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Assessment of genetic diversity in guava

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ABSTRACT

An extensive survey was made to the diversity rich areas of Gujarat during the year 2016 and 2017 to earmark the elite guava genotypes having desirable traits in terms of shape, size, pulp colour, seed content, morphological and qualitative attributes of fruits. Twenty five genotypes of seedling origin were studied for their quantitative and qualitative characters. Fruit weight ranged between 53.50-318.50 g; length 4.09-9.53 cm; width 4.30-7.90 cm; length:width ratio 0.86-1.40; seed core length 2.70-5.25 cm, pulp thickness 1.00-2.25 cm; number of seeds fruit^{-1} 55.30-600.00; seed weight fruit^{-1} 0.94-9.12 g; 100 seed weight 0.66-2.95 g and seed texture was found medium soft in most of the genotypes. Similarly, the chemical quality attributes also varied significantly among all the different genotypes. Among the genotypes, the total soluble solids content varied between 10.80-16.33°B; acidity 0.28 to 0.70%; TSS:acidity ratio 20.37-39.82; pectin 0.88-1.42%; ascorbic acid 136.50-280.50 mg/100 g; reducing sugar 4.11-7.45%, non-reducing sugar 1.11-2.83% and total sugars 5.70-9.78% and high variability was also recorded in mineral contents of fruits which ranged from 11.48-17.48 P, 268.37-370.17 K, 16.31-23.18 Ca and 12.62-24.66 mg 100 g^{-1} FW. Lycopene content in pink fleshed guava genotypes ranged from 0.67-2.43 mg 100 g^{-1}. Results of the study revealed that different genotypes exhibited wide range of diversity with respect to quality attributes under rain-fed semiarid conditions of Gujarat.

Key words: *Psidium guajava*, genotype, physico-chemical attributes.

INTRODUCTION

Guava is one the most delicious and popular fruits, widely grown in tropical and subtropical regions of India. It is rich source of vitamin C and minerals and is common raw material in fruit processing industry. Among most of the tropical and subtropical fruit trees guava plants exceed in adaptability, productivity, tolerance to adverse weather conditions and possibility of value addition makes guava an important fruit crop (Tiwari *et al.,* 13). A large number of named cultivars are available in India, only a few like Allahabad Safeda and L-49, occupy the major area under its cultivation. Efforts have been made over past few decades to widen the genetic base through creating new variability or by utilizing natural variability for selection of elite variety (Tiwari *et al.,* 13). In India, it is the fourth and fifth most important fruit crop by area and production, respectively. It occupies an area of 0.27 m ha with a total production of 3.67 mt. In Gujarat, it is mainly grown in Ahmadabad, Bhavnagar, Rajkot and Bharuch districts with a total production 140.80 thousand tonnes from an area of 10.80 thousand ha; the average productivity is 13.0 t ha^{-1} (Anonymous, 1). Guava exhibits high levels of genetic diversity which is due to prevalence of seed propagation in these areas. Therefore, survey was undertaken to find out the diversity in fruit characteristics, and also to select elite seedlings from existing heterozygous seedling population having desirable horticultural traits. The physico-chemical attribute of the fruit are important as high TSS and titrable acidity in fruits along with red pulp are desirable for processing industry and low acidity and high TSS are desirable for fresh consumption (Corrêa *et al.,* 4). For development of improved guava cultivars, a diverse gene pool is essential. Knowledge of the genetic diversity available and the origin of the cultivars would assist in the selection of parents for effective improvement programmes (Singh *et al.,* 12; Hazarika *et al.*, 6). In this regard, Yadav and Shankar (14) identified several elite seedling guava types based on bearing and fruit quality while surveying in Allahabad region. Development of nutrient rich cultivars has been a focus of fruit breeding studies (Corrêa *et al.,* 4). Similar approach has been followed by Singh *et al.* (11) for identification of elite genotypes of wood apple seedling from Gujarat. Keeping above facts in view, an attempt was made to identify elite genotypes and their *ex-situ* establishment in field gene bank for further evaluation and crop improvement.

MATERIALS AND METHODS

The diversity rich areas of semi-arid areas of Gujarat *viz*., Panchmahals, Mahisagar, Vadodara Bharuch, and Bhavnagar were surveyed extensively

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to identify elite guava genotypes during the fruiting season of 2016 and 2017. The detailed about germplsm and their source of collection are given in Table 1. Matured fruits were collected from selected trees to study the physico-chemical characteristics. Ten fruits were randomly selected from all the directions for recording the data and brought to the laboratory of Central Horticultural Experiment Station, Vejalpur, Panchmahal (Godhra), Gujarat. For measuring physical parameters like fruit weight, seed weight and fruit size were recorded as per standard procedures with the help of an electronic balance and vernier caliper respectively. The fruit shape, fruit shape at stalk end and pulp colour were described with the help of standard descriptors for guava prescribed by Rodrguez *et al.* (9). Seed hardness was observed organoleptically. Juice was filtered through filter paper, thereafter, juice samples were subjected to determine the following parameters; titratable acidity (% of citric acid) using N/10 NaOH and phenolphthalein as indicator, total soluble solids (TSS°Brix) using hand refractometer and ascorbic acid (mg 100 g^{-1} pulp) using a dye (2, 6-dichlorophenol indophenol), pectin, sugar contents and Lycopene content (mg100 g^{-1}) according to the standard method of AOAC (2). To determine the mineral contents on fresh weight (FW) basis in fruit pulp, 3g fruit pulp passed through nitric-perchloric (9:4) digestion. Potassium, phosphorus, magnesium and calcium were determined by the method described by Bhargava and Raghupathi (3) and expressed as mg 100 g^{-1} FW. The data were statistically analyzed as per method outlined by Gomez and Gomez (5).

RESULTS AND DISCUSSION

Results on the fruit morphological characters showed wide range of variation amongst different guava genotypes. In all studied genotypes, considerable variability was observed in fruit shape, seed content, peel and pulp colour (Table 1). Fruit morphological characters are complex trait, which depends upon genetic makeup and edapho-climatic conditions and their interaction. The rich diversity in these characters may be due to highly heterozygous and diverse genetic background of parents (Singh *et al.,* 10). Diverse fruit characters in wood apple were also observed by Singh *et al.* (11) while making surveys in Gujarat.

The analysis of variance of 25 guava genotypes studied in this investigation revealed significant differences in various physico-chemical characters of the fruits (Table 2 & 3). The fruit weight of different genotypes ranged between 53.50 and 318.50 g being maximum in GG-8 (318.50 g) followed by GG-7 (292.50 g), GG-19 (262.25 g) and GG-21 (253.66 g). However, the minimum fruit weight was observed in GG-12 (53.50 g) followed by GG-22 (88.20 g) and GG-9 (98.50 g). The diverse fruit weight in different guava genotypes has been reported by Yadav and Shankar (14) in guava, Hazarika *et al.* (6) in hatkora, Singh *et al.* (10) in aonla and Singh *et al.* (11) in wood apple genotypes. Among the different genotypes studied, the maximum fruit length was recorded in GG-21 (9.95 cm), followed by GG-8 (9.53 cm), while the minimum fruit length was recorded in GG-22 (4.09 cm) followed by GG-16 (5.20 cm). The fruit width varied from 4.30 cm in GG-12 followed by 4.50 cm in GG-22 to 8.25 cm in GG-8 followed by 7.90 cm in GG-7. However, highest fruit length: width ratio was recorded in GG-11 (1.45) followed by GG-21 (1.40), whereas it was lowest in GG-15 (0.86). The length of seed core varied from 2.5 to 5.45 cm. The maximum seed core length was recorded in GG-5 (5.45 cm) followed by GG-8 (5.25 cm), whereas, the minimum seed core length was measured in GG-12 (2.50 cm) followed by GG-22 (2.70 cm). The highest pulp thickness was observed in GG-8 (2.30 cm) and least in GG-12 (1.00 cm). The number of seed $fruit^{-1}$ varied between 55.30 to 609 and being the maximum in GG-25 (609.0) followed by GG-20 (600.0) and GG-20 (510.0) and the minimum number of seed $fruit^{-1}$ was recorded in GG-12 (55.30) followed by GG-9 (98) among the studied genotypes of guava. The maximum seed weight $fruit^{-1}$ was recorded in GG-20 (9.12 g) followed by GG-13 (8.16 g), while it was found minimum in GG-12 (0.94 g) followed by GG-19 (1.62 g) and GG-23 (1.85 g). Among the different genotypes, 100 seed weight was recorded highest in fruits of GG24 (2.95 g) and it was lowest in GG16 (0.66 g). It is established fact that the softness of seed influences the quality of fruit, which was found soft in GG-18, GG-19, GG-22 and GG-23; medium soft in GG-1, GG-3, GG-4, GG-5, GG-6, GG-8, GG-10, GG-11, GG-14, GG-15, GG-16, GG-17 and GG-21; medium hard in GG-2, GG-7, GG-9, GG-15 and GG-16 and hard in GG-12, GG-13, GG-20, GG-24 and GG-25. Similar variations in fruit size, seed core dia, pulp thickness and seed content among diverse guava genotypes were reported by Yadav and Shankar (14) and Singh *et al.* (12).

The data presented in Table 3 showed significant variations in chemical quality attributes and mineral contents of fruits. The TSS of fruit juice ranged from 10.80 to 16.33 °B, being the highest in GG-24 (16.33 °B) followed by GG-21 (16.0 °B), while the minimum TSS was recorded in GG-19 (10.80 °B). The titrable acidity in fruit juice ranged from 0.28 to 0.70%, being the highest in GG-24 (0.70%) followed by GG-21 (0.60%) and GG-20 (0.56%) and the minimum

Table 1. Topography of place of collection of guava genotypes and their fruit characteristics.

Genotypes	Latitude	Longitude	Elevation	Place of collection	Shape	Peel colour	Pulp colour	Shape at stalk end	Calyx cavity	Longitudinal ridges	Fruit surface
GG-1	22049'46.01"	73047'41.74"	153.62 m	Bodidra	Subglobose	Yellowish green	White	Rounded	Small	Absent	Smooth
GG-2	22052'56.78"	73049'05.27"	142.04 m	Rampur	Round	Green	Red	Rounded	Medium	Present	Rough
GG-3	22034'45.49"	73036'51.12"	113.99 m	Paroli	Round	Yellow	White	Broadly rounded	Small	Absent	Smooth
GG-4	22034'44.80"	73036'51.29"	113.39 m	Paroli	Round	Orange grrenish	Creamish white	Broadly rounded	Small	Absent	Smooth
GG-5	22034'48.71"	73036'51.61"	113.53 m	Paroli	Round	Yellow	Creamish white	Rounded	Broad	Absent	Smooth
GG-6	22053'54.15"	73048'05.94"	140.21 m	Rampur	Pyriform	Yellowish green	White	Pointed	Small	Present	Rough
GG-7	22052'54.39"	73048'02.64"	136.55 m	Rampur	Subglobose	Dark yellow	White	Rounded	Small	Absent	Rough
GG-8	22045'09.73"	73038'23.27"	127.41 m	Godhra	Pyriform	Yellow green	White	Rounded	Small	Present	Rough
GG-9	22045'08.03"	73038'27.68"	127.40 m	Godhra	Conical	Yellow green	Pink	Pointed	Small	Absent	Smooth
GG-10	22045'04.32"	73038'19.61"	129.84 m	Godhra	Round	Yellowish green	White	Rounded	Broad	Present	Rough
GG-11	22031'18.71"	73040'38.59"	155.14 m	Zingiri	Pyriform	Green	White	Necked	Small	Absent	Smooth
GG-12	22034'43.41"	73036'53.17"	112.47 m	Paroli	Obovate	Yellow	Light pink	Rounded	Small	Absent	Smooth
GG-13	22051'50.48"	73049'05.60"	150.88 m	Kasanpur	Conical	Greenish yellow	White	Pointed	Small	Absent	Smooth
GG-14	22018'46.67"	73025'02.13"	61.57 m	Waghodiya	Conical	Pale yellow	Light pink	Pointed	Small	Present	Smooth
GG-15	21043'20.43"	71056'46.15"	41.45 m	Sihor	Round	Grey yellow	Pale pink	Broadly rounded	Small	Absent	Smooth
GG-16	21043'08.68"	71057'02.33"	45.41 m	Sihor	Round	Yellow	Pink	Rounded	Broad	Absent	Smooth
GG-17	23019'03.03"	72044'44.62"	90.83 m	Chandrala	Oblong	Greenish yellow	Creamish white	Necked	Small	Absent	Smooth
GG-18	22054'45.46"	73052'25.84"	159.72 m	Kuazar	Round	Orange grrenish	Yellow white	Rounded	Broad	Present	Smooth
GG-19	23012'39.36"	73033'22.94"	109.73 m	Veerpura	Oblong	Yellow	Creamish white	Rounded	Small	Present	Rough
GG-20	23012'14.45"	73033'56.05"	107.59 m	Veerpura	Subglobose	Yellowish green	Pale pink	Rounded	Small	Absent	Rough
GG-21	21042'35.05"	71054'44.40"	67.06 m	Mota surkha	Conical	Yellow	Pale pink	Rounded	Small	Absent	Rough
GG-22	22055'45.57"	73056'26.57"	182.27 m	Pipliya	Round	Green	White	Broadly rounded	Small	Absent	Smooth
GG-23	21043'06.07"	71057'05.84"	47.24 m	Sihor	Conical	Whish yellow	Creamish	Pointed	Small	Absent	Smooth
GG-24	22051'21.03"	73045'39.73"	164.59 m	Rampur	Round	Greenish yellow	Pale pink	Truncate	Small	Present	Bumpy
GG-25	22050'49.55"	73045'02.19"	168.55 m	Rampur	Subglobose	Pale yellow	Creamish light pink	Rounded	Broad	Absent	Rough

Table 2. Physical quality attributes and lycopene content of guava genotypes.

Genotypes	Weight (g)	Length (cm)	Width (cm)	Length: width	Seed core length (cm)	Pulp thickness (cm)	No. seed/ fruit	Seed weight / fruit (g)	100 seed weight (g)	Seed texture	Lycopene (mg 100 g^{-1})
GG-1	169.45	6.50	6.90	0.94	4.22	1.45	158.40	4.25	2.69	Medium soft	-
GG-2	158.60	6.16	6.93	0.88	4.13	1.25	106.20	2.93	2.77	Medium hard	2.12
GG-3	187.30	6.82	7.32	0.93	4.00	1.41	169.35	2.90	1.73	Medium soft	-
GG-4	155.34	6.33	6.40	0.99	4.40	1.40	215.03	4.51	1.55	Medium soft	-
GG-5	173.20	7.10	7.01	1.01	5.45	1.32	315.40	5.32	1.86	Medium soft	-
GG-6	234.75	9.16	7.12	1.28	3.87	1.80	174.50	2.89	1.71	Medium soft	-
GG-7	292.50	9.30	7.90	1.17	4.60	2.25	182.30	2.76	1.53	Medium hard	-
GG-8	318.50	9.53	8.25	1.15	5.25	2.30	189.00	3.98	2.11	Medium soft	-
GG-9	98.50	6.0	5.30	1.13	3.50	1.20	98.00	2.10	2.15	Medium hard	1.14
GG-10	204.73	7.86	7.41	1.06	5.20	1.75	164.71	2.80	1.72	Medium soft	-
GG-11	163.07	8.61	5.91	1.45	4.15	1.30	477.00	3.67	0.80	Medium soft	-
GG-12	53.50	5.60	4.30	1.30	2.50	1.00	55.30	0.94	1.70	Hard	1.57
GG-13	198.35	7.32	6.07	1.21	4.30	1.40	510.00	8.16	1.62	Hard	-
GG-14	186.50	7.20	7.05	1.02	5.20	1.30	225.70	2.95	1.31	Medium soft	1.86
GG-15	187.75	6.20	7.20	0.86	4.20	1.70	395.00	5.35	1.36	Medium hard	1.48
GG-16	108.50	5.20	5.50	0.95	3.90	1.50	361.12	2.35	0.66	Medium hard	1.71
GG-17	155.16	8.39	6.04	1.38	2.80	1.83	298.80	4.73	1.59	Medium soft	-
GG-18	202.20	6.47	7.43	0.87	4.20	1.65	212.00	3.23	1.53	Soft	-
GG-19	262.25	9.33	7.67	1.21	3.70	2.10	95.00	1.62	1.72	Soft	--
GG-20	184.20	8.40	6.10	1.37	4.40	1.70	600.00	9.12	1.54	Hard	0.97
GG-21	253.66	9.95	7.13	1.40	3.60	1.75	160.40	2.70	1.69	Medium soft	2.43
GG-22	88.20	4.09	4.50	0.91	2.70	1.20	189.00	4.12	2.18	soft	-
GG-23	137.50	7.18	6.05	1.19	3.30	1.65	110.60	1.85	1.68	Soft	-
GG-24	187.45	6.37	6.20	1.03	4.30	1.66	88.00	2.60	2.95	Hard	2.32
GG-25	123.11	6.17	6.26	0.99	4.10	1.20	609.00	7.79	1.28	Hard	0.67
SEm±	1.63	0.58	0.56	0.06	0.58	0.15	6.85	0.46	0.016	-	-
CD (0.05)	4.63	1.67	1.61	0.19	NS	0.44	19.46	1.31	0.046	-	-
CV%	1.60	14.05	14.94	9.82	-	17.29	4.82	20.85	1.61	-	-

Table 3. Chemical quality attributes and mineral content of guava genotypes.

Genotypes	TSS (ºB)	Acidity (%)	TSS: acidity	Ascorbic acid (mg/100g)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Pectin (%)	Mineral content (mg 100 g^{-1} FW)			
									P	K	Ca	Mg
GG-1	12.24	0.35	34.97	222.20	6.25	2.35	8.72	1.27	15.41	362.97	23.19	24.66
GG-2	11.30	0.42	26.90	163.50	5.80	2.47	8.40	1.33	13.43	329.15	19.33	15.29
GG-3	15.20	0.40	38.00	230.50	7.45	2.07	9.63	0.92	14.18	322.88	19.02	21.93
GG-4	13.20	0.42	31.40	275.72	4.21	1.95	6.27	1.11	16.27	295.93	17.67	14.29
GG-5	11.15	0.28	39.82	243.10	4.29	1.98	6.38	0.97	14.47	339.61	20.84	15.01
GG-6	14.20	0.54	26.29	192.20	7.35	2.15	9.61	1.04	14.84	283.57	17.06	18.93
GG-7	15.50	0.45	34.44	280.50	7.61	2.06	9.78	1.07	13.96	315.47	19.64	13.57
GG-8	12.20	0.31	39.35	235.73	7.05	1.11	8.22	0.95	14.77	339.26	19.83	12.69
GG-9	15.30	0.49	31.22	167.80	5.70	1.63	7.42	1.24	17.48	308.18	18.28	21.57
GG-10	12.16	0.33	36.84	227.50	4.74	2.73	7.62	1.15	12.71	279.79	16.87	20.38
GG-11	13.50	0.43	31.39	189.56	5.97	2.27	8.36	1.02	13.18	273.11	17.55	20.53
GG-12	12.45	0.41	30.36	167.52	4.35	1.28	5.70	1.08	13.11	299.55	18.86	22.71
GG-13	15.25	0.52	29.32	274.77	5.77	2.53	8.44	1.13	15.32	268.37	16.31	12.62
GG-14	11.50	0.41	28.04	195.63	5.54	1.27	6.88	1.29	14.53	312.42	19.49	22.99
GG-15	13.10	0.38	34.47	239.30	4.82	2.75	7.72	1.42	13.25	319.17	20.53	23.09
GG-16	13.00	0.45	28.88	189.60	5.32	1.32	6.71	1.31	14.43	335.63	20.64	23.14
GG-17	14.00	0.37	37.83	240.50	7.15	1.09	8.20	1.22	15.35	288.71	17.32	20.18
GG-18	14.30	0.50	28.60	203.75	6.30	2.37	8.80	0.98	11.48	272.95	16.54	17.34
GG-19	10.80	0.53	20.37	200.50	4.11	2.18	6.41	1.09	13.66	345.19	21.12	23.66
GG-20	13.50	0.56	24.10	177.32	5.18	1.20	6.45	1.17	12.58	303.86	18.07	21.17
GG-21	16.00	0.60	26.66	220.75	6.57	1.60	8.26	1.39	11.59	366.15	22.16	15.72
GG-22	13.00	0.35	34.28	136.50	6.01	2.83	8.99	0.95	15.81	291.46	18.46	21.54
GG-23	12.40	0.38	32.63	215.45	6.82	1.26	8.15	1.20	12.83	370.17	21.36	16.84
GG-24	16.33	0.70	23.32	249.00	7.33	1.99	9.43	0.96	13.58	333.28	20.53	20.86
GG-25	13.50	0.46	29.34	176.02	5.17	1.22	6.46	0.88	13.38	289.39	17.36	20.32
SEm±	0.54	0.026	2.23	1.63	0.50	0.06	0.50	0.02	0.59	1.46	0.73	0.77
CD (0.05)	1.55	0.074	6.40	4.64	1.51	0.19	1.50	0.06	1.68	4.16	2.07	2.19
CV%	7.06	10.26	12.48	15.28	15.60	5.93	11.63	3.26	7.27	0.80	6.58	6.93

acidity was noted in GG-5 (0.28%). The TSS:acid ratio among different accessions varied from 39.82 in GG-5 followed by 39.35 in GG-8 to 20.37 in GG-19 followed by 23.32 in GG-24. The maximum ascorbic acid content was recorded in GG-7 (280.50 mg 100 g^{-1}), followed by GG-4 (275.72 mg 100 g^{-1}), while lowest ascorbic acid was recorded in GG-22 (136.50 mg 100 g^{-1}). GG-7 had the maximum reducing (7.61%) and total sugar (9.78%) followed by GG-6 (7.35 & 9.61%), while the minimum reducing and total sugar was recorded in GG-19 (4.11%) and GG-12 (5.70%) respectively. The highest non-reducing content was obtained in GG-22 followed by GG-10, and it was the minimum in GG-17 (1.09%). Similar kind of variation is recorded by Yadav and Shankar (14) and Corrêa *et al.* (4) in guava. The pectin content differed significantly among the different genotypes and ranged from 0.88 to1.39 %. The highest pectin content was recorded in GG-15 (1.42%) followed by GG-21 (1.39%) and the lowest was observed in GG-25 (0.88%). Guava fruit is one of the best sources of food grade pectin, which is used for making good quality jelly (Patel *et al.*, 8). This finding is in agreement with the observations of Singh *et al.* (12) and Yadav and Shankar (14) in guava. Similarly, sugar contents also varied significantly among the genotypes. The highest value for reducing sugar (7.61%) and total sugars (9.78%) were recorded in GG-7, while, the lowest reducing sugar (4.11%) and total sugars were recorded in GG-19 and GG-12 respectively. The maximum non-reducing content was obtained in GG-22(2.83%) followed by GG-13 (2.53%) and it was the minimum in GG-17 (1.09%). The highest lycopene content was also observed in pink pulped guava genotypes which ranged from 0.67 mg 100 g^{-1} in GG-25 to 2.43 mg 100 g^{-1} in GG-21 (Pandey *et al.*, 7). Various workers have recorded similar kind of variation in guava genotypes, which may be due to different genetical constitution of the individual genotypes (Yadav and Shankar, 14; Patel *et al.*, 8).

There was a significant difference among the genotypes with respect to mineral contents of guava fruits on fresh weight (FW) basis (Table 3). Among the 25 guava genotypes, the highest level of phosphorus was found in GG-9 (17.48 mg 100 g^{-1}) followed by GG-4 (16.27 mg 100 g^{-1}), and the lowest was recorded in GG-18 (11.48 mg 100 g^{-1}). The potassium content ranged from 268.37-370.17mg 100 g^{-1} being the maximum in GG-23 (370.17 mg 100 g^{-1}) followed by GG-1 (362.97 mg 100 g^{-1}) and it was minimum in GG-13 (268.37 mg 100 g^{-1}). The highest calcium content was recorded in GG-1 (23.19 mg 100 g^{-1}) followed by GG-21(22.16 mg 100 g^{-1}), while the lowest was recorded in GG-13 (16.31 mg 100 g^{-1}). The magnesium content ranged between 12.62-24.66 mg 100 g^{-1} being the maximum in GG-1 (24.66 mg 100 g^{-1}) followed by GG-19 (23.66 mg 100 g^{-1}) and minimum in GG-13 (12.62 mg 100 g^{-1}). Corrêa *et al.* (4) found wider variation for fruit mineral contents in various guava genotypes of seedling origin. This finding is also substantiated by the results reported by Singh *et al.* (11) in wood apple.

In general, the result of the study showed wider diversity for various physico-chemical characters especially for high TSS:acidity ratio and mineral contents. Based on the results, it has been observed that, among all the genotypes of guava collected from different locations of Gujarat, GG-1, GG-4, GG-15, GG-21, GG-23 and GG-24 having the desirable physico-chemical characters for consumers and breeders.

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