

Changes in fruit colour and composition of dokong (*Lansium domesticum* Corr.) during maturation

[Perubahan warna dan komposisi buah dokong (*Lansium domesticum* Corr.) semasa kematangan]

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Key words: colour, chemical compositions, harvesting index, *Lansium domesticum*

Abstrak

Buah dokong yang dipetik pada 4, 7, 11, 14 dan 17 hari selepas peringkat mula menguning diperhatikan perubahan warna dan ciri-ciri kimianya. Peringkat mula menguning (FY) ialah peringkat kulit semua buah dokong dalam satu jambak kelihatan hijau kekuningan. Kulitnya berubah menjadi kuning pekat (tinggi nilai b^* dan C^*) dengan sedikit kehijauan (nilai a^* negatif) pada hari keempat, kuning tua (rendah nilai L^*) pada hari ketujuh, dan kuning cerah (tinggi nilai L^*) pada hari ke-11. Pada 14 atau 17 hari selepas FY, warna buah menjadi kuning kecoklatan ($\text{hue} \leq 83^\circ$). Warna buah juga berkorelasi secara negatif dengan jumlah pepejal terlarut (-0.68) dan nisbah jumlah pepejal terlarut kepada jumlah keasidan tertitrat (-0.73) tetapi berkorelasi secara positif dengan jumlah keasidan tertitrat (0.65). Korelasi ini menunjukkan bahawa kemanisan buah meningkat apabila warna buah berubah daripada kuning kepada kuning kecoklatan. Perubahan warna kuning sesuai dijadikan indeks pemetikan untuk buah dokong. Semasa perubahan warna kulit berlaku, berat setiap biji buah dan kandungan gula meningkat, masing-masing kepada 18 g dan 10% pada hari yang ke-11 dan kekal selepas itu. Perubahan jumlah gula ini selaras dengan peningkatan jumlah pepejal terlarut. Walau bagaimanapun, jumlah keasidan tertitrat menunjukkan arah aliran yang menurun apabila buah semakin matang iaitu serendah-rendah 0.7% pada 14 hari selepas FY. Berdasarkan penilaian rasa, buah yang dipetik pada 4 dan 7 hari selepas FY agak masam walaupun boleh diterima, sementara buah yang dipetik pada 11 dan 14 hari lebih manis dan lebih digemari.

Abstract

Dokong harvested at 4, 7, 11, 14 and 17 days after fruit yellowing stage were monitored for changes in colour and chemical characteristics. Fruit yellowing (FY) is the stage at which all dokong fruit in a bunch have yellowish-green pericarp. The pericarp changed from yellowish green to intense yellow (higher b^* and C^* values) on the fourth day, dark yellow (lower L^* value) on the seventh day, and light yellow (higher L^* value) on the 11th day. At 14 or 17 days after FY, the fruit turned brownish yellow ($\text{hue} \leq 83^\circ$). The colour or hue angle of the fruit was negatively correlated with total soluble solids (-0.68) and the ratio of total soluble solids to total titratable acidity (-0.73) but positively correlated with total titratable acidity (0.65). These correlations indicated that the sweetness of the fruit aril increased as the pericarp changed from yellow to brownish yellow.

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The change in the yellow colour of the fruit can be an acceptable harvesting index for dokong. As the pericarp colour changed, there was an increase in fruit weight and sugar content of aril up to about 18 g and 10% respectively on the 11th day and remained constant thereafter. This change in total sugars content paralleled the increase in total soluble solids. However, total titratable acidity showed a decreasing trend as the fruit matured, and at 14 days after FY only 0.7% was present. Based on taste evaluation, fruit harvested at 4 and 7 days after FY were sourish though acceptable, whereas fruit harvested at 11 and 14 days were sweeter and more preferred.

Introduction

Dokong, also known as 'longkong' in Thailand, is another form of *Lansium domesticum* Corr. (Meliaceae) besides langsat (or lanzones of the Philippines), duku-langsat and duku. Dokong is intermediate between langsat and duku-langsat (Norlia 1997) while duku-langsat is intermediate between langsat and duku (Salma and Razali 1987) in terms of external and internal characteristics of the fruit. Dokong fruit is generally regarded as superior to langsat and duku but its taste and flavour are comparable to duku-langsat. Dokong is almost seedless, thin skinned and free of latex while langsat has 1–2 seeds and thin skin that exudates latex when peeled even when fully ripe (Bamroongrugsá 1992). Another good characteristic of dokong which is absent in duku-langsat is that all the fruit in a bunch ripen simultaneously which facilitates harvesting.

Dokong is a new important economic crop that is gaining popularity in Malaysia. Very little information is available on the physico-chemical characteristics of the fruit at different developmental stages. Reports are available on the compositional changes in langsat during growth and development (Del Rosario et al. 1977; Paull et al. 1987). In a study on flowering and fruiting behaviours of dokong, it was reported that the pericarp of dokong fruit started to develop yellow colour about 87 days after fruit set (Norlia 1997). Fruit are harvested 18 days after development of yellow colour. Dokong at this stage are sweet as preferred by local consumers. Harvesting at a later stage of

maturity, however, may affect postharvest storability of the fruit. Therefore, this study aimed to determine the changes in colour, chemical compositions and sensory of dokong at different stages of yellow colour development, and to establish relationship of fruit quality and maturity.

Materials and methods

Fruit samples

Dokong used in this study were obtained from MARDI Research Station, Jeram Pasu, Kelantan, in September 1996. Fruit bunches were observed throughout the growing period to monitor the changes in pericarp colour from green to yellow. The colour stage called 'fruit yellowing' (FY) at which all fruit in a bunch turned yellowish green was used as the basis for harvesting. Fruit were harvested after 11.00 am to avoid fruit splitting. Fruit bunches were harvested randomly from five trees at 4, 7, 11, 14 and 17 days after FY. Ten bunches from each colour stage were individually wrapped with newsprint, packed in corrugated fibreboard cartons and transported on the same day to the laboratory in Serdang, Selangor.

Colour assessment and fruit weight

The fruit bunches from each stage of maturity were observed subjectively for yellow colour development on their pericarp. Fruit surface colour of individual fruit was also measured objectively using a hand-held tristimulus reflectance colourimeter (Chromameter Model CR-200, Minolta Corp., Ramsey, NJ). Colour was recorded in numerical notation system as L^* , a^* and b^*

uniform colour space (CIELAB system). L^* indicates lightness or darkness (0, black; 100, white) while a^* indicates the hue on a green-to-red axis (negative value, greenness; positive value, redness) and b^* indicates the hue on a blue-to-yellow axis (negative value, blueness; positive value, yellowness). The mean values of L^* , a^* and b^* for each bunch were the average from the total number of fruit measured for a particular bunch. The numerical values of a^* and b^* were converted into hue angle ($H^\circ = \tan^{-1} b^*/a^*$) and chroma [$C^* = (a^{*2} + b^{*2})^{1/2}$] (Carreño et al. 1995; Nunes et al. 1995). H° is an angle in the colour wheel of 360° , with 0, 90, 180 and 270° representing the hue red-purple, yellow, bluish green and blue respectively, while C^* is the intensity of the hue (vivid or dull).

The fruit from each bunch were detached from peduncle and weighed. The average weight of individual fruit was calculated by dividing the total fruit weight with the total number of fruit in each bunch.

Chemical compositions

The arils of four replicated samples of 40 fruit for each colour stage were homogenised in a waring blender and analysed for total soluble solids, titratable acidity and total sugars.

Total soluble solids of the juice from homogenates was determined with a hand-held digital refractometer (Model PR-1, Atago Co. Ltd, Tokyo, Japan). Results were expressed as degrees Brix.

Ten grams of homogenates was made up to volume with 100 mL distilled water, and the total titratable acidity was determined by titration with 0.1N NaOH to an end point of pH 8.1 using a digital burette (Hirschmann Laborgerate Co., Eberstadt, Germany). Results were converted to per cent anhydrous citric acid and expressed in terms of fresh weight.

Sugars were extracted from 30 g of blended aril with 80% warm ethanol according to AOAC (1975). Total sugars was then determined by titration with

boiling Fehling's solution according to the method of Lane and Eynon (Ranganna 1977). Results were expressed as per cent total sugars (as invert sugars) in terms of fresh weight.

Taste

The arils of fruit harvested at different stages of yellow colour development were tasted by 10 taste penalists to determine the general acceptability of the fruit at each maturity stage. The arils were rated for their overall acceptability as 1 = very good, 2 = good, 3 = acceptable and 4 = bad.

Statistical analysis

The Statgraphics Statistical Graphics System computer package was used for data analysis to perform one-way analysis of variance (ANOVA). Significant differences among stages of yellow colour development were detected using Duncan's multiple range test (DMRT).

Results

Fruit colour

The pericarp colour of dokong changed from green to trace of yellow as the fruit were approaching ripening stage. At 'fruit yellowing' (FY) stage, the colour of each fruit in a bunch varied from yellowish green to greenish yellow. As the maturity advanced, the green colour disappeared. The colour changed from yellowish green at FY stage to brownish yellow at 14 days after FY (Table 1).

The changes in pericarp colour were explained further by L^* , a^* , b^* , C^* and H° values as presented in Table 2. Higher L^* , a^* , b^* and C^* values respectively indicated lighter, more reddish, more yellowish and brighter (more intense) surface colour of the fruit. Generally, the intensity of yellow colour of the fruit differed significantly at different ripening stages. Dokong harvested at 4 days after FY were intense yellow (higher b^* and C^* values) with slight greenish colour (negative a^* value). The colour of the fruit changed to dark yellow (lower L^*

Table 1. Changes in pericarp colour of dokong at different maturity stages

Days after fruit yellowing	Pericarp colour
4	Fruit were pale yellow with 6–8 fruit per bunch having greenish colour at the styler end. The greenish colour appeared on fruit facing the sunlight
7	Fruit were deep yellow with 1–2 fruit located at the bottom of the bunch exhibiting shade of green at styler end
11	Fruit were light to bright yellow
14	Fruit were brownish yellow
17	Fruit were brownish yellow with more intense browning

Table 2. Colour of dokong at different stages of yellow colour development using L^* , a^* , b^* colour notation system

Days after fruit yellowing	L^*	a^*	b^*	C^*	H°
4	64.98b	-0.12a	+35.72c	35.74c	89.85c
7	62.79a	+2.89b	+33.71b	33.83b	85.10b
11	66.12b	+2.99b	+32.58a	32.73a	84.74b
14	65.22b	+3.88c	+32.45a	32.68a	83.17a
17	63.97ab	+4.70d	+32.68a	32.94a	81.80a

Mean values with the same letter within each column are not significantly different ($p \leq 0.05$) according to DMRT

value) at 7 days after FY. At 11 days, the fruit pericarp became less yellow, lighter (higher L^* value) and less intense (lower C^* value). As ripening advanced, the a^* values increased significantly which indicated that the fruit pericarp changed towards reddish colour, and thus the fruit looked brownish yellow. Fruit harvested at 17 days after FY was more reddish in pericarp colour than those harvested at 14 days and the colour became darker as indicated by a decreased in L^* value. The browning of the fruit was explained further by the decrease in H° values from about 90° at 7 days to 82° at 17 days after FY. These changes indicated that the colour changed from yellow at the early stage of ripening to reddish or brownish yellow at the advanced stage.

Fruit weight

The number of fruit in each bunch ranged from 10 to 23 and the weight of each fruit was almost uniform. The fruit weight continued to increase as maturity progressed

even after the pericarp colour had changed to yellow (Table 3). However, the fruit weight remained unchanged after 11 days of maturation.

Chemical compositions

Results showed that the trend of changes in sugar content of aril was similar to that of fruit weight (Table 3). Total sugars increased significantly ($p \leq 0.05$) from 6% at 7 days to about 11% at 11 days and remained unchanged thereafter. This change in sugar paralleled the change in total soluble solids (TSS).

Total titratable acidity (TTA) in the fruit aril showed a decreasing trend as maturity advanced. However, there was no more decrease in TTA in fruit harvested after 14 days of colour development. The increase and decrease in TSS and TTA respectively had resulted in an increase in the TSS-to-TTA ratio. As shown in Table 3, the TSS-to-TTA ratio increased as maturity

Table 3. Changes in fruit weight and chemical compositions of dokong at different maturity stages

Days after fruit yellowing	Fruitlet weight (g)	Sugars (%)	TSS (°Brix)	TTA (%)	TSS:TTA ratio
4	15.4a	6.2a	15.2a	1.05c	14.5a
7	15.0a	6.2a	16.1a	0.94b	17.5b
11	18.4b	10.8b	18.6b	0.91b	20.5c
14	18.0b	10.0b	18.4b	0.69a	26.7d
17	18.1b	11.1b	18.7b	0.74a	25.8d

Mean values with the same letter within each column are not significantly different ($p \leq 0.05$) according to DMRT

advanced. These changes indicated an increase in the sweetness of the fruit.

Fruit colour-chemical composition relationship

Fruit colour or hue angle shows significant linear correlation ($p \leq 0.05$) with TSS, TTA and TSS-to-TTA ratio of dokong fruit (Figure 1). A negative correlation (-0.68) between hue angle and TSS implied that the TSS content in dokong increased as fruit colour changed from yellow to brownish yellow. A similar correlation (-0.73) also occurred with TSS-to-TTA ratio where the ratio increased as the fruit colour became more brownish. However, hue angle correlated positively (0.65) with TTA and this is indicated by the decrease in acid content as the fruit colour changed from yellow towards brownish yellow.

Taste

Fruit harvested as early as 4 days after FY were acceptable but their sourness was stronger than sweetness (Table 4). As maturation advanced, the fruit became sweeter. Fruit harvested at 11 and 14 days were rated as good by the panelists. At these stages, sweetness was more intense than sourness. The fruit were sweet and juicy at the later stage of maturity (ripeness).

Discussion

The weight of dokong fruit continued to increase even after the pericarp colour had partially turned yellow until the 11th day

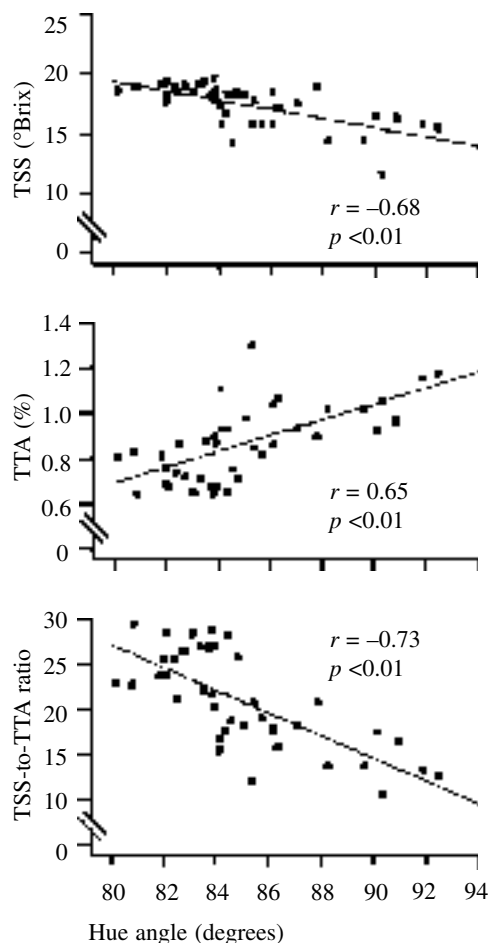


Figure 1. Relationship between fruit colour (hue angle) and total soluble solids (TSS), total titratable acidity (TTA), and TSS-to-TTA ratio of dokong

Table 4. Taste and acceptability of dokong harvested at different maturity stages

Days after fruit yellowing	Aril taste	Overall acceptability*
4	More sour than sweet	3
7	More sour than sweet	3
11	More sweet than sour	2
14	More sweet than sour	2
17	Sweet and juicy	1.5

*1 = very good 3 = acceptable
2 = good 4 = bad

after FY. According to Norlia (1997), the increase in fruit size during growth and development was constant until the yellow colour started to develop on some of the fruit at 7 weeks after fruit set. In langsats, the growth was very slow during the first 100 days after anthesis and the growth rate increased sharply after 115 days, just before pericarp changed from green to yellow colour (Paull et al. 1987). This result indicated that maximum yield of dokong can be obtained when the fruit are harvested at 11 days after FY.

Total sugars and TSS of fruit at different maturity stages were 6–11 °Brix and 15–19 °Brix respectively while acid content was 0.7–1.0%. Total sugars and TSS in dokong reached the maximum at 11 days after FY. Though dokong had TSS content as high as in langsats (Del Rosario et al. 1977; Paull et al. 1987), TTA in langsats was found to be higher (1.14–2.41%) (Del Rosario et al. 1977). Low acid content in dokong resulted in high TSS-to-TTA ratio which made dokong fruit sweeter than langsats. The ratio between TSS and TTA in dokong was higher towards the end of maturation. The ratio indicated that fruit harvested at a later stage seemed to be sweeter than those harvested earlier.

The change in the fruit colour is the best indicator for determining fruit maturation of dokong since the degree of yellowness at different stages is quite easily distinguishable. The differences in the degree of yellowness can be used to develop harvesting index for dokong. The fruit at 11

days after FY could be differentiated from fruit of other stages as all fruit were uniformly light yellow in colour. Furthermore, no fruit with tinge of green was found on bunches harvested at 11 days after fruit yellowing.

The hue angle of the fruit pericarp correlated well with TSS, TTA and TSS-to-TTA ratio of dokong. Similar patterns of correlation were also reported by Carreño et al. (1995) in maturation study of table grape. The aril of dokong fruit contained higher TSS and lower TTA which resulted in higher TSS-to-TTA ratio as the fruit colour turned to more brownish yellow. The increase in this ratio made the aril tasted sweeter as maturation advanced. The increase in sweetness was also recorded during fruit tasting.

The best maturity stage for harvesting of dokong depends on the consumer acceptance and market needs. Although the fruit are acceptable for consumption at 4–7 days after FY, dokong are best harvested at 11 days after FY. At this stage, the fruit have reached the maximum weight and total sugars content. Fruit harvested at a later stage may have poor keeping quality.

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