International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
ISSN: 2664-7133
Received: 11-09-2026, Accepted: 11-10-2026, Published: 26-10-2026
Volume 8, Issue 4, 2026, Page No. 137-144

Morpho-pomological and biochemical characterization of jamun (*Syzygium cumini* L. Skeels) genotypes

Karthik Vaidya[1*], Pampanna Y[2], Shekharagouda Patil[1], Ramesh G[3], Kisan B[4]
[1] Department of Fruit Science, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India
[2] Department of Horticulture, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur, Karnataka, India
[3] AICRP Scientist, CAE, University of Agricultural Sciences, Raichur, Karnataka, India
[4] Department of Molecular Biology and Biotechnology, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India
Corresponding Author: Karthik Vaidya
DOI: https://doi.org/10.66856/ijees.2026.8.4.8108

Abstract
Jamun (*Syzygium cumini* L. Skeels) is a nutritionally and medicinally important underutilized fruit tree whose commercial development has been constrained by the absence of officially released varieties and the limited systematic evaluation of germplasm from India's semi-arid production zones. Sixteen *S. cumini* genotypes, comprising three established named cultivars (Konkan Bahadoli, Chintamani and AJG-85), three institutional Kawadimatti Jamun Selections (KJS-01, KJS-02 and KJS-03) and ten uncharacterized farmer-maintained accessions (JG-1 through JG-10), were evaluated at three geographically distinct sites in the North-Eastern Dry Zone of Karnataka during 2025–26, following the Distinctness, Uniformity and Stability (DUS) guidelines of the PPV&FRA (2015). Tree and canopy architecture, fruit and seed biometrics, pulp recovery, yield per tree, and a comprehensive suite of biochemical quality parameters at commercial harvest were recorded. Significant variation was observed among the genotypes for all quantitative traits. Konkan Bahadoli recorded the highest fruit weight (15.62 g), pulp content (81.70%), pulp-to-seed ratio (4.53), and total soluble solids (TSS) at harvest (19.00 °Brix), establishing it as the superior genotype for fresh-market consumption. AJG-85 recorded the highest total sugar content (21.25%) and reducing sugar content (13.00%). KJS-01 recorded the highest fruit yield (258.00 kg tree^{-1}), the greatest number of fruits per panicle (22.00), and the highest ascorbic acid content (44.26 mg 100 g^{-1}), identifying it as a promising genotype for productivity-oriented commercial cultivation. JG-2 recorded the highest TSS-to-acid ratio at harvest (26.43) and the lowest acidity (0.74%) among the farmer-maintained accessions, indicating favourable fruit palatability. These findings provide a baseline for the multi-site morpho-pomological and biochemical characterization of *S. cumini* germplasm from this agro-climatic zone using DUS guidelines. The results can support variety recommendation, participatory breeding, and cultivar development in semi-arid Karnataka.

Keywords: *Syzygium cumini*, germplasm evaluation, fruit quality, DUS guidelines, pomological characterization, varietal development

Introduction

Jamun (*Syzygium cumini* L. Skeels), commonly referred to as Java plum or Indian blackberry, is an evergreen tropical fruit tree of the family Myrtaceae (2n = 44) native to the Indian subcontinent and Southeast Asia (Uddin *et al*., 2022) [27]. The fruit is prized for its anthocyanin-rich deep purple pulp and an impressive nutritional profile comprising vitamin C, folic acid, iron, calcium, potassium, magnesium and dietary fibre at low caloric density and a low glycaemic index, making it inherently suitable for diabetic diets (Saini *et al*., 2026; Tripathi *et al*., 2025) [20, 26]. Its phytochemical matrix encompasses anthocyanins (42.59–268.50 mg C3GE 100 g $^{-1}$), total phenols (120.78–936.26 mg GAE 100 g $^{-1}$), flavonoids, tannins and the alkaloid jamboline, the latter documented to exert hypoglycaemic effects by inhibiting starch-to-sugar conversion, positioning *S. cumini* as a functional food and nutraceutical ingredient of significance in type-2 diabetes management (Stephen, 2012; Kannan and Puraikalan, 2013; Saini *et al*., 2026) [9, 20, 23]. Reported pharmacological activities also include anti-inflammatory, antimicrobial, radioprotective and neuroprotective effects (Uddin *et al*., 2022) [27]. India accounts for about 15.4% of global jamun production, with about 32,000 hectares producing around 85,000 metric tonnes annually; Uttar Pradesh, Maharashtra, Tamil Nadu, Gujarat and Assam are the major producing states (Anon., 2023; Saini *et al*., 2026) [20]. Despite this scale, jamun remains substantially underutilized as a modern commercial crop: no improved varieties have been officially released, orchards are predominantly heterogeneous seedling populations, the extremely short ambient shelf life (2–3 days) of fresh fruit impedes commercial value chains, and the genetic potential of regional germplasm collections remains poorly documented (Tripathi *et al*., 2025) [26].

A significant agronomic advantage of *S. cumini* is its tolerance to salinity, seasonal waterlogging and moderate drought, making it particularly well suited to semi-arid and degraded marginal lands of peninsular India (Tripathi *et al*., 2025) [26]. Flowering occurs during March–April and fruits ripen May–July, providing a valuable income opportunity for farmers during the lean summer period of the Deccan Plateau. Processing avenues like juices, jams, wines, vinegar, dehydrated powders, candies and probiotic beverages have been demonstrated but remain largely

cottage-scale owing to the absence of standardized high-yielding cultivars with uniform fruit quality (Uddin *et al*., 2022; Kannan and Puraikalan, 2013) [9, 27]. Systematic germplasm evaluation under standardized protocols is thus the critical first step for any variety development programme: it enables identification of genotypes combining superior pomological and biochemical traits, provides baseline descriptor data for Plant Variety Protection under the PPV&FRA framework and creates a platform for participatory selection and future marker-assisted breeding.

The species is predominantly cross-pollinated and seed-propagated, generating substantial inter-tree variability in fruit size, pulp content, sugar-acid balance and yield within a single orchard (Patel *et al*., 2005; Ghojage *et al*., 2011) [7, 16]. Published characterization studies from India and internationally document a wide phenotypic range: fruit weight 1.93–20.74 g, pulp content 53–94 per cent, TSS 8.47–28.20 °Brix, ascorbic acid 7.8–65.07 mg 100 g $^{-1}$, anthocyanins 42.59–268.50 mg C3GE 100 g $^{-1}$ and total phenols 120.78–936.26 mg GAE 100 g $^{-1}$ (Megha *et al*., 2017; Kumar *et al*., 2025; Saini *et al*., 2026; Tripathi *et al*., 2025; Khadivi *et al*., 2022; Uddin *et al*., 2024) [10, 11, 13, 20, 26, 28] confirming that substantial variation exists to support variety development. Several recent multi-site evaluations from Karnataka (Swamy *et al*., 2017; Talang *et al*., 2017) [24, 25] and comparative studies across India (Tripathi *et al*., 2025; Saini *et al*., 2026) [20, 26] corroborate the richness of this diversity pool. Genotypes from the North-Eastern Dry Zone of Karnataka, institutional selections at MARS Raichur and ARS Kawadimatti and farmer accessions from Chandlapur village, Surpur taluk, have not been subjected to systematic evaluation under standardized protocols. The present study was undertaken to: (i) characterize sixteen *S. cumini* genotypes from three sites in this zone for tree canopy, fruit, seed, pulp and yield traits under DUS guidelines; (ii) quantify biochemical quality at commercial harvest and (iii) identify superior genotypes for variety recommendation and future breeding.

Materials and Methods

1. Experimental sites and plant material

The study was conducted during 2025–26 at three geographically distinct sites within the North-Eastern Dry Zone (Zone 2) of Karnataka: MARS, UAS Raichur (16.20°N, 77.37°E; ~389 m a.s.l.), ARS Kawadimatti (16.12°N, 77.30°E; ~400 m a.s.l.) and Chandlapur village, Surpur taluk, Yadgir district (~360 m a.s.l.). All three sites experience a semi-arid tropical climate with mean annual rainfall of 600–700 mm (predominantly June–September south-west monsoon), mean annual temperature of 28–32°C and maximum summer temperatures exceeding 40°C; soils are predominantly red sandy loam to red laterite with moderate fertility and pH 7.5–8.0, characteristic of the Deccan Plateau. The commercial harvest window for jamun at these sites falls between late May and early July. Sixteen *S. cumini* genotypes (Table 1), comprising three established cultivars (Konkan Bahadoli, Chintamani, AJG-85), three institutional KJS selections and ten farmer-maintained accessions (JG-1 to JG-10), were evaluated in a Randomized Block Design (RBD) with four replications, each tree canopy divided into North, South, East and West sectors as replications.

Table 1: Details of sixteen *Syzygium cumini* (L.) Skeels genotypes evaluated in the present study

No.	Genotype	Collection Site
1	Konkan Bahadoli	MARS, UAS Raichur
2	Chintamani	MARS, UAS Raichur
3	AJG-85	MARS, UAS Raichur
4	KJS-01	ARS, Kawadimatti
5	KJS-02	ARS, Kawadimatti
6	KJS-03	ARS, Kawadimatti
7	JG-1	Chandlapur village, Surpur taluk
8	JG-2	Chandlapur village, Surpur taluk
9	JG-3	Chandlapur village, Surpur taluk
10	JG-4	Chandlapur village, Surpur taluk
11	JG-5	Chandlapur village, Surpur taluk
12	JG-6	Chandlapur village, Surpur taluk
13	JG-7	Chandlapur village, Surpur taluk
14	JG-8	Chandlapur village, Surpur taluk
15	JG-9	Chandlapur village, Surpur taluk
16	JG-10	Chandlapur village, Surpur taluk

KJS: Kawadimatti Jamun Selection; JG: Jamun Genotype.

2. Tree characters

Tree age, height and canopy shape were assessed visually as per PPV&FRA (2015) DUS guidelines and recorded as categorical classes: age (young <20 years; medium 20–40 years; old >40 years), height (small <10 m; medium 10–15 m; large >15 m) and canopy shape (round, irregular, oval). Canopy spread was measured independently in north-south (N-S) and east-west (E-W) directions using a calibrated measuring tape; both readings were recorded separately (m). Stem girth was measured at 15 cm above the graft union using a measuring tape and expressed in centimetres (Tripathi *et al*., 2025) [26].

3. Fruit, seed and pulp characters

Ten randomly selected ripe fruits (uniformly deep purple-black skin colour, free from mechanical damage) were harvested at commercial maturity per replication. Fruit and seed length and breadth were measured using a calibrated digital Vernier calliper (mm), weight by an electronic balance (g) and volume by water displacement in a graduated measuring cylinder (cm³) (Saini *et al*., 2026) [20]. Pulp weight, pulp content, seed content and pulp: seed ratio were computed using the following formulae:

4. Yield parameters

Fruits per panicle were counted from ten randomly selected panicles per sector of each tree. Yield per tree (kg tree $^{-1}$) was recorded by weighing all harvested fruits at each successive harvest across the entire commercial harvest season (May–July) using a platform scale and cumulating across harvests.

5. Biochemical quality at harvest

All biochemical parameters were determined in triplicate on freshly extracted pulp at commercial harvest (full purple-black skin colour, TSS ≥15 °Brix). Total soluble solids (TSS) were measured using an Erma hand refractometer (0–32 °Brix; calibrated at 20°C; Anon., 1995). Titratable acidity (TA) was determined by titrating 2 g pulp dissolved in 50 mL distilled water against 0.1 N NaOH using phenolphthalein indicator to a permanent pink end-point (Ranganna, 1977 [19]; AOAC, 2000); results were expressed as per cent citric acid equivalent. Ascorbic acid was quantified by the 2,6-dichlorophenolindophenol (DCPIP)

titrimetric method (Anon., 1980), expressed as mg 100 g^{-1} fresh weight. Reducing and total sugars were determined by the Nelson-Somogyi photometric method (Nelson, 1944; Somogyi, 1952) [14, 22]. Formulae used:

$$TA\ (\%) = \frac{T \times N \times Eq.wt. \times V}{W \times v \times 1000} \times 100$$

Where,

T = titre (mL), N = normality of NaOH (0.1),

Eq. wt. of citric acid = 64, V = total extract volume (mL),

W = sample weight (g), v = aliquot (mL)

$$Ascorbic\ acid\ (mg\ 100\ g^{-1}) = \frac{T \times F \times V}{v \times W} \times 100$$

Where,

T = titre (mL of dye consumed by sample),

F = dye factor (mg ascorbic acid equivalent to 1 mL dye solution),

V = total extract volume (mL),

v = aliquot volume (mL), W = sample weight (g)

$$Non-reducing\ sugars\ (\%) = (Total\ sugars - Reducing\ sugars) \times 0.95$$

$$TSS: acid\ ratio = \frac{TSS\ (°Brix)}{Titratable\ acidity\ (\%)}$$

6. Statistical analysis

All quantitative data from the four replications were subjected to analysis of variance (ANOVA) under RBD following Panse and Sukhatme (1967) [15]; treatment means were compared using the critical difference (CD) at 5% probability. Pearson product-moment correlation coefficients (r) were computed among key quantitative traits to assess inter-trait relationships. All statistical analyses were performed using Windostat version 9.3 and OPSTAT (Indostat Services, Hyderabad).

Results

1. Tree and canopy characteristics

Tree characteristics are presented in Table 2. Thirteen genotypes were young (<20 years) while KJS-01, KJS-02 and KJS-03 were medium-aged (20–40 years). Height was large for all three KJS genotypes, medium for JG-3, JG-4, JG-6 and JG-8, and small for the remaining nine. Canopy spread was greatest in KJS-01 (21.00 m N-S; 20.00 m E-W) and least in Konkan Bahadoli (5.83 m N-S) and AJG-85 (5.18 m E-W). Canopy shape was round in five genotypes, oval in three (JG-3, JG-4 and JG-6) and irregular in eight.

Table 2: Tree and canopy characteristics of sixteen *Syzygium cumini* genotypes

Genotype	Age	Height	Spread N-S (m)	Spread E-W (m)	Canopy shape
Konkan Bahadoli	Young	Small	5.83	5.63	Round
Chintamani	Young	Small	6.10	5.53	Irregular
AJG-85	Young	Small	6.20	5.18	Round
KJS-01	Medium	Large	21.00	20.00	Irregular
KJS-02	Medium	Large	15.00	16.50	Irregular
KJS-03	Medium	Large	13.85	16.00	Round
JG-1	Young	Small	8.02	7.78	Round
JG-2	Young	Small	7.65	7.42	Irregular
JG-3	Young	Medium	9.12	8.88	Oval
JG-4	Young	Medium	9.86	9.61	Oval
JG-5	Young	Small	7.83	7.56	Round
JG-6	Young	Medium	10.42	10.09	Oval
JG-7	Young	Small	8.08	7.82	Irregular
JG-8	Young	Medium	9.37	9.13	Irregular
JG-9	Young	Small	8.26	8.01	Irregular
JG-10	Young	Small	7.72	7.48	Irregular

Age: Young <20 years; Medium 20–40 years. Height: Small <10 m; Medium 10–15 m; Large >15 m.

2. Fruit characteristics

Fruit biometrics varied significantly among genotypes (Table 3; Fig. 1). Konkan Bahadoli recorded the largest fruit length (3.27 cm), breadth (2.31 cm), weight (15.62 g) and volume (15.05 cm^3), representing a nearly two-fold difference in fruit weight over the lightest genotype, KJS-03 (7.87 g). AJG-85 (13.01 g) and JG-2 (12.00 g) ranked second and third for fruit weight. The KJS genotypes consistently formed a compact low-end group for all four fruit dimensions.

3. Seed and pulp characteristics

Seed and pulp parameters for all sixteen genotypes are presented in Table 4. Seed length and breadth were greatest in JG-2 (2.10 cm; 1.30 cm) and least in KJS-03 (0.97 cm; 0.70 cm); seed weight was highest in Chintamani (3.05 g) and lowest in KJS-02 and KJS-03 (1.70 g each); seed volume was highest in JG-2 (2.82 cm^3) and lowest in JG-5 (1.49 cm^3). Pulp weight was highest in Konkan Bahadoli (12.77 g) and lowest in KJS-03 (6.17 g). Pulp content was greatest in Konkan Bahadoli (81.70%) and least in JG-5 (71.02%). The pulp: seed ratio was highest in Konkan Bahadoli (4.53), on par with AJG-85 (4.00), KJS-02 (3.87) and JG-10 (3.76), and lowest in JG-5 (2.46). All traits differed significantly at CD (5%).

4. Yield parameters

Fruits per panicle was highest in KJS-01 (22.00) and lowest in JG-8 (12.00) (Table 5). Yield per tree was strongly linked to tree age and canopy size and fruit yield per tree varied considerably among the sixteen jamun (*Syzygium cumini* (L.) Skeels) genotypes evaluated across three locations (Table 11). At MARS, Raichur, Konkan Bahadoli recorded the highest yield (54.31 kg tree $^{-1}$), followed by AJG-85 (48.25 kg tree $^{-1}$), whereas Chintamani recorded the lowest yield (41.80 kg tree $^{-1}$). At ARS, Kawadimatti, KJS-01 recorded the highest yield (258.00 kg tree $^{-1}$), followed by KJS-02 (196.50 kg tree $^{-1}$) and KJS-03 (179.85 kg tree $^{-1}$).

Among the genotypes evaluated at Chandlapur village, JG-6 recorded the highest yield (105.00 kg tree $^{-1}$), followed by JG-4 (98.00 kg tree $^{-1}$) and JG-8 (94.36 kg tree $^{-1}$), while JG-2 recorded the lowest yield (65.00 kg tree $^{-1}$). Across all sixteen genotypes, the reported mean yield was 100.02 kg tree $^{-1}$, with the highest yield in KJS-01 and the lowest in Chintamani.

5. Biochemical quality at harvest

All biochemical parameters at harvest differed significantly among genotypes (Table 6). TSS was highest in Konkan Bahadoli (19.00 °Brix) and lowest in JG-3 (15.06 °Brix). Titratable acidity was highest in JG-3 (1.58%) and lowest in JG-2 (0.74%). AJG-85 recorded the highest reducing sugars (13.00%), non-reducing sugars (8.25%) and total sugars (21.25%); JG-3 recorded the lowest non-reducing and total sugars (2.30%; 9.20%). Ascorbic acid was highest in KJS-01 (44.26 mg 100 g $^{-1}$) and lowest in AJG-85 (25.70 mg 100 g $^{-1}$). The TSS: acid ratio was highest in JG-2 (26.43) and lowest in JG-3 (9.69).

Table 3: Fruit biometric characteristics of sixteen *Syzygium cumini* genotypes

Genotype	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Fruit volume (cm^3)
Konkan Bahadoli	3.27	2.31	15.62	15.05
Chintamani	3.04	2.28	12.25	11.74
AJG-85	3.17	2.24	13.01	12.70
KJS-01	2.14	1.25	8.47	8.13
KJS-02	1.92	1.12	8.08	7.88
KJS-03	1.73	1.01	7.87	7.71
JG-1	2.60	1.84	10.42	10.08
JG-2	3.10	2.26	12.00	11.63
JG-3	2.29	1.55	9.18	8.94
JG-4	2.85	2.08	11.26	10.89
JG-5	2.17	1.36	8.93	8.71
JG-6	2.73	1.97	10.87	10.51
JG-7	2.41	1.68	9.64	9.36
JG-8	2.95	2.17	11.58	11.19
JG-9	2.31	1.60	9.37	9.08
JG-10	2.42	1.73	10.15	9.84
Mean	2.57	1.78	10.54	10.22
S.Em. ±	0.12	0.10	0.33	0.45
CD @ 5%	0.35	0.30	0.94	1.27

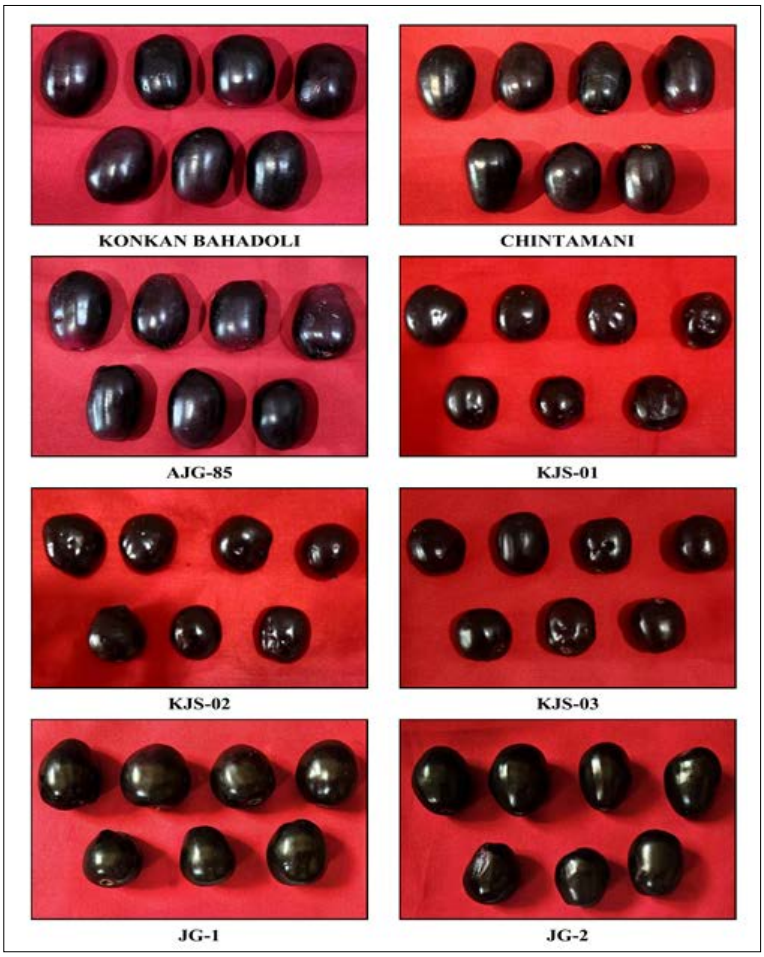


Fig 1a: Fruit variability among Syzygium cumini genotypes: Konkan Bahadoli, Chintamani, AJG-85, KJS-01, KJS-02, KJS-03, JG-1 and JG-2.



Fig 1b: Fruit variability among Syzygium cumini genotypes: JG-3, JG-4, JG-5, JG-6, JG-7, JG-8, JG-9 and JG-10.

Table 4: Seed and pulp characteristics of sixteen *Syzygium cumini* genotypes

Genotype	Seed length (cm)	Seed breadth (cm)	Seed weight (g)	Seed volume (cm^3)	Pulp weight (g)	Pulp content (%)	Seed content (%)	Pulp: seed ratio
Konkan Bahadoli	2.09	1.28	2.85	2.61	12.77	81.70	18.32	4.53
Chintamani	1.96	1.12	3.05	2.68	9.20	74.99	25.00	3.23
AJG-85	2.10	1.10	2.83	2.35	10.18	78.71	21.29	4.00
KJS-01	1.28	0.82	1.86	1.75	6.61	79.26	20.73	3.56
KJS-02	1.12	0.76	1.70	1.68	6.38	79.61	20.39	3.87
KJS-03	0.97	0.70	1.70	1.65	6.17	78.00	22.00	3.45
JG-1	1.74	1.06	2.34	2.21	8.08	77.52	22.49	3.68
JG-2	2.10	1.30	2.96	2.82	9.04	75.43	24.57	3.11
JG-3	1.66	1.02	2.31	1.63	6.87	74.75	25.25	2.97
JG-4	1.97	1.21	2.68	2.54	8.58	76.19	23.81	3.27
JG-5	1.86	1.14	2.58	1.49	6.35	71.02	28.98	2.46
JG-6	1.75	1.08	2.43	2.30	8.44	77.74	22.27	3.60
JG-7	1.46	0.95	2.11	1.81	7.53	78.04	21.96	3.57
JG-8	2.08	1.28	2.81	2.66	8.77	75.69	24.32	3.20
JG-9	1.43	0.88	2.10	1.75	7.27	77.54	22.47	3.46
JG-10	1.54	1.00	2.17	2.05	7.98	78.60	21.40	3.76
Mean	1.69	1.04	2.41	2.12	8.14	77.17	22.83	3.48
S.Em. ±	0.10	0.11	0.24	0.20	0.30	1.38	1.53	0.27
CD @ 5%	0.29	0.30	0.67	0.58	0.87	3.94	4.36	0.78

Table 5: Yield parameters of sixteen *Syzygium cumini* genotypes across three evaluation sites

Genotype	Fruits per panicle (no.)	Yield (kg tree $^{-1}$)
Konkan Bahadoli	17.68	54.31
Chintamani	13.35	41.80
AJG-85	14.50	48.25

KJS-01	22.00	258.00
KJS-02	15.75	196.50
KJS-03	18.50	179.85
JG-1	12.25	69.00
JG-2	13.75	65.00
JG-3	14.25	80.25
JG-4	13.00	98.00
JG-5	14.75	75.00
JG-6	14.00	105.00
JG-7	13.00	79.18
JG-8	12.00	94.36
JG-9	16.25	82.00
JG-10	13.75	73.82
Mean	14.92	100.02
S.Em. ±	1.07	—
CD @ 5%	3.05	—

Yield per tree not subjected to pooled ANOVA due to evaluation across three separate age-class groups at distinct sites; means are presented for reference. Fruits per panicle: CD (5%) = 3.05.

Table 6: Biochemical quality parameters of sixteen *Syzygium cumini* genotypes at commercial harvest

Genotype	TSS (°Brix)	Acidity (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg 100 g $^{-1}$)	TSS: acid ratio
Konkan Bahadoli	19.00	0.96	11.25	6.30	17.55	38.56	21.27
Chintamani	17.29	1.08	7.36	2.74	10.10	35.47	16.27
AJG-85	18.74	1.00	13.00	8.25	21.25	25.70	18.75
KJS-01	16.30	1.50	9.34	5.43	14.77	44.26	11.37
KJS-02	16.14	1.36	7.53	6.00	13.53	27.38	12.09
KJS-03	15.18	1.33	8.40	5.05	13.45	35.13	11.63
JG-1	16.84	1.25	8.42	3.84	12.26	33.84	13.96
JG-2	18.28	0.74	11.90	5.96	17.86	41.23	26.43
JG-3	15.06	1.58	6.90	2.30	9.20	26.50	9.69
JG-4	17.92	0.96	10.14	4.88	15.02	37.16	20.18
JG-5	16.13	1.42	6.23	3.38	9.61	28.74	11.49
JG-6	18.00	0.91	11.08	5.42	16.50	39.52	20.11
JG-7	15.88	1.50	7.18	3.16	10.34	30.18	10.71
JG-8	17.36	0.82	9.62	4.37	13.99	35.64	21.96
JG-9	16.52	1.27	8.04	3.58	11.62	31.42	13.30
JG-10	18.47	0.91	11.42	6.00	17.42	40.06	20.49
Mean	17.07	1.16	9.24	4.79	14.03	34.42	16.23
S.Em. ±	0.62	0.11	0.27	0.21	0.33	2.24	1.86
CD @ 5%	1.76	0.31	0.77	0.61	0.93	6.40	5.32

Discussion

1. Morpho-pomological traits

The wide variation recorded across tree, fruit, seed and pulp traits confirms the rich phenotypic diversity expected in seed-propagated jamun populations (Patel *et al*., 2005; Ghojage *et al*., 2011) [7, 16]. The striking contrast in canopy size between the medium-aged KJS genotypes (spread 13.85–21.00 m) and the young MARS and JG-series trees (5.18–10.42 m) reflects the well-documented progressive canopy expansion of perennial jamun trees with age, which directly influences bearing surface, photosynthetic capacity and ultimately yield per tree (Swamy *et al*., 2017) [24].

Fruit weight (7.87–15.62 g) is consistent with the 1.93–20.74 g span in broader germplasm surveys (Megha *et al*., 2017; Kumar *et al*., 2025; Saini *et al*., 2026) [11, 13, 20]. Konkan Bahadoli's superiority (15.62 g) is corroborated by evaluations at IIHR Bengaluru (13.16 g; Kumar *et al*., 2020) [12] and multiple Karnataka sites (Talang *et al*., 2017) [25]. The smaller fruit size of KJS genotypes (7.87–8.47 g) reflects the yield-quality trade-off widely reported in jamun, where high-yielding old-canopy trees produce individually smaller fruits (Swamy *et al*., 2017; Khadivi *et al*., 2022) [10, 24]. Seed parameters followed parallel trends — the KJS group consistently formed the smallest-seeded cluster, while JG-2 had the largest seeds. Pulp content (71.02–81.70%) and pulp: seed ratio (2.46–4.53) are consistent with published ranges and directly reflect commercial value; Konkan Bahadoli's highest values on both metrics position it as the most suitable for fresh consumption and processing, consistent with Kumar *et al*. (2020) and Talang *et al*. (2017) [12, 25]. JG-5's lowest pulp content (71.02%) and ratio (2.46) indicate a proportionally larger seed fraction, reducing its fresh-market suitability but potentially of interest for pharmaceutical applications given jamun seed's antidiabetic alkaloids.

Fruit yield per tree appeared to be closely associated with tree age and canopy development. The comparatively higher yields of the medium-aged KJS genotypes may be attributed to their greater tree height and wider canopy spread, which provide a larger bearing surface and photosynthetic area to support fruit production. The yield recorded in KJS-01 was comparable to the 260 kg tree $^{-1}$ reported for the old-canopy GLH-85 selection by Laxmikanth (2004) and higher than the 150 kg tree $^{-1}$ reported for Chintamani Selection-1 by Venkataramana *et al*. (2020) [29]. Among the younger JG-series, the relatively higher yields of JG-6 and JG-4 indicate promising fruit-bearing potential, which warrants further evaluation as the trees mature. Conversely, the lower yield

of Chintamani compared with Konkan Bahadoli and AJG-85 suggests that inherent genotypic differences in fruit-bearing capacity may also influence productivity. However, since tree age, genotype and location varied simultaneously, the individual contributions of these factors could not be distinguished in the present study. Similar variation in jamun yield associated with tree vigour and fruit-bearing characteristics has been reported by Kundu *et al*. (2001) and Swamy *et al*. (2017) [24].

2. Biochemical quality at harvest

The TSS range (15.06–19.00 °Brix) falls within the 8.47–28.20 °Brix span documented in published jamun studies (Megha *et al*., 2017; Kumar *et al*., 2025; Saini *et al*., 2026) [11, 13, 20], with Konkan Bahadoli's highest TSS (19.00 °Brix) consistently exceeding the upper bounds reported by Kumar *et al*. (2025) [11] (16.91 °Brix) and Saini *et al*. (2026) [20] (18.20 °Brix). Titratable acidity (0.74–1.58%) is within published ranges (Saini *et al*., 2026; Devi *et al*., 2002) [4, 20]. JG-2's lowest acidity (0.74%) combined with high TSS (18.28 °Brix) produced the most favourable TSS: acid ratio (26.43) — the primary predictor of consumer acceptability, since consumers prefer genotypes with higher TSS and lower acidity (Venkataramana *et al*., 2020; Rajangam and Sankar, 2022) [18, 29]. Genotypes with TSS: acid ratios above 20 at harvest — Konkan Bahadoli, JG-2, JG-4, JG-6, JG-8 and JG-10 — represent the priority group for fresh-market selection.

AJG-85's highest total sugars (21.25%) and reducing sugars (13.00%) are notable for processing, since reducing sugars contribute to sweetness, colour and flavour in jamun products (Devi *et al*., 2002; Singh *et al*., 2015) [4, 21]. KJS-01's highest ascorbic acid (44.26 mg 100 g $^{-1}$) is nutritionally significant, placing it at the upper end of the Indian germplasm range of 30.00–45.30 mg 100 g $^{-1}$ (Srivastava *et al*., 2012) and relevant for nutraceutical and functional food applications. The inverse pattern between AJG-85's highest sugars and lowest ascorbic acid suggests a possible carbon-partitioning trade-off between sugar accumulation and ascorbic acid biosynthesis, a pattern also noted in Dissanayake *et al*. (2021) [6]. The TSS:acid ratio range (9.69–26.43) matches the 9.69–26.39 range reported by Swamy *et al*. (2017) [24] from Karnataka, validating this collection as representative of the state's germplasm diversity.

3. Genotype-specific recommendations

Based on the integrated evaluation, Konkan Bahadoli is the outstanding genotype for fresh-market cultivation, offering the largest fruit size, highest pulp content and TSS, best pulp:seed ratio and the highest overall eating quality balance — findings that consistently align with multiple Karnataka studies (Kumar *et al*., 2020; Talang *et al*., 2017) [12, 25]. AJG-85 is recommended for processing into sugar-rich products. KJS-01 is recommended for large-scale commercial cultivation on account of its highest yield and ascorbic acid content. Among the ten previously uncharacterized JG-series farmer accessions, JG-2 (best TSS:acid ratio and lowest acidity), JG-6 (high TSS and yield), JG-4 (high yield) and JG-10 (high TSS and good overall quality) emerge as the most promising for multi-season evaluation and future inclusion in hybridization programmes aimed at combining the large fruit size and high quality of Konkan Bahadoli with the yield potential of the KJS group.

Conclusions

This study delivers the first DUS guideline-based multi-site morpho-pomological and biochemical characterization of sixteen *S. cumini* genotypes from the North-Eastern Dry Zone of Karnataka. Significant variation was documented for all quantitative traits. Konkan Bahadoli is identified as the superior genotype for fresh-market use, having largest fruit weight (15.62 g), highest pulp content (81.70%) and TSS (19.00 °Brix), best pulp: seed ratio (4.53). AJG-85 offers the highest total sugar content (21.25%) for processing; KJS-01 leads in yield (258.00 kg tree $^{-1}$) and ascorbic acid (44.26 mg 100 g $^{-1}$) for productivity-focused commercial cultivation. Among the ten previously uncharacterized JG-series farmer accessions, JG-2, JG-6, JG-4 and JG-10 demonstrate the most promising quality profiles warranting further multi-season evaluation and potential use in participatory breeding. These findings constitute an actionable germplasm baseline for variety recommendation and targeted hybridization programmes in jamun across the semi-arid regions of Karnataka.

Declarations

Author contributions: Karthik Vaidya: Conceptualization, Methodology, Data curation and Writing – original draft; Pampanna Y: Supervision, Validation, Writing –review and editing; Shekharagouda Patil: Supervision; Ramesh G: Supervision; Kisan B: Methodology and supervision.

Funding: Authors declare this study did not receive any fundings.

Conflict of interest: The authors declare no conflict of interest.

Acknowledgements: The authors sincerely acknowledge the Department of Horticulture, MARS, UAS Raichur; ARS, Kawadimatti; the Department of Molecular Biology and Biotechnology, College of Agriculture, UAS Raichur; and the farming households of Chandlapur village, Surpur taluk, for providing access to plant material, laboratory facilities and field support.

Data availability: No new data were created or analysed; authors declare every data are available in the manuscript itself.

References

1. Anonymous. Official Methods of Analysis, 12th edition. Association of Official Analytical Chemists, Washington, D.C., 1980.
2. Anonymous. Official Methods of Analysis, 16th edition. Association of Official Analytical Chemists, Washington, D.C., 1995.
3. Anonymous. Horticultural Statistics at a Glance. National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India, 2023. https://nhb.gov.in
4. Devi PS, Thangam M, Desai AR, Adsule PG. Studies on variability in physico-chemical characters of different jamun (*Syzygium cumini* Skeels) accessions from Goa. Indian J. Hortic.,2002:59(2):153–156.
5. AOAC. Official Methods of Analysis of the Association of Official Analytical Chemists, 17th ed.

AOAC International, Gaithersburg, MD, USA, 2000. https://doi.org/10.1093/9780197610145.003.1380
6. Dissanayake PK, Wekumbura WGC, Wijeratne AW, Wijesundara D. Morphological characterization, antioxidant capacity and diversity of *Syzygium cumini* trees from Sri Lanka. Hortic. Plant J.,2021:8(1):53–67. https://doi.org/10.1016/j.hpj.2021.09.002
7. Ghojage AH, Swamy GSK, Kanamadi VC, Jagdeesh RC, Kumar P, Patil CP, et al. Studies on variability among best selected genotypes of jamun (*Syzygium cumini* Skeels.). Acta Hortic.,2011:890(2):255–260. https://doi.org/10.17660/actahortic.2011.890.36
8. Halder A, Deb P, Rakshit D, Sarkar KA. Diversity in jamun [*Syzygium cumini* (L.) Skeels] genotypes from the dry tracts of Eastern India: a multivariate approach. N. Z. J. Crop Hortic. Sci.,2026:54(1):70038. https://doi.org/10.1002/nzc2.70038
9. Kannan A, Puraikalan YD. Development and organoleptic evaluation of jamun juice. Int. J. Sci. Res.,2013:4(3):1765–1766. https://doi.org/10.21275/v5i4.nov163016
10. Khadivi A, Mirheidari F, Saeidifar A, Moradi Y. Selection of the promising accessions of jamun (*Syzygium cumini* (L.) Skeels) based on pomological characterizations. Food Sci. Nutr.,2022:11(1):470–480. https://doi.org/10.1002/fsn3.3078
11. Kumar A, Singh K, Prakash J, Goswami AK, Patel VB, Ingole AD, et al. Multivariate assessment of morpho-biochemical and bioactive diversity in *Syzygium cumini* (L.) Skeels for the selection of superior genotype and breeding applications. BMC Plant Biol.,2025:25(1):962. https://doi.org/10.1186/s12870-025-06977-x
12. Kumar KA, Rekha A, Venugopalan R, Shivashankara KS, Kumar SM, Honnabyraiah MK, et al. Grouping of jamun genotypes based on fruit quality parameters. Indian J. Hortic.,2020:77(3):412–417. https://doi.org/10.5958/0974-0112.2020.00059.6
13. Megha H, Ningot EP, Dahale S, Bharad G, Nagre PK. Studies on variability in physico-chemical characteristics of jamun (*Syzygium cuminii* Skeels) genotypes from Eastern Maharashtra. Life Sci. Int. Res. J.,2017:4(1):251–257.
14. Nelson N. A photometric adaptation of the Somogyi method for the determination of glucose. J. Biol. Chem.,1944:153(2):375–380. https://doi.org/10.1016/s0021-9258(18)71980-7
15. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers, 2nd edition. ICAR, New Delhi, 1967.
16. Patel VB, Pandey SN, Singh SK, Das B. Variability in jamun (*Syzygium cumini* Skeels) accessions from Uttar Pradesh and Jharkhand. Indian J. Hortic.,2005:62(3):244–247.
17. PPV&FRA. Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on Jamun (*Syzygium cuminii* Skeels). Protection of Plant Varieties and Farmers' Rights Authority, Government of India, New Delhi, 2015.
18. Rajangam J, Sankar C. Evaluation of jamun (*Syzygium cumini* Skeels.) genotypes for flowering and yield attributes. J. Pharm. Innov.,2022:11(2):2374–2377.
19. Ranganna S. Manual of Analysis of Fruit and Vegetable Products. Tata McGraw-Hill, New Delhi, 1977.
20. Saini K, Ganesan K, Reddy L, Mahadevaiah C, Kumar P, Chaturvedi K, et al. Morphological, biochemical and SSR molecular insights of jamun (*Syzygium cumini* Skeels). Sci. Rep.,2026:16(1):7536. https://doi.org/10.1038/s41598-026-38816-w
21. Singh PJ, Singh AK, Bajpai A, Ahmad IZ. Characterization of different *Syzygium cumini* Skeels accessions based on physico-chemical attributes and phytochemical investigations. Int. J. Pharm. Sci.,2015:7(5):158–164.
22. Somogyi M. Notes on sugar determination. J. Biol. Chem.,1952:195:19–23. https://doi.org/10.1016/s0021-9258(19)50870-5
23. Stephen A. *Syzygium cumini* (L.) Skeels: a multipurpose tree, its phytotherapic and pharmacological uses. J. Phytother. Pharmacol.,2012:1(4):22–32.
24. Swamy GSK, Anushma PL, Jagadeesha RC. Morphological characterization of elite jamun (*Syzygium cuminii* Skeels) genotypes. Int. J. Minor Fruits Med. Aromat. Plants.,2017:3(1):9–15.
25. Talang HD, Rekha A, Dinesh MR, Shivashankara KS. Physico-chemical variability of selected genotypes of jamun (*Syzygium cumini* Skeels). Indian J. Hortic.,2017:7(1):64–66. http://dx.doi.org/373-16-IHJ-2610-12
26. Tripathi M, Kumar A, Singh R, Verma R, Kumar P, Srivastava S, et al. Characterization of jamun (*Syzygium cumini* Skeels) accessions for economic traits based on multivariate analysis. Eur. J. Hortic. Sci.,2025:90(1):1–15. https://doi.org/10.1079/ejhs.2025.0003
27. Uddin ABMN, Hossain F, Reza ASMA, Nasrin MS, Alam AHMK. Traditional uses, pharmacological activities, and phytochemical constituents of the genus *Syzygium*: a review. Food Sci. Nutr.,2022:10(6):1789–1819. https://doi.org/10.1002/fsn3.2797
28. Uddin S, Jaskani MJ, Deng Z, Maqbool R, Naqvi SA, Parajuli S, et al. Phenotypic and molecular-markers-based assessment of jamun (*Syzygium cumini*) genotypes from Pakistan. Horticulturae,2024:10(8):879. https://doi.org/10.3390/horticulturae10080879
29. Venkataramana P, Sivappa P, Priyadarshini SK, Mahesh MA. A new jamun (*Syzygium cumini* L.) variety — Chintamani selection-1. Int. J. Chem. Stud.,2020:8(1):1874–1877. https://doi.org/10.22271/chemi.2020.v8.i1ab.8538