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PHYSICOCHEMICAL CHANGES DURING RIPENING OF RED BANANA

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Abstract: The physicochemical changes occur during artificial ripening of Red banana variety using ethylene was studied for nine days of storage in a ripening chamber at a storage temperature and relative humidity of 22 °C and 85-88% respectively. It was observed that moisture content of pulp increased gradually during the storage time along with gradual increase in TSS till the end of storage period. Steep depletion in firmness was positively correlated with the reduction in peel thickness. Pulp to peel ratio and specific gravity was increased steadily with decreasing fruit weight. Titrable acidity was increased gradually from unripen to ripen stage and then decreased suddenly with over ripening or spoilage. A significant change in color was observed in terms of lightness and redness of banana. The prominent maturity indices in Red banana variety are weight, TSS and firmness.
Keywords: Red banana, ripening, physicochemical changes, storage time.

INTRODUCTION

The Red banana (*Musa acuminata*) is one of the important variety among different banana varietieswith reddish-purple skin grown in few countries like Australia, Central America Brazil etc. In India, it is normally found in Kerala and some parts of Tamilnadu. They are smaller and plumper than the common Cavendish banana. When ripe, raw red bananas have a flesh that is cream to light pink in color. During ripening the physiological stage and compositional changes of harvested banana varies for each individual variety and may depend on the factors such as climate, cultivation practices, post-harvest handling, storage condition etc. Moreover, the stage of ripeness of fruit after harvest is an important aspect in determining its suitability for processing and development of better products. Physicochemical changes during ripening of Monthan variety of banana was well studied (Patil *et al.,* 2015). Investigation is done to understand the textural changes of banana and plantain pulp during ripening (Kajuna *et al.,* 1995). Physicochemical properties of some local banana cultivars also studied (Perera *et al.,* 1999). The effect of storage temperature on properties of banana fruit is investigated (Ahmad *et al.,* 2001). Investigation on effect of storage humidity, temperature and fruit length on characteristics of banana fruit were done

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(Ahmad *et a.,* 2006). The changes in color and texture of banana during storage at 10°C and 20°C also reported in literature (Salvador *et al.,* 2007). However, literature scan reveals that, none of the researcher investigated the physicochemical changes during ripening of Red banana. Therefore, the intention of this work is to investigate the physicochemical changes during ripening of Red banana (AAA) variety using ethylene in order to ascertain maturity indices and suitable stage for the transportation, consumption and processing of bananas.

MATERIAL AND METHODS

Fruit materials

The Red banana was procured from the local farmer of Thanjavur district, Tamilnadu. The banana fruits have been stored at 25 °C temperature when transferred and stored in the ripening chamber of IICPT. The experiment was carried out in ripening chamber with fruits kept at humidity level of 85–88% and 22 °C temperature for 9 days, the time needed for completing the ripening treatment of fruits from a stage of fully unripen to fully ripened. Ethylene gas with 100 ppm concentration was treated about 24 h on first day and subsequently the experiments were conducted.

Chemical analysis

The pulp moisture content was analyzed from the unripen stage to the fully ripened stage using standard method (A.O.A.C, 1996). Pulp moisture content was determined by making each of slices of 3-4 mm thick placed in moisture boxes in drying oven. Drying was done in tray dryer (Ms. Everflow, Chennai), for 24 hours at 100°C. Total soluble solids content was determined by using lab level refractometer (ATAGO, RX7000α, Japan), ideally both the instrument and fruit pulp were maintained at the same temperature (22°C). A scoop of banana pulp from the apical, middle and basal part of fruit placed on a muslin cloth separately, and a drop of it squeezed out onto the refractometer. In case of unripe banana, juice was extracted by squeezing pulp in muslin cloth, three-four drops of squeezing banana set on the sensing screen of refractometer. Titrable acidity in each day of storage was determined in the basis of % malic acid present in red banana (A.O.A.C, 1996).

Physical analysis

Weight loss was determined by weighing the bananas every day. The specific gravity was determined by using platform scale method (A.O.A.C, 1996). The weight of individual bananais taken in air and water by using lab level weight balance (PHOENIX, India), having 0.001 precision. Precaution was to ensure that fruit was fully immersed in water without touching beaker. The specific gravity was calculated using the following equation.

$$\text{Specific gravity} = \frac{\text{Sample weight in air} \times \text{Density of water}}{\text{Weigt of displaced water}}$$

Pulp to peel ratio were determined by dividing the weight of pulp to peel. The sharp edge knife was used to peel the unripe bananas. The peel thickness was determined by cutting the fruits at four places across the length, and thickness measured by using digital thickness caliper having a least count of 0.01mm. Color of banana peel was determined using Hunter Lab Colorimeter (CFEX-0925, USA) during each day of ripening.

Textural analysis

Firmness was determined by using a texture analyzer (TA-HD plus TPA). The working conditions during the measurements were; mode-measure force in compression, pre-test speed 1.5 mm/s, test speed 1.0 mm/s, post-test speed 10mm/s trigger type-auto 5 kg, the data acquisition rate and accessory was 2 mm cylinder probe (P/2) and heavy duty platform (HDP/90). During experiment fruit kept at its most stable position on a heavy duty platform of texture analyzer, readings taken at apical, middle and basal part of fruit and recorded in gram unit. The mean of the three readings calculated as a measure of firmness for each fruit. The samples were selected randomly from the same bunch every day. The data is expressed as means±standard deviation.

RESULTS AND DISCUSSIONS

Moisture content

Moisture content of pulp was continued to increase during ripening (Fig. 1). It reveals that within fruit, moisture have been migrated from peel to pulp. Mohapatra *et al.* (2010) reported that there was increase in moisture content of pulp occurred due to increase in sugar content in the pulp as a result of starch hydrolysis to sugar. The correlation between moisture content and TSS is 0.91. Therefore, it can be inferred that amount of moisture content has a significant influence on the TSS content.

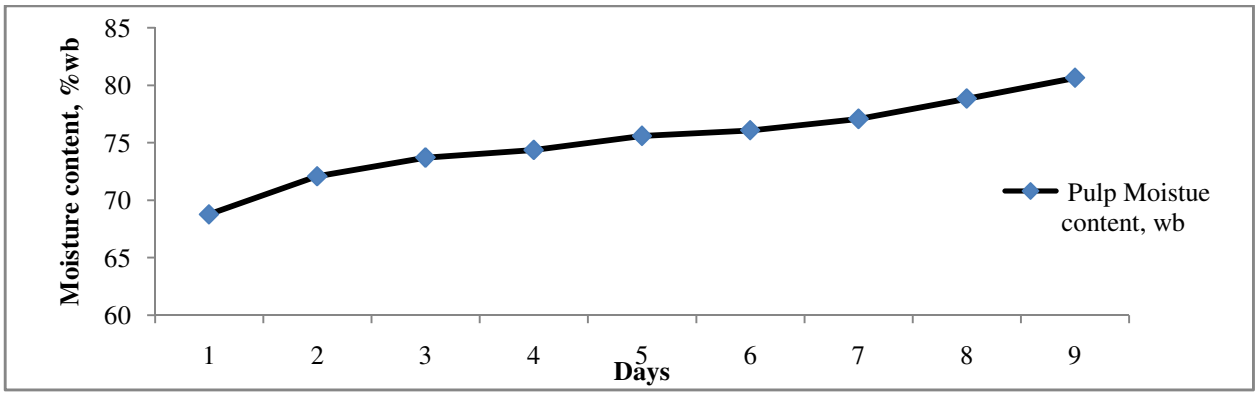

Fig. 1- Changes in pulp moisture content with ripening days of Red banana

Total soluble solids

In most ripen fruits including banana, incidence of post-harvest causes sugar formation as a result of starch hydrolysis. In this study the increase in TSS was 5 to 23.41 during nine days of ripening (Fig. 2). The magnitude of increase of total soluble solids in banana is dependent on cultivar or hybrid (Hibler and Hardey, 1994). Similar trend of TSS during banana ripening is reported in literature (Saalvador *et al.,* 2007). The correlation between TSS and storage days was found to be 0.96.

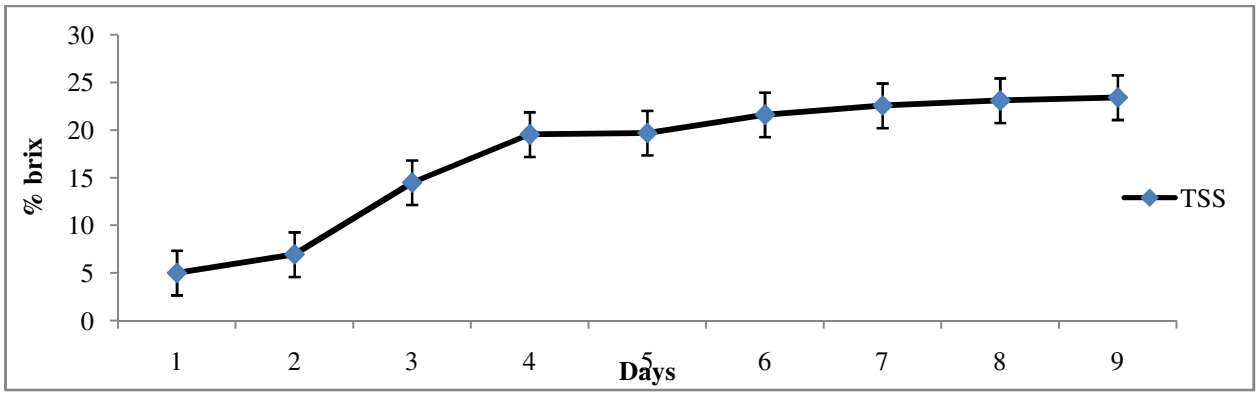

Fig. 2- Changes in TSS with ripening days of Red banana (Vertical bar shows standard deviation)

Pulp to peel ratio

Pulp to peel ratio was elevated with consequent increase in ripening and it was found 2.60 at the end of ripening (Fig. 3). Increasing pulp to peel ratio of banana is related to accumulation of moisture in the pulp derived from carbohydrate breakdown and osmotic transfer from peel to pulp (Palmer, 1991). Correlation between pulp to peel ratio and pulp moisture content was 0.87. Increasing the sugar content in the pulp could allow the water to move from the peel to the pulp, hence pulp to peel ratio was increasing with increase in TSS and moisture content. Rise in pulp to peel ratio during fruit ripening suggested due to changes in sugar concentration in the two tissues. A rapid increase in sugar contents in the pulp than those in the peel leads to changes in osmotic pressure because of which water is withdrawn from the peel and hence pulp to peel ratio increases accordingly. The correlation between pulp to peel ratio and TSS is 0.84.

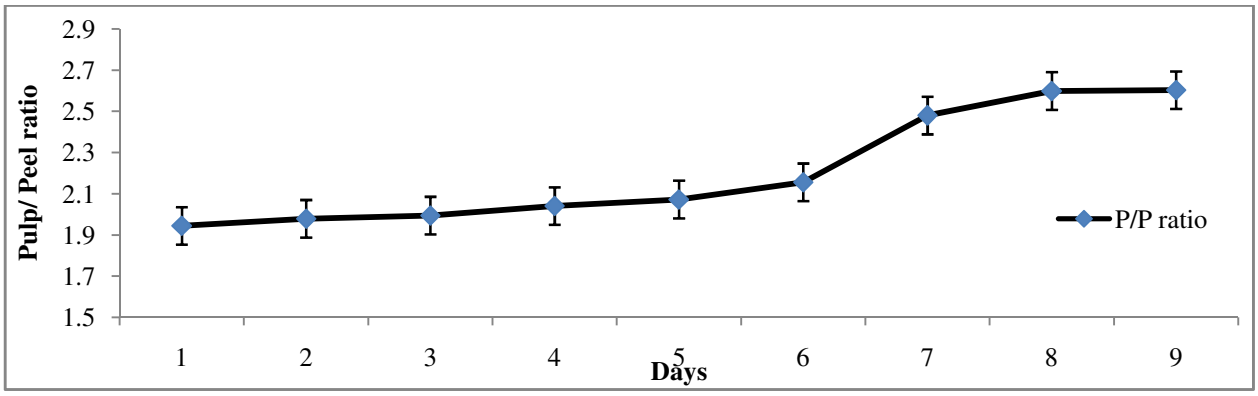

Fig. 3- Changes in pulp to peel ratio with ripening days of Red banana (Vertical bar shows standard deviation)

Peel thickness

Banana fruit naturally wrapped up in thick skin, the peel not only protects fruit, but it plays a crucial role in compositional changes during ripening. In present study, significant decrease in peel thickness from 4.20±0.28 to 2.52±0.24 was observed during ripening (Fig. 4). This is due to the modification of cell wall of peel which may affect firmness loss and ultimately lead in vanishing void space and hence reduction in peel thickness. Parker and Maalekuu (2013) observed that, peel thickness and the cell layer number decreased continuously when banana ripening was initiated. Results of moisture content of pulp suggest that the moisture is getting migrated from peel to pulp and causes diminution of peel thickness. A little variation in peel thickness in early storage period was observed due to negligible swelling in the peel. This might be due to the absorption of moisture of peel from surrounding. The correlation between pulp moisture content and peel thickness was found to be 0.93.

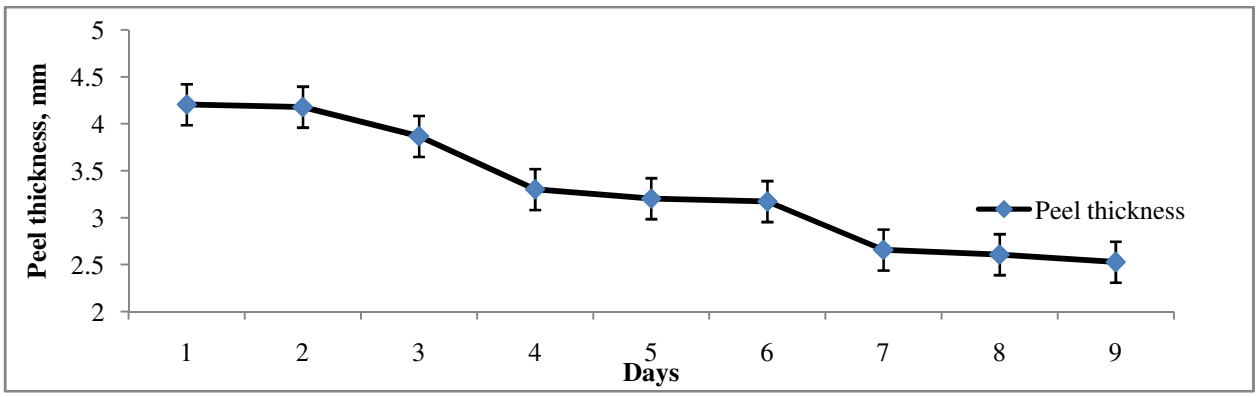

Fig. 4- Changes in peel thickness with ripening days of Red banana (Vertical bar shows standard deviation)

Firmness

The rapid loss in firmness of banana observed after third day of storage (Fig. 5). In the beginning the fruit shown good resistant over penetration of texture analyzer probe, which was reduced with ripening. Rapid changes in biochemical and other properties such as peel

thickness, TSS and moisture content are the main cause of alteration in textural properties of peel in banana. The correlation between peel thickness and firmness was found to be 0.95. Degradation of nutrients and increased in moisture content of pulp can cause the strength reduction of peel fiber and may result in the flushness of pulp, which ultimately reduces the firmness quality of fruit (Harker, 1997).

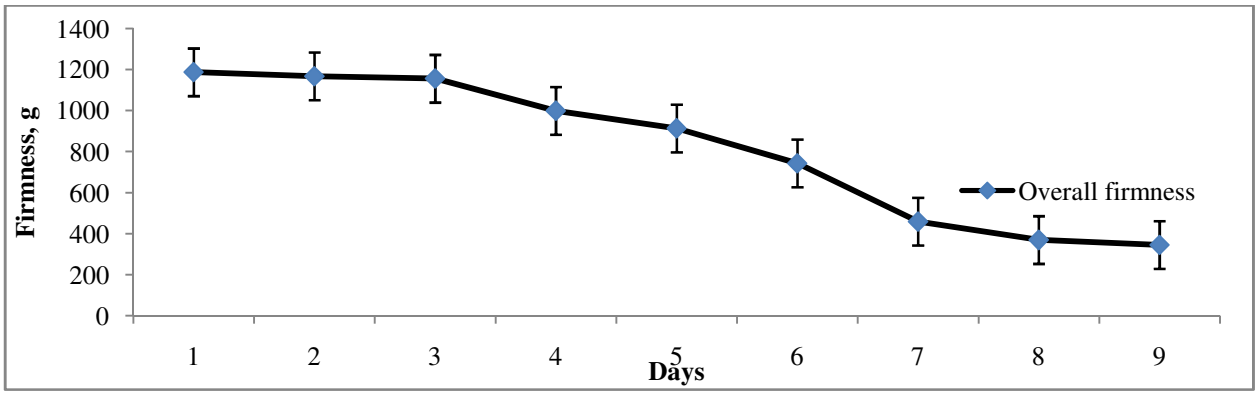

Fig. 5- Changes in firmness with ripening days of Red banana (Vertical bar shows standard deviation)

Weight

Difference in vapor pressure causes osmotic withdrawal of fruit moisture and hence weight reduction after harvesting. Water loss after harvesting causes fruit mass reduction and may also induce senescence. The weight loss was found to be 22.77% in this study. Several factors responsible for this phenomena including peel morphology, post-harvest treatment, atmospheric condition etc. As decrease in peel thickness with passage of ripening period accelerates the weight loss of fruit. The correlation between peel thickness and moisture content was found 0.93.

Titrable acidity

In banana flesh, the total amount of acid increases during ripening; the main acids being: malic, citric and oxalic acid. While the first two acids are responsible for tartness in the unripe banana, oxalic acid is contributed to astringent taste of the fruit (Seymour, 1993). As the fruit ripened, these acids were reduced and, the taste changed to a sweet taste, mainly from the hydrolyzed sugar from the starch degradation. The titrable acidityis increased from 0.093 to a peak of 0.22 up to seventh day coincided with the peak of ethylene accumulation and started to decline onwards during over ripening or spoilage (Fig. 6).

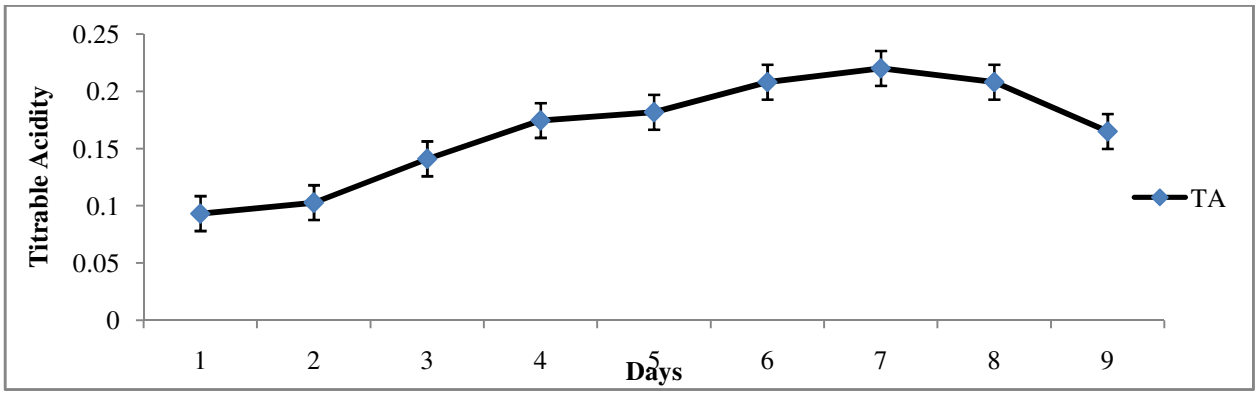

Fig. 6- Changes in titrable acidity with ripening days of Red banana (Vertical bar shows standard deviation)

Color

The color of red banana changes significantly with increase in ripening days. The lightness (L^*) value increases gradually from first day to sixth day i.e. the stage of fully ripening and afterwards decreases due to over ripening. Similar results were found out in redness (a^*)and blueness (b^*) of banana. Redness of peel increases continuously up to sixth day and then decreases gradually due to over ripening (Fig. 7).

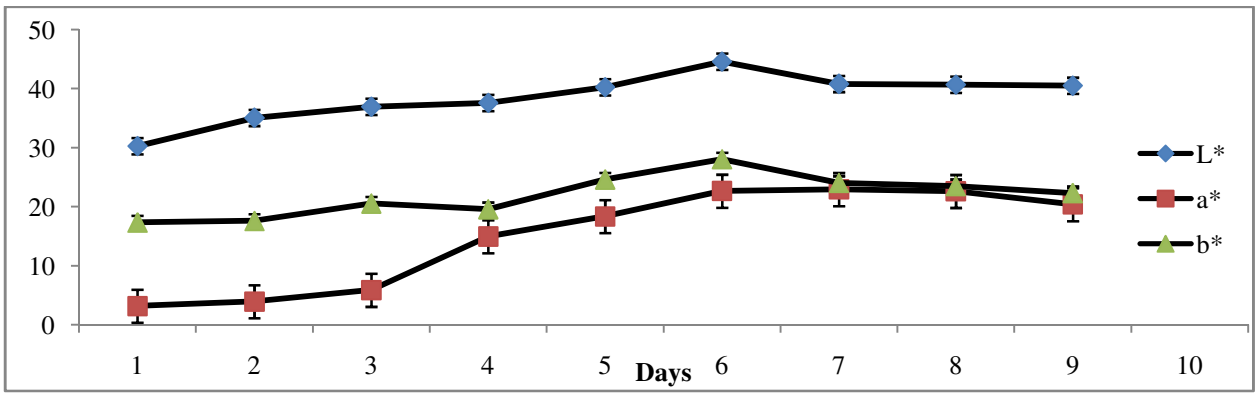

Fig. 7- Changes in color with ripening days of Red banana (Vertical bar shows standard deviation)

CONCLUSIONS

The extracted data shows significant differences in physical and chemical properties of red banana on a daily basis with passage of storage time. It was observed that moisture content of pulp increased gradually during the storage time along with gradual increase in TSS during ripening. Steep depletion in firmness was positively correlated with the reduction in peel thickness. Pulp to peel ratio and specific gravity was increased steadily with decreasing fruit weight. Titrable acidity was increased gradually from unripen to ripen stage and then decreased suddenly with over ripening. A significant change in color was observed in terms of lightness and redness of banana. The prominent maturity indices in red banana variety are weight, TSS, texture and color. The physicochemical characteristics evaluated in this study

can be important postharvest quality criteria for the processing, screening and consumption of red banana.

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