Indian Journal of Agricultural Sciences **93** (1): 78–83, January 2023/Article
https://doi.org/10.56093/ijas.v93i1.103455

Morpho-physico-biochemical characterisation of Avocado (*Persea americana*) for selection of elite types

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Received: 12 August 2020; Accepted: 2 December 2022

ABSTRACT

Avocado (*Persea americana* Mill.) is found scattered throughout Mizoram. Although, the agro-climatic condition of Mizoram is found suitable for the growth and development, there are some specific areas where the performance of Avocado is found better in terms of yield and production. In order to assess the genetic diversity of locally grown avocado in Mizoram, present study was carried out during 2015–17 to find out the elite types of avocado from home gardens of Mizoram, north-east India. The mature fruits were collected and analyzed for morpho-physico-biochemical traits. The individual fruit weight ranged from 230.39–411.49 g, fruit length from 83.25–125.33 mm, diameter from 71.29–92.41 mm, volume from 213.47–399.67 cc; pulp weight from 152.30–267.97 g, peel weight from 37.45–67.64 g, pulp-peel ratio from 2.96–5.47, pulp thickness from 12.22–19.52 cm, peel thickness from 0.14–0.32 cm, seed length from 34.43–52.93 mm, seed weight from 29.95–129.26 g, moisture content from 82.64–65.73%, TSS from 6.21–8.63%, acidity from 0.140–0.299%, ascorbic acid from 9.80–18.34 mg/100 g, total sugars from 1.88–2.96%, reducing sugar from 1.05–1.86%, non-reducing sugar from 0.78–1.49%, sugar:acid ratio from 7.34–21.47 and TSS:acid ratio from 25.45–62.77. Out of all the germplasms studied in the present study, HAMP-MZU-AVS-1, HAMP-MZU-AVS-18 and HAMP-MZU-AVS-21 were found superior in all the parameters. Hence, HAMP-MZU-AVS-1, HAMP-MZU-AVS-18 and HAMP-MZU-AVS-21 could be considered as elite types and they can be used by the breeders to develop new cultivars.

Keywords: Avocado, Bio-chemical characteristics, Mizoram, North-east India, Variability

Avocado (*Persea americana* Mill.) also known as 'Butter fruit' belongs to *Lauraceae* family. The fruit is generally pear shaped and its outer surface is dark green to blackish brown in colour. Botanically, the fruit is a berry having only one seed and the plant is cultivated commercially both in tropical and mediterranean regions of the world. Nutritionally, avocado fruits are very rich, have medicinal properties, are used for manufacturing many cosmetic products, and contain proteins, fibres, potassium, phosphorus and magnesium etc (Nath *et al.* 2009). In India, avocado has a status of minor fruits and is commercially grown on a small scale in sub-tropical areas of south India. The major avocado producing states of India are Tamil Nadu. Maharashtra, Kerala, Karnataka, Sikkim and Mizoram. In Mizoram, the fruits are being commercially grown in few districts with an altitude of 800–1600 m amsl.

In any crop improvement programme, accession is the primary requisite. The extent of variability among the accessions plays an important role in selection of elite types with desirable quality (Hazarika *et al.* 2021). In rich gene pool, variability among the germplasm is another important consideration which may help the breeder in breeding works (Kumar 2010). In addition, the superior traits and lines may be successfully utilized as parents in hybridization (Jaiprakash *et al.* 2010). Breeding and development of high quality superior varieties through hybridization require thorough knowledge about genetic variation and more of the parental lines to be used in hybridization (Rajan *et al.* 2009).

Although a number of research work has been carried out on avocado characterization throughout the globe (Nkansah *et al.* 2013, Ge *et al.* 2017, Abraham *et al.* 2018, Poudel *et al.* 2018, Juma *et al.* 2020, Augustine *et al.* 2021, Juma *et al.* 2021, Ranjitha *et al.* 2021), however, no research work has been carried out in the northeast India to assess the diversity of avocado. Hence, the present study was carried out to evaluate the elite types of avocado by using morpho-physico-biochemical characters. The results of this study would definitely help the breeders to make proper strategies for conservation of superior traits.

MATERIALS AND METHODS

The present study was carried out during 2015–2017 in three geographically distinct districts of Mizoram, India to know the extent of diversity in the natural population of

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avocado and also to select the elite type with horticultural potentialities. In Mizoram, the avocado trees are found in the home gardens, abandoned lands as well as in primary and secondary forests. The preliminary survey and identification of avocado plants were done randomly and after preliminary survey, 30 plant orchards from three districts, i.e. Aizawl, Serchhip and Lunglei were randomly selected based on plant general health, fruit size, colour and attractive appearance during 2015–17 to identify the superior types by following IPGRI descriptors. During the survey and collection of fruits, it was observed that, the diversity of avocado fruits resembles most with West Indian races. Table 1 depicts the details of the accessions and their geographical information. From each selected accessions, 20 fruits were collected randomly from different locations and brought to the research laboratory for further analysis.

Standard procedures were followed for measuring the physical parameters of the fruits. Electronic digital balance was used to measure the weight of the different parts of fruits. Chemical parameters were estimated by following standard procedures (AOAC 2016). The ascorbic acid of the fruit pulp was estimated by visual titration method. The ANOVA was performed using PROC GLM of statistical analysis system (SAS) software (version 9.3; SAS Inc, Cary, NC).

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) of 30 Avocado accessions showed significant variations among the accessions (Table 2, 3). In the present study, the fruit weight of the studied accessions varied between 230.39–411.49 g. Among all the studied accessions, the highest fruit weight was observed in MZU-HAMP-AVS-1 (411.49 g) , followed by MZU-HAMP-AVS-21 (410.80 g), MZU-HAMP-AVS-18 (402.90 g), MZU-HAMP-AVS-22 (393.31 g), MZU-HAMP-AVS-4 (390.83 g), MZU-HAMP-AVS-23 (381.55 g), MZU-HAMP-AVS-20 (377.58 g), and MZU-HAMP-AVS-7

Table 1 Accessions and their sources

Accessions	Location	Latitude	Longitude	Elevation (m)
MZU-HAMP-AVS-1	Khawlailung	N23°14’12.9”	E093°00’30.8”	943
MZU-HAMP-AVS-2	Khawlailung	N 23°14’05.4”	E093°00’30.1”	907
MZU-HAMP-AVS-3	Khawlailung	N 23°13’56.9”	E093°00’23.8”	1036
MZU-HAMP-AVS-4	Khawlailung	N 23°13’32.0”	E 093°00’09.3”	1054
MZU-HAMP-AVS-5	Chekawn	N23°11’15.5”	E093°01’04.8”	833
MZU-HAMP-AVS-6	Sialsir	N23°10’15.7”	E092°59’35.7”	1196
MZU-HAMP-AVS-7	Lungchhuan	N23°08’44.0”	E093°01’10.4”	1282
MZU-HAMP-AVS-8	N.Vanlaiphai	N23°07’44.2”	E093°03’04.5”	1291
MZU-HAMP-AVS-9	Khawlailung	N23°12’38.0”	E093°00’22.4”	1062
MZU-HAMP-AVS-10	Khawlailung	N23°12’46.1”	E093°00’18.2”	1072
MZU-HAMP-AVS-11	Khawlailung	N23°12’13.4”	E093°00’28.9”	1357
MZU-HAMP-AVS-12	Hlimen	N23°41’06.2”	E092°43’19.9”	1021
MZU-HAMP-AVS-13	Hlimen	N23°40’14.5”	E092°43’04.0”	1048
MZU-HAMP-AVS-14	Serchhip	N23°18’32.1”	E092°50’35.0”	883
MZU-HAMP-AVS-15	Serchhip	N23°17’21.8”	E092°51’52.0”	857
MZU-HAMP-AVS-16	Serchhip	N23°34’17.0”	E092°85’02.0”	543
MZU-HAMP-AVS-17	Selesih	N23°80”80.0”	E092°73’37.2”	1348
MZU-HAMP-AVS-18	Durtlang	N23°73’22.7”	E092°73’13.1”	1273
MZU-HAMP-AVS-19	Durtlang	N23°73’03.0”	E092°44’04.2”	1154
MZU-HAMP-AVS-20	Durtlang	N23°75’86.7”	E092°73’14.8”	1324
MZU-HAMP-AVS-21	Lunglei	N22°53’11.2”	E92°44’20.1”	722
MZU-HAMP-AVS-22	Lunglei	N22°83’61.0’’	E92°74’54.2”	926
MZU-HAMP-AVS-23	Tlangnuam	N23°42’08.5”	E092°43’11.5”	1081
MZU-HAMP-AVS-24	Tlangnuam	N23°42’23.0”	E092°43’18.3”	1107
MZU-HAMP-AVS-25	Republic	N23°23’21.0”	E092°93’02.4”	960
MZU-HAMP-AVS-26	Republic	N23°72’08.2”	E092°72’39.0”	970
MZU-HAMP-AVS-27	Mission veng	N23°42’47.2’’	E092°42’44.7”	1044
MZU-HAMP-AVS-28	Bethlehem	N24°04’27.9”	E092°80’82.1”	950
MZU-HAMP-AVS-29	Ramhlun	N23°45’05.9”	E092°43’42.7”	1180
MZU-HAMP-AVS-30	Chaltlang	N23°75’15.3”	E092.72’37.3”	1223

Table 2 Physical parameters of the different avocado accessions

Accessions	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Fruit volume (cc)	Specific gravity (g/cc)	Pulp weight (g)	Peel weight (g)	Pulp-peel ratio	Pulp thickness (cm)	Peel thickness (cm)	Seed length (mm)	Seed diameter (mm)	Seed weight (g)
MZU-HAMP-AVS-1	411.49	120.07	92.41	399.67	1.03	267.97	53.02	5.06	19.52	0.32	51.17	57.11	90.50
MZU-HAMP-AVS-2	333.20	115.52	85.67	316.42	1.06	231.03	57.37	4.03	15.33	0.27	44.55	46.39	44.80
MZU-HAMP-AVS-3	255.82	99.95	82.62	228.93	1.12	152.30	50.94	2.99	13.50	0.27	42.44	45.33	52.57
MZU-HAMP-AVS-4	390.83	101.27	91.17	316.80	1.31	229.72	67.64	3.38	15.77	0.29	48.22	54.40	93.47
MZU-HAMP-AVS-5	266.67	93.31	84.23	250.50	1.08	160.91	45.20	3.56	14.19	0.28	46.50	51.50	60.57
MZU-HAMP-AVS-6	319.03	111.05	82.67	306.50	1.04	183.42	50.02	3.69	16.27	0.23	40.93	45.60	85.59
MZU-HAMP-AVS-7	372.10	116.13	87.25	333.67	1.11	257.23	55.39	4.65	15.33	0.20	45.85	51.53	59.48
MZU-HAMP-AVS-8	349.66	103.77	88.33	317.00	1.11	203.72	58.27	3.50	16.67	0.29	47.53	53.17	87.68
MZU-HAMP-AVS-9	326.67	112.60	85.78	297.33	1.10	200.24	53.00	3.78	14.33	0.30	48.27	54.93	73.42
MZU-HAMP-AVS-10	294.71	115.22	83.67	276.67	1.06	192.10	40.75	4.72	16.22	0.20	44.89	48.95	61.86
MZU-HAMP-AVS-11	330.35	101.27	85.48	292.67	1.13	191.06	55.92	3.41	15.22	0.27	46.22	51.85	83.38
MZU-HAMP-AVS-12	317.48	105.89	85.81	278.40	1.14	191.64	65.01	2.96	14.67	0.28	42.11	48.93	60.82
MZU-HAMP-AVS-13	282.33	95.27	84.55	253.43	1.11	187.34	37.45	5.00	14.33	0.20	49.26	51.11	57.54
MZU-HAMP-AVS-14	288.98	94.37	86.67	257.80	1.12	170.37	37.74	4.51	13.28	0.18	44.89	55.27	80.87
MZU-HAMP-AVS-15	259.08	92.33	84.33	239.30	1.08	164.12	38.82	4.23	12.33	0.20	44.50	49.56	56.14
MZU-HAMP-AVS-16	333.77	113.87	85.48	311.83	1.07	233.42	53.53	4.36	17.19	0.22	41.89	43.78	46.82
MZU-HAMP-AVS-17	340.98	106.27	83.67	315.60	1.08	240.46	44.62	5.36	14.67	0.17	42.11	41.93	55.90
MZU-HAMP-AVS-18	402.90	125.33	90.73	389.03	1.03	257.13	47.00	5.47	18.33	0.31	51.04	54.10	98.77
MZU-HAMP-AVS-19	290.65	96.33	82.27	267.17	1.09	174.13	49.81	3.49	12.22	0.15	38.40	46.87	66.71
MZU-HAMP-AVS-20	377.58	107.50	83.83	343.96	1.10	225.68	60.89	3.72	16.18	0.23	46.50	54.15	91.01
MZU-HAMP-AVS-21	410.80	114.62	85.24	287.47	1.43	251.88	52.77	4.77	17.67	0.28	52.93	54.50	106.15
MZU-HAMP-AVS-22	393.31	114.19	81.03	374.47	1.05	218.57	45.49	4.81	14.28	0.27	48.53	52.83	129.26
MZU-HAMP-AVS-23	381.55	99.23	85.88	360.40	1.06	233.98	49.01	4.76	17.62	0.20	47.20	50.41	98.56
MZU-HAMP-AVS-24	231.27	83.25	71.29	213.47	1.08	157.70	43.62	3.62	17.33	0.14	34.43	41.75	29.95
MZU-HAMP-AVS-25	282.99	94.33	78.82	256.33	1.10	188.54	41.11	4.57	13.88	0.20	36.53	43.53	53.35
MZU-HAMP-AVS-26	283.65	96.90	83.69	258.20	1.10	190.87	40.27	4.74	14.67	0.23	36.38	46.48	52.51
MZU-HAMP-AVS-27	241.23	86.83	79.52	217.53	1.11	162.97	41.07	3.97	13.33	0.22	38.83	43.17	37.20
MZU-HAMP-AVS-28	262.06	92.60	83.48	235.50	1.12	178.23	38.94	4.58	13.28	0.20	41.87	46.83	44.89
MZU-HAMP-AVS-29	284.55	98.53	86.85	253.50	1.13	194.43	45.77	4.23	15.17	0.25	44.17	49.53	44.35
MZU-HAMP-AVS-30	230.39	86.67	74.04	223.63	1.03	154.01	37.70	4.08	14.28	0.22	38.50	44.27	38.67
SEm (±)	25.78	7.80	2.65	17.27	-	16.59	2.82	0.23	1.11	0.03	1.78	1.81	16.95
CD(0.05)	43.08	13.03	4.42	28.86	NS	27.72	4.71	0.39	1.86	0.05	2.97	3.02	28.32

Table 3 Chemical characteristics of the fruits among different accessions

Accessions	Moisture (%)	TSS (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Total sugars (%)	Reducing sugar (%)	Non reducing sugar (%)	Sugar: acid ratio	TSS: acid ratio	Total sugars (%)	Reducing sugar (%)
MZU-HAMP-AVS-1	82.33	8.53	0.142	18.03	2.92	1.93	1.09	21.47	62.77	2.92	1.93
MZU-HAMP-AVS-2	75.42	6.75	0.171	11.25	2.42	1.73	0.78	14.83	41.82	2.42	1.73
MZU-HAMP-AVS-3	72.39	6.60	0.235	10.35	2.83	1.50	1.41	12.32	28.57	2.83	1.50
MZU-HAMP-AVS-4	77.44	6.30	0.235	10.83	2.13	1.10	1.08	9.59	28.47	2.13	1.10
MZU-HAMP-AVS-5	75.40	6.40	0.171	10.24	2.54	1.60	1.02	15.37	39.02	2.54	1.60
MZU-HAMP-AVS-6	71.16	7.33	0.278	13.26	2.22	1.20	1.08	8.08	26.66	2.22	1.20
MZU-HAMP-AVS-7	76.80	6.37	0.213	12.05	2.48	1.39	1.16	11.66	30.33	2.48	1.39
MZU-HAMP-AVS-8	76.16	6.81	0.171	16.11	2.80	1.59	1.29	17.05	40.97	2.80	1.59
MZU-HAMP-AVS-9	77.46	6.92	0.272	13.50	2.02	1.30	0.79	7.45	25.49	2.02	1.30
MZU-HAMP-AVS-10	74.41	8.02	0.192	10.92	2.51	1.29	1.29	14.28	45.02	2.51	1.29
MZU-HAMP-AVS-11	74.12	6.52	0.256	13.43	1.88	1.05	0.88	7.34	25.45	1.88	1.05
MZU-HAMP-AVS-12	74.75	7.76	0.235	17.83	2.41	1.30	1.17	10.94	35.01	2.41	1.30
MZU-HAMP-AVS-13	78.12	8.04	0.235	12.91	2.32	1.60	0.80	10.11	34.98	2.32	1.60
MZU-HAMP-AVS-14	73.75	7.43	0.278	11.57	2.55	1.86	0.79	9.30	27.18	2.55	1.86
MZU-HAMP-AVS-15	73.68	7.32	0.254	9.80	2.68	1.42	1.33	10.68	29.22	2.68	1.42
MZU-HAMP-AVS-16	74.09	7.59	0.278	16.40	2.19	1.13	1.11	7.98	27.65	2.19	1.13
MZU-HAMP-AVS-17	73.81	7.83	0.171	17.46	2.69	1.69	1.08	16.34	47.55	2.69	1.69
MZU-HAMP-AVS-18	82.64	8.63	0.140	18.34	2.88	1.75	1.22	20.88	62.34	2.88	1.75
MZU-HAMP-AVS-19	68.67	6.21	0.149	10.71	2.27	1.27	1.06	15.46	43.10	2.27	1.27
MZU-HAMP-AVS-20	75.03	7.34	0.171	10.49	2.57	1.46	1.18	15.66	44.66	2.57	1.46
MZU-HAMP-AVS-21	81.73	7.90	0.168	10.03	2.31	1.48	0.90	13.69	47.13	2.31	1.48
MZU-HAMP-AVS-22	77.49	7.67	0.171	10.38	2.91	1.49	1.49	17.64	46.66	2.91	1.49
MZU-HAMP-AVS-23	76.07	7.85	0.299	11.65	2.96	1.65	1.39	10.01	26.57	2.96	1.65
MZU-HAMP-AVS-24	65.73	6.81	0.175	10.64	2.62	1.42	1.27	14.93	38.87	2.62	1.42
MZU-HAMP-AVS-25	67.10	6.58	0.213	11.02	2.56	1.64	1.00	12.36	31.41	2.56	1.64
MZU-HAMP-AVS-26	67.77	7.79	0.213	10.65	2.28	1.17	1.17	10.93	37.15	2.28	1.17
MZU-HAMP-AVS-27	66.43	7.03	0.194	15.65	2.37	1.33	1.11	12.81	37.93	2.37	1.33
MZU-HAMP-AVS-28	70.13	6.49	0.213	11.25	2.18	1.18	1.06	10.45	31.16	2.18	1.18
MZU-HAMP-AVS-29	73.27	6.80	0.220	10.80	2.70	1.73	1.06	12.48	31.34	2.70	1.73
MZU-HAMP-AVS-30	67.30	8.14	0.171	10.47	2.94	1.77	1.26	17.80	49.34	2.94	1.77
SEm (±)	2.56	0.18	0.032	1.92	0.12	0.08	0.06	2.39	6.70	0.12	0.08
CD (0.05)	4.28	0.31	0.054	3.21	0.20	0.14	0.11	3.99	11.19	0.20	0.14

(372.10 g), whereas, the lowest fruit weight was recorded in MZU-HAMP-AVS-30 (230.39 g). Our study is in the line of conformity with the studies of Nkansah *et al.* (2013) in avocado.

The highest fruit length was recorded in MZU-HAMP-AVS-18 (125.33 mm), followed by MZU-HAMP-AVS-1 (120.07 mm), MZU-HAMP-AVS-7 (116.13 mm), MZU-HAMP-AVS-2 (115.52 mm), MZU-HAMP-AVS-10 (115.22 mm), MZU-HAMP-AVS-21 (114.62 mm) MZU-HAMP-AVS-21 (114.62 mm), and MZU-HAMP-AVS-16 (113.87 mm), while, the lowest was observed in MZU-HAMP-AVS-24 (83.25 mm). The differences in the individual genetic make-up of each genotype makes variation in fruit length (Hazarika *et al.* 2013). Similar result was also reported by Abraham *et al.* (2018) in avocado. Fruit diameter of avocado also varied significantly among the accessions. Among all the accessions, MZU-HAMP-AVS-1 (92.41 mm), recorded the highest fruit diameter followed by MZU-HAMP-AVS-4 (91.17 mm), MZU-HAMP-AVS-18 (90.73 mm), and MZU-HAMP-AVS-8 (88.33 mm), while, MZU-HAMP-AVS-24 recorded the lowest (71.29 mm). Our study is in the line of similarity with the findings of Augustine *et al.* (2021) in avocado. .

The fruit volume of the accessions ranged between 213.47–33-399.67 cc. MZU-HAMP-AVS-1 (399.67 cc), recorded the highest fruit volume followed by MZU-HAMP-AVS-18 (389.03 cc), and MZU-HAMP-AVS-22 (374.47 cc), while, MZU-HAMP-AVS-24 (213.47 cc) recorded the lowest. Ranjitha *et al.* (2021) also observed differences in the volume of the fruits among different avocado accessions. There was no statistical variation among the collected accessions in fruits specific gravity. However, MZU-HAMP-AVS-12 recorded highest (1.14 g/cc), and MZU-HAMP-AVS-1, HAMP-AVS-18 and HAMP-AVS-30 (1.03 cc), recorded lowest value. The maximum pulp weight was observed in MZU-HAMP-AVS-1 (267.97 g), followed by MZU-HAMP-AVS-18 (257.13 g), MZU-HAMP-AVS-7 (257.23 g), and MZU-HAMP-AVS-21 (251.88 g), while, the MZU-HAMP-AVS-3 recorded the lowest (152.30 g). Poudel *et al.* (2018) also obtained similar findings as that of our results in avocado.

The peel weight ranged between 37.45–67.64 g among the accessions. MZU-HAMP-AVS-4 recorded the highest (67.64 g), followed by MZU-HAMP-AVS-12 (65.01 g), while, MZU-HAMP-AVS-13 recorded the lowest (37.45 g). Similar reports with respect to peel weight of avocado were also reported by Yunus *et al.* (2019). Like other parameters of peel, maximum pulp:peel ratio was observed in MZU-HAMP-AVS-18 (5.47) which was significantly superior to all the accessions except MZU-HAMP-AVS-17 (5.36), while, the lowest was observed in MZU-HAMP-AVS-12 (2.96). Poudel *et al.* (2018) also obtained similar results in avocado with respect to pulp:peel ratio.

MZU-HAMP-AVS-1 recorded the maximum thickness of the peel (0.32 cm), while, MZU-HAMP-AVS-24 recorded the least (0.14 cm). Our study is in the line of conformity with the studies of Juma *et al.* (2020, 2021), in avocado. MZU-HAMP-AVS-1 recorded maximum thickness of the pulp (19.52 cm), followed by MZU-HAMP-AVS-18 (18.33 cm), while, the lowest was recorded in HAMP-AVS-19 (12.22 cm). Yunus *et al.* (2019) also reported variation in pulp thickness among avocado accessions.

Among all the accessions, MZU-HAMP-AVS-21 recorded the maximum length of the seeds (52.93 mm) while, MZU-HAMP-AVS-24 recorded the least (34.43 mm). Our results are in the line of conformity with the findings of Abraham *et al.* (2018) in avocado. Similarly, among the accessions, MZU-HAMP-AVS-1 recorded the highest seed diameter (57.11 mm) and the lowest seed diameter was recorded in MZU-HAMP-AVS-24 (41.75 mm). Variations in seed diameter in different fruits have also been reported by Augustine *et al.* (2021). Accession MZU-HAMP-AVS-26 recorded the least seed weight (29.95 g), whereas the highest was observed in MZU-HAMP-AVS-22 (129.26 g). Similar reports have also been reported by Augustine *et al.* (2021) and Ranjitha *et al.* (2021).

The quality parameters of the fruits varied significantly among the accessions. The moisture content was found maximum in MZU-HAMP-AVS-18 (82.64%), and accession MZU-HAMP-AVS-24 recorded the significantly lowest moisture per cent of the fruits (65.73%). Orhevba and Jinadu (2011), and Mooz *et al.* (2012) also observed significant variations with respect to moisture content of the avocado fruits.

The maximum TSS was recorded in MZU-HAMP-AVS-18 (8.63%), followed by MZU-HAMP-AVS-1 (8.53%), while, the lowest was recorded in MZU-HAMP-AVS-19 (6.21%). The fruits growing in different edaphic and climatic conditions may contribute variation in TSS among the different accessions. Our study is in the line of conformity with the studies of Yunus *et al.* (2019) in avocado. The highest value with respect to ascorbic acid was recorded in MZU-HAMP-AVS-18 (18.34 mg/100 g), while the least was recorded in MZU-HAMP-AVS-15 (9.80%). Ge *et al.* (2017) also reported similar results with respect to ascorbic acid content of avocado fruits. Titratable acidity of the avocado fruits ranged between 0.140–0.299%. MZU-HAMP-AVS-18 (0.140%), recorded the lowest titratable acidity, while the highest was recorded in MZU-HAMP-AVS-23 (0.299%). Ge *et al.* (2017) also obtained differences in titratable acidity of avocado fruits which is in the line of similarity with our results.

Among the different avocado accessions, MZU-HAMP-AVS-23 (2.96%) recorded the maximum total sugars, while, MZU-HAMP-AVS-11 (1.88%) recorded the least. Similarly, MZU-HAMP-AVS-1 (1.93%) and MZU-HAMP-AVS-11 (1.05%) recorded the highest and lowest reducing sugars and MZU-HAMP-AVS-22 (1.49%), MZU-HAMP-AVS-2 (0.78%), recorded the highest and lowest non-reducing sugars. The different genetic makeup of the fruits alongwith environmental factors may play significant role in making the differences with respect to sugar content of the fruits. Similar results with respect to the sugar content of the fruits were also reported by Mooz *et al.* (2012) and Ge *et al.* (2017) in avocado.

The maximum sugar:acid ratio was recorded in MZU-HAMP-AVS-1 (21.47) followed by MZU-HAMP-AVS-18 (20.88), MZU-HAMP-AVS-21 (17.64) and MZU-HAMP-AVS-30 (17.80), while MZU-HAMP-AVS-11 recorded the least (7.34). Similarly, MZU-HAMP-AVS-1 recorded the highest TSS:acid ratio (62.77) and MZU-HAMP-AVS-11 recorded the least (25.45).

Out of all the germplasms studied in the present investigation, HAMP-MZU-AVS-1, HAMP-MZU-AVS-18 and HAMP-MZU-AVS-21 showed the overall superiority in all the parameters. Hence, HAMP-MZU-AVS-1, HAMP-MZU-AVS-18 and HAMP-MZU-AVS-21 could be considered as elite types for use in future breeding programmes. For crop improvement thorough selection and hybridization, better understanding of genetic diversity and idea about the structure of the population is foremost important. In the present study, the highly significant differences among the population with respect to various morpho-physico-biochemecal properties suggest good scope for the breeders for selection of varieties with good yield and quality traits. The results of the present study will help the breeders to develop novel breeding strategies for improving yield and quality traits and resistance to biotic and abiotic stresses.

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