decreased with ripening time in W mangoes (Fig. 4) as well as on most treatments, except for S1 mangoes at 13°C (Fig. 6), in which the L values remained statistically unchanged with respect to their initial values (ca. 60). The cutting and slicing allows polyphenoloxidase to come in contact with phenolic compounds and oxygen and lead to tissue browning (Schwimmer, 1978; Brecht, 1995; Reyes, 1996). The appearance of brown pigments in mango slices may have caused the drop in luminosity. This reaction was partly inhibited by immersion of the slices in sulfite solution, as previously described; however a smaller decrease in L for S1 slices was noted and attributed to the fruit ripening stage. There is some degree of consistency with chroma values. Whole mangoes (Fig. 4) and all the other treatments (Fig. 7) displayed a concomitant drop in chroma values, which suggests a loss of colour purity. S1 mangoes at 13°C showed the least changes in chroma during the first 8 days. Decay occurred sooner (*i.e.* between days 5 and 7) in all slices stored at 23°C. This decay was not caused by microbial proliferation but by greater metabolic activity in the fruit tissue due to the slicing operation and storage temperature. Slices tended to soften after 4 days at either temperature. From all the parameters monitored it may be concluded that degree of maturity S1 and a temperature of storage of 13°C minimized the compositional changes caused by the mechanical damage. However, the higher acidity, decreased soluble solids and lower pH, as well as inadequate colour development of the slices makes the overall quality attributes and probable acceptability not comparable with those observed in naturally-ripened whole fruit.

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