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Effect of Maturity Stages and Ripening Process on the Colour (L*, a* and b*) Values and Physico-chemical Composition of Mango (*Mangifera indica* L.) *var.* Manjeera

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ABSTRACT

Background: Mangoes are a tremendous source of nutrients that are vital for human nutrition and health. The concentrations of these nutrients vary across different kinds according to the environmental factors, ripening processes and maturity stages. Hence, the study was undertaken to study the influence of maturity stages, ripening process and days of storage on the colour values and physicochemical properties of Manjeera variety of mango.

Methods: Mangoes that were gathered and processed at the FRS, SKLTSHU, Sangareddy. The mangoes' physico-chemical examination and colour value were performed. Mangoes were collected at two maturity stages- 7-9Úbrix and 9-11Úbrix and processed using three different methods, control, 100 ppm ethylene treatment and 150 ppm ethylene treatment, before being stored for 12 days. At the fourth, eighth and twelfth days of storage, samples were taken for further evaluation.

Result: The colour L*, a*, b* values gradually increased from day 4 to day 12 in all the treatments with the exception of L* value for 100 ppm ethylene treated mangoes harvested at 7-9°brix TSS and 9-11°brix TSS. It was found that acidity in all treatments reduced as ripening progressed. With the exception of control samples at 9-11°brix TSS, all 8th day samples for all treatments in the 7-9°brix and 9-11°brix TSS were found to have a high sugar: acid ratio. TSS, a measure of mango sweetness, was found to be highest on the eighth day in 150 ppm treated mangoes with 7-9°brix TSS, followed by 12 ppm ethylene-treated mangoes with 7-9°brix and 9-11°brix TSS and control mangoes with 9-11°brix TSS. Physical and chemical characteristics revealed that mangoes collected at 7-9°brix TSS have high TSS, total sugar and sugar: acid ratios in both 100 ppm and 150 ppm ethylene-treated mangoes.

Key words: Manjeera, Maturity stage, Physico-chemical, Ripening.

INTRODUCTION

One of the healthiest tropical fruits is the mango (*Mangifera indica* L.), which is indigenous to southern Asia and particularly eastern India. Mango output worldwide in 2010 was predicted to be at 35 million tonnes, making up close to 50% of the total production of tropical fruits worldwide (FAOSTAT, 2012). Mangoes are a fantastic source of dietary fiber, which is crucial for human nutrition and health, as well as bioactive substances such provitamin A carotenoids, vitamin C and phenolics (Sogi *et al*., 2012). Mangoes have a reputation for having medical benefits in both their unripe and ripe states (Sarkiysyi *et al*., 2013).

Mango is considered a model "superfruit," a term used to highlight the potential health benefits of several edible fruits, due to its abundance in a range of phytochemicals and nutrients. The levels of key minerals such potassium, copper and 17 amino acids as well as vitamins B6 and K, as well as other B vitamins are found to be higher (Chauhan *et al*., 2006). Beta-carotene was found to be highest among 25 distinct carotenoids that are found in mango pulp (Chen *et al*., 2004).

Mango cultivar, growing conditions, maturation stage and storage all have an impact on the amount of nutrients the fruit contains (Lee and Kadar, 2000). Fruit ripening is a complicated process that alters the colour, flavour, aroma, texture and nutritional content of the flesh dramatically (Giovannoni, 2004). By assessing texture, brix and palatability (ratio of soluble dry extract/titratable acidity), one can evaluate the uniformity of ripening.

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MATERIALS AND METHODS

At the Fruit Research Station, SKLTSHU, Sangareddy, sixty mature, green, undamaged and healthy fruits of the Manjeera cultivar were harvested at two maturity stages (7-9°brix TSS and 9-11°brix TSS). The research study was conducted between January to June, 2016 at Department of Foods and Nutrition, Post Graduate and Research Centerand MFPI - Quality Control Laboratory, Professor Jayashankar Telangana State Agricultural University. Fruits for the experiment that were physically identical, physically blemish-free and largely uniform in size, shape and colour were hand plucked off the tree. After being harvested, the fruits were left to dry for an hour before having their skins cleaned with a cloth and being washed with sandovit (0.5 ml/litre), a mild neutral detergent. The fruits were subsequently taken for two ethylene treatment after being shade-dried. Fruits from each treatment were removed on day 4, day 8 and day 12 for study of colour and physicochemical composition, respectively (Fig 1, 2 and 3). A three factorial experimental design was planned for carrying out the study as follows (Table 1).

Colour (AOAC 1998)

Mango pulp's colour properties (L*, a* and b* values) were measured using a spectrocolorimeter with a 36 mm measuring aperture.

pH

Determination of was done by pH meter.

TSS

Using a refractometer total soluble solids were calculated (AOAC, 1980) and expressed as brix.

Titrable acidity (IS 13844: 2003)

Mango pulp solution (10 ml) was poured into a conical flask, then two to three drops of phenolphthalein indicator was added. As soon as a permanent pink tint formed, it was promptly filtrated with 0.1 N NaOH solutions from a burette. The formula below was used to compute the percent titrable acidity:

$$\% \text{ Titrable acidity} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 1000} \times 100$$

Sugar acid ratio (Joao, 2011)

The total soluble solids were divided by the total titrable acid at 20°C to get the Brix/acid ratio.

$$\text{Brix/acid ratio} = \frac{^{\circ}\text{Brix}}{(\% \text{ Acid, w/w})}$$

Total and reducing sugars (Nelson, 1944)

Total soluble sugars

Montgomery (1957) method was used to estimate the total soluble sugars. A known volume of sample aliquot was diluted to 1.0 ml in a test tube and then mixed with 0.1 ml of phenol that was 80% (w/v), then 5 ml of sulfuric acid was added.

Total reducing sugars

The Nelson-Somogyi method was used to estimate total reducing sugars using an aliquot from the extract created

Fig 1: Mangoes sample from 4th day of storage.

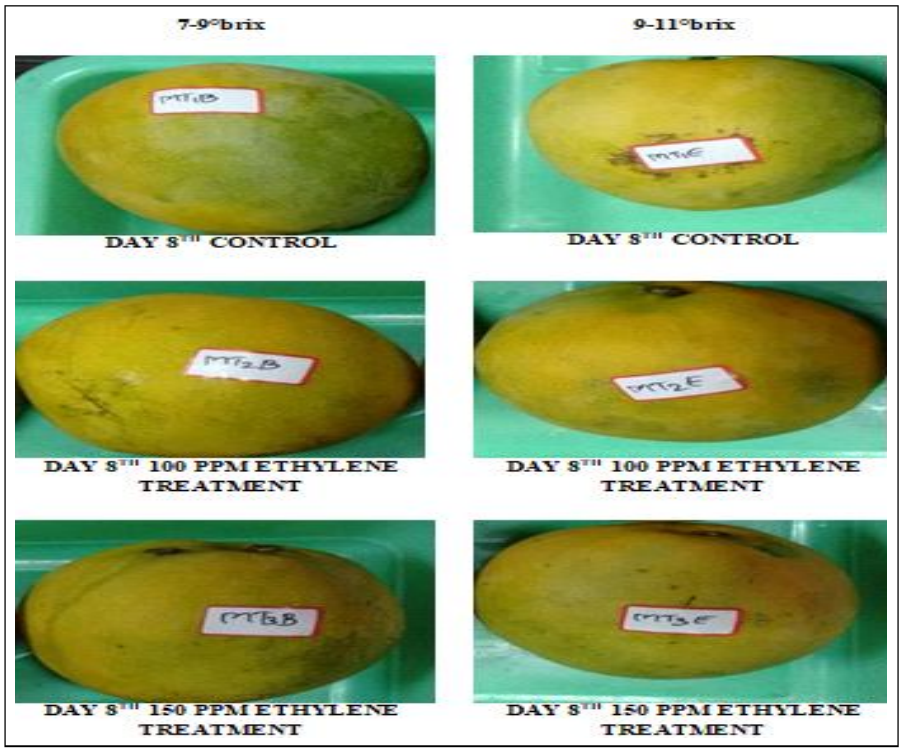

Fig 2: Mangoes sampale for 8th day of storage.

Fig 3: Mangoes sample from 12th day of storage.

for estimating total soluble sugar (Nelson, 1944., Somogyi, 1952).

Calculations

Total sugars =

$$X \times \frac{10}{0.2} \times \frac{50}{10} \times \frac{100}{1} \times \frac{1}{1000} = \text{mg/100 g sample}$$

Reducing sugars=

$$X \times \frac{50}{0.5} \times \frac{100}{1} \times \frac{1}{1000} = \text{mg/100 g sample}$$

RESULTS AND DISCUSSION

Results for colour

Table 2 contains the results of colour investigations as L*, a* and b*. All colour parameters increased as the raw mango's exterior colour changed from green to a reddish yellow during ripening. This resulted from the breakdown of chlorophyll, which made the yellow carotenoid pigments visible (Rathore *et al*., 2007). Mango L* values ranged from 52.16±0.09 to 64.16±0.00 when harvested at 7-9°brix TSS and from 50.86±0.16 to 65.93±0.08 when harvested at 9-11°brix TSS. The L* values increased gradually in all treatments from the fourth day to the twelve-day mark, demonstrating a reduction in the greenness and lighting of the fruit as it ripened.

According to the data in Table 2, there was an increase in the a* values for each maturity and ripening stage measured from the fourth to the twelveth day that was significant ($p<0.05$). From negative (blue) to positive (yellow), the b* values are displayed. The b* value significantly ($p<0.05$) increased for each maturity and ripening stage measured from the fourth to the twelve-day mark, showing an increase in fruit yellowness.

Due to the mango peel's yellow colour becoming more intense during storage, the L*, a* and b* values grew. On the 12th day, mangoes treated with 150 ppm ethylene showed the greatest colour alterations, which may have been caused by an accelerated loss of chlorophyll, which caused a transition from green to yellow tones.

Results for pH

Acidity and pH are negatively connected, with pH serving as an internal ripeness indicator (Vinson *et al*., 2010). According to the results (Table 3), all of the treatments saw a significant ($p<0.05$) rise in the acidity of the mangoes harvested at 7-9 brix and 9-11°brix from days 4 to 12, with the exception of the 150ppm ethylene-treated 9-11°brix TSS

Table 1: Three factorial experimental design of the study.

Maturity stage	7-9°brix			9-11°brix		
Days of storage	4	8	12	4	8	12
Ripening treatment						
Control	M T1A	M T1B	M T1C	M T1D	M T1E	M T1F
100 ppm Ethylene	M T2A	M T2B	M T2C	M T2D	M T2E	M T2F
150 ppm Ethylene	M T3A	M T3B	M T3C	M T3D	M T3E	M T3F

Table 2: Colour (L*, a* and b*) values for the mangoes (*Mangiferaindica L var Manjeera*)during 4th, 8th and 12th day of storage in all the treatments at 7-9°brix TSS and 9-11°brix TSS maturity stage.

Treatment/day of storage	Colour						Se Value
	Maturity stage						
	7-9°brix			9-11°brix			
	Control	100 ppm	150 ppm	Control	100 ppm	150 ppm	
Colour L							
4th day	52.39±0.20^{c}	55.34±0.13^{c}	52.16±0.09^{bc}	51.82±0.01^{a}	50.86±0.16^{a}	53.17±0.01^{d}	0.40
8th day	56.63±0.07^{f}	53.33±0.40^{d}	58.16±0.20^{g}	61.80±0.23^{i}	63.76±0.03^{j}	55.37±0.01^{e}	
12th day	60.46±0.04^{h}	64.16±0.00^{j}	63.35±0.08^{ef}	65.10±0.57^{k}	65.93±0.08^{l}	62.07±0.01^{i}	
Colour a*							
4th day	-8.43±0.00^{a}	-6.56±0.16^{c}	-5.88±0.11^{d}	-7.34±0.03^{b}	-5.36±0.06^{e}	-8.53±0.01^{a}	0.40
8th day	-5.20±0.24^{e}	-3.56±0.15^{g}	-3.43±0.58^{g}	-5.32±0.40^{e}	5.72±0.07^{h}	-4.43±0.04^{f}	
12th day	7.22±0.02^{i}	16.83±0.01^{j}	19.88±0.01^{m}	16.38±0.42^{j}	19.25±0.08^{l}	18.31±0.021^{k}	
Colour b*							
4th day	32.71±0.25^{b}	33.50±0.25^{bc}	33.70±0.04^{c}	32.88±0.01^{bc}	25.48±0.02^{a}	33.51±0.03^{bc}	0.98
8th day	41.89±0.78^{e}	53.99±1.21^{i}	46.15±0.76^{f}	51.72±0.49^{h}	51.80±0.00^{h}	40.84±0.12^{d}	
12th day	49.13±0.04^{g}	56.73±0.00^{k}	56.74±0.25^{k}	60.83±0.80^{l}	54.26±0.15^{i}	55.76±0.11^{j}	

Note: All the values are expressed as mean±SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level.

harvested mangoes, where pH fell significantly from days 8 to 12. When compared to control mangoes and 150ppm treated mangoes from day 4 to day 12, the increase in acidity content in mangoes harvested at 9-11°brix was considerably ($p<0.05$) higher in 100 ppm.

Loaiza *et al*. (2014) showed a similar rise in pH (reduction in acidity) during the ripening of mango fruits.

Results for titrable acidity

According to Clark *et al*. (2003) the rate of metabolism, particularly respiration, which consumes organic acid and causes acidity to drop during storage, has a substantial impact on changes in titrable acidity (TA).

According to the results, the titrable acidity of mangoes harvested at 7-9°brix TSS and 9-11 brix TSS in all treatments (Control, 100 ppm, 150 ppm) decreased significantly ($p<0.05$) from day 4 to day 8 and the titrable acidity increased significantly ($p<0.05$) from day 8 to day 12 with the exception of 9-11 brix TSS harvested control mangoes, where there was no increase in TA content from day 8 to day 12. According to Othman (2011), the loss of dominating citric acid during the ripening of pineapple led to a drop in the titrable acidity.

Results for TSS

According to Tehrani *et al*. (2011), TSS is a key indicator of fruit quality because it is connected with the texture and composition and includes the soluble sugars sucrose, glucose and fructose as well as acids (Kamiloglu, 2011). According to the results, the TSS content of mangoes in the 7-9°brix range increased significantly ($p<0.05$) in the control case whereas in the 100 ppm and 150 ppm treated mangoes, there was a significant increase ($p<0.05$) from the fourth to the eighth day, which decreased significantly ($p<0.05$) on the day 12. In mangoes harvested at 9-11°brix, the TSS content for 100 pm treated mangoes was found to be consistent over the course of storage, whereas for control mangoes and 100 ppm treated mangoes, there was a significant increase ($p<0.05$) in the TSS content According to Nadzirah *et al*. (2013), the TSS concentration of pineapple core extracts reduced during the ripening process and then dramatically rose ($p<0.05$). In contrast to Hossain *et al*.

Table 3: pH,titrable acidity,TSS (°Brix),Total Sugar (mg/100 g), Reducing Sugar (mg/100g) and Sugar: Acid Ratio fo the mangoes for the mangoes (*Mangifera indica L var Manjeera*) during 4th,8th and12th day of storage in all the treatments at 7-9° brix TSS and 9-11° brix TSS maturity stage.

Treatment/day of storage	Maturity stage						Se value
	7-9°brix			9-11°brix			
	Control	100ppm	150ppm	Control	100ppm	150ppm	
				pH			
4th day	3.24±0.01^{a}	3.61±0.00^{c}	4.06±0.12^{e}	4.05±0.06^{e}	3.80±0.00^{d}	3.46±0.01^{b}	0.09
8th day	4.85±0.09^{g}	5.47±0.00^{i}	5.14±0.06^{h}	4.80±0.01^{g}	4.52±0.06^{f}	6.05±0.02^{l}	
12th day	6.21±0.00^{m}	5.77±0.01^{j}	5.75±0.01^{j}	5.84±0.00^{jk}	6.16±0.03^{m}	5.92±0.01^{k}	
				Titrable acidity (%)			
4th day	0.90±0.01^{i}	0.74±0.00^{g}	0.64±0.00^{ef}	1.27±0.01^{j}	0.84±0.01^{hi}	0.68±0.13^{fg}	0.07
8th day	0.38±0.01^{c}	0.19±0.01^{a}	0.25±0.01^{ab}	0.64±0.00^{ef}	0.31±0.01^{bc}	0.32±0.00^{bc}	
12th day	0.58±0.00^{de}	0.61±0.04 ^{de}	0.54±0.05 ^{d}	0.64±0.00^{ef}	0.58±0.00^{de}	0.61±0.04^{de}	
				TSS (°Brix)			
4th day	13.75±1.20^{a}	20.20±0.42^{e}	17.05±0.21^{c}	15.85±0.49^{b}	17.60±0.14^{c}	18.90±0.28^{d}	1.15
8th day	19.95±0.49^{d}	20.65±0.92^{e}	21.80±0.28^{f}	19.50±0.71^{d}	18.15±1.06^{c}	16.75±0.07^{b}	
12th day	19.95±0.21^{d}	19.80±0.49^{d}	20.55±0.07^{e}	21.30±0.14^{e}	17.85±0.35^{c}	20.85±0.35^{e}	
				Total sugar (mg/100 g)			
4th day	13.54±0.15^{g}	13.48±0.21^{g}	11.45±0.46^{ef}	3.52±0.20^{a}	4.46±0.09^{b}	19.42±0.39^{i}	0.81
8th day	16.25±0.32^{h}	19.99±0.85^{i}	19.66±0.49^{i}	10.75±0.11^{e}	11.67±0.08^{f}	16.68±0.32^{h}	
12th day	29.77±0.00^{k}	30.32±0.35^{k}	25.22±0.00^{j}	9.77±0.78^{d}	5.73±0.12^{c}	6.17±0.45 ^{c}	
				Reducing sugar (mg/100 g)			
4th day	1.72±0.02^{d}	2.15±0.08^{g}	2.89±0.02^{g}h	0.71±0.08^{a}	0.70±0.08^{a}	0.83±0.01^{a}	0.21
8th day	1.70±0.08^{d}	2.23±0.28^{g}	2.13±0.06^{fg}	1.96±0.01^{e}	1.48±0.02^{c}	1.86±0.02^{de}	
12th day	2.71±0.22^{h}	2.14±0.04^{g}	2.30±0.11^{g}	4.60±0.03^{i}	1.74±0.01^{d}	1.05±0.03^{b}	
				Sugar: acid ratio			
4th day	15.28±1.58^{b}	27.30±0.57^{d}	26.64±0.32^{d}	12.43±0.32^{a}	20.95±0.52^{c}	33.09±1.97^{fg}	1.75
8th day	52.26±0.97^{i}	51.80±0.42^{i}	57.54±0.65^{k}	30.47±1.10^{e}	54.67±0.42^{j}	52.34±0.22^{i}	
12th day	34.39±0.36f^{g}	34.54±0.33^{g}	44.85±0.93^{h}	33.33±0.15^{fg}	30.77±0.61^{e}	32.74±0.32^{f}	

Note: All the values are expressed as mean±SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level.

(2014) study, which found that mangoes' TSS content gradually increased under varied storage conditions, our study's results were inconsistent for an unidentified cause.

Results for total sugar

According to the results, the total sugar content of 7-9°brix TSS harvested mangoes showed a significant ($p<0.05$) increasing pattern throughout the storage days for all three treatments.

In mangoes collected at 9-11°Brix, the TS content displayed a distinct trend, increasing significantly ($p<0.05$) from the fourth to the eighth day of storage and then significantly ($p<0.05$) decreasing from the eighth day up to the twelfth day in the case of control and 100 pm treated mangoes.

Birto and Narain (2002) and Dhar *et al*. (2008) reported an increase in total sugars during various phases of pineapple and sapota maturation. Hoda *et al*. (2001) found that the initial value of total sugar grew with increasing storage time before falling as total sugar after reaching its peak, possibly because it was used more quickly in respiration when the fruits were over-ripe.

Results for reducing sugars

The reducing sugar content in mangoes treated with 100 ppm increased from the fourth to the eighth day of storage and then decreased on the twelveth day. These changes, however, were not all statistically significant. In 150 ppm-treated mangoes decreased from the fourth to the eighth day and then slightly increased from the eighth to the twelveth day. In control mangoes from fourth to the eighth day there was decrease then increased significantly ($p<0.05$) from the eighth to the twelfth day.

When compared to mangoes harvested at 7-9°Brix, mangoes harvested at 9-11°Brix displayed a substantially distinct pattern in terms of RS content. Mangoes treated with 100 ppm and those left untreated both displayed a significantly ($p<0.05$) increasing pattern during the length of storage days which was not in case of 150 ppm ethylene mangoes. The findings of this experiment are consistent with those found in sapota fruits at various stages of maturity by Pawar *et al*. (2011).

Results for sugar: acid ratio

According to the findings, the sugar: acid ratio in the 7-9°Brix maturation stage exhibits a substantial increase from the fourth to the eighth day of storage and then a significant drop ($p<0.05$) from the eighth to the twelveth day of storage. The sugar: acid ratio was significantly higher in 150ppm treated mangoes compared to control and 100ppm treated mangoes.

In mangoes harvested at 9-11°Brix, the sugar: acid ratio in control mangoes showed a significant increase ($p>0.05$) from the fourth to the twelfth day whereas in mangoes treated with 100 ppm and 150 ppm, there was a significant increase ($p>0.05$) from the fourth to the eighth day followed by a significant decrease from the eighth to twelfth day of storage.

CONCLUSION

The results thus interpreted were as follows harvesting manjeera variety mangoes at 7-9°brix maturity stage resulted in superior physico-chemical properties. The impact of ripening via, ethylene also led to higher TSS, total sugar and sugar: acid ratio in the fruits. Accelerated ripening led to enhancement of the colour values of the mangoes during the early stages of storage whereas the control fruits needed more days of storage for achievement of an appealable colour. However, it was also noted that 150 ppm ethylene-treated mangoes lost their firmness and became very soft on the 12th day of storage. As a result, they could not be stored any longer since they were no longer fit for consumption. Throughout the course of the trial, it was shown that mangoes treated with 100ppm ethylene maintained their quality better than control mangoes beyond the 12th day of storage.

Conflict of interest: None.

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