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# Physico-Chemical, Biochemical and Sensory Characteristics of Berangan and Mas Banana (*Musa sapientum*) Cultivars and Their Suitability for Value Added Processing

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**Abstract:** Berangan and Mas revealed significant differences ($p<0.05$) for pH, TA, TSS, total solid, moisture contents and luminosity (L-value). No significant difference ($p<0.05$) was found between the two cultivars for total sugars, vitamin C, tannins, total carotenoids, citric and tartaric acid, which can affect their suitability for value added processing. However Berangan cultivar was found more suitable in this respect particularly for juice processing because of its biochemical characteristics i.e. lower peroxidase and polyphenoloxidase activity and soluble protein concentration, which are responsible for developing browning in fruit tissues and also ultimately in the juice. Also the sensory evaluation results showed preference for Berangan cultivar in terms of better taste intensity, colour and overall acceptability as compared to Mas cultivar. Biochemical and sensory results revealed Berangan as better cultivar for its suitability for value added processing as compared to Mas.

**Key words:** Banana cultivars, juice processing, enzymatic activity, taste intensity

## INTRODUCTION

The banana belongs to the genus *Musa* of the family Musaceae. Most edible bananas plantains are descended from a wild ancestor, *Musa acuminata* and *Musa balbisiana*. The diploids (AA, AB), triploids (AAB, ABB) or tetraploids (AAAA, ABBB) arising from the genomes of these two genera give rise to various types of edible bananas and plantains[1].

Banana cultivars differ in characteristics such as shape, size, colour of peel and flavour. Simmons[2] and Samson[3] have described major banana cultivars grown all over the world. The triploid genome groups such as AAA, AAB and ABB are the most important among commercially grown bananas.

The banana is a widely consumed fruit. A large portion of banana crop produced worldwide never reaches the fresh market due to various factors Koffi[4,5] and is normally discarded or underutilized, even though the fruit may be sound and could be used in various products. A small portion of the banana crop is processed into puree and other products[5] and interest in a clarified, stable banana juice has increased in recent years.

Among the local fruits banana ranks second in importance and production after durian. The data in 1999 recorded that banana was grown over an area of 25,301 hectares in the peninsular Malaysia. Its production increased considerably from 233,095 metric ton in 1990 to 372, 7200 metric ton in 1994 FAMA[6]. However the per capital consumption of banana is low (7 kg) as compared to other developing countries (15 kg). It contains mainly carbohydrates and supplies good source of energy i.e., 100 cal/100 g and good source of vitamin A, B1, B2 and C and potassium. Therefore to increase its consumption, there is a need to maximize efforts towards downstream processing of the commodity for the production of value added products. Another reason for its emphasis on downstream processing is to enhance its position in the commercial market as problems of poor post harvest handling and packaging, uncompetitive freight rates, problem with quarantine regulations remain to be major constraints in expanding Malaysian exports to other countries.

The present study was carried out to evaluate and compare the different characteristics of Berangan and Mas banana cultivars, two widely grown cultivars in

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peninsular Malaysia, to determine their suitability for value added processing especially for the production of juices.

## MATERIALS AND METHODS

**Raw material:** Fresh Berangan and Mas banana fruits of ripe yellow maturity stage were obtained from local market. To reduce the variability, three representative samples were obtained randomly from three different combs of each variety. The randomly selected fruits from each comb were hand- peeled and blended into puree to get a pool sample to conduct various analyses. All the samples were stored at freezing temperature of -20°C until analyses. Each analysis was run in triplicate to minimize the experimental error. The whole experiment was repeated for two replicates.

### Physical determination

**Texture:** TA-XT2i Texture analyzer was used to carry out texture evaluation. The accessory used was HDP/BSK (Blade set with knife). Banana fruit was cut with BSK using load cell 25 kg and with pre-test speed of 2.0 mm $s^{-1}$, test speed of 2.0 mm $s^{-1}$ and post test speed of 10 mm $s^{-1}$. The mean value for maximum force was calculated. The results were reported as resistance to shear in $Ng^{-1}$.

**Colour:** Colour was measured for each cultivar pulp with a Hunter lab D25 A-9 Tristimulus Colorimeter. A standard white plate (No, c2-22951), having reflectance value of X = 81.17, Y = 83.27, Z = 97.59, was used as a reference. Banana pulp was placed on the light port using a 5 cm diameter plastic dish with cover. Each value represents a mean of triplicate determinations of two different samples. Results were reported, as an average of individual values, as L (lightness), aL (+a is red, -a is green) and bL (-b is yellow, +b is blue).

### Physico-chemical determinations

**pH:** The pH was determined by a glass-electrode pH meter (Cyberscan 500, EUTECH Instruments Singapore) using buffers of pH 4.0 and 7.0 for calibration.

**Titratable acidity:** Titratable acidity was determined as described by Rangana[7].

**Soluble solids:** Total soluble solids content was determined by using PR-101 Atago digital refractometer (Atago, Tokyo, Japan) with a scale of 0-45°Brix. Results were expressed as degree brix.

### Chemical determination

**Sugars:** Sugars were determined by the method described by Hunt[8].

**Organic acids:** The procedure used for organic acids extraction and separation was a modification of the method of Wills[9].

**Vitamin C:** Ascorbic acid was determined according to Ranganna[7].

**Tannins:** Estimation of tannins was carried out by using colorimetric method[9].

**Total carotenoids:** Total carotenoids were determined by colorimetric method[10].

### Biochemical determination

**Preparation of enzyme extract:** A crude enzyme extract was prepared by homogenizing 10 g of raw banana sample in mixer with 50 mL of phosphate buffer (pH 7.0) containing 10 g $L^{-1}$ insoluble polyvinylpyrrolidone. Homogenization was carried out, with external cooling for 2 min and 30 s intervals. The homogenate was centrifuged at 16, 000 g at 4°C for 15 min. the supernatant was filtered through a nylon cloth and the volume obtained was carefully measured.

**Polyphenol oxidase assay:** The enzyme activity was determined by measuring the rate of increase in absorbance at 420 nm and 25°C in a Lambda 15 double beam spectrophotometer (Perkin-Elmer). The reaction mixture contained 2.9 mL of 0.07 M catechol solution in 0.05 M phosphate buffer (pH 7.0) and 100 μL of diluted (1:1, v/v, 0.2 M phosphate buffer, pH 7.0) or undiluted enzyme extract. The activity was calculated on the basis of the slope of linear portion of the curve of $\Delta A_{420}$ plotted against time (up to 3 min). Enzyme activity was expressed as $\Delta A_{420}$ $min^{-1}$ $g^{-1}$ FW.

**Peroxidase assay:** The enzyme activity was determined by measuring the rate of increase in absorbance at 485 nm and 25°C of a mixture containing 2.7 mL of 0.05 M phosphate buffer (pH 7.0), 200 μL of p-phenylenediamine solution (10 g $L^{-1}$ in distilled water, hydrogen donor), 100 μL of hydrogen peroxide solution (15 mL $L^{-1}$; oxidant) and 25 μL of diluted or undiluted enzyme extract (total reaction volume 3.25 mL). The enzyme activity was calculated on the basis of the slope of the linear portion of a plot $\Delta A_{485}$ against time (up to 3 min). Enzyme activity was expressed as $\Delta A_{485}$ $min^{-1}$ $g^{-1}$ FW.

Table 1: Quantitative descriptive analysis scale for berangan and mas banana cultivars

| Appearance/colour | Score | Taste | Score | Firmness | Score |
|---|---|---|---|---|---|
| White yellow | 5 | Very sweet | 5 | Extremely firm | 5 |
| Pale yellow | 4 | Less sweet | 4 | Very firm | 4 |
| Yellow | 3 | Sweet | 3 | Firm | 3 |
| Brown yellow | 2 | Fairly sweet | 2 | Slightly firm | 2 |
| Brown | 1 | Dull | 1 | Soft | 1 |

**Soluble proteins:** Soluble protein concentration in all extracts was determined employing a Bio-Rad kit for the Bradford reaction[12] with bovine serum albumin as standard.

**Sensory analysis:** A trained eight-member panel was selected to evaluate the banana cultivars sensory quality. At each session, random duplicate samples of each variety were assessed for appearance/colour, flavour/taste and firmness, each on a structured scale of 1-5 Table 1. For overall acceptability, the scale range was 1-9 (1 for dislike extremely and 9 for like extremely).

**Statistical analysis:** The data obtained was analyzed by the ANOVA and significant differences were analyzed by DMRT range at $p<0.05$ using Statistical Analysis System[13].

## RESULTS AND DISCUSSION

**Physical and physico-chemical characteristics:** Results of the physical and physicochemical determinations of both banana fruits cultivars are shown in Table 2. All determinations were carried in the banana fruits at the same stage of ripeness characterized by peel colour (fully yellow, maturity index-6). Firmness values were higher (4.93) in the Mas fruits as compared to Berangan fruits (4.21) and there was no significant difference between both the cultivars regarding this characteristic. Usually, firmness differences could be correlated to the different amounts of structural polysaccharides, starch and pectic substances found in banana fruit.

Objective colour parameters Table 2 showed significant differences between Berngan and Mas cultivars. Mas exhibited a lower luminosity (L = 50.24) than the Berangan (L = 51.91) and showed a significant difference. However no significant differences were found for the other Hunterlab parameters, aL and bL, although the aL and bL values (10.59 and 17.13) were higher in Berangan cultivar as compared to Mas cultivars with values of (8.02 and 16.96). The hue parameters, h = arctan (bL/aL) for both banana cultivars gave useful information. The Mas banana cultivars had the higher value (h = 64.70) indicating that the fruits of this cultivar were more yellow than the fruits of berangan cultivar (h = 58.04).

Table 2: Physical and physicochemical characteristics of banana fruit pulp

| Characteristics | Cultivars: Berangan | Mas |
|---|---|---|
| Firmness ($Ng^{-1}$) | $4.21^a$ | $4.93^a$ |
| Colour | | |
| L | $51.91^a$ | $50.24^b$ |
| aL | $10.59^a$ | $8.02^a$ |
| bL | $17.13^a$ | $16.96^a$ |
| Hue ($h = \tan^{-1}$ [bL/aL]) | $58.04^b$ | $64.70^a$ |
| pH | $4.54^b$ | $4.82^a$ |
| Titratable acidity (%) | $0.51^a$ | $0.35^b$ |
| Soluble solids (brix degrees) | $22.48^b$ | $26.30^a$ |
| Total solids (%) | $28.20^b$ | $31.00^a$ |
| Moisture contents | $71.80^a$ | $69.00^b$ |

Different superscripts in the same row indicate significant differences ($p<0.05$)
Each value in the table is a mean of two replicates for six analysis

pH values ranged between 4.5 and 4.8 in banana fruits Table 2. pH characterized the acidic taste of juice. There was significant difference between the two cultivars in terms of this parameter. Similar results were obtained for titratable acidity Table 2 where berangan fruits have higher acidity (0.5 g malic acid per 100 g) than Mas fruits (0.35 g malic acid per 100 g).

Significant differences were also found between both the cultivars in terms of soluble and total solids Table 2. Berangan has lower total solids than Mas and this relates to the lower firmness values at the same ripening stage. In addition both cultivars of banana showed significant differences in total solids and moisture contents Table 2. In general, the moisture contents of banana fruits increased when the fruit became ripe. This could be the result of breakdown of carbohydrates during respiration, the hydrolysis of starch and the moisture transfer from the peel to the pulp by osmosis[14,15]. However, there are cultivar differences in terms of these biochemical processes, which could result in significant differences in banana moisture contents. Berangan cultivar showed the higher moisture contents (71.80 g/100 g) than the Mas cultivar (69.00/100 g) and both values were significantly different ($p<0.05$).

**Chemical and biochemical characteristics:** The chemical characteristics of the two banana cultivars are shown in Table 3. No significant difference was found between Berangan and Mas banana cultivars in terms of total soluble sugars (sucrose, fructose and glucose). Although Mas cultivars contain less sucrose (8.97 g per 100 g) but it contain more total sugars (14.49 g per 100 g) as compared to berangan cultivar (14.02 g per 100 g). This shows that contribution of soluble monosaccharides (fructose and glucose) to the total sugars was greater in Mas as compared to Berangan and these results agree with the taste perception of sweetness reported in Table 4. These findings are quite similar to findings of Cano[16]. Sugars are important carbohydrates in juices as

Table 3: Chemical and biochemical characteristics of banana fruit pulp

| | Cultivars | |
|---|---|---|
| Characteristics | Berangan | Mas |
| Soluble sugars (%) | | |
| Total | 14.02[a] | 14.49[a] |
| Sucrose | 9.76[a] | 8.97[b] |
| Fructose | 2.02[b] | 2.68[a] |
| Glucose | 2.24[b] | 2.84[a] |
| Vitamin C (mg ascorbic acid/100 $g^{-1}$) | 8.85[a] | 7.19[a] |
| Tannin contents (%) | 0.0094[a] | 0.0070[a] |
| Total carotenoids (mg/100 g) | 0.387[a] | 0.577[a] |
| Citric acid (mg/100 g) | 611.67[a] | 530.17[a] |
| Malic acid (mg/100 g) | 446.17[b] | 736.50[a] |
| Succinic acid (mg/100 g) | 165.00[a] | 311.33[b] |
| Tartaric acid (mg/100 g) | 8.57[a] | 9.82[a] |
| Soluble proteins (mg/100 g FW) | 0.72[a] | 2.96[b] |
| Peroxidase activity ($\Delta A$ min$^{-1}$ g$^{-1}$ FW) | 1.76[a] | 6.42[b] |
| Polyphenoloxidase activity ($\Delta A$ min$^{-1}$ g$^{-1}$ FW) | 4.85[a] | 9.63[b] |

Different superscripts in the same row indicate significant differences ($p<0.05$)
Each value in the table is a mean of two replicates for six analyses, FW, fresh weight

Table 4: Sensory analysis of banana fruits (pulp)

| | Cultivars | |
|---|---|---|
| Characteristics | Berangan | Mas |
| Acceptance test | | |
| Colour | 7.75[a] | 6.50[a] |
| Taste | 7.00[a] | 6.16[a] |
| Firmness | 7.00[a] | 7.25[a] |
| Overall acceptability | 7.66[a] | 6.50[b] |
| Descriptive test | | |
| Colour | 3.75[a] | 3.00[a] |
| Taste | 3.66[a] | 2.83[b] |
| Firmness | 2.80[a] | 3.00[a] |

Different superscripts in the same row indicate significant differences ($p<0.05$)

they not only give body and mouthfeel to the juice in addition to sweetness but also mask the astringency effects caused by tannins on its taste.

Table 3 also shows the Vitamin C content of the two banana cultivars. Though Berangan exhibited higher Vitamin C value (8.85 mg ascorbic acid per 100 g) than Mas (7.19 mg ascorbic acid per 100 g), but statistical analysis revealed no significant difference between the two cultivars. This suggests that juice prepared from both cultivars will exhibit same level of antioxidant activity.

No significant difference was found in Tannins Table 3 between both the cultivars. Tannins normally contribute towards the astringency of the fruit and decreases with increase in fruit ripening and can contribute astringent effect on the taste of the juice prepared from these cultivars. The reported tannins Table 3 in both the cultivars however do not signify any change in the reported taste perception Table 4.

The soluble protein contents of the banana cultivars showed significant differences. The Mas cultivar had the higher amount of protein than the Berangan cultivar (2.96 mg per 100 g FW and 0.72 mg per 100 g FW (Fresh Weight), respectively).

Both banana cultivars also showed no significant differences in terms of total carotenoids Table 3 as this compound constitute the visible pigmentation of the juice.

Citric and malic acids are shown as the major organic acids present in both cultivars along with succinic and tartaric acids in lesser amounts Table 3. The values of citric and tartaric acids for berangan (611.67 and 8.57 mg/100 g) were non significant from Mas (530.17 and 9.82 mg/100 g). However significant differences were found for malic acid and succinic acid between berangan (446.17 and 165 mg/100 g) and Mas (736.50 and 311.32 mg/100 g). Organic acids are components in fruits which are important attributes of flavour, that in combination with sugars, have an impact on sensory quality of the juices. In addition, by functioning as a synergists to antioxidants such as Butylated Hydroxy Anisole (BHA), Butylated Hydroxy Toluene (BHT) and ascorbic acids, organic acids can indirectly prevent discolouration and rancidity in the fruit juices and other finished products. Because organic acids reduce pH, they can also act as mild preservatives and in some respects as a flavour enhancer, depending n other components present. The above results for organic acids in both the cultivars showed similar results in terms of taste and flavour perception Table 4.

An evaluation of two oxidoreductases, polyphenol oxidase (PPO, EC 1.14.18.1) and peroxidase (POD, EC 1.11.1.7) was made in order to establish possible differences between the two banana cultivars. These enzymes are closely related to the development of browning in fruit tissue and also ultimately in the juice and for this reason their characterization is relevant to the suitability of banana cultivars for certain types of processing to prepare value added products. Table 3 shows the values obtained for soluble polyphenol oxidase and soluble peroxidase in flesh of the two banana cultivars studied. Polyphenol oxidase activity was significantly lower in Berangan culivar. This cultivar also had the lower peroxidase activity. These results correlated with the value obtained for total soluble proteins in this variety, which is lower than Mas banana variety. Fruits contaning higher levels of enzymic activity may exhibit a faster browning rate when the fruit flesh is exposed to the air during preparative operations on processing lines (peeling, cutting, slicing, etc). Browning seems more likely to take place in Mas banana fruits undergoing preparative operations for further processing into any value added products. Tarasker and Modi[17] have established the importance of peroxidase activity in the development of chilling injury in banana fruits exposed to temperatures below 10°C. Chill-injured bananas showed low peroxidase activity compared to fruit stored at normal ripening temperature and the study suggested that peroxidase may be one of the enzymes affected during low-temperature storage. Banana cultivars that exhibit a higher peroxidase activity could therefore be more susceptible to chilling injury problems during handling and transport. At the same maturity stage Mas banana cultivar showed three-fold higher peroxidase activity compared to Berangan cultivar Table 3 and 4. From these results, it is apparent that Berangan banana variety would be very likely to be more resistant to handling and transport, making processing easier.

**Sensory characteristics:** The results test panel are reported in Table 4. In the acceptance tests, panellists preferred the colour and taste of Berangan cultivar as compared to Mas cultivar. Berangan was rated higher in colour (7.75) and taste (7.00) while Mas cultivar was scored (6.50) for colour and (6.16) for taste. However, statistical analysis of these sensory data did not show any significant difference between samples. Results from overall acceptability however, showed significant difference of ($p<0.05$) between the two cultivars with Berangan cultivar rated significantly higher (7.66) as compared to Mas (6.50).

Different conclusions were obtained from studying the results from sensory descriptive test for each quality parameter in Table 4. No significant difference ($p<0.05$) was observed between the flesh colours of two cultivars, however berangan cultivar was noted near to pale yellow (3.75) as compared to Mas was observed having yellow flesh colour (3.00). Significant difference ($p<0.05$) was observed for the taste intensity between the two cultivars. Berangan cultivar was categorized as sweet (3.66) while Mas cultivar was rated as fairly sweet (2.83). The other quality parameter, firmness, was not useful in differentiating cultivars. Panelists rated Berangan as less firm compared to Mas cultivars. Similarly Berangan was also categorized higher for taste intensity in terms of sweetness as compared to Mas.

Some correlation could be obtained between the physico-chemical and chemical characteristics of the two banana cultivars and their corresponding sensory appreciations. Objective colour measurements showed that Berangan flesh was more yellow (higher bL value) than the Mas flesh. This conclusion agreed with the sensory description of flesh colour of the two cultivars. A correlation was also obtained between sucrose +fructose and the sensory perception of sample sweetness

In this respect, Berangan cultivar was ranked as more sweet (3.66), having a sucrose+fructose content of 11.78 per 100 g FW, while Mas was ranked fairly sweet (2.83) with a sucrose + fructose content of 11.65 per 100 g FW. However total sugars showed no correlation with sensory tests, probably because of the levels of glucose, a less sweet monosaccharide.

Sensory assessment of firmness did not show any significant difference between the two banana cultivars either by descriptive of by acceptance tests Table 4. Objective determination of banana slice firmness by TA-XT2i Texture Analyzer was also not able to differentiate significant difference between Berangan and Mas cultivar Table 2.

## CONCLUSION

No significant difference was found between the two cultivars for vital physico-chemical (firmness and colour) and chemical characteristics (total sugars, Vitamin C, tannins and organic acids), which can have effect on their suitability for value added processing. Also the sensory evaluation results showed preference for Berangan cultivar in terms of better taste intensity, colour and overall acceptability as compared to Mas cultivar.

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