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Biochemical and morphological characteristics of avocado genotypes in Kerala

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Abstract

In India, avocado cultivation is limited and scattered in the southern and northeastern region of India. A large number of avocado genotypes were available in Kerala, which vary widely in terms of biochemical as well as morphological attributes. In the present study, about 27 accessions (Acc.) were collected from different parts of Kerala, including high-altitude areas and plains. Wide variability in biochemical and morphological traits was observed among accessions collected from different locations. Acc. 11 had the highest vitamin C and Acc. 15 had the highest protein content. The highest fat content was reported in Acc. 7, while the highest oleic acid was recorded in Acc. 10. Acc. 25 reported the highest flavonoid and calcium content. Genotypes collected from Wayanad recorded comparatively higher values for vitamin C, phenols, potassium and crude fibre content. Protein, total fat and calcium contents were comparatively higher in genotypes collected from Idukki. Accessions 7, 10, 11, 12, 14, 15 and 25 could be selected for future conservation, popularization and commercial cultivation based on their biochemical and morphological quality attributes.

Key words: Avocado, *Persea americana* Mill., genotypes, fruits, characterization**,** biochemical, morphological, oleic acid, fat

Introduction

Avocado (*Persea americana* Mill.) is a subtropical fruit tree native to Central and South America that belongs to the Lauraceae family. It is an introduced fruit crop in India and is grown in a small area scattered throughout the south-central and eastern Himalayan states. Avocado is grown in Kerala primarily in high-altitude regions such as Wayanad and Idukki districts and, to a lesser extent, in the plains. The main cultivars grown in Kerala are Pollock, Kallar Round, Purple Hybrid and Fuerte (Nair and Chandran, 2018). To ripen properly, the avocado must be mature enough on the tree, determined by the dry matter content, oil content, and texture.

Avocado is one of the most nutritive fruits in the New World. Avocado is a good source of essential nutrients such as protein, fat, vitamins, and minerals such as calcium, potassium and iron. Also, avocado oil contains monounsaturated fat, which varies depending on the varieties (Orhevba and Jinadu, 2011). Oil extracts from avocado fruit pulp have a similar fatty acid composition to olive oil, especially in oleic acid content (Mooz *et al.,* 2012).

Avocado exhibits a high degree of cross-pollination, primarily attributed to its distinctive flowering pattern known as Protogynous diurnally synchronous dichogamy. Coupled with seed propagation, this unique feature results in a diverse array of genotypes, showcasing significant variations in morphology, physico-chemical properties, and nutritional content. As suggested by Juma *et al.* (2020), most of the studies were mainly focused on production, propagation and processing; therefore, research assessing the diversity of avocados is gaining importance. Tripathi *et al.* (2020) mentioned that study on genetic diversity related to morphological and biochemical traits helps in categorizing avocado accessions based on geographical origin and provides evidence of the existence of significant diversity and selecting superior accessions as parents for the development of promising varieties suitable for the desired region.

The selection of superior nutritional and morphological fruit characters will be of immense significance from the consumer's point of view. A substantial quantity of avocado fruit is being wasted in many parts of Kerala due to the lack of awareness of the health benefits and processing. Therefore, identifying and utilizing better varieties suitable for commercial purposes are necessary. The present study is focused on characterizing the biochemical and nutritional attributes and phenotypic traits of avocado fruit accessions cultivated in the hilly areas such as Wayanad and Idukki districts and in the plains of Kerala as the available information regarding the characterization is limited in the State.

Materials and methods

The research was conducted in the Department of Post Harvest Technology at the College of Agriculture, Thrissur, affiliated with Kerala Agricultural University. The study was carried out during the 2019-2020 period to ensure compliance with ethics approval. Fresh and mature avocado fruits of 27 accessions were collected from Ambalavayal in Wayanad district, located at 974 m above MSL and from Kanthalloor in Idukki district, located at 1525 m above MSL and one accession from Thrissur district (plains), located at 21 m above MSL, in Kerala. Acc. 1 to 14 were collected from Wayanad, Acc. 15 to 26 from Idukki district, and Acc. 27 from Thrissur. The fruits were analyzed for nineteen morphological traits according to IPGRI descriptors

(1995), and biochemical and nutritional attributes were also quantified. The colour of fruit skin and flesh were analyzed using RHS colour chart, while fruit skin thickness was measured with vernier calipers.

Total soluble solids: Total soluble solids were measured using a digital refractometer (ATAGO, PAL-1, 0-53 ^{0}Brix, Japan) and were expressed in ^{o}Brix.

Titratable acidity: Titratable acidity was measured by titrating the diluted sample to a known volume against 0.1 N sodium hydroxide using phenolphthalein as an indicator. The value was expressed in per cent of malic acid (AOAC, 1998).

Vitamin C: Vitamin C content was determined by titrating the sample against 2, 6- dichlorophenol indophenol dye using metaphosphoric acid (AOAC, 1998).

Total protein: The amount of protein was determined using Biuret reagent and Folin Ciocalteau reagent and absorbance was measured at 660 nm and from the standard graph, total protein content was expressed in g 100g^{-1} (Lowry *et al.,* 1951).

Total phenols: Total phenol content was determined using Folin-Ciocalteau reagent and 20 % sodium carbonate. The absorbance was measured with a spectrophotometer at 650 nm. Total phenol content was calculated from the standard curve and expressed as milligram per 100g (Asami *et al.,* 2003).

Total flavonoid: Total flavonoid content was determined spectrophotometrically by the aluminium chloride colorimetric method (Dewanto *et al.,* 2002). The absorbance was measured at 510 nm. Total flavonoid content was determined from the calibration curve of catechol standard solutions and expressed as catechol equivalent (mg g^{-1}).

Total fat: Fat was extracted with petroleum ether, distilled off in soxhlet apparatus, and from the dry weight of sample total fat was determined and expressed in percentage (Ranganna, 1986).

Oleic acid: One to ten g of oil or melted fat was dissolved in 50 mL of the neutral solvent (25 mL ether mixed with 25 mL 95 % alcohol) in a 250 mL conical flask and a few drops of phenolphthalein were added to it. The content was titrated against 0.1N KOH with constant shaking until a pink colour persisted for 15 seconds developed (AOAC, 2000).

Calcium and potassium: Minerals such as calcium and potassium were estimated in the flame photometric method (Flame photometer CL 378, Elico Ltd, India) using the ash solution prepared from the dry ash of the samples.

Iron: Ash solution prepared by dry ashing the sample was used to estimate iron content. 5 mL of ash solution was added with 0.5 mL of concentrated sulphuric acid, 1 mL of potassium persulphate and 2 mL of potassium thiocyanate and made up the solution to 15 mL with distilled water and measured the colour development at 480 nm (Ranganna, 1986).

Results and discussion

Biochemical parameters: The results obtained for the biochemical and nutritional contents of fruits of avocado accessions are presented in Table 1.

Total soluble solids: Significant variation was noticed among genotypes with respect to their TSS content in which significantly highest value was observed in Acc. 13 followed by Acc. 25. Astduillo-Ordonez and Rodrigez (2018) reported a range between 5.07 and 7.26 ^{o}Brix and Kassim and Workneh, (2020) reported total soluble solids of 2.9 ^{o}Brix in avocado fruits before storage, which is similar to the results obtained.

Titratable acidity: Titratable acidity varied non-significantly among the accessions, which ranged from 0.28 to 2.84 % in Acc 27 and Acc 12, respectively. Kassim and Workneh (2020) reported titratable acidity of 1.7 to 1.9 mg mL^{-1} in fresh avocado fruits without treatments or storage. As the ripening advanced, the total acid content in avocado (malic acid, tartaric acid, citric acid and ascorbic acid) decreased, decreasing titrable acidity (Defilippi *et al*., 2015).

Vitamin C: The significantly highest Vitamin C content in ripe avocado fruits was reported in Acc. 11 and least value in Acc. 18 and Acc. 20. It was observed that accessions of Wayanad had comparatively higher vitamin C content than those from Idukki. Tripathi and Sanker (2014) mentioned the chemical composition of avocado fruit per 100g of edible portion in which ascorbic acid content was about 16 mg.

Total protein: Total protein content of fruit significantly varied among the avocado genotypes collected from Wayanad (0.5 to 1.593 mg g^{-1}) had lower protein content than that from Idukki (8.33 to 11.93 mg g^{-1}). Maitera *et al.* (2014) and Duarte *et al.* (2016) reported about 1-4% and 1-3% crude protein, respectively.

Total phenols: The antioxidant potential of the plants are correlated with the content of phenolic compounds. Least and highest total phenolic content with significant differences were observed in Acc. 22 and Acc. 12, respectively. Comparatively lower values were reported in accessions collected from Idukki, which may contribute to the lower discolouration and off-flavours due to rancidity. Hurtado-Fernández *et al*. (2015) reported that the concentration of phenolic acids generally decreased as the fruit ripened.

Total flavonoid: Significant variation was not observed among genotypes with respect to their total flavonoid content. The results obtained were similar to the study of Cenobio-Galindo *et al.* (2019), who observed 36.04 to 37.07 mg 100g^{-1} in nanoemulsion-coated Hass avocado during the initial storage period.

Total fat: Fat content in the fruits varied significantly from 0.790 to 10.02 % in Acc.4 and Acc.7, respectively, comparable to the fat content in the West Indian race with 2.59 to 11.8 % as reported by Teng *et al.* (2016). Mostert *et al.* (2007) reported that ripe fruits of avocado have higher oil yield than unripe fruits.

Oleic acid: Avocado oil contains monounsaturated fatty acids mainly oleic acid which makes its biochemical composition similar to olive oil. Oleic acid is the most predominant fatty acid in avocado that ranged from 13.49 to 86.86 mg g^{-1} in Acc. 6 and Acc. 10 respectively which varied significantly among the genotypes. Avocado pulp with oleic acid content of 41.91 to 43.37 % was obtained in 250 mL hexane for two hours extraction (Gatbonton *et al.,* 2013).

Calcium: Minerals such as calcium content in fresh avocado

Table 1 Biochemical parameters of avocado accessions

	TSS (ºBrix)	Titratable acidity (%)	Vitamin C (mg 100g^{-1})	Total protein (mg g^{-1})	Total phenols (mg 100g^{-1})	Total flavanoid (mg 100g^{-1})	Total fat (%)	Oleic acid (mg g^{-1})	Calcium (mg 100g^{-1})	Potassium (mg 100g^{-1})	Iron (mg 100g^{-1})
Acc 1	10.00	2.33	16.00	0.88	92.50	31.30	5.82	24.45	9.65	436.80	0.11
Acc 2	7.00	1.55	17.33	1.00	86.67	39.20	1.06	45.53	6.75	138.80	0.11
Acc 3	6.67	2.58	17.33	0.74	84.67	59.10	1.16	60.87	9.60	154.60	0.13
Acc 4	9.00	1.03	10.00	1.04	100.17	62.90	0.79	46.91	8.85	314.60	0.12
Acc 5	6.67	1.55	12.67	0.81	82.83	64.50	2.14	39.72	8.30	168.40	0.13
Acc 6	9.33	1.03	13.33	0.91	64.00	63.17	2.08	13.49	8.40	209.40	0.11
Acc 7	9.33	2.07	16.00	1.24	71.50	52.57	10.02	18.69	9.80	345.60	0.10
Acc 8	8.67	2.58	16.00	1.32	87.83	58.70	3.29	22.88	9.65	320.00	0.14
Acc 9	7.33	1.03	14.67	0.50	87.17	24.80	2.81	26.79	8.20	228.00	0.10
Acc 10	9.00	1.81	14.67	0.88	100.50	54.17	1.63	86.86	13.35	460.00	0.11
Acc 11	8.00	1.55	20.00	0.90	65.33	48.13	1.20	69.48	7.55	216.20	0.09
Acc 12	10.33	2.84	19.33	1.59	102.83	28.37	8.86	25.13	8.10	356.40	0.09
Acc 13	11.33	2.07	16.00	1.59	82.67	42.26	1.24	48.50	8.35	223.20	0.15
Acc 14	7.67	2.07	18.67	1.14	73.67	32.93	2.46	36.35	8.25	278.00	0.13
Acc 15	7.00	1.29	9.33	11.93	56.50	39.34	2.77	30.85	9.03	178.17	0.09
Acc 16	6.00	1.03	8.00	11.60	42.17	51.70	1.85	58.75	4.90	122.27	0.15
Acc 17	5.33	1.29	7.33	9.63	55.83	29.85	2.76	54.32	5.46	147.83	0.04
Acc 18	6.67	1.29	5.33	9.87	45.00	33.69	2.61	34.12	5.83	146.27	0.11
Acc 19	5.40	1.03	7.33	9.20	50.00	53.58	3.61	72.21	7.64	133.23	0.08
Acc 20	4.27	1.29	5.33	9.80	40.00	32.08	2.23	42.12	8.75	165.20	0.19
Acc 21	6.67	1.29	6.67	9.55	39.17	36.30	4.49	19.13	12.12	174.57	0.16
Acc 22	5.07	1.29	8.00	8.67	33.33	32.18	7.07	34.60	11.67	134.93	0.30
Acc 23	8.00	1.29	6.67	8.33	38.33	53.28	7.22	18.24	11.33	193.67	0.15
Acc 24	5.33	1.55	7.33	9.60	56.67	46.08	1.75	44.92	5.84	151.37	0.31
Acc 25	10.93	1.29	10.00	8.57	50.00	66.67	1.83	72.69	13.46	198.43	0.20
Acc 26	7.10	1.03	8.00	9.90	63.33	41.97	2.10	28.09	6.50	140.27	0.44
Acc 27	10.50	0.28	17.33	2.27	53.33	47.54	1.33	67.20	5.72	190.50	0.20
CD	3.55	1.13	0.93	4.65	2.28	NS	1.29	0.94	3.42	1.22	0.16

fruits varied significantly among genotypes from 4.9 mg 100g^{-1} in Acc. 16 to 13.46 mg 100g^{-1} in Acc. 25. Nair and Chandran (2018) reported about 9, 9.2, 9.5 and 9.8 mg 100g^{-1} in avocado cultivars such as Pollock, Fuerte, Kallar Round and Purple Hybrid respectively.

Potassium: Fruits collected from Wayanad had comparatively higher potassium content than those from Idukki. Potassium content in fresh avocado fruits varied significantly among genotypes. Avocado is a rich source of potassium than other fruits, ranging from 122.27 mg 100g^{-1} in Acc. 16 to 460 mg 100g^{-1} in Acc. 10, which is comparable with the result obtained by Nair and Chandran (2018), which was about 300, 400, 500 and 525 mg 100g^{-1} in different cultivars such as Pollock, Kallar Round, Purple Hybrid and Fuerte respectively.

Iron: Iron content obtained in fresh and mature avocado fruits varied significantly, and the lowest and highest values were reported in Acc. 19 and Acc. 26, respectively. Nair and Chandran (2018) obtained 0.40-0.60 mg 100g^{-1} of iron content in different accessions of avocados cultivated in Kerala.

Phenotypic characterization: Table 2a, b shows the results of the phenotypic characterization of fruits from avocado accessions, with each trait evaluated in five fruits chosen after sorting. Fruit shape varied from spheroid to pyriform among the fruits of different genotypes. Among the 27 accessions, the lowest and highest fruit length, diameter, and weight were observed in accessions 13 and 14, respectively. Thus, significant variation was observed with respect to fruit size among the genotypes. In most genotypes, ridges were absent, while strong glossiness with smooth skin were observed on the fruit surface. The fruit skin colour of accessions from Wayanad had turned to purplish on ripening while those from Idukki remained light green even after ripening. Fruits from Idukki had higher skin thickness, which may result in lesser damage to the fruit's surface.

Regarding the pliability of fruit skin, most of the genotypes had brittle fruit skin. Adherence of skin to flesh was slight in many of the genotypes favouring easy removal of fruit peel from flesh. Colour of flesh next to skin was generally observed as greenish yellow, while colour of the flesh next to the seed was light yellowish in the ripe fruits. Flesh texture of ripe fruits in most of the genotypes was buttery, while there were a few fruits with pastose flesh. Avocado fruit flesh was neither sweet nor bitter, with low fibre content. General taste of flesh was observed from excellent to poor and Acc. 16, 19 and 25 were observed with excellent taste. Degree of discolouration of open fruit after 4 hours was observed only in Acc. 3, 5, 14, 22 and 26, and the discolouration was brown for all accessions except Acc. 5, which showed grey discolouration.

Abraham *et al.* (2018) from Ghana reported a fruit length range of 10-13 cm, fruit diameter of 7-9 cm, fruit weight between 220-370 g, 35.8 % of strong glossy skin with 96.2 % thickness between 2-6 mm and strong adherence of skin to flesh in 13.2 % of fruits. Ayal-Silva *et al.* (2019) reported that avocado fruit, botanically a berry, may have round, pear-shaped or oblong with flexible to woody, smooth to rough skin with green-yellow, reddish-purple, purple, or black. Fruit flesh is greenish-yellow to bright yellow and is buttery, while fruit weight varies from 150 g to 1.5 kg.

The study on biochemical and nutritional contents and

Table 2a. Morphological traits of avocado accessions in Kerala (Wayanad)

Parameters	Acc 1	Acc 2	Acc 3	Acc 4	Acc 5	Acc 6	Acc 7	Acc 8	Acc 9	Acc 10	Acc 11	Acc 12	Acc 13	Acc 14
Fruit shape	High spheroid	Clavate	Clavate	Clavate	Spheroid	Spheroid	Narrowly obovate	Narrowly obovate	Pyriform	Narrowly oboate	Clavate	Spheroid	Narrowly obovate	Obovate
Fruit length (cm)	6.08	11.18	12.86	8.62	6.68	6.86	8.60	8.52	11.04	6.92	6.73	6.58	5.50	12.76
Fruit diameter (cm)	5.61	6.37	7.00	5.15	6.59	7.08	6.94	6.74	6.71	6.15	7.00	6.68	4.62	9.87
Fruit weight (g)	89.42	247.80	312.38	113.78	163.70	182.50	209.06	209.16	224.92	329.98	312.42	149.68	58.34	640.41
Fruit size uniformity	High	INT	High	High	High	High	High	High	INT	High	INT	High	INT	High
Fruit base shape	Flat	Inflated	Inflated	Inflated	Inflated	Flattened	Pointed	Pointed	Inflated	Inflated	Inflated	Inflate	Pointed	Flattened
Fruit apex shape	Flat	Rounded	Rounded	Rounded	Round	Flattened	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Rounded	Flattened
Fruit apex position	ASY	Central	Central	Central	ASY	Central	Central	Central	ASY	ASY	Central	ASY	Central	ASY
Ridges on fruit	None	None	None	Entire	None	None	None	Partial	None	Entire	None	None	None	None
Gloss on fruit	MED	Strong	Strong	Weak	Weak	Strong	Strong	MED	Weak	Strong	Strong	Strong	Weak	MED
Pedicel position on fruit	Central	ASY	Central	ASY	Central	Central	Central	Central	Central	Central	Central	Central	Central	ASY
Fruit skin surface	INT	Smooth	Smooth	Rough	INT	INT	INT	Rough	INT	Rough	Smooth	Smooth	INT	INT
Fruit skin colour	142 Strong yellowish purple	67A Strong purplish red	74A Deep reddish purple	142A Strong yellowish purple	142B Brillant yellowish green	142A Strong yellowish purple	77A Deep reddish purple	202A Dark grayish purple	79A Dark purple	141C Strong yellowish green	79C Deep purplish	64C Strong purplish red	141C-80A Speckled Green Purple	66B Vivid purplish red
Fruit skin thickness (mm)	1.34	1.04	3.04	1.34	1.02	1.04	1.12	2.23	2.02	3.12	1.06	1.21	2.24	2.31
Pliability of fruit skin	Brittle	Brittle	Brittle	Pliable	Brittle	Pliable	Brittle	Brittle	Brittle	Brittle	Pliable	Pliable	Brittle	Brittle
Adherence of skin to flesh	INT	INT	Strong	Slight	Slight	Slight	Slight	INT	Slight	Slight	Slight	Strong	Strong	INT
Colour of flesh next to skin	141D Strong yellowish green	142C Light yellowish green	142A strong yellowish green	142D Light yellowish green	142B Brillant yellowish green	149A Brillant yellowish green	142AStrong yellowish green	149C Brillant yellowish green	142A Strong yellowish green	142B Brillant yellowish green	142A Strong yellowish Green	142A Strong yellowish Green	142A Strong yellowish Green	142A. Strong yellowish green
Colour of flesh next to seed	1D Pale greenish yellow	154D Light yellowish green	2C light yellowish green	150D Light yellowish green	154D Light yellowish green	154B brilliant yellowish green	4C Light greenish yellow	2C-Light yellowish green	2B Brillant greenish yellow	2C Light yellowish green	2C Light yellowish green	2C light yellowish green	2C light yellowish green	3D Light greenish yellow
Flesh texture	Buttery	Buttery	Buttery	Buttery	Pastose	Buttery	Buttery	Buttery	Pastose	Buttery	Buttery	Buttery	Buttery	Watery
Sweetness of flesh	Low	INT	INT	Low	Low	Low	INT	Low	Low	Low	INT	Low	INT	Low
Bitterness of flesh	Low	INT	Low	Low	Low	Low	Low	Low	High	High	Low	INT	Low	Low
Fibre in flesh	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
General taste of flesh	Fair	Good	Good	Good	Fair	Fair	Fair	Fair	Poor	Poor	Good	Fair	Good	Fair
Degree of colouration of open fruit after 4hr.	Nil	Nil	High	Nil	High	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	High
Colour of discolouration			Brown		Grey									Brown

INT: Intermediate, M: Medium, ASY: Asymmetric

Table 2b. Morphological traits of avocado accessions in Kerala (Idukki and Thrissur)

Parameter	Acc 15	Acc 16	Acc 17	Acc 18	Acc 19	Acc 20	Acc 21	Acc 22	Acc 23	Acc 24	Acc 25	Acc 26	Acc 27
Fruit shape	Ellipsoid	Clavate	High spheroid	High spheroid	Narrowly obovalte	Narrowly obovalte	High spheroid	Spheroid	Obovate	Ellipsoid	Narrowly obovate	Spheroid	Narrowly obovate
Fruit length (cm)	7.75	10.5	8.95	8.70	9.65	8.85	9.30	8.60	11.10	9.20	9.50	7.28	12.06
Fruit diameter (cm)	6.82	6.87	8.02	7.98	7.20	7.29	8.97	8.02	8.02	7.61	7.69	7.81	7.14
Fruit weight (g)	188.92	247.74	305.36	310.84	267.97	247.27	395.00	275.39	335.00	273.66	480.10	242.94	452.40
Fruit size uniformity	INT	High	Low	High	INT	INT	High	High	High	High	High	High	High
Fruit base shape	Inflated	Pointed	flattened	Flattened	Pointed	Pointed	Flattened	Depressed	Inflated	Inflated	Inflated	Depressed	Inflated
Fruit apex shape	Rounded	Rounded	Rounded	Flattened	Rounded	Slightly depressed	Flattened	Flattened	Round	Round	Round	Flattened	Round
Fruit apex position	Central	Central	Central	ASY	Central	ASY	ASY	Central	ASY	Central	Central	Central	ASY
Ridges on fruit	Absent	Partial	Partial	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Gloss on fruit	Medium	Weak	Medium	Medium	Medium	Strong	Weak	Strong	Strong	Medium	Weak	Strong	Medium
Pedicel position on fruit	Central	Central	Central	Central	Central	Central	Central	ASY	ASY	Central	Central	Central	Central
Fruit skin surface	Smooth	Rough	INT	Rough	Rough	Smooth	INT	Smooth	Smooth	Smooth	INT	Smooth	Smooth
Fruit skin colour	202A Dark greyish purple	142A Strong yellowish green	142B Brillant yellowish green	142B Brillant yellowish green	154AVivid yellowish green	202A Dark greyish purple	153C Strong greenish yellow	142A Strong yellowish green	142A Strong yellowish green	142A Strong yellowish green	186A Moderate purplish red	58C Strong purplish red	149A Brilliant yellowish green
Fruit skin thickness (mm)	3.08	2.03	2.52	3.03	3.04	3.05	3.06	1.04	2.03	3.06	2.55	2.06	1.02
Pliability of fruit skin	Brittle	Brittle	Brittle	Brittle	Brittle	Brittle	Brittle	Pliable	Brittle	Brittle	Brittle	Brittle	Pliable
Adherence of skin to flesh	INT	Slight	Strong	Strong	Slight	Strong	INT	Slight	Slight	INT	INT	Slight	Slight
Colour of flesh next to skin	142A Strong yellowish green	149A Bright yellowish green	142D Light yellowish green	142D Light yellowish green	144D Light yellowish green	154D Light yellowish green	142B Brillant yellowish green	142C Light yellowish green	142D Light yellowish green	142B Brillant yellowish green	142C Light yellowish green	142D Light yellowish green	149C Brilliant yellowish green
Colour of flesh next to seed	3D Light greenish yellow	4D Pale yellowish	4D Pale yellowish	4D Pale yellowish	4D Pale yellowish	154D Light yellowish green	3D Light greenish yellow	4D Pale yellowish green	3D Light greenish yellow	3D Light greenish yellow	2C Light yellowish green	4D Pale yellowish green	1C Light greenish yellow
Flesh texture	Pastose	Pastose	Buttery	Buttery	Buttery	Buttery	Buttery	Pastose	Buttery	Buttery	Pastose	Buttery	Pastose
Sweetness of flesh	INT	High	INT	INT	INT	Low	Low	INT	INT	Low	Low	High	Low
Bitterness of flesh	Low	Low	Low	Low	Low	Low	High	INT	INT	INT	Low	Low	Low
Fibre in flesh	Low	Low	Low	INT	Low	Low	Low	High	INT	Low	Low	INT	Low
General taste of flesh	Good	Excellent	Good	Good	Excellent	Fair	Fair	Good	Good	Fair	Excellent	Fair	Fair
Degree of colouration of open fruit after 4hr	Nil	Nil	Nil	Nil	Nil	Nil	Nil	High	Nil	Nil	Nil	High	Nil
Colour of discolouration								Brown				Brown	

INT: Intermediate, M: Medium, ASY: Asymmetric

Fig. 1. Avocado fruits from subtropical hilly areas and humid tropical plains in Kerala

horticultural traits of fruits among the widely varying avocado accessions collected from different parts of Kerala would help identify promising cultivars and enhance its further cultivation and utilization. It was observed that high-altitude fruits had comparatively higher horticultural and nutritional qualities.

This study highlights the diverse nutritional, biochemical, and morphological traits of avocado genotypes in Kerala. Variability in these traits is largely due to the prevalent seed propagation. Avocado fruits from Idukki district exhibit superior appearance, size, shape, and weight. To promote avocado cultivation, we recommend conserving and propagating genotypes Acc. 7, 10, 11, 12, 14, 15, and 25, which possess favorable quality attributes. Widespread cultivation of this high-value fruit can significantly benefit trade and increase farmers' income.

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