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subbaraman.Sriram@icar.gov.in
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Shankar, K.; Singh, S.R.

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Original Research Papers

Morphological and biochemical characterization of Passiflora quadrangularis L.- A source of vegetable from East Siang district, Arunachal Pradesh, India

K. Shankar rawkripa.s99@gmail.com
Central Agricultural University, India
S.R. Singh
Central Agricultural University, India

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Abstract: Present research investigation was aimed at morphological and biochemical assessment of Passiflora quadrangularis L. commonly known as giant granadilla and locally called as vegetable squash grown as vegetable crop by the Adi tribe of Arunachal Pradesh. Seven genotypes collected during survey were characterized for different morphological and biochemical traits. Results showed that average fruit weight was 432.57g/fruit, with juice content 100.11 mL/fruit, vitamin C content 25.79 mg, vitamin A content 1.65 mg, Mean total flavonoids content was 16.75 mg/100 g of fruit juice, total soluble solids 12.040 Brix, antioxidant activity (DPPH) 6.07 %, titratable acidity 1.69 %, total carbohydrates 9.95 %, phenol content 338.38 mg/100 g of leaf was noted among the genotypes tested. The mean anthocyanin content in leaf was 1.20 mg/100 g, tendril 0.90 mg/100 g and petiole 1.69 mg/ 100 g among the genotypes. Seed protein profiling of Passiflora quadrangularis L. with SDS- PAGE showed diverse molecular weights ranging from 11 KD to 163.53 KD. However, monomorphic banding pattern among the protein profiling of giant granadilla was recorded among the selected genotypes. The results of the study show that the collected genotypes are belonged to Passiflora quadrangularis L. and are good source of nutritive value which can be used as source of vegetable.

Keywords: Giant granadilla, *Passiflora quadrangularis* , SDS-PAGE , vegetable source.

INTRODUCTION

Passiflora quadrangularis L. commonly known as Giant granadilla, belongs to Passifloraceae family consists of about 700 species and 16 genera and among them only two genera, Passiflora and Tetrapathaea are cultivated (Feuillet, 2004) and about 520 species of the genus Passiflora are distributed to Neotropics and Africa (Ulmer and MacDougal, 2004). The most important genus is Passiflora, with the most common commercial species being the purple passion fruit (Passiflora edulis) for the fresh market and the more acid yellow passion fruit (Passiflora edulis f. flavicarpa) for the juice industry (Tripathi et al., 2014). Leaves of purple and yellow passion fruit are used as leafy vegetable in Manipur and also used as folk traditional medicine as anti-diabetic (Singh et al., 2014). The total area under passion fruit cultivation is about 0.014 million hectares

with a production of 0.082 million tonnes in India during 2020 (Anon, 2020). P. quadrangularis L. is a lesser-known member of the genus also grown for its fruit as well as vegetable. It is locally known as vegetable squash by the Adi tribe of Arunachal Pradesh.

This novel P. *quadrangular* is helps the rural sectors in mitigating the malnutrition and hence enabling them a quality life. During investigation it was observed that P. quadrangularis L. is grown by the Adi tribe of Arunachal Pradesh and sold as squash in the market. However, very few systematic, inventory and documentation about the Passiflora species found in Northeast India and sporadic attempts have been made on characterization of passion fruit found in Arunachal Pradesh. Therefore, the present research was initiated to explore and document for the morphological and biochemical characteristics features of P. quadrangularis L. found in East Siang district of Arunachal Pradesh.

MATERIALS AND METHODS

Survey was carried out in East Siang district of Arunachal Pradesh during the year 2019-2020 which is located at 28p 03'N, 95p 20'N covering an area of 1865 sq. km. and having the altitude of 176.57m above MSL and represent a mild subtropical zone with cool, dry winter, a warm summer and a moderate season. The identification and description of the plant were adopted from De Jesus et al. (2017). During the survey, Passiflora species viz. purple passion fruit, yellow passion fruit and giant granadilla were found growing in East Siang district. Data on passion fruit uses were obtained through interview of knowledgeable elderly people of Adi tribe (both genders of 30-75 ages) inhabiting in the East Siang district to which the P. quadrangularis L. identified on the basis of vernacular name, regional floras and published literatures (Singh et al., 2003). Totally seven genotypes were collected during the survey and the passport information of the collected genotypes are presented in Table 1. The collection of fruits and leaves have been done from different direction of single plant. Fifty fruits were collected from each genotype and every replication had 10 fruits with five replications.Recorded morphological traits viz., leaf length (cm), leaf breadth (cm), flower length (cm), number of flowers/node, peduncle length (cm), fruit length (cm), fruit breadth (cm), fruit weight (g), number of fruits/vine, fruit yield (kg/vine), peel weight (g), seed length (cm), seed breadth (cm), number of seeds/fruit and seed weight/fruit. Biochemical traits viz., juice content (mL/fruit), total soluble solid content (°Brix), titratable acidity (%) (AOAC, 2006), Vitamin C content (mg/100 g) (Ranganna, 1986), total carbohydrate (%) (Hedge, 1962), reducing sugar (%) (Somogyi, 1952), Vitamin A (mg/100 g) (Bayfield and Cole, 1980), total flavonoid (mg/100 g) (Vijay and Rajendra, 2014), and antioxidant activity (%) (AOAC, 2006). Anthocyanin content (mg/100 g) of leaf, tendril and petiole (Malick and Singh, 1980), vitamin C content of leaf (mg/100 g) (Ranganna, 1986) and phenol content of leaf (mg/100 g) using FolinCiocalteu reagent (Malick and Singh, 1980) and

chlorophyll content of leaf (mg/g) (Arnon, 1949) and shelf life (days) at room temperature were estimated for the collected genotypes.

Seed protein extraction

Seed protein extraction was as described Lowry et al. (1951) in seven genotypes and was carried out protein banding pattern was determined using SDS-PAGE as described by Laemmli (1970). 0.2 g of seeds were soaked overnight in phosphate buffer (pH 7.0) solution. Seeds were crushed with a solution of TrisHCl 0.06 M (PH 7.4), 10 mM urea, 1 mM EDTA, 0.1% TCA, 2.5% glycerol, 0.5% SDS and 1.25% β-mercaptoethanol. Electrophoresis was performed in vertical electrophoresis unit and gel run at 25 mA. Silver staining was performed as described by Mortz et al. (2001) and sensitizing with 0.02% sodium thiosulphate solution. The reaction was stopped with 12% acetic solution. Gel was washed thoroughly but gently with double distilled water until protein bands became clearly visible for bands scoring. The electrophorograms developed on protein mobility and density expressed in Rm values. The gels were scored as presence (+) or absence (-) of protein bands. Depending upon the presence (+) or absence (-) of bands, similarity index between the genotypes were calculated (Nei and Li, 1979).

Data analysis

The statistical analysis *viz.*, standard error of mean, coefficient of variance and test of significance were performed by following Singh and Chowdhury (1985).

RESULTS AND DISCUSSION

Morphological characters are important for identification and documentation of horticultural traits for crop improvement. A large variability having unique characters was recorded for morphological traits of fruits and other plant parts of the collected giant granadilla (Fig 1a and Fig 1b). There are no significant variations in different qualitative traits recorded. All the accessions had quadrangular stem, large green cordate leaves having entire margin and leaf lamella. Leaf had deep sinus, stipule and heterophylly was absent. All the lines showed axillary tendrils bearing 2.33 to 3.00 flowers/node. Flowers had light red color petals and sepals are green from outside and whitish pink from inside with yellowishgreen ovary. The flowers possess yellowish green stamens with violet dots, blue, brown speckled corona. All the lines produced light yellowish brown oblong fruits possessing dark brown seeds. The same qualitative characters were also reported by Lim, 2012. Among the genotypes leaf length varied from- 9.95 to 12.08 cm, leaf width from-8.89 to 11.14 cm.

Table 1:
List of collected *Passiflora quadrangularis* L. genotypes from East Siang district, Arunachal Pradesh, India and their sources

S.No.	Genotypes	Code	Source	Latitude	Longitude	Altitude
1	*Passiflora quadrangularis* L.	P1	Pasighat, Arunachal Pradesh	28^0 03' N	95^0 20' N	156 m
2	*Passiflora quadrangularis* L.	P2	CHF, Pasighat, Arunachal Pradesh	28^0 04' N	95^0 19' N	183 m
3	*Passiflora quadrangularis* L.	P3	Baptist Church, Pasighat, Arunachal Pradesh	28^0 05' N	95^0 18' N	192 m
4	*Passiflora quadrangularis* L.	P4	Agami House, Pasighat, Arunachal Pradesh	28^0 06' N	95^0 31' N	168 m
5	*Passiflora quadrangularis* L.	P5	Police line, Pasighat, Arunachal Pradesh	28^0 05' N	95^0 32' N	166 m
6	*Passiflora quadrangularis* L.	P6	Teachers Residence, Pasighat, Arunachal Pradesh	28^0 03' N	95^0 19' N	159 m
7	*Passiflora quadrangularis* L.	P7	Tekang, Pasighat, Arunachal Pradesh	28^0 04' N	95^0 22' N	212 m

Flowers are 8.40 to 9.41 cm in length which was maximum among other cultivated passion fruit. Significant variation for quantitative traits like peduncle length, fruit length, fruit breadth, fruit weight and peel weight, seed length, seed breadth, number of seeds/fruit and weight of seeds/fruit were recorded (Table 2a and 2b).

This Passiflora species is commonly used as vegetable in unripe stage having an average yield of 15.88 to 23.89kg/vine. Fruit juice content of giant granadilla was about 53.39 to 131.04 mL/fruit which was maximum in comparison to other Passiflora species because of bigger size of fruits. This finding was similar with the result of Arjona and Matta, 1991. Based on the yield and yield attributing traits genotypes for leaf length (P7; 12.08 cm), number of flowers per node (P6; 3.67), fruit weight (P1; 488.33), number of fruits/vine (P2; 51.33), peel weight (P1; 352.33), number of seeds/fruit (P1; 172) and flower length (P7; 9.41 cm) were identified. Selecting the genotypes with large leaf and flower aid in imparting

Table 2a:
Morphological characters of *Passiflora quadrangularis* L. genotypes from East Siang district, Arunachal Pradesh

Genotyps	Leaf Length (cm)	Leaf Breadth (cm)	Flower length (cm)	Number of flowers / nodes	Peduncle length (cm)	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)
P1	9.95	8.89	9.15	2.33	2.37	14.60	9.59	488.33
P2	11.64	11.14	8.40	2.67	1.96	13.42	9.11	463.67
P3	10.99	9.48	9.11	2.67	2.50	13.89	11.04	476.67
P4	10.51	9.70	8.77	3.00	2.62	12.19	10.08	408.00
P5	11.25	9.65	9.40	2.33	2.42	11.82	9.84	407.00
P6	11.46	10.19	8.57	3.67	2.52	12.83	10.80	402.67
P7	12.08	10.59	9.41	2.67	2.65	12.43	10.44	381.67
Mean	11.12	9.95	8.97	2.76	2.43	13.03	10.13	432.57
CV (%)	3.18	6.54	5.92	1.14	3.81	4.19	5.96	9.93
SE (m)+	0.78	0.55	0.46	0.38	0.08	0.69	0.52	12.32
C.D (5%)	1.31	1.62	1.36	0.54	0.24	1.59	1.55	3.34

Table 2b:
Morphological characters of *Passiflora quadrangularis* L. genotypes from East Siang district, Arunachal Pradesh

Genotypes	No. of Fruits / vine	Peel weight (g)	Fruit yield (Kg / vine)	Seed length (cm)	Seed breadth (cm)	No. of seeds / Fruit	Seed weight/Fruit (g)
P1	48.00	352.33	23.44	0.77	0.61	172.00	9.33
P2	51.33	320.67	23.86	0.69	0.59	168.00	9.13
P3	42.00	343.33	20.05	0.65	0.61	156.67	8.78
P4	45.33	306.33	18.45	0.68	0.59	157.67	9.03
P5	42.67	304.33	17.36	0.71	0.64	149.67	8.34
P6	45.00	349.67	18.19	0.72	0.64	153.00	9.07
P7	40.67	296.67	15.55	0.71	0.65	168.00	8.83
Mean	45.00	324.76	19.56	0.70	0.62	160.71	8.93
CV (%)	8.04	2.38	4.76	1.10	1.24	2.96	1.60
SE (m)+	4.69	4.90	2.23	0.01	0.02	2.75	0.19
C.D (5%)	2.83	27.11	1.58	0.04	0.04	8.10	0.55

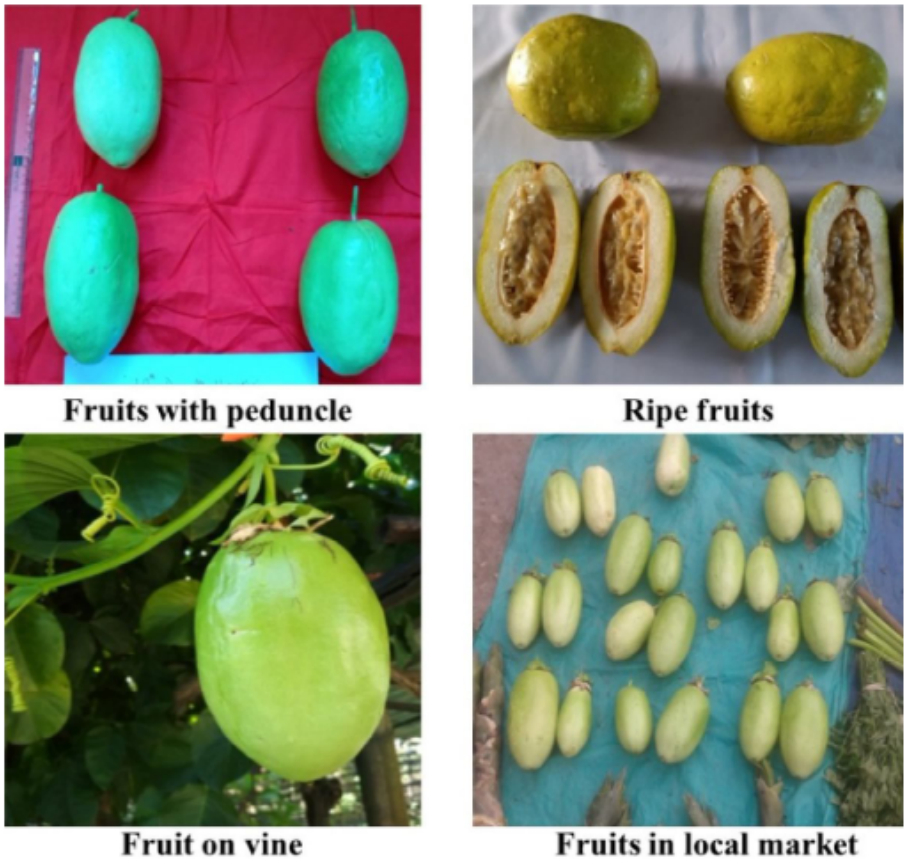

Fig. 1a:
Fruits of *Passiflora quadrangularis* L.

Fig. 1b:
Leaf, flower and ovary colour of *Passiflora quadrangularis* L.

maximum photosynthate accumulation to the sink leading to high crop yield.

Biochemical characteristics

Biochemical characterization also revealed that the TSS content of fruit juice was ranging from 10.26 to 13.44 °Brix which is in agreement with data of Ramaiya et al. (2021) in P. quadrangularis. The higher TSS may be due to the fact the fruit tree is grown under natural water scarce condition

without care and management and eventually increasing the TSS content Meghwal et al. (2004). In giant granadilla, citric acid is the predominated organic acid followed by malic acid that is about 1.49 to 1.80 % which is in conformity to the data of Velente et al. (2011). The high acidity may be due to the prevalence of primary organic acids, such as malic and citric acid, in mature fruits, which accumulate in the mesocarp cells during the fruit development process and are controlled by both genetic and environmental factors. Ascorbic acid varied from 22.45 to 29.53 mg/100 g in fruit juice and 44.78 to 50.15 mg/100 g in fresh leaf and finding similar with Ramaiya et al. (2021).

Total carbohydrate content data showed variation from 9.49 to 10.75 % and is in agreement with Shanmugamet al. (2018). Reducing sugar content was about 5.00to 5.68 % and similar results were reported by Patel etal. (2014). The increasing suga r is due to thehydrolysis of starch to sucrose as fruit approach toripening (Pandy and Deen, 2018). Vitamin A (mg/100 g) content was recorded between 1.62 to 1.69 mg/100g of fruit juice and data was in agreement with Oliveira et al. (2014); Homnava et al. (1990) and itmay be due to biosynthesis genes controls itsaccumulation and composition in fruit during maturity.The DPPH free radical scavenging antioxidant (%)activity was recorded as 5.91 to 6.28 % which is inconformity with Loizzo et al. (2019) and Marroquinet al. (2011). As these fruits are known to contain avariety of antioxidant compounds, and ascorbic acid(vitamin C) which implying that fruits high in vitamin C are powerful antioxidants as reported by Esti et al.(2002).

Chlorophyll content of leaves were ranging from 1.56 to 1.69 mg/g which was an agreement with Do Valle et al. (2018). Phenol content was as 319.67 to 351.32 mg/100 g of fresh leaf and similar data was reported by Rudnicki et al. (2005) and Marroquin et al. (2011). Anthocyanin (mg/100 g) content in leaf, petiole and tendril varied from 1.17 to 1.24 mg/100 g, 1.59 to 1.76 mg/100 g and 0.85 to 0.94 mg/100 g respectively which was in agreement with Aizza et al., 2019 and Reis et al., 2018. The anthocyanin, phenol and chlorophyll concentration of petioles, tendrils and leaves might differ according to a variety of external and internal factors such as genetic, agronomic and climatic factors (Kayesh et al., 2013). Shelf life (days) of Passiflora quadrangularis genotypes at room temperature was recorded maximum for genotype P1 which is 27.22 days at room temperature. It is due to

Table 3:
Biochemical parameters in fruits of *Passiflora quadrangularis* L. genotypes from East Siang district, Arunachal Pradesh

Genotype	Juice content (mL/fruit)	Vit. C (mg/100 g)	TSS (o Brix)	Vit. A (mg/100 g)	Total fla-vonoids (mg/100 g)	Antio-xidant Acti- vity (%)	Titrata-ble Aci-dity (%)	Total carbohy-drates (%)	Reducing sugar (%)	Shelf-lif (days)
P1	123.78	29.53	13.21	1.67	17.42	6.28	1.80	10.75	5.54	27.22
P2	131.04	29.04	12.74	1.61	16.62	6.22	1.49	9.49	5.54	25.57
P3	124.38	22.45	11.90	1.69	16.37	5.98	1.72	9.83	5.29	22.25
P4	92.67	25.66	13.44	1.62	17.20	6.01	1.69	10.29	5.00	18.67
P5	95.03	25.68	11.73	1.64	15.78	6.09	1.69	9.29	5.14	18.67
P6	53.39	23.26	10.97	1.64	16.40	5.91	1.68	9.51	5.21	19.00
P7	80.49	24.93	10.26	1.67	17.45	6.00	1.77	10.48	5.68	25.67
Mean	100.11	25.79	12.04	1.65	16.75	6.07	1.69	9.95	5.34	22.43
CV (%)	4.65	5.35	3.13	1.75	0.69	2.50	2.42	1.59	0.68	3.11
SE (m)+	2.69	0.80	0.22	0.02	0.07	0.09	0.02	0.09	0.02	1.70
C.D (5%)	7.93	2.35	0.64	0.05	0.20	0.26	0.07	0.27	0.06	1.01

Table 4:
Biochemical parameters in leaves, petioles and tendrils of *Passiflora quadrangularis* L. genotypes from East Siang district, Arunachal Pradesh

	Leaf				Petiole	Tendril
Genotypes	Anthocyanin (mg/100 g)	Vit. C (mg/100 g)	Phenol (mg/100 g)	Chlorophyll (mg/g)	Anthocyanin (mg/100 g)	Anthocyanin (mg/100 g)
P1	1.24	47.69	351.32	1.67	1.76	0.94
P2	1.19	50.15	336.33	1.56	1.73	0.92
P3	1.24	47.67	343.00	1.64	1.69	0.91
P4	1.19	44.78	319.67	1.61	1.74	0.89
P5	1.18	46.06	324.33	1.66	1.69	0.92
P6	1.17	48.72	345.00	1.69	1.59	0.88
P7	1.22	46.72	349.00	1.57	1.64	0.85
Mean	1.20	47.40	338.38	1.63	1.69	0.90
CV (%)	1.81	3.75	3.34	1.11	0.80	1.81
SE (m)+	0.01	1.03	12.39	0.01	0.01	0.01
C.D (5%)	0.04	3.03	9.55	0.03	0.02	0.03

the thick exocarp which prevents easy decay under biotic and abiotic stress.

Present investigation recorded a total 70 numbers of bands having molecular weights ranging from 11 KD to 163.53 KD. All the seven selected genotypes found in East Siang District, Arunachal Pradesh exhibited monomorphic banding pattern in the protein profiling of giant granadilla. Beena and Beevy, (2015) also reported the highest molecular weight i.e., 69.94 KD was generated by Passiflora foetida var. hispida, while the lowest (12.95KD) was produced in Passiflora foetida var. *gossippifolia* in *Passiflora species*.

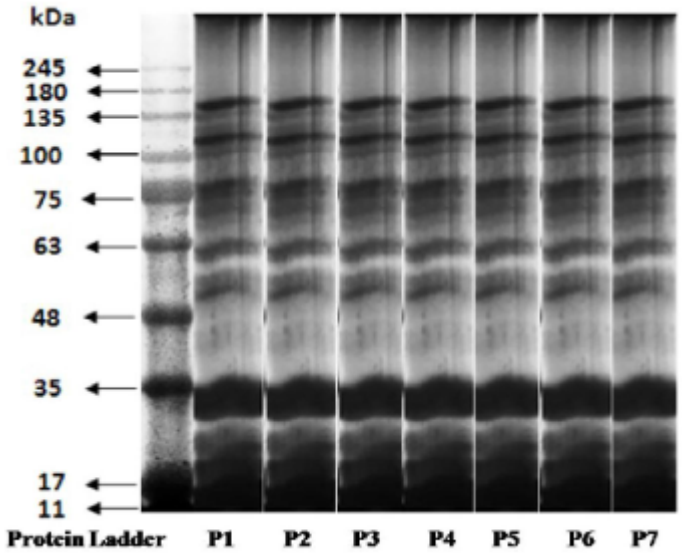

Fig. 2:
SDS-PAGE protein profiling of seven genotypes of *Passiflora quadrangularis* L. from East Siang district, Arunachal Pradesh

From the study of morphological, biochemical and seed protein profiling it could be concluded that all seven genotypes belong to same species i.e., *Passiflora quadrangularis* L. locally known as vegetable squash (by *Adi* tribe of Arunachal Pradesh). As its green fruits and leaves are nutritious this novel underexploited *Passiflora* species can be explored for commercial cultivation as a source of vegetable in the future. Because of its higher fruit yielding capability, the fruits also have a lot of potential in the food processing industry.

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