PHYSICO-CHEMICAL CHANGES DURING MATURATION AND AFTER RIPENING OF BANANAS (MUSA SAPIENTUM CV. EMBUN)

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Keywords: Banana (Musa sapientum cv. Embun), Maturity indices, Maturation, Ripening.

INTRODUCTION

The importance of maturity index in post harvest handling of fruits has been discussed by many workers including PANTASTICO, SUBRAMANYAM, BHATTI, ALI and AKAMINE, (1975), MARRIOT and PROCTOR (1978), MARRIOT (1980) and VAKIS (1981). It involves the measurement of some characteristics which change as the produce matures. The criteria for measuring maturity can be subjective, objective or both. Some of the methods used involved visual means, physical characteristics, chemical attributes, computation and physiological means (PANTASTICO et al., 1975). With bananas, the most common maturity index used is the shape of the fruit fingers (ABDULLAH, 1982). Other physical methods include measuring the ratio of the fruit length to its diameter, the ratio of pulp to peel weight, and firmness (VON LOESECKE, 1950; MARRIOT, 1980). Even though changes in firmness during fruit maturation have been studied in some detail by DEULLIN and MONNET (1956), these changes are primarily of interest as an experimental tool rather than for commercial control of maturity (MARRIOT, 1980).

The changes in the physical properties during maturation occur simultaneously with the changes in the chemical composition of the fruit. The most common chemical indices used are starch, sugar and acidity (VON LOESECKE, 1950; PALMER, 1971; SINGH, GANGWAR, SINGH and MOTIRAM, 1976). However, other chemical compounds such as protein, phenolics, chlorophyll and enzymes (LAL, GARG and KRISHNAN, 1974) have also been studied to a lesser extent.

Since optimum harvesting stage is required for better post harvest handling system of local bananas, there is a need to provide precise information regarding its maturity indices. The study on the maturity indices of Emas cultivar was reported by ABD. SHUKOR and AHMAD TARMIZI (1979). However, it is also important to establish the facts on the maturity indices of other local bananas. This paper reports a study on the physico-chemical changes during maturation of Embun cultivar, which is one of the most promising local cultivars for export, in relation to its quality after ripening. By studying these aspects, the maturity indices of the banana cultivar can be established both objectively and subjectively.

*Ringkasan

MATERIALS AND METHODS

Fruits

Fifty banana plants (cv. Embun) were tagged randomly from September to October 1982 during flower emergence in an orchard near Raub, Pahang. The fruit growth was observed weekly. Harvesting commenced after the ninth week from flower emergence. Four bunches of bananas which represented four replicates were harvested weekly until ripening took place. The harvested fruits were immediately transported to the laboratory of the Food Technology Division in Serdang, Selangor for further evaluation. Special precaution was taken to minimize fruit damage during transportation by lining the fruits underneath with sponge.

Sampling

The hands from each bunch were divided into upper, middle and lower portions where the upper portion refers to the bigger end of the cut stem of the bunch. General observations on the nature of stylar ends, appearance, shape and skin colour development were carried out on all fruits. Determination of pH, total soluble solids, pulp weight to peel weight ratio were carried out on fingers located right at the first, middle and final hands of the bunch. The starch and total sugar contents were determined in fingers of the first hands only.

Determination of Pulp Weight to Peel Weight Ratio

The pulp and the peel of two fingers from each of the required hands in each hand were weighed separately using an analytical balance (August Sauter GabH – 7470 Albstadt I – Ebingen).

Determination of Fruit Length to Diameter Ratio

The length of the fruit finger was determined by taking the average of the lengths of the concave and convex sides. The diameter was measured at the middle of the finger. Two fingers from each of the required hands were measured.

Determination of Starch and Total Sugar Contents

The fingers were cut into very small pieces followed by grinding in a mortar. The total sugar and starch contents were analysed according to AOAC (1970).

Determination of pH

Ground sample was mixed homogeneously with warm distilled water (60°C) in the ratio of 1:9 (w:v). After allowing to cool at room temperature, the pH of the solution was determined by using a Beckman digital pH meter.

Determination of Total Soluble Solids

Total soluble solids were determined by a hand refractometer model HR – 1A (Kyowa) (measurement range: 0% – 32%)

Sensory Evaluation

The bananas from each bunch at different stages of maturity were dipped in 1 000 ppm ethrel (Amchem Products, Inc., Pennsylvania, U.S.A.) and allowed to ripen uniformly at 25°C until they reach the colour stage between 5 and 6 (CSIRO, 1972). The organoleptic properties of the ripened bananas were evaluated by 12 trained panelists. In each evaluation, each panelist was presented with four fruits representing four bunches at the particular stage of maturity. The panelists were requested to evaluate the fruit quality based on the peel and pulp colour, pulp texture, taste, aroma and overall acceptability according to a hedonic scale from 1 to 7 (1 – very bad, 4 – neither good nor bad, 7 – very good) (LARMOND, 1977).

RESULTS

Physical Changes During Maturation

The general characteristics of Embun banana harvested between nine and 16 weeks after flower emergence are summarized in Table 1. The most obvious changes observed were the peel colour, stylar ends and the shape of the fruits which
Table 1. General physical characteristics of Embun banana harvested between 9 and 16 weeks after flower emergence

<table>
<thead>
<tr>
<th>Maturity stage (week)</th>
<th>Portion of hands</th>
<th>Colour of peel*</th>
<th>Stylar ends**</th>
<th>General appearance and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Upper</td>
<td>1</td>
<td>1</td>
<td>Immature, small and very angular.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Upper</td>
<td>1</td>
<td>1</td>
<td>Immature, small and very angular.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Upper</td>
<td>2</td>
<td>2</td>
<td>The upper hands are slightly mature.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Upper</td>
<td>2</td>
<td>2</td>
<td>Slightly mature, slightly angular.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Upper</td>
<td>2</td>
<td>3</td>
<td>Round and full in shape, less visible angles, except the lower portion.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Upper</td>
<td>2</td>
<td>3</td>
<td>Round and full in shape, less visible angles.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Upper</td>
<td>2</td>
<td>3</td>
<td>Rust-like formation on the skin due to sun scald especially upper portion, full and round in shape.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Upper</td>
<td>3</td>
<td>3</td>
<td>Severe sun-scald, splitting of the skin, full and round in shape.</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

*Colour of peel: 1 = dark green, 2 = light green and 3 = some fingers are yellow.
**Stylar ends: 1 = firmly attached, 2 = loosely attached, brittle, and 3 = very loosely attached, very dry.

started after the 11th week. At the age of nine and ten weeks the fruits were totally dark green in colour, very small and angular in shape, and the stylar ends attached very firmly to the fruits. As the fruits advanced in maturity the skin colour changed from dark green to light green. The stylar ends became drier and loosely attached to the fruits towards completion of maturation process. The changes in skin colour and the nature of the stylar ends occurred simultaneously with the change in the fruit shape in terms of its angularity, roundness and fullness of fingers. Maturation started from the upper hands to the lower ends of the bunch. At 13 weeks all the fruits attained their complete stage of maturity, where they became light green in colour, generally round and full in shape, less visible angles and the remaining stylar ends were completely dry and very loosely attached to the fruits. As the harvesting period was extended to 15 weeks, rust-like formation due to sun scald started to appear on the skin. At the 16th week, some fruit on the upper hands had already ripened, sun scald was more pronounced and some of the fruit peel started splitting.

During maturation, the ratio of pulp to peel weight (Figure 1) increased gradually. On the other hand, the ratio of fruit length to its diameter (Figure 2) decreased only after the 12th week and remained constant after the 15th week.

Chemical Changes during Maturation

The starch composition of Embun banana during maturation (Figure 3) accumulated gradually until the 14th week
followed by a sharp decrease the following weeks. The total sugar contents were almost nil in fruits harvested at 15 weeks and below (Figure 4), whereas a sharp increase was noted at 16th week which occurred simultaneously with the onset of fruit ripening on the plant itself. However, the pH values showed an irregular pattern during the maturation process (Figure 5). A sharp and sudden increase occurred between the 11th and 12th weeks and a decline at 14th week, after which it fluctuated within a narrow range of pH (5.7–5.9).

**Quality after Ripening**

*Table 2* summarized the results on the sensory evaluation of ripe Embun banana which were harvested at different stages of maturity. Since the fruits at ninth and tenth weeks were very small and slightly astringent in taste after being ripened, sensory evaluation test was conducted only on fruits with maturity stage of 11 to 16 weeks. It was found that all the fruits presented for the sensory evaluation were organoleptically accept-
analysrs of pH values and total soluble solids in the ripened fruits did not show any significant variation with respect to the maturity at harvest (Table 3).

**DISCUSSION**

The stage of maturity plays a very important role in determining the quality of bananas after they are harvested. In the case of Embun banana, the optimum harvesting stage was between 12 and 15 weeks (84 and 105 days). Below this region, the fruits were very small in size. On the other hand, fruits harvested after 15 weeks were poor in quality due to discoloration and splitting of the skin. According to BARNELL (1940), the optimum stage of maturity for Gros Michel bananas is between 80 and 100 days from flower emergence. SINGH et al. (1976) found that the optimum time for harvesting Basrai bananas was 80–95 days after spike emergence. Similar results were also reported by DESAI and DESHPANDE (1978) in three varieties of banana, i.e. Pachabale, Rasabale and Rajabale.

The changes in the colour of the peel, the dryness and the density of stylar ends and the shape of the fruit fingers (Table 1) can be considered as the most practical and simplest methods for determining the maturity indices of Embun banana. Except for the colour of the peel, these parameters have been used widely for farmers in this country even though they are very subjective and less precise in their applications.

During maturation of Embun banana, the ratio of pulp to peel weight (Figure 1) increased gradually. Similar results were also reported by VON LOESECKE (1950) on Gros Michel bananas. On the other hand, the ratio of fruit length to the diameter (Figure 2) decreased only after the 12th week, which suggests that this parameter could also be used as a good maturity index for Embun banana.

Apparently, there was a one-week lapse between the sudden reduction in the
Table 2. Sensory evaluation of Embun bananas ripened after harvesting at different stages of maturity

<table>
<thead>
<tr>
<th>Maturity stage (week)</th>
<th>Peel colour</th>
<th>Pulp colour</th>
<th>Pulp texture</th>
<th>Taste</th>
<th>Aroma</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Reasonably good</td>
<td>Good</td>
<td>Reasonably good</td>
<td>Good</td>
<td>Reasonably good</td>
<td>Good</td>
</tr>
<tr>
<td>12</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>13</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>14</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>15</td>
<td>Reasonably good</td>
<td>Good</td>
<td>Reasonably good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>16</td>
<td>Reasonably good</td>
<td>Good</td>
<td>Reasonably good</td>
<td>Good</td>
<td>Good</td>
<td>Reasonably good</td>
</tr>
</tbody>
</table>

Table 3*. The pH values and total soluble solids (TSS) of Embun banana fruits ripened after harvesting at different stages of maturity

<table>
<thead>
<tr>
<th>Maturity stage (week)</th>
<th>pH</th>
<th>TSS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>5.4 a</td>
<td>21.3 a</td>
</tr>
<tr>
<td>10</td>
<td>5.4 a</td>
<td>21.5 a</td>
</tr>
<tr>
<td>11</td>
<td>5.0 a</td>
<td>22.1 a</td>
</tr>
<tr>
<td>12</td>
<td>5.0 a</td>
<td>22.9 a</td>
</tr>
<tr>
<td>13</td>
<td>5.0 a</td>
<td>21.1 a</td>
</tr>
<tr>
<td>14</td>
<td>5.1 a</td>
<td>21.9 a</td>
</tr>
<tr>
<td>15</td>
<td>5.0 a</td>
<td>20.7 a</td>
</tr>
<tr>
<td>16</td>
<td>5.0 a</td>
<td>20.2 a</td>
</tr>
</tbody>
</table>

*Each value is the mean of 24 fruits sampled from four bunches. Values followed by the same letter in the same column are not significantly different at 5% level by Duncan’s Multiple Range Test (LITTLE and HILLS, 1978).

The results from this study indicated that the changes in pH during fruit maturation were irregular. These results are in agreement with SINGH et al. (1976) who found that the acidity could not be related with maturity or quality of Basrai bananas.

The finding on the organoleptic acceptability of fruits sampled at various stages of maturity, i.e. 11th to 16th weeks after flower emergence, showed that Embun banana can be harvested within a wide range of maturity stages. DALAL, NAGARAJA, THOMAS and AMAL (1969) observed that the Dwarf Cavendish bananas ripened acceptably with a minimum pulp to peel ratio of 1:1. In the case of Embun banana, the earliest stage for organoleptic acceptance was obtained after 11th week when the pulp to peel ratio was at 1.8.

The total soluble solids in fruits indicate the degree of sweetness. The results in Table 3, however, proved that these values were not significantly different in ripe fruits with regard to the maturity stage at harvest. These results are not in agreement with SINGH et al. (1976) who found maximum total soluble solids and sugar contents in ripened Basrai bananas harvested between 80 and 95 days. This study also showed that the sourness of fruits (based on pH values) was not significantly different once they ripened. Similar results were also reported by SINGH et al. (1976).

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ABSTRACT

Studies on the maturity index of Embun banana based on the physico-chemical changes at maturity stage between nine and 16 weeks from flower emergence were carried out. The optimum
maturity stage for harvesting was between 12 and 15 weeks, where the changes could be seen on the peel colour from dark green to light green, the remaining stylar ends were dry and brittle and the fruits were less angular in shape. During maturation, the pulp to peel weight ratio increased gradually. The length to diameter ratio decreased only after 12 weeks but remained constant after 15 weeks. The starch contents increased up to the 14th week but decreased suddenly the following weeks. The sugar contents were almost nil at 15th week and earlier, but suddenly increased at 16th week. Fruits harvested between 11 and 16 weeks were organoleptically acceptable after allowing them to ripe. The pH value and total solids in the ripe fruits were not significantly different.

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