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EFFECT OF PERIOD OF MATURITY ON PHYSICAL CHARACTERS AND HEAT UNITS REQUIRED OF MANGO (*MANGIFERA INDICA* L.) CV. ALPHONSO

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Abstract

An investigation entitled "Effect of period of maturity on physical characters and Heat units required of mango (*Mangifera indica* L.) cv. Alphonso" was undertaken with an objective to evaluate different maturity stages of Alphonso mango for physical characters. The study was carried out at the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Dr. B.S.K.K.V., Dapoli, during the year 2011-12. The experiment was laid out in RBD with four stages of mango maturity *viz.*, 90 days, 105 days, 120 days, 135 days (after fruit set) with five replications. The mango fruits harvested from trees were selected for the study and in each tree, 100 fruits were labelled at fruit set of above mentioned days. From the results of the present investigation, its revealed that the physical characteristics of mango cv. Alphonso fruits varied with the different stages of maturity of fruits. The L*, a* and b* values from peel colour at harvest as well as ripe stage increased with increase in the period of maturity of mango cv. Alphonso fruits. Heat units received by Alphonso for fruit development was highest in 135 days mango fruit (1072.75 degree days) followed by 120 and 105 days mango fruit.

Key words : Mango, fruit set, maturity, harvest, colour, degree days.

Introduction

Mango (*Mangifera indica* L.) unarguably is one of the oldest and choicest tropical fruits of the world and is rightly designated as "King" of all fruits. Mango belongs to family Anacardiaceae, which is originated in Indo-Burma at an early date. Due to its wide adaptability, high nutritive value, richness in variety, delicious taste, pleasant flavour, attractive appearance, it enjoys the unique popularity among the masses and classes (Anonymous, 1998). It is especially valuable for as a fresh fruit for international markets, processing and for export. India enjoys a monopoly in it's trade being the biggest mango producing country in the world. Mango is believed to be indigenous to the Indian sub-continent. It is under cultivation in India for more than 4000 years and hence conspicuous bonds have been formed between the fruit and cultural history of the country.

Mango occupies an important socio-economic position within the religion and culture of India and South East Asian countries, where it is held with high esteem (Singh, 1978 and Sukonthasing *et al*., 1991).

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India exports mango and mango based products to more than 80 countries, so it is an important foreign exchange earner, with the earnings of Rs. 16292.10 million from export of 59220.8 tonnes of fresh fruits and Rs. 81400.6 million from the export of 171929.4 Mt of mango pulp (Anonymous, 2011).

The selection effort of adequate maturity for harvest is very important. The postharvest quality and the shelf life of mango fruit (as is the case with all other fruits) is strongly dependent upon the stage of maturity at harvest. Fruit has to be harvested at the ideal stage in order to develop the most adequate organoleptic quality and the longest postharvest life. Less mature fruit is usually more sensitive to chilling injury when stored at low temperature. Fruit harvested before it reaches full maturity may not be ripened adequately after harvest, or in some cases (when harvested immature) it will never ripe. In addition, fruit harvested at full maturity indices show physiological disorders, such as spongy tissue very shortly after harvest.

Mango is the commercial crop of Konkan region of Maharashtra state. The agroclimatic conditions of this region are most suitable for commercial production of

excellent quality mango. At present, only few cultivars such as Alphonso, Kesar, Pairi and newly developed hybrid Ratna and Sindhu are grown on commercial scale. Alphonso is the most popular and choicest cultivar grown extensively in this region which has great demand in local as well as in foreign market. But the problems like spongy tissue and irregular and erratic bearing in Alphonso resulted in inconsistent yield patterns causing economical set back to the mango growers in the region. With varying climatic conditions every year the performance of mango cultivars varies greatly.

Maturity indices are important criteria for deciding the stage of harvesting so as to provide some flexibility in marketing and to ensure the attainment of acceptable eating quality. Various maturity indices for harvesting mangoes have been suggested for different varieties, however, little effort has been made to determine indices which have a practical significance. Traditionally, maturity has been determined by the shape, size and external colour of the fruit. Studies have also been conducted on the biochemical composition, relating it to morphology and peel colour. However, these vary from variety to variety and no generalization can be made. Hence, the present study the effects of harvest maturity on various post harvest quality characteristics of Alphonso mango have been proposed.

In general, the external morphological criteria such as fruit size, colour of peel and fruit shape help to estimate the stage of maturity for harvesting mango fruit. Other elements such as the internal pulp colour are used to attest fruit maturation with the global external morphology. Taking this into account, the study was conducted to effect of period of maturity on physical characters and Heat units required of mango (*Mangifera indica* L.) cv. Alphonso.

Materials and Methods

The study was undertaken at Department of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Management, Dr. B.S.K.K.V., Dapoli (Maharashtra), India; during 2011-12. During the investigation physical characteristics of mango fruit were evaluated immediately after harvest stage. Calculated growing degree days (heat units) received from fruit set to maturity of mango fruits. The experimental material, *i.e.* Alphonso mango fruits were obtained from the orchard of Department of Horticulture College of Agriculture, Dapoli (M.S.), India. Dapoli is situated on the west coast (Arabian Sea) of the Konkan region of Maharashtra. This place lies between 17°45, North latitude and 73°12, East longitude and at an elevation of 250 meters above Mean Sea Level. Fifteen uniform mango tree of Alphonso were selected for the study and on each tree 100 fruits were labeled at 70 per cent fruit set stage. The tagged fruits of uniform size were harvested for conducting the experiment during the year 2011-12. They were harvested at four stages (90, 105, 120 and 135 days). The experiment was laid out in RBD with five replication and four treatment, *viz.* $\mathbf{T_1}$ (Mango fruit harvested at 90 days after fruit set), $\mathbf{T_2}$ (Mango fruit harvested at 105 days after fruit set), $\mathbf{T_3}$ (Mango fruit harvested at 120 days after fruit set), ($\mathbf{T_4}$ Mango fruit harvested at 135 days after fruit set). These fruits were allowed to ripen under ambient conditions (31^{0}C, 85% RH). The observations were recorded and when they immediately after harvest stage. For studying physical parameters ten fruits were randomly selected and observations were recorded on the physical characteristics *i.e.*, fruit weight, volume, specific gravity, length, breadth, pulp weight, peel weight, stone weight, stone length, stone breadth. Peel colour was measured at the equator on opposite cheeks of the fruit. Pulp colour was measured in the center of one cut cheek, with two measurements per fruit. Colour measurements were made using the Konica Minolta CR-410 colorimeter and were expressed as lightness (L*), redness (a*), yellowness (b*). Colorimetry is the technique, which quantifies colour by measuring three primary colour components of light, which are seen by the human eye, specifically red, green and blue (also referred to as "RGB"). This "tristimulus" colour measurement provides data on how much of these three components are present in the light reflected (solids) or transmitted (typically liquids) by a sample. Growing degree days were calculated for various phenophases such as flowering and maturity of fruits on a specific base temperature 10^{0}C (Estrada, 1996) and 17.9^{0}C (Oppenhemer, 1947). Maximum minimum temperature recorded at 8 a.m and 1.30 p.m in everyday with help of Max. Min. thermometer. Following formula was used to determine the heat unit expression in growing degree days

$$\text{Heat units (degree days)} = \frac{\text{Max. Temp.+ Min. Temp.}}{2} - \text{Base temp. (Tb)}$$

The statistical analysis was done according to the techniques given by Panse and Sukhatme (1985) using Randomized Block Design and valid conclusion were drawn only on significant differences between treatment mean at 0.05% level of significance.

Results and Discussion

Data pertaining to physical characteristics, *viz.* weight, volume, specific gravity, length, diameter

Table 1: Physical parameters of mango cv. Alphonso influenced by the period of maturity (At harvest stage)

Treatments	Physical parameters									
	Weight of fruit (g)	Volume of fruit (ml)	Specific gravity	Length of fruit (cm)	Breadth of fruit (cm)	Weight of pulp (g)	Weight of peel (g)	Weight of stone (g)	Length of stone (cm)	Breadth of stone (cm)
T_1	250.10 c	250.00 c	1.000 c	8.50 c	6.15 b	157.30c	29.90c	30.70b	6.61b	2.29 c
T_2	258.24 c	256.40 c	1.007 b	8.53 c	6.22 b	184.70b	32.25b	35.20a	7.07ab	2.72 b
T_3	291.14 b	287.30 b	1.013 a	9.50 b	7.58 a	198.65ab	35.30a	35.45a	7.43a	3.23 a
T_4	314.05 a	309.80 a	1.013 a	9.91 a	7.64 a	205.70a	35.71a	36.05a	7.31a	2.90 ab
S.Em ±	6.380	6.370	0.0006	0.118	0.080	5.809	0.627	1.092	0.209	0.113
CD at 5%	18.529	18.496	0.002	0.345	0.233	16.858	1.821	3.171	0.608	0.330

(breadth), weight of pulp, weight of peel, weight of stone, length and breadth of stone and colour of mango fruits during different maturity stages are presented in tables 1 and 2. It is revealed from the data that most of the physical parameters showed variation due to different maturity stages of mango. It is evident from the data presented in table 1 that all the stages of mango under study differed significantly with each other with respect to their fruit weight at harvest stage and recorded an increasing trend in fruit weight throughout its growth and development. The T_4 stage mango fruits recorded significantly maximum fruit weight at harvest stage, followed by T_3 and T_2. The T_1 stage mango fruits recorded minimum fruit weight at harvest stage, but it was at par with the treatment T_2. An increase in fruit weight can be related with the increase in size of cell with accumulation of metabolites and moisture in intercellular spaces. Similar results were obtained in mango (Roy, 1972). The T_4 stage mango fruits recorded significantly maximum fruit volume at harvest stage followed by T_3 and T_2. The T_1 stage mango fruits recorded minimum fruit volume at harvest stage, but it was at par with the T_2 stage of maturity. Volume was found to increase with increase in weight. The increase in volume of the fruit during maturation could be attributed to the growth and development of mango fruit (Palaniswamy, 1974). The T_4 and T_3 stage mango fruits showed significantly maximum specific gravity and at par with each other, followed by T_2 maturity stage of fruit. The specific gravity was minimum in T_1 stage mango fruit. Specific gravity of fruits increased significantly with advance of maturity due to the rapid depletion of starch and formation of sugars (Joshi and Roy, 1985). It could be revealed from the results that the T_4 stage mango fruits recorded significantly maximum fruit length at harvest (9.91cm), followed by T_3 and T_2, However, T_1 stage mango fruits were characterised by the significantly minimum (8.50 cm) fruit length, but at par with the T_2 stage of maturity. An increase in linear dimensions could be attributed to an increase in volume, so the linear dimensions are also important physical indices of maturity of mango fruits (Palaniswamy, 1974). The breadth (diameter) of mango fruit at harvest stage was significantly maximum in T_4 stage fruits, followed by T_3 and T_2 with 7.58 and 6.22 cm length, respectively The minimum fruit length was noticed in T_1 stage of maturity; however, it was at par with T_2 stage mango fruits (Gole, 1986). The weight of the pulp was significantly maximum in T_4 stage fruits, however, it was at par with the fruit from T_3 stage of maturity. Minimum weight of pulp was observed in T_1 stage fruits, followed by T_2 stage fruit. The pulp weight was found to increase with maturity of the fruit. The variation in the weight of pulp in all stages of mango fruits under study was statistically significant. Similar increasing trend was also reported by Naik (1985) in Alphonso and Ratna cultivars of mango. The weight of peel of fruit increased with the growth and development of the mango fruit. Weight of peel at harvest recorded significantly highest in T_4 stage fruits, but at par with T_3 stage fruit, followed by T_2 stage fruits. The T_1 stage fruits were characterized by the lowest weight of peel. The difference in weight of peel of mango fruits was found to be statistically significant which could be attributed to the period of maturity. The weight of stone was significantly maximum in T_4 stage mango fruit at harvest, while minimum weight of stone was observed in T_1 stage mango fruits at harvest. The variation in stone weight amongst the mango stages under study appeared to be due to the varied period required for fruit maturation. The length of mango stone increased at harvest significantly with increase in the period of maturity. The maximum length was noticed in T_3 stage fruit; however, it was at par with the T_4 stage fruits. The mango fruit from T_1 stage maturity recorded minimum stone length, but at par with T_2 stage fruits. The variation in the length of stone in all the stages under study was statistically significant, which could be attributed to variation in the

Table 2 : Colour of Alphonso mango fruits influenced by stages of maturity.

Sr. no.	Treatments	Peel colour (At harvest)			Pulp colour (At harvest)			Peel colour (At ripe)			Pulp colour (At ripe)		
		L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
1.	T_1	49.05b	-15.83a	21.90c	85.03a	-8.537c	47.42b	61.81c	-4.53b	46.78b	72.39a	24.17c	72.14a
2.	T_2	49.66b	-16.26ab	23.41bc	83.62ab	-3.613b	60.52a	63.31bc	11.59a	55.39a	68.44b	24.90bc	69.83ab
3.	T_3	51.14b	-17.01b	24.71b	82.62bc	-3.590b	62.25a	66.18ab	12.99a	55.74a	66.10b	26.40ab	67.45bc
4.	T_4	55.72a	-18.08c	31.59a	81.29c	-0.197a	63.90a	66.87a	13.30a	61.51a	65.99b	27.20a	65.49c
S.Em±	-	0.858	0.268	0.683	0.594	0.775	1.720	0.970	0.710	2.130	0.896	0.452	1.144
C.D. at 5%	-	2.970	0.931	2.366	2.058	2.683	5.953	3.358	2.458	7.398	3.103	1.565	3.960

maturity. The breadth of mango stone of fruit increased at harvest from 90 days maturity stage (T_1) to 120 days maturity stage (T_3). The decline in breadth of stone was noticed in T_4 stage maturity stage *i.e.* 135 days maturity stage. A decrease in breadth of the mango stone after 135 days maturity is the natural physiological phenomenon taking place during maturation (Gole, 1986).

The data pertaining to the L*, a* and b* values for peel colour of mango fruit cv. Alphonso at harvest are presented table 2. It is evident from the data the L*, a* and b* values for peel colour increased with increase in the period of maturity of mango cv. Alphonso fruit. The mango fruit from T_4 stage of maturity recorded highest L* value for peel colour and significantly superior to rest of the treatments. However, all other treatments were at par with each other and they did not exhibit any significant variation in the lightness of peel colour. Similarly, maximum a* and b* values for peel colour was recorded in T_4 stage of maturity, followed by the T_3 stage fruits. The lowest negative a* and positive b* value for peel colour was recorded in the T_1 stage mango fruit, but it was at par with the T_2 stage mango fruits.

Table 3 : Heat units received from fruit set to reach the different stages of maturity in mango cv. Alphonso fruits.

Treatments	Heat units (degree days)	
	Base temperature	
	10^0C	17.9^0C
T_1	1321.7	610.7
T_2	1594.7	765.2
T_3	1866.7	918.7
T_4	2142.2	1075.7

The higher b* value in T_3 and T_4 stage than T_1 indicate the decreased greenness of fruit with increase in the period of maturity. The b* value for pulp colour increased with increase in the period of maturity, however L* and a* value of pulp colour decreased as the maturity of fruit increased. The mango fruit from T_1 stage of maturity indicated highest L* value for pulp colour and significantly maximum to rest of the other treatments, whereas minimum L* value was recorded in T_4 stage of maturity and exhibited a significant variation in the lightness of pulp colour. The a* and b* values of pulp colour were maximum in T_1 and T_4 stage mango fruit, followed by T_3 and T_2 stage mango fruit. The minimum negative a* and b* value for pulp colour was observed in the T_1 stage mango fruit. In T_4, T_3 and T_2 stage mango fruit the b* value was at par with each other and they did not exhibit any significant variation in the yellowness of pulp at harvest. The T_3 and T_2 stage mango fruit were at par with each other with respect to a* value for pulp colour and they did not exhibit any significant variation in the redness of pulp colour of mango fruit.

It is endent from the data the L*, a* and b* values for peel colour at ripe stage increased with increase in the period of maturity of mango cv. Alphonso fruit. The mango fruit from T_4 stage of maturity recorded maximum L* value for peel colour and significantly superior to rest of the treatments, but at par with the treatment T_3 with L* value for peel colour. The minimum L* value for peel colour was observed in T_1 stage of maturity; however, it was at par with T_2 stage mango fruits. Similarly maximum a* and b* value for peel colour was recorded in T_4 stage of maturity; however, it was at par with the T_3 and T_2 stage fruits. The lowest a* and b* value for peel colour was recorded T_1 stage of mango fruit. This clearly indicates that the peel colour development at ripe stage was influenced by the maturity of mango fruit. Higher the days required to harvest the fruit, better could be the colour development after ripening in mango fruits. The a* and b* value for pulp colour at ripe stage increased with increase in the period of maturity and decrease in L* value of pulp colour of mango cv. Alphonso fruit. The

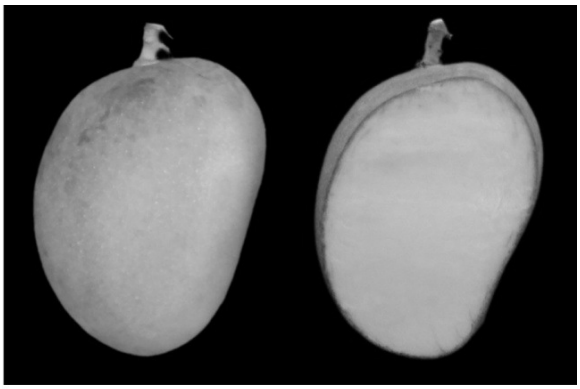

Fig. 1 : 90 days mango fruit – $\mathbf{T_1}$ (at harvest).

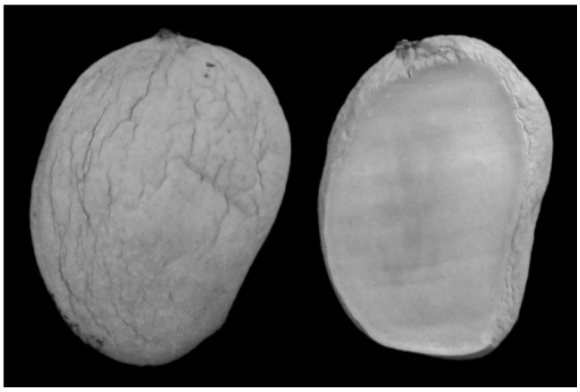

Fig. 2 : 90 days mango fruit – $\mathbf{T_1}$ (at ripe).

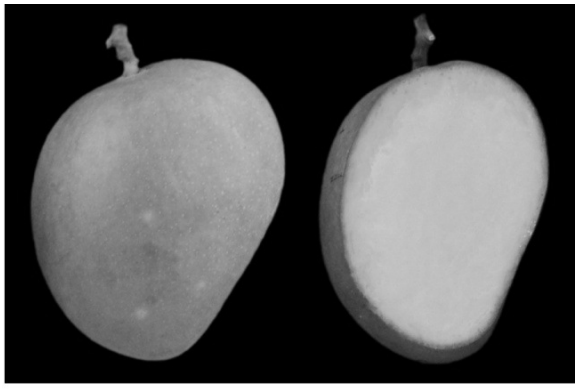

Fig. 3 : 105 days mango fruit – $\mathbf{T_2}$ (at harvest).

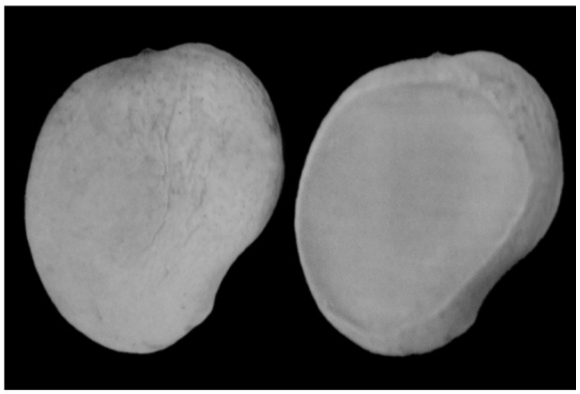

Fig. 4 : 105 days mango fruit – $\mathbf{T_2}$ (at ripe).

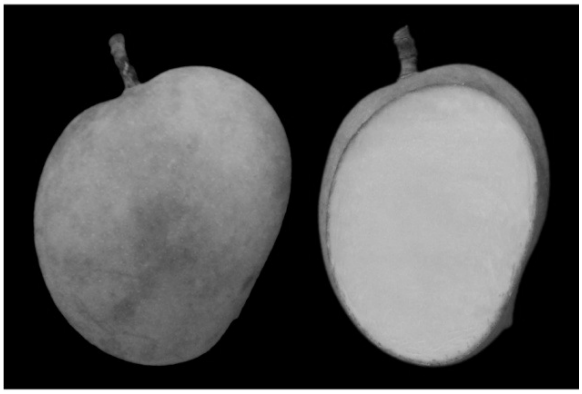

Fig. 5 : 120 days mango fruit – $\mathbf{T_3}$ (at harvest).

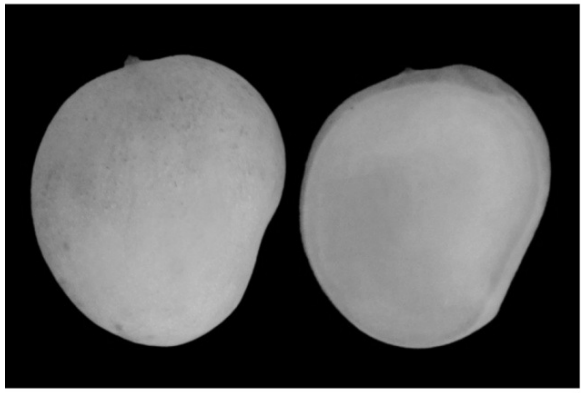

Fig. 6 : 120 days mango fruit – $\mathbf{T_3}$ (at ripe).

Fig. 7 : 135 days mango fruit – $\mathbf{T_4}$ (at harvest).

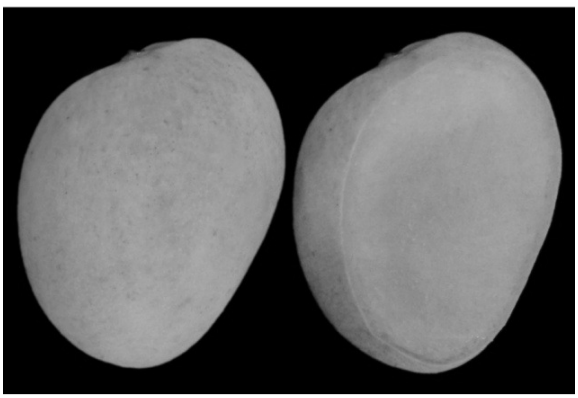

Fig. 8 : 135 days mango fruit – $\mathbf{T_4}$ (at ripe).

mango fruit from $\mathbf{T_1}$ stage of maturity showed highest L* value for pulp colour and significantly superior to rest of the treatments, whereas minimum L* value was recorded in $\mathbf{T_4}$ stage of maturity, but at par with $\mathbf{T_3}$ and $\mathbf{T_2}$ and they did not exhibit any significant variation in the lightness of pulp colour. The a* value of pulp colour was recorded maximum in $\mathbf{T_4}$ stage mango fruit and at par with $\mathbf{T_3}$ stage mango fruits. The minimum a* value for pulp colour was observed in the $\mathbf{T_1}$ stage mango fruits; however, it was at par with the $\mathbf{T_2}$ stage of maturity. Similarly the b* value of pulp colour was highest in $\mathbf{T_1}$ stage mango fruits and at par with the $\mathbf{T_2}$ stage of maturity and minimum in $\mathbf{T_4}$ stage of mango fruits, but at par with the $\mathbf{T_3}$ stage fruit. The higher L* and b* values indicated the yellowness of pulp in 90 days maturity stage while increased a* values with low L* and b* values in 120 and 135 days maturity stage indicated better orange colour development in the mango fruits. Thus, it is evident from the data that the number of days required for harvesting, better could be the peel as well as pulp colour of the mango cv. Alphonso fruit. The similar trend in variation of colour of peel and pulp of mango was also reported by Thomas *et al*. (2005) and Padda *et al*. (2011) in mango fruit.

The data pertaining to the heat units received by the mango cv. Alphonso fruits to attain the different maturity stages are presented in table 3. The maximum (1075.7 and 2142.2^0 days, respectively) heat units were received by the fruits from $\mathbf{T_4}$ stage maturity at 17.9 and 10^{0}C base temperature, followed by $\mathbf{T_2}$ and $\mathbf{T_3}$ stage maturity mango fruits, whereas, minimum (610.7 and 1321.7^0 days, respectively) heat units were received by the mango fruits from $\mathbf{T_1}$ stage maturity (90 days) at 17.9 and 10^{0}C base temperature. However, based on the physico-chemical composition, ripening behaviour and organoleptic qualities it has been suggested to harvest the fruits after receiving 918.7 or 1866.7 heat units *i.e.* $\mathbf{T_3}$ stage fruit maturity to get optimum fruit quality. The observation analogous to this finding were also reported by Rao and Shrinath (1967), Singh *et al*. (2011) in different varieties of mango.

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