

COMPARING THE PHYSICO-CHEMICAL CHARACTERISTICS OF MAS, RASTALI AND BERANGAN BANANAS AT 3 STAGES OF MATURITY

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Abstract

Basic informations on the physico-chemical characteristics of different varieties of bananas at different stages of maturity were determined to understand and assist in future research on product development. The statistically analysed values for skin and flesh colour (Hunter Lab colorimeter), weight, hardness (Kg Force), pH, soluble solids content (SSC), titratable acids (% malic), ascorbic acid (mg/100g), starch, sugars, tannin and pectin were determined at the mature green, half-ripe and fully-ripe stages of maturity for Mas, Rastali and Berangan bananas. Ascorbic acid increased on ripening and was highest in Mas, followed by Rastali and finally Berangan. Starch decreased on ripening and was highest in Berangan throughout the 3 stages of maturity. Fructose was only present when the bananas ripened and was highest in Mas at the fully-ripe stage. Glucose was highest in Mas, followed by Berangan and finally Rastali. Glucose were absent in Rastali and Berangan at the green and half-ripe stage. Sucrose was present throughout all the stages of maturity and was highest in Mas at the half-ripe stage. When fully ripe, Berangan had the highest sucrose content followed by Rastali and finally Mas. Tannin decreased on ripening and was highest in Rastali and least in Mas. Pectin increased on ripening and was highest in Mas, followed by Rastali and least in Berangan. Titratable acids increased on ripening and were highest in Berangan and lowest in Mas. SSC also increased on ripening and were highest in Mas and least in Rastali. Hardness of fruit decreased on ripening and was firmest in Berangan, followed by Rastali and finally Mas. The flesh : skin ratio increased on ripening and were highest in Rastali, followed by Mas and finally Berangan even though Berangan were the heaviest fruit and Mas was the smallest/lightest banana, showing that the skin of Berangan are fairly thick.

Introduction

Malaysia exported about RM 27.8 million worth of bananas in 1994. Bananas contain approximately 73.3% moisture, 1.3% protein, 0.4% fat, 23.6% carbohydrates, 0.5% crude fibre, 0.9% ash and 103 kcalories, 11mg calcium, 28 mg phosphorus, 0.6 mg iron, 29 mg sodium, 241 mg potassium, 300 ug beta-carotene, 0.07 mg thiamin, 0.08 mg riboflavin, 17.3 mg ascorbic acid and 0.7 mg niacin per 100g edible portion (Tee et al 1988). Bananas are non seasonal and the fruits are produced 8-10 months after planting. Harvesting of bananas at the correct harvesting time are important for they affect the physico-chemical characteristics and eating quality of the fruit on ripening. This work was carried out to obtain basic information on the physico-chemical

characteristics of Mas, Rastali and Berangan varieties of bananas at mature green, half ripe and fully ripened stages of maturity in order to understand and assist in future research on product development.

Materials and Methods

Bananas at the mature green stage of the Mas, Rastali and Berangan varieties were obtained from a plantation in Sabak Bernam Selangor Malaysia. Only the 2nd, 3rd and 4th hands from a bunch were used since they show no significant difference in physico chemical characteristics (Mustaffa et al. 1997). The analysis were done on 3 trials, each trial consisted of 15 bananas. Bananas were individually analysed at 3 stages i.e. mature green, half ripe and fully ripened for : weight (Electronic balance Model FX 6000); pulp:skin ratio; firmness (Instron Universal Testing Machine model 1140 with 8 mm plunger and 20 kg load cell); colour (Minolta CR 300 Lab Chromometer; L=lightness; -a = greenness; b: yellowness); soluble solids (Otago hand refractometer 0-32^oB); ascorbic acid by dichlorophenol indophenol titration (Ranganna, 1977); titratable acidity (with 0.1M N NaOH); pH (Cyberscan 550 pH meter); starch (Clegg, 1956); sucrose, fructose, glucose (Hunt et al., 1977; using HP1084B HPLC, 10 μ Lichrosorb-NH2 column and 80:20 (acetonitrile:water), pectin (Ranganna, 1977) and tannin (Ranganna, 1977). Data were subjected to Duncan's Multiple range test and ANOVA analysis using SAS computer programs.

Results and Discussion

Table 1 summarises the different characteristics of Mas, Rastali and Berangan bananas. Mas bananas are small and sweet, each measuring 9 cm long by 3.5 cm wide. Each bunch weighs about 7-9 kg and carries about 6-7 hands. The flesh and skin are bright yellow in colour and the thin peel often sticks to the pulp when ripe. The trees are about 3 m high. Rastali bananas are slightly astringent when consumed fresh. They measure 10-12 cm long and 3.7 cm wide. When ripe they have a yellow but fairly rough spotted skin. The bunch is normally 1 m long and weighs about 10 kg, and contains 7-8 hands. Each hand hold about 10-14 fingers. The trees are about 4 m high. Berangan bananas have thick skin covering the yellow, firm, sweet flesh in their long fingers. Each bunch weighs 9-10 kg and contains 6-7 hands, each hand carrying 14-15 fruits. Each fruit is 13-15 cm long and 3-3.5 cm wide.

Table 1: Characteristics of Mas, Rastali and Berangan bananas

Cultivars	Mas	Rastali	Berangan
Length / cm	9	10-12	13-15
Width / cm	3.5	3.7	3-3.5
Skin	Bright yellow	Rough, spotted, yellow	Thick, yellow
Flesh	Sweet yellow	Slightly astringent	Firm sweet
Tree height / m	3	4	
Height of bunch /m		1	
Weight of bunch /kg	7-9	10	9-10
No of hands/bunch	6-7	7-8	6-7
No of fingers/hand	23	10-14	14-15
Months before flowering	10-11	10	11-12
Weeks before harvest	7-9 ^A	11-14 ^B	10-13 ^C

A : Abd Shukur & Tarmizi, 1979

B : Abdullah et al 1985

C: Tarmizi & Pauziah 1987

Table 2: The physico-chemical characteristics of Mas, Rastali and Berangan bananas at Matured green, Half ripe and Fully ripened stages of maturity.

	Mature green			Half ripe			Fully ripened		
	Mas	Rastali	Berangan	Mas	Rastali	Berangan	Mas	Rastali	Berangan
Weight	67.08 ^{A3}	76.84 ^{A2}	96.69 ^{A1}	63.29 ^{B3}	72.08 ^{B2}	93.05 ^{B1}	55.69 ^{C3}	66.07 ^{C2}	91.88 ^{C1}
Flesh colour	2.14 ^{B1}	1.90 ^{C2}	1.49 ^{B2}	2.63 ^{B1}	2.76 ^{B1}	1.88 ^{B2}	3.89 ^{A2}	4.30 ^{A1}	2.78 ^{A3}
Texture	10.99 ^{A3}	11.16 ^{A2}	12.66 ^{A1}	7.98 ^{B2}	9.20 ^{B1}	9.79 ^{B1}	0.93 ^{C3}	1.26 ^{C2}	2.77 ^{C1}
Skin colour	L 54.15 ^{C1}	47.70 ^{C2}	42.31 ^{B2}	64.48 ^{B1}	51.54 ^{B2}	47.70 ^{B3}	73.22 ^{A1}	73.73 ^{A2}	70.53 ^{A3}
	a -16.28 ^{C3}	-15.74 ^{B2}	-13.60 ^{B1}	-7.97 ^{B1}	-16.60 ^{C2}	-17.43 ^{C3}	-1.32 ^{A2}	-3.21 ^{A3}	-0.70 ^{A1}
Pulp colour	L 83.88 ^{A2}	85.82 ^{A1}	83.50 ^{A2}	79.65 ^{B3}	81.04 ^{B1}	80.53 ^{B2}	70.42 ^{C3}	79.94 ^{C1}	74.55 ^{C2}
	a 1.86 ^{A2}	2.06 ^{C3}	0.37 ^{C1}	-1.56 ^{A2}	-1.02 ^{B1}	1.40 ^{B1}	-0.76 ^{A2}	0.56 ^{A2}	2.67 ^{A1}
PH	L 34.71 ^{B1}	30.36 ^{B2}	31.28 ^{A2}	31.41 ^{B2}	30.36 ^{B3}	32.18 ^{A1}	44.77 ^{A1}	44.73 ^{A1}	37.48 ^{A2}
	a 5.51 ^{A1}	5.37 ^{A1}	5.21 ^{A1}	5.33 ^{A1}	5.16 ^{A1}	5.09 ^{A1}	5.20 ^{A1}	4.98 ^{B2}	4.85 ^{B2}
SSC	3.03 ^{C1}	1.75 ^{C3}	2.23 ^{C2}	15.00 ^{B1}	9.23 ^{B3}	11.93 ^{B2}	24.51 ^{A1}	21.86 ^{A3}	23.60 ^{A2}
Malic a.	0.28 ^{C3}	0.37 ^{C2}	0.69 ^{C1}	0.36 ^{B3}	0.43 ^{B2}	1.36 ^{B1}	0.45 ^{A3}	0.56 ^{A2}	2.20 ^{A1}
Asc a.	1.39 ^{C1}	1.13 ^{C1}	1.06 ^{C1}	4.27 ^{B1}	2.32 ^{B2}	2.16 ^{B2}	8.43 ^{A1}	7.41 ^{A2}	5.40 ^{A3}
Starch	19.86 ^{A3}	19.35 ^{A3}	22.38 ^{A1}	11.90 ^{B3}	10.52 ^{B3}	12.25 ^{B1}	1.23 ^{A3}	1.47 ^{A3}	3.01 ^{A1}
Fructose	0 ^{C1}	0 ^{C1}	0 ^{C1}	1.67 ^{B1}	1.45 ^{B1}	1.80 ^{B1}	8.76 ^{A1}	4.66 ^{A2}	4.97 ^{A2}
Glucose	0 ^{C1}	0 ^{C1}	0 ^{C1}	1.95 ^{B1}	0 ^{C1}	0 ^{C1}	9.97 ^{A1}	6.59 ^{A3}	7.89 ^{A2}
Sucrose	0.96 ^{C1}	0.92 ^{C1}	0.87 ^{C2}	11.86 ^{B1}	4.34 ^{B3}	7.60 ^{B2}	6.13 ^{B3}	9.43 ^{A2}	10.31 ^{A1}
T. sugar	0.96 ^{C1}	0.92 ^{C1}	0.87 ^{C2}	15.48 ^{B1}	5.79 ^{B3}	9.4 ^{B2}	24.86 ^{A1}	20.68 ^{A3}	23.17 ^{A2}
Tannin	4.18 ^{A1}	4.78 ^{A1}	4.33 ^{A1}	2.89 ^{B3}	4.02 ^{A1}	3.86 ^{B2}	0.85 ^{C3}	1.03 ^{B1}	0.97 ^{C2}

Different superscripted alphabets within a row show significant differences between maturity stages of each variety and different superscripted numbers within a row show significant differences ($p < 0.05$) between varieties.

Weight and flesh:skin ratio

The weight of bananas increase during maturation (Von Loesecke 1949) and decrease on ripening (Lodh *et al.*, 1971). The significant decrease in weight on ripening and storage is due to the loss of water and volatiles (including ethylene and carbon dioxide) by respiration. Although Berangan bananas were heaviest (91-97 g), they had the lowest flesh:skin ratio when ripe, indicating of their thick skin. At the mature green stage Mas had the highest flesh:skin ratio because of its small size (55-68 g) and high surface to volume ratio. However, Mas have thin skins therefore they have relatively high flesh:skin ratios, higher than the others at the mature green stage, comparable to Rastali at the half ripe stage and lower than Rastali at the fully ripened stage. Rastali (weight 66-77 g) had the highest flesh:skin ratio when fully ripe. The increase in flesh:skin ratio is thought to be because of the loss of moisture from the skin to the atmosphere and also to the flesh from the osmotic pull by the increasing sugars and soluble solids contents in the banana flesh on ripening.

Starch, texture, and pectin content

Starch contents decrease on ripening. The starch content in Berangan were significantly highest amongst all the 3 banana cultivars throughout all the three stages of maturity and may explain for the firm texture of Berangan. The starch content of Mas were insignificantly different from Rastali at the mature green stage, were higher than Rastali at the half ripe stage but were lower than Rastali at the fully ripened stage. The starch are broken down to glucose on ripening and starch content decreased from about 20% at the mature green stage to between 1% (Mas and Rastali) to 4% (Berangan) at the ripe stage.

The loss of firmness on ripening are due to the conversion of starch, protopectin and other macromolecules to sugars and acids and other more soluble compounds. This is confirmed by the increase in acids and soluble solids contents of all the bananas during ripening and storage, comparable to the decrease in starch, and increase in total sugars and soluble pectins (Table 2). Berangan had the firmest texture, followed by Rastali and Mas was the softest of the bananas.

The soluble pectin content did not change significantly from the mature green to the half ripe stage for Rastali and Berangan but increased tremendously when fully ripened. Mas had the highest soluble pectin content throughout the 3 stages of ripening, followed by Rastali. Berangan had the least soluble pectin content. The presumably high insoluble pectin content in Berangan may again add to the firm texture of Berangan. Protopectins are broken down by polygalacturonase to soluble pectins on ripening (Palmer, 1971). The pectin in bananas have low methoxyl content (20-45%) (Nwaneskezi *et al.*, 1994).

Soluble solids content, Total sugars, Sucrose, Fructose and Glucose

Mas had the highest soluble solids content, followed by Berangan, while Rastali had the least. The total sugars increase from below 1% at the mature green stage to more than 20% on ripening. The total sugars content of Mas were highest amongst the 3 cultivars, throughout all the stages of maturity. Berangan had higher total sugars content compared to Rastali when half or fully ripe, but were lower than Rastali at the mature green stage.

Sucrose content increase on ripening. The sucrose content in Mas and Rastali were insignificantly different but higher than Berangan at the mature green stage. At the half ripe stage the sucrose content of Mas were highest, followed by Berangan and finally Rastali. At the fully ripened stage the sucrose contents of Berangan and Rastali increased while that in Mas decreased, probably because sucrose were broken down into glucose and fructose. When fully ripened, Berangan had the highest sucrose contents, followed by Rastali and least of all Mas.

There was no trace of fructose or glucose in all the 3 cultivars of bananas at the mature green stage. At the half ripe stage there was still no trace of glucose in Berangan and rastali, and the fructose contents of all the 3 cultivars were insignificantly different. When fully ripe Mas had the highest fructose and glucose content, the fructose content of Rastali and Berangan were insignificantly different from each other, while the glucose content of Berangan were higher than Rastali.

Titrateable acidity, pH and ascorbic acid

Titrateable acids increase on ripening and storage. Throughout the study Berangan had the highest titrateable acid (TA) content, followed by Rastali. Mas had the lowest titrateable acid value at all the stages studied. Malic acid is the main organic acid in banana, but citric and oxalic acids are also present (Forsyth 1980; Wills et al 1983). There was a corresponding decrease in pH of the Rastali and Berangan bananas when they become fully ripened, however Mas bananas do not show any significant pH change at all. The pH values were insignificantly different between all the three cultivars of bananas during the mature green and half ripe stages. At the fully ripened stage the pH values of Rastali and Berangan were not significantly different from each other but were lower than Mas.

The ascorbic acid values increase on ripening and the highest vitamin C contents are obtained at the fully ripened bananas. Mas bananas had the highest vitamin C contents at the half ripe and fully ripened stages (4.3 and 8.4 mg/100 g respectively), followed by Rastali and finally Berangan. The vitamin C contents at the mature green stage were insignificantly different for all the three cultivars of bananas. Vitamin C content decrease rapidly on senescence (Wills et al., 1983). Banana contains at least other 11 vitamins (Simmonds, 1966).

Tannin

Tannin contents decrease on ripening and the tannins content were insignificantly different among the 3 banana cultivars at the mature green stage. The tannin contents of Rastali were highest in half ripe and fully ripe bananas, followed by Berangan and Mas had the least tannin contents on ripening. The relatively high tannin and low sugar contents of Rastali are responsible for their slight astringent taste, while the relatively high sugar and low tannin contents of Mas are responsible for their sweet taste. Berangan were intermediate between these two banana cultivars.

Colour

The skin colour of all the three banana cultivars increase in lightness on ripening, and Mas had the lightest colour, followed by Rastali and Berangan had the darkest skin colour at all the stages studied. Greenness of the skin decreased on ripening and storage. Mas was most green and least yellow, followed by Rastali. Berangan was least green and most yellow at the mature green stage. At the half ripe stage, Berangan was most green and least yellow, and Mas was the least green and most yellow. At the fully ripe stage Rastali was most green followed by Mas which also had the highest yellow colour and finally Berangan had the least green and yellow colour.

The lightness of the flesh colour decreased on ripening and storage. Rastali had the lightest flesh colour at the mature green stage, whilst the lightness of Mas and Berangan were insignificantly different. At the half ripe and fully ripened stage Rastali still had the lightest flesh colour followed by Berangan and finally Mas. Greenness of the flesh decreased while yellowness increased on ripening. In fact this decrease is overcome by an increase in reddish hue in Berangan. Rastali flesh had higher greenish and lower yellow hue at the mature green and at the half ripe stage than Mas. However the green colour in Mas was higher than Rastali in the fully ripe stage. The yellow colour of Mas was higher than both Rastali and Berangan at the mature green stage. At the half ripe stage the yellowness and redness hue of Berangan were highest. At the fully ripe stage, Berangan had the highest reddish and lowest yellow hue, whilst the yellow hue of Mas and Rastali were insignificantly different from each other.

Conclusion

Mas bananas had the highest soluble solids contents (SSC) among the bananas studied and SSC increase on ripening. They also had the lowest percentage of titratable acids (expressed as malic acids) compared to the other banana cultivars although there is an increase in acids content on ripening. Mas also had the highest ascorbic acids contents amongst the 3 bananas studied and the vitamin C were highest at the fully ripened stage. Ascorbic acid increased on ripening and was highest in Mas, followed by Rastali and finally Berangan. Starch decreased on ripening and was highest in Berangan throughout the 3 stages of maturity. Fructose was only present when the bananas ripened and was highest in Mas at the fully-ripe stage. Glucose was highest in Mas,

followed by Berangan and finally Rastali. Glucose were absent in Rastali and Berangan at the green and half-ripe stage. Sucrose was present throughout all the stages of maturity and was highest in Mas at the half-ripe stage. When fully ripe, Berangan had the highest sucrose content followed by Rastali and finally Mas. Tannin decreased on ripening and was highest in Rastali and least in Mas. Pectin increased on ripening and was highest in Mas, followed by Rastali and least in Berangan. Titratable acids increased on ripening and were highest in Berangan and lowest in Mas. SSC also increased on ripening and were highest in Mas and least in Rastali. Hardness of fruit decreased on ripening and was firmest in Berangan, followed by Rastali and finally Mas. The flesh to skin ratio increased on ripening and were highest in Rastali, followed by Mas and finally Berangan even though Berangan were the heaviest fruit and Mas was the smallest/lightest banana, showing that the skin of Berangan are fairly thick.

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