



Exploring Nutritional and Value-Added Products of *Diospyros Melanoxylon* (Roxb.) Fruits

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<p>CC License CC-BY-NC-SA 4.0</p>	<p style="text-align: center;">Abstract</p> <p>Kendu fruits are minor tropical fruit has a unique characteristic. Despite their relatively limited cultivation, consumption, and trade compared to other fruits, Kendu fruits had a remarkable resilience, thriving under adverse climatic conditions. Kendu fruits, with their rich phytochemical constituents, have gained attention for the numerous health benefits they provide. The biochemical contents of Kendu fruits contribute to their potential application in the field of medicine, sparking interest in exploring their therapeutic properties further. To facilitate this, efforts were made to create awareness about the health benefits associated with Kendu fruits. Moreover, exploring avenues for value addition could enhance the appeal of Kendu fruits, making them accessible throughout the entire year. This could involve the development of innovative products such as Kendu fruit jams, juices, or snacks. By diversifying the ways in which Kendu fruits are presented to consumers, there is an opportunity to not only extend their availability but also to cater to a broader audience with varying preferences.</p> <p>Keywords: <i>Value-Added Products, therapeutic properties, phytochemical constituents, Kendu fruits, tropical fruit.</i></p>
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1. Introduction:

India possesses a valuable natural heritage consisting of ancient systems of medicine. The advancement of these traditional systems in terms of safety, effectiveness, and quality is crucial for preserving this heritage. *Ebenaceae* is a taxonomic family of angiosperms that encompasses many species of trees and plants which are predominantly found in tropical and subtropical regions. *Diospyros melanoxylon* (Roxb.), a member of the Ebenaceae family, is distributed in subtropical and tropical regions of China, India, Sri Lanka, Nepal, Bhutan, Myanmar, Bangladesh, Indonesia, and the Malay Peninsula. The *Diospyros* genus has 700 species of both deciduous and evergreen trees, shrubs, and tiny bushes, with 59 of these species found in India.

Coromandel Ebony is tropical fruit product popularly called as Malabar Ebony or East Indian Ebony in English whereas in local language called as Tendu (Hindi), Tuniki (Telugu), Karai (Tamil), Kari (Malayalam), Balai (Kannada), Dirghapatraka (Sanskrit), Kend (Bengali) and Kendu (Odia) (Orwa et al., 2009; Kumawat et

al.,2019). The Generic name has been derived from two Greek words “Dios” and “pyros” which means “divine” and “fruit” respectively. The specific name “melanoxylon” is also have a greek word meaning “dark wood” (Chintala et al., 2012). Its preferred area for growing is plain, plateaus and sub mountain regions receiving rainfall ranging from 500mm-1500mm per year (Pareek and Sharma, 1993). This species in most commonly found in the forests of Indian states viz., Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Rajasthan, Gujarat, Andhra Pradesh, Tamil Nadu and Odisha (Mallik et al., 2010). This endemic plant of India is widely known for its astringent effect and highly nutritive value. It is used as antipyretic drug and anti-inflammatory by local tribals of India. (Kirtikar and Basu, 1999). Its utility is more in utilizing its leaves and wood. This fruit is famous for its leaf which is utilized for making “bidi” (Rathore, 1972). Systematic position of *Diospyros melanoxylon* Roxb. has been shown Fig.1.

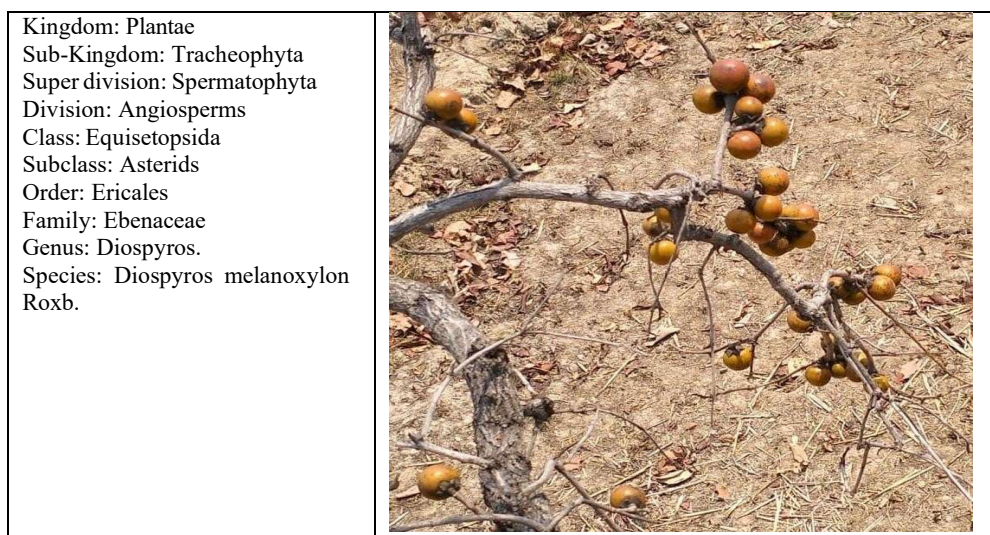


Figure 1: *Diospyros melanoxylon* Roxb.

Tendu plants exhibit adaptability to a wide range of soils, including laterite and black soil. In forested areas with rich humus content, the plant thrives and bears fruit. Even in rocky soils within forest ecosystems, tendu plants can be found. Optimal conditions for commercial cultivation involve soils with excellent water retention capabilities and high humus content. The plant demonstrates resilience by flourishing in poor, denuded soils, hot and dry hill slopes, stony soils with quartzite, shale, and sandstone, as well as heavy clays.

While tendu can grow in various soils, it achieves its peak growth and development in loose, porous soils situated in cool and moist sheltered valleys, often forming dense clusters. Tendu is categorized as a subtropical deciduous fruit plant, thriving at altitudes ranging from sea level up to 900 meters. The plant can be cultivated in areas where the mean annual temperature falls within the range of 0 to 48 degrees Celsius, accompanied by a mean annual rainfall between 500 and 1500 mm. During the clear winter months from November to February, tendu plants undergo a period of dormancy, with growth resuming as temperatures rise during spring. The emergence of new foliage and flowers coincides with this phase. For optimal fruit development and ripening, tendu plants benefit from high temperatures and humidity.

This plant, typically manifests as a medium-sized tree or shrub reaching up to 25 meters in height with a girth of 1.9 meters. Its leaves, measuring up to 35 cm in length, are either opposite or alternate, possessing a leathery texture and exhibiting tomentose characteristics on both surfaces (Chintala et al., 2012). The plant experiences a brief period of leaflessness during hot weather but regains its foliage in the months of May and June. In humid environments, it maintains evergreen qualities (Orwa et al., 2009). The branches of this plant are notably irregular, often numerous and rigid, creating an expansive and spreading canopy. Young shoots exhibit a downy texture. The primary root starts as a lengthy, thick, and fleshy structure, later transforming into a woody, grayish form, occasionally swelling near the upper part close to the ground level (Parmer et al., 2012). Flowering occurs during February – April (Kumawat et al., 2020). The male flower is mauve in colour, tetramerous to sextamerous, yellowish white, 18- 24 stamens in 2 rows, ovatotriangular; corolla tube urceolate. The female flower is mauve, mostly extra-axillary or sometimes solitary, axillary, presence of four lobbed large dark green calyx, 8 undeveloped stamens, triangular, margin reflexed; corolla tube cylindrical-urceolate (Patil et al., 2017).

This plant holds long-lived, deciduous, dioecious, and parthenocarpic berry fruit with/without seeds (Malik et al., 2010), which are available in the month of May and June. Fruits olive green to brown, ovoid or globose 3-4 cm across; 1, 2-, 3-, 4-, 5-, 6-, or 8seeded berries. Pulp is yellow, soft and sweet. Seeds compressed, oblong, shiny, often banded (Parmer et al., 2012).

Seeds are 2-4 elongated seed is the fruit. Seeds develop mainly from the elongated chalazal end of the ovules. The seed is encircled longitudinally by a persistent, distinctly raised (rarely inconspicuous), straight, and sometimes branched, vascular strand (Jadhav et al., 2009).

2. Uses of *Diospyros melanoxylon* Roxb:

2.1 Traditional uses:

This plant has been traditionally used for many years. It has been also mentioned in *Veda* and *Unani* text, for ethnobotanical uses. Various parts of the plant possess medicinal potentiality and are used by tribal communities. Dried flowers and powdered fruit may help urinary, skin, and blood problems (Jadhav et al., 2009). Mental illnesses, heart palpitations, and neurological breakdown are treated with seeds (Roy et al., 2019). Diarrhoea and diabetes are treated with the astringent bark decoction (Jadhav et al., 2009). Fruits are used to manage gastrointestinal issues. Stem bark relieves dyspepsia, astringent (eye), dysentery, corneal ulcers, and post-natal discomfort (Lalita et al., 2002). The leaves are used to wrap cheap Indian cigarettes, called “bidis” (Rathore, 1972). Buildings, shoulder poles, mine supports, and carriage shafts are made of wood. The bark of this tree is burned to treat “small pox”. It detects “sulphur dioxide” (Panda et al., 2010).

2.2 Nutritional Potential:

Kendu fruit has high value of mineral composition. This fruit is rich in vitamins especially Vitamin C which is essential for human immune system. It is a good source of iron and calcium (it plays a vital role in providing strength to bones and teeth). When taken with turmeric it helps in curing vitamin deficiencies (Bagdara Farm). This fruit pulp and skin is also rich in Potassium, Manganese, Zinc, Magnesium (Jamil et al., 2020). The fruit pulp contains different Vitamins such as Vit. B₁, B₂, B₃, Vitamin C and Beta-carotene (Hmar et al., 2017). Tendu fruit is a rich source of Crude fibre content (Singh et al., 2016). The fruit has high amount of moisture, ash and carbohydrate contents (Hmar et al., 2017). The wine made from kendu exhibited high nutritive value. It contains ethanol, methanol in low concentration (Sahu et al., 2012).

The analysis of fruit pulp and fruit skin revealed variations in several parameters. The moisture content in the fruit pulp was found to be 68.8%±2.3, while the fruit skin exhibited a significantly lower moisture content at 30.87%±1.63. In terms of ash content, the fruit pulp contained 1.81%±0.03, whereas the fruit skin showed a higher ash content of 3.27%±0.20. Carbohydrate content, a crucial nutritional factor, was measured at 26.70%±0.06 in the fruit pulp and notably higher at 62.45%±0.12 in the fruit skin. Crude fiber content, indicative of dietary fiber, was observed to be 6.59%±0.05 in the fruit pulp and remarkably elevated at 35.39%±1.60 in the fruit skin. The reducing sugar content in the fruit pulp was determined to be 11.10%±0.23, while no value was recorded for the fruit skin. Zinc was present in the fruit pulp at a concentration of 0.67±0.05, whereas the fruit skin did not show any detectable amount. Potassium content was higher in the fruit skin (1012.3±2.96) compared to the fruit pulp (305.52±8.94). Calcium, phosphorus, magnesium, iron, vitamin C, and β-carotene were also analyzed. Calcium concentration in the fruit pulp was 90.86±2.41, while in the fruit skin, it was significantly higher at 470.37±1.67. Phosphorus content in the fruit pulp was 167.3±3.06, whereas in the fruit skin, it was lower at 38.08±1.17. Magnesium content in the fruit pulp was 56.29±1.55, and in the fruit skin, it was slightly higher at 67.49±1.21. Iron concentration in the fruit pulp was 0.66±0.03, whereas in the fruit skin, it showed a substantial increase to 6.79±0.34. The presence of vitamin C and β-carotene was detected only in the fruit pulp, with values of 2.8±0.56 and 22.0±1.0, respectively, while these compounds were not present in the fruit skin as shown in Table-1.

Table 1: Nutritional compositions of *Diospyros melanoxylon* Roxb.

Parameters	Fruit Pulp	Fruit Skin
Moisture (%)	68.8±2.3	30.87±1.63
A sh(%)	1.81±0.03	3.27±0.20
Carbohydrate content (%)	26.70 ±0.06	62.45 ±0.12
Crude fibre content (%)	6.59±0.05	35.39±1.60
Reducing sugar (%)	11.10±0.23	-----

Zinc (mg)	0.67±0.05	-----
Potassium (mg)	305.52±8.94	1012.3±2.96
Calcium(mg)	90.86±2.41	470.37±1.67
Phosphorus(mg)	167.3±3.06	38.08±1.17
Magnesium(mg)	56.29±1.55	67.49±1.21
Iron(mg)	0.66±0.03	6.79±0.34
Vitamin C(mg)	2.8±0.56	-----
β-carotene(μg)	22.0±1.0	-----

(Sources: Sahu et al., 2012, Hmar et al., 2017, Jamil et al., 2020)

2.3 Phytochemical analysis of *Diospyros melanoxylon* Roxb.

2.3.1. Phytochemical composition: The fruits of *Diospyros melanoxylon* contain various bioactive compounds, including flavonoids, saponins, tannins, terpenoids, and alkaloids. Different extracts from the plant, such as petroleum ether, ethyl acetate, alcoholic, and aqueous extracts, exhibit diverse phytoconstituents. The petroleum ether extract contains steroids and triterpenoids, while the ethyl acetate extract contains flavonoids, tannins, phenolic compounds, sterols, and triterpenoids. The alcoholic extract contains flavonoids, tannins, phenolic compounds, and steroids, while the aqueous extract contains carbohydrates, proteins, amino acids, flavonoids, tannins, phenolic compounds, and tartaric acid. Active phytoconstituents in the petroleum ether extract include ceryl alcohol, lupeol, betulin, β-sitosterol, and a triterpene alcohol. These include steroids, triterpenoids, flavonoids, tannins, phenolic compounds, sterols, carbohydrates, proteins, amino acids, and tartaric acid. The distribution of chemical constituents in various parts of *Diospyros melanoxylon* (Roxb) plant has been shown in table 2.

Table 2: Distribution of chemical constituents in various parts of *Diospyros melanoxylon* (Roxb) plant.

Class of compound	Part of plant
Carotenoids	Fruits
Tannins	Fruits And Leaves
Sugars	Fruits, Seeds, Roots
Hydrocarbons	Fruit, Seed, Leaf
Lipids	Seed, Bark
Flavonoids	Fruit, Root, Leaf, Sap Wood
Terpenoids	Fruit, Root, Leaf, Calyx, Seed, Bark
Napthaquinones	Fruit, Root, Leaf, Bark

2.3.2 Traditional Medicinal uses: The crushed fruit juice is traditionally applied to cut wounds due to its perceived medicinal properties. Regular consumption of 4-5 fruits daily is believed to help control high blood pressure and purify the blood. The plant is traditionally used for various purposes such as a diuretic, carminative, laxative, styptic, and for conditions like epitaxis and night blindness (Banarjee et al., 2013).

2.3.3 Phytoconstituents and Biological Activities: The petroleum ether extract of *Diospyros melanoxylon* contains active phytoconstituents like ceryl alcohol, lupeol, betulin, β-sitosterol, and a triterpene alcohol (C₃₀H₅₀O). Bioactive triterpenoids have demonstrated multiple biological activities, including effects on glucose absorption, insulin secretion, and diabetic complications like vascular dysfunction, retinopathy, and nephropathy. Steroids, like lupeol and β-sitosterol, show potential in reducing glycosylated hemoglobin, serum glucose, and nitric oxide levels, while increasing serum insulin. Lupeol also has lipid-normalizing and cardioprotective effects (Patil et al., 2017).

Due to the presence of phytochemical it is used as anti-inflammatory, anti-diuretic, antioxidant, anti-mutagenic, anti-carcinogenic and also very helpful in modifying the gene expressions (Jamil et al., 2020). The aqueous methanol extract of unripe fruit possesses free radicals scavenging properties that are useful in mitigating induced DNA damage. This fruit contains intestinal α-glucosidase and pancreatic α-amylase which and utilized for mitigating diet-induced postprandial hyperglycemic burden in diabetic patient (Jaiswal et al, 2012). The fruit pulp turns brown in colour to the presence of enzyme PPO (polyphenol oxidase), this enzyme burns the phenolic content of the fruit (Kasim et al, 2015). The fruit showed DPPH scavenging activity that ranged 83.806 ± 1.03% (mg/g). Kendu fruit also exhibited FRAP which valued 5876.02 ± 0.52%mg TE/100g of DW (Hmar

et al, 2017). The kendu fruit also possess following phytochemicals Aurone, β -amyrin, Uvavol, Bauerenol, Oleanolic acid, Hentri-acotanol, 7-mthyljuglone, Dimelquinone, Dihydroxy triterpenic acid, Methoxy derivative of -1, 4-Naphthquinone, Disinidigo A&B, Penta cyclicquinone Biramentaceone, Dimethoxy derivative of 1-naphthol Hentriancontane, 8-hydroxy-octadec-10(Z) -enoic acid Malvalic acid, Bicylic sesquiterpene, Sterculic acid (Sinha et. al,2008). The fruit peel has activated carbon due to which act as effective bio-adsorbent (Sahu et.al, 2020).

Diospyros melanoxylon is used in traditional medicine for managing diverse diseases, including diabetes, anemia, inflammation of the spleen, dyspepsia, diarrhea, scabies, and as a hypotensive agent. Flavonoids found in the plant are noted for their potential role in diabetes management, possibly acting as insulin secretagogues or mimetics. The tannins in *Diospyros melanoxylon*, with their strong astringent action, are found to be useful in cosmetics, particularly for skincare. The fruits of *Diospyros melanoxylon* is crushed and its juice is applied to cut wounds, exhibiting traditional medicinal properties such as diuretic, carminative, laxative, styptic, and efficacy in night blindness. Consuming 4-5 fruits daily is believed to help control high blood pressure and purify the blood (Maridass et al., 2008).

The other plant parts also contain steroids, glycosides, mucilage. It also contains phenolic metabolites due to which it is able to show biochemical activities like Ceryl alcohol, Lupeol, Betulin, β -sitosterol, Sequoyitol, carboxylic acid, Diospyric acid and Naphthoquinones. The ethanolic extract in the stem bark, used in the cure of acute inflammatory pain (Gupta et al, 2013). The fruit leaves contains b-sitosterol Monohydroxy monocarboxylic acid, Monohydroxy triterpene Bauererys acetate, Ursolic, Betulinic acid, Baurenol, ursolic, Diospyric acid, Isobanerenol, Methyl betulinate (Sidhu et al., 1968). These medicinal values of plant parts which has been shown in the following table 3.

Table 3: Medicinal properties of *Diospyros melanoxylon* (Roxb).

Plant part	Property	Reference
Bark	Used as astringent, Its decoction is used in treatment of diarrhoea and diabetes	Jadhav et. al, 2009
Seeds	It can be used to cure mental disorder, nervous breakdown and palpitation of heart	Jadhav et. al, 2009
Leaves	It is used as diuretic, styptic, laxative and carminative.	Kirtikar and Basu, 1999
	It is also used to cure night blindness. It has also antimicrobial effect.	Gupta et al., 2013
Fruit	It maintains the euglycemic state and has cooling oxidatives stress effect.	Sailakshmi et. al, 2018
	It is also helpful in solving stomach problem	Lalit et. al, 2002
Flowers	These are in the cure of urinary, skin and blood diseases.	Roy et. al, 2019
Root	The root extract act as an effective antiplasmodial drug against <i>P.falciparum</i>	Kantamreddi et al., 2007

3. Value Added products from Kendu

Value addition implies the change in the physical form of the food material that results in great acceptability, extended availability, increasing market viability and increasing the cost efficiency benefit (Srivastava et al., 2017). The different value added products from kendu are nectar, jam, powder, bar, wine, ice-cream, squash etc (Fig.2).

3.1 Nectar

It is prepared from the fresh fruit pulp. The pulp is mixed with sugar syrup then was placed in a sterilized bottle. It can be taken in liquid form (Hmar et al., 2017)

3.2 Jam

It is prepared by mixing the fruit pulp with ingredients like sugar, water, citric acid, pectin. The mixture is now boiled to o btained the required consistency and acidity. The jam is then placed in sterile bottled and placed in refrigerator. (Hmar et al., 2017)

3.3 Powder

The fresh fruit pulp was dried in a tray dryer at a temperature of 60° C and the moisture content is maintained at 4%. This powder can be kept in an airtight glass container. Its shelf life stability is higher due to which it can be stored for 6-12 months. (Hmar et al., 2017)

3.4 Bar

The pulp of the fruit was mixed with sugar, water, citric acid and Sodium benzoate (0.2%) was heated at 70°-80° C was placed in the hot tray dryer and dehydrated until the consistency is reached. The product was sliced and wrapped in cellophane paper (Hmar et al., 2017).

3.5 Wine

Tendu fruit was utilized in making wine. Must from kendu was fermented and converted into wine which was liked by many. It is commercially available in the market. There was no significant difference between the market available wine and wine produced from kendu (Sahu et al., 2012).

3.6 Ice-cream

Fruit pulp was preserved and utilized for making ice-cream. It was made with KMS preservatives which showed a self-life period of 4 months. It also provides income generations to the forest fringe people (Supriya et al., 2023).

3.7 Squash

The fruit has been used for making ready to serve drink by mixing it with sugar, water, citric acid (Srivastava et al., 2017).

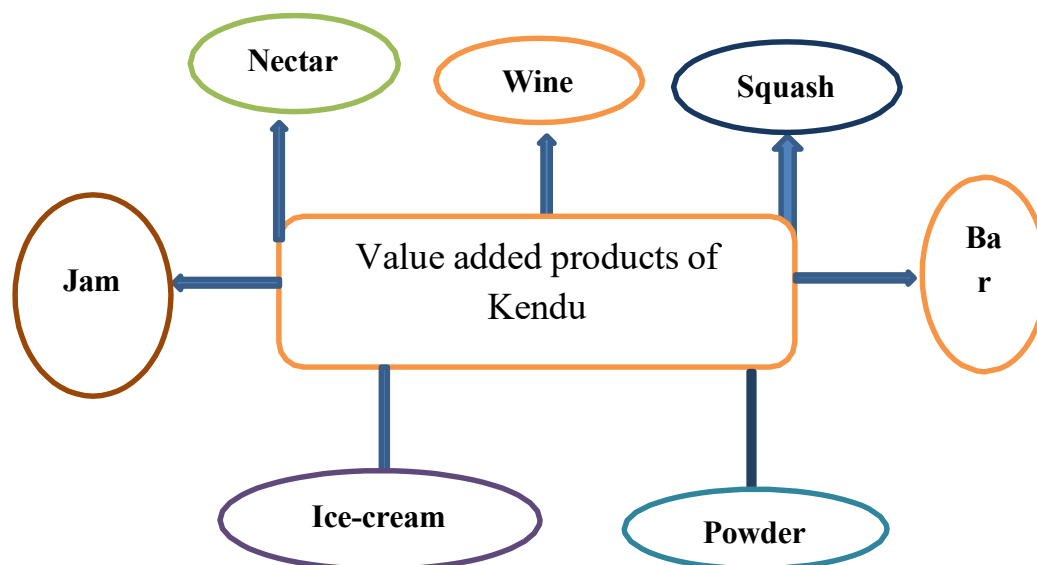


Figure 2: Value added products of Kendu Fruit.

4. Conclusion

Kendu fruits, considered a minor tropical fruit, are readily abundant during an alternative season. Despite their limited cultivation, consumption, and trade, these fruits thrive under adverse conditions and are recognized for their nutritional value. Catering to the preferences of health-conscious consumers, Kendu fruits boast numerous health benefits attributed to their rich phytochemical constituents. With significant biochemical contents, these fruits hold great potential in the field of medicine. Therefore, there is a crucial need to promote the popularity of Kendu fruits. Additionally, through the creation of value-added products, this fruit can be made accessible throughout the entire year.

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