

MATURITY STAGE AT HARVEST AFFECTS PHYSICOCHEMICAL QUALITY OF MS16 PINEAPPLE

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ABSTRACT

MS16 is a new hybrid pineapple developed by MARDI tolerant to bacterial heart rot resulting from several crossings from Josapine (a local pineapple variety) with 53-116 (Australian pineapple variety). As a new hybrid, information on the optimum maturity stage at harvest and proper postharvest handling is imperative for adequate shelf-life and maintaining good product quality. The objective of this study was to determine the optimum harvest maturity (day after flower induction) for MS16 pineapple. The fruits were harvested at 125, 130, 135 and 140 day after flower induction (DAFI) and held at room temperature ($25 \pm 2^\circ\text{C}$) for four days. Physicochemical quality including colour, firmness, soluble solids concentration (SSC), titratable acidity (TTA), pH, SSC/TTA ratio and ascorbic acid (AA) content were evaluated daily. The peel colour of MS16 pineapple fruits tends to change to a lighter green, which was observed with a significant ($p < 0.05$) decrease in L and increased in chroma value when maturity progressed. Pulp colour of MS16 fruits changed from light yellow to deep yellow as maturity progressed. Fruits harvested at 130 and 135 DAFI is significantly ($p < 0.05$) sweeter (14-15 % SSC) and less acidic (pH 4.11-4.27) compared to fruits harvested at 125 DAFI. However, fruits harvested at 140 DAFI had higher translucency in the pulp and overripe off-flavours. The ascorbic acid content, pH value and fruit firmness tend to decrease as maturity days progressed. Chemical qualities and fruit firmness of MS16 pineapples were not significantly ($p > 0.05$) affected when held at room temperature for up to 4 days except for colour. To achieve better eating quality, MS16 pineapple fruits are recommended to be harvested at 130-135 DAFI.

Key words: day after flower induction, hybrid pineapple, maturity, soluble solids concentration

INTRODUCTION

Pineapple (*Ananas comosus* L. Merr) is considered as one of the important exported fruits of Malaysia. In 2018, Malaysia pineapple production is ranked at 19th with 322,459.52 metric ton worth RM 600,580.85 (Department of Agriculture, 2018) and is one of the top five exporters in the world (Suhana et al., 2019). Pineapple such as Moris, N36, Sarawak, Gandul, Yankee, MD2, Josapine and Maspine (Lasekan and Hussein, 2018) are the main pineapples varieties currently grown in Malaysia. Josapine (Chan, 2008) and Maspine (Pauziah et al., 2013) are introduced by the Malaysian Agriculture Research and Development Institute (MARDI) researchers in 1996 and 2005 respectively intended for fresh consumption and processing. Research on pineapple breeding and production practices is vital to the Malaysian pineapple industry to produce better quality and competitive varieties for market

expansion. MS16 is a new hybrid pineapple developed from Josapine (a local pineapple variety) with 53-116 (Australian pineapple variety) with better fruit size, tolerant to bacterial heart rot, sweeter and less biting (Rozlaily et al., 2018).

Since pineapple is categorized as a non-climacteric fruit, it is recommended to be harvested when the fruit is fully matured physiologically. Unlike climacteric fruit such as banana which can ripen when harvested at green mature stage, the sugar and acid content of non-climacteric fruit will not increase any further after harvest (Lobo and Yahia, 2017). Harvesting time for pineapple is usually determined by colour (peel and pulp), appearance (size, condition and shape), taste (sugar, acids), aroma, flesh translucency, texture and fibre content (Paull and Chen, 2003). For most Malaysian pineapple, the optimum maturity stage at harvest was developed using skin colour to determine the various stage of maturity (Ahmad Tarmizi and Pauziah, 2005). Since MS16 is a newly introduced pineapple hybrid, information on the optimum harvest stage and proper postharvest handling is imperative for adequate shelf-life and maintaining good product quality. Like Maspine, the skin colour for MS16 could not be used as an indicator of maturity or ripeness as the fruit is harvested when mature green. Therefore, this study was conducted to develop the most optimum maturity stage of MS16 for fresh consumption based on physicochemical quality.

MATERIALS AND METHODS

Fruits

Pineapple hybrid MS16 were obtained from a farmer's plot located in Pontian, Johor, Malaysia. Flowering was induced within 10 months of planting. Fruits were harvested at 125, 130, 135 and 140 day after flower induction (DAFI) and transported to Postharvest Complex, Serdang, Selangor after harvest within 4 h. Fruits of good quality and uniform size were selected for the storage study. Fruits were kept at 25°C and evaluated at 1, 2, 3 and 4th day for postharvest qualities.

Fruit peel and pulp colour determination

Colour of pineapple peel and pulp (L^* , C^* and h°) were measured by using a portable chromameter (model CR-400 Minolta Corp., Osaka, Japan). The L^* value ranged from 0 = black to 100 = white. The h° is an angle in a colour wheel of 360°, with 0° or 360° representing red hue, whilst angles of 90°, 180° and 270° represent yellow, green and blue hues, respectively. Chroma (C^*) is the intensity or purity of the hue. Three measurements were made on the longitudinal position of the peel and pulp of each fruit.

Fruit firmness determination

Fruit firmness was measured using a TA-TXT2i texture analyzer (Stable Micro Systems, England) fitted with a 5mm diameter stainless steel probe. The rate of penetration used was 2mm s⁻¹ with a final penetration depth of 10mm and data recorded in Newtons (N) were analysed. Three measurements were made on the longitudinal position of the fruit pulp.

Postharvest quality analysis

Soluble solids concentration (SSC) was determined using juice extracted from pulp samples using a digital refractometer (Atago, Japan). Results were recorded in % SSC. The pH of the fruit juice was determined using a pH meter (model Hanna pH 211 microprocessor pH meter, USA). Total titratable acidity (TTA), expressed as milliequivalents of citric acid are determined based on the method of Saradhuldat and Paull (2007). Blended pulp sample (5 g) was diluted with 20 mL distilled water and titrated with 0.1 M NaOH to the endpoint of pH 8.2. The results were expressed as % of citric acid. SSC/TTA ratio was calculated by dividing the SSC values by TTA values for each sample. Ascorbic acid content was measured according to the method described by Ranggana (1977). Blended pulp sample (10 g) was extracted with 100ml of 3% metaphosphoric acid (HPO₃), filtered through Whatman No. 4 filter paper. A volume of 10ml from the filtered solution was determined by titrating with 2,6-dichlorophenol-indophenol to a pink endpoint that persisted for 15 s. The results were expressed as mg of ascorbic acid per 100 g fresh weight (FW).

Statistical analysis

The experiment was conducted using a completely randomized design (CRD) with four replications. All data were subjected to analysis of variance (ANOVA) and means separated using Duncan Multiple Range Test (DMRT) by using SAS 9.4 (SAS Institute Inc., USA).

RESULTS AND DISCUSSION

As fruit ripened, the peel colour of MS16 turned to a lighter green, which was observed with a decrease in L^* and an increase in chroma (Table 1). There were no significant changes in hue colour indicated the fruits remained green in all maturity stages. Similar to Maspine (Pauziah et al., 2013) and Gandul (Abdullah, 1993) pineapples, it was difficult to harvest MS16 fruit based solely on peel colour since harvesting at breaker stage (Index 2) might lead to overripe fruits. In term of pulp colour, both lightness and hue value decreased while chroma increased significantly from 125 to 140 DAFI (Table 1). At 125DAFI, the pulp was whitish yellow and gradually turned to fully yellow when ripening progressed. The changes of pulp colour of MS16 fruits during ripening is similar to other pineapple varieties such as Maspine (Pauziah et al, 2013) and MD2 (Ding and Syawani, 2016).

Firmness is one the typical indicator as ripening progressed in most fruits. Based on harvest time, firmness of MS16 fruits decreased significantly from 125 DAFI to 140 DAFI (Table 2). During ripening process, the loosening of cell wall loosening caused texture change from firm to soft due to the degradation of cell wall components such as hemicellulose, cellulose and pectin in pineapple (Vidal-Valverde et al., 1982).

The chemical changes during fruit development of MS16 fruits from 125 to 140 DAFI are shown in Table 2. The results indicated the soluble solids concentration (SSC) increased significantly when ripening progressed from 125 to 135 DAFI. Similar findings were reported for other pineapple varieties such as Maspine (Pauziah et al, 2013), Sarawak (George et al., 2006) and MD2 (Ding

and Syazwani, 2016). The accumulation of sugar (mainly sucrose) was suggested to be due to the high activity of the cell wall invertase as fruit ripened (Chen and Paull, 2000). However, there is a decrease of SSC at 140 DAFI as the fruits were perceived to be slightly overripe had higher translucency in the pulp.

As ripening stage progressed from 125 to 140 DAFI, pH value tends to increase significantly with titratable acidity showing the opposite declining trend (Table 2). Fruits harvested at 125 DAFI is found to be sourer (pH 3.98) compared to fruits harvested at 130-140 DAFI. Titratable acidity (TTA) is measured as percentage were found to decrease significantly from 125 (0.67%) to 140 DAFI (0.56%) (Table 2). Organic acids usually decline during ripening as they are considered as reserve source of energy for metabolic activities such as respiration or converted into sugar (Wills et al., 1998). The decrease of fruit acidity of MS16 when approaching maturity indicate low-acid clone characteristic (Saradhulat and Paull, 2007). Compared to high-acid clone pineapples, low-acid clones tend to have lower acidity (low pH and higher TTA) when the fruit started to ripen. This contributed to the increase of SSC/TTA of fruits harvested at 130 and 135 DAFI (Table 2).

Titratable acidity is a measurement to perceive tartness whereas SSC is to sweetness (Smith, 1993). By measuring the sugar to acid ratio as SSC/TTA, it could be used as a maturity indicator during harvesting. Recommended SSC/TTA ratio of 20-40 is recommended for fresh pineapple (Soler, 1992) while for canning industry, 8-23 is recommended (Smith, 1988). SSC/TTA ratio were found to increase from 125 DAFI (20.36) followed by 130 DAFI (25.96) and 135 DAFI (30.88). At 140 DAFI, the fruits were slightly overripe hence the decline of SSC/TTA ratio at 24.43 (Table 2). Higher SSC/TTA related to sweeter and less tart fruits which is often associated with better organoleptic quality (Colaric et al., 2005).

Ascorbic acid (AA) content decrease as ripening progressed (Table 2). The initial AA content was the highest in 125 DAFI at 48.18 mg 100 g⁻¹ FW followed by 130 DAFI (34.88 mg100 g⁻¹ FW), 135 DAFI (31.74 mg 100 g⁻¹ FW) and 140 DAFI (28.00 mg100 g⁻¹ FW). Similar trend found for Maspine (Pauziah et al., 2013) and MD2 (Ding and Syazwani, 2016) pineapples with advancement to ripening. The decrease in AA content of MS16 fruits might be associated with an increase of ascorbate activity (Yahia et al., 2001) which coincided with the initiation of ripening as indicated of higher SSC and declining TTA.

CONCLUSION

In summary, chemical attributes such as SSC and TTA were found to be a more reliable maturity indicator compare to peel colour for MS16 pineapple fruit. It is concluded that fruits of MS16 harvested at 130 and 135 DAFI had higher SSC and better eating quality compared to fruits harvested 125 and 140 DAFI.

Table 1: Peel and pulp colour (L, C and h) of MS16 pineapple fruits at different maturity stages

Day after flower induction (DAFI)	Peel colour			Pulp colour		
	L	C	h	L	C	h
125 DAFI	41.06±1.19a	11.69±0.56b	96.17±1.04a	80.03±0.52a	31.36±1.00c	94.79±0.25a
130 DAFI	36.28±1.34b	10.11 ±0.62b	97.55±1.26a	78.13±0.47b	38.37±0.70b	93.28±0.24b
135 DAFI	38.32±1.22b	15.47±0.87a	94.54±1.53a	79.13±0.39b	41.18±0.66a	92.10±0.19c
140 DAFI	36.32±1.01b	14.37±0.57a	95.79±1.07a	75.98±0.11b	40.68±0.80a	93.28±0.31c
F-sig	*	**	ns	*	**	**
Holding at 25°C (H)						
D1	43.26±0.79a	14.04±0.71a	97.88±1.52a	78.96±0.53a	34.82±1.15b	93.51±0.23a
D2	33.18±1.51b	10.07±0.82b	99.35±1.22a	79.62±0.57a	36.48±1.15b	93.87±0.36a
D3	36.48±1.62b	1118±0.71b	97.27±1.58a	78.81±0.52a	36.38±1.12b	93.54±0.33a
D4	36.28±1.23b	11.41±1.06b	95.64±1.41b	79.07±0.58a	40.21±1.03a	92.52±0.28b
F-sig	**	**	*	ns	*	*

Mean ± S.E presented. Mean values in the same row followed by different letters (a, b, and c) indicate significant differences ($P < 0.05$) using the Duncan's multiple range test.

Table 2: Firmness, soluble solids content (SSC), titratable acidity (TTA), sugar to acid (SSC/TTA) ratio and ascorbic acid content of MS16 fruits at different maturity stages

Day after flower induction (DAFI)	Firmness (N)	SSC (%)	pH	TTA (%)	SSC/TTA ratio	Ascorbic acid content (mg/100 FW)
125 DAFI	10.90±0.26a	13.26±0.46b	3.98±0.02c	0.67±0.02a	20.36±1.15c	48.18±0.96a
130 DAFI	9.80±0.27b	14.73±0.30a	4.11±0.02b	0.57±0.01b	25.96±0.94b	34.88±1.33b
135 DAFI	9.18±0.23c	15.79±0.36a	4.27±0.01a	0.51±0.01b	30.88±0.97a	31.74±2.00b
140 DAFI	9.25±0.52c	13.68±0.41b	4.15±0.14a	0.56±0.04b	24.43±1.34b	28.00±1.15c
F-sig	**	*	*	**	**	**
Holding at 25°C (H)						
D1	10.25±0.29	14.69±0.37	4.13±0.04	0.61±0.03	25.22±1.56	35.60 ±2.17
D2	10.00±0.34	13.66±0.57	4.14±0.07	0.65±0.03	24.51±2.00	33.93±3.01
D3	10.00±0.41	14.50±0.38	4.10±0.05	0.60±0.03	24.84±1.42	40.02±2.31
D4	10.04±0.27	15.18±0.41	4.14±0.03	0.57±0.02	26.70±1.15	39.02±1.92
F-sig	ns	ns	ns	ns	ns	ns

Mean ± S.E presented. Mean values in the same row followed by different letters (a, b, and c) indicate significant differences ($P < 0.05$) using the Duncan's multiple range test.

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