Variability in physico-chemical characteristics and selection of superior types among local pummelo (*Citrus grandis* (L.) Osbeck) germplasms from Mizoram, North East India

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Thirty-five pummelo (*Citrus grandis* (L.) Osbeck) genotypes were assessed with respect to their quality parameters considered most essential with respect to horticultural aspects. Among the genotypes, significant to highly significant differences were observed in all the parameters. Different fruit physical parameters such as weight, diameter, length, volume pulp weight, pulp thickness, pulp–peel ratio and seed number varied significantly among the genotypes. Similarly, there were high level of differences among the genotypes with respect to chemical parameters of the fruits. The juice content varied from 13.64% to 43.56%, vitamin C from 17.40 to 52.70 mg/100 ml, total soluble solids from 7.73% to 11.67%, acidity from 0.76% to 1.86%, total sugars from 7.47% to 9.95% and sugar–acid ratio from 4.88 to 12.58. The present study reveals that parameters such as weight of the fruit, length of the fruit, diameter, volume, pulp weight, pulp–peel ratio, juice, TSS, acidity, ascorbic acid, total sugars and sugar–acid ratio can be considered as selection criteria for future breeding programmes in pummelo. The high level of differences with respect to various physical and chemical parameters of the fruits shows the great scope for superior genotype selection based on these particular parameters for genetic improvement programmes in near future.

Keywords: *Citrus grandis*, genotype selection, horticultural aspects, physico-chemical characteristics.

CITRUS, belonging to the family Rutaceae, is one of the most important commercial and nutritional fruits which has gained importance due to its gigantic industrial expansion the world over. It is the third most important fruit crop next to apple and banana, with a production of about 6.71 crore million tonnes from an area of cultivation spread over a massive of 36.67 lakh hectares[1]. It is a long-duration fruit crop and is grown in almost all tropical and subtropical countries across the world[2]. Brazil is the leading producer, with 26.8% of the world's total *Citrus* production[1]. Although there exist a good number of species under the genus *Citrus*, only a few are economically and commercially important, viz. *Citrus sinensis* (L.) Osbeck (sweet orange), *C. reticulata* Blanco (mandarin), *C. grandis* (L.) Osbeck (pummelo), *C. paradisi* Mac. f. (grapefruit), *C. limon* (L.) Burm.f. (lemon), *C. aurantifolia* (Christm) Swing. (lime) and *C. aurantium* (L.) (sour orange).

India, having a varied range of climatic conditions and being one of the eight Vavilovian centres of crop plant origin and diversity, displays a wide range of variability in *Citrus* and related genera[3]. Due to the presence of wide genetic variability, India also occupies a prime position in the *Citrus* belt of the world[4]. In India, the northeastern hill region is considered as home of many *Citrus* species[5–7] showing genetic variability. The region is a reservoir of various *Citrus* species, including mandarin orange[8–10]. Due to its unique combination of diverse soil-physiographic and climatic set-up, the region has several *Citrus* species with variability among them. Among different states of North East India, prime production of citrus comes from Meghalaya, followed by Manipur, Assam, Tripura, Mizoram, Nagaland, Arunachal Pradesh and Sikkim[11].

However, commercial cultivation of this high-valued crop in northeastern region is still far behind the rest of India; most of the area under citrus in this region is home gardens[12]. At present, these non-commercial home gardens as well as a few commercial plantations of citrus have vanished, partly because of general neglect, and partly due to extensive jhuming and malnutrition. Most of the citrus trees are located on the untraced hill slopes and practically no soil conservation measures are adopted, leading to washing away of the nutrient-rich surface soil by heavy erosive rainfall resulting in comparatively less fertile and extremely acidic subsurface, which causes untimely decline in productivity of orchards. In addition to these factors, due to population pressure some non-edible

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species of citrus are also on the verge of extinction. Therefore there is urgent need to explore the available genetic diversity of this crop in its natural home.

Pummelo (*Citrus grandis* (L.) Osbeck) is one of the popular species grown in almost all the *Citrus* growing countries of the world. In Asian countries, the species is normally used as table fruit during daytime and also to prepare juices and preserves. It is the biggest among all *Citrus* fruits in the world. The red-fleshed fruit juice is a good source of antioxidants compared to the white fleshed pummelo, and has the capacity to scavenge free radicals present in our body[13]. In India, the plant is abundantly found in the northeastern states on the foothills up to an altitude of 1500 m amsl (ref. 14). Different strains of pummelo are also reported to grow in semi-wild conditions in the northeastern hill region[15]. Diverse forms of pummelo have been frequently observed growing in lower hills of Assam, Meghalaya, Manipur and Tripura[16,17]. Maximum diversity of pummelo was reported in the western parts of Aizawl district, Mizoram and Jampui Hills area of north Tripura. In Mizoram, pummelo trees are found growing wild or semi-wild in marginal land or in home gardens without any commercial cultivation[18]. So they are propagated through seeds only, due to which large genetic variability exists in their population in terms of plant morphology as well as fruit characters.

However, so far no systematic studies have been undertaken to screen superior genotypes in terms of physico-chemical properties of the pummelo fruits in this biodiversity hotspot region of the world. Therefore, we explored the genetic variation among natural populations in their home for interpretation of phenotypic characters as well as for genotypic gain of this valuable *Citrus* species.

Materials and methods

Considering the vast spread of pummelo trees in Mizoram, assessment of genetic diversity in their natural habitat and identification of superior fruits from seven geographically different places in Aizawl district, comprising 35 different germplasms were carried out during 2013–15 to select the superior genotypes in their natural habitats. Table 1 provides the details of the genotypes along with their latitude and longitudes. Immediately after collection of fruits from their natural population, they were brought to the Post-Harvest Laboratory, Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University for estimation of quality parameters.

The physical parameters were estimated by selecting 20 fruits randomly from each replication. Standard procedures were followed for the estimation of physical parameters such as fruit weight, pulp weight, peel weight and seed weight. Water displacement method was used to measure volume of the fruit. Standard procedures were followed for the estimation of quality parameters such as juice, total soluble solids (TSS), acidity, ascorbic acid, reducing, non-reducing and total sugars. Mechanical juice extractor was used to estimate juice content of the fruit. The titrable acidity, reducing, non-reducing and total sugars of the fruit were measured following standard method[19]. The ascorbic acid content of fruit pulp was estimated using the visual titration method[20] and the results were expressed in mg per 100 g. The data were analysed subjected to Fisher's method of analysis of variance (ANOVA) by following completely randomized design. By calculating the respective F value and comparing with the appropriate value of F at 5% probability level, significance and non-significance differences among various treatments were determined[21]. The CD value was calculated at 5% probability level by comparing different treatments among themselves.

Results and discussion

ANOVA of 35 pummelo germplasms identified from different locations in Mizoram revealed significant to highly significant differences among germplasms in various quality parameters of the fruit. Table 2 reveals that among different genotypes of pummelo, the highest fruit weight was observed in MZU-HAMP-PS-31 (1861.20 g), followed by MZU-HAMP-PS-32 (1624.99 g). Minimum value with respect to this parameter was recorded in MZU-HAMP-PS-9 (338.67 g). The present findings are in agreement with other studies[18,22,23], which observed differences in fruit weight among pummelo germplasms collected from NE India.

The accessions ranged between 9.41 and 17.89 cm with respect to fruit length. Maximum value was recorded in MZU-HAMP-PS-31 (17.89 cm) and minimum in MZU-HAMP-PS-14 (9.41 cm). Variation in genetic constitution of the individual genotypes may be the reason behind the differences in fruit length[22]. Similarly, among the studied accessions, the highest fruit diameter was recorded in MZU-HAMP-PS-31 (21.56 cm). Accession MZU-HAMP-PS-9 recorded the lowest fruit diameter of 10.39 cm. Our study is in close conformity with previous studies in sweet orange[24] and pomegranate[25].

In the present study, the highest fruit volume was recorded in MZU-HAMP-PS-31 (2316.87 cc), followed by MZU-HAMP-PS-32 (2116.93 cc), and the lowest value was recorded in MZU-HAMP-PS-9 (386.87 cc). A wide range of variability among pummelo genotypes from the northeastern hill region in fruit volume has also been reported[17]. Similarly, among the studied accessions, MZU-HAMP-PS-29 recorded significantly maximum value (1.23 g/cc) with respect to specific gravity, while minimum was recorded in MZU-HAMP-PS-32 (0.76 g/cc). Differences in specific gravity of fruits among different germplasms in pomegranate[26] and in mango[25] have been reported earlier.

Table 1. Germplasms and their sources

Germplasm	Altitude	Longitude	Elevation (m)
MZU-HAMP-PS-1	N 23°48′48.5″	E 92°44′22.3″	1268
MZU-HAMP-PS-2	N 23°48′30.3″	E 92°44′42.8″	1214
MZU-HAMP-PS-3	N 23°48′26.0″	E 92°44′46.2″	1200
MZU-HAMP-PS-4	N 23°47′14.5″	E 92°44′01.6″	1109
MZU-HAMP-PS-5	N 23°44′41.4″	E 92°42′52.1″	761
MZU-HAMP-PS-6	N 23°44′44.4″	E 92°42′50.1″	722
MZU-HAMP-PS-7	N 23°44′43.5″	E 92°42′51.4″	737
MZU-HAMP-PS-8	N 23°44′44.9″	E 92°42′51.5″	730
MZU-HAMP-PS-9	N 23°44′39.5″	E 92°43′02.9″	818
MZU-HAMP-PS-10	N 23°44′30.5″	E 92°41′00.8″	896
MZU-HAMP-PS-11	N 23°44′15.5″	E 92°41′01.0″	885
MZU-HAMP-PS-12	N 23°44′50.2″	E 92°41′40.3″	970
MZU-HAMP-PS-13	N 23°44′45.5″	E 92°41′28.7″	943
MZU-HAMP-PS-14	N 23°44′40.0″	E 92°40′59.5″	904
MZU-HAMP-PS-15	N 23°44′39.5″	E 92°41′59.0″	903
MZU-HAMP-PS-16	N 23°47′56.0″	E 92°38′51.3″	206
MZU-HAMP-PS-17	N 23°47′58.2″	E 92°38′52.0″	150
MZU-HAMP-PS-18	N 23°47′58.3″	E 92°38′52.2″	140
MZU-HAMP-PS-19	N 23°47′58.6″	E 92°38′52.2″	137
MZU-HAMP-PS-20	N 23°47′57.8″	E 92°38′51.8″	140
MZU-HAMP-PS-21	N 23°47′57.6″	E 92°38′51.4″	137
MZU-HAMP-PS-22	N 23°47′56.6″	E 92°38′52.1″	144
MZU-HAMP-PS-23	N 23°48′02.6″	E 92°38′59.7″	139
MZU-HAMP-PS-24	N 23°48′03.3″	E 92°39′00.5″	132
MZU-HAMP-PS-25	N 23°48′26.9″	E 92°39′14.3″	106
MZU-HAMP-PS-26	N 23°48′22.6″	E 92°39′31.2″	167
MZU-HAMP-PS-27	N 23°48′26.4″	E 92°39′38.0″	188
MZU-HAMP-PS-28	N 23°47′56.3″	E 92°38′50.8″	152
MZU-HAMP-PS-29	N 23°48′38.9″	E 92°39′24.2″	98
MZU-HAMP-PS-30	N 23°48′47.3″	E 92°39′21.6″	83
MZU-HAMP-PS-31	N 23°48′45.7″	E 92°39′21.8″	86
MZU-HAMP-PS-32	N 23°48′44.6″	E 92°39′22.1″	92
MZU-HAMP-PS-33	N 23°48′42.7″	E 92°39′23.7″	95
MZU-HAMP-PS-34	N 23°47′56.2″	E 92°38′51.3″	189
MZU-HAMP-PS-35	N 23°47′56.2″	E 92°38′51.6″	152

Peel weight of the genotypes ranged between 132.91 and 755.31 g (Figure 1). MZU-HAMP-PS-31 recorded the maximum peel weight (755.31 g), which was significantly higher than all other germplasms, except MZU-HAMP-PS-32 (601.84 g), with which it was found statistically at par. Among the different accessions, MZU-HAMP-PS-9 recorded the lowest value (132.91 g) with respect to peel weight. Our findings are in agreement with the results of other studies[14,23]. Figure 1 shows that among all the germplasms, MZU-HAMP-PS-31 recorded maximum value with respect to pulp weight (1105.90 g), while MZU-HAMP-PS-9 recorded the lowest pulp weight (205.76 g). ANOVA presented in Table 2 and Figure 1 reveals a positive correlation between fruit weight and pulp weight, maximum fruit weight is observed in the fruits which have higher pulp weight. This clearly indicates that during selection of any genotype based on fruits, the breeder should give emphasis on those fruits having more pulp content as well as weight. This is because both parameters contribute equally in the selection of superior genotypes. Previous studies[22,27] also obtained significant variation in pulp weight among aonla and pummelo accessions from NE India. With respect to pulp–peel ratio of the fruits, no significant variation was observed among the accessions.

MZU-HAMP-PS-33 recorded significantly highest value of 4.13 cm for peel thickness, which was found statistically at par with MZU-HAMP-PS-34 (3.80 cm); the lowest was recorded in MZU-HAMP-PS-23 (1.21 cm). The variation in genetic constitution of the individual genotypes may be the probable reason for differences in peel thickness among the studied accessions. Among the different parameters which govern the quality of a fruit, pulp thickness is important. Maximum pulp thickness was observed in MZU-HAMP-PS-31 (17.43 cm). These findings are in conformity with those of other studies[3,22].

Genotype MZU-HAMP-PS-33 recorded the highest number of segments (18.89) and MZU-HAMP-PS-24 recorded the lowest (10.22). Similarly, MZU-HAMP-PS-2 recorded maximum seed number (131.33) and MZU-HAMP-PS-32 recorded the lowest value (31.67). Differences in seed number among various accessions in sweet orange[24] and guava[28] were reported earlier.

Different pummelo germplasms indicated significant to highly significant differences in seed weight (Table 2). In the present study, the maximum seed weight was

Table 2. Physical parameters of the different pummelo germplasms

Germplasm	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cc)	Specific gravity (g/cc)	Pulp–peel ratio	Pulp thickness (cm)	Peel thickness (cm)	No. of segments	Seed number	Seed weight (g)
MZU-HAMP-PS-1	938.15	12.37	15.87	1071.83	0.89	1.75	14.23	1.64	14.78	87.33	35.21
MZU-HAMP-PS-2	991.35	11.57	12.71	1036.83	0.95	1.50	10.25	2.46	16.89	131.33	81.86
MZU-HAMP-PS-3	698.29	9.77	12.89	853.33	0.81	3.12	11.37	1.52	15.78	77.00	33.58
MZU-HAMP-PS-4	905.38	11.63	14.31	1093.33	0.83	2.28	11.96	2.35	16.33	123.67	73.27
MZU-HAMP-PS-5	508.08	10.05	10.72	653.50	0.78	1.82	9.34	1.38	17.11	53.33	15.27
MZU-HAMP-PS-6	581.41	11.00	11.84	706.67	0.82	1.71	9.90	1.94	13.89	70.67	22.85
MZU-HAMP-PS-7	738.23	12.17	12.20	746.90	1.00	1.53	9.66	2.54	14.44	40.33	21.45
MZU-HAMP-PS-8	725.62	10.48	13.89	753.33	0.96	1.42	11.98	1.91	14.11	65.00	25.37
MZU-HAMP-PS-9	338.68	9.75	10.39	386.87	0.86	1.73	9.07	1.32	15.22	86.00	23.41
MZU-HAMP-PS-10	535.11	10.77	12.76	703.47	0.77	1.77	11.33	1.43	15.00	84.33	24.23
MZU-HAMP-PS-11	540.41	11.65	12.59	653.40	0.83	1.75	11.05	1.54	17.56	92.33	28.96
MZU-HAMP-PS-12	652.69	13.39	14.02	730.87	0.91	2.22	12.05	1.97	13.67	94.00	40.51
MZU-HAMP-PS-13	929.89	11.27	13.65	888.47	1.05	1.88	11.59	2.07	16.56	87.33	25.95
MZU-HAMP-PS-14	597.45	9.41	12.31	754.53	0.79	1.51	10.49	1.83	13.33	43.33	14.37
MZU-HAMP-PS-15	793.52	12.29	13.62	783.47	1.01	1.22	11.06	2.56	13.33	51.33	12.23
MZU-HAMP-PS-16	1091.99	13.92	14.86	1251.87	0.87	1.87	12.29	2.57	11.89	59.33	16.58
MZU-HAMP-PS-17	635.57	12.23	13.33	781.80	0.81	1.14	11.15	2.18	12.22	47.67	22.98
MZU-HAMP-PS-18	784.58	13.42	15.74	903.53	0.87	2.43	13.28	2.45	14.00	60.67	21.03
MZU-HAMP-PS-19	603.04	10.75	12.29	747.20	0.80	1.64	10.88	1.40	15.33	96.00	31.41
MZU-HAMP-PS-20	987.69	14.16	13.07	1203.53	0.81	2.00	11.64	1.43	13.56	75.67	39.51
MZU-HAMP-PS-21	790.73	12.36	14.41	877.13	0.90	2.35	13.20	1.21	14.33	46.33	26.43
MZU-HAMP-PS-22	647.98	14.64	12.75	777.40	0.83	1.29	10.46	2.29	10.78	33.33	28.03
MZU-HAMP-PS-23	1246.60	14.17	15.52	1552.07	0.81	1.12	12.76	2.76	14.67	52.67	26.58
MZU-HAMP-PS-24	490.39	9.87	12.29	502.60	1.01	1.67	11.03	1.25	10.22	44.00	14.78
MZU-HAMP-PS-25	1177.25	12.96	14.88	1104.87	1.06	1.76	12.41	2.47	13.33	53.33	30.63
MZU-HAMP-PS-26	1271.13	13.05	17.48	1366.80	0.94	1.35	14.02	3.46	15.00	40.67	20.65
MZU-HAMP-PS-27	1303.28	13.82	16.81	1503.53	0.87	1.49	13.57	3.24	14.11	43.67	18.99
MZU-HAMP-PS-28	652.21	12.88	11.87	683.60	0.96	2.52	10.27	1.60	10.67	70.00	38.94
MZU-HAMP-PS-29	711.74	12.12	11.38	581.87	1.23	1.50	8.83	2.55	13.78	102.33	42.30
MZU-HAMP-PS-30	1062.56	13.42	17.12	1266.83	0.84	1.42	14.35	2.78	13.78	76.33	33.50
MZU-HAMP-PS-31	1861.20	17.89	21.56	2316.87	0.80	1.46	17.43	4.13	13.67	36.33	10.69
MZU-HAMP-PS-32	1624.99	16.81	19.42	2116.93	0.76	1.97	15.63	3.80	14.89	31.67	11.12
MZU-HAMP-PS-33	671.61	10.68	12.88	703.53	0.96	1.46	10.47	2.41	18.89	115.33	31.45
MZU-HAMP-PS-34	750.01	11.46	14.17	823.60	0.91	1.29	12.02	2.15	15.44	94.67	28.96
MZU-HAMP-PS-35	702.00	10.88	13.13	783.40	0.90	2.14	11.11	2.02	16.56	56.00	20.11
S.Em (±)	145.17	0.89	1.30	163.26	0.07	–	1.28	0.36	1.37	8.87	5.76
$CD_{0.05}$	287.44	1.76	2.57	323.25	0.15	NS	2.54	0.71	2.71	17.56	11.40

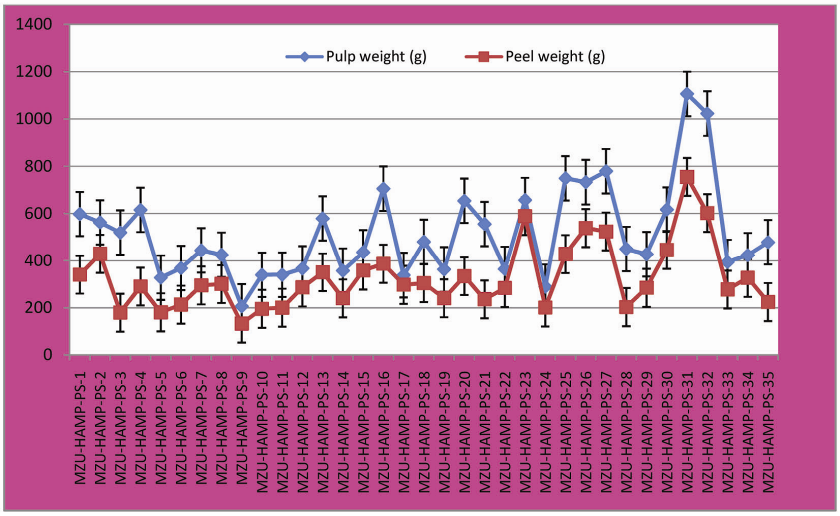

Figure 1. Pulp weight and peel weight in different pummelo germplasms.

observed in MZU-HAMP-PS-2 (81.86 g), but there was no statistical difference with MZU-HAMP-PS-4 (73.27 g). Variation in seed weight among different germplasms of aonla[29] was reported earlier.

Table 3 presents the chemical parameters of different pummelo fruits. MZU-HAMP-PS-31 recorded the highest juice content (43.56%), followed by MZU-HAMP-PS-32 (43.20%), whereas the lowest juice content was observed in MZU-HAMP-PS-29 (13.64%). Our findings were in close conformity with those of previous study, where significant variation in juice content among different pummelo accessions was reported[22].

Similarly, germplasms MZU-HAMP-PS-31 and MZU-HAMP-PS-28 (11.67%), recorded maximum TSS, followed by MZU-HAMP-PS-32 (11.23%), MZU-HAMP-PS-34, MZU-HAMP-PS-19 (11.07%), MZU-HAMP-PS-21 (10.87%), MZU-HAMP-PS-15 and MZU-HAMP-PS-29 (10.73%). It has been reported that fruits when grown under water-scarce conditions accumulate more dry matter and low moisture, which ultimately increase their TSS[30]. Variation in TSS among pummelo collections from NE India has been reported[18,23].

Among all genotypes, MZU-HAMP-PS-32 recorded maximum value (52.89 mg/100 g) of ascorbic acid. Previous workers also reported differences in ascorbic acid among various germplasms in fruits like mango and bael[31,32].

In the present study, the acidity of pummelo fruits varied from 0.76% to 1.86%. MZU-HAMP-PS-27 (0.76%) recorded the lowest titrable acidity which was significantly lower than all other germplasms, except MZU-HAMP-PS-32 (0.78%), MZU-HAMP-PS-24 (0.79%), MZU-HAMP-PS-31 (0.81%), MZU-HAMP-PS-33 and MZU-HAMP-PS-28 (0.84%), MZU-HAMP-PS-29 and MZU-HAMP-PS-25 (0.84%), MZU-HAMP-PS-35 (0.92%), MZU-HAMP-PS-30 (0.96%), MZU-HAMP-PS-26 (1.03%) and MZU-HAMP-PS-2 (1.04%), with which it was statistically at par. In many fruits TSS is negatively correlated with acidity. Owing to this, lowest acidity was observed in MZU-HAMP-PS-8, MZU-HAMP-PS-3 and MZU-HAMP-PS-12.

Similarly, maximum value of total sugar was recorded in MZU-HAMP-PS-5 (9.95%), which was significantly higher than all other germplasms, except MZU-HAMP-PS-7 (9.93%), MZU-HAMP-PS-31 (9.91%), MZU-HAMP-PS-19 (9.87%), MZU-HAMP-PS-22 (9.80%), MZU-HAMP-PS-23 (9.79%), MZU-HAMP-PS-15 (9.76%), MZU-HAMP-PS-32 (9.68%), MZU-HAMP-PS-4 and MZU-HAMP-PS-29 (9.63%), MZU-HAMP-PS-16 (9.61%), MZU-HAMP-PS-6 (9.57%), MZU-HAMP-PS-20 (9.54%), MZU-HAMP-PS-14, MZU-HAMP-PS-19 (9.53%), MZU-HAMP-PS-3 (9.52%), MZU-HAMP-PS-18 and MZU-HAMP-PS-34 (9.04%), MZU-HAMP-PS-17 (8.95%) and MZU-HAMP-PS-21 (8.85%), with which it was statistically at par. The various genetic constitutions among individual genotypes might be the reason for differences in total sugars among the accessions.

Similarly, MZU-HAMP-PS-31 recorded maximum reducing sugar of fruits (5.59%) and MZU-HAMP-PS-27 recorded the lowest reducing sugar (3.23%). Previous studies also reported significant variation in reducing sugar in pummelo[22]. The significantly highest non-reducing sugar was observed in MZU-HAMP-PS-4 (5.95%) and the lowest was observed in MZU-HAMP-PS-8 (2.70%).

Variation among different germplasms in sugar–acid ratio was also found significant (Table 3). MZU-HAMP-PS-32 recorded the highest value of sugar–acid ratio (12.58) and significantly lowest value was recorded in MZU-HAMP-PS-13 (4.88). These findings are in agreement with those of other studies[19,30]. Similarly, MZU-HAMP-PS-31 recorded maximum TSS–acid ratio (14.66), which was significantly higher than most of the germplasms, except MZU-HAMP-PS-32 (14.61), MZU-HAMP-PS-28 (13.94), MZU-HAMP-PS-33 (12.61), MZU-HAMP-PS-29 (12.52), MZU-HAMP-PS-27 (12.44)

Table 3. Chemical parameters of the different pummelo germplasms

Germplasm	Juice (%)	TSS (%)	Acidity (%)	Ascorbic acid (mg/100g)	Total sugars (%)	Reducing sugar (%)	Non-reducing sugar (%)	Sugar– acid ratio	TSS–acid ratio
MZU-HAMP-PS-1	27.11	9.23	1.45	37.44	8.01	4.11	3.71	5.72	6.48
MZU-HAMP-PS-2	24.76	10.70	1.04	48.40	8.60	4.51	3.89	9.26	11.61
MZU-HAMP-PS-3	41.37	10.67	1.61	45.43	9.18	4.16	4.77	5.87	6.93
MZU-HAMP-PS-4	30.08	10.13	1.73	32.65	9.63	3.36	5.95	5.60	5.88
MZU-HAMP-PS-5	38.43	9.83	1.64	21.69	9.95	4.09	5.56	6.16	6.11
MZU-HAMP-PS-6	27.96	8.67	1.54	23.06	9.58	5.18	4.17	6.25	5.64
MZU-HAMP-PS-7	18.42	8.40	1.43	23.53	9.93	5.40	4.30	6.98	5.90
MZU-HAMP-PS-8	30.46	9.00	1.15	17.65	7.47	4.63	2.70	6.47	7.82
MZU-HAMP-PS-9	34.53	9.70	1.56	39.71	8.18	5.27	2.77	5.32	6.25
MZU-HAMP-PS-10	22.70	9.43	1.22	45.10	8.67	5.04	3.44	7.16	7.79
MZU-HAMP-PS-11	38.66	8.17	1.34	22.55	8.08	5.15	2.79	6.02	6.08
MZU-HAMP-PS-12	31.70	8.37	1.72	34.85	8.73	5.22	3.34	5.21	4.97
MZU-HAMP-PS-13	34.53	9.90	1.71	40.91	8.28	5.34	2.80	4.88	5.87
MZU-HAMP-PS-14	39.52	9.87	1.22	40.91	9.54	5.06	4.26	7.85	8.12
MZU-HAMP-PS-15	23.16	10.73	1.57	34.85	9.76	5.57	3.98	6.59	7.30
MZU-HAMP-PS-16	19.14	10.20	1.86	19.83	9.61	4.97	4.41	5.17	5.50
MZU-HAMP-PS-17	15.93	7.73	1.26	24.37	8.98	4.34	4.41	7.16	6.14
MZU-HAMP-PS-18	30.99	8.73	1.13	17.43	9.05	5.04	3.80	8.12	7.93
MZU-HAMP-PS-19	28.38	11.07	1.41	40.22	9.54	4.18	5.09	6.84	7.92
MZU-HAMP-PS-20	29.82	9.97	1.22	41.32	9.54	4.69	4.61	7.85	8.20
MZU-HAMP-PS-21	27.08	10.87	1.24	35.54	8.85	4.99	3.67	7.16	8.78
MZU-HAMP-PS-22	19.69	8.27	1.20	29.03	9.80	4.72	4.83	8.29	7.04
MZU-HAMP-PS-23	24.11	8.97	1.39	21.29	9.79	5.18	4.38	7.72	7.01
MZU-HAMP-PS-24	36.56	8.97	0.79	19.14	7.93	4.33	3.42	10.50	11.84
MZU-HAMP-PS-25	24.61	9.30	0.85	19.78	9.03	4.51	4.29	10.82	11.13
MZU-HAMP-PS-26	29.05	8.97	1.03	32.53	8.81	4.17	4.40	8.77	8.93
MZU-HAMP-PS-27	28.08	9.40	0.76	38.15	8.33	3.23	4.85	11.05	12.44
MZU-HAMP-PS-28	25.12	11.67	0.84	30.77	8.71	4.56	3.94	10.44	13.95
MZU-HAMP-PS-29	13.64	10.73	0.85	37.50	9.63	4.08	5.27	11.36	12.52
MZU-HAMP-PS-30	26.00	9.63	0.96	34.80	8.04	4.45	3.41	9.01	10.78
MZU-HAMP-PS-31	43.56	11.67	0.81	50.98	9.91	5.59	4.10	12.40	14.66
MZU-HAMP-PS-32	43.20	11.23	0.78	52.89	9.68	5.38	4.09	12.58	14.61
MZU-HAMP-PS-33	26.76	10.63	0.84	20.39	8.35	4.60	3.57	9.89	12.61
MZU-HAMP-PS-34	29.48	11.07	1.59	18.73	9.04	4.76	4.06	6.14	7.55
MZU-HAMP-PS-35	36.00	9.83	0.92	22.31	8.52	3.42	4.84	9.39	10.84
S.Em (±)	4.68	0.49	0.18	4.48	0.59	0.49	0.67	1.30	1.45
$CD_{0.05}$	9.28	0.96	0.35	8.87	1.17	0.96	1.32	2.57	2.87

and MZU-HAMP-PS-24 (11.84), with which it was found statistically at par. Previous studies have also reported differences in TSS–acid ratio among various genotypes in sweet orange[24] and aonla[29].

In any table fruit, buyers always prefer fruits with maximum weight and size as well as maximum pulp content and ratio of pulp and peel. Like other table fruits, in pummelo also, fruits with maximum size and weight as well as more pulp are always preferred by the buyers. Fruits with minimum seed number are also preferred. Similarly, with respect to quality parameters of fruits, those yielding maximum juice, vitamin C, TSS, sugar–acid ratio and low acidity are always preferred by the buyers.

In addition, for selection or hybridization work, plant breeders always prefer germplasms that possess all the above-mentioned criteria. So, from the results of the present study, it can be concluded that MZU-HAMP-PS-31 and MZU-HAMP-PS-32 possess all the desired physico-chemical characters preferred by the buyers as well as plant breeders. Hence, MZU-HAMP-PS-31 and MZU-HAMP-PS-32 could be considered as superior pummelo accessions from Mizoram.

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