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Review Article

An Insight into the Therapeutic Value of *Dillenia indica* Linn: Phytochemical and Pharmacological Aspects

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ABSTRACT

Dillenia indica Linn. is an evergreen tree belonging to the Dilleniaceae family, primarily found in the Himalayan and sub-Himalayan areas. The fruits of this plant are sour and are used as flavouring agents in cuisine. The leaves, fruit, flowers, roots, stems, barks and woods of the plant are rich in diverse chemical constituents and used traditionally for their medicinal properties. *Dillenia indica* is traditionally used in Assam, Manipur, Arunachal Pradesh, Mizoram and other states of India in the management of cough, hair loss, abdominal pain, hair dandruff, fever, dysentery, diarrhoea, weakness, flatulence, jaundice, fatigue, astringent, asthma and cholera. The plant has also been investigated scientifically for the treatment of different disorders like diabetes mellitus, inflammation, hyperlipidemia, microbial infection, diarrhoea, constipation, skin infection, dandruff, hair loss, respiratory diseases, kidney diseases, cardiotonic, Central Nervous System (CNS) problems, cancer, analgesia, parasite infection, liver diseases. The plant is a rich source of different flavonoids, triterpene, steroids and tannins such as malic acid, ascorbic acid, tocopherol, carotene, glycoside, dillenetin, betunaldehyde, betulinic acid, lupeol, β-sitosterol, saponins, proteins, free amino acids, fixed oil, dihydro-isorhamnetin, myricetin, naringenin, rhamnetin etc. *Dillenia indica* fruit is a rich source of vitamin C, carbohydrates, fats, proteins, amino acids, glucose, minerals and crude fibre, which is attributed to the nutritional properties of the plant. Traditionally, *Dillenia indica* fruits are used to prepare pickles, curries, jellies, jams, juices and chutneys, making it an integral part of regional cuisine. This paper explores the therapeutic potential and bioactive components of *Dillenia indica* and underscores its importance in the management of human health.

Keywords: *Dillenia indica*, Phytochemical, Traditional Value, Pharmacological Activities.

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INTRODUCTION

Dillenia indica Linn. is a medicinal plant belonging to the Dilleniaceae family. The plant is popularly known as elephant apple in English, chalta in Hindi, outenga in Assamese,[1] karambel in Gujrati and avartaki in Sanskrit.[2] The plant is an evergreen, middle-sized plant that mainly grows in moist and evergreen forests in the Himalayan and sub-Himalayan areas in the tropic, subtropic and temperate zones; it is also available all over India.[1,3,4] The height of the plant is usually 30-80 feet and the girth is 6-8 feet. This plant bears large and hard fruit 3-5 inches in diameter. The flowering period of this plant is May-August and fruits ripen from September to February.[1,3] This plant can be found in many countries, including Nepal, Bhutan, China, Bangladesh, Meghalaya, Sri Lanka, Indonesia, Myanmar, Malaysia, Philippines, Thailand, Vietnam, India, etc.[2,5] In Assam, unripe fruits are used to make pickles and used as cousins.[5] Major phytoconstituents of the plant are the lupeol groups of triterpene, such as betulinic acid and betulin and flavonol, such as myricetin. Quercetin, kaempferol, naringenin, isorhamnetin and phenolic materials present as flavonoids. Leaves, barks, fruits and roots have different medicinal properties such as anti-inflammatory (arthritis, cough, fever) activity, antimicrobial, Central Nervous System (CNS) depressant, antidiabetic and anticancer, antidiarrheal, laxative activity due to the presence of this important phytoconstituents.[6] This plant is also used as an expectorant, astringent, gastroprotective.[7] About 100 Dillenia species exist, but only eight are popularly used in preparing traditional medicines. Some of the dillenia species are, *Dillenia indica* Linn., *Dillenia pentagyna* Roxb, *Dillenia andamanica* C.E, *Dillenia meliosmifolia, Dillenia parviflora*, *Dillenia papuana* martelli, *Dillenia ovata*.[8,9] Leaf and fruit juices are used as antidiarrhoeal agent.[10] Leaf extract was investigated for antidiabetic activity.[11] Aqueous acetone extract of bark and fruits possesses antibacterial and antimutagenic

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activity.[12] Leaves extract of *Dillenia indica* exhibited potent antioxidant activity when tested through reducing power ability, 2,2-Diphenyl-1-Picrylhydrazyl (DPPH), superoxide radical, hydroxyl radical and nitric oxide scavenging assay.[13] Fruit juices of *Dillenia indica* are considered as 'Vat' (suppressant) and 'Pitta' (augmenting) drugs in Ayurveda.[14] Fruits of the plant were investigated for nephroprotective activity.[15,16] The fruits of this plant are used to prepare jam and jellies and as flavouring agents in curries.[8,17] Secondary metabolites present in *Dillenia indica* are alkaloids, tannins, phenols, glycosides, saponins, steroids and terpenoids, carbohydrates[18] flavonoids and phenolic compounds.[19] Conditions required for growing the *Dillenia indica* plant are propagated by seed, well grown in slightly acidic and loamy soil at pH 5.5-7 and this plant requires rainfall between 3,000-4,000 mm or 2,000-5,500 mm.[19]

Physical features of *Dillenia indica* Linn.

Dillenia indica Linn. is an evergreen plant in tropical and subtropical areas. Figure 1 includes the image of the flower and fruits of the plant. The physical properties of various parts of this plant, such as leaves, fruits, flowers, seeds, stems and roots, are listed in Table 1.

Kingdom: Plantae

Super division: Spermatophyta

Division: Phanerogamae

Subdivision: Angiosperm

Class: Magnoliopsida

Subclass: Dilleniidae

Order: Dilleniales

Family: Dilleniaceae

Genus: Dilleni

Species: *Dillenia indica.*

Phytochemical constituents

A number of primary and secondary metabolites are present in this plant, including flavonoids, saponins, phenols, glycosides, terpenoids, tannins, steroids, carbohydrates, anthocyanins, coumarins, etc. Table 2 includes the different phytochemicals present in the plant.

Traditional medicinal uses

Dillenia indica has been exclusively used as a medicinal plant in India, Southeast Asia, the Philippines, Bangladesh, etc. Almost all parts of this plant are utilised for medicinal purposes. Various medicinal uses of the plant include the treatment of leucoderma, loss of appetite, wound, diarrhea, jaundice, stomach disorders, flatulence, boils, fever, cough, abdominal pain, dysentery, fever, weakness, hair loss, constipation, cholera, food poisoning, cancer, pimples, bleeding piles, stomach ulcer, body pain and rheumatism etc. Primary traditional medicinal uses of this plant are tabulated in Table 3.

Pharmacological Activities

The plant parts were investigated for diverse pharmacological activities, including anti-diabetic, anti-inflammatory, antiulcer, anti-fungal, anti-hyperlipidemic and anti-cancer, wound healing, cardioprotective, hepatoprotective, antibacterial and neuroprotective activities. Table 4 includes different pharmacological activities of the plant.

Methanolic extracts of *Dillenia indica* leaves are anti-inflammatory against carrageenan-induced inflation at 200 mg/kg to 400 mg/kg.[1] Alcoholic extract of *Dillenia indica* at a dose of 50 mg/kg has shown a protective effect on diabetes mellitus against streptozotocin-induced diabetes.[1] One research revealed that the methanolic extract of *Dillenia indica* fruits suppresses hyperglycemia at a dose of 50-350 mg/kg by acting on GLUT-4

Figure 1: *Dillenia indica* flower and fruit.

protein expressions. This extract also decreases malondialdehyde, as confirmed by the lipid peroxidation assay.[23] From the methanolic extract of *Dillenia indica* prepared fractions and isolated different secondary phytochemicals such as quercetin, β-sitosterol, dase Inhibition and α-amylase inhibition assay was conducted and found that these two enzymes had effects on different secondary metabolites like quercetin, betulinic acid, β-sitosterol and stigmasterol and decreased oligosaccharide breakdown and increased carbohydrate digestion.[24] *Dillenia indica* decreases hydrolysis of carbohydrates by inhibiting α-amylase and α-glucosidase enzymes; it shows antidiabetic activity against STZ (90 mg/kg)-induced type II diabetes mellitus. This plant also has antihyperlipidemic activity. Hyperlipidaemia was induced by feeding cholesterol (1%), cow fat diet (5%)

Table 1: Physical features of *Dillenia indica* Linn.

Sl. No.	Plant parts	Features
1	Leaf	The length is 8-14 inches, broad 2-4 inches and large oval 15-36 cm. The margin is pointed apex and toothed and the colour is green and lanceolate.[1,2,9,20]
2	Fruit	Fruit is a hard greenish-yellow coloured, edible, berry-like shape, enclosed with fleshy calyx; size is 5-12 cm, length is 93.10 mm, width is 83.20 mm, thickness is 80.60 mm, geometric diameter is 86.87 mm, the surface area is 23702.77 mm 2 and sphericity is 0.85.[9,17]
3	Flowers	The blooms have colourful petals (white, yellow, or red) and obvious reproductive components. They are primarily bisexual or very rarely unisexual. 5 tightly fitting imbricate sepals encasing many seeds embedded in a sticky pulp; hard, 5-8 inches in diameter. Huge, single, end-to-end branching white blossom.[1-3,9]
4	Seed	Little, compact, dark brown reniform with hairy edges.[1,19]
5	Stem	Stem is yellow in color.[19]
6	Root	Roots are yellowish brown in colour.[19]

Taxonomical Classification of *Dillenia indica* is as follows.[2]

Table 2: Phytochemical present in *Dillenia indica* Linn.

Plant parts	Phytochemicals present
Leaf	flavonoids, triterpene, n-heptacosan-7-one, n-nonatriacontan-18-one, quercetin, β-sitosterol, stigmasterol and stigmasterol palmitate, chromane 3,5,7,-trihydroxy-2-(4-hydroxy-benzyl)-chroman-4-one were isolated from leaves, steroids, tannins, cycloartenol, n-hentriacontanol, sitosterol, betulin, betulinic acid, kaempferol,[1,19] 1- hentriacontanol, tannic acid, betulinic acid, beta-sitosterol.[20]
Fruit	malic acid[1,19] ascorbic acid, tocopherol, carotene and phenolic,[15] tannin, glucose, polysaccharide arabinogalactan, glycoside, steroids, flavonoids and saponins, reducing sugar, trihydroxy-3, dimethyl flavone, stigmasterol, betulinaldehyade, lupeol, myricetin hydroxy-lactone, dihydro- isorhamnetin, myricetin, hydroxylactone,[18] galactoarabinan, l-(+)arabinose, betulin, betulinic acid, d- galactose, beta-sitosterol, d- galacturonic acid, d- mannose.[20]
Stem Bark	Flavonoids (rhamnetin, dihydro-isorhamnetin, lupeol, myricetin, naringenin, quercetin), triterpenes, tannin, dillenetin, betulinaldehyde, betulinic acid, kaempferol glucoside,[1] betulin, naringetol, beta- sitosterol.[20]
Wood	betulinic acid, lupeol, β-sitosterol,[1] betulin, beta-sitosterol, cycloartenone, kaempferide, myricetin, dillenetin, 1-hentriacontanol, betulinaldehyde, isorhamnetin, naringetol, tannic acid, d- glucose.[20]
Seed	fixed oil, colouring matter, sterols, glycosides, saponins, proteins, free amino acids, sugars, free acids and tannins.[1]
Flower	Tannic acid, d- glucose.[20]

Table 3: Traditional medicinal value of *Dillenia indica* Linn.

Sl. No.	Plant Parts	Ethno Pharmacological Uses	References
1	Fruit	Antidiabetic activity For the treatment of dandruff and hair fall. Mucilage used for hair growth Fruits are used to manage fever, cough and other respiratory diseases. Fruits provide energy, increase appetite and reduce weakness. Fruit juice mixed with a few drops of honey is taken once daily to cure dysentery. Fruits are used as a remedy for stomachache. Fruit is used in the treatment of diarrhoea. The fruits are used as a laxative. Mature fruit juice removes flatulence. Treatment for jaundice Treatment for fever and fatigue.	[1,2,5,9]
2	Leaves	Anti-diabetic. Leaves are used as insect repellent. Leaves are used for the treatment of gallbladder stones. Leaves are used as astringent. Treatment for fever, cough and constipation.	[1,5,9]
3	Bark	By Local Kabiraj, bark paste filtrate is mixed with sugar in a glass of water and kept overnight. It is then taken regularly in the morning on an empty stomach for blood cancer. Bark and leaves are astringent. Bark powder is used for diabetes, diarrhoea and dysentery.	[1,5,9]
4	Shoot	Tender shoots of plants are used for asthma.	[1]
5	Flowers	Flowers are taken orally for treating dysentery. Treatment for dysentery.	[1,9]
6	Stem	Stem bark and fruit from plants are used to treat stomachaches.	[1]
7	Roots	Used as phytochemical treatment for cholera.	[5]

and coconut oil (5%) for 28 days. Ethanolic extract of *Dillenia indica* was administered for 28 days and it was found that this plat decreases serum cholesterol level, total cholesterol level and low-density lipoprotein.[25] *Dillenia indica* shows diabetic nephroprotective activity by inhibiting advanced glycation end-product formation at different doses of extracts, such as 100 mg/kg, 200 mg/kg and 400 mg/kg. Type II diabetes was induced by injecting streptozotocin (65 mg/kg, i.p.) and 15 min after injecting nicotinamide (230 mg/kg, i.p.).[26] One novel compound was isolated from *Dillenia indica* leaf named chromane (2-(4-hydroxybenzyl) 3, 5, 7-trihydroxy chroman-4-one) and identified the protective activity against diabetes mellitus, which was induced by streptozotocin. This activity was also confirmed by an *in vitro* study like the α-amylase and α-glucosidase enzyme inhibition assay.[28] Different extracts of *Dillenia indica* have antibacterial activity. Ethyl acetate and diethyl ether extracts of *Dillenia indica* leaves have protective activity against microorganisms such as *Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeruginosa*.[31,32] A study found that a methanolic extract of *Dillenia indica* leaves at 250 and 500 mg/kg body weight provided antidiabetic activity against alloxan-induced diabetes mellitus and hypoglycemic activity in diabetic rats.[32-34]

Polyherbal formulations of *Dillenia indica* Linn. are used to treat type 2 diabetes mellitus. It was also effective in lowering blood lipid profile.[35] One study was conducted on humans in Guwahati Ayurvedic College, Guwahati, to determine the protective activity of *Dillenia indica* fruit powder against type II diabetes mellitus. Forty-one volunteers (20 male and 21 female) were included in that study. The study continued for 24 weeks and 2 doses were given daily, 15 gm half an hour before breakfast and 15 g half an hour before dinner. Sugar levels were checked in the 8th, 16th and 24th weeks and it was noticed that fruit powder and diet control tremendously reduced blood glucose levels. From this study, it was concluded that the trial drug of *Dillenia indica* may act by decreasing glucose absorption from the gastrointestinal tract or by acting on insulin secretion.[36]

Table 4: Pharmacological activities of *Dillenia indica* Linn.

Sl. No.	Activities	Parts used	Extract/ fraction	Chemical constituent	Dosing	Model or Method of Test	References
1	CNS depressant	Bark	Methanolic	Alkaloid and flavonoids	100, 200, 400 mg/kg	Cross hole and open field test	[1]
2	Anticancer	Fruits	Methanolic	Betulinic acid	Not reported	Healthy human cell lines namely u937, hl60 and k562	[1,9]
3	Anti-inflammatory	Leaves	Methanolic	Flavonoids and Triterpene	200,400 and 800 mg/kg	Acetic acid-induced colitis	[1]
4	Anti- inflammatory	Leaves	Methanolic	Flavonoids and Triterpene	25, 50, 75 mg/kg p.o.	Carrageenan induced paw	[1]
5	Anti- inflammatory	Leaves	Methanolic	Not reported	200 and 400 mg/kg	Carrageenan induced paw	[6]
6	Antidiabetic	Leaves and fruit	Methanolic	Lupeol	250-500 mg/kg p.o.	Streptozotocin (STZ), nicotinamide and alloxan induced diabetic wistar rat.	[1,9]
7	Antidiabetic	Leaves	Alcoholic	3,5,7-trihydroxy-2-(4-hydroxybenzyl)-chroman-4-one	100, 200 and 400 mg/kg	STZ (50 mg/kg) induced diabetic rats	[11]
8	Wound healing	Fruits	Glycolic	Flavonoids	Not reported	Surgically induced on the back of the Wistar rat	[1]
9	Antidiarrhoeal	Leaves and fruit	Ethanolic	Not reported	200 and 400 mg/kg)	Castor oil induction and charcoal plug method.	[1]
10	Antidiarrhoeal	Root	Methanolic	Not reported	500mg/kg)	Castor oil induction and charcoal plug method.	[1]
11	Anti- nociceptive	Root	Not reported	Not reported	250 mg/kg and 500 mg/kg)	Acetic acid-induced	[1]
12	Antidiarrhoeal activity	leaf	ethanolic	Not reported	200 mg/kg, 400 mg/kg	castor oil-induced	[10]
13	Antioxidant activity	Leaves	Methanolic	Phenolic compound	Not reported	*In vitro* antioxidant activity (DPPH, reducing power and phosphomolybdenum radical scavenging activity)	[1]
14	Antimicrobial activity	Leaves	Methanolic	Flavonoids	At a concentration of 400 µg/disc.	Sixteen microbial strains	[1]
15	antibacterial	fruit and bark extracts	70% aqueous acetone	Not reported	500 µg/plate concentration	Sodium azide induced mutation in Salmonella tester strain (TA-1531).	[11]

Sl. No.	Activities	Parts used	Extract/ fraction	Chemical constituent	Dosing	Model or Method of Test	References
16	Anxiolytic activity	Leaves	Hydroethanolic	Not reported	100, 200 and 400 mg/kg p.o	Hole board, open field	[1]
17	Anthelmintic activity	Stem bark	Methanolic	Not reported	10, 15, 20, 25 mg/mL		[1]
18	Hepatoprotective activity	Leaves	Ethanolic	Not reported	300 mg/kg p.o.	Carbon tetrachloride-induced hepatotoxicity	[1]
19	Antiarthritic activity	Leaves	Methanolic	Not reported	25, 50, 75 mg/kg	Complete Freund's adjuvant induced (0.1 mL) in the left hind paw of the rat.	[1]
20	Analgesic activity	Leave	Methanolic	Not reported	100, 200, 400 mg/kg, p.o.	Hot plate, tail immersion, acetic acid-induced writhing and formalin-induced nociception.	[1]
21	Analgesic activity	Leave	Methanol extract	Not reported	400 mg/kg	Formalin induced nociception	[1]
22	Analgesic activity	Stem bark	Methanol extract	Not reported	100, 200 and 400 mg/kg	Acetic acid-induced writhing,	[1]
23	Anti-leukemic activity	fruit	Methanolic	Betulinic acid	up to 1.5 g/kg i.p was non-toxic	Human leukemic cell lines U937, HL60 and K562.	[8]
24	Antidiabetic and antihyperlipidemic	Leaves	Methanolic	Not reported	250 and 500 mg/kg	Streptozotocin induced diabetic Wistar rats	[21]
25	Nephrotoxicity.	Fruits	Methanol, petroleum ether	Flavonoids	300 mg/kg/day, p.o.	Cisplatin-induced nephrotoxicity.	[16]
26	Antidiabetic	Bark	Methanol	Not reported	350 mg/kg	STZ-induced diabetic mice model	[22]
27	Antidiabetic	Fruit	Methanolic	Not reported	50, 350 mg/kg	Alloxan-induced diabetic rats	[23]
28	Antidiabetic	Leaves	Methanol	Not reported	10 mg/kg.	Alloxan and STZ induced diabetes	[24]
29	Antihyperlipidemic, antidiabetic	Fruit	Water, ethanol	Not reported	1.25 g/10 m/kg	STZ (90 mg/kg)	[25]
30	Diabetic nephropathy	Leaves	alcohol and hydro-alcohol extract	Not reported	100, 200 and 400 mg/kg	STZ (65 mg/kg i.p.)	[26]
31	Hyperglycemia	Fruits and leaves	alcohol	Not reported	100, 200 and 400 mg/kg, p.o	STZ (65 mg/kg)	[27]
32	Antidiabetic	Leaves	Synthesised Novel New Chromane	Not reported	100 mg/kg	STZ (50 mg/kg i.p)	[28]

Sl. No.	Activities	Parts used	Extract/ fraction	Chemical constituent	Dosing	Model or Method of Test	References
33	Antidiabetic	Leaves	ethyl acetate fraction	Flavonoids	200 and 400 g/kg	STZ (50 mg/kg i.p)	[29]
34	Sub-Acute Toxicity	leaves	enriched fraction	Not reported	50 and 500 mg/kg	OECD guideline 423	[30]
35	Acute Toxicity	leaves	enriched fraction	Not reported	200, 800 and 1600 mg/kg	OECD guideline 423	[30]

CONCLUSION

Dillenia indica, with its diverse phytochemical composition and nutritional profile, is a promising natural resource for medicinal and culinary applications. Traditionally, it has been used in the Indian subcontinent to treat various ailments such as cough, fever, dysentery, asthma and hair loss. Modern scientific studies have validated its therapeutic potential in diabetes, inflammation, microbial infections, hyperlipidemia, respiratory disorders, skin diseases and cancer. The plant's bioactive compounds, including flavonoids, triterpenes, steroids, tannins and essential vitamins, contribute to its multifunctional properties. Fruit of the plant is a rich source of nutrients like vitamin C, proteins and crude fibre, enhancing its value as a dietary supplement. Future research should focus on isolating and characterising the bioactive compounds in *Dillenia indica* to understand their mechanisms of action and therapeutic efficacy. The development of standardised extracts and formulations and clinical trials of those can pave the way for its incorporation into modern medicine.

Furthermore, exploring its potential in nutraceuticals and functional foods can enhance its value in global markets. Sustainable cultivation and conservation strategies are essential to ensure its availability while maintaining ecological balance. Overall, *Dillenia indica* holds significant promise as a natural remedy and nutritional resource for improving human health.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

CNS: Central Nervous System; **DPPH:** 2,2-diphenyl-1-picrylhydrazyl; **STZ:** Streptozotocin.

SUMMARY

Dillenia indica is a versatile plant with medicinal and nutritional value. Traditionally, parts of the plant have been used in the Indian subcontinent to treat diverse ailments such as cough, fever, asthma, gallbladder stones, diabetes and more. It has proven therapeutic potential in managing diabetes, inflammation, wounds and cancer. Its bioactive compounds, including flavonoids and vitamins, make it valuable for health. Rich in vitamin C and fiber, the fruit supports dietary needs. Research on its bioactive components and sustainable cultivation can further expand its role in medicine and nutraceuticals.

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