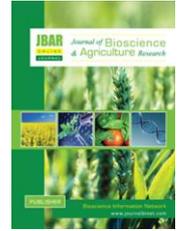


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## Response of physical quality and biochemical characteristics to different maturity stages of *Mangifera indica* (cv. Amrapali)

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### ABSTRACT

Mango fruit consumers often confuse to select exact fruits from markets. A study was conducted to analyze the physical quality and biochemical components at different stages of mango cultivar "Amrapali". The study was conducted at the postharvest laboratory, Department of Horticulture, PSTU during the period from January to December 2015. Stage-1 was marked when the peel color was dark olive green and turning to yellow at the seed and the subsequent maturity stages determined at 2-days intervals as stage-2 was olive, stage-3 was apple green, stage-4 was brown, stage-5 was saddle brown and stage-6 was dark golden rod in color. At each maturity stages, physical (peel color, firmness and weight loss) and biochemical (anthocyanin content, titratable acidity, pH, total soluble solids, ascorbic acid, reducing sugar, non-reducing sugar and total sugar) maturity indices were determined. The pH (4.54), anthocyanine content (430 mg/100 g), TSS (24.33%), reducing sugar (7.56%), non-reducing sugar (5.84%) and total sugar (13.40%) were significantly highest at stage-6 (dark golden rod colour). The titratable acidity (0.30%) and ascorbic acid (25.29 mg/100 g) were significantly highest at stage-1 (dark olive green). Firmness decreased gradually with the advancement of maturation and flesh color turned dark olive green to dark golden rod. Total soluble solids were increased while TA was gradually decreased with increase of maturity. Dark olive green colour stage (stage-1) is suitable for harvesting and transportation due to highest physical quality and dark golden rod colour stage (stage-6) is suitable for consumption due to highest biochemical composition.

**Key Words:** *Mangifera indica*, Physiological characteristics, Bio-chemicals and Maturity indices

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## I. Introduction

Mango (*Mangifera indica* L.) belongs to *Anacardiaceae* family, is an economically important and well known fruit crops grown in Bangladesh. It is enriched with a numerous number of varieties. There are about 1600 varieties are found in all over the world while 100 in Bangladesh. Amrapali, Mallika, Langra, Aswina, Fazli, Gopalbhog, Himsagar, Khirsapati, Kishanbhog, Kohinoor, Kuapahari, Mohanbhog, Deshari, Neelumare the well known cultivars in Bangladesh. On an average 100 g mango pulp contains 60 kcal energy, protein 0.82 g, total lipid (fat) 0.38 g, carbohydrates 15.0 g, fibre 1.6 g, sugars 13.7 g, calcium 11 mg, phosphorus 14 mg, iron 0.16 mg, potassium 168 mg, vitamin C 36.4 mg, vitamin A 54 µg, vitamin 0.90 mg, riboflavin 0.04 mg, niacin 0.67 mg, thiamin 0.03 mg, and vitamin B6 0.12 mg (USDA 2015). Ripe mango pulp contains 16.9% carbohydrate (Nilish and Banik, 2005). Amrapali is a high yielding and regular bearing variety. Shape of fruit is oblong, medium sized, prominent ventral shoulder, curved back, prominent beak, round apex, thin skin and smooth texture. The pulp is yellow, texture is firm, fibreless, very pleasant aroma, very sweet taste and juicy. Average fruit weight is 220 g. However, very little information on proper maturity colour of fruits is available at growers and consumers level. As a result, fruit consumers confuse to buy fruits from markets due to artificial fruit colour. Therefore objectives of this study were to evaluate the physical quality and chemical characteristics at different colour stages of the fruits and develop a standard maturity color chart of 'Amrapali' mango varieties.

## II. Materials and Methods

The experiment was carried out at the Postharvest laboratory, Department of Horticulture, Patuakhali Science and Technology University (PSTU), Patuakhali, Bangladesh from January to December 2015. The temperature and relative humidity of the storage room were recorded daily at the study period by a digital thermo hygrometer (TFA Dostmann GmbH & Co. KG, Germany). The minimum and maximum temperatures were 24.0°C and 33.0°C, respectively. The minimum and maximum relative humidity was 82% and 90%, respectively. A total 100 healthy fruits with uniform size, shape and color were collected from the residential area of vice chancellor, PSTU. Fruits were harvested when they attained in light green colour with uniform size and shape. The fruits having no defect were cut off with a sharp knife keeping intact about 2 cm stalk with them and loaded immediately with care to transfer in the Laboratory. The experiment was laid out in completely randomized design (CRD) with three replications.

### Determination of physical characteristics at different stages of the fruits

**Weight loss:** Individual fruit was weighted in every alternative day by an electronic balance. The percentage of weight loss was calculated using the following formula:

$$\text{Weight loss (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where,  $W_1$  = Initial weight of the fruit

$W_2$  = Weight of fruits after storage

**External peel colour:** The fruit peel colour was determined by "On Color Measure" (an Android Application Software developed by PotatotreeSoft, Version 3.0) where color was identified by using a mobile device camera (Plate 01).



**Stage-1**  
(dark olive green)



**Stage-2**  
(olive)



**Stage-3**  
(apple green)



**Stage-4**  
(brown)



**Stage-5**  
(saddle brown)



**Stage-6**  
(dark golden rod)

**Plate 01. Different maturity stages of Amrapali**

**Firmness:** Firmness of mango was determined by hand feeling using a numerical rating scale of 1-5 (Hasan, 2006) where; 5= mature hard, 4= sprung, 3= between sprung and eating ripe, 2= eating ripe and 1= over ripe.

#### **Determination of chemical characteristics at different stages of the fruits**

**Anthocyanine content:** Total Anthocyanine content of peel and the carotinoid content of pulp were determined by the method of Sims and Gamon (2002).

**Titrateable acidity:** Titrateable acidity (TA) was determined according to Titration method described By Ranganna (1979) and calculated followed by the formula:

$$\text{Titrateable acid (\%)} = \frac{\text{Titre (mL)} \times \text{NaOH normality (0.1 M)} \times \text{Vol. made up (50 mL)} \times \text{Citric acid eq. weight (64 g)} \times 100}{\text{Volume of sample for titrate (5 mL)} \times \text{Weight of sample taken (10 g)} \times 1000}$$

**pH:** Remaining of the filtrated juice from TA determination was used to measure the pH of the fruit pulp. The pH was determined by using a glass electrode pH meter (PHS-25 Precision pH/mV meter, Shanghai LIDA Instrument Factory, China)

**Total soluble solids (TSS):** The percentage of TSS was determined by a digital refractometer (BOE 32195, BOECO, Germany).

**Ascorbic acid (Vitamin C):** Ascorbic acid was determined according to the dye method (Ranganna, 1979).

**Total sugar:** Sugar content was determined by the procedures described by Lane and Eynon (1923).

**Standardization of Fehling's solution:** 50ml of both Fehling's solution A and B were mixed in a beaker and 10 ml was taken into a 250ml conical flask. 25ml distilled water was added to it. Standard sugar solution was taken in a burette. The conical flask containing mixed Fehling's solution was heated on a hot plate. Three drops of methylene blue indicator solution was added to the solution when it started to boil without removing the flask from the hot plate. Mixed Fehling's solution was titrated by standard sugar solution. The end point was indicated by discoloration. Fehling's factor was calculated by using the following formula:

$$\text{Fehling's factor (g of sugar)} = \frac{\text{Titre} \times 2.5}{100}$$

**Preparation of sample:** Fruit juice (50 ml) was mixed with distilled water (100ml) and neutral lead acetate (5 ml). kept it for ten minutes to homogenize. Solution was transferred to a 250 ml volumetric flask and the volume was made up to the mark with distilled water. Solution was then filtered.

**Estimation of reducing sugar:** 10ml of mixed Fehling's solution was taken in a 250ml conical flask and made 250ml with distilled water. Purified juice solution (filtrated) was taken in a burette. Conical flask containing mixed Fehling's solution was heated on a hot plate. Three to five drops of methylene blue indicator was added to the flask when boiling started and titrated with solution taken in burette. End point was indicated by discoloration. Percentage of reducing sugar was calculated by following formula:

$$\text{Reducing sugar (\%)} = \frac{F \times D \times 100}{T \times W \times 1000}$$

Where ,      F= Fehling's solution  
                   D= Dilution  
                   T= Titre, and  
                   W= Weight of sample

**Estimation of total invert sugar:** 50ml of purified solution (filtrated) was taken in a 250ml conical flask. 5ml citric acid and 50ml distilled water was added to it. The conical flask containing sugar solution boiled for inversion of sucrose and cooled. Then the solution was transferred to a 250ml volumetric flask and neutralized by 1N NaOH using phenolphthalein indicator. The volume was made up to the mark with distilled water. The mixed Fehling's solution was titrated as same as reducing sugar. The percentage was also calculated similarly as reducing sugar.

**Estimation of non-reducing sugar:** Non-reducing sugar was estimated by using the following formula:

$$\text{Non-reducing sugar (\%)} = \text{Total invert sugar (\%)} - \text{Reducing sugar (\%)}$$

**Statistical analysis:** The data on different parameters were tabulated and analyzed MSTAT-C programme (Gomez and Gomez, 1984). All the treatment means were calculated and the analysis of variances (ANOVA) was done by Duncan's Multiple Range Test (DMRT). The means were separated by Least Significant Difference (LSD) test at 1% levels of significance.

### III. Results and Discussion

#### Physical characteristics at different stages of the fruits

##### Peel colour

Colour is one of the most important criteria of quality of most fruits. Changes in colour of mango peel dark olive green to dark golden rod are the most obvious changes which occur during storage of fruits (Plate 01).

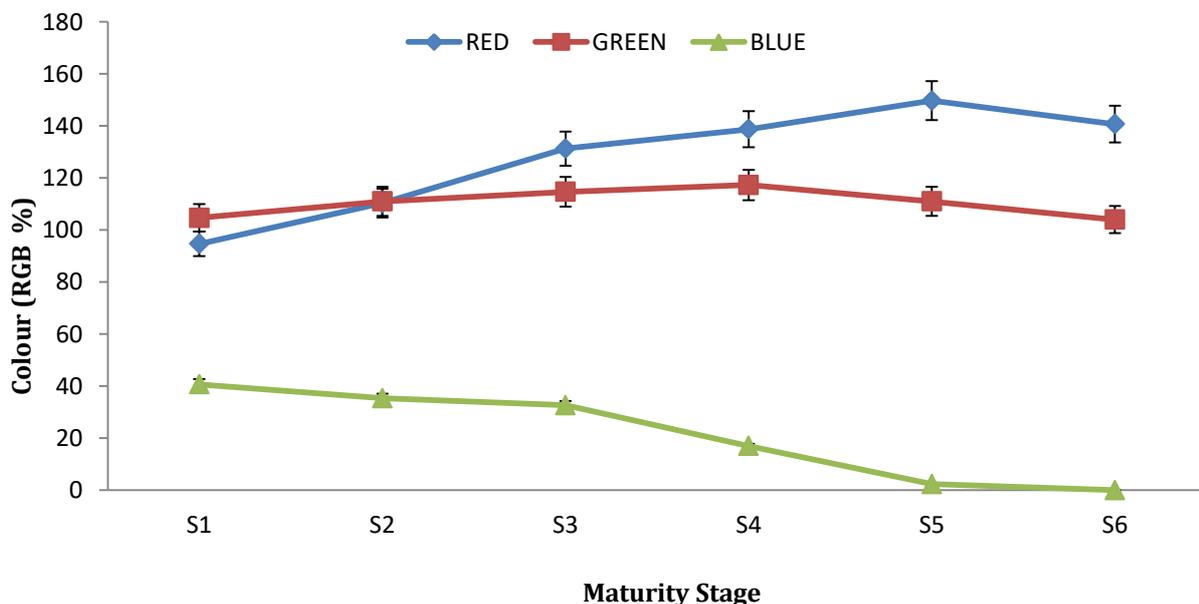
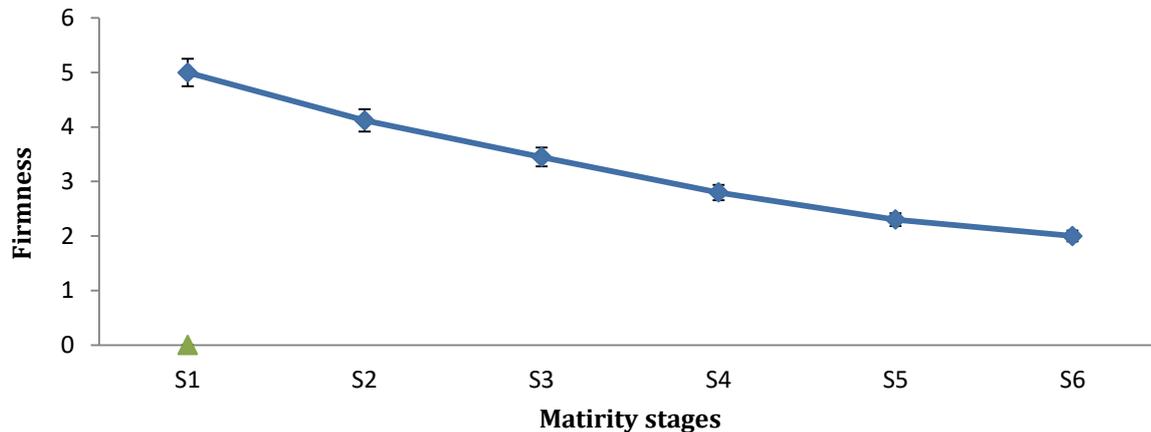


Figure 01. RGB % of Amrapali at different maturity stages.

At early stage green (G) colour was prominent and gradually decreased with maturity. At stage-1, red green and blue color were 94.67%, 104.7% and 40.67%, respectively. The red (R) colour content was highest at stage-5 (RGB% - 150). Then value of RGB% was decreasing due to deterioration of colour pigment. Change of peel colour during ripening and senescence of fruits involves chlorophyll degradation or qualitative and quantitative alternation of the green pigment into other pigments (Figure 01 and Plate 01).

### Firmness

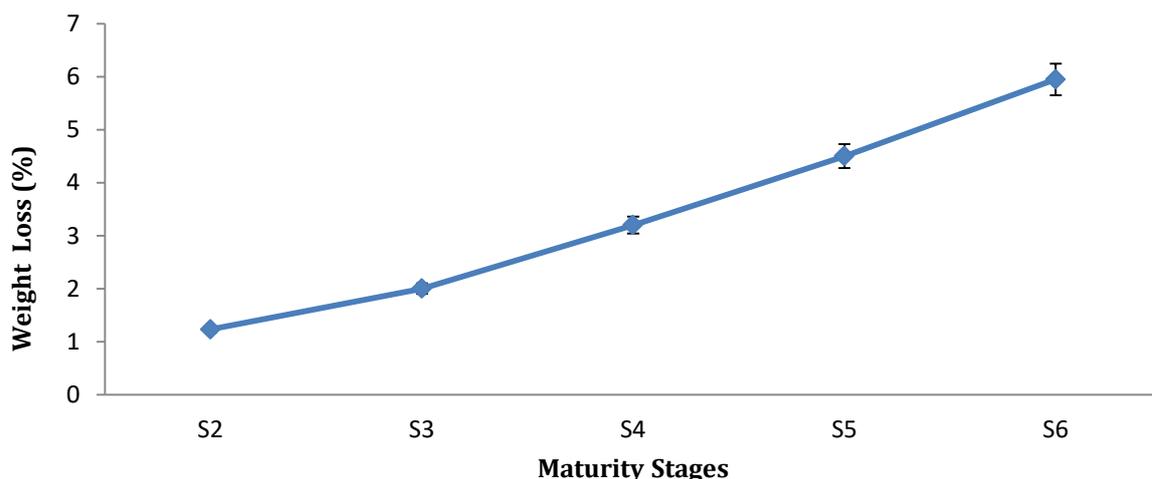
Firmness is an important criteria of fruits quality. Firmness of mango pulp from stage-1 to stage-6 is an obvious change during storage.



**Figure 02. Firmness of Amrapali at different maturity stages.**

Significant variation was observed in respect of firmness of mango pulp at different stages (Figure 02). The highest firmness was recorded at stage-1, and then the firmness of mango was decreased due to conversion of starch and pectin into sugars.

During colour and firmness change the pulp becomes softer and sweeter as the ratio of the sugar to starch increased and the characteristic aroma is produced.



**Figure 03. Percent weight loss of Amrapali at different maturity stages.**

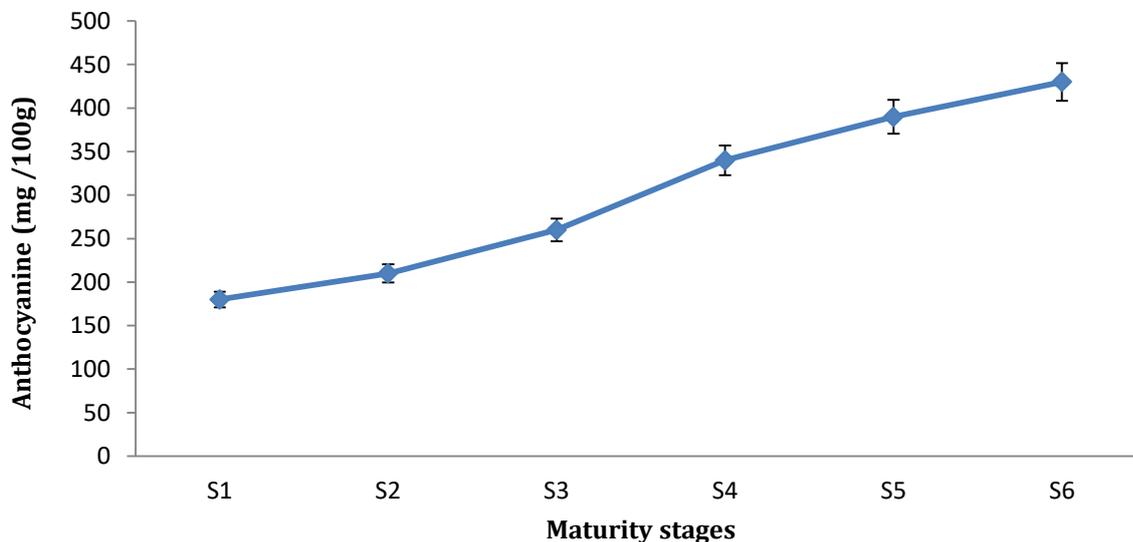
### Weight loss

Significant variation was observed in total weight loss at different maturity stages of the fruits (Figure 03). The highest weight loss was 5.95% at stage-6 (Figure 03). Weight loss of the fruits was occurred due to the loss of water from the fruits, microbial decay and storage environment like temperature

and humidity. High temperature enhanced weight loss but low temperature reduced weight loss during ripening and storage.

## Biochemical characteristics at different stages of the fruits

### Total anthocyanin content



**Figure 04. Anthocyanin content in Amrapali mango varieties.**

It was found that, the anthocyanin content was more in ripe mango peel and it was found highest at stage-6, 430 mg/100 g (Figure 04).

### Titratable acidity

Titratable acidity content of fruits varied significantly at different stages during storage (Table 01). The highest titratable acidity (0.31%) was recorded at stage 1 which was followed by stage- 2 (0.28%) and stage-3 (0.25%). Then the titratable acidity was decreased at fully ripen stage i.e., stage-6 (0.17%). A gradual decrease in titratable acidity with the advancement of maturity may cause due to various enzymatic activities.

### pH of fruit juice

The pH of the fruit pulp at different stages ranged from 3.96-4.54 at different maturity stages (Table 01). The lowest pH (3.96) was recorded at stage -1, followed by stage- 2 (4.09) and stage-3 (4.19). The pH was increased up to stage-6 significantly and the highest pH (4.54) was recorded at stage-6. Statistically highly significant variation of pulp pH was observed at different stages due to conversion of pectin into sugars.

### TSS of fruit juice

TSS ranged from 17.86-24.33% at different maturity stages (Table 01). The lowest TSS (17.86%) was recorded at stage-1, followed by stage- 2 (19.23%) and stage-3 (19.95%) while the highest TSS (24.33%) was recorded at stage-6. During the development of the flesh of a fruit, in many species, nutrients are deposited as starch, which during the ripening process is transformed into sugars. The progression of the ripening process leads to increasing sugar levels.

### Ascorbic acid

The highest ascorbic acid (25.90 mg) was recorded at stage-1, followed by stage- 2 (21.20 mg) and stage-3 (20 mg) whereas the lowest (11.60 mg) at stage-6 (Table 01).

### Reducing sugar

Reducing sugar content of fruit ranged from 3.90-7.64% at different maturity stages (Table 01). Lowest reducing sugar (3.90%) content was found at stage-1 which was followed by stage-2 (4.20%) and stage-3 (4.90%). On the other hand, the highest reducing sugar (7.56%) was recorded at stage-6. A gradual increase in reducing sugar was observed with the advancement of maturity due to various enzymatic activities.

### Non-reducing sugar

The lowest non-reducing sugar (2.34%) was found from stage-1, followed by stage- 2 (2.63%) and stage-3 (3.22%) while the highest non reducing sugar (5.84%) was recorded at stage-6 .

### Total sugar

Total fruit sugar content ranged from 6.23-13.40% at different maturity stages (Table 01). The lowest total sugar (6.23%) was recorded at stage-1, followed by stage- 2 (6.83%) and stage-3 (8.13%). The highest total sugar (13.40%) was recorded at stage-6.

Mango pulp contains amylase, invertase and high percentage of starch. Starch accumulation is the main activity of fruit which increases fruit weight. Amylase and invertase in the mango pulp play an important role during the development of mango. The hydrolysis of starch during fruit ripening by hydrolytic enzymes has been reported for mango. Changes in amylase activity in mango fruits during development and after being exposed to chilling temperatures have been reported. Fruit softening during ripening is complex process that presumably involves structural changes in the walls of fruit cells. It is thought that these changes are brought about through the action of cell wall hydrolyses, degrading various wall polymers although other mechanisms may be involved. Activities of all these enzymes increased with degree of maturity.

**Table 01. Biochemical characteristics of Amrapaliat different fruit maturity stages**

Maturity Stages	TA(%)	TSS(%)	AA(mg)	pH	RS(%)	Non-RS(%)	TS(%)
Stage-1	0.30a	17.86d	25.90a	3.96f	3.89d	2.34e	6.23e
Stage-2	0.28ab	19.23cd	21.17b	4.09e	4.19cd	2.63de	6.82de
Stage-3	0.26ab	19.95c	20.08b	4.19d	4.91bc	3.21cd	8.13cd
Stage-4	0.23abc	22.16b	15.04c	4.40c	5.23b	3.45c	8.60c
Stage-5	0.20bc	23.23ab	12.64d	4.51b	7.00a	5.16b	12.17b
Stage-6	0.17c	24.33a	11.60de	4.54a	7.56a	5.84a	13.40a
LSD <sub>(0.01)</sub>	0.076	1.38	2.31	0.03	0.91	0.72	1.51
CV%	15.88	2.64	5.72	7.66	6.50	7.35	11.36

Means in a column followed by the same letter(s) are not significantly different at 1% level of significance

TSS= Total soluble solids; AA=Ascorbic acid; TA= Titratable acidity;RS= Reducing sugar; Non-RS= Non reducing sugar; TS= Total sugar

## IV. Conclusion

Physical quality is highest at stage-1, i.e., dark olive green. This stage is suitable for harvesting and transportation. Chemical composition is highest at stage-6, i.e., dark golden rod colour and this stage is suitable for consumption. Further studies are suggested on maturity stages.

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#### APA (American Psychological Association)

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