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Short Communication

Morpho-biochemical characterization of a unique avocado (*Persia americana* Mill.) accession PA-026 (IC0644455)

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ABSTRACT

A unique avocado accession PA-026 (IC0644455) bearing yellow colour fruits was identified and evaluated for morphological and biochemical parameters. The accessions PA-026 characterise as yellow coloured pulp, young shoots and leaf midribs, fruit weight (398.3 g), pulp weight (255.38 g), seed weight (92.35 g) and peel thickness (1.43 mm). The biochemical profiling showed that, it has high carotenoid content (7.17 mg/100 g), total phenols (102.24 mg GAE/100 g), FRAP activity (87.32 AEAC/100 g) and high β-carotene (3.85 µg/g) followed by α-carotene (1.03 µg/g), while, fatty acid profile showed presence of five fatty acids, among which oleic acid (52.11%) and palmitic acid (41.56%) were most dominant. In conclusion, avocado accession PA-026 was found unique with respect to yellow fruit, pulp colour, and high carotenoid content especially β-carotene, which could be used to improve the carotenoids content in avocado through breeding.

INTRODUCTION

The avocado is one of the important emerging fruit crops, widely used in cosmetic and food industries for preparation of different products. It belongs to the family Lauraceae and originated in Mexico and Central America (Dreher & Davenport, 2013). Avocado includes approximately 150 species, among which Guatemalan (*Persea americana* var. *guatemalensis* Williams), Mexican (*Persea americana* var. *drymifolia* Blake), and West Indian (*Persea americana* var. *americana* Mill) (Bergh & Ellstrand, 1986) races are very important from horticultural point of view. It is a good source of bioactive compounds and minerals especially lipids, fibers, carotenoids and potassium (Sinyinda & Gramshaw, 1998). Avocado is commercially grown in more than 80 countries (FAO, 2019). Presently, in India it is grown in Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Maharashtra, Sikkim and to some extent in Uttarakhand, Himachal Pradesh and Arunachal Pradesh. The wide variability in fruit size, shape, colour and other pulp traits has been reported (Tripathi et al., 2022). Avocado is gaining popularity among growers and consumers due to the presence of enormous health benefits and high market price. Keeping this in mind, a survey was conducted to identify superior and unique avocado genotypes in hotspots *i.e.* Coorg, Wayand, Salem, Dindigul districts of South India. A unique avocado accession 'PA-026' with dark yellow pulp colour fruits was identified and evaluated for morphological and biochemical parameters.

About 20 years old avocado accession PA-026 was characterise for morphological and biochemical parameters, with three replications at ICAR-Indian Institute of Horticultural Research, Bengaluru, and Central Horticultural Experiment Station, Chettalli during 2019 to 2021. The observations on tree, leaf, fruit and seed traits were recorded as per descriptors of Bioversity International for avocado (IPGRI, 1995). The morphological characters *viz.*, leaf length (cm), leaf width (cm), fruit weight (cm), fruit length (cm), fruit width (cm), seed weight (g), seed length (cm), pulp weight (g) and peel thickness (mm) were recorded systematically.

Biochemical traits such as total antioxidants, total phenols (mg GAE/100g), total carotenoids (mg/100 g), oil content (%), dry matter content (%), total soluble solids (°B) and crude fibre (%) were also recorded. The moisture content was estimated as per Ranganna

(1986). The ferric-reducing antioxidant potential was studied (Benzie & Strain, 1996), and the absorbance was recorded at 593 nm. The total phenols were estimated according to Singleton & Rossi (1965) with slight modifications and readings were recorded at a wavelength of 700 nm. Total carotenoids were estimated by using spectrophotometric method developed by Lichtenthaler (1987) and observations were recorded at 470 nm in UV/VIS spectrometer. The pulp oil was extracted using a Soxhlet apparatus as per Rangana (1986) with slight modifications, and total crude fibre content was analyzed (Maynard, 1970).

The fatty acid profiling of avocado pulp oil was carried out using Shimadzu GCMS-TQ8040 equipped with an ion trap triple quad mass spectrometer with electron ionization mode 0.1 kV with the scan mass range of 45-500 m/z at a sampling speed of 1666. An auto sampler AOC-20i and a capillary column Rxi-5MS were used. The total fatty acid production was calculated by the sum of all GC peak areas in the chromatogram and expressing individual compounds as relative per cent areas. The compounds were identified by comparing the retention index, which was determined using homologous series of n-alkanes (C5 to C32) as a standard. They compared the spectra using spectral libraries available in Wiley/ NIST-2015.

Carotenoids profiling was carried out by using UPLC method as given by Serino et al. (2009), with slight modifications. The PDA detector was equipped with an Acquity-UPLC BEH-C18 column (1.7 µm, 2.1 × 50 mm) and a BEH-C18 (1.7 µm, 2.1 ×5 mm) guard column was used. The individual carotenoids were identified on the basis of their diode array spectral characteristics, retention time and relative elution order in comparison to those of the standards and quantified as β-carotene equivalent. The fifteen fruits and leaves were used for recording morphological characters and three replications were used for all biochemical analysis.

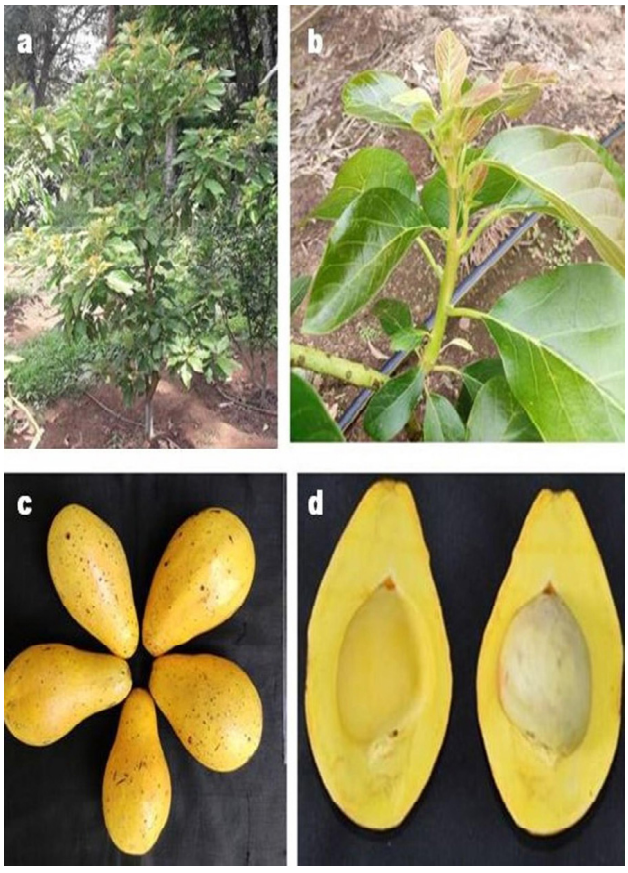
The morphological characters such as leaf, fruit, pulp, seed and pulp quality of accession PA-026 was studied using Bioversity International descriptors (Table 1). The plant showed a rough trunk surface, roundish leaf shape, acute and obtuse leaf base. These leaf traits are not distinct from regular once, and similar leaf traits were also reported (Ranjitha et al., 2021) in different accessions of avocado.

Table 1 : Characterization of avocado accession PA-026 (IC0644455) as per Bioversity International descriptors

Trait	Descriptor
Trunk surface	Rough
Leaf shape	Roundish
Leaf apex shape	Acute
Leaf base shape	Obtuse
Fruit shape	Narrowly obovate
Fruit size uniformity	Intermediate
Fruit base shape	Inflated
Fruit apex shape	Slightly depressed
Fruit apex position	Slightly depressed
Ridges on fruit	Partial
Gloss of fruit peel	Strong
Fruit peel surface	Smooth
Fruit peel colour	Yellow
Pedicel position of fruit	Asymmetrical
Pedicel shape	Cylindrical
Adherence of peel to pulp	Slight
Pulp texture	Buttery
Sweetness of pulp	Intermediate
Bitterness of pulp	Low
Nut taste of pulp	Intermediate
Fibre in pulp	Intermediate
General taste of pulp	Fair
Seed shape	Broadly ovate
Seed position in fruit	Apical
Free space of the seed cavity	Space on seed apex
Cotyledon surface	Intermediate
Seed coat	Seed not free, coat not attached to the pulp

The fruit shape was narrowly obovate, intermediate size, uniform, fruit base shape inflated with slightly depressed fruit apex, firm glossy peel with partial ridges and smooth peel surface. The occurrence of obviate, rhomboid, pyriform and ellipsoid fruit shapes indicate the existence of the West Indian race (Abraham et al., 2018). The most interesting characteristic of this accession was immature yellow colour fruit peel (Muralidhara et al., 2023) which was not reported earlier (Fig. 1). The pedicel position was asymmetrical with cylindrical shape. The dominance of the conical shape of pedicel was observed in

Indonesian and Tanzanian accessions compared to cylindrical shape (Abraham et al., 2018; Juma et al., 2020).



a. Plant, b. Yellow coloured twigs and midribs of leaves, c. Fruits, d. cut fruit

Fig. 1 : Characteritic features of acovado accessions PA-026

The pulp of PA-026 was buttery in texture, low bitterness, intermediate nutty taste and fair pulp quality. The seed shape was broadly ovate and placed at apical portion of the fruit, however, broadly ovate shapes were more dominant to Indonesian and Tanzanian types (Abraham et al., 2018; Juma et al., 2020). The seed coat is not free and not attached to the pulp with intermediate cotyledon surface.

On the perusal of data presented in Table 2 showed that PA-026 recorded medium sized leaves with medium fruit weight (398.3 g), pulp (>60%) with peel (12.6%). Oliveira et al. (2013) reported wide variation in pulp weight in Brazilian accessions. The accession had medium thick peel (1.43 mm), thereby enhances the shelf life of fruit and provides tolerance to anthracnose and scab infections.

Table 2 : Morphological and biochemical characteristics of avocado accession PA-026 (IC0644455)

Trait	Mean
Leaf length (cm)	11.9
Leaf width (cm)	7.13
Pedicel diameter (cm)	0.9
Fruit weight (g)	398.3
Fruit length (cm)	13.2
Fruit width (cm)	7.9
Pulp weight (g)	255.38
Pulp per cent (%)	64.25
Peel weight (g)	50.6
Peel per cent (%)	12.6
Peel thickness (mm)	1.43
Seed weight (g)	92.35
Seed per cent (%)	23.15
Seed length (cm)	6.33
Seed diameter (cm)	5.23
Length of seed cavity (cm)	7.03
Width of seed cavity	5.3
Average yield (kg/tree)	99.83
CUPRAC activity (µmol Trolox/100 g)	0.25
FRAP activity mg (AEAC/100 g)	87.32
DPPH activity mg (AEAC/100 g)	53.83
Total phenols mg (GAE/100 g)	102.24
Total carotenoids (mg/100 g)	7.17
TSS (^{o}Brix)	8.2
Moisture content (%)	81.54
Dry matter content (%)	18.47
Oil content in dry pulp (%)	44.5
Oil content in fresh pulp (%)	8.23
Crude fiber (%)	12.5

In the biochemical characterization, accession PA-026 showed good amount of FRAP activity (87.32 AEAC/ 100 g), total phenols content (102.24 GAE/100 g), total carotenoids (7.17 mg/100 g) and crude fibre (12.5%) in fresh pulp (Table 2). The lower FRAP activity was observed by Wang et al. (2012) in the avocado pulp (2.93 µmol Fe^{2}+ /g FW). The high carotenoids content is mainly due to the presence of dark yellow pulp colour.

The oil content in fresh pulp was medium (8.23%), which was lower than the Hass (15.4 g/100) (USDA, 2011) and Fuerte (12.55%) varieties (Rodriguez-Carpena et al., 2011). The avocado oil is highly digestible and contains mainly unsaturated fatty acids, primarily oleic acid (Gomez-Lopez, 1999). The fatty acid profiling of yellow avocado accession showed five major fatty acids (Table 3). The accession showed high content of oleic acid (52.11%) followed by palmitic acid (41.56%) and palmetoleic acid (4.32%). Galvo et al. (2014) reported 60.79% monounsaturated fatty acids (MUFAs) content and MUFA/SFA ratio (1.31) in var. Fortuna.

Avocado is good source of carotenoids which are fat-soluble in nature (Cortes-Herrera et al., 2019), and profiling of carotenoids showed nine compounds *i.e.* lutein, neoxanthin, violoxanthin, α-carotene, β-carotene, all trans lutein 5,6 epoxide, neochrome, chrysanthemaxan and an unidentified compound (Table 4). Lu et al. (2009) reported lutein (6.02 µg/g) as major compound in Hass variety pulp and Jacobo-Velazquez & Hernandez-Brenes (2012) identified lutein (4.02 µg/g) as major compound in avocado paste.

In this study, accession PA-026 showed maximum values for β-carotene (3.85 µg/g) followed by α-carotene (1.03 µg/g), all trans lutein 5, 6 epoxide (0.61 µg/g) and neoxanthin (0.59 µg/g). In conclusion, the avocado accession PA-026 showed unique traits such as yellow pulp colour, high carotenoid content and β-carotene, which can be exploited in avocado improvement.

Table 3 : Fatty acid profile of avocado accession PA-026 (IC0644455)

Fatty acids	Content (%)
Palmitic acid (C16:0)	41.56
Stearic acid (C18:0)	1.56
Palmetoleic acid (C16:1)	4.32
Oleic acid (C18:1)	52.11
Linoleic acid (C18:2)	0.47
Linolenic acid (C18:3)	0
SFA	43.11
MUFA	56.43
PUFA	0.47
UFA	56.9
MUFA/SFA	1.31
PUFA/SFA	0.01
UFA/SFA	1.33

SFA-saturated fatty acids, MUFA-mono unsaturated fatty acids, PUFA-poly unsaturated fatty acids, UFA-unsaturated fatty acids

Table 4 : Carotenoids profile of avocado accession PA-026 (IC0644455)

Carotenoids	R. Time (min)	λ_{max} (nm)	Quantity (µg/g)
Lutein (µg/g)	0.74	420, 440, 472	0.42
Neoxanthin (µg/g)	0.94	398, 420, 448	0.59
Violoxanthin (µg/g)	1.24-1.33	400, 424, 452	0.53
α-carotene (µg/g)	1.55	415, 438, 467	1.03
β-carotene (µg/g)	1.71	428, 449, 474	3.85
All trans lutein 5,6 epoxide (µg/g)	2.72	415, 440, 469	0.61
X (µg/g)	3.23-3.5	420, 443, 469	0.55
Neochrome (µg/g)	4.38	399, 421, 446	0.44
Chrysanthemaxanthin (µg/g)	5.21	415, 439, 446	0.15

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