Research Article

Barringtonia acutangula: Ethnobotanical and Phytopharmacological Review

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ABSTRACT

Barringtonia acutangula is small or medium-sized tree distributed in tropical Africa, Asia, Australia and Polynesia. It is commonly known as 'Hinjolo' in Oriya belonging to the family Barringtoniaceae/Lecythidacea. It is used in several traditional medicine systems to cure various diseases. This plant has been known to possess antidiabetic, antioxidant, anticonvulsant, anti-inflammatory, cytotoxicity, anti-arthritis, antimicrobial, antibacterial, hepatoprotective, hypolipidemic, anthelmintic, CNS depressant, antiepileptic activity. A wide range of active chemical compound including triterpenoids, triterpenoid sapogenins, barringtogenol D, barringtogenol B, barringtogenol C, triterpene saponins have been isolated from various morphological parts. The current study describes pharmacognostical, physiochemical, phytochemical and biological activity of *Barringtonia acutangula.*

Keywords: *Barringtonia acutangula,* pharmacognostic, phytochemical, pharmacological.

INTRODUCTION

Ethno botanical studies deal with the study of traditional system of medicines. People have used herbs and organic materials as food, medicine since ancient times. The natural bioactive substances from these sources are used for treatment of various ailments. As the natural products are easily available to human beings, they are explored to the maximum therapeutic effectiveness. Various morphological parts of the plant are used for their medicinal value.[1] Herbal medicines are considered as more convenient than synthetic drugs due to their less or no side effects. Fresh and dried plant materials are used for the preparation of herbal formulations. So the detail information regarding their phytoconstituents and uses are very much important in the preparation, safety and efficacy of the herbal medicines.[2]

Herbal drugs play an important role in traditional systems of medicines. Plant parts serve as sources of various new therapeutic bioactive substances. In current times, it has been marked that people are shifting towards herbal drugs due to the cumulative and irreversible reactions of synthetic drugs.[3] In the present study the detail information of plant *Barringtonia acutangula* are given. *Barringtonia acutangula* belonging to family Barringtoniaceae is traditionally used in treatment of diarrhoea and dysentery, fish poison,[4] febrifuge, antipyretic, emetic,[5] anthelmintic, syphilis, wound and ulcer.[6]

Scientific classification

The scientific classification of *Barringtonia acutangula* is demonstrated as follows.[7]

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Ericales

Family: Lecythidacea/Barringtoniaceae.

Genus: *Barringtonia*

Species: acutangula

Synonyms[4,7,8]

Eugenia acutangula

Barringtonia spicata

Stravadium acutangulum

Stravadium obtusangulum

Barringtonia rubra

Butonica acutangula

Caryophyllus acutangulus

Eugenia acutangula

Huttum acutangulum

Michelia acutangula

Stravadium acutangulum

Vernacular names

The vernacular names of *Barringtonia acutangula* is described as follows.[5]

Oriya-Hinjolo

Sans-Samudraphala, Hijjala, Vidula.

Beng-Hijal, kumia

Hind-Hijjal

Eng-Indian Oak

Tam-Adampa, kadappai

Tel-Kadapa, kanapachettu

Guj-Samudraphala

Kan-Nerruganegalu, Holegonvamara

Mal-Manjal kadamba

Assam-Hindole

Distribution

It is a middle sized evergreen tree,[4] distributed in tropical Africa, Asia, Australia and Polynesia.[5] It is mostly found common in Meghalaya, Assam, West Bengal, Bihar, Orissa, Madhya Pradesh and Deccan peninsula, Bangladesh, Myanmar and Sri Lanka.[8]

Description

Macroscopical character

The bark *Barringtonia acutangula* is thick and dark greying colour. Furrows are appeared on old trees. Leaves are crowded at the ends of the branches. Flowers are red & fragrant. Hypanthium acutely 4-angled, obpyramidal; calyx lobes 2.5 mm, denticulate. Petals cadulous, 5mm. Stamens bright red.[9] Fruits are broadest in the middle, slightly narrowed towards and truncate at each end, crowned by the small persistent calyx.[6] (Table 1)

Table 1: Macroscopical character of *Barringtonia acutangula*[6,9]

Parts	Parameter	Description
Leaves	Shape	Obovate or oblanceolate
	Length and width	7-13 x 4-10 cm
	Apex	Rounded or subacute, glabrous
	Base	Narrowed
	Margin	Crenate-serrate
Petiole	Length	5-15 mm
Flowers	Length	1-1.2 cm
Petals		Cadulous
	Length	5mm
Fruit	Length and width	3.2-3.8 x 1.3-2 cm
Flowers	Length	1-1.2 cm

Ethnobotanical information

Barringtonia acutangula possesses various medicinal uses and chemical constituents which are given in Table 2.

Table 2: Ethnobotanical uses and chemical constituents of *Barringtonia acutangula*

Parts	Chemical constituents	Uses
Leaves[4,8,10]	Steroids, terpenoids, flavonoids, tannins, phenolics and saponins, acutangulic acid, barringtogenic acid, oleanolic acid, tangulic acid, β-amyrin, β-sitosterol, stigmasterol and stigmasterol glucoside	Tonic and possess properties similar to cinchona, diarrhoea and dysentery
Heart wood[5]	Triterpenoid named tanginol, barringtogenic acid, β- and γ-sitosterols, a triterpene dicarboxylic acid, barringtonic acids, triterpenoid sapogenol, barringtogenol E, a monoarabinoside of barringtogenol C monobenzoate, triterpene diacid, barrinic acid.	
Branch wood[8,5]	Barringtogenol E, barrinic acid.	Haemostatic in metrorrhagia.
Fruit[4,5,6]	Three triterpenoid sapogenins i.e barringtogenol B, C and D, triterpene acid sapogenin, barrigenic acids	Anthelmintic, diseases of the blood, bronchitis, sore eyes, headache, hallucinations; cures 'tridosha', abdominal colic, jumbar pain, syphilis, nasal catarrh, wound, ulcer, leprosy, cough, Dysmenorrhoea
Seed[4,5,8,10]	Barringtogenin and barringtogentin, Three monodesmosidie glucuronide saponins of barringtogenol C, named as barringtosides A, B and C.	Liver troubles, expectorant and emetic, fish poison, aromatic, carminative, emetic.
Bark[5]	Tannin (16%), small amounts of sapogenin.	Diarrhoea and blennorrhoea, febrifuge, to relieve pain from bites and stings of insects, fish poison.
Flower[10]	Shikimic and gallic acids.	
Stem[4]		Antiprotozoal.
Root[4]		Antipyretic, stimulant, an emetic, catarrh, intermittent fever and constipation.

Microscopic characters

Preliminary microscopical characters of *Barringtonia acutangula* leaves and bark are given in Table 3.

Table 3: Microscopical study of leaf and bark of *Barringtonia acutangula*

Parts	Microscopic parameter	Description		Analytical method
Leaves[11]	Transverse section of the leaf	Dorsiventral nature		HPTLC
	Lamina	Three distinct regions *viz*., adaxial epidermis, abaxial epidermis, and mesophyll.		
		Adaxial epidermis	Single layered with squarish cells covered by a distinct cuticle	
		Abaxial epidermis	Single layered with rectangular cells having prominent peg like outgrowths	
		Mesophyll	Differentiated into palisade and spongy parenchyma. palisade parenchyma has two layers of narrow, cylindrical, and compact cells, spongy parenchyma consists of about 12 layers of small, lobed, loosely arranged cells with wide air-chambers.	
	Midrib	Prominent adaxial hump and wide semicircular abaxial part		
		Epidermal layer	Thin, comprising of small thick walled squarish cells with outer papillate walls.	
		Ground tissue	Parenchymatous and homocellular. A wide mass of thick walled cells are located in the centre of the adaxial hump.	
		Vascular bundles	Xylem elements are thick walled circular and it occurs in parallel radial rows with small sclerenchyma cells in between the rows and phloem occurs in thin sheath around the xylem, two circular lateral bundles and a row of six small circular vascular strands.	
		Calcium oxalate crystals	Found in the vascular strands, veins of leaf, ground tissue of midrib and petiole as well as in phloem parenchyma.	
	Petiole	Circular with slightly flat adaxial side.		
		Epidermal layer	Consist of narrowly rectangular thick walled cells and some of them have peg like outgrowths on the tangential walls.	
		Ground tissue	Thick walled, angular, compact parenchymatous cells.	
		Vascular bundle	Vascular system is complex, multi-stranded consisting of larger deeply curved main vascular bundle, two circular lateral bundles and eleven small vascular strands arranged in arcs. The main vascular bundle consists of several parallel rows of vessel multiples alternating with narrow intervening sclerenchyma cells. Phloem occurs in thick band all along the outer part of the xylem arc.	
	Powder characteristics	Trichomes, Starch grains, Fibers of petiole (660-750 µm long 20-25 µm wide), Fibers of the lamina (550- 650 µm long, 15-20 µm wide.)		
	Vein-islet number	8-11/sq.mm.		
	Vein-islet termination number	13-27/sq.mm.		
	Palisade ratio	5-10.		
	Stomata index	Adaxial-3% Abaxial-9%		
	Ash values	Total ash-6 %w/w Acid insoluble ash-0.032% w/w Water soluble ash-3.92% w/w Sulphated ash-7.48%w/w		

	Extractive values	Water soluble extractive value-26.395w/w Ethanol soluble extractive value-36.89%w/w Non volatile ether soluble extractive value-5.40%w/w		
Bark[12]	Transverse section of bark	Cork region	The cork cells were of two types- outer region of thick walled (24-31 x10-17Am, lumen: 8-15Am) and inner thin walled cells (24-31 x 10-17Am), both rectangular in shape. In between the thin walled cork cells, were tangential rows of rectangular sclereids (10-31 x 10-17Am).	
		Bast	Bast was composed of square, oval or spherical shaped parenchyma cells (24-58 x 14-51Am) and tangential patches of gelatinous fibres (10-17 x 13-34Am, lumen: 10-32Am).	
	Powder study of bark	Cork cells, sclereids, sphaeraphides, gelatinous fibres.		

Phytochemical Study

Various parts of *Barringtonia acutangula* plant have yielded different phytoconstituents on their extraction and isolation is given in (Table 4).

Table 4: Phytochemical study of *Barringtonia acutangula*

S. No	Parts	Name of chemical constituents	
1	Fruits[13,14,15,16,40]	New triterpenoid sapogenins	
		Barringtogenol D	3β:22β:28-trihydroxy-16α:21 α-oxido-olean-12-ene
		Barringtogenol B, a new triterpenoid sapogenin	3β, 21β, 22α, 28-tetrahydroxy-16α-angeloyloxy-olean-12-ene
		New triterpene acid (barrigenic acid)	2α,3β,19β-trihydroxyolean-12-en-23,28-dioic acid
2	Wood[17]	Hexahydroxy triterpene(tanginol), β- and γ-sistosterols, barringtogenic acid, triterpene carboxylic acid	Tanginol-3β,6β,7β,16β,23,28-hexahydroxy olean-Δ^{12}-ene.
3	Seeds[18]	Three monodesmosidic glucuronide saponins of barringtogenol C(barringtosides A, B and C)	Barringtoside A, 3-O-beta-D-xylopyranosyl(1-->3)-[beta-D-galactopyranosyl(1-->2)]-beta-D-glucuronopyranosyl barringtogenol C; barringtoside B, 3-O-beta-D-xylopyranosyl(1-->3)-]beta-D galactopyranosyl(1-->2)]-beta-D-glucuronopyranosyl-21-O-tigloyl-28-O-isobutyryl barringtogenol C;barringtoside C,3-O-alpha-L-arabinopyranosyl(1-->3)-[beta-D-galactopyranosyl(1-->2)]-beta-D - glucuronopyranosyl barringtogenol C.
4	Bark[19,20]	Nine triterpene saponins, acutangulosides A-F (2-7), and acutanguloside D-F methyl esters (5a-7a) and a single triterpene aglycone (1)	
		Compound 1 , Compound 2, Compound 3	(þ)-epigallocatechin, (þ)-gallocatechin 40-O-methyl ether, (þ)-gallocatechin 40-O-methyl ether 5-O-b-D-glucopyranoside
5	Stem barks[21]	Compound BA-1 , Compound BA-2	betulin 3-caffeate, amyrin

Pharmacological Study

Various pharmacological studies have been carried out on different parts of *Barringtonia acutangula* which are given below.

Antidiabetic activity

Nilesh evaluated antidiabetic activity of aqueous ethanolic extract of roots of *Barringtonia acutangula* (EBA) at 250 and 500 mg/kgb.w/p.o on streptozotocin induced diabetes rat. The aqueous EBA extract reduced blood glucose levels significantly at two doses, but aqueous EBA extract at 500 mg/kg and standard glibenclamide at 0.5 mg/kg orally showed significant ($p<0.01$) reduction in blood glucose level in STZ-induced diabetic rat.[22]

Khatib evaluated the hypoglycemic activity of aqueous, methanol and chloroform extract of fruit of *Barringtonia acutangula* (BA) in streptozotocin (STZ) 50mg /kg induced hyperglycemic Wistar rats. It was observed that aqueous extract at 400 mg/kg showed significant ($P<0.001$) decrease in fasting blood glucose levels (BGL) both in acute and chronic study in STZ induced hyperglycemic rats as compared to the standard drug glibenclamide (0.9 mg/kg).[23]

Palanivel investigated the antidiabetic activity of ethanolic leaf extract of *Barringtonia acutangula (L.Gaertn)* in normal and alloxan (150mg/kg bw) induced diabetic rats at dose of 250 and 500 mg/kg bw/da. It was found that ethanolic extract at dose (250 and 500 mg/kg bw/day) showed significantly decreased 40-50% of the elevated blood glucose level, cholesterol, triglycerides, urea, creatinine, billirubin comparison to untreated diabetic Wister strain albino rats.[24]

Marslin evaluated the anti-diabetic activity of the ethanol and aqueous extracts of leaf of *Barringtonia acutangula* at dose of 250 mg/kg and 500 mg/kg in a streptozotocin (STZ 60 mg/kg.) induced diabetes animal model.

The extract significantly reduced blood glucose level, serum total cholesterol and triglyceride levels in treated animal.[25]

Antioxidant activity

Babre evaluated free radical scavenging activity and antioxidant property of the hydroalcoholic extract of *Barringtonia acutangula* Linn root (EBA) by reduced glutathione (GSH), catalase, superoxide dismutase (SOD) and lipid peroxidation (malondialdehyde).

All the *in vitro* models showed dose dependent antioxidant activity.[26]

Kathirvel evaluated antioxidant activity of methanolic extract leaf of *Barringtonia acutangula.* Methanol extract showed significant DPPH - radical scavenging and reducing power activity as compared to chloroform and petroleum ether extracts.[27]

Sandhyarani evaluated antioxidant activity of ethanol extract (250 mg/kg, 500 mg/kg) of *Barringtonia acutangula* root in rat brain after induction of epilepsy by Maximal Electroshock. It was observed that ethanolic extract significantly reduced superoxide dismutase, catalase and lipid peroxidation.[28]

Sandhyarani investigated antioxidant activity of ethanol extract of flower *Barringtonia acutangula* L. by DPPH scavenging and reducing power method. It was found that ethanol extract of flower *Barringtonia acutangula* L showed significant anti-oxidant activity.[29]

Sandhyarani evaluated antioxidant activity of ethanol extract of *Barringtonia acutangula* (EBA) leaves in rat brain after induction of epilepsy by PTZ (Pentylenetetrazole). Ethanolic extract significantly reduced superoxide dismutase, glutathione peroxidase, glutathione reductase, catalase and lipid peroxidation in rat.[30]

Asaduzzaman investigated antioxidant potential of petroleum ether extract of bark of *Barringtonia acutangula* by DPPH (1,1-diphenyl-2-picrylhydrazyl) and NO radical scavenging assay. Petroleum ether extract of bark showed highest DPPH and NO radical scavenging.[31]

Anti convulsant activity

Sandhyarani evaluated anticonvulsant activity of the ethanol extract of leaves of *Barringtonia acutangula* (EEBA) on Maximal Electroshock (MES) model in albino wistar rats. The EEBA at doses of 250 and 500 mg/kg body weight reduced significantly the mean duration of extensor phase in treated groups as compared to control group.[32]

Anti-inflammatory activity

Muralidhar evaluated the anti-inflammatory activity of ethanol and aqueous extracts (200mg/kg. 400mg/kg) of fruit of *Barringtonia acutangula* (Linn) in carrageenan induced paw oedema, cotton-pellet induced granuloma and carrageenan induced air-pouch model in rats. The ethanol extract reduced the inflammation more significantly than the aqueous by augmenting antioxidant defence system in the inflammation bearing rat.[33]

Sandhyarani investigated anti-inflammatory activity of ethanolic extract of whole plant of *Barringtonia acutangula* (L.) by HRBC (Human Red Blood Cells) method. It was concluded that ethanol extract showed anti-inflammatory activity probably by inhibition of prostaglandin synthesis.[34]

Anti cancer activity

Florida evaluated anticancer activity of ethyl acetate extracts of leaf of *Barringtonia acutangula* against Colon cancer cells lines Colon 320. NO assay and MTT assay showed free radical scavenging and cytotoxicity activity. DNA fragmentation assay showed cytotoxicity of the plant extracts to apoptosis. The apoptosis activation was proved in the cells treated with plant extracts by CASPASE assay. Hence the present study suggested that *Barringtonia acutangula* has anti-cancer potential.[35]

Jayashree evaluated anticancer activity against Human Colon Cancer cell lines HT29 by using two species of Endophytic fungi (EFB01 and EFB02) which were isolated from leaves of *Barringtonia acutangula.* The extract obtained from endophytic fungus, EFB01 showed highest cytotoxicity. The endophytic fungus, EFB01 was identified as *Colletotrichum gloeosporioides.*[36]

Anti-arthritis activity

Thirumal evaluated the anti-arthritic effect of chloroform extract (200 and 400 mg/kg) of the leaves of *Barringtonia acutangula* (CEBA) in Complete Freund's Adjuvant (CFA)-induced arthritis model. The chloroform extract showed significant anti- arthritic activity as compared to control group.[37]

Antimicrobial and antibacterial activity

Rahman investigated antimicrobial activities of the petroleum ether extract the stem bark of *Barringtonia acutangula* (L.) Gaertn (Fam. Lecythidaceae) against two Gram-positive bacteria, two Gram-negative bacteria and two fungi using a micro dilution titre assay. The major compound PE16 was identified as 12, 20(29)-lupadien-3-ol by NMR spectroscopy.[38]

Sahoo investigated *in vitro* antibacterial activity of ethanolic extracts of seed of *Barringtonia acutangula*. Result showed that ethanol (95%) extract exhibited broader spectrum of inhibition against the urinary tract pathogens under test.[39]

Padmavathi evaluated *in vitro* antibacterial activity of ethanolic extracts of leaf of *Barringtonia acutangula*. The result showed that ethanolic extract of leaves possess potential antibacterial activity.[40]

Vijaya investigated antibacterial and antifungal activity of various extract of leaves of *Barringtonia acutangula* (Lecythidaceae) against gram-positive, gram-negative bacteria and fungus by Minimum Inhibitory Concentration (MIC) and Agar Disc Diffusion method. The results revealed that n-hexane extract of the leave the *Barringtonia acutangula* possess potential antibacterial and antifungal activity among the various extract.[41]

Panomket evaluated antimicrobial activity of various extracts of whole plant *Barringtonia acutangula* (L.) Gaertn., by disc diffusion assay and micro-dilution assay. From the above study it was observed that the methanolic extract of *Barringtonia acutangula* (L.) Gaertn. showed the best antimicrobial activity. From the nuclear magnetic resonance spectroscopy (NMR) study chemical structure was elucidated and it was confirmed that chemical constituent belongs to the group of steroids.[42]

Jalal Uddin evaluated the antimicrobial activity of chloroformic extract of bark of *Barringtonia acutangula* at 500µg and 1000µg by disc diffusion assay.[43]

Mohon evaluated antimicrobial activity of the ethanolic extract and fractionates of fresh stem bark of *Barringtonia acutangula*. The extract and fractionates of fresh stem bark showed a significant and remarkable antimicrobial activity.[44]

Hepatoprotective activity

Mishra evaluated *in vitro* and *in vivo* hepatoprotective activity of the methanol extract of *Barringtonia acutangula* (BA) leaves on carbon tetrachloride (CCl_4) with liquid paraffin (1:1) induced hepatic injury in rats. The methanol extract showed significant hepatoprotective activity at a dose of 3.3 mg/mL and 250 mg/kg when screened *in vitro* and *in vivo,* respectively.[45]

Hypolipidemic activity

Nilesh evaluated the hypolipidemic activity of hydro-alcoholic extract (250mg/kg, 500mg/kg) of *Barringtonia acutangula* Linn root (EBA) on streptozotocin (STZ 45 mg/kg)-induced rats. The root extract treated groups showed significant improvement in the lipid profile at both doses as comparable to glibenclamide treated group.[46]

Anthelmintic activity

Padmavathi evaluated the anthelmentic activity of various doses of ethanolic extract of leave of *Barringtonia acutangula* in adult Indian earthworms, *Pheretima postuma*. This study concluded that all the doses of ethanolic extracts showed good anthelmintic activity as comparable to the standard drug Piperazine citrate.[47]

Anti-nephrotoxicity activity

Mishra evaluated nephroprotective activity of methanol-dichloromethane (1:1) extracts of *Vitex negundo* Linn. (VN), *Oroxylum indicum* Vent. (OI) and *Barringtonia acutangula* BA (200 mg/kg; p.o) leave against experimentally induced acute nephrotoxicity Wistar rats. It was observed that the extracts of VN, OI and BA significantly reduced the nephrotoxicity by elevation of body weight, CAT, GPx and SOD or lowering urine LDH and creatinine, serum urea; serum creatinine and LPO respectively.[48]

Antinociceptive, antidiarrheal and neuropharmacological activity

Imam tested methanol extracts (200 and 400 mg/kg; p.o.) of *Barringtonia acutangula* leaves and seeds for antinociceptive activity by acetic acid-induced writhing, hot plate and tail immersion models; antidiarrheal activity by castor oil-and magnesium sulphate-induced diarrheal models, and neuropharmacological activity by hole cross and open field models in mice. Result suggested that the methanol extracts of *Barringtonia acutangula* leaves and seeds possess good antinociceptive, antidiarrheal, and central nervous system (CNS) depressant activities.[49]

Hurmatul Quader evaluated the anti-nociceptive and anti-inflammatory activity of the crude ethanolic root extract of the plant *Barringtonia acutangula* at two doses of 250 mg/kg and 500 mg/kg body weight in mice and rats. The result showed that *Barringtonia acutangula* roots possess significant central and peripheral anti-nociceptive and anti-inflammatory activity.[50]

Balaji evaluated CNS depressant activity of ethanolic extract of *B.acutangula* leaves by sodium pentobarbitone induced sleeping time assay, locomotor activity assay, rota rod test and exploratory activity after performing the gross behavioural study. It was concluded that ethanolic extract of *B.acutangula* leaves causes a maximum inhibition of neuronal activity in the central nervous system which leads to its depressant activity.[51]

Antiepileptic activity

Sandhyarani investigated the effect of ethanol extract of *Barringtonia acutangula* (EBA) on biogenic amines concentrations in rat brain after induction of seizures by pentylenetetrazole (PTZ). It was found that EBA showed significant increase the monoamines in forebrain of rats in PTZ model which may be decreased the susceptibility to PTZ induced seizure in rats.[52]

CONCLUSION

The scientific research on *Barringtonia acutangula* suggests a huge biological potential of this plant. The plant extract and an isolated compound have shown a variety of pharmacological activities like antidiabetic, antioxidant, anticonvulsant, anti-inflammatory, cytotoxicity, anti-arthritis, antimicrobial, antibacterial, hepatoprotective, hypolipidemic, anthelmintic, CNS depressant, antiepileptic activity. It is strongly believed that detailed information as presented in this review on the phytochemical and various biological properties of the extracts might provide detailed evidence for the use of this plant in different medicines. The quantification of individual phytoconstituents as well as pharmacological profile based on *in vitro*, *in vivo* studies and clinical trial should be further investigated. This review will be helpful for further phytochemical and pharmacodynamic investigations to find the active constituents responsible for the known activities, as well as to explore some new and promising therapeutic efficacy of this wonderful plant.

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