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# Dynamics of physico-biochemical changes in Passion fruit varieties across maturity

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**Abstract**
This study was undertaken to evaluate the physico-biochemical changes of three passion fruit varieties *viz.* Yellow, Purple and Kaveri at three different maturity stages classified according to the peel colour as green mature, turning, and full ripe under natural ripening process. The results showed that properties of fruits were significantly changed corresponding to different maturity levels. The fruit length, breadth and weight increased gradually from initial green mature stage to turning stage thereafter, slightly decline at full ripe stage in all the varieties. TSS of fruit juice increased with the advancement of maturity in all the varieties with Purple variety exhibiting the highest TSS content (16.23 °B) at full ripe stage. Ascorbic acid content, total sugar, reducing sugar and β-carotene content showed increasing trends across maturity in all the varieties. Kaveri recorded the highest ascorbic acid content (43.97 mg/100 g) and reducing sugar (7.26 %) while Purple variety recorded maximum total sugar (15.67 %) and Yellow variety exhibited highest β-carotene content (3.92 µg/100 g) at full ripe stage. Acidity increased across maturity followed by a reduction at full ripe stage in all the varieties of which Yellow variety recorded maximum of 4.23 % at full ripe stage. The decrease in acidity coincided with increase in juice pH. Meanwhile, a decreasing trend in total phenols was observed in all the three varieties with the advancement in maturity. The maximum fruit juice content was extracted from the variety Kaveri with 34.53 % closely followed by Yellow variety with 33.98 % at full ripe stage.

**Keywords:** Passion fruit, varieties, physico-biochemical changes, maturity, ripening

## Introduction
Passion fruit (*Passiflora edulis* Sims.), a native of tropical America (Brazil), belongs to the family Passifloraceae, a perennial vine with auxiliary tendrils (Dhawan *et al*. 2004) [8] characterized by their exotic and distinctive aroma. Passion fruit is a high value fruit crop having export potential due to its juice flavor. In India, fruits are grown in the Nilgiris, Wynad, Kodaikanal, Coorg and Malabar in the south, Himachal Pradesh in the north. Of late, this crop has gained 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. The fruit plants are grown for fruit consumption or for its juice which are widely used in preparation of beverages or are often added to other fruit juices to enhance aroma due to its unique and delicate flavor. Fruits are utilized only after maturity, as immature fruits are 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*. 2006) [21]. It is known that the quality 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 scanty. Therefore, a study was carried out to evaluate the biochemical changes on the passion fruit varieties with the aim to physicochemically and sensory characterize the fruits harvested at three maturity stages under natural ripening process.

## Materials and Methods
A study was conducted at ICAR Research Complex for NEH Region, Arunachal Pradesh centre, Basar situated at an elevation of 650 m msl during 2015-2016. Ten year old bearing plants of three passion fruit varieties *viz*., *Passiflora edulis* Sims (Purple), *P. edulis* f. *flavicarpa* Degener (Yellow) and Kaveri (a hybrid variety developed through cross between

purple and yellow variety) were selected for study. The experiment was laid out in randomized block design with eight replications and three vines per replication. Few vines from all side of the plant were selected and then fruits were tagged. The fruits from different varieties were harvested at three different stages of maturity, and classified according to the peel colour as green mature (stage I), turning (stage II), and full ripe (stage III). Average fruit length, breadth and weight were measured from five randomly selected fruits from each vine with the help of digital vernier calipers and electronic weighing balance. The fruit juice was extracted from the pulp by squeezing and straining through muslin cloth and 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. The pH of fruit juice was determined by using the pocket pH meter. As far as biochemical analysis was concerned, total soluble solids (TSS) was determined by one drop of the juice calibrated in digital refractometer. Titratable acidity was estimated by titrating against 0.1N sodium hydroxide using phenolphthalein as indicator (AOAC, 2000) [3]. Ascorbic acid content was determined by titrating sample filtrate in 4% oxalic acid using 2, 6 - dichlorophenol indophenol dye to a pink point and expressed as mg/100 g (AOAC, 2005) [4]. Reducing sugar and total sugar was estimated by Nelson-Somogyi method and Anthrone method respectively as described by (Sadasivam *et al.* 2005) [18]. Total phenol was determined using the Folin-Ciocalteau reagent (Singleton and Rossi, 1965) [22]. β-carotene was determined using colorimetric method of (Srivastava and Kumar, 2002) [23]. Data recorded were tabulated and subjected to statistical analysis as outlined by (Gomez and Gomez, 1984) [10]. Significance difference between treatment means was tested through 'F' test and the critical difference (CD) was worked out wherever 'F' value was found to be significant for treatment effect. The results are presented at 5% level of significance (P=0.05).

**Results and Discussion**

Fruit growth (length and breadth) of passion fruit increased from stage-1 (green mature) to stage-11 (turning) thereafter, slightly decline at stage-111 (fully ripe) in all the varieties (Fig. 1 & 2). The fruit length and fruit breadth was recorded highest in Yellow variety at all the stages exhibiting maximum fruit length (7.17 cm) and breadth (6.75 cm) at stage-111 (fully ripe). (Singh *et al*. 2006) [21] reported that growth of passion fruit showed single sigmoid growth curve where there was slight decline in fruit size at 80 days after fruit set. The weight of passion fruit increased from initial stage of fruit growth and thereafter, slightly decreased at fully ripe stage in all the varieties (Fig. 3). Increase in fruit size and weight during initial stage could be due to fast cell differentiation and cell enlargement followed by slow rate (Ram *et al*. 1983) [17]. Initial fruit growth is also mainly associated with rind growth and later on seed and aril. The linear increase in fruit weight at stage-1 and stage-11 and subsequent decline towards fully ripe stage might be due to loss of water from fruits through transpiration (Patel *et al.*, 2014) [15]. Data presented in Table 1 indicated that the TSS of fruit juice increased with the advancement of maturity in all the varieties. The highest TSS content (16.23 °B) was recorded in Purple variety followed by Kaveri with 15.88 °B at full ripe stage. The increase in TSS content is attributed to the hydrolysis of starch to sugars during later stage of harvest maturity according to the behaviour of carbohydrates during fruit ripening. Similar trends were also reported by (Singh *et al*. 2006) [21] in passion fruit, Rajput *et al*. 1999) [16] in mango and (Lamare *et al*. 2013) [13] in S*ohshang*. Acidity in fruits increased from stage-1 up to stage-11 followed by a reduction at stage-111 in all the varieties with Kaveri exhibiting 3.67 %, Purple with 3.28 % and Yellow with 4.23 % respectively at stage-111. The increase in acidity might be attributed to increased biosynthesis of organic acid during early stage of fruit growth and decreased 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*. 1998) [14] in guava and (Kishore *et al*. 2006) [12] in passion fruit. The pH of the juice increased gradually from green mature stage to full ripe stage in all the three varieties (Table 1). The decrease in acidity coincided with increase in juice pH. Increased ascorbic acid content was observed during the three growth stages in all the three varieties with Kaveri recording the highest ascorbic acid content (43.97 mg/100 g) followed by Purple type (42.64 mg/100 g) at fully ripe stage. Higher ascorbic acid content during fruit growth stages might be attributed to the adequate supply of hexose sugars in photosynthetic activity (Patel *et al.* 2014) [15]. The increasing trend of ascorbic acid during growth and development in passion fruits is an exception to what is generally demonstrated in many fruits. This is in agreement with the findings of (Arriola *et al.* 1975) [5] and (Abu-Bakr Ali Abu-Goukh *et al.* 2010) [1] who found that ascorbic acid gradually increased during growth and development of papaya fruit and reaching the maximum value at ripeness. Similar trend of increased in ascorbic acid content at advancing maturity was also reported by (Fawole *et al.* 2013) [9] in pomegranate. The data presented in Table 2 showed an increasing trend in both total and reducing sugar content in fruits at all stages. The maximum total sugar content was recorded in Purple variety (15.67 %) closely followed by Kaveri (15.49 %) at full ripe stage. The increase in sugar content during later stage might be due to hydrolysis of starch into simple sugars and conversion of acids into sugar (Chandra, 1990) [6]. The increase in sugar might also be due to an increase in TSS. Similar trend was also reported by (Selvaraj *et al*. 1989) [19] in grapes, (Kishore *et al*. 2006) [11] in passion fruit and (Deka *et al*. 2007) [7] in pineapple. At the same time the highest reducing sugar content was analyzed in the variety Kaveri (7.26 %) followed by Purple variety (6.99 %) at full ripe stage. The increase in reducing sugar might be due to hydrolysis of polysaccharides (Patel *et al.*, 2014) [15]. A significant increase in β-carotene (Table 3) in all the three varieties of passion fruit were observed with an increase in maturity and ripening of the fruits wherein yellow variety recorded the highest content with 3.92 µg/100 g at full ripe stage. Similar finding was also reported by (Aggarwal and Sandhu, 2003) [2] in kinnow mandarin. Meanwhile there was a decreasing trends in total phenols in all the three varieties with the advancement in maturity (Table 3). The decrease in total phenol has been attributed to the oxidation of polyphenols by polyphenoloxidase during fruit maturity while the decrease in total phenols with advancing fruit maturity had been reported for different pomegranate cultivars by (Shwartz *et al.* 2009) [20]. The maximum juice content was extracted from the variety kaveri with 34.53 % closely followed by yellow variety with 33.98 % at full ripe stage. A similar trend of increasing juice percentage across maturity was also reported by (Fawole *et al.* 2013) [9] while studying the biochemical content during fruit developmental stage in pomegranate fruit var. Bhagwa.

Based on the study, it can be concluded that there was a significant variation in physico-biochemical characteristics studied in three varieties of passion fruit at three different stages. Fruit peel colour, TSS, acidity may be considered as a suggested indices for taking harvest decision in passion fruit.

**Table 1:** Changes in the TSS, acidity and juice pH of passion fruit varieties at different stages of maturity

| Varieties | TSS (°B) | | | Acidity (%) | | | Juice pH | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) |
| Kaveri | 8.55 | 13.55 | 15.88 | 3.07 | 4.33 | 3.67 | 4.02 | 4.11 | 4.24 |
| Purple | 6.43 | 12.23 | 16.23 | 3.87 | 3.99 | 3.28 | 4.13 | 4.23 | 4.43 |
| Yellow | 9.70 | 10.50 | 12.13 | 3.79 | 5.14 | 4.23 | 5.28 | 5.97 | 6.36 |
| Sem ± | 0.52 | 0.44 | 0.73 | - | 0.33 | - | 0.19 | 0.16 | 0.20 |
| CD (0.05) | 1.12 | 0.95 | 1.56 | NS | 0.71 | NS | 0.42 | 0.35 | 0.43 |

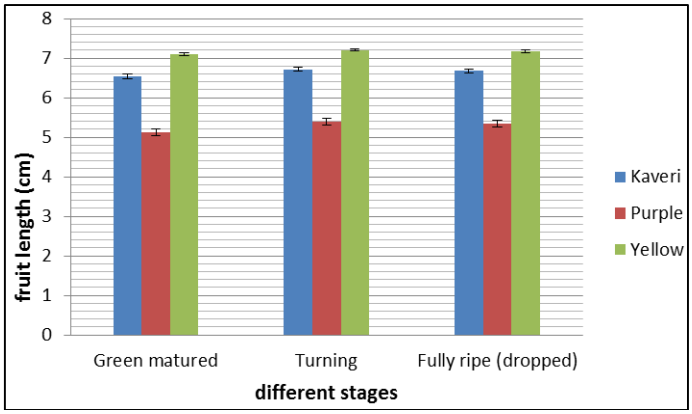


**Fig 1:** Changes in the fruit length of passion fruit varieties across maturity

**Table 2:** Changes in the ascorbic acid content, total and reducing sugar of passion fruit varieties at different stages of maturity

| Varieties | Ascorbic acid (mg/100 g) | | | Total sugar (%) | | | Reducing sugar (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) |
| Kaveri | 38.12 | 40.87 | 43.97 | 11.48 | 14.05 | 15.49 | 5.21 | 6.27 | 7.26 |
| Purple | 38.06 | 41.37 | 42.64 | 12.77 | 13.57 | 15.67 | 5.13 | 5.97 | 6.99 |
| Yellow | 25.56 | 29.82 | 32.15 | 9.92 | 10.96 | 11.97 | 4.22 | 4.96 | 5.33 |
| Sem ± | 1.81 | 1.37 | 1.97 | 0.96 | 0.82 | 0.92 | 0.32 | 0.43 | 0.33 |
| CD (0.05) | 3.89 | 2.93 | 4.22 | 2.06 | 1.76 | 1.96 | 0.68 | 0.93 | 0.72 |

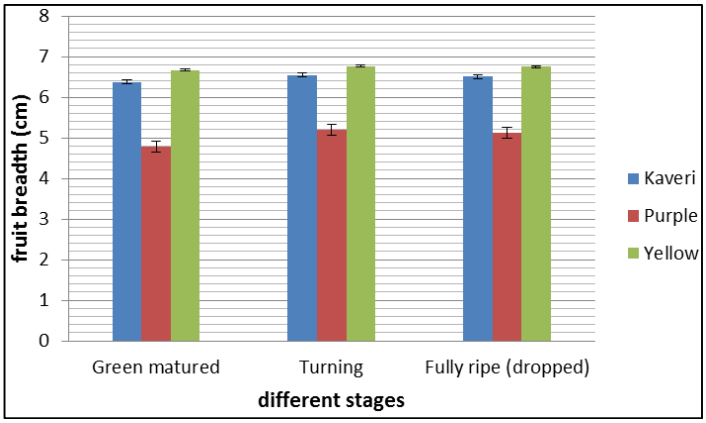


**Fig 2:** Changes in the fruit breadth of passion fruit varieties across maturity

**Table 3:** Changes in the β-carotene, total phenols and juice percentage of passion fruit varieties at different stages of maturity

| Varieties | β-carotene (µg/100 g) | | | Total phenols (mg/100 g) | | | Juice % | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) | Stage-1 (Green mature) | Stage-11 (Turning) | Stage-111 (Full Ripe) |
| Kaveri | 1.17 | 1.50 | 2.59 | 4.93 | 4.40 | 3.82 | 16.49 | 25.98 | 34.53 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Purple | 1.24 | 1.52 | 2.50 | 5.60 | 5.26 | 5.03 | 15.95 | 24.69 | 31.40 |
| Yellow | 3.02 | 3.51 | 3.92 | 4.78 | 4.72 | 4.68 | 17.25 | 26.10 | 33.98 |
| Sem ± | 0.11 | 0.09 | 0.18 | 0.08 | 0.18 | 0.14 | - | - | 1.21 |
| CD (0.05) | 0.24 | 0.18 | 0.40 | 0.17 | 0.39 | 0.29 | NS | NS | 2.60 |

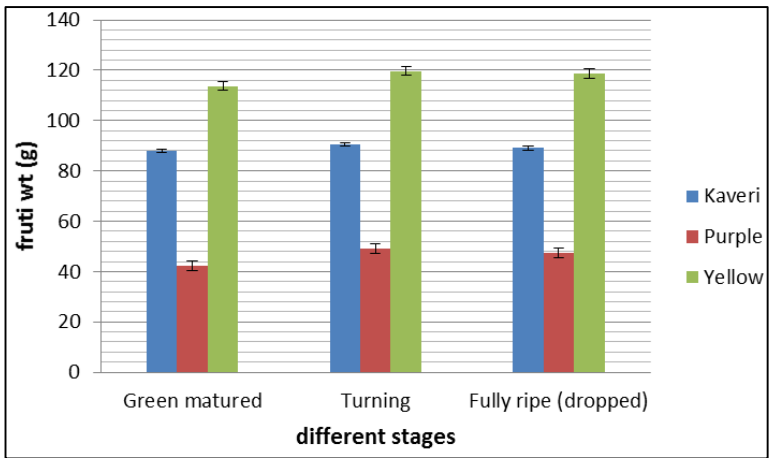


**Fig 3:** Changes in the fruit weight of passion fruit varieties across maturity

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