EFFECT OF FRUIT MATURITY AND STORAGE TEMPERATURE ON THE QUALITY AND STORAGE LIFE OF TOMATO SLICES

Pengaruh Kematangan Buah dan Suhu Simpan Terhadap Kualitas dan Daya Simpan Irisan Buah Tomat

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ABSTRAK

Penelitian ini bertujuan mengevaluasi pengaruh kematangan buah dan suhu simpan terhadap kualitas dan daya simpan irisan buah tomat. Penelitian yang menggunakan tomat cv. 'Revolution' ini dilaksanakan di Laboratorium Pascapanen Hortikultura milik 'School of Agronomy and Horticulture' The University of Queensland, Australia pada tahun 2003. Perlakuan disusun secara faktorial 4 x 3 dalam rancangan acak lengkap dengan 5 ulangan. Faktor pertama adalah 4 tingkat kematangan buah yaitu buah semburat-kuning ('turning'), oranye ('pink'), merah muda ('light-red') dan merah ('red') dan faktor kedua adalah 3 suhu simpan berturut-turut suhu 0, 5 dan 10 °C. Buah tomat diiris dengan 'slicing machine'. Hasil penelitian menunjukkan bahwa pericarp irisan tomat dari buah semburat-kuning lebih keras, pembentukan warna merah lebih lambat, mengandung padatan terlarut lebih rendah, tingkat keasaman lebih tinggi, umur simpan lebih lama (10 hari) daripada irisan tomat dari buah merah. Irisan tomat yang disimpan pada suhu 0 °C pericarpnya lebih keras, menghasilkan padatan terlarut lebih tinggi, tingkat keasaman lebih tinggi, pembentukan warna merah yang lebih lambat daripada irisan tomat yang disimpan pada suhu 10 °C. Irisan buah tomat dari buah oranye dan merah muda menunjukkan kualitas terbaik untuk dikonsumsi pasca penyimpanan, sedangkan suhu 0 °C adalah suhu simpan yang menghasilkan kualitas irisan tomat terbaik dan umur simpan lebih lama (12 hari).
Keyword: tomato, fruit maturity level, storage temperature, quality, storage life

INTRODUCTION

Tomato is a vegetable fruit and little attention has been paid to fresh-cut tomato slices. Tomatoes have great potential for fresh-cut processing (Anonymous 2002). As tomato slices are a fresh commodity, there is a need for ready-to-eat tomato slices that have an acceptable condition for the food service industries, for use on sandwiches, burgers and in restaurants.

The stage of maturity influences the physiology and chemical composition of the tomato. Kader *et al.* (1977) found that fruits picked at the earlier stages of maturity and ripened to table ripeness at 20 °C had reduced flavour characteristics compared with those fruits picked at the later stages of maturity. On the other hand, low storage temperature is able to minimise the deterioration of the product caused by slowing changes in physiological processes such as ripening, senescence, and growth of microorganisms (Watada *et al.* 1996). Mencarelli & Saltveit (1988) experimented on 'mature-green' tomato cv. 'Castlemart' and found that equatorial 7 mm-thick slices ripened normally at a storage temperature of 20 °C. They concluded that tomato slices could be ripened to an acceptable level of quality. Artes *et al.* (1999) reported that slices from 'pink' cv. 'Durinta' continued to ripen during storage at 5 °C for 10 days. Hakim *et al.* (2000) found that slices obtained from 'turning' fruit continued to ripen during storage at 10 °C for 10 days. In these reports, the ripening of tomato slices was conducted using a single maturity stage, so the effect of different maturity stages could not be determined under the same storage conditions.

Optimal storage temperature for fresh-cut products is critical for maintenance of quality. Generally, fresh-cut products should be stored at lower temperatures than those recommended for intact fruit and vegetables, because fresh-cut products are much more perishable than intact products due to injury sustained during processing (Senesi *et al*. 2000, Watada & Qi 1999). The recommended storage temperatures for fresh-cut vegetables such as broccoli, lettuce and carrots are in the range of 0 to 8 °C (Ahvenainen 1996, Varoquaux & Wiley 1994). According to Verlinden & Nicolai (2000), storage temperature 0 °C is preferable in most cases, but temperatures between 5 and 10 °C are more commonly found in practice. Artes *et al.* (1999) found that during 10 days of shelf life, the quality attributes of tomato slices were lower when the slices were kept at 10 °C than when it was kept at 2 °C. Gil *et al.* (2002) showed that after 7 days of storage there was no difference in quality of slices when they were maintained at 0 and 5 °C. However, the authors observed that when the storage period was prolonged to 10 days, quality attributes (soluble solids and soluble solids/titratable acidity ratio) were better preserved in the slices at 0 °C.

The experiment reported in this paper examines the postharvest quality of tomato slices in relation to maturity of the fruit and storage temperature. Physiological aspects that characterise tomato slice quality including firmness, juice colour, soluble solids and titratable acidity were measured. In addition to that, fungal infection, taste and storage life were also examined in this experiment.

METHODS

Plant materials

Fruits of tomato cv. 'Revolution' were harvested from a commercial field in March 2003. Medium-sized fruits were chosen with a mean fresh weight of 150.0 ± 14.6 g, and equatorial and longitudinal dimensions of 68.7 ± 1.6 mm and 65.4 ± 2.4 mm, respectively. The four stages of maturity were characterised by colour skin (hue angle, h°) (Cantwell & Kasmire 2002) and firmness (Newtons, N) as 'turning' (h° 80-100, 21 ± 0.9 N), 'pink' (h° 63-77, 18 ± 0.8 N), 'light-red' (h° 55-63, 15 ± 0.6 N), and 'red' (h° 46-54, 12 ± 0.5 N).

Slice preparation

A total of 5 slices (each 7 mm-thick) were cut from each fruit. To ensure uniformity only equatorial slices were taken, and the upper stem-end and lower blossom-end slices were discarded. The five equatorial slices from each fruit were considered as one replicate and were arranged within plastic containers as vertical stacks. Each plastic container (high density polyethylene with length: 16.5 cm, width: 10.5 cm, depth: 6.5 cm) was capped with a lid perforated with 2 holes (10 mm-diameters). The holes were packed with clean cotton wool to assist in maintaining sterility, and to enable adequate ventilation of the atmosphere inside (Wu & Abbott 2002). Each container containing two layers of absorbent paper on the bottom to prevent juice accumulation (Gil *et al*. 2002). All containers were held in storage rooms at 0,5 and 10 °C with relative humidity at 95 %.

Assessments and experimental design

Tomato slices were brought from the storage room and before the sample temperature could change, pericarp firmness was assessed at the outer pericarp at two opposite locations using a materials tester pericarp firmness (Autograph, Shimadzu AGS-H 500N). The firmness measurements were undertaken by placing each slice on a flat plate held perpendicular to the probe. Firmness (N) was determined by measuring the force required for a 4 mm-diameter cylindrical probe to penetrate the cut surface 3 mm at a speed 1 mm/sec, following the method developed by Wu & Abbott (2002).

Juice colour was measured using juice extracted by using the CIELAB L^*, a^*, and b^* values obtained with a Minolta CR-200 (Minolta Camera Co. Ltd. Osaka, Japan) tristimulus colormeter. Colour, as hue angle (h°), was measured by aiming the sensor through the base of a glass jar containing 40 ml of juice (Artes *et al.* 1999). Hue angle was calculated on the basis of the following equations (Arias *et al*. 2000, Lancaster *et al*. 1997):

h° = arctangent (b^*/a^*), when $a^* > 0$ and b^*

≥ 0

or

$h^\circ = 180^\circ + \text{arctangent}(b^*/a^*)$, when $a^* < 0$ and $b^* > 0$;

Juice was extracted from slices by homogenising them at high speed for 1 minute in a food blender. The homogenate was filtered through two layers of cheesecloth to obtain the clear filtrate. Soluble solids content of the resulting clear juice (about 5 g) was determined at 20 °C using an Atago Digital Refractometer (PR-101, Fuji, Japan), in units of °Brix. The refractometer was initially calibrated using distilled water, and the prism was wiped with clean tissue paper and then rinsed with distilled water after each measurement.

Titratable acidity (TA) was measured on 10 g of juice diluted with 50 ml of distilled water. The diluted juice was stirred (IKAMAG, Janke & Kunkel, Australia) then titrated with 0.1 N NaOH to an end point of pH 8.2. An automatic titrator (Metrohm, Swiss) equipped with a 632 pH meter and 765 Dosimat Autoburette was used to measure titratable acidity. Titratable acidity was expressed as percentage (w/w) citric acid. The percent total titratable acidity as citric acid was calculated by the following equation (Roberts *et al.* 2002).

$$\% \text{ citric acid} = \frac{\text{Vol.NaOH (mL)} \times 0.1 \text{ (Normality of NaOH)} \times 0.064 \times 100}{10 \text{ g of juice}}$$

Where 0.064 = milliequivalent factor for citric acid

The ratio soluble solids to titratable acidity was calculated as

$$\frac{\text{Soluble Solids content}}{\text{Titratable acidity}}$$

Tomato sliced were prepared for assessments of fungal infection and taste at the end of the experiment (day 10). Fungal infection of fruit slices was evaluated subjectively using a scale of 1 to 5, where 1 = none, 2 = slight, 3 = moderate, 4 =moderately severe, 5 = severe (Hakim *et al.* 2000).

To asses taste, slices were brought to room temperature over 2 hours and a panel of seven untrained judges (UQ postgraduate students, unassociated with the research) assessed the slices using a scale of 1 to 5, with 1 = none, 2 = slight, 3 = moderate, 4 = moderately full, 5 = full typical aroma and flavour. Taste assesment was conducted under diffuse light under panel room.

'Shelf life' refers to the maximum life at room temperature, and 'storage life' refers to the maximum life at low temperature. Individual slices were scored as described in Table 1 and averaged to give a mean score for the sample. Storage life was expressed as the number of days required at low temperature for the sample to deteriorate to an average score of 6.

The experiment was laid out in a completely randomised design. The factors were 4 levels of fruit maturity ('turning', 'pink', 'light-red', 'red'), and 3 levels of storage temperature (0, 5 and 10 °C). Each treatment was replicated 5-fold. Experimental assessments were made on days 1, 4, 7, and 10 after slicing preparation. In the following graphs, where maturity is the main factor, data from all temperatures are combined. Where temperature is the main factor, all maturities are combine.

Table 1. Rating scale for storage life of tomato slices

Score	Criteria	Slice description
9	Excellent	No loss of juice or seeds
8	Very good	A few drops of juice or seeds may be lost
7	Good	Some juice and seeds lost
6	Fair	Considerable juice and seeds lost
5	Poor	Much of the juice and seeds is lost

RESULTS AND DISCUSSION

Results

Rates of softening of tomato slices differed with the maturity of the source fruit. The tomato slices obtained from the 'turning' stage of maturity were generaliy the firmest (P<0.05) and slices from the 'red' stage of maturity were generally the least firm (Fig. 1A). Slices stored at 0 and 5 °C were significantly firmer (P<0.05) than the slices were stored at 10 °C after 4 days of storage (Fig. 1B). Juice extracted from slices of all maturity stages started with significantly different (P<0.05) hue values, as expected. By the end of storage (10 days) juice from 'pink' and 'light-red' slices developed a colour that was not significantly different from that of 'red' slices (Fig. 2A). There were significant (P<0.05) and gradual reductions in juice hue angle with an increase in temperature during storage (Fig. 2B). After 4 days storage, juice from slices stored at 0 °C had higher hue angles than juice from slices stored at higher temperatures. Higher hue angle indicated more yellow, and less red, colouration.

The soluble solids content of the slices increased significantly (P<0.05) with time

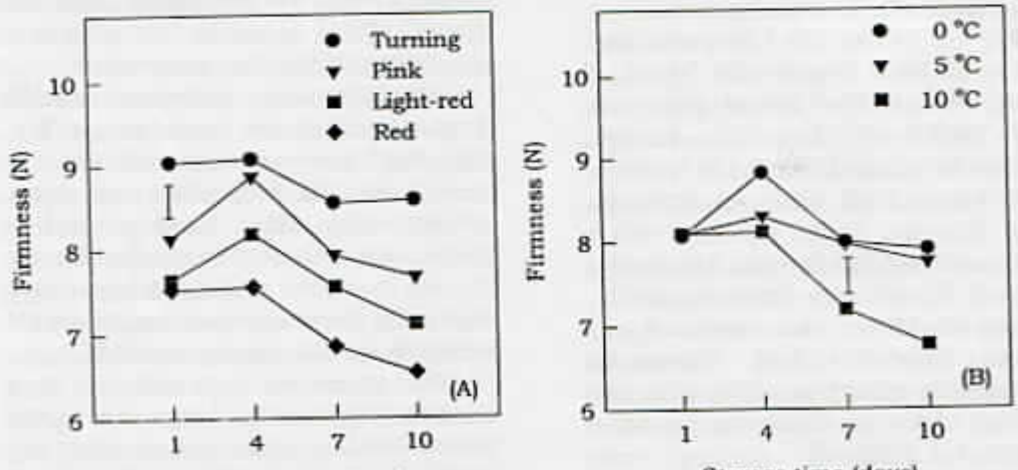

Figure 1. Changes in pericarp firmness of slices from tomato fruit of different stages of maturity (A) and storage temperature (B) during storage. Vertical bars represent LSD 0.05

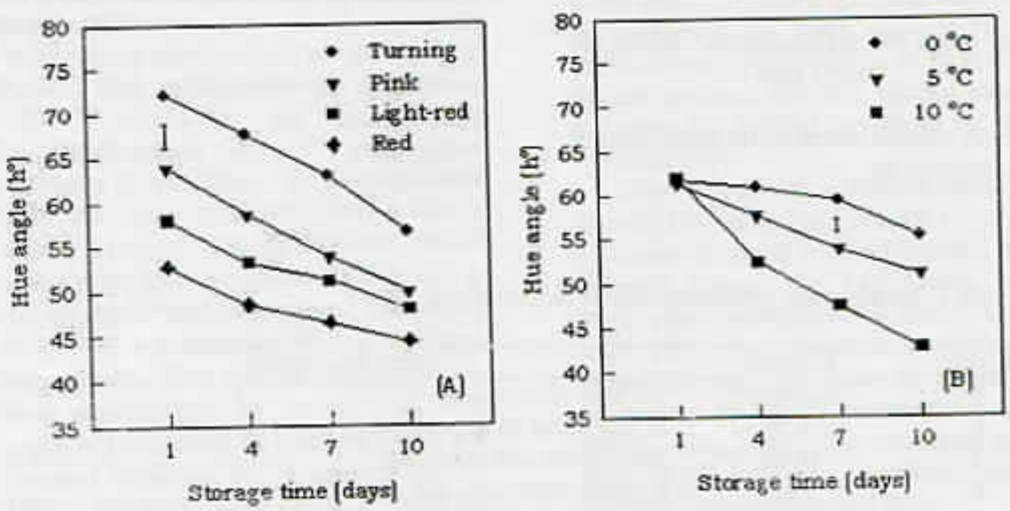

Figure 2. Changes in juice hue angle of slices from tomato fruit of different stages of maturity (A) and storage temperatures (B) during storage. Vertical bars represent LSD 0.05

in storage (Fig. 3A). The slices obtained from the 'red' stages of maturity had the highest soluble solids content, while the slices obtained from the 'turning' stages of maturity had the lowest soluble solids content until day 7. There were also small but significant differences ($P<0.05$) in soluble solids content of the slices stored at different temperatures (Fig. 3B). Higher storage temperatures reduced the soluble solids content of the slices from day 1 to day 4.

There were significant differences ($P<0.05$) in titratable acidity among the slices at different stages of maturity. The titratable acidity of the slices decreased significantly with time in storage, and was highest in the 'turning' stage and the lowest in the 'red' stage of maturity (Fig. 4A). Storage temperature also caused significant differences ($P<0.05$) in titratable acidity. The titratable acidity content of the slices stored at 0 and 5 °C were higher compared to those stored at 10 °C (Fig. 4B). There were significant differences ($P<0.05$) in the ratio of soluble solids titratable acidity of the slices as affected by fruit maturity and storage temperature.

The ratio increased as the stage of maturity advanced from 'turning' to 'red' (Fig. 5A) and as the temperature increased

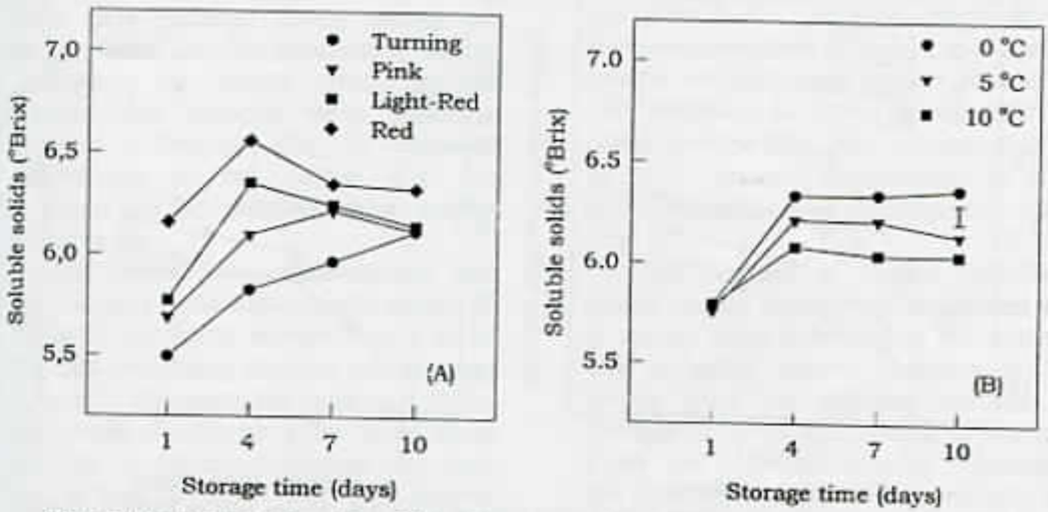

Figure 3. Changes in soluble solids of slices from tomato fruit of different stages of maturity (A) and storage temperatures (B) during storage. Vertical bars represent LSD 0.05

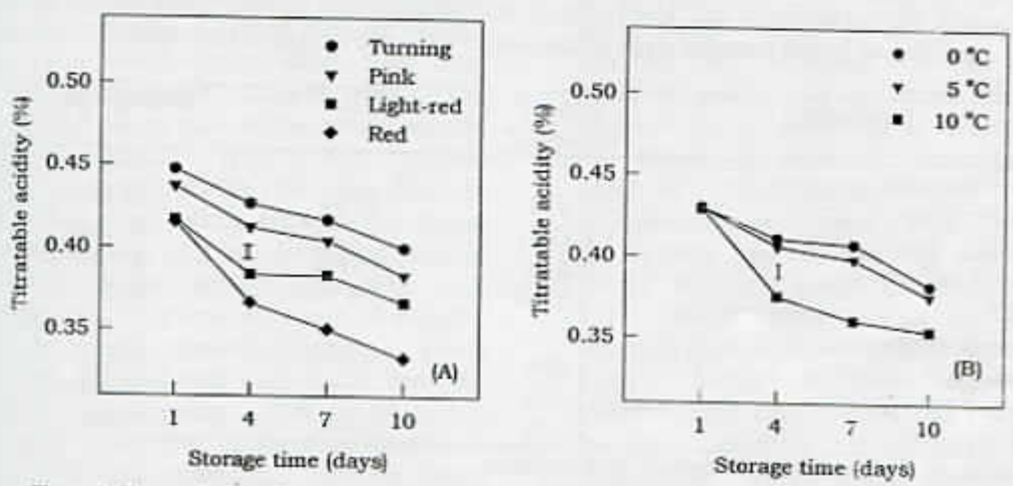

Figure 4. Changes in titratable acidity (as % citric acid) of slices from tomato fruit of different stages of maturity (A) and storage temperature (B) during storage. Vertical bars represent LSD 0.05

(Fig. 5B), indicating that all slices continued to ripen during storage. The soluble solids/titratable acidity ratio of 'red' slices was higher than that in slices from other maturities during storage (Fig. 5A). Slices that were maintained at 0 °C had significantly lower ($P<0.05$) ratios than those slices kept at 10 °C, after 4 days storage (Fig. 5B). Results relating to fungal infection, taste and storage life are summarised in Table 2. Fungal infection in the slices became apparent during the later part of storage. Although there were differences in fungal infection between the 'pink', 'light-red', and 'red' stages of maturity on the one hand and in 'turning' stage slices on the other, differences were very small. Higher storage temperature (10 °C) produced significantly more fungal infections ($P<0.05$). Slices from 'turning' maturity fruit had lower taste scores than slices from 'red' maturity fruit, but mean scores for 'pink', 'light-red' and 'turning' were very similar, despite the statistical differences recorded. Slices from lower storage temperatures (0 and 5 °C) had significantly better taste scores than that of the slices stored at higher temperature (10

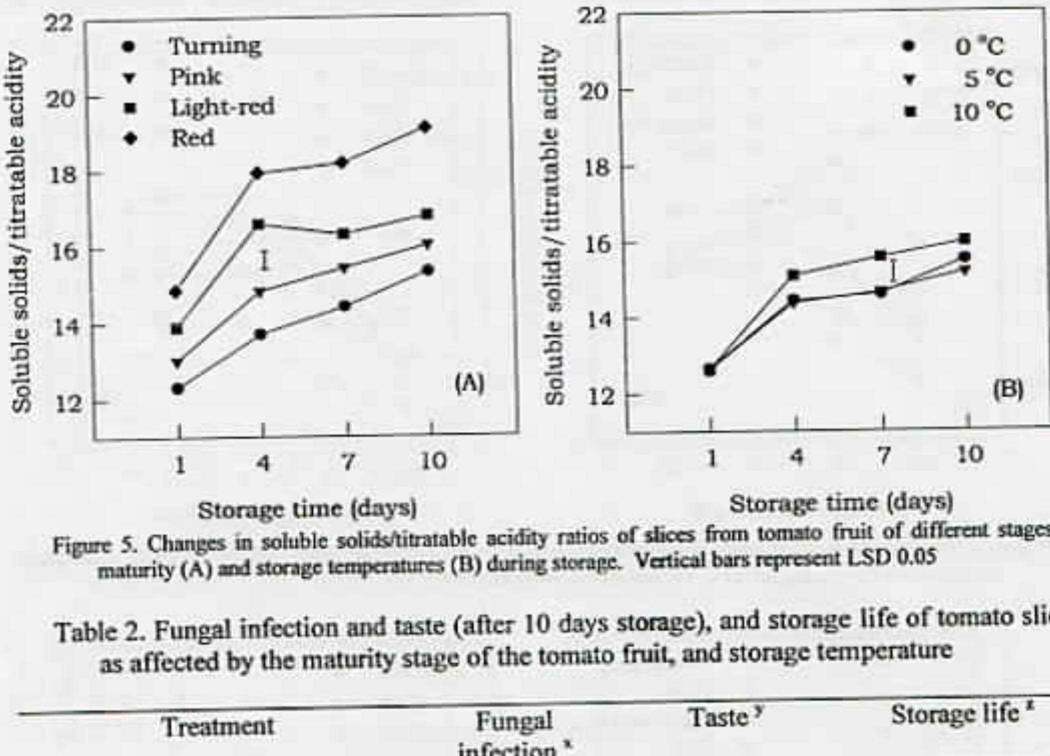

Figure 5. Changes in soluble solids/titratable acidity ratios of slices from tomato fruit of different stages of maturity (A) and storage temperatures (B) during storage. Vertical bars represent LSD 0.05

Table 2. Fungal infection and taste (after 10 days storage), and storage life of tomato slices as affected by the maturity stage of the tomato fruit, and storage temperature

Treatment	Fungal infection [x]	Taste [y]	Storage life [z]
Fruit maturity			
'Turning'	1.27a	3.53a	10.33a
'Pink'	1.33ab	4.27b	10.13ab
'Light-red'	1.67b	4.47bc	9.73b
'Red'	1.73b	4.67c	9.27c
Storage temperature (°C)			
0	1.00a	4.65a	12.05a
5	1.15a	4.25b	10.35b
10	2.35b	3.80c	7.20c

[x] Score on a scale of 1 (no infection) to 5 (severe)

[y] Score on a scale of 1 (none) to 5 (full taste)

[z] Number of days to achieve score 6 (limit of marketability)

°C). Maturity stage at slicing produced a significant effect ($P<0.05$) on storage life. The slices obtained from the 'red' maturity stage had the shortest storage life while the 'turning' and 'pink' stage slices had longer storage life, although slices from 'pink' and 'light-red' fruit had the same storage life. Tomato slices from all maturity stages had longer storage life when maintained at 0 °C and 5 °C than at 10 °C.

Discussion

During the ripening of the intact tomato, the colour, flavour, and texture of the fruit changes dramatically (Grierson & Kader 1986, Kinet & Peet 1997). These events also occurred during storage of tomato slices. In this experiment, during storage of the tomato slices, general changes that occurred were softening (decrease in firmness) (Fig. 1), continued development of red colour (Fig. 2), increased soluble solids/titratable acidity ratio (Fig. 5).

The present study demonstrated that fruit maturity could influence the quality of tomato slices during storage at 0, 5 or 10 °C. The best quality of slices was obtained from fruit taken from the 'pink' and 'light-red' stages of maturity. The 'pink' slices continued to develop red colour (Fig. 2A), and retained firmness (Fig. 1A), soluble solids/titratable acidity ratio (Fig. 5A) better than 'turning' slices. 'Light-red' slices had higher soluble solids/titratable acidity ratio (Fig. 5A) than 'turning' slices.

The lowest quality slices were from 'turning' and 'red' maturity fruit. The 'turning' slices showed the lowest soluble solids content (Fig. 3A), soluble solids/titratable acidity ratio (Fig. 5A). In addition, 'red' slices showed the lowest firmness (Fig 1A), but the highest soluble solids/titratable acidity ratio (Fig. 5A). Therefore, fruit from all stages of maturity used in this research ('turning', 'pink', 'light-red' and 'red') could be used for fresh-cut processing. This would give a broad choice for fresh-cut processors in choosing raw materials. However, based on the data in the current study, the 'pink' and 'light-red' maturity stages of maturity could be best used for commercial fresh-cut processing and would be acceptable for marketing. Other researchers, such as Hakim *et al.* (2000), made fresh-cut tomato slices from tomato cv. 'Solarset' at 'pink' maturity, while others, such as Hong *et al.* (2000) used tomato cv. 'Sunbeam' at the 'red-ripe' stage of maturity, and Gil *et al.* (2002) used partially ripe ('pink') tomato cv. 'Durinta'. These results suggest that the maturity at which tomatoes are sliced should be carefully selected to ensure the slices meet market requirements.

Another finding from this research is that the most suitable storage temperatures for slices from all 4 maturity stages tested was 0 or 5 °C. At those temperatures, slices remained firm (Fig. 1B), increased in soluble solids/titratable acidity ratio (Fig. 5B), continued to ripen, as indicated by colour changes (Fig. 2B). Storage at 0 °C or 5 °C reduced deterioration in slice quality as indicated by retention of firmness (Fig. 1B).

High firmness of tomato fruits is a critical quality attribute for consumers and in tomato slices softening is also critical. The softening pattern observed in the present study demonstrated that loss of firmness or texture degradation of tomatoes slices was linked to ripening. Generally, the more advanced the fruit maturity the greater the loss of firmness (Fig. 1A), which is in agreement with Soliva-Fortuny *et al.* (2002) in their study of fresh-cut apple slices. Agar *et al.* (1999) also reported flesh softening was the major cause of quality loss of stored fresh-cut kiwifruit slices. Softening is initiated by the action of pectolytic enzymes, in particular pectinmethylesterase and polygalacturonase (Gross 1990). During the ripening process, the fruit cell walls release soluble calcium (Hopkirk *et al.* 1990), which would explain the higher softening rates observed in slices from 'red' fruits. Storage at lower temperature retarded these enzyme-mediated softening processes resulting in firmer slices (Crookes & Grierson 1983). The findings of the present investigation are in agreement with those obtained by Artes *et* *al.* (1999), who showed that tomato slices maintained better firmness during storage at 2 °C. Firmer slices are easier to transport and handle and are preferred by the consumer.

Colour is an important sensory attribute of visual appearance (Clydesdale 1991). In general, the colour of juice obtained from all slices changed during the period of storage. However the colour development of slices from 'red' maturity fruit was slightly slower than that in slices from 'turning' fruit. Juice from the 'turning' and 'pink' slices developed light red colour (h° ≈ 55 - 60), whereas 'light-red' slices developed a red colour (h° ≈ 50) (Fig. 2A). The hue angle decreased in all temperatures during storage (Fig. 2B), which indicates the continued ripening of the slices even at 0 or 5 °C, but red colour development was certainly faster at the higher temperature of 10 °C. These results are in agreement with those obtained in studies of tomato slices by Artes *et al.* (1999) and Gil *et al.* (2002).

The level of soluble solids in tomato slices increased with advances in fruit maturity (Fig. 3A), as found by others researching intact tomatoes (Islam & Khan 2000, Kader *et al.* 1978, Yelle *et al.* 1991). Moreover, soluble solids levels were lower in the slices stored at higher temperatures (Fig. 5.5B), as found by Artes *et al.* (1999).

Slices from advanced stages of maturity yielded lower titratable acidity concentrations during storage (Fig 4A), as observed also by Shi *et al.* (1999). Titratable acidity was lower at higher storage temperature (Fig 4B). This is in agreement with results of Artes *et al.* (1999). The rapid decrease in titratable acidity might be due to the faster utilisation of acids during respiration at higher temperatures (Moller & Palmer 1984).

The ratio of soluble solids/titratable acidity is often used to estimate quality, and is important to tomato flavour (De Bruyn *et al.* 1971, Picha 1986). The ratio of soluble solids/titratable acidity in slices from all maturities (Fig. 5A) and storage temperatures (Fig. 5B) steadily increased during storage. This is due to a substantial monosaccharide increase together with a decrease in total organic acids (Islam & Khan, 2000, Petro-Turza 1986). Maintaining high soluble solids and titratable acidity is essential for ensuring high quality fresh-cut produce. The soluble solids/titratable acidity ratio is closely related to its organoleptic properties. A higher ratio of soluble solids/titratable acidity would give better taste.

The present study demonstrated that fruit maturity could influence the quality of tomato slices during storage and extends their storage life. The best quality of slices was obtained from fruit taken from the 'pink' and 'light-red' stages of maturity. The 'pink' slices exhibited the longest storage life (Table 2) better than 'turning' slices. 'Light-red' slices had a storage life of about 9 days, which is not much different from the storage life of 'turning' maturity slices (10 days, Table 2).

The lowest quality slices were from 'turning' and 'red' maturity fruit. The 'turning' slices showed the lowest taste score (Table 2). In addition, 'red' slices showed the lowest storage life (Table 2). Based on the data in the current study, the 'pink' and 'light-red' maturity stages of maturity could be best used for commercial fresh-cut processing and would be acceptable for marketing. Other researchers, such as Hakim *et al.* (2000), made fresh-cut tomato slices from tomato cv. 'Solarset' at 'pink' maturity, while others, such as Hong *et al.* (2000) used tomato cv. 'Sunbeam' at the 'red-ripe' stage of maturity, and Gil *et al.* (2002) used partially ripe ('pink') tomato cv. 'Durinta'. These results suggest that the maturity at which tomatoes are sliced should be carefully selected to ensure the slices meet market requirements.

Another finding from this research is that the most suitable storage temperatures for slices from all 4 maturity stages tested was 0 or 5 °C. Storage at 0 °C or 5 °C resulted in a longer storage life of the slices compared with slices stored at 10 °C (Table 2). The extension in storage life using low temperatures could allow the tomato slices to be more easily managed during handling, and could offer greater flexibility to retailers and consumers. Temperature is a critical factor in the maintenance of slice quality. Tomato slices that were held at 0 °C had a longer storage life than those at 5 or 10 °C (Table 2). The storage life of tomato slices could be maintained for 12 days at 0 °C and 10 days at 5 °C, while the slices stored at 10 °C became unmarketable within 7 days. Agar *et al.* (1999) also reported that the storage life of fresh-cut kiwifruit slices held at 0 - 2 °C was longer compared with slices at 5 °C or 10 °C. For some chilling-sensitive commodities such as tomatoes, Gil *et al.* (2002) considered 5 °C to be the optimum storage temperature to prevent chilling injury and to promote maximum storage life. This statement is confirmed by results of this experiment and by the experiments on tomato slices by Hong & Gross (2000, 2001) who used 5 °C for storage of fresh-cut tomato slices.

Generally, there were no visible fungal infections found during low storage temperature (Table 2). However, the food safety and microbiology of tomato slices needs to be considered as this aspect was outside the scope of this present study. O'Connor-Shaw *et al.* (1994) showed that temperatures higher than 4 °C enhanced physiological deterioration and microbial growth in fresh-cut honeydew melon, papaya and pineapple. Fungal infections after 12 days storage of tomato slices were observed by Hong *et al.* (2000).

CONCLUSION

In conclusion, criteria used to determine the optimal tomato fruit maturity for fresh-cut processing should be acceptable marketing quality of the slices. The results of the present experiment for tomato cv. *Revolution* used in this experiment clearly showed that the best maturity stages for fresh-cut tomato processing were 'pink' and 'light- red' stages within the range of storage temperature of experiment (0, 5, 10°C) . Low temperatures at 0 or 5 °C were the best temperature regimes for storing tomato slices of tomatoes sliced from fruit maturity of experiment ('turning', 'pink', 'light-red' and 'red' maturity). During storage those tomato slices also retained good marketing qualities based on tissue firmness, juice colour, soluble solids and titratable acidity. Keeping produce at a low temperature allows better retention of taste, as well as slowing undesirable pathogens. Tomato slices obtained from fruit at early stages of development ('turning' and 'pink' maturity) had longer post-slicing storage life than slices from advanced stages of development ('light-red' and 'red' maturity) within the storage temperature of experiment.

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