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Physiochemical changes during different stages of fruit ripening of climacteric fruit of mango (*Mangifera indica* L.) and non-climacteric of fruit cashew apple (*Anacardium occidentale* L.)

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Abstract

The present investigation was made to study the ripening behavior of climacteric fruit of mango (*Mangifera indica* L.) and a non–climacteric fruit of cashew apple (*Anacardium occidentale* L.) The different stages of fruit namely immature, mature, quarter ripen, half ripen, full ripen and over ripen were used for various analyses with pericarp tissues of mango and cashew apple fruits. Physio–Chemical parameters such as fruit firmness, total soluble solids, titratable acidity and pH. The fruit firmness and titratable acidity high at immature stage and low in over ripen stage. On the other hand, Total Soluble Solids and P^H low at immature stage and high in over ripen stage.

Key words: Fruit ripening, Fruit firmness, Titratable acidity and pH

Introduction

Fruit ripening is a complex, genetically programmed process that culminates in dramatic changes in colour, texture, flavour and aroma of fruits. Based on their respiratory pattern, fruits can be divided into two groups: climacteric, in which ripening is accompanied by a peak in respiration and concomitant burst of ethylene, and non-climacteric in which there is no change in respiration, and ethylene production remains at a very low level (Alexander and Grierson,2002).

Fruits can be divided into two groups according to the regulatory mechanisms underlying the ripening process. Climacteric fruit, such as tomato, apple, pear, and melon are characterized by a ripening-associated increase in respiration and in ethylene production. By contrast, non-climacteric fruits, such as orange, grape and pineapple are characterized by the lack of ethylene-associated respiratory peak. At the onset of ripening climacteric fruit present a peak in respiration, and a concomitant burst of ethylene production. The relationship existing between the climacteric respiration and fruit ripening has been questioned following the discovery that ripening on the number of fruit may occur in the absence of any increase in respiration (Salveit 1993; Shellie and Salveit 1993).

Fruits are harvested at complete maturity. They are self–sufficient with their own catalytic machinery to maintain an independent life, even when detached from the parent plant. Based on their respiratory pattern and ethylene biosynthesis during ripening, harvested fruits can be further classified as climacteric and non- climacteric types. Climacteric fruits, harvested at full maturity can be ripened the parent plant. The respiration rate and ethylene formation though minimal at maturity rise dramatically to a climacteric peak, at the onset of ripening, after which it declines (Gamage and Rehman, 1999).

Non –climacteric fruits are not capable of continuing their ripening process, once they are detached from the parent plant. Also, these fruits produce a very small quantity of endogenous

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ethylene, and do not respond to external ethylene treatment, Non climacteric fuits show comparatively low profile and a gradual decline in their respiration pattern and ethylene production throughout the ripening process (Gamage and Rehman, 1999). Ripening is the process by which fruits attain their desirable flavour, quality, colour, palatable nature and other texture and other textural properties ripening is associated with change in composition i,e. conversion of starch to sugar.

Mango (*Mangifera indica* L.) is a "National fruit of India" because of its delicious taste, excellent flavor, aroma, attractive colour, vitamin A and C. India contributes 12% of total fruit production of the world. Out of these, India contributes 39.5% share of mango in world production (Anonymous, 2008). Moreover mango fruit are usually harvested at the hard green stage (unripe) when they are physiologically mature but before the onset of the climacteric rise (Lakshminarayana *et al*., 1970). Cashew apple is a non-climacteric fruit found in three colors yellow, orange and red with the same pale yellow pulp, weighs about 75–80 g (Maciel, 1986).

All biochemical and physiological changes during fruit ripening are driven by the coordinated expression of fruit ripening-related genes. These genes encode enzymes that participate directly in biochemical and physiological processes (Bouzayen *et al.,* 2010).

Fruit size, Titratable acidity and Total soluble solids (TSS) content depend on type, environment and cultivation conditions (Kingston, 1992). Changes in TSS are quite important for fruit taste development. In most fruits, ripening and fruit quality are determined by sugar content (Villanueva *et al*., 2004).

In mango during ripening, some physio-chemical changes may occur and which result softening of the fruit, change in colour and flavor of the fruit, increase in sugar content, reduction in organic acids and formation of pigments, especially carotenoids (Ulrich,1970). The changes in physio–chemical characteristic features during ripening was studied in detail by earlier researchers (Khan *et al*., 2008; Rodrigo *et al*., 2009; Ali *et al.,* 2011; Venkatesan and Tamilmani, 2013).

Material and Methods

The detached climacteric fruit (*mangifera indica* L.) and a non-climacteric fruit (*anacardium occidentale* L.) belong to the family Anacardaceace were selected for the present ripening study. The Mango and Cashew apple fruits were collected from Ramapuram Village at Cuddalore District, Tamil nadu. The fruits were kept at temperature of 28±2ºC with relative humidity of 85 per cent in the laboratory of Botany Department, Annamalai University. The different stages of fruits namely immature, mature, quarter ripen, hailf ripen, full ripen, over ripen fruits were used for analyses the studies in Mango and Cashew apple fruits. All the experiments were conducted with seven replicates. The peri carp tissue were used to study the ripening process. Fruit firmness was determined by using screw gauge, by hand force. Total soluble solids in the fruits were determined by using a refractometer P20 model RL2 and their concentration was designated in Brix degree at 33°C. The fruit juice was obtained from 100 g of the fruit. The total titratable acidity was determined by diluting the juice with 25 ml of deionized water, and titrating to pH 8.1 with 0.1 M sodium hydroxide. Results were expressed in citric acid equivalent in 100 g of fresh weight. 100 g of pericarp tissue was ground with mortar and pestle. Fruit juice was diluted with 25 ml of deionized water and the pH was measured by (Ranganna, 1977).

Results and Discussion

Mango *(Mangifera indica)* is a climacteric fruit .cashew apple (*Anacardium occidentale)* is a non-climacteric fruit. The climacteric and non–climacteric fruits considerably differ in their ripening process. The different stages of fruits were used for analyses namely immature, Mature, quarter ripen, Half ripen, full ripen and over ripened fruit. Physio-chemical analysis were made with the following parameters Fruit firmness, Total Soluble solid, Titratable acidity and pH. The results were made the following obtained during different stages of fruit ripening.

Table-1 showed that the fruit firmness gradually decreased during ripening process both in mango and cashew apple fruits. The highest fruit firmness was observed in immature stage and lowest was found to be over repined stage in both fruits. The decreases of fruit firmness were faster in cashew apple when compared to mango. Ali *et al.,*(2011) studied decreasing fruit firmness might be associated with fruit softening which in coincide with the report. Moreover, cell wall breakdown caused by the conversion of insoluble pectin into soluble forms is also a factor for loss of firmness (Verlent *et al*., 2005; Nikolic and Mojovic, 2007).

Table-2 showed that the total soluble solids gradually increased during ripening process both in mango and cashew apple fruits. Very lowest values observed in immature stage and highest values over ripened stage both fruits. The increased total soluble solids activity same in both fruits. In the studies carried out with different fruit types, increase in TSS was reported during fruit ripening period (Wu *et al*., 2005; Karlidag and Bolat, 2007; Prinsi *et al*., 2011). Jiménez *et al*., (2011) stated that TSS in gulupa (*Passiflora edulis*) fruits increased from 13.5 to 17.4% during ripening progress. Tandon and Kalra, (1986) and Khan *et al*., (2008) showed that the cherimoya fruits, during its ripening, there was a considerable loss in fruit firmness leads to an increase in total soluble solid. Studied the physical and mechanical properties of mango during growth and storage to assess the stage of maturity. In some varieties of mango fruits traded commercially for consumption as ripe fruits all were harvested green and ripened after harvest. If picked immature, however, fruits develop white patches or air patches and show lower amounts of brix or total soluble solids (TSS) to acid ratio, taste and flavor, whereas over-mature fruits lose their storage life.

Table-3 showed that the Titratable acidity gradually decreased during ripening process both in mango and cashew apple fruits. The decreasing Titratable acidity of mango and cashew apple high at immature stage and low at over ripened stage. The rate of decreases of acidity was more in mango than cashew apple. Woodward, (1972) and Moing *et al*., (2001) were reported titratable acidity increased during development, but was less in ripe fruits. Acidity was inversely correlated to pH. The ripe sample which had a low acid content had a correspondingly high pH. Evolution of titratable acids and the pH of blackberry recorded above agree with published data on strawberries. Organic acids usually decline during ripening as they are respired or converted to sugars. Moreover increased pH attributed to more palatable fruit with less acidity when pineapple fruit reaching advanced stage of ripening. Nunes *et al*., (2009) reported that the acid content in fruits of guava (*Psidium guajava*) and plum (*Prunus domestica*) initially increased significantly and then decreased during ripening period. In addition to that titratable acidity is responsible for the distinct sour taste and flavor of most fruits (Yamaki, 1989) and is often regarded as a reliable indicator to evaluate the overall quality of fruits (Bhat *et al.*, 2011).

The table-4 showed that the pH gradually increased during ripening process both in mango and cashew apple fruits. The mango and cashew apple shows low at immature high in over ripen stage in both fruit. The level increasing pH the comparative was high in cashew apple than mango. The mango pH value (from 3.3 to 7.9) and cashew apple pH value (from 4.4 to 8.8). As compared to untreated controls during ripening this is closely associated with the report of (Ranganna, 1977). Moreover Titratable acidity of fruits decreases during different ripening periods, their pH and TSS increase (Jiménez *et al*., 2011). In addition to that All the sample juices showed a slight increase in pH, while the TA levels decreased as the fruits matured. Generally higher values of TA in a typical fruit are negatively linked with the flavor and

Table 1. Fruit firmness Changes during different stages of fruit ripening of climacteric fruit of Mango (*Mangifera indica* L.) and non-climacteric fruit of Cashew apple (*Anacardium occidentale* L.)

Stage	Mango	Stage	Cashew Apple
	Mean ± SE		Mean ± SE
Immature (M_1)	43.8 ± 2.19	Immature (C_1)	11.0 ± 0.55
Mature (M_2)	34.4 ± 2.06	Mature (C_2)	9.4 ± 0.56
Quarter Ripen (M_3)	28.4 ± 1.98	Quarter Ripen (C_3)	7.2 ± 0.50
Half Ripen (M_4)	22.4 ± 1.12	Half Ripen (C_4)	6.2 ± 0.31
Full Ripen (M_5)	18.5 ± 1.11	Full Ripen (C_5)	5.5 + 0.33
Over Ripened (M_6)	14.8 ± 1.03	Over Ripened (C_6)	4.5 ± 1.71

(Values are Mean ± SE of 7 samples expressed in kg cm$^{2)}$

Table 2. Total Soluble Solid Changes during different stages of fruit ripening of climacteric fruit of Mango (*Mangifera indica* L.) and non-climacteric fruit of Cashew apple (*Anacardium occidentale* L.)

Stage	Mango	Stage	Cashew Apple
	Mean ± SE		Mean ± SE
Immature (M_1)	9.2 ± 0.46	Immature (C_1)	11.3 ± 0.56
Mature (M_2)	11.2 ± 0.67	Mature (C_2)	12.3 ± 0.73
Quarter Ripen (M_3)	13.3 ± 0.93	Quarter Ripen (C_3)	15.0 ± 1.05
Half Ripen (M_4)	15.1 ± 0.75	Half Ripen (C_4)	17.8 ± 0.89
Full Ripen (M_5)	19.1 ± 0.95	Full Ripen (C_5)	20.2 + 1.21
Over Ripened (M_6)	24.9 ± 1.74	Over Ripened (C_6)	24.1 ± 0.28

(Values are Mean ± SE of 7 samples expressed in ± of Brix)

Table 3. Titratable acidity Changes during different stages of fruit ripening of climacteric fruit of Mango (*Mangifera indica* L.) and non-climacteric fruit of Cashew apple (*Anacardium occidentale* L.)

Stage	Mango	Stage	Cashew Apple
	Mean ± SE		Mean ± SE
Immature (M_1)	26 ± 1.30	Immature (C_1)	45 ± 2.25
Mature (M_2)	24 ± 1.44	Mature (C_2)	36 ± 2.16
Quarter Ripen (M_3)	17 ± 1.19	Quarter Ripen (C_3)	34 ± 2.38
Half Ripen (M_4)	16 ± 0.80	Half Ripen (C_4)	28 ± 1.40
Full Ripen (M_5)	14 ± 0.84	Full Ripen (C_5)	26 + 1.56
Over Ripened (M_6)	10 ± 0.70	Over Ripened (C_6)	20 ± 1.40

(Values are Mean ± SE of 7 samples expressed in percentage basis)

Table 4. pH Changes during different stages of fruit ripening of climacteric fruit of Mango (*Mangifera indica* L.) and non-climacteric fruit of Cashew apple (*Anacardium occidentale* L.)

Stage	Mango	Stage	Cashew Apple
	Mean ± SE		Mean ± SE
Immature (M_1)	3.3 ± 0.16	Immature (C_1)	4.4 ± 0.22
Mature (M_2)	3.9 ± 0.23	Mature (C_2)	5.3 ± 0.31
Quarter Ripen (M_3)	4.8 ± 0.33	Quarter Ripen (C_3)	5.9 ± 0.41
Half Ripen (M_4)	5.9 ± 0.29	Half Ripen (C_4)	7.0 ± 0.35
Full Ripen (M_5)	6.8 ± 0.40	Full Ripen (C_5)	8.0 + 0.48
Over Ripened (M_6)	7.9 ± 0.55	Over Ripened (C_6)	8.8 ± 0.61

(Values are Mean ± SE of 7 samples expressed in percentage basis)

consumer acceptance (Chitarra, and Chitarra, 2005). Similarly, the pH of the fruit was observed as in cashew apple (Soares *et al*., 2007). In addition to that Modi and Reddy (1967) were observed the physio-chemical changes such as fruit firmness, titratable acidity and pH during the storage and ripening of papaya fruit. Though no change was occured in titratable acidity where the pH was slightly increased

Conclusion

Among the physiochemical changes during different stages of fruit ripening of mango and cashew apple in the fruit firmness, titratable acidity high at immature stage and low in over ripen stage. In addition to that Total Soluble Solid, pH low at immature stage and high in over ripen stage.

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