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Quality characteristics and antioxidant activity of passion fruit (*Passiflora edulis* Sims.) accessions

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ABSTRACT

Passion fruit accessions (yellow and purple types) from various locations in Kerala along with Kaveri, the only released variety of passion fruit in India were collected and characterized based on physico-morphological, nutritive and biochemical parameters. Considerable variation in physical composition, fruit length, fruit diameter, fruit girth, rind thickness and fruit weight was observed among the accessions. Juice recovery ranged from 23.93 to 44.46%in purple types while it was in the range of 15.27 to 40.04% in yellow types. Yellowish orange was the commonly observed colour of the juice in majority of the accessions, followed by light yellow and deep yellow. Nutritional and biochemical characteristics also varied significantly among the different accessions. Purple types had comparatively higher TSS (15.2 to 17.73 °Brix), reducing sugars (2.88 to 8.06%), total sugars (6.31 to 13.04%) and vitamin C (18.62 to 30.50 mg 100g^{-1}) whereas, titratable acidity (3.19 to 4.86%), non reducing sugars (2.63 to 5.27%), total carotenoids (1.19 to 2.81 mg 100g^{-1}), total phenols (18.66 to 27.33 mg 100g^{-1}) and total flavanoids (7.33 to 18.00 mg 100g^{-1}) were higher in yellow types. Antioxidant activity was comparatively higher in yellow types.

Key words: Physico-morphological characters, Nutritional attributes, Biochemical characteristics.

INTRODUCTION

Passion fruit (*Passiflora edulis* Sims.), which is considered as a minor fruit in India, bears a delicious fruit which occurs in purple (*Passiflora edulis* Sims.) and yellow (*Passiflora edulis f. flavicarpa*) fruited forms (Joy, 8). It belongs to the family *Passifloraceae* and is believed to have originated in the Amazon region of Brazil. The fruit is grown mostly in tropical and sub-tropical parts of the world from South America to Australia, Asia and Africa. It was introduced to India during twentieth century in the Nilgiris, Coorg and Malabar areas of southern India. Passion fruit is a perennial, woody vine which produces round or ovoid fruits having a tough, smooth, waxy dark purple/yellow coloured rind with faint, fine white specks. It contains yellowish to orange coloured pulpy juice with large number of small, hard, dark brown to black pitted seeds. It is not used for table purpose because of its high acidity, low juice content and large number of seeds. The juice is delicious with good flavour, intense aroma and sweet-acid taste and is well known for its excellent blending quality. The juice contains very good proportion of acids, sugars, vitamin-A, fibre, phenolic compounds, ascorbic acid (Ramaiya *et al.,* 13) and minerals such as sodium, magnesium, sulphur, chlorides, etc. (Rao *et al.,* 15). Yellow type fruits are generally larger than purple type with yellow mottled spots and turns golden yellow during ripening whereas purple type attains deep purple colour. The juice of yellow type is more acidic and its recovery is comparatively less (25-30%) than the purple type (35-38%) (Rao *et al.,* 15).

With increase in purchasing power coupled with enhanced health consciousness, demand for nutritive food items has been on the rise in recent years. Consequently, owing to the high nutritional and medicinal properties along with the exotic flavour, demand for passion fruit and its processed products has been growing over the years. Even though the high acidity of passion fruit limits its utilisation for table purpose, its intense flavour offers ample scope for processing into numerous value added products like fruit beverages, concentrate, etc. By far the greatest benefit of passion fruit to humankind is its fruit and the delicious juice made from it. Passion fruit juice is highly acidic due to predominance of citric and malic acid. The strong and intense flavour of passion fruit offers ample scope for processing it into a refreshing fruit nectar (Kishore *et al.*, 10). The bioactive compounds in passion fruit, particularly the antioxidants are believed to possess free radical scavenging property and are therefore, considered to be a natural remedy against oxidative stress induced degenerative diseases. Some phenolic compounds identified in *Passiflora* species showed therapeutic

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effects like immunomodulation, anticarcinogenic and antioxidant activities (da Silva *et al.,* 5).

Therefore, a comprehensive study was undertaken to assess the quality characteristics of passion fruit accessions found across Kerala, in terms of horticultural traits, biochemical and nutritional attributes. The study would further help in the identification of promising types which could result in their large scale multiplication, cultivation and subsequent utilization in processing industries.

MATERIALS AND METHODS

The present investigation was carried out with accessions of passion fruit collected from different parts of Kerala. These accessions were compared with Kaveri, the only variety of passion fruit released in India. The investigation was carried out in the Department of Post Harvest Technology, College of Horticulture (KAU), Vellanikkara, Thrissur during 2014-2016.

Passion fruit accessions (yellow and purple types) were collected from various locations in Kerala. Kaveri, the only variety of passion fruit released in India by the Central Horticultural Experiment Station (CHES), Chettalli, a sub-station of the Indian Institute of Horticulture Research (IIHR), Bengaluru, which is a purple fruited type was used as check variety (Table 1).These accessions were characterized based on physico-morphological and biochemical parameters, of which special emphasis was given to determine the antioxidant activity. Fruit length, fruit diameter and rind thickness of ten fruits of each accession was measured by using vernier calliper and the average of these values was expressed in centimetre. Similarly, fruit girth was taken with the help of a thread and accordingly, the girth was determined on a scale in centimetre. Fruit size was expressed by the method suggested by Ramaiya *et al.* (13). Rind colour was expressed as yellow or purple based on the external colour of the fruit. Fruit weight of ten fruits was taken by using a weighing balance and the average values were expressed in gram. Colour of the juice was determined by visual observation and was expressed as described by Patel *et al.* (11). For juice percentage, juice extracted from each fruit of a single accession was weighed separately and the average was calculated by the formula, Juice (%) = [Weight of juice (g)/Weight of fruit (g)] × 100. For physical composition, weight of each physical component of fruits of a single accession was taken separately and its proportion to the total weight of the fruit was expressed by the formula, Physical composition (%) = [Weight of physical component (g)/Weight of fruit (g)] × 100.

Biochemical parameters like titratable acidity, ascorbic acid, total carotenoids and total phenols were estimated as per the procedure suggested by AOAC (1) whereas reducing sugars, non-reducing sugars and total sugars were determined as per the method suggested by Ranganna (14). Total flavanoids were estimated as per the procedure suggested by Chang *et al*. (4). Total soluble solids (TSS) were determined by using hand refractometer. Antioxidant activity was determined by the method suggested by Braca *et al.* (3) wherein, 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) was used as the free radical compound.

Table 1. Passion fruit accessions from various locations in Kerala and Karnataka.

Accessions	Type	Location
Acc. 1	Yellow	Ambalavayal, Wayanad, Kerala
Acc. 2	Purple	
Acc. 3	Yellow	Vellanikkara, Thrissur, Kerala
Acc. 4	Yellow	Mannuthy, Thrissur, Kerala
Acc. 5	Purple	Thiruvalla, Pathanamthitta, Kerala
Acc. 6	Yellow	
Acc. 7	Yellow	Athirampuzha, Kottayam, Kerala
Acc. 8	Yellow	Pineapple Research Station (PRS), Vazhakulam, Ernakulam, Kerala
Acc. 9	Purple	
Acc. 10 (Kaveri)	Purple	CHES, Chettalli, Kodagu, Karnataka

RESULTS AND DISCUSSION

Wide variation in physico-morphological (Table 2) and biochemical attributes (Table 3) was found in passion fruit accessions collected from various locations spread across Kerala and Karnataka.

Fruit length of passion fruit accessions varied significantly and ranged from 5.33 to 6.63 cm and 5.70 to 6.96 cm in yellow and purple types, respectively. Similar range in fruit length of passion fruit was reported by Joy (8) and Ramaiya *et al.* (13). Fruit diameter also varied significantly and ranged from 5.70 to 6.36 cm in yellow types whereas it was in the range of 5.63 to 7.10 cm in the purple ones. These findings are in accordance with those reported by Ramaiya *et al.* (13) and Patel *et al.* (11). Considerable variation in fruit girth was observed among accessions. It varied from 18.30 to 21.16 cm and 19.20 to 22.83 cm in yellow and purple types, respectively. Fruit size to a very great extent is dependent on genetic, environmental and cultural factors. Significant variation in rind thickness was seen among the accessions. It varied from 0.46 to 0.70 cm in yellow and 0.46 to 0.96 cm in purple types. In the present study, the maximum rind thickness of

0.96 cm reported in Acc. 2 (yellow) is in contrast with those reported by da Silva *et al.* (7), wherein a range of 0.56 to 0.58 cm in rind thickness was observed. Rind thickness of the check variety was only 0.63 cm. Santos *et al.* (16) also reported a lower range of 0.32 to 0.35 cm rind thickness in yellow type passion fruit. Rind thickness contributes to fruit weight as rind is the major physical component in passion fruit. Fruit

Table 2. Physico-morphological characteristics of passion fruit accessions.

Accessions	Fruit size (appearance)		Fruit girth (cm)	Rind thickness (cm)	Fruit weight (g)	Physical components (%)			Colour of rind	Colour of juice
	Fruit length (cm)	Fruit diameter (cm)				Juice	Rind	Seed		
Acc. 1 (Y)	6.63	6.36	20.00	0.70	97.96	40.04	45.37	14.74	Yellow with white specks	Yellowish orange
Acc. 2 (P)	6.40	6.76	21.10	0.96	86.17	28.78	56.39	14.84	Deep purple with white specks	Deep yellow
Acc. 3 (Y)	5.66	6.26	21.16	0.60	65.98	28.94	57.54	13.50	Yellow with white specks	Light yellow
Acc. 4 (Y)	6.00	6.16	20.20	0.70	84.08	30.74	58.49	10.75	Yellow with white specks	Light yellowish orange
Acc. 5 (P)	6.86	6.43	21.06	0.46	98.26	46.46	37.78	15.73	Purple with white specks	Yellowish orange
Acc. 6 (Y)	5.66	5.86	18.66	0.66	79.64	31.26	53.20	15.52	Yellow with white specks	Yellowish orange
Acc. 7 (Y)	5.33	5.70	18.30	0.46	62.73	15.27	78.12	6.58	Light yellow with white specks	Light yellow
Acc. 8 (Y)	6.23	6.10	19.30	0.50	87.15	36.60	51.91	11.47	Yellow with white specks	Deep yellow
Acc. 9 (P)	6.96	7.10	22.83	0.70	82.66	27.17	62.96	9.84	Light purple with white specks	Yellowish orange
Acc. 10 (P)	5.70	5.63	19.20	0.63	55.83	23.93	57.58	18.47	Deep purple with white specks	Light yellow
CD 0.05	0.38	0.39	1.38	0.16	15.14	7.57	9.45	2.74	-	-

Y: Yellow type; P: Purple type

Table 3. Biochemical characteristics of passion fruit accessions.

Accessions	TSS (°Brix)	Titratable acidity (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Vitamin C (mg $100g^{-1}$)	Total carotenoids (mg $100g^{-1}$)	Total phenols (mg $100g^{-1}$)	Total flavanoids (mg $100g^{-1}$)
Acc. 1 (Y)	16.00	4.22	3.45	5.27	8.71	22.16	1.61	20.66	11.33
Acc. 2 (P)	16.43	3.17	8.06	4.98	13.04	18.62	2.43	22.66	13.33
Acc. 3 (Y)	13.33	3.92	5.36	4.48	9.85	21.09	1.19	19.33	18.00
Acc. 4 (Y)	12.66	3.64	4.92	4.27	9.20	23.05	1.53	18.66	7.33
Acc. 5 (P)	17.73	3.66	4.86	1.44	6.31	30.50	1.51	17.33	12.00
Acc. 6 (Y)	13.33	4.86	2.34	2.63	4.98	16.98	1.47	27.33	17.33
Acc. 7 (Y)	14.60	3.19	6.41	4.38	10.80	19.60	2.46	22.66	14.66
Acc. 8 (Y)	14.93	3.64	6.03	4.11	10.14	20.90	2.81	24.00	7.33
Acc. 9 (P)	17.13	2.87	2.88	3.91	6.80	20.90	1.07	24.00	6.33
Acc. 10 (P)	15.20	3.15	6.68	4.16	10.84	21.08	1.98	24.66	9.00
SE ±	0.48	0.19	0.32	0.41	0.56	1.22	0.25	1.49	1.96
CD 0.05	1.44	0.57	0.99	1.21	1.67	3.64	0.77	4.42	5.82

Y: Yellow type; P: Purple type

weight varied significantly from 62.73 to 97.96 g in yellow and from 55.83 to 98.26 g in purple types. Fruit weight contributes to marketability. The check variety Kaveri recorded the lowest fruit weight (55.83 g).The findings are in conformity with those reported by Arjona *et al.* (2) and Ramaiya *et al.* (13). Juice percentage of accessions varied significantly from 15.27 to 40.04% in yellow and from 23.93 to 46.46% in purple types. The check variety had the lowest juice percentage among purple accessions. These findings are in agreement with those reported by da Silva *et al.* (7) and Arjona *et al.* (2). Accessions with high juice content can be utilised in processing industries. Significant variation in rind percentage was also observed among accessions which ranged from 45.37 to 78.12% in yellow, whereas it was from 37.78 to 62.96% in purple types. The finding is in consonance with the one reported by Arjona *et al.* (2). Seed percentage also varied significantly which ranged from 6.58 to 15.52% in yellow type and from 9.84 to 18.47% in purple ones. Similar range in percentage of rind and seed was reported by da Silva *et al.* (7).

Colour of rind and juice are presented in Table 2. Rind colour in Acc. 1, 3, 4, 6, and 8 were yellow with white specks whereas in accession 7, it was light yellow with white specks. The rind colour in Acc. 5 was purple with white specks. Colour of the rind in Acc. 9 was light purple with white specks while it was deep purple with white specks in Acc. 2 and 10. Patel *et al.* (11) observed deep purple colour in Megha Purple and Nagaland Purple, yellow colour in Kerala Yellow, RCPS-1 and Panama Yellow, deep yellow colour in *Passiflora alata* types of passion fruit. Yellowish orange was the commonly observed juice colour in majority of the accessions, followed by light yellow and deep yellow. However, juice colour of yellow fruited accessions varied from light yellow to deep yellow while in purple types, the commonly observed juice colour was yellowish orange. Patel *et al.* (11) observed the colour of juice in passion fruit cultivars as yellowish orange in Megha Purple and Nagaland Purple, orange in Kerala Yellow, RCPS-1 and Panama Yellow, deep orange in *Passiflora alata* types of passion fruit.

Considerable variation in biochemical attributes, including antioxidant activity was found among the accessions (Table 3). TSS of passion fruit accessions ranged from 12.66 to 16.00 Brix in yellow and 15.20 to 17.73 Brix in purple types, respectively, whereas, the TSS of check variety Kaveri is 15.20 Brix. The desirable level of TSS in passion fruit is in the range of 15 to 16 Brix. The level of photosynthate accumulation is the cumulative effect of genotypic and growing conditions. These results are in conformity with those reported by Ramaiya *et al.* (13) and Patel *et al.* (11). Titratable acidity of yellow types was in the range of 3.19 to 4.86% while that of purple ones was from 2.87 to 3.66%. This is in contrast with the findings of Silva *et al.* (17) who reported that the titratable acidity in yellow passion fruit was in the range of 4.99 to 5.53% while Ramaiya *et al.* (13) reported a titratable acidity of 3.03% in yellow and 1.80% in purple types of passion fruit. The variation in titratable acidity when compared to the earlier findings might be due to the influence of the environmental and cultural factors during the fruit growth and developmental phases. The reducing sugars which are mainly responsible for sweetness were predominant in accessions with purple type fruits. Considerable variation in sugar content was observed among accessions in which the reducing sugar content ranged from 2.34 to 6.41% in yellow and 2.88 to 8.06% in purple types, respectively. The non reducing sugar content was in the range of 2.63 to 5.27% in yellow and 1.44 to 4.98% in purple types respectively. Total sugar content in yellow types was in the range of 4.98 to 10.80%, while in purple ones it ranged from 6.31 to 13.04%. These findings are in accordance with those reported by Patel *et al.* (11). Passion fruit is a good source of ascorbic acid and its content ranged from 16.98 to 23.05 mg $100g^{-1}$ in yellow and 18.62 to 30.50 mg $100g^{-1}$ in purple types, respectively and the ascorbic acid content of Kaveri variety is 21.08 mg $100g^{-1}$. The findings are in conformity with those reported by Patel *et al.* (11) and Joy (8). The accumulation of total carotenoids in fruits is variable according to stage of maturity and systems of cultivation (Pertuzatti *et al.,* 12). In the present study, total carotenoids varied significantly among the accessions and it ranged from 1.19 to 2.81 mg $100g^{-1}$ in yellow and 1.07 to 2.43 mg $100g^{-1}$ in purple types, respectively, while the carotenoid content in Kaveri variety is 1.98 mg $100g^{-1}$. Similar findings were also reported by Pertuzatti *et al.* (12) and Kathiravan *et al.* (9) in yellow passion fruit. Considerable variation in total phenols was observed among passion fruit accessions. Total phenol content varied significantly from 18.66 to 27.33 mg $100g^{-1}$ in yellow types and 17.33 to 24.66 mg $100g^{-1}$ in purple types respectively, while it was 24.66 mg $100g^{-1}$in the check variety Kaveri. These findings are in accordance with those reported by Ramaiya *et al.* (13); the total phenols in fresh passion fruit juice is dependent mainly on species/cultivars and level of ripeness. Significant variation in total flavanoids was observed among passion fruit accessions and it ranged from 7.33 to 17.33 mg $100g^{-1}$ in yellow types and from 6.33 to 13.33 mg $100g^{-1}$ in purple ones respectively. Wide variation in antioxidant activity was observed among passion fruit accessions (Fig. 1) in which the inhibitory

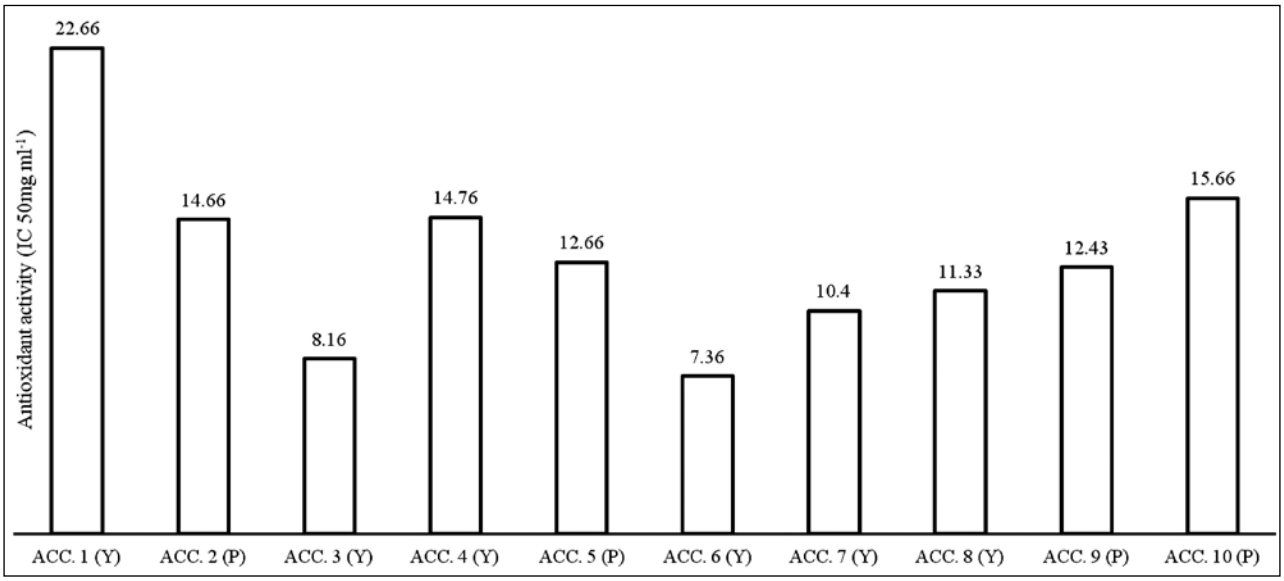

Fig. 1: Antioxidant activity of passion fruit accessions.

Y: Yellow type; P: Purple type

concentration of passion fruit juice extract ranged from 7.36 to 22.66 mg ml^{-1} in yellow and 12.43 to 15.66 mg ml^{-1} in purple types, respectively, while the antioxidant activity of the check variety Kaveri is 15.66 mg ml^{-1}. Maximum antioxidant activity in yellow types may be due to higher concentration of total phenols and total flavanoids as compared to purple ones. According to da Silva *et al.* (6) the antioxidant activity of passion fruit is due to the presence of polyphenols which are involved in neutralizing the oxidants. Ramaiya *et al.* (13) reported that the total antioxidant activity ranged from 409.13 to 1964.90 µmol Trolox $litre^{-1}$ in seven different passion fruit cultivars and the strongest antioxidant activity of 547 ± 3.08 µmol Trolox $litre^{-1}$ and 524 ± 1.96 µmol Trolox $litre^{-1}$ was observed in vine ripened purple and yellow passion fruit cultivars respectively.

Based on the findings of the study, it could be said that purple types had comparatively higher TSS, reducing sugars, total sugars and vitamin C whereas, titratable acidity, non-reducing sugars, total carotenoids, total phenols, total flavanoids and antioxidant activity were higher in yellow types. Also, purple types in general have better flavour properties owing to lower levels of acidity and higher TSS. Acc. 5 is ideal for processing purposes due to its high juice recovery, followed by Acc. 1. Acc. 6 can also be popularised for its nutritional properties on account of higher levels of polyphenols, flavanoids and maximum inhibition of DPPH radical scavenging activity.

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