

## CHANGES ASSOCIATED WITH DIFFERENT STAGES OF HARVESTING AND RIPENING OF EKSOTIKA PAPAYA AT AMBIENT TEMPERATURES

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### RINGKASAN

Betik Eksotika dipetik berdasarkan indeks warna yang berbeza dan disimpan pada suhu ambien sehingga masak. Indeks warna tersebut ialah: 1 = seluruh kulit berwarna hijau, 2 = hijau dengan sedikit kekuningan, 3 = lebih banyak hijau daripada kuning, 4 = lebih kuning daripada hijau, 5 = kuning dengan sedikit hijau dan 6 = kuning sepenuhnya. Buah berindeks warna 1 hingga 3 mempunyai perbezaan kekerasan yang bererti ( $P < 0.05$ ) berbanding dengan buah pada peringkat 4 hingga 6. Buah yang dipetik pada semua peringkat indeks warna kecuali indeks warna 6 boleh disimpan selama lima hingga sembilan hari. Penilaian citarasa menunjukkan bahawa buah betik pada peringkat indeks warna 4 hingga 6 dapat memenuhi citarasa pengguna lebih-lebih lagi pada peringkat indeks warna 5. Kandungan jumlah pepejal larut pada semua peringkat indeks warna ialah 9.5%–16.5% manakala pH dan jumlah asid tertitrat masing-masing ialah 5.0–5.7 dan 0.10%–0.25% persamaan asid sitrik anhidrat.

### INTRODUCTION

Ripening of papaya has been reported previously but the work mainly centred on the well established cultivar of Sunrise Solo (BROUGHTON, HASHIM, SHEN and TAN, 1977; CHAN, TAM and SEO, 1981; SELVARAJ, PAL, SUBRAMANYAM and IYER, 1982). In the breeding work of CHAN and OOI (1975), the total soluble solid of 11 indigenous and exotic papaya varieties were described. The total soluble solids and agronomic characteristics of Sunrise Solo were described by CHAN and TEE (1975). The Eksotika papaya (formerly MARDI Backcross Solo) is a new dessert variety that has potential for local consumption and export. This variety is developed after 14 years of breeding and selection at MARDI using the Subang 6 and Sunrise Solo parents, and has very good quality and yield (CHAN, 1985). However, its ripening behaviour was hitherto not well understood. This study aimed to develop the best harvest index for optimal storage life without sacrificing the fruit quality. This aspect is very important, particularly for this new variety which has good potential for export.

### MATERIALS AND METHODS

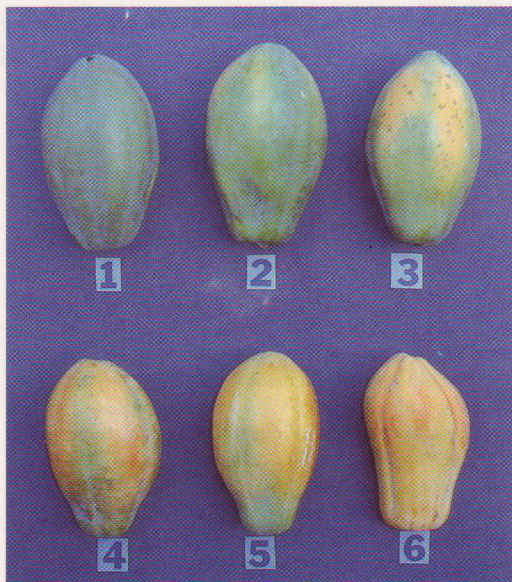
Hermaphrodite (elongated) papaya (*Carica papaya* L.) fruit of Eksotika variety were obtained from MARDI orchard at Serdang, Selangor. The fruit were washed with potable water and the experiments were carried out at ambient temperatures (23°C to 34°C). Four fruit, each representing a replicate, were used in each treatment.

### Physical Changes

The colour of the harvested fruit was classified into six indices as shown in *Plate 1*.

The fruit were kept at ambient temperatures for 0, 3 and 5 days before the firmness was determined. Firmness readings on punctures of the different colour indices at 0, 3 and 5 days after harvest were determined with an Instron 1140 machine using a 11-mm diameter Magness Taylor probe. A puncture was made on the equatorial region of each unpeeled fruit. The cross-head and chart speeds were 50 and 500 mm/min respectively. The mean colour indices of the fruit at each determination were noted.

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Colour index: 1 = all green; 2 = green with a tinge of yellow; 3 = more green than yellow; 4 = more yellow than green; 5 = yellow with a tinge of green; 6 = all yellow.

Plate 1. The ripening colour chart of *Eksotika papaya*.

The step-wise changes in colour indices were determined daily on fruit harvested with initial colour indices 1 to 5.

### Sensory Evaluation

Fruit with colour indices of 1 to 6 at harvest were scored by a panel of ten experienced members. The sensory attributes rated were colour, texture, sweetness, flavour and overall acceptability. Each member was given a piece of 3 cm x 5 cm peeled fruit from each treatment. The ratings were from 1 to 5 with 1 = dislike extremely, 3 = neither like nor dislike and 5 = like extremely.

Sensory evaluation was also done on fruit with colour indices 4 to 6 at harvest, and fruit of initial colour indices 1 to 3 stored for a week after attaining colour indices 4 to 6 respectively.

### TSS, TTA and pH Changes

Total soluble solid (TSS), total titratable acidity (TTA) and pH were determined at each increasing colour stage. The

determination was continued until the fruit attained stage 6 of the colour index. This included fruit harvested at index 6, indices 2 to 5 and those which reached these stages after storage.

The TSS, TTA and pH were determined according to the methods of AOAC (1975). The TSS was determined with a Kyowa HR1-A hand refractometer and TTA by titrating with 0.1N NaOH to a pH of 8.1.

## RESULTS

### Physical Changes

The colour chart for the ripening of the *Eksotika papaya* is shown in *Plate 1*. The firmness readings of fruit with colour indices 1 to 3 differed significantly from those of 4 to 6, irrespective of whether the determination was done at harvest or after storage (*Table 1*). The firmness readings can be used to group fruit into ripe and unripe stages. Unripe fruit were those with colour indices 1 to 3 while ripe fruit were those with colour indices 4 to 6. Unripe fruit had a firmness reading of 27–31 kg.f/11-mm diameter probe. A considerably lower reading of 2–5 kg.f/11-mm probe was recorded for ripe fruit. The firmness reading of the unripe fruit was approximately eight folds higher than that of the ripe fruit. Differences in firmness between the unripe fruit at indices 1 to 3 were non-significant. Similarly, no differences were recorded between ripe fruit at indices 4 to 6 (*Table 1*).

The rate of peel colour changes in fruit harvested at colour indices 2 to 4 was similar in the first few days. However, it was slower in fruit of colour index 1 during the first four days (*Figure 1*). There was no change in colour index 5 fruit during the first day. The shelf life of papaya with colour indices 1 to 5 stored at ambient temperature lasted for five to nine days. Less mature fruit had a longer shelf life.

### Sensory Evaluation

Fruit with colour indices 4 to 6 were scored higher than those with colour indices

Table 1. Firmness of unpeeled Eksotika papaya at various initial colour indices and days after harvest

Colour index at harvest	Mean colour index when test was done	Days after harvest	Firmness (kg.f/11-mm probe)
1	1	0	30.3 a
2	2	0	29.6 a
3	3	0	27.3 a
4	4	0	5.2 b
5	5	0	4.8 b
6	6	0	3.4 b
1	1.50	3	30.8 a
2	3.00	3	30.0 a
3	4.75	3	2.6 b
4	5.75	3	2.1 b
5	6.00	3	2.2 b
1	1.75	5	26.8 a
2	4.00	5	3.8 b
3	5.25	5	1.8 b

Means with different subscript are significantly different ( $P < 0.05$ ) with the LSD test.

Table 2. Sensory evaluation score for different colour indices at harvest of Eksotika papaya

Colour index	Colour	Texture	Sweetness	Flavour	Overall acceptability
1	1.3 c	1.1 b	1.7 b	1.6 b	1.1 d
2	2.9 b	1.5 b	2.0 b	2.2 b	2.3 c
3	3.2 b	1.9 b	2.4 b	2.4 b	2.5 c
4	3.7 ab	3.4 a	4.0 a	3.8 a	3.6 ab
5	4.2 a	4.0 a	4.3 a	4.3 a	4.4 a
6	4.1 a	3.4 a	4.4 a	3.8 a	3.5 b

Means ( $n=10$ ) with different subscript within the same column are significantly different ( $P < 0.05$ ) with the LSD test. Range of scores: 1 = dislike extremely to 5 = like extremely.

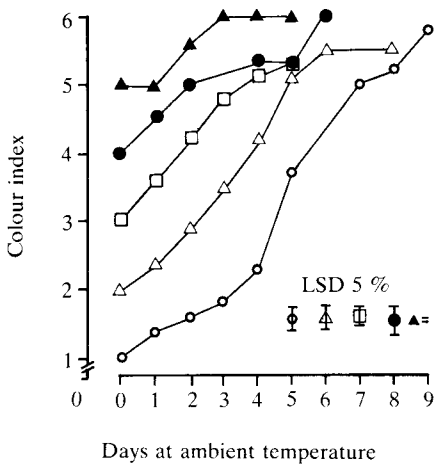


Figure 1. Changes in colour indices of Eksotika papaya harvested at different colour indices and stored at ambient temperature.

1 to 3 (Table 2). The trend of scores for all attributes except sweetness increased from colour index 1, peaked at colour index 5 and decreased at colour index 6. The scores for sweetness although peaked at colour index 6, no differences were recorded at stages 4, 5 and 6. Papaya fruit with colour indices 4 to 6 were acceptable, but colour index 5 was most preferred by the panel. This difference in the acceptability could again classify unripe papayas as those with colour indices 1 to 3, and the ripe papayas as those with colour indices 4 to 6. Such classification was similar to that by physical changes.

The scores for all sensory attributes between the fruit of colour index 4 at harvest, and those harvested with initial colour index 1 and attained colour index 4 after storage were significantly different ( $P < 0.05$ ) (Table 3). However, there was no

Table 3. Sensory evaluation score for different colour indices at harvest and after storage of Eksotika papaya

Attribute	Fruit colour index evaluated	At harvest		After storage (1 week)	
		Initial colour index	Score	Initial colour index	Score
Colour	4	4	3.9 a	1	2.6 b
	5	5	3.6 a	2	3.6 a
	6	6	3.9 a	3	3.6 a
Texture	4	4	3.9 a	1	2.2 b
	5	5	3.9 a	2	2.9 a
	6	6	4.0 a	3	3.3 a
Sweetness	4	4	4.0 a	1	1.6 b
	5	5	3.9 a	2	3.7 a
	6	6	4.2 a	3	3.7 a
Flavour	4	4	3.7 a	1	2.0 b
	5	5	3.5 a	2	2.9 a
	6	6	3.7 a	3	3.2 a
Overall acceptability	4	4	3.8 a	1	2.0 b
	5	5	3.5 a	2	3.2 a
	6	6	3.8 a	3	3.1 a

Means (n=10) with different subscript within the same row are significantly different ( $P<0.05$ ) with the LSD test. Range of score: 1 = dislike extremely to 5 = like extremely.

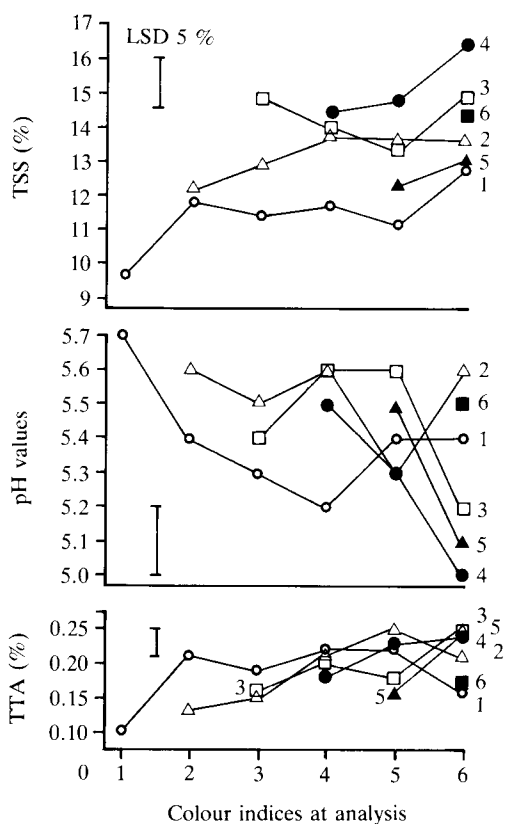


Figure 2. Changes in total soluble solid, pH and total titratable acidity of Eksotika papaya after attaining different colour indices from different initial colour indices at harvest.

significant difference between fruit with colour indices 5–6 at harvest and those stored fruit of initial colour indices 2 and 3 at harvest which attained the colour indices of 5 and 6 respectively. This shows that fruit harvested at colour index 1 and kept for one week to attain colour index 4 (ripen) do not achieve the same qualities as fruit harvested at colour index 4 stage. Colour index 1 fruit which would ripen further than colour index 4 were not sensory evaluated. However, chemical compositions of these fruit were determined.

### TSS, TTA and pH Changes

Generally, the TSS and TTA showed a gradual increasing trend while the pH showed a decreasing trend during fruit ripening (Figure 2). The TSS, TTA and pH of fruit at the full colour stage (index 6) ranged from 12.5% to 16.5%, 0.15% to 0.25% and 5.0 to 5.6 respectively. TTA is expressed as anhydrous citric acid.

### DISCUSSION

The Eksotika papaya had a TSS range of 11.0%–16.5% (Figure 2) at the colour indices of 4 to 6. The TSS values of Sunrise Solo (15.5%–16.0%) obtained by CHAN

and TEE (1975) were within the range of values of the Eksotika. CHAN, CHANG, STAFFORD and BREKKE (1971) showed that citric and malic acids were present in approximately similar amounts while alpha-ketoglutaric acid in a much lesser amount; these three acids and ascorbic acid accounted for 85% of the total acid in the Solo cultivar of Hawaii, a yellow-fleshed papaya. They obtained a pH of 5.0–5.5. The Eksotika had a range of 5.0–5.7 which was about the same range as Sunrise Solo.

The Eksotika papaya should be harvested earliest at colour index 2 stage. Harvesting at colour index 1 stage is not recommended due its inferior colour, less sweetness, poor texture and flavour after ripening. Similarly, HALL, MILLINGTON and IRNSIDE (1948) found that fruit harvested before the development of a tinge of yellow usually failed to develop satisfactory taste upon ripening and were less juicy and poor in flavour. Colour indices 2 and 3 are

recommended stages for fruit harvest of the Eksotika papaya when multiple handling or long transportation is practised. Harvesting at colour index 4 or 5 stage requires careful handling. Harvesting at full colour is not recommended in any circumstances. Fruit of 4 to 6 colour indices are not suitable for transportation. ZOHADIE (1982) showed that there was a considerable drop in modulus of elasticity as the papaya fruit ripened. The elasticity reflects the capacity of the fruit in taking elastic or recoverable deformation. Hence, the considerable drop in elasticity indicates that the resistance to bruising and damage decreases considerably as the fruit matures. The most preferred stage of ripeness for table consumption is at colour index 5 although colour indices 4 and 6 are also acceptable. Fruit at colour index 5 stage were rated highest in terms of colour, texture, sweetness, flavour and overall acceptability. At this stage, the TSS, TTA and pH were 12.2%, 0.15% and 5.5 respectively.

### ABSTRACT

Eksotika papaya fruit were harvested at stages of different colour indices and were ripened at ambient temperature. The colour indices were classified as 1 = all green on the skin surface, 2 = green with a tinge of yellow, 3 = more green than yellow, 4 = more yellow than green, 5 = yellow with a tinge of green and 6 = all yellow. Fruit with colour indices 1–3 and 4–6 were significantly different in their firmness. The shelf life of all fruit except those of colour index 6 ranged from five to nine days. Less mature fruit had a longer shelf life. In sensory evaluation, fruit colour indices 4–6 were acceptable with colour index 5 being the most preferred. The total soluble solids, pH and total titratable acidity were 9.5%–16.5%, 5.0–5.7 and 0.10%–0.25% (anhydrous citric acid equivalent) in fruit at various stages of colour indices.

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