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# *Dillenia indica* Linn. and *Dillenia pentagyna* Roxb.: Pharmacognostic, Phytochemical and Therapeutic aspects

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**ABSTRACT**

*Dillenia indica* Linn. and *Dillenia pentagyna* Roxb. plants are commonly known as 'Karmal' and 'Mota Karmal' respectively belonging to family Dilleniaceae. These plants are distributed in many Asian countries, in India from Himalaya to south India. Morphologically leaves, bark and fruit are having major differentiating characters of both species. Traditionally the different parts of these plants have curing properties like cancer, wound healing, diabetes, diarrhea, bone fracture, in cut and burns, abdominal pains etc. Based on phytochemical investigations these plants are reported to contain active constituents like betulin, betulinic acid, dillenetin, dipoloic acid, myricetin, quercetin derivatives etc. Different prepared extracts of these plants and their parts has been reported to contain wide range of flavonoids, steroids, triterpenoids, phenolics, saponins, fixed oil which may exert varied pharmacological activities like anticancer, antidiarrheal, antimicrobial, antioxidant and many more. The present review approaches for pharmacognostical description, phytochemical investigations and therapeutic importance of both the species.

## INTRODUCTION

Medicinal plants have provided copious leads to combat diseases, from the dawn of civilization. India is one of the world's 12 biodiversity centers with the presence of over 45000 different plant species (Jawla *et al.,* 2009). Traditional systems of medicine continue to be widely practiced on many accounts. Many of these plants are rare and endemic and found only in forest region. There is neither biological information nor adequate knowledge that led to their rarity in the habital (Kerrigan *et al.,* 2011). Creation of a network of regional and sub-regional ethno-medicinal plant gardens which should contain accessions of all the medicinal plants known to the various ethnic communities in different regions of India.

There are many plant species which has been used by tribal and folk communities of various forest regions of India but their pharmacognostical as well as phytopharmacological importance is yet unknown as these plants are rarely available. Amongst these plants there are few plants belonging to family Dilleniaceae which is not much known but having very good medicinal value. The genus Dillenia has 60 species, of which *Dillenia indica*, *Dillenia pentagyna*, *Dillenia alata*, *Dillenia suffruticosa*, *Dillenia papuana*, *Dillenia excelsa*, *Dillenia serrata*, *Dillenia ovata*, *Dillenia phllipinensis* etc. which are found to have good medicinal value, there are only two plants *Dillenia indica* Linn. (*D. indica*) and *Dillenia pentagyna* Roxb. (*D. pentagyna*) which is available in India (Dickison, 1979). The leaf, bark, and fruit of these plants are used as traditional medicine is having good therapeutic values.

These plants are being used by tribal and folk communities of various regions, fruits of *Dillenia indica* as well as *D. pentagyna* also eaten raw but not very much well known by people (Dubey *et al*., 2009; Pradhan & Badola, 2008; Sharma & Pegu, 2011). The present review includes detailed pharmacognostical description, phytochemical investigations and therapeutic importance of these plants. These plants may have very good medicinal potential which can be further explored for preparation of formulations.

## VERNACULAR NAMES

In addition to scientific names, *D. indica and D. pentagyna* also have multiple common (local) names (Nadkarni & Nadkarni, 1954; Shah, 1978; Khanum *et al.,* 2007; Khare, 2007; Rastogi *et al.,* 2001) shown in Table 1.

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**Table. 1**: Vernacular names of *Dillenia indica* and *Dillenia pentagyna.*

| Language | *Dillenia indica* | *Dillenia pentagyna* |
|---|---|---|
| English | Elephant apple | Dog Teak |
| Sanskrit | Bhavya, ruvya | --- |
| Hindi | Chalta, girnar | Aggai, Kallai |
| Gujarati & Marathi | Karmbel, Mota Karmal, Mota Karambal | Karmal |
| Bengali | Chalta, Hargesa | Korkotta |
| Assam | Chalita, Outenga | Akshi |
| Uriya | Uvu, Chalota, Ou, Rai | Rai |
| Nepali | Ramphal, Panchphal, Panchkule | Tatri |
| Telugu | Peddakalinga | Chinnakalinga, Ravudana |
| Tamil | Akku, Ugakkay, uva, uvav, uvatteku | Naytekku |
| Kannada | Betta Kanigala, Kondukanagala | Kanigala, Kadu-Kanigala |
| Malyalam | Chalitha, Punna, Syalitha, valapunna | Punna, Kodapunna |
| Konkani | Corombol | --- |
| Burma | Thabyu, thibuta, Zinbrun, Zinpyunngan | --- |
| Monghyr | Chilta | --- |
| Trade | --- | Dillenia |

## TAXONOMICAL CLASSIFICATION

According to the botanical scheme of Engler, the plant is classified as follows (Metcalfe & Chalk, 1983):

Kingdom : Plantae
Division : Phanerogamae
Subdivision : Angiospermae
Class : Dicotyledonae
Subclass : Polypetalae
Order : Dilleniales
Family : Dilleniaceae
Genus : Dillenia
Species : *indica* Linnaeus or *speciosa* Thunberg
: *pentagyna* Roxburgh or *hainanensis* Merrill

## PHARMACOGNOSTICAL DESCRIPTION

Morphologically bark, leaves and fruits of *D. pentagyna* and *D. indica* are having major distinguishing characters.

### *Dillenia indica* Linnaeus

### *Synonym: Dillenia speciosa* Thunberg

Medium sized evergreen trees up to 30 m tall, ca. 1.2 m d.b.h., trunk is straight but not much high, branches are spreading and forming round-shady head (Figure 1a). Bark is reddish brown in colour, exfoliating; young branchlets is brown pubescent, glabrescent and contains leaf scars (Figure 1b). Leaves are fasciculate at the ends of branches; veins are close, running into serratures, not forking at the margins, upper surface and nerves beneath are more or less pubescent; petiole is narrowly winged, 2.5-5 cm long, channeled, sheathing; leaf blade oblong or obovate-oblong, 15–40 × 7–14 cm, secondary veins (20–)30–40(–70) on either side, parallel, margin serrate, apex is acute (Figure 1c). Flowers are solitary, 12–20 cm in diameter, bud is more than 5 cm in diameter. Sepals are 5 in number, approximately rounded, orbicular, concave, 4–6 cm in diameter, thickly and fleshy. Petals are 7-9 cm in size, white, obovate. Stamens in 2 distinct groups, outer very numerous, slightly curved in bud, inner ca. 25, apically reflexed outward in bud; anthers dehiscing with 2 pores. Carpels are 16–20 in number; stylodia spreading; ovules many per carpel. Flowers occur in May-June. Fruits are aggregate and globose, 10–15 cm in diameter, indehiscent, persistent sepals, fleshy, slightly swollen. Fruiting in July-August and ripens in November-December. The fruit of this species is edible (Figure 1c, 1d). Seed contains 5 or more per carpel, exarillate, imbedded in glutinous pulp, compressed, with hairy margins (Kirtikar, Basu, 1999; 1984).

**Fig. 1a:** *Dillenia indica* Linn. Tree;

**Fig. 1b:** *Dillenia indica* Linn. Bark.

Microscopically leaves showed presence of anomocytic stomata, unicellular lignified trichomes, xylem fibers, calcium oxalate crystals etc., while section of sepals showed epidermis with thin cuticle, collenchymatous hypodermis, parenchymatous mesophyll embedded with mucilage and fibro vascular bundles as well as starch grains (Shome *et al.*, 1980; Shome *et al.*, 1979; Kumar *et al.*, 2011b).

**Fig. 1c:** *Dillenia indica* Linn. Fruit and Leaves .

**Fig. 1d:** *Dillenia indica* Linn. Section of fruit.

***Dillenia pentagyna* Roxburgh**

***Synonym: Dillenia hainanensis* Merrill.**

It is deciduous trees up to 15 m tall and 1 m d.b.h (Figure 2a). Bark is grayish in colour, smooth, exfoliating; branchlets glabrous, stout (Figure 2b).

Leaves are petiolate 2–5 cm, glabrous, with narrow wings; shape is oblong to obovate-oblong, 20–60 × 10–25 cm in size, leathery surface, secondary veins 25–50 on either side, showing parallel margin with shallowly undulate teeth, apex obtuse to subacute (Figure 2c).

Flower are 2–7 in number, small, fascicled at top of lateral spurs, 2–3 cm in diameter, less than 2 cm in diameter in bud; pedicels 2–4 cm, bractlet is deciduous. Total 5 sepals and petals, yellow coloured and obovate. Stamens are in 2 distinct groups, outer 60–90, 3–4 mm, slightly curved in bud, inner ca. 10, reflexed, 6–9 mm; anthers dehiscing with longitudinal slits. Carpels are 5 or 6, 3.5–4 mm in diameter; stylodia spreading containing 5-20 ovules per carpel. Pseudocarp is indehiscent, yellow/orange/red in colour. Flowering starts in April-May. Fruits are globose in shape, 0.5–1 cm in diameter, indehiscent, greenish when fresh (Figure 2d).

Seeds are exarillate (Panda, 2009; Nadkarni & Nadkarni 1954, Shah, 1978; Khanum & Khan, 2007; Khare, 2007; Metcalfe & Chalk, 1983; Kirtikar & Basu, 1999 & 1984).

**Fig. 2a:** *Dillenia pentagyna* Roxb. Tree

**Fig. 2b:** *Dillenia pentagyna* Roxb. Bark

**Fig. 2c:** *Dillenia pentagyna* Roxb. Fruits

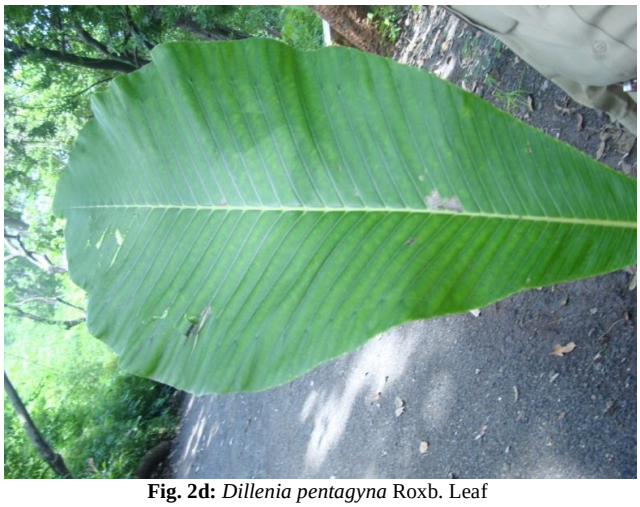

**Fig. 2d:** *Dillenia pentagyna* Roxb. Leaf

## OCCURRENCE AND DISTRIBUTION

*D. indica* and *D. pentagyna* are widely distributed in many Asian countries. *D. indica* distributed in valleys, streamsides, Bhutan, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam. In India, distributed in sub Himalayan tract, Assam, North Bengal, Bihar, Orissa, Madhya Pradesh, Gujarat (Khanum & Khan, 2007; Khare, 2007). *D. pentagyna* is distributed in rain forests, thickets, hills; below 400 m. Hainan, Yunnan in Bhutan, India, Indonesia, Malaysia, Myanmar, Nepal, Thailand, Vietnam. In India, distributed in Himalayan terrain, also from Punjab to Assam, South India, Andamans, Gujarat, Mizoram and West Bengal (Khanum & Khan, 2007; Khare, 2007).

## CHEMICAL CONSTITUENTS

From literature survey it is revealed that different parts of these plants contain many primary and secondary metabolites. *D. indica* and *D. pentagyna* are rich source of triterpenoids, flavonoids, tannins and various other phytoconstituents.

Stem bark of *D. indica* contains 10% tannin, dillenetin (Figure 3), betunaldehyde, betulinic acid (Figure 4), flavonoids like rhamnetin, dihydro-isorhamnetin, lupeol, myricetin, naringenin, quercetin derivatives and kaempferol glucoside (Shah, 1978; Khanum & Khan, 2007; Khare, 2007). The ethanol extract of stem bark afforded two flavonoids viz., kaempferol glucoside and quercetin derivative as well as a triterpenoids (Srivastava & Pande, 1981). Parvin *et al* reported methanolic extract of stem after partitioning with n-hexane yielded four compounds lupeol, betunaldehyde, betulinic acid and stigmasterol using column chromatographic separation (Parvin *et al.*, 2009).

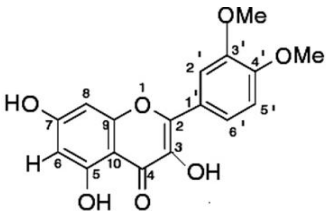


**Fig. 3:** Structure of Dillenetin (Quercetin-3',4'-dimethyl ether).

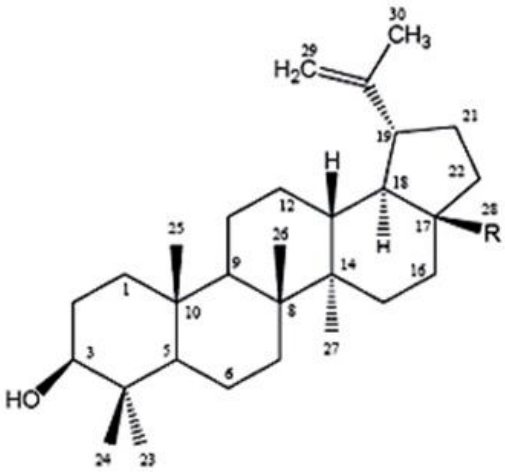


**Fig. 4:** Structure of Betulinic acid.

Apart from this it has been observed that leaves of twelve species of Dilleniaceae family contain betulin, betulinic acid, lupeol and β-sitosterol (Dan & Dan, 1980). Leaves of *D. indica* found to contain flavonoids, triterpenoids, steroids, tannins; its petroleum ether extract afforded cycloartenone, n-hentriacontanol, sitosterol, betulin; chloroform extract contains betulinic acid (Mukherjee, 1981). Methanolic extract of leaves after fractionation with n-hexane and chloroform also yielded compounds like betulinic acid, β-sitosterol, stigmasterol as well as dillenetin (Md. Muhit *et al.*, 2010). Further phytochemical studies has been performed on acid hydrolyzed extracts of dried leaves which

showed presence of kaempferol; while fresh leaves contain dihydrokaempferide and 7-glucosides of naringenin which get oxidized to ten corresponding flavonols (Bate-smith & Harborne, 1975). Kumar *et al* isolated and quantified betulinic acid using validated HPLC method from different fractions like methanol, ethyl acetate, n-butanol and water. Amongst which highest concentration was found in ethyl acetate fraction (97.9977.61 mg/g of fraction) (Kumar *et al.*, 2010).

Fruit of *D. indica* also contain about 34% of total phenolics in methanolic extract (Md. Abdille *et al.*, 2005) and polysaccharide like an arabinogalactan. Uppaalapati reported presence of fixed oil, colouring matter, sterols, glycosides, saponins, proteins, free amino acids, sugars, free acids and tannins in the seeds (Uppalapati & Rao, 1980).

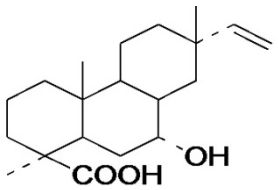


**Fig. 5:** Structure of Dipoloic acid.

Another species belonging to family Dilleniaceae, *D. pentagyna* reported to contain 6% of tannins, its stems are found to contain naringenin-41-O-b-D-xylopyranoside, flavonoid glycosides, naringenin 7-galactosyl glucoside and dihydroquercetin 5-galactoside along with rhamnetin-3-glucoside (Uppalapati & Rao, 1980), diterpene namely dipoloic acid (Figure 5) from the methanolic extract (Srivastava *et al.*, 1984), saponin namely alpha- L-rhamnopyranosyl-3-beta-hydroxyl-lup20(29)-en-28-oic acid (Tiwari *et al.*, 1980). Stem bark contains flavanoids like kaempferol, quercetin, isorhamnatin, naringenin-7 galactosyl (1-4) glucoside and rhamnetin-3-glucoside; terpenoids like lupeol, betunaldehyde, betulin, betulinic acid, mallic acid, β-sitosterol, stigmasterol; and phenolics (Khanum *et al.*, 2007; Khare, 2007).

From the above complied information it is concluded that betulin, betulinic acid and β-sitosterol is present in almost all parts of *D. indica* as well as *D. pentagyna.* Many research works has been done on the isolation, separation and quantification of the various phytoconstituents from different parts of *D. indica* but very few phytochemical investigations has been done from *D. pentagyna.*

## THERAPEUTIC IMPORTANCE AND USES

These plants are found to have very good therapeutic values in various different diseases. Different parts are used traditionally and pharmacologically to cure ailments and diseases. Traditionally, whole plant of *D. indica* used in case of fever, as an aphrodisiac and also promotes virility; decoction of it can be used as an universal antidote (Panda, 2009; Nadkarni *et al.*, 1954; Shah, 1978; Khanum, 2007).

Its roots as prophylactic in the cholera season, an ingredient of a medicine for burning sensation in the chest, root bark extract cures food poisoning; paste of root-bark along with leaf paste applied externally in sprains; young bark and leaf as an astringent; decoction of *D. pentagyna* is given in case of body pain twice daily till cure (Khanum, 2007).

Stem-bark of *D. indica* serve as component of medicine for sores caused by mercury poisoning, chronic progredient sores and carbuncle and as a prophylactic in the cholera season. Stem extract applied on and around the wound caused by spider bite helps to remove the poison. *D. pentagyna* bark powder is given with water for curing diabetes, also in diarrhea and dysentery. Sugar is mixed with bark powder and given to women for easy delivery and also applied externally to check infection. Bark paste is applied on head once a week for hair growth (Panda, 2009; Nadkarni *et al.*, 1954; Shah GL, 1978; Khanum A *et al.*, 2007; Janick J & Paull RS, 2008). 3 inches of stem bark of *D. pentagyna* is crushed with sufficient quantity of salt and the extract is administered orally daily once for three days in treatments of cut and burns (Khanum *et al.*, 2007).

Pradhan and Badola reported use of 118 medicinal plants species, belonging to 71 families and 108 genera found in Lepcha tribe of Dzongu valley, in North Sikkim, India. They have mentioned that leaves and fruit of *D. indica* are used for diseases like fever, constipation, dysentery and in treatment of stomachache (Pradhan & Badola, 2008).

Leave of *D. indica* are used as an astringent, antiamphetamine, while of *D.pentagyna* in case of cut and wounds. Different leaf preparations are used for treatments; like paste is applied on bone fracture, poultice is used in bleeding piles, decoction is used in skin disease and body pain; powder is given in treatment of breast cancer (Janick & Paull, 2008; Anisuzzaman *et al.*, 2007).

The fruits of *D. indica* are said to be relished by elephant and hence named as 'Elephant Apple'. The green fruit (unripe) is acidic, sour, bitter, pungent, astringent, removes bile, phlegm, fetid and flatulence, cardiotonic, but the ripe fruit is sweet, sour, appetizing, tasty; removes 'vata' and 'kapha'; dispels fatigue; stops abdominal pains (ayurveda), laxative, beneficial in colic associated with mucous, is apt to induce diarrhea if too freely indulged in (Nadkarni *et al.*, 1954; Khare, 2007). Fruit decoction used for curing dandruff and checking falling of hairs, eaten to combat weakness; as tonic. Ripe fruits are eaten fresh as well as cooked, which contains 0.9% total soluble solids; juice, mixed with sugar and water, serves as a cooling beverage in fever, fit, and as a cough syrup; ripe fruit-juice removes flatulence, increases quantity of semen, galactogogue, external application helps supuration of boil, thickened and fleshy calyx on fruits used as a flavoring agent, or made into jams and jellies (Rastogi *et al.*, 2000).

The seed of *D. indica* is covered by fleshy proteinacious aril which is used in curry, pickle and jelly preparations. Seed, seed oil and its unsaponifiable matter is having antimicrobial, antifungal and antibacterial property, respectively. It is widely used for garnish in indigenous ayurvedic medicine for

nervousness. Mucilage is applied on wounds of burns (Janick & Paull, 2008).

## PHARMACOLOGICAL IMPORTANCE OF DIFFERENT PARTS OF PLANTS

Pharmacologically, it has been reported that *D. indica* shows activities like antileukemic, anti-inflammatory, antioxidant, antiproliferative, antidiabetic, antimicrobial, antifungal, antidiarrheal, cytotoxic, hepatoprotective and many more.

Antileukemic activity of the fruits of *D. indica* using different human leukemic cell lines U937, HL60 and K562 has been performed by Vedasiromoni *et al*. Fractionation of methanolic extract has been done with different solvents like ethyl acetate, n-butanol and water. Ethyl acetate fraction showed lower $IC_{50}$ value compared to methanolic which was also compared with betulinic acid (Bate-smith & Harborne, 1975).

Saowakhon *et al* studied anti-proliferation activities of around 12 Thai Lanna medicinal plant recipes in cancer cell lines by SRB assay including *D. indica* which found more effective than doxorubicin compare to other medicinal plants. Anticancer potential of *D. indica* can be further explored for treatment (Saowakhon *et al.,* 2008).

Antidiabetic and hypolipidemic activities of bioactive fraction of *D. indica* methanolic extract (fractioned with ethyl acetate) was analysed in experimental diabetic Wistar rats. Type 1 and Type 2 diabetes was induced using streptozotocin and nicotinamide as a standard (Intraperitoneally) and treated by giving fraction orally. Blood glucose, serum cholesterol and triglycerides levels whereas HDL-C level was found to be increased ($P<0.05$) as compared with the diabetic control group (Kumar *et al*., 2011c). Kumar *et al* also performed antidiabetic, hypolipidemic histopathological analysis using methanolic extract of *D. indica* leaves in alloxan induced diabetic rat by administering oral doses. *D. indica* possess good antidiabetic property as well as improved body weight, liver profile, renal profile and total lipid levels. Methanol extract has favorable effect to inhibit the histopathological changes of the pancreas and kidney in alloxan induced diabetes (Kumar *et al.,* 2011a). Seeds of *D. indica* were taken to evaluate the hepatoprotective effect and safety evaluation of hexane extract against $CCl_4$ induced toxicity and its safety evaluation in wistar albino rats, The levels of AST, ALT, ALP, bilirubin, urea and creatinine levels were significantly increased but protein content was significantly decreased in $CCl_4$ induced liver damage rats. DNA damage of rat WBC caused by $CCl_4$ injection was considerably counteracted by treatment with the extract. The seed extract produced significant hepatoprotective effect by decreasing the activity of serum enzymes, bilirubin, urea, creatinine and lipid peroxidation and significantly increased the level of SOD, CAT, GPx, GR, GST, GSH, Vitamin C and E and protein (Reddy *et al.,* 2010).

Fruits of these plants are also analyzed for different pharmacological potential. The powder of fruits was extracted with ethyl acetate, methanol and water. The total phenolic content of the extracts was determined in different prepared extracts. Antioxidant capacity of the extracts was checked equivalent to ascorbic acid (μmol/g of the extract). Results obtained in order like methanol extract > ethyl acetate extract > water extract which also showed same result using β-carotene-linoleate model system, and DPPH (Md. Abdille *et al.,* 2010). Different extraction procedures were applied like sonication, soxhlet, and high-pressure extraction for preparation of extracts using leaves of *D. indica* and checked for antioxidant activity amongst which maximum activity was observed in extract prepared by sonication using carotene-bleaching assay. High pressure extraction method with circulation produced extracts that have total phenolic content higher than sonication and soxhlet extraction method (Arbianti *et al.,* 2007). Utami *et al* studied about the antioxidant effect by increasing solvent pressure, extraction time, extraction temperature, and solvent flow rate by high pressure extraction. They have also checked content of total phenolics at different condition which could affect the measurement of antioxidant activity (Utami *et al.,* 2007). Bark of *D. indica* also found to contain around 54% of total phenolics which was analyzed for antioxidant capacity by phosphomolybdenum method, radical scavenging activity using α, α-diphenyl-β- picrylhydrazyl method, hydroxyl radical (•OH) scavenging activity by deoxyribose method, and superoxide anion ($O2•-$) scavenging activity by phenazine methosulphate/NADHnitroblue tetrazolium system. Antioxidant capacity of the extract was found to be 3.12 mmoles/g as equivalent to ascorbic acid at 50 ppm concentration. At 25 ppm concentration, the radical scavenging activity of butylated hydroxyanisole and extract showed 90.9% and 91.0%, respectively. The •OH scavenging activity of the extract was shown to be 53.9% at 100 ppm concentration. At a concentration of 50 μg, the $O_2•-$ scavenging activity of the extract was 31.7% as compared to 47.7% by gallic acid (Deepa & Jena, 2011).

Parvin *et al* used non-polar fractionation from methanol extract to check different antimicrobial activity, cytotoxicity and antioxidant activity. The extractives were also subjected to brine shrimp lethality bioassay. In the study, the crude methanolic extract and dichloromethane soluble fractions were found to be highly toxic to brine shrimp nauplii, with $LC_{50}$ of 8.92 μg/ml and 2.38 μg/ml, respectively. The crude methanol extract and its *n*-hexane, carbon tetrachloride and chloroform soluble fractions were screened against 13 test bacteria amongst which chloroform extract showed very weak activity. Antioxidant screening of the crude methanolic extract showed very strong free radical scavenging activity with $IC_{50}$ value of 4.58 μg/ml while other showed moderate (Parvin *et al.,* 2009).

Antimicrobial activity of fixed oil and unsaponifiable matter of *D. indica* was checked. It was reported that fixed oil does not exhibit any activity against most of test bacteria except Vibrio cholerae and mild antifungal activity, while unsaponifiable matter showed good activity. Acetone and alcoholic extracts of seeds of *D. indica* showed good antimicrobial activity while chloroform extract found to have mild activity (Uppalapati & Rao, 1980). The methanolic extract along with some organic soluble fractions of

the bark of *D. indica* were tested against four gram-positive and seven gram-negative bacteria and against three pathogenic fungi. n-Hexane and dichloromethane fractions showed remarkable activities against all the tested bacteria in which n-hexane fraction showed highest activity against *Shigella dysenteriae* (Alam *et al.*, 2010). Gogoi *et al* made efforts to characterize a bioactive molecule synthesized by endophyte Hypocrea spp. NSF-08; analyzed the impact and subsequent optimization of submerged culture conditions to facilitate improved production of the antimicrobial agent. The effect of various culture conditions, supplementary carbon, nitrogen sources and amino acid amendment on growth and antimicrobial agent production by the fungus was determined. The enhanced production of bioactive metabolite by the fungus has been observed by making amendments in various conditions (Gogoi *et al.*, 2008).

The anti-inflammatory activities of the methanol extract of *D. indica* leaves were observed in various experimental models. In case of carrageenan-induced paw edema doses of 200 and 400 mg/kg of the extract significantly inhibited the percent increase in reaction time while acetic acid induced capillary permeability. All doses of extract and Indomethacin at a dose of 20 mg/kg showed a significant decrease in dye leaking in the peritoneal fluid. The methanolic extract of *D. indica* at 200 and 400 mg/kg showed a significant anti-inflammatory activity and the possible mechanism might be inhibition of mediator release and PG biosynthesis (Yeshwante *et al.*, 2009). A glycolic extract of *D. indica* prepared from the mature fruits of the plant showed significant wound healing activity alone or in combination with microcurrent stimulation to skin wounds surgically induced on the back of Wistar rats. It is mentioned that the result probably due to the efficacy of microcurrent application since the extract alone did not significantly accelerate the healing process. *D. indica* fruit extract is most likely participates in the wound healing process as a result of its anti-inflammatory properties (Domenico *et al.*, 2011).

Yeshwante *et al* checked for the anti-diarrheal activity of the methanolic extract of *D. indica* leaves using castor oil induced diarrhea model and concluded that the inhibition of the diarrhea and prolongation of onset might be due to inhibition of inflammatory mediator release and phytoconstituents such as flavonoids and tannins may have also contributed to the anti-diarrheal activity (Yeshwante et al, 2009). Hydroethanolic extract of leaves of *D. indica* used to check for anxiolytic activity in various models of experimentally induced mice and showed significant result at dose of more than 200 mg/kg against Diazepam as a standard (Lahkar *et al.*, 2011).

Pantoprazole loaded microbeads were prepared by ionotropic gelation technique using sodium alginate and natural mucoadhesive substance from the fruit of *D. indica* followed by a coating with Eudragit L100-55 (Sharma *et al.*, 2010).

Few research works has been performed on different parts of *D. pentagyna*. Rosangkima *et al* taken total five plants for its antitumour activity against murine ascites Dalton's lymphoma (DL) in vivo amongst which methanolic extract of stem bark *D. pentagyna* showed remarkable activity (Rosangkima & Prasad, 2004). Extract showed maximum survivability of Dalton's lymphoma-bearing mice at dose of 20 mg/ml. It is also showed that treatment with the extract also showed decrease in sialic acid content in DL cells as well as decrease in degree of DL cell agglutination with concanavalin A and wheat germ agglutinin (Rosangkima *et al.*, 2008). The another report is to measure level of glutathione and glutathione-related enzyme activities in host tissue which can found to have important contributing factor in *D. pentagyna* mediated antitumour activity in Dalton's lymphoma bearing mice, decrease in level was observed (Rosangkima *et al.*, 2008). The antibacterial and antifungal activity of the crude extracts as well as for the isolated pure compounds has been checked using fifteen bacterial strains, which included seven gram-positive and eight gram-negative organisms, and nine fungi. Studies on the antifungal activities showed that ethyl acetate extract and Grisofulvin have shown promising zone of inhibition against the fungi except *Candida albicans* and *Candida krusei*. Methanol extract showed no activity while ethyl acetate extract also exhibited toxicity towards brine shrimp (Md. Haque *et al.*, 2008). In addition to therapeutic and pharmacological uses, these plants are also found to have few non-medicinal uses like green leaves used as feed for tusser silkworms, leaves of *D. pentagyna* as a green manure, dried leaves as substitute to sandpaper. Wood and timber has been used for house-posts, planks and rafters for internal work; also for preparing tool-handles, boats, cupboards and paneling. Bark yields fiber used for cordage. A Cot or bed is made from wood for sleeping to ward off the evil spirit and to know forth coming events (Dubey *et al*., 2009).

The tribal communities of Vindhya region, Madhya Pradesh, India worship tree of *D. pentagyna* on 'Dipalvali' festival day thinking it as Goddess Luxmi. A statue or picture of God or Goddess is placed on stool or stand prepared from its wood.

## CONCLUSION

The extensive literature survey as well as reports on research revealed that *Dillenia indica* and *Dillenia pentagyna* are highly regarded to have good potential in the herbal medicine. Detailed pharmacognostical description will give an overview about the identification of these plants in the different forest regions throughout India, but microscopical investigation is yet remaining to be carried out for *D. pentagyna*. Betulin and betulinic acid are the major constituents found to be present in almost all the parts of these plants which can serve good potential in curing various ailments and diseases. Fruits of *D. indica* eaten row by tribal communities having good nutritional value, thus juice is taken as an energy drink.

Different prepared extracts of these plants and their parts has been reported to contain phytoconstituents like flavonoids, steroids, triterpenoids, phenolics, saponins, fixed oil which may be responsible for good pharmacological activities performed on animal models. From available reports it has been observed that different parts of *D. indica* have curing properties like wound healing, diabetes, bone fracture, in cut and burns, abdominal pains

and many more but scientific evidence of these reports is yet not much developed. Few pharmacological investigations has been done using different parts like leaves are having various activities like antioxidant, cytotoxic, antimicrobial, antidiarrheal and anxiolytic. Others parts like seeds are hepatoprotective and antimicrobial, fruit used as antileukemic.

Bark of *D. pentagyna* is having good antitumour potential against Dalton's lymphoma. Other parts are also having good therapeutic potential; therefore large-scale, controlled pharmacological study is needed to validate these results. Secondly, there is still little evidence for quantification of different active phytoconstituents which may be responsible to have good pharmacological activity. It is evident from the available reports and literatures that these two plants belonging to family Dilleniaceae possesses adequate therapeutic potential and could be explored further for chemical and pharmacological investigations. Additionally, employing new modern techniques, which are more economical for better extraction of the required active phytochemicals needs to be applied. *D. indica* and *D. pentagyna* is available only in forest regions and rarely cultivated but found to have good therapeutic potential so further evaluation needs to be carried out on these plants in order to explore the concealed areas and their practical pharmacological as well as clinical applications, which can be used for the welfare of the mankind.

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## REFERENCES

Alam B, Hossain S, Haque E. Evaluation of antimicrobial and toxicity of different fractions of *Dillenia indica* linn. bark extract. *Journal of Global Pharma Technology* 2010; 2, 11:37-42.

Anisuzzaman M, Rahman AHMM, Harun-Or-Rashid M, Naderuzzaman ATM, Islam AKMR. An Ethnobotanical Study of Madhupur, Tangail. *J of Appl Scie Res* 2007; 3, 7:519-30.

Arbianti R, Utami TS, Kurmana A, Sinaga A. Comparison of antioxidant activity and total phenolic content of *Dillenia indica* leaves extracts obtained using various techniques. *Proceedings of 14th Regional Symposium on Chemical Engineering, Yogyakarta, Indonesia* 2007.

Bate-smith EC, Harborne JB. Differences in flavonoids content between fresh and herbarium leaf tissue in *Dillenia*. *Phytochemistry* 1975; 10, 5:1055-8.

Dan S. and Dan SS. Triterpenoids of Indian Dilleniaceae, *J Chem Soc* 1980; 57:760.

Deepa N, Jena BS. Antioxidant Fraction from Bark of *Dillenia indica*. *International Journal of Food Properties* 2011; 14:1152-9.

Dickison WC. A note on the wood anatomy of *Dillenia* (Dilleniaceae), *IAWA bulletin* 1979; 2-3.

Domenico LD, Emch KJ, Landsman AR. Effect of Glycolic Extract of *Dillenia indica* L. Combined with microcurrent stimulation on experimental lesions in wistar rats. *Wounds* 2011; 23, 5:111-20.

Dubey PC, Sikarwar RLS, Khanna KK, Tiwari AP. Ethnobotany of *Dillenia pentagyna* Roxb. in Vindhya region of Madhya Pradesh, India. *Nat Prod Rad* 2009; 8, 5:546-8.

Gogoi DK, Mazumder S, Saikia R, Bora TC. Impact of submerged culture conditions on growth and bioactive metabolite produced by endophyte Hypocrea spp. NSF-08 isolated from *Dillenia indica* Linn. in North-East India. *Journal of Medical Mycology* 2008; 18:1-9

http://www.bsienvis.nic.in/medi.htm#*Dillenia indica*.

Janick J, Paull RE. 2008. The encyclopedia of fruit and nuts. 1st ed. London.

Jawla S, Gupta AK, Singla R, Gupta V. General awareness and relative popularity of allopathic, ayurvedic and homeopathic systems. *J Chem Pharm Res* 2009; 1, 1:105-12.

Kerrigan RA, Craven LA, Dunlop CR. Dilleniaceae, *Flora of the Darwin Region* 2011; 1-6.

Khanum A, Khan I, Ali A. *Ethnomedicine and Human Welfare*, Ukaaz Publications 2007; 4:52.

Khare CP. 2007. Indian Medicinal Plants. Springer. New York.

Kirtikar KR, Basu BD. 1984. Indian Medicinal Plants. Springer. New York.

Kirtikar KR, Basu BD. 1999. Indian Medicinal Plants. Springer. New York.

Kumar D, Mallick S, Vedasiromoni JR, Pal BC. Anti-leukemic activity of *Dillenia indica* L. fruit extract and quantification of betulinic acid by HPLC. *Phytomedicine* 2010; 17:431–5.

Kumar S, Kumar V, Prakash O. Antidiabetic and hypolipidemic activities of *Dillenia indica* extract in diabetic rats. *Journal of Chinese integrative medicine* 2011c; 9, 5:570-4.

Kumar S, Kumar V, Prakash O. Antidiabetic, hypolipidemic and histopathological analysis of *Dillenia indica* (L.) leaves extract on alloxan induced diabetic rats. *Asian Pacific journal of tropical medicine* 2011a; 4, 5:347-52.

Kumar S, Kumar V, Prakash O. Microscopical evaluation and physiochemical analysis of *Dillenia indica* leaf. *Asian Pacific Journal of Tropical Biomedicine*. 2011b; 337-40.

Lahkar M, Thakuria B, Pathak P. A study of the anxiolytic-like activity of *Dillenia indica* Linn. leaves in experimental models of anxiety in mice. *Internet J Pharmacol* 2011; 9, 2.

Md. Abdille H, Singh RP, Jayaprakasha GK, Jena BS. Antioxidant activity of the extracts from *Dillenia indica* fruits. *Food Chemistry* 2005; 90, 4:891-6.

Md. Abdille H, Singh RP, Jayaprakasha GK, Jena BS. Antioxidant activity of the extracts from *Dillenia indica* fruits. *Food Chemistry* 2010; 90:891–6.

Md. Haque E, Md. Islam N, Hossain M, Mohamad AU, Md. Karim F, Md. Rahman A. Antimicrobial and Cytotoxic Activities of *Dillenia pentagyna, Dhaka Univ. J. Pharm. Sci.* 2008; 7, 1:103-5.

Md. Muhit A, Tareq SM, Apu AS, Basak D, Islam MS. Isolation and Identification of compounds from the leaf extract of *Dillenia indica* Linn. *Bangladesh Pharm J*. 2010; 13, 1:49-53.

Metcalfe CR, Chalk C. 1983. Anatomy of the Dicotyledons. Clarendon Press. Oxford. London.

Mukherjee KS, Badruddoza S. Chemical constituents of *Dillenia indica* Linn. and *Vitex negundo* Linn. *J Indian Chem Soc* 1981; 58:97–98.

Nadkarni KM, Nadkarni AK. 1954. *Dillenia indica* Linn. and *Dillenia pentagyna*, The Indian Materia Medica. 448-9. Bombay.

Parvin N, Md. Rahman S, Md. Islam S, Md. Rashid A. Chemical and biological investigations of *Dillenia indica* Linn. *Bangladesh J Pharmacol* 2009; 4:122-5

Pradhan BK, Badola HK. Ethnomedicinal plant use by Lepcha tribe of Dzongu valley, bordering Khangchendzonga Biosphere Reserve, in North Sikkim, India. *J Ethnobio and Ethnomed*, 2008; 4:22.

Rastogi RP, Mehrotra BN, Sinha S, Seth R. 2001. Compendium of Indian Medicinal Plants. CDRI, Lucknow.

Reddy KH, Tharanath V, Nagi Reddy KB, Sharma PVGK, Reddy OVS. Studies on hepatoprotective effect of hexane extract of *Dillenia indica* against $CCl_4$ induced toxicity and its safety evaluation in wistar albino rats. *Res J Pharm Biol Che Sci* 2010; 1, 3:441-50.

Rosangkima G, Prasad SB. Antitumor activity of some plants from Meghalaya and Mizoram against murine ascites Dalton's lymphoma. *Indian J Exp Biol* 2004; 42:981-8.

Rosangkima G, Rongpi T, Prasad SB. Effect of *Dillenia pentagyna* extract on sialic acid content and agglutinability of normal and

tumor cells with concanavalin A and wheat germ agglutinin. *International Journal of Zoological Research* 2008; 4, 4:203-13.

Rosangkima G, Rongpi T, Prasad SP. Role of Glutathione and Glutathione related Enzymes in the antitumour activity of *Dillenia pentagyna* in Dalton's lymphoma-bearing Mice. *Indian Journal of Cancer Research* 2008; 4, 3:92-102.

Saowakhon S, Manosroi J, Manosroi A. Anti-proliferation activities of Thai Lanna medicinal plant recipes in cancer cell lines by SRB assay. *Journal of Thai Traditional & Alternative Medicine* 2008; 6, 2: Supplement.

Shah GL. 1978. *Dillenia indica* and *Dillenia pentagyna*. Flora of Gujarat. 49 & 214.

Sharma H, Pradhan SP, Sarangi B. Preparation and in vitro evaluation of Enteric Controlled release Pantoprazole loaded microbeads using natural mucoadhesive substance from *Dillenia indica* L. *Int J Pharm Tech Res* 2010; 2, 1:542-51.

Sharma UM, Pegu S. Ethnobotany of religious and supernatural beliefs of the Mising tribes of Assam with special reference to the 'Dobur Uie'. *J Ethnobio and Ethnomed* 2011; 7: 16.

Shome U, Khanna RK, Sharma HP. Pharmacognostic studies on *Dillenia indica* Linn: II-Fruit and Seed. *Proc. Indian Acad Sci (Plant Sci)* 1980; 89: 91-104.

Shome U, Khanna RK, Sharma HP. Pharmacognostic studies on *Dillenia indica* Linn. I. leaf. *Proc. Indian Acad Sci (Plant Sci)* 1979; 88: 35-48.

Srivastava BK, Pande CS. Chemical examination of bark of *Dillenia indica*, *Acta cienc. Indica* 1981; 7(1-4), 170-4.

Srivastava SD. Flavonoids from the stem of *Dillenia pentagyna*. *Phytochemistry* 1981; 20, 10:2445.

Srivastava SK, Srivastava SD. A new diterpene, Dipoloic acid from the stem of *Dillenia pentagyna*. *Current science* 1984; 53, 12:646-7.

Tiwari KP, Srivastava SD, Srivastava SK. Alpha- L-rhamnopyranosyl-3 beta- hydroxyl-lup20(29)-en-28-oic acid from stem of *Dillenia pentagyna*. *Phytochemistry* 1980; 19, 5:980-1.

Uppalapati L, Rao JT. Antimicrobial efficiency of fixed oil and unsaponifiable matter of *Dillenia indica* Linn. *Indian Drugs Pharm Ind* 1980; 15, 3:35-38.

Utami TS, Arbianti R, Kurmana A, Sinaga A. 2007. Operating condition effect on high-pressure extraction to antioxidant activity of *Dillenia indica* leaves extract, Proceedings of 14th regional symposium on chemical engineering, Yogyakarta, Indonesia.

Yeshwante SB, Juvekar AR, Nagmoti DM, Wankhede SS, Shah AS, Pimprikar RB, Saindane DS. Anti-inflammatory activity of methanolic extracts of *Dillenia indica* L. leaves. *Pharmacology* 2009; 1, 1:63-66.

Yeshwante SB, Juvekar AR, Pimprikar RB, Kakade RT, Tabrej M, Kale MK and Firke SD. Anti-Diarrheal Activity of Methanolic and Aqueous Extracts of *Dillenia indica* L. Research Journal of Pharmacology and Pharmacodynamics, 2009; 1, 3:140-2.

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