Indian J. Hort. 71(4), December 2014: 486-493

Physico-biochemical changes during fruit growth, development and maturity in passion fruit genotypes

R.K. Patel[*], Akath Singh, Jai Prakash[**], Amit Nath and Bidyut C. Deka
Division of Horticulture, ICAR Research Complex for NEH Region, Umiam 793 103, Meghalaya

ABSTRACT

Physiological and biochemical changes during fruit growth, development and maturity of six passion fruit genotypes, *i.e.* three species (*P. edulis* Sims (Meghalaya purple and Nagaland purple), *P. edulis* f. *flavicarpa* Degener (Kerala Yellow, RCPS-1 and Panama Yellow) and *P. alata*) were studied at weekly interval after fruit set till maturity and dropping from vine. Fruit growth of passion fruit followed a single sigmoid growth curve. Fruit length, diameter and weight increased continuously from the initial stage till maturity, which slightly declined at ripening stage. Fruits developed acceptable physico-chemical qualities with good colour and flavour, when harvested at 83 to 90 days after fruit set (DAF) in *P. edulis* Sims (Megha Purple and Nagaland Purple) and at 90 DAF in *P. edulis* f. *flavicarpa* Degener (Kerala Yellow, RCPS-1 and Panama Yellow) and *P. alata* passion fruit. The study further revealed that the days taken from fruit set to maturity and ripening, colour change, TSS and acidity may be considered as the most reliable maturity indices for taking harvest decision in passion fruit.

Key words: Passion fruit, physico-biochemical changes, fruit development, maturity.

INTRODUCTION

Passion fruit (*Passiflora* sp.) belongs to family Passifloraceae, of which purple (*P. edulis* Sims) and yellow type (*P. edulis* f. *flavicarpa* Degener) are common, while *P. alata* is less common. It is a high value crop having export potential due to its juice flavour. In India, it grows wildly in Niligiri Hills, Kodaikanal, Coorg, Malabar, Kerala and Himachal Pradesh. Of late, this crop is gaining popularity in the northeastern hill states of India because of its adoptability, easy method of cultivation and higher yield per unit area without much care. Due to its unique and delicate flavour, the fruits are widely used in preparation of beverages, squash and cordials. Besides, purple passion fruit is also eaten as fresh by the people of this region due to its better eating quality. Fruits are utilized only after maturity, as immature fruits are highly acidic and contain less juice as well as flavour. Since, it is a climacteric fruit, ripening may also take place off the plant (Singh *et al*., 15).

It is known that the quality and storage life of fruits depend on various physico-biochemical changes, which occur during fruit growth, development and maturity. Harvesting at appropriate maturity is an important factor affecting fruit quality as well as the rate of change of quality during post harvest handling. The information pertaining to the physico- biochemical changes of passion fruit in different species at different stages of maturity and ripening is very scanty. Therefore, a comprehensive study was carried to study such changes on passion fruit genotypes.

*Corresponding author's present address: NRC on Litchi, Muzaffarpur, Bihar; E-mail: rkpatelicar@gmail.com
**Div. of Fruits and Hort. Tech. IARI, New Delhi

MATERIALS AND METHODS

An experiment was conducted at ICAR Research Complex for NEH Region, Umiam, Meghalaya at an elevation of 1,000 m msl. during 2008-2009. Two-year-old bearing plants of six passion fruit genotypes comprising three species, *viz*., *Passiflora edulis* (Megha Purple and Nagaland Purple), *P. edulis* f. *flavicarpa* (Kerala Yellow, RCPS-1 and Panama Yellow) and *P. alata* were selected for study. The experiment was laid out in randomized block design with three replications and four vines per replication. Few vines from all side of the plant were selected and then flowers were tagged with numbered metallic labels on the day of anthesis. The fruits initially set were marked in each vine. The first sample of the fruit was collected at 13 days after fruit set (DAF) and thereafter, samples were collected at weekly interval till maturity and dropping of fruits. Fruit length and diameter were measured from five randomly selected fruit during study with digital vernier calipers. The weight of the fruits was calculated on the basis of 10 representative fruits. Specific gravity of the fruits was calculated as the weight per unit volume of the fruits (Shivasankar and Kumar, 14).

The fruits from different genotypes were weighed, cut and then juice was extracted from the pulp by squeezing and straining through muslin cloth under aseptic condition. The juice obtained was measured and the juice per cent was determined from the volume of the juice divided by fruit weight and multiplied by 100. Similarly, fruit rind per cent was also calculated. The total soluble solids (TSS) content was determined with Erma hand refractometer (0-32°Brix) with necessary temperature correction. The titratable acidity, sugars (reducing and total sugars) and ascorbic acid content of juice were estimated as per AOAC (1). The pH of fruit juice was determined by using the pocket pH meter (Eutech Instrument, Singapore). TSS: acid ratio was calculated by dividing the TSS value with acidity. The changes in physical appearance of fruit colour, juice colour and flavour were determined by visual and sensory evaluation. The data were subjected to statistical analysis for ANOVA. Least significant of difference at 5% level was used for finding the significance of differences if any, among the treatment means.

RESULTS AND DISCUSSION

Fruit growth (length and diameter) of passion fruit increased continuously from the initial stage of fruit development up to 83 days after fruit set (DAF) and thereafter, slightly decline till fruit dropping in all genotypes except *P. alata*, which showed the fruit growth up to 90 DAF (Figs. 1 & 2).

Fruit growth of passion fruit followed a single sigmoid growth curve. The fruit reaches towards maturity showed the slow growth and declined at harvest maturity. The maximum fruit length and fruit diameter was recorded under *P. alata* (10.17 mm, 7.05 mm) followed by RCPS-1 (7.33 mm, 6.75 mm), Panama Yellow (7.24 mm, 6.70 mm) and Kerala Yellow (6.5 mm, 6.38 mm), whereas, minimum in Nagaland Purple (4.9 mm, 4.2 mm) at 90 DAF. In case of dropped fruits, similar trend was also noticed (Fig. 1 & 2). Singh *et al*. (15) reported that growth of passion fruit (Purple and Yellow type) showed the single sigmoid growth curve and slight decline in fruit size at 80 days after fruit set.

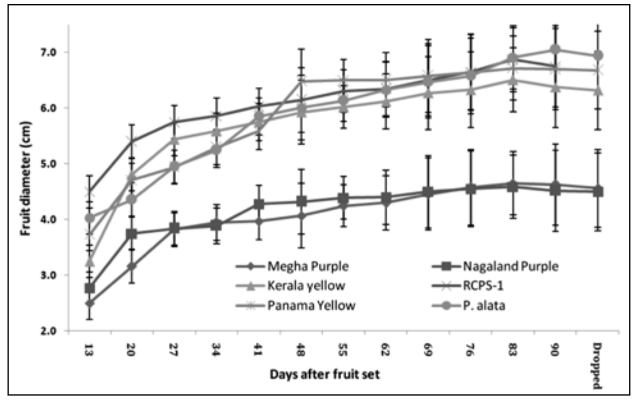

Fig. 2. Changes in fruit diameter of passion fruit genotypes at different stages of fruit maturity.

The weight of passion fruit increased linearly from initial stage of fruit growth up to 83 DAF and thereafter, slightly decreased in all genotypes except *P. alata*, where fruit weight increased up to 90 days (Fig. 3). It is apparent from that the fruit weight rapidly increased from 13 to 55 DAF and thereafter the increase was slow till 83 DAF in almost all the genotypes. Rapid increase in fruit size and weight during initial stage could be due to fast cell differentiation and cell enlargement initially followed by slow rate (Ram *et al*., 12). The maximum fruit weight was recorded in the *P. alata* (192.87 g) followed by RCPS-1 (133.75 g), while the minimum fruit weight of 41.02 and 43.04 g was recorded in Megha and Nagaland Purple, respectively at 90 DAF. Initially fruit growth was mainly associated with rind growth and later on seed and aril. The linear increase in fruit weight till 83 DAF and subsequent decline in weight towards ripening might be due to loss of water from fruits through transpiration.

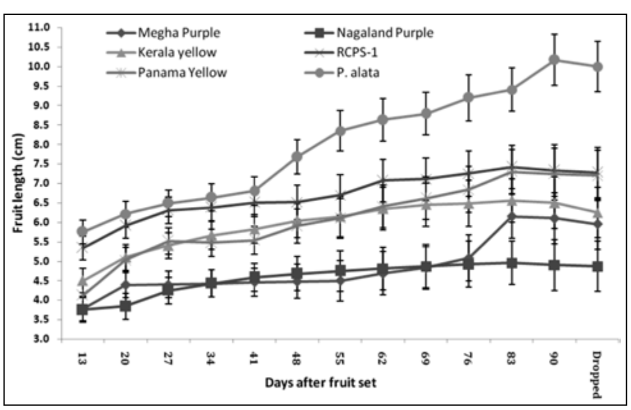

Fig. 1. Changes in fruit length of passion fruit genotypes at different stages of fruit maturity.

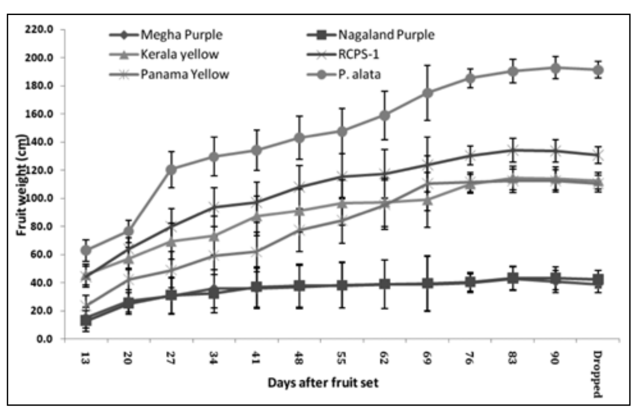

Fig. 3. Changes in fruit weight of passion fruit genotypes at different stages of fruit maturity.

Specific gravity of passion fruit under different genotypes did not showed any significant difference irrespective of days after fruit set except 27 DAF (Fig. 4). However, it was found that the specific gravity of fruit started decreasing after 55, 62 and 69 DAF in RCPS-1 & Panama Yellow, Kerala Yellow & *P. alata* and Megha and Nagaland Purple, respectively till fruit dropping. Decline in specific gravity towards fruit maturity was also observed by Dubey *et al*. (5, 6) in citrus, Kishore *et al*. (7) and Singh *et al*. (15) in passion fruit. This might be due to loss in fruit weight as ripening progresses. Initially rind thickness showed increasing trend from the first sampling to 20 DAF and thereafter, decreased till maturity in all genotypes except Kerala Yellow and RCPS-1, which showed decreasing, trend from first sampling (Fig. 5). Rind thickness ranged from 2.83 to 13.48 and 2.70 to 12.58 mm at 90 DAF and dropped fruit, respectively under Megha Purple and *P. alata*. However, *P. alata* showed declining trend of rind thickness from 27 DAF onwards till 32 DAF and again increasing trend from 76 DAF to 90 DAF. This could be due to increases in water content into the rind during ripening of fruit. The present finding is in conformity with the findings of Kishore *et al*. (7) and Singh *et al*. (15) in passion fruit.

The juice formation started at 34 days after fruit set and increased rapidly up to 62 DAF and continue comparatively slow rate of increase till 83 DAF and then started decreasing at full ripe stage in most of the genotypes. However, *P. alata* showed declining trend in juice content only at fruit dropping stage. Findings are in accordance to Kishore *et al*. (7) and Singh *et al*. (15) in passion fruit.

The maximum juice content was extracted in RCPS-1 (40.76 & 38.25%) followed by Panama Yellow (38.15 & 35.7%), Kerala Yellow (36.31 & 35.12%) and minimum in *P. alata* (22.35 & 22.25%) at 90 DAF and fruit dropped stage, respectively (Fig. 6). Loss of water from pulp and breaking down of polysaccharides to mono-saccharides during ripening could be the reason for reduction in juice content. Fig. 7 indicated that the rind content was very high till 27 DAF. However,

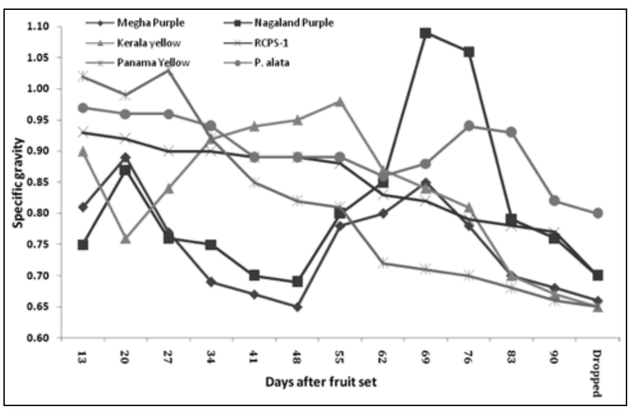

Fig. 4. Changes in specific gravity of passion fruit genotypes at different stages of fruit maturity.

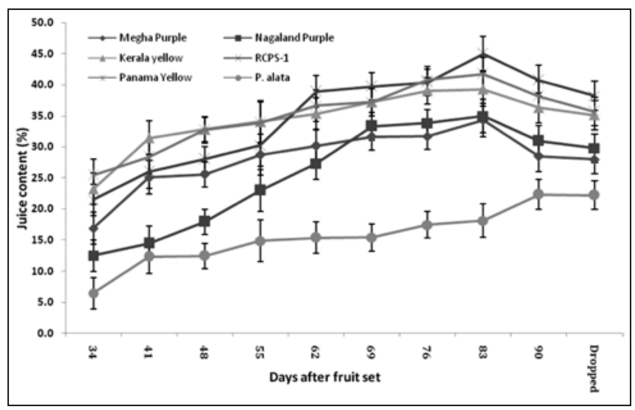

Fig. 6. Changes in juice content of passion fruit genotypes at different stages of fruit maturity.

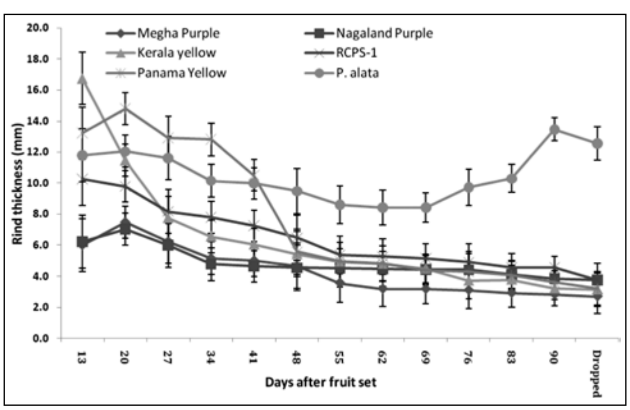

Fig. 5. Changes in fruit rind thickness of passion fruit genotypes at different stages of fruit maturity.

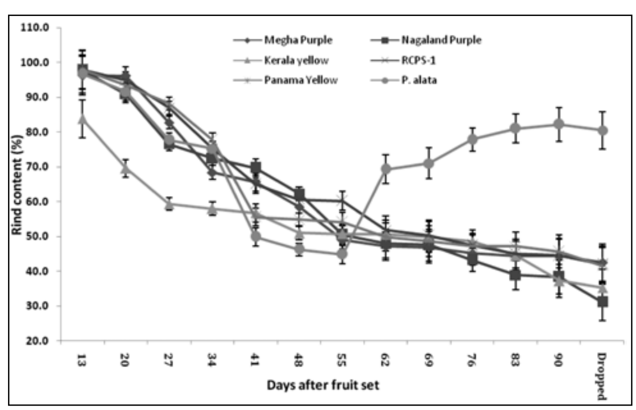

Fig. 7. Changes in rind content of passion fruit genotypes at different stages of fruit maturity.

most of the genotypes showed the decreasing trend for rind content from 13 DAF to till ripening (90 DAF and dropped) except *P. alata*, which showed declining trend till 55 DAF and then gradually increased till 90 DAF and thereafter slightly declined at fruit dropping stage. The lowest (37.23%) and highest (82.23%) rind thickness was recorded in Kerala Yellow and *P. alata*, respectively at 90 DAF. High rind content during early stage of fruit development might be due to non-formation of seed and juice content in fruit. Whereas, declining trend in rind content till maturity could be due to increase in seed size and water content in the fruit pulp.

Data presented in Table 1 indicated that the TSS of fruit juice increased gradually with the advancement of maturity (till 90 DAF) and slightly decreased in the dropped fruits under all the genotypes. A steady rise in TSS of the fruit was observed till final stage of harvesting. Similar results were also reported by Singh *et al*. (15) in passion fruit, Rajput *et al*. (11) in mango and Lamare (8) in S*ohshang*. The increase in TSS content might be due to degradation of starch during later stage of harvest maturity as well as quick metabolic transformations in soluble compounds, mainly sugars. The TSS content in fruit ranged from 15 to 19% and the highest TSS content (19%) was recorded from fruit harvested at 90 DAF in *P. alata* followed by Panama Yellow (17.4%), RCPS-1 (16.8%), Kerala Yellow (16.4%), Megha Purple (15.75%) and lowest (15%) in Nagaland Purple. The fruit showed continuous and progressive increase in acidity up to 55 DAF in most of the genotypes and afterwards, there was a continuous reduction in acidity till maturity (90 DAF and dropped fruits) (Table 2). The increase in acidity might be attributed to increased biosynthesis of organic acid during early stage of fruit growth. The decreased in acidity at later stages of fruit maturity was considered to be due to conversion of organic acids into sugars. Similar results were also reported by Mercado-Silva *et al*. (9) in guava, Deka *et al*. (3) in Khasi mandarin, Kishore *et al*. (7) in passion fruit and Lamare (8) in *Sohshang*. When fruits were 90-day-old, acidity contents of 4.50, 4.35, 3.5, 3.25, 2.82 and 1.41%

Table 1. Changes in TSS (°Brix) of passion fruit genotypes at different stages of fruit maturity.

Genotype	Days after fruit set												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	5.4	6.67	7.5	9.35	14.0	14.45	15.0	15.5	15.75	15.0
Nagaland Purple	-	-	-	6.8	7.2	10.3	10.8	13.0	14.0	14.4	14.6	15.0	14.8
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	9.0	10.0	11.0	12.0	13	14.2	15.0	16.0	16.4	16.2
RCPS-1	-	-	-	7.4	8.0	10.0	12.0	14.4	15.0	15.4	16.0	16.8	16.6
Panama Yellow	-	-	-	7.5	9.0	10.0	12.0	13.0	14.0	15.0	16.2	17.4	17.2
P. alata	-	-	-	10.0	12.0	14.0	16.0	16.5	17.0	18.0	18.4	19.0	18.8
CD at 5%	-	-	-	3.6	4.4	2.95	4.8	2.3	1.85	1.75	1.5	1.8	2.15

Table 2. Changes acidity content (%) of passion fruit genotypes at different stages of fruit maturity.

Genotype	Days after fruit set												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Pssiflora edulis													
Megha Purple	-	-	-	3.45	4.25	4.55	4.67	4.89	4.14	3.5	2.92	2.82	2.78
Nagaland Purple	-	-	-	4.24	5.12	5.38	5.63	5.44	4.86	4.35	3.50	3.25	3.10
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	7.42	7.42	7.81	7.94	6.66	6.45	6.32	5.15	4.5	4.50
RCPS-1	-	-	-	4.85	5.76	5.82	6.14	6.96	6.4	5.5	5.38	4.35	4.3
Panama Yellow	-	-	-	5.25	5.38	6.02	5.49	4.66	4.54	4.28	3.82	3.5	3.4
P. alata	-	-	-	4.88	2.45	2.32	2.25	2.18	2.05	2.05	1.92	1.41	1.30
CD at 5%	-	-	-	1.90	2.45	1.75	1.50	2.25	2.0	1.35	1.6	1.89	1.90

were recorded in Kerala Yellow, RCPS-1, Panama Yellow, Nagaland Purple, Megha Purple and *P. alata*, respectively. Increased in acidity value corresponded with decreased in pH value (Table 3).

The data presented in Table 4 revealed that the increasing trend in ascorbic acid content during growth period and thereafter it declined as fruit reaches towards maturity and ripening in all genotypes except Megha and Nagaland Purple. Higher ascorbic acid content during the initial fruit growth stage might be attributed to the adequate supply of hexose sugars in photosynthetic activity. The reduction in ascorbic acid content at later stages might be attributed to enzymatic oxidation of the L-ascorbic acid to dehydro-ascorbic acid during metabolic process (Neeraj *et al*., 10). These findings were also in accordance with the findings of Dubey *et al*. (6) in *Khasi* mandarin and Kishore *et al*. (7) in passion fruit.

Fruit harvested at 90 DAF produced the maximum ascorbic acid content of 48.75 and 41.34 mg/100 ml for Megha and Nagaland Purple, respectively, while it was lowest in Panama Yellow (22.5 mg/100 ml). The data presented in Table 5 showed an increasing trend in reducing sugar content of fruit juice till last harvesting. However, no significant difference was observed in reducing sugar due to genotypes in most of the date of observations except 55, 83 and 90 DAF. The highest reducing sugar content was analyzed in *P. alata* (6.67%) and lowest in Nagaland Purple (3.92%) at 90 DAF. The increase in reducing sugar might be due to hydrolysis of polysaccharides. A similar trend was also noticed by Lamare (8) in *Sohshang.*

After first observation to maturity (90 DAF), total sugars content showed a continuous increase (Table 6) in all the genotypes. Total sugars were increased rapidly at later stage of fruit development for all genotypes. The maximum total sugar content was recorded in Nagaland Purple (18.1%) followed by Kerala Yellow (16.6%), RCPS-1 (15.38%) and Megha Purple (14.58%), while lowest 13.34 and 13.75% in Panama Yellow and *P. alata*, respectively at 90 days after fruit set. The increase in sugar content could be due to the breakdown of starch into glucose and sucrose (Selvaraj *et al*., 13).

Table 3. Changes in juice pH of passion fruit genotypes at different stages of fruit maturity.

Genotype	Days after fruit set												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	3.4	3.3	3.2	3.23	3.75	3.92	3.95	4.1	4.12	4.0
Nagaland Purple	-	-	-	4.1	4.1	3.93	3.6	4.5	4.7	4.7	4.75	4.8	4.5
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	5.8	5.8	5.6	5.5	5.5	5.6	5.6	5.7	6.0	5.8
RCPS-1	-	-	-	6.0	6.0	5.75	5.6	5.5	5.6	5.7	5.7	6.0	6.2
Panama Yellow	-	-	-	5.9	5.7	5.4	5.9	6.0	6.1	6.0	6.1	6.1	6.0
P. alata	-	-	-	4.4	5.4	5.4	5.8	5.8	5.9	5.9	5.9	6.0	5.9
CD at 5%	-	-	-	NS	NS	1.2	1.5	1.44	1.25	NS	NS	1.32	1.24

Table 4. Changes in ascorbic acid content (mg/100 ml) of passion fruit genotypes at different stages of fruit maturity.

Genotype	Days after fruit set												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	24.0	23.4	28.6	30.8	40.99	43.35	45.6	45.76	48.75	45
Nagaland Purple	-	-	-	25.2	25.4	25.4	26.5	26.5	36.04	36.04	37.1	41.34	40.71
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	56	54.4	51.2	36.8	34.8	30	28.8	28.4	22.8	22.5
RCPS-1	-	-	-	48.4	49.0	32.2	42	37.7	33.8	32.5	32.25	31.5	31.2
Panama Yellow	-	-	-	55.5	57.6	51.2	37.5	37.5	34.5	34.5	25.5	22.5	21.5
P. alata	-	-	-	49.0	39.2	42.0	44.8	47.6	50.4	56.0	51.8	30.8	28.7
CD at 5%	-	-	-	8.8	10.5	6.9	5.75	6.75	10.2	12.4	4.78	8.34	5.85

Table 5. Changes in reducing sugar (%) of passion fruit genotypes at different stages of fruit maturity.

Genotype	Days after fruit set												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	0.46	0.55	0.73	1.2	3.55	3.93	4.4	5.13	5.15	5.88
Nagaland Purple	-	-	-	1.0	1.16	2.0	2.38	2.89	3.22	3.44	3.77	3.92	6.89
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	0.81	0.83	0.93	1.37	3.12	3.22	3.77	4.08	5.26	5.50
RCPS-1	-	-	-	1.10	1.13	1.61	1.85	3.17	3.33	3.63	4.25	5.4	5.57
Panama Yellow	-	-	-	1.25	1.39	1.83	2.89	3.38	3.57	4.16	4.34	5.0	5.10
P. alata	-	-	-	2.0	2.12	2.43	2.70	4.0	4.45	5.12	6.15	6.67	6.70
CD at 5%	-	-	-	NS	NS	NS	1.5	NS	NS	NS	2.15	2.4	NS

Table 6. Changes in total sugars (%) of passion fruit genotypes at different stages of fruit maturity.

Genotype	Days after fruit set												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	1.54	2.98	6.45	6.66	7.46	9.72	11.45	12.92	14.58	12.8
Nagaland Purple	-	-	-	3.50	3.70	3.77	4.34	10.5	11.7	14.2	16.6	18.1	15.5
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	5.0	5.85	6.0	6.2	6.67	7.4	8.33	9.52	16.6	14.5
RCPS-1	-	-	-	1.60	1.76	1.83	5.71	6.89	8.33	9.52	11.10	15.38	15.0
Panama Yellow	-	-	-	2.0	2.15	2.43	8.0	8.69	10.0	10.52	12.5	13.34	13.34
P. alata	-	-	-	1.78	2.35	4.2	8.20	8.65	10.0	10.8	13.2	13.75	13.69
CD at 5%	-	-	-	1.82	2.75	2.50	2.52	1.78	3.0	2.68	1.82	2.35	1.78

The rapid increase in sugar content during later stage might be due to hydrolysis of starch into simple sugars and conversion of acids into sugar too as reported by Chandra (2). The increase in sugar might also be due to an increase in TSS. Similar trend was also reported by Selvaraj *et al*. (13) in grapes, Kishore *et al*. (7) in passion fruit and Deka *et al*. (4) in pineapple. Changes in fruit colour presented in Table 7 revealed that a gradual change in colour of passion fruit was observed during fruit growth and development. The rind colour remained green till 48 and 62 days of harvesting in both *P. edulis* (Megha and Nagaland Purple) and *P. alata,* respectively and thereafter the colour changed with the advancement of maturity. However, initiation of purple colour started from 62 DAF and fruit became purple and deep purple in colour at 83 and 90 DAF, respectively.

Likewise, fruit of all the genotypes of yellow type (*P. edulis* f. *flavicarpa*) showed the green colour up to 20 DAF and thereafter changed into dark green colour till 48 DAF and then became light green, greenish-yellow, light yellow and yellow colour at 62, 69, 83 and 90 DAF, respectively. Whereas, fruit of *P. alata* changed from green to light yellow at 69 DAF and remained in the same stage till 83 DAF and thereafter changed in deep yellow at 90 DAF.

A gradual change in juice colour of passion fruit was observed from 34 up to 90 DAF. The pattern of juice colour presented in Table 8 showed that the juice remained whitish in colour till 48 DAF and then became light yellow (55 DAF), yellowish-orange (62 DAF), orange (69 to 83 DAF) and finally yellowish orange during ripening (90 DAF and dropped fruits) in both purple genotypes.

While, genotypes of yellow passion fruit showed whitish juice colour only at 34 DAF thereafter became yellow up to 48 DAF and orange in colour at 55 DAF onwards till maturity and ripening, whereas, *P. alata* showed whitish colour up to 48 DAF. It became orange in colour till 83 DAF and finally became deep orange in colour during fruit ripening stage. Although, change in juice colour

Table 7. Changes in fruit colour of passion fruit genotypes at different stages of fruit maturity.

Genotype	Fruit colour (Days after fruit set)												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	G	G	G	G	G	G	LG	GP	LP	LP	P	DP	DP
Nagaland Purple	G	G	G	G	G	G	LG	GP	LP	LP	P	DP	DP
P. edulis f. *flavicarpa*													
Kerala Yellow	G	G	DG	DG	DG	DG	LG	LG	GY	GY	LY	Y	Y
RCPS-1	G	G	DG	DG	DG	DG	LG	LG	GY	GY	LY	Y	Y
Panama Yellow	G	G	DG	DG	DG	DG	LG	LG	GY	LY	LY	Y	Y
P. alata	G	G	G	G	G	G	G	G	LY	LY	LY	DY	DY

G = green; P = purple; Y = yellow; DG = dark green; DP = deep purple; DY = deep yellow; LG = light green; LP = light purple; LY = light yellow; GP = greenish purple and GY = greenish yellow

Table 8. Changes in juice colour of passion fruit genotypes at different stages of fruit maturity.

Genotype	Juice colour (Days after fruit set)												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	W	W	W	LY	YO	O	O	O	YO	YO
Nagaland Purple	-	-	-	W	W	W	LY	YO	O	O	O	YO	YO
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	W	Y	Y	O	O	O	O	O	O	O
RCPS-1	-	-	-	W	Y	Y	O	O	O	O	O	O	O
Panama Yellow	-	-	-	W	Y	Y	O	O	O	O	O	O	O
P. alata	-	-	-	W	W	W	O	O	O	O	O	DO	DO

W = whitish; Y = yellow; O = orange; LY = light yellow, YO = yellowish orange and DO = deep orange

from whitish to yellowish orange started quite early during fruit growth and development but flavour in fruit juice was started at 62 DAF in purple type and at 83 DAF in yellow type and *P. alata.* However, all the genotypes showed the quality flavour in juice at 90 days of fruit harvesting as well as in dropped fruits (Table 9). These findings are in consonance with the findings of Kishore *et al*. (7) and Singh *et al*. (15) in passion fruit.

Based on these finding, the following indices might be taken as the basic criteria for judging the maturity of passion fruit (Table 10).

Table 9. Changes in juice flavour of passion fruit genotypes at different stages of fruit maturity.

Genotype	Juice flavour (Days after fruit set)												
	13	20	27	34	41	48	55	62	69	76	83	90	Dropped
Passiflora edulis													
Megha Purple	-	-	-	-	-	-	-	Very less	Mild	Mild	Good	Good	Very good
Nagaland Purple	-	-	-	-	-	-	-	Very less	Mild	Mild	Good	Good	Very good
P. edulis f. *flavicarpa*													
Kerala Yellow	-	-	-	-	-	-	-	-	-	-	Mild	Good	Good
RCPS-1	-	-	-	-	-	-	-	-	-	-	Mild	Good	Good
Panama Yellow	-	-	-	-	-	-	-	-	-	-	Mild	Good	Good
P. alata	-	-	-	-	-	-	-	-	-	-	Mild	Good	Good

Table 10. Maturity indices for passion fruit genotypes.

Index	*P. edulis* Sims	*P. edulis* f. *flavicarpa* Degener	*P. alata*
Days from fruit set to harvesting	> 83	> 90	> 90
Fruit colour	Purple to deep purple	Yellow	Deep yellow
TSS (%)	>14.5-15	>16	>18
Acidity (%)	<3.5	<4.50	<1.42

REFERENCES

1. A.O.A.C. 2000. *Official Methods of Analysis* (17th Edn.), Association of Official Analytical Chemist, Washington, DC.
2. Chandra, R. 1990. Biochemical changes during maturity and storage in guava fruits. *Indian J. Hill Fmg*. **8**: 16-21.
3. Deka, B.C., Sharma, S. and Borah, S.C. 2006. Post harvest management practices of mandarin. *Indian J. Hort*. **63**: 251-55.
4. Deka, B.C., Saikia, A. and Pal, R.K. 2007. Physico-chemical changes of pineapple at different stages of maturity. *Indian J. Hort*. **64**: 464-66.
5. Dubey, A.K., Nath, A. Patel, R.K., Babu, K.D. and Yadav, D.S. 2002. Standardization of maturity indices of Kinnow under Meghalaya conditions. *Progr. Hort.* **34**: 119-22.
6. Dubey, A.K., Patel, R.K. and Singh, A.K. 2003. Standardization of fruit maturity indices in *Khasi* mandarin (*Citrus reticulata* Blanco.) under Meghalaya. *Ann. Agric. Res*. **24**: 559-62.
7. Kishore, K., Bharali,R., Pathak, K.A. and Yadav, D.S. 2006. Studies on ripening changes in purple passion fruit (*Passiflora edulis* Sims). *J. Fd. Sci. Tech*. **43**: 599-602.
8. Lamare, Rikadakini. 2009. Physico-chemical changes of *Sohshang* (*Elaegnus latifolia* L.) at different stages of maturity and storage. A M.Sc. (Agril.) thesis submitted to CAU, Imphal.
9. Mercado-Silva, E., Benito-Bautistab, P. and Garcia-Velascoa, M.A. 1998. Fruit development, harvest index and ripening changes of guavas produced in central Mexico. *Post harvest Biol. Tech*. **13**: 143-50.
10. Neeraj, M.S. and Bhatia, S.K. 2002. Effect of plastic packaging on biochemical parameters of fruits during storage- A review. *Haryana J. Hort. Sci*. **31**: 1-7.
11. Rajput, S.S., Pandey, S.S. and Sharma, H.G. 1999. A study on physico-chemical changes associated with growth and development of mango (*Mangifera indica* L.) fruits. *Orissa J. Hort*. **27**: 17-22.
12. Ram, H.B., Jain, S.P., Tripathi, A.K. and Singh, S. 1983. Composition of aonla fruits during growth and development, Part 1. *Indian Food Packer*, **37**: 57-61.
13. Selvaraj, Y., Kumar, R. and Pal, D.K. 1989. Changes in sugars, organic acids, amino acids, lipid constituents and aroma characteristics of ripening mango (*Mangifera indica* L.) fruit. *J. Fd. Sci. Tech.* **26**: 308-13.
14. Shivasankar, S. and Kumar, V. 1999. Pattern of fruit development in six banana varieties. *Indian J. Plant Physiol*. **4**: 286-88.
15. Singh, A., Patel, R.K., Babu, K.D. and Bhuyan, M. 2006. Flowering, fruiting and ripening physiology of passion fruit. *Env. Ecol.* **245**: 693-97.

Received : January, 2013; Revised : July, 2014;
Accepted : August, 2014