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Evaluation of Qualitative Attributes of Wild Jamun [*Syzygium cumini* (L.) Skeels] Fruits with Emphasis on their Potential as Natural Food Colourants

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Abstract

The experiment was conducted during October, 2024 to April, 2025 at the Department of Postharvest Management, KRCCH, Arabhavi, Belagavi, Karnataka to study the physical and biochemical characteristics of wild jamun fruits to assess their anthocyanin pigment for food applications. The fruits were examined for their physical dimensions, colour, and biochemical composition using standard analytical methods. The average fruit weight, length, width, and volume were 2.02 g, 1.68 cm, 1.28 cm, and 3.00 cm^3, respectively, with a pulp-to-seed ratio of 1.40, indicating a seed-dominant structure. Colour measurements (L^*=16.76, a^*= 6.66, b^*=-7.00) revealed a deep-purple hue characteristic of high anthocyanin content. The fruits exhibited total soluble solids of 14.4°Brix and titratable acidity of 0.67%, yielding a TSS/acid ratio of 21.5, suitable for fresh consumption. Biochemical analysis showed exceptionally high total monomeric anthocyanin content (1094.11 mg 100 g^{-1}), ascorbic acid (166.2 mg 100 g^{-1}), flavonoids (118.99 mg 100 g^{-1}), total sugars (12.40%), and ash content (0.76%). Overall, the selected wild jamun was identified as a nutrient-rich, functionally valuable fruit with significant potential for utilization in food and nutraceutical applications. Specifically, for the application as natural food colorant, the jamun anthocyanin pigment can be utilized due to its deep-purple hue and high anthocyanin content. Despite its low pulp yield, the fruit's seed fraction may be further explored for value-added products such as oil and protein recovery.

Keywords: Wild jamun, anthocyanin, natural food colourant, antioxidant activity

1. Introduction

Jamun [*Syzygium cumini* (L.) Skeels] is an unconventional fruit from the Myrtaceae family, originally from tropical Asia (Leandro et al., 2020). Botanical studies have identified two main morphotypes of jamun in the Indian subcontinent based on morphological and organoleptic features: Kaatha jamun (wild type) having small, less juicy, slightly round, deep-purple or blackish fruits with larger seeds, acidic taste, and lower sweetness (Adithya et al., 2025). Whereas, Ras jamun (cultivated type) have oblong, dark-purple or bluish fruits with pink, sweet fleshy pulp and smaller seeds (Baliga et al., 2011).

Jamun is a small, delicate, and highly perishable fruit with a short shelf life of just 1–2 days under ambient conditions (Singh et al., 2019). Due to the absence of organized cultivation, it remains an underutilized crop (El-Safy et al., 2023). It is a fruit with high nutraceutical value, rich in essential nutrients including carbohydrates, minerals, vitamins, and a wide range of phytochemicals (Sahu et al., 2020). It contains significant amounts of phenolic acids, flavonoids, anthocyanins, tannins, and terpenes, all contributing to its strong antioxidant properties (Madani et al., 2021). Additionally, five non-acylated anthocyanins were identified as 3,5-diglucoside derivatives of cyanidin, peonidin, malvidin, petunidin, and delphinidin (Lestario et al., 2017).

Its sensory attributes are remarkable, which create a strong visual appeal because it offers an exotic flavour that combines acidity, astringency, and sweetness (Artilha-Mesquita et al., 2024).

The fruits are rich in minerals like calcium and potassium, B vitamins, vitamin C, sugars such as glucose and sucrose,

amino acids including alanine, arginine, and asparagine, anthocyanins, tannins, and dietary fiber, which promote healthy digestion and support weight loss and cholesterol reduction (Gomez et al., 2022). Renowned for its therapeutic qualities, it has been used in traditional medicine for centuries to treat diabetes, due to the compounds like alkaloids (Glucoside Jamboline) and ellagic acid, which inhibit the conversion of starch to sugar in the pancreas (Gautam, 2024). It also possess numerous nutritional and therapeutic properties, including hypoglycemic, antimicrobial, hypotensive, diuretic, cardiotonic, anti-inflammatory, antiemetic, antipyretic, anticonvulsant, antihemorrhagic, carminative, and antiscorbutic activities (Silva et al., 2023). It is also known to have anticancer property (Qamar et al., 2022)

Jamun protects DNA from toxic agents (metals, chemicals, ionizing radiation) and enhances fatty acid and glucose metabolism by activating PPAR-α and PPAR-γ (Jagetia et al., 2024). Cultuvated jamun is eaten fresh or processed into products like wine, squash, RTS drinks, jelly, syrup, and fruit bars (Kaur et al., 2024), but it suffers significant post-harvest losses due to poor handling and its perishable nature (Saeed et al., 2018).

Despite limited research on Kaatha jamun (wild jamun) utilization, this variety is particularly rich in anthocyanins and other bioactive compounds. These existing limitations present a valuable opportunity to evaluate wild jamun fruits as sources for anthocyanin extraction, which shows promising applications in both food products and nutraceutical industries.

With the growing focus on nutrition and health, consumers now recognize that natural pigments from fruits, vegetables, and edible flowers are not only safe and clean-label but also offer proven health benefits, whether consumed fresh or used in processed foods (Netravati et al., 2022).

In this context, the present study aims to explore the potential of wild jamun fruits as a source of anthocyanins for application as natural food colorants, addressing the gap in knowledge regarding wild jamun utilization while contributing to sustainable food ingredient development.

2. Materials and Methods

The experiment was conducted during October, 2024 to April, 2025 at the Department of Postharvest Management, KRCCH, Arabhavi, Belagavi, Karnataka, India. Wild jamun fruits were collected from Belagavi district, Karnataka. The harvested fruits were ripe and were consistent in size, shape and appearance. The fruits were sorted manually to remove dirt, immature and damaged ones. The fruits were washed and pat dried to remove adhered water. Then the fruits were observed for the following parameters.

2.1. Fruit weight (g)

The weight of the fruit was measured by weighing in analytical balance and was indicated in grams.

2.2. Fruit length (cm)

The length of the fruit was measured by vernier callipers and was indicated in centimetres.

2.3. Fruit width (cm)

The width of the fruit was measured by vernier callipers and was indicated in centimetres.

2.4. Fruit volume (cm^3)

The volume of the fruit was determined by water displacement method and was calculated using the following equation.

Volume = B–A

Where, 'A' represents the initial volume of water and 'B' represents the final volume.

2.5. Pulp to seed ratio

The weight of the pulp and seed were measured separately using a digital weighing balance. The pulp to seed ratio was calculated using the following formula:

Pulp to seed ratio=Weight of pulp (g)/Weight of seed (g)

2.6. TSS (°Brix)

A total soluble solid (TSS) conten of fruit was measured by using hand refractometer and was expressed in °Brix.

2.7. Titratable acidity (%)

The acidity of the concentrated juice was measured by titration method. A 2 g sample was reconstituted with 25 ml distilled water, then titrated with 0.1N NaOH using phenolphthalein. The endpoint was a light pink color, and acidity was expressed as percent citric acid, following the Anonymous (1984) method.

Titratable acidity (%)=(T×E×N×V1×100)/V2×1000×W

Where,

T=Titre value

E=Equivalent weight of citric acid (g)

N=Normality of NaOH (0.1 N)

W=Weight of the sample used for the titration

V_1=Volume made up to 25 ml

V_2=Volume of the sample was taken for estimation

2.8. Total monomeric anthocyanin content (TMAC) (mg l^{-1})

The TMAC was measured using the pH differential method as outlined by Netravati et al. (2024) with some modifications. For each treatment, aliquots of the concentrated pigment extract were diluted using buffers, potassium chloride (0.025 mol l^{-1}) for pH 1.0 and sodium acetate (0.4 mol l^{-1}) for pH 4.5. The dilution factor was determined beforehand. After preparation, the diluted samples were allowed to stand for 15 minutes to reach equilibrium. Absorbance readings were then taken at 510 nm and 700 nm using a spectrophotometer, with distilled water serving as the blank. Finally, the absorbance

difference was calculated by comparing the readings obtained at the two pH levels and wavelengths.

$A=(A_{510nm} - A_{700nm})_{pH\ 1.0}-(A_{510nm} - A_{700nm})_{pH\ 4.5}$

The TMAC in the sample was calculated as cyanidin-3-glucosideusing,

TMAC (mg l^{-1})=(A×MW×DF×100)/(ε×l)

Where,

MW-Molecular weight (449.2 g/mol for cyanidin-3-glucoside)

DF-Dilution factor

ε-Molar coefficient (26,900 L/mol/cm for cyanidin-3-glucoside)

l-Path length (1 cm)

2.9. Ascorbic acid content (mg 100 g^{-1})

Ascorbic acid content was measured using the volumetric method by Sadasivam and Manickam (1996). A 5 g sample was homogenized with 4% oxalic acid, filtered, and adjusted to 25 ml. A 5 ml aliquot was titrated with 2,6-dichlorophenol indophenol dye until a faint pink color persisted. The dye volume (V_2) was recorded, and the same procedure was done with a standard ascorbic acid solution (V_1). The ascorbic acid content was calculated using the formula,

Ascorbic acid (mg 100^{-1})=(0.5 mg/V_1 ml)× (V_2/5 ml)×(100 ml/ Wt.of the sample)×100

2.10. Anti-oxidant activity (%)

The antioxidant activity was determined using DPPH free radical scavenging method described by Eghdami et al. (2011). A 2.5 ml of DPPH was added to 0.2 ml of the extract and it was incubated for 30 minutes in the dark condition. The absorbance of a mixture was measured at 517 nm. The radical scavenging activity was calculated from,

Antioxidant activity (%)=(A_{517nm} of control-A_{517nm} of sample)/ A_{517nm} of control

Where, A is Absorbance value and control indicates DPPH solution.

2.11. Total phenolics (mg GAE 100 g^{-1})

Total phenolic content was determined using the Folin-Ciocalteu reagent following the method outlined by Singleton and Rossi, 1965. Absorbance readings were recorded at 765 nm using a UV-Visible spectrophotometer. Quantification was carried out using a gallic acid calibration curve, and results were expressed as milligrams of gallic acid equivalent (GAE) per 100 grams of sample.

Total phenolic content (mg GAE 100 g^{-1})=(OD700nm×Std. value (µg OD^{-1})×Total Vol. of extract×100)/(Assay volume×Wt. of sample (g)×1000)

2.12. Total flavonoid content (mg 100 g^{-1})

The total flavonoid content was determined using the method by Mehmoodetal. (2019). The sample was treated with 0.3 ml of 5% sodium nitrite, 0.3 ml of 10% aluminum chloride, and 1 ml of 1 mol l^{-1} sodium hydroxide, then adjusted to 10 ml with distilled water. Absorbance was measured at 415 nm. Results were expressed as milligrams of quercetin equivalents (QE) per 100 grams of sample.

Total flavonoid content (mg QE 100 g^{-1} FW)=OD510nm×Std. value (µg OD^{-1})×Volume made up (50 ml)×100/Assay volume (ml)×Weight of sample (g)×1000

2.13. Instrumental colour (L, a, b) values

The visual colour of the samples in terms of L^*, a^* and b^* instrumental colour values were measured by using colorimeter. The colorimeter measured lightness (L^*) value and two coordinates a^* and b^*. Lightness (L^*) values 100 and 0 represent absolute white and absolute black, respectively, while positive and negative a^* ($+a^*$ and $-a^*$) values denoted the direction of redness and greenness, respectively. Values of positive and negative b^* ($+b^*$ and $-b^*$) were in the direction of the vector for yellowness and blueness, respectively (Azima et al., 2017).

2.14. Total ash content (%)

Ash content in jamun fruit was analyzed using the muffle furnace method as outlined by Nielsen and Ismail (2017). A 5 gramsample was placed in a pre-weighed, dried porcelain crucible and incinerated at temperatures exceeding 500°C in an air atmosphere. After complete combustion of organic matter, the crucible was cooled in a desiccator to room temperature and reweighed. The ash content was calculated using the standard formula.

Ash (%)=(Weight of ash/Weight of sample)×100

2.15. Total sugars (%)

The total sugar content was measured using the DNSA method by Miller (1959). A 100 mg sample was extracted with 10 ml of hot 80% ethanol, then evaporated at 80°C. The residue was dissolved in distilled water, hydrolyzed with 1 N HCl, and neutralized with NaOH and HCl. An aliquot was mixed with DNSA reagent, heated, and stabilized with Rochelle salt. Absorbance was measured at 510 nm. Total sugar content was calculated from a glucose standard curve and expressed as a percentage.

Total sugars (%)=(Sugar value from graph @ (µg)/(Aliquot of alcohol @ free @ extract used (ml))×(Total volume of alcohol-@ free extract (10 ml)/(Weight of sample (100 mg)×(1/1000)

3. Results and discussion

The wild jamun fruits were small berries with an average weight of 2.02 g and a compact, ovoid geometry (length 1.68 cm; width 1.28 cm). The calculated geometric mean diameter (4.63 cm) is markedly larger than the actual length/width values, indicating that the fruit is nearly spherical with a slight longitudinal compression. A volume of 3.00 cm^3 corresponds well to the weight-derived density (~0.67 g cm^{-3}), suggesting

moderate porosity of the pulp matrix. The pulp-to-seed ratio of 1.40 demonstrates that jamun is a seed-dominant fruit, with the edible portion contributing only ~58% of the total mass (Table 1).

Table 1: Physical parameters of jamun fruit	
Fruit weight (g)	2.02
Fruit length (cm)	1.68
Fruit width (cm)	1.28
Fruit diameter	4.63
Fruit volume (cm^3)	3.00
Pulp to seed ratio	1.40
L^* (dark-light)	16.76
a^* (green-red)	6.66
b^* (blue-yellow)	-7.00

Colour analysis shows a dark-purple appearance reflected by a low L^* value (16.76). The positive a^* (6.66) and negative b^* (–7.00) coordinates locate the fruit colour in the deep-purple quadrant (Plate 1). The low luminosity indicates a high pigment

Plate 1: Appearance of wild jamun fruits

density, which is desirable for natural colourant applications.

The biochemical profile of fruits (Table 2) is exceptionally high in total monomeric anthocyanin content (1094.11 mg 100 g^{-1}), far exceeding values reported for *M. nigra* (571 µg cy-3-glu/g fw) by Ozgen et al. (2009). This aligns with the dark-purple colour and corroborates the suitability of jamun as a natural source of stable anthocyanin pigments. The wild jamun fruits exhibited a TSS of 14.4°Brix, coupled with a low acidity (0.67% malic acid), yielding a TSS/acid ratio of 21.5. This ratio falls within the range of 20–25 considered optimal for fresh consumption and minimal astringency. Total sugars (12.40%) are primarily monosaccharides, as indicated by the close agreement between TSS and sugar content. Total soluble solid content (15.67°Brix %), total titratable acid (1.90%), ascorbic acid (18.47 mg 100 g^{-1} FW) and total anthocyanin (152.66 mg 100 g^{-1} FW) were observed in Chinese dwarf cherries (*Cerasus humilis*) reported by Liu et al. (2018). Ascorbic acid levels (166.2 mg 100 g^{-1}) are also elevated relative to most temperate berries (30–60 mg 100 g^{-1}), contributing to the observed antioxidant activity (38 % DPPH inhibition). The moderate total phenolic content (72.44 mg GAE 100 g^{-1}) is consistent with the predominance of anthocyanins over other phenolic subclasses, whereas the flavonoid fraction (118.99 mg 100 g^{-1}) likely represents flavonols and proanthocyanidins that act as copigments, enhancing anthocyanin stability. Mineral content, expressed as total ash (0.76%), is modest but typical for fleshy fruits.

Table 2: Bio-chemical parameters of jamun fruit	
Total soluble solids (°Brix)	14.4
Titratable acidity (%)	0.67
Total monomeric anthocyanin content (mg 100 g^{-1})	1094.11
Ascorbic acid content (mg 100 g^{-1})	166.2
Anti-oxidant activity (%)	38.45
Total phenolics (mg GAE 100 g^{-1})	72.44
Total flavonoid content (mg 100 g^{-1})	118.99
Total ash content (%)	0.76
Total sugars (%)	12.40

4. Conclusion

Wild jamun [*Syzygium cumini* (L.) Skeels] is rich in anthocyanins, phenols, and flavonoids, giving it a deep purple colour and strong antioxidant properties.Jamun's rich anthocyanin content and balanced nutrient profile highlight its potential as a natural food colourant with added nutraceutical benefits. Limited research on anthocyanin extraction from wild jamun indicates a significant study gap and scope for further investigation. Despite its relatively low pulp yield, the fruit remains suitable for food and beverage applications, while its seed fraction offer prospects for value-added products.

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