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Physico-chemical Changes During Growth and Development of Sapota Fruit (*Manilkara achras* Mill.)

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Abstract

Various changes during growth and development are the prime concern for determining the optimum maturity, maintain high nutritional quality and reduce postharvest losses of fruits. Therefore, this study was undertaken in order to determine the physical and chemical changes during growth and development of sapota fruit at different days after fruit set (DAFS). The experiment was carried out in a randomized complete block design with three replications. Two sapota varieties viz. BAU Sapota 1 and BAU Sapota 3 were used for this study. The results demonstrated that the physico-chemical properties of two sapota varieties changed with time progressed during growth and development. It was observed that some of the physical and chemical properties of those varieties reached a peak at 105 DAFS while most of the other characters exhibited better at 119 DAFS. Therefore, it can be concluded that BAU sapota variety will be ready to harvest at 119 DAFS which could provide better nutritional quality with minimum postharvest losses.

Key words: Growth; physical characters; chemical properties; maturity; sapota fruit

Introduction

Sapota (*Manilkara achras* Mill.) is one of the prominent fruits in Bangladesh belonging to the family Sapotaceae. It is originated from tropical America and now widely cultivated in the tropics, including India, Mexico, Vietnam, Guatemala and Venezuela (Roy and Joshi, 1997). India is the largest producer of sapota followed by Guatemala and Venezuela (Pawar et al., 2011). It is grown throughout Bangladesh but widely grown in Barisal, Khulna, Jessore, Chittagong and Chittagong Hill Tract districts. It starts bearing early from second or third year of planting but economical yields can be obtained from 7th year onwards. Under tropical conditions, flowers are seen almost throughout the year. In Bangladesh, the main fruiting season of sapota is December to March (Rahim et al., 2011). The fruits become mature 4 to 6 months after flowering. In general, the sapota fruit requires 100 to 165 days to mature after anthesis, depending on the cultivar, agro climatic location and temperature (Sulladmath, 2001). Since sapota tree bears flowers almost year round, therefore, fruits of all stages of maturity can be found on the tree at the same time, making it difficult to determine the optimum maturity date for harvesting. In addition, the climacteric nature of sapota fruits requires proper harvesting maturity and careful postharvest handling to reduce postharvest losses, further hindering the storage and distribution. Measurable parameters such as fruit size, color of skin after scratching and external color have been correlated with the stage of maturity at harvest. Therefore, more precise determination of the time after fruit set required to reach maturity is to ensure the fruit quality. In general, once cell division ends, cell expansion become the dominant way to increase fruit size (Bertin, 2005). Final fruit size is directly related to the number of cells produced in the period just immediately following pollination (Zhang et al., 2006). Major changes in the chemical composition of the fruit are strongly associated with its growth (Shinde, 2003). It has been reported that as ripening proceeds, the total sugars in the fruit increase while acidity decreases. Sugars are the major component of the soluble solids in sapota fruit. Therefore, the taste of sapota fruits, like most other fruits is highly correlated with the percentage of soluble solids, and is a major factor in determining the quality of the fruit.

Characterization is an important aspect for documentation of the performance of the studied cultivars, which subsequently will help to introduce, select and improve existing sapota varieties. Unfortunately, information regarding the fruit growth, physico-chemical compositions of sapota varieties growing under different regions of Bangladesh is very limited. The experiment was therefore, undertaken in order to study the physico-chemical changes during growth and development of sapota fruit.

Materials and Methods

Strains and Media

The experiment was conducted at Bangladesh Agricultural University Germplasm Centre (BAU-GPC) from April-October, 2011. The single factor experiment was laid out in a randomized complete block design with three replications. Two sapota varieties viz. BAU Sapota 1 and BAU Sapota 3 were used for this experiment. About 5-6 years old six sapota plants of two varieties were selected. Flowers were tagged after full bloom to determine the days after fruit set (DAFS) and data collection was started from 35 DAFS and continued up to full mature stage at seven days intervals. Data were collected on length, breadth, volume, fresh weight, dry weight, % water content, total soluble solids (TSS, °Brix), vitamin C, total sugar, reducing and non-reducing sugar contents of fruits at different DAFS. Lengths and breadths of fruits were measured consecutively from five randomly selected fruits with the help of digital slide calipers and average was calculated and expressed in centimeter (cm). Fruit volume was measured by water displacement method and expressed in milliliter (ml). Fresh weight of fruits was measured by digital balance and expressed in gram. Fruits were sliced in to small pieces and placed in an electric oven at 60 °C for 96 hours until the weight become constant. It was then cooled and weighed again and % water content was determined by using the following formula:

Water content (%) of fruit

$$= \frac{\text{Fresh weight of fruit} - \text{Dry weight of fruit}}{\text{Fresh weight of fruit}} \times 100$$

Total soluble solids (TSS) content of fruit pulp was determined by using hand-held Abbe's Refractometer. Temperature corrections were made by using Temperature Correction Chart that described by Ranganna (1979). Total sugar content of fruit pulp was determined colorimetrically followed by the method of Jayaraman (1981). Reducing sugar content was determined according to the method of Miller (1972) where Dinitrosalicylic acid was used for the development of color. Non-reducing sugar content was calculated by using the following formula:

% non-reducing sugar = (% total sugar - % reducing sugar)

Vitamin C content of fruit pulp was determined by using 2, 6- dichlorophenol indophenols visual titration method as described by Plummer (1971). The titratable acidity of sapota pulp was determined by the method of Ranganna (1979). The data obtained from the experiment on various parameters were statistically analyzed by using MSTAT C computer program. The mean values for all parameters were calculated and analysis of variances for the characters was accomplished by *F* variance test. The significance of difference between pair of means was tested by the least significant difference test at 5% and 1% levels of probability (Gomez and Gomez, 1984).

Results and Discussion

Fruit length of two varieties of sapota was found to increase during the entire period of experiment. It was observed that the average length of fruits increased rapidly until 105 DAFS and then the growth slowly increased until 119 DAFS (Figure 1A). Between the two sapota varieties, the rates of increase in fruit length during 56 to 119 DAFS were significant. The patterns of increase in fruit length of two varieties were similar with a little variation between them (Figure 1A). The final length of fruits after maturity ranged from 5.85 cm to 7.12 cm. The higher fruit length (7.12 cm)was recorded from BAU Sapota 3 at 119 DAFS, while, lower fruit length (5.85 cm) was found in BAU Sapota 1 (Figure 1A). Fruit length was expanded with time probably due to increase in number of cells as well as cell expansion.

Fruit breadth of two varieties of sapota was found to increase during the entire period of study. It was observed that the average breadth of fruit increased rapidly up to 98 DAFS and then slowly up to 119 DAFS (Figure 1B). Between the two varieties, the rates of increase in fruit breadth during 42 to 119 DAFS were significant. Breadth of fruits after maturity ranged from 4.85cm to 5.36 cm. The higher fruit breadth (5.36 cm) was recorded from BAU Sapota 1 at 119 DAFS and lower breadth (4.85) cm was found in BAU Sapota 3. deBrito and Narain (2001) reported that the average length and diameter of the half-ripe sapota fruit were 6.4 cm and 7.5 respectively, and there was a significant difference in these parameters between the mature green and the half-ripe stages.

Fruit volume showed significant differences between two varieties at DAFS. The result indicated that the average volume of fruit increased rapidly up to 105 DAFS and then increased slowly up to 119 DAFS (Figure 2A). The rates of increase in fruit volume of the two varieties during 70 to 119 DAFS were significant. The average volume of fruit at maturity stage was recorded maximum (87.0 ml) in BAU Sapota 1 at 119 DAFS and 75.96 ml in BAU Sapota 3. Statistically significant variation in fresh weight of fruits was noticed between the two varieties at DAFS. The result showed that the average fresh weight of fruits increased rapidly up to 105 DAFS and thereafter increased slowly up to 119 DAFS (Figure 2B). The rates of increase in fresh weight of fruits were significant from 70 to 119 DAFS. As fruit volume increased significantly from 70 to 119 DAFS therefore fruit fresh weight was increased in similar pattern.

Statistically significant variation was observed in case of dry weight of fruits at different growth stages. Results showed that the average dry weight of fruits of the two varieties were significant from 77 to 119 DAFS (Figure 3A).

The variations between the two varieties in terms of % water content at different growth stages were significant from 70 to 119 DAFS (Figure 3B). The water content of fruits during maturity stage ranged from 72.52 to 77.01%. The maximum water content was found in BAU Sapota 1 (77.01%) and minimum in BAU Sapota 3 (72.52%).

It was observed that TSS content of both the varieties was zero (0 °Brix) at 35 DAFS thereafter the values increased rapidly up to 105 DAFS and then slowly up to 119 DAFS (Figure 4A). TSS content in mango found to increase with advancement of growth and development time reported by Akter (2012). The differences of TSS content of two varieties were significant from 42 to 119 DAFS. However, the higher TSS content was found in BAU sapota 3 and lower from BAU sapota 1 during the whole growth period. TSS content was increased as fruit mature which may be due to accumulation of more sugars in to the fruits through hydrolysis of starch. Similar result was observed by Raut (1999); Pawar et al. (2011); Bhutia et al. (2011).

Significant variation in respect to vitamin C content of fruits was noticed at different growth stages. It was found that vitamin C content of fruit decreased rapidly up to 98 DAFS and then slowly up to 119 DAFS (Figure 4B). At the initial growth stage both the varieties content highest amount of vitamin C but it decreased gradually with time up to the final maturity. This reduction is due to oxidative destruction of ascorbic acid by enzymes, mainly ascorbic acid oxidase. However, BAU Sapota 1 contained highest amount of vitamin C (9.41 mg/100 g) at the initial stage of fruit setting and lowest (9.20 mg/100 g) was recorded in BAU Sapota 3 (Figure 4B). Ingale et al. (1992) reported that ascorbic acid content of sapota fruits was initially increased thereafter continuously decreased during development.

The different growth stages involved in this investigation were found significant variations in relation to total sugar content. It was observed that the total sugar content of both the varieties was 0 % at 35 DAFS then it was increased rapidly up to 112 DAFS and thereafter slowly up to 119 DAFS (Figure 5A). The total sugar content at the maturity stage was recorded maximum (17.57%) in BAU Sapota 3 and minimum (16.52%) from BAU sapota 1. The rates of increase in total sugar content during 70 to 119 DAFS were significant between the two varieties. The contents of total sugar in sapota fruits was increased due to conversion of starch into sugar. This results are in agreement with the findings of de Brito and Narain (2001); Pawar et al. (2011).

The effects of different growth stages of fruit in relation of reducing sugar content recorded in the study was significant during 70 to 119 DAFS. It was found that the reducing sugar content of both the varieties was 0 % at 35 DAFS then it was increased rapidly up to 112 DAFS and finally steadily increased up to 119 DAFS (Figure 5B). The higher reducing sugar (9.21%) was recorded from BAU Sapota 3 and the lowest (8.8%) was recorded from BAU Sapota 1 at 119 DAFS. Reducing sugar content was increased due to inversion of sucrose. deBrito and Narain (2001) observed almost similar results in sapota fruits.

Results showed that non-reducing sugar content of fruit increased rapidly up to 105 DAFS and then it increased slowly up to 119 DAFS (Figure 6A). At the initial stage non-reducing sugar content of both varieties was 0% but it increased gradually day by day up to the final maturity. The fruit flesh of BAU Sapota 3 contained the higher amount of non-reducing sugar (8.2%) and lower (7.7%) was recorded in BAU Sapota 1 at the 119 DAFS. The contents of non-reducing, reducing and total sugar in sapota fruits was increased due to conversion of starch into sugar.

Different growth stages of sapota fruits showed significant variation in relation to titratable acid content. The result showed that the content of titratable acid decreased rapidly with advancement of time (Figure 6B). At the initial stage, both the varieties showed highest amount of titratable acidity but it decreased gradually as fruits become mature. The fruit flesh of BAU sapota 1 contained the higher amount of titratable acidity (0.98%) and BAU sapota 3 contained lower amount (0.82 %) at 35 DAFS. Decrease in acid content with maturity of sapota fruits may be attributed to the oxidation of organic acids. This results are in agreement with findings of Paralker (1985); Pawar (1988); Akter (2012). Sugar acid ratio was significantly increased during 77 to 119 DAFS between two varieties (Figure 7). At the initial stage, this ratio was zero (0) in two varieties later on it increased gradually with time until the final maturity. The maximum sugar acid ratio (70.33) was recorded in BAU Sapota 3 and the minimum (62.23) in BAU Sapota 1 at 119 DAFS.

However, physico-chemical properties of sapota fruits of both the varieties changed differently during growth and development of fruits. Some of the parameters reached in peak at 119 DAFS while others at 105 DAFS. Since both the physical and chemical properties of fruits are the major indicators for considering better quality fruits therefore, it can summarized that BAU sapota varieties would be ready to harvest after 119 days after fruit set which could maintain high nutritional quality and reduced postharvest losses.

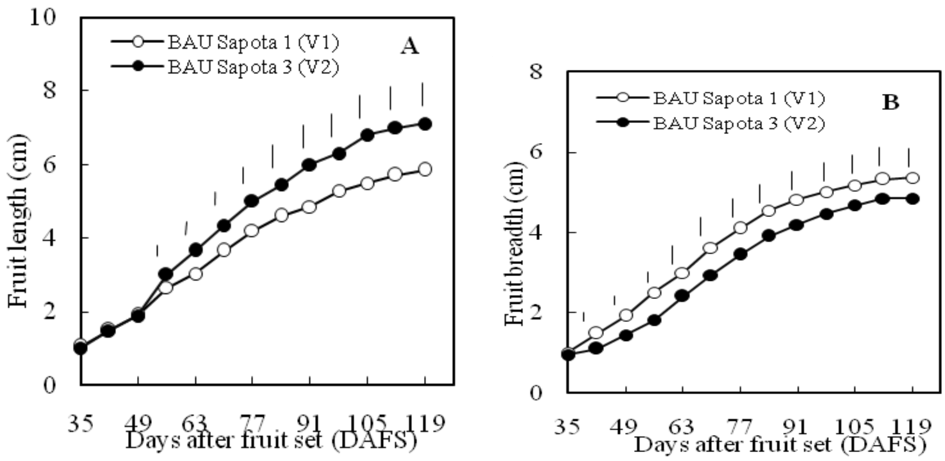

Figure 1. Length (A) and breadth (B) of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

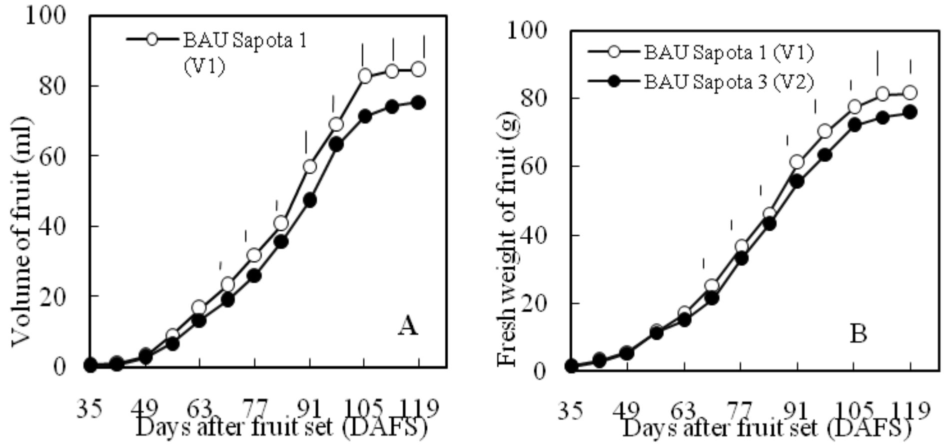

Figure 2. Volume (A) and fresh weight (B) of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

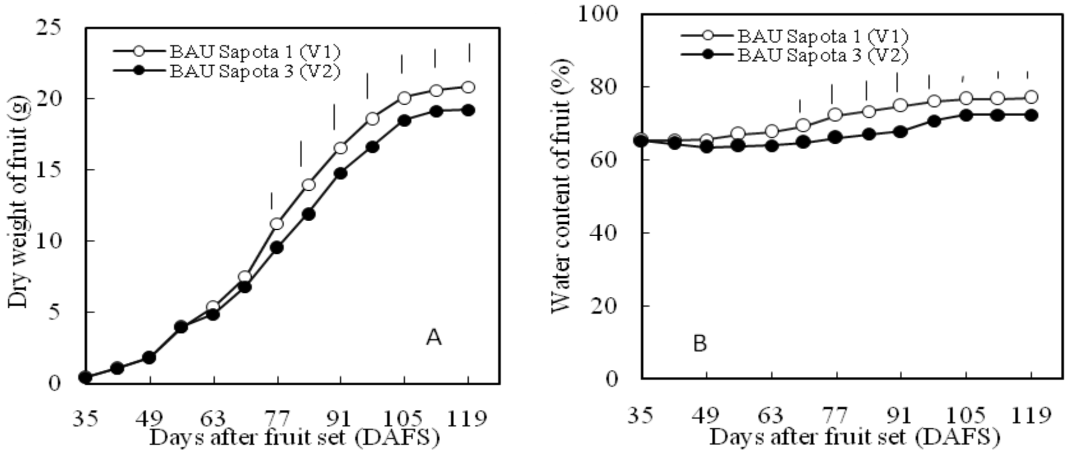

Figure 3. Dry weight (A) and % water content (B) of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

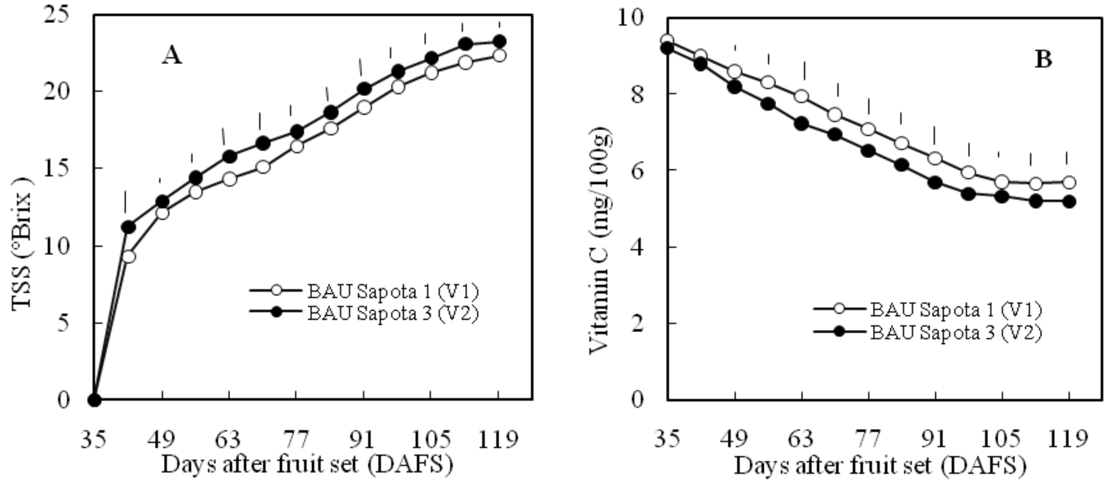

Figure 4. Total soluble solids (A) and vitamin C (B) contents of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

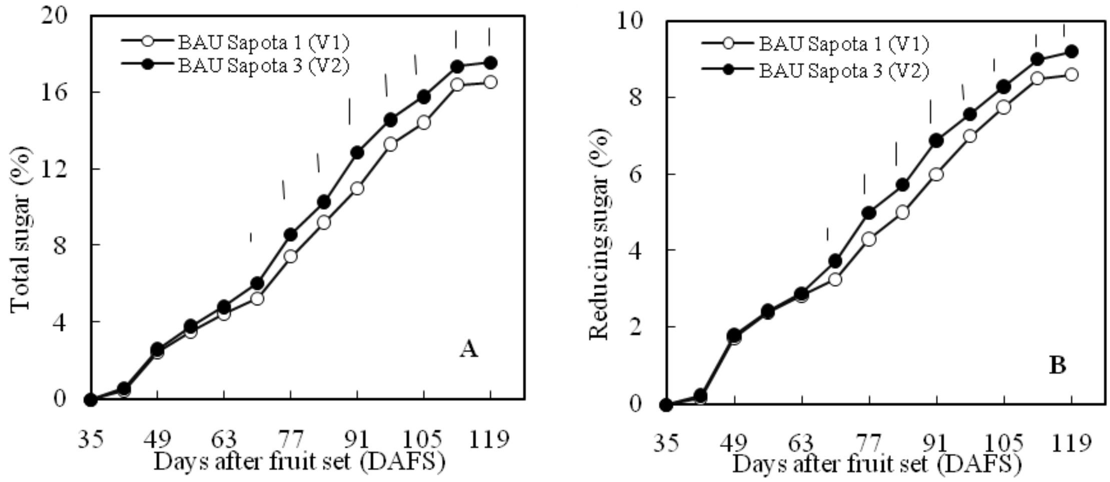

Figure 5. Total sugar (A) and reducing sugar (B) contents of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

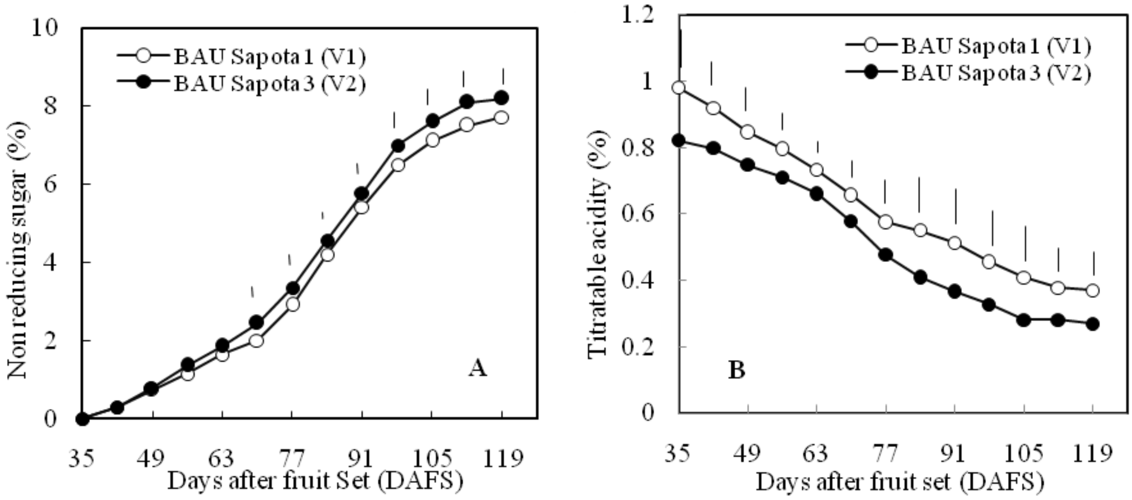

Figure 6. Non reducing sugar (A) and % titratable acid contents (B) of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

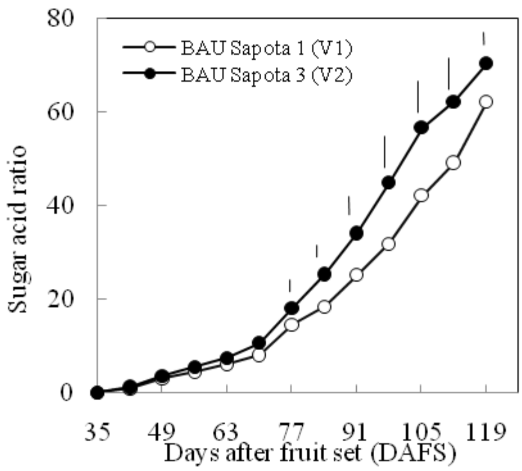

Figure 7. Sugar acid ratio of two varieties of sapota fruits at different days after fruit set (DAFS). Vertical bars indicate 1% level of significance.

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