A Comprehensive Review on Pharmacological Activity of Terminalia Arjuna

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Abstract
Since ancient times, herbal medicines have been a primary source of therapeutic compounds used to treat ailments. Terminalia arjuna (Roxb) is widely used as indigenous medicine to treat a variety of serious ailments. This review covers ethnomedical, pharmacological, phytochemical, pharmacognostical, and clinical uses for various diseases. This herb is safe to use with other conventional medications. This review examines the therapeutic effects of Terminalia arjuna, including its antioxidant, anti-atherogenic, anti-hypertensive, anti-inflammatory, anti-mutagenic, anti-carcinogenic and gastro-protective effects.

Key words: Terminalia arjuna, Therapeutic effects, Herbal medicine.

Introduction:

Medicinal plants serve a crucial role in health care, serving as the primary raw material for both traditional and conventional medicine. Despite this, many individuals choose herbal medications over conventional ones. These treatments gained popularity due to their effectiveness, scarcity of alternatives, rising costs, and cultural preferences. Ethno botanical studies are crucial for understanding the history and culture of plants worldwide, as well as preserving traditional medicinal knowledge. Quantitative ethnobotanical investigations identified plant uses for food, health care, veterinary medication, and economic value.

Traditional treatment methods such as Ayurveda, Siddha, and Unnani are gaining popularity due to their lower cost and less adverse effects compared to synthetic pharmaceuticals.[1]
Approximately 80% of the global population still relies on conventional medicine to cure various disorders.[2]

Traditional herbal treatments have a significant role in rural and indigenous communities in underdeveloped countries. WHO (World Health Organisation) reports that traditional medicine is used by about 80% of the global population, with 60% of rural Indians relying on herbal remedies. In recent years, the use of herbal supplements has climbed from 2.5% to 12%.

The evaluation of new medications, particularly those derived from phytochemicals, has shifted from traditional to modern medicine in India, opening up new research opportunities. Although medicinal plants are used as Indian traditional medicine to treat various diseases, they are rarely used in modern medicine. These diseases include cardiovascular disease, ulcers, diabetes, cough, excessive perspiration, asthma, tumours, inflammation, and skin conditions.

In ancient India, medicinal plants were employed to prevent ailments and provide a variety of medications.Valuing the rich heritage of traditional medicine is crucial. The use of therapeutic plants, both individually and in combination, is becoming more prevalent in human health care. [3-6]Phytomedicine is the therapeutic use of plant parts such as bark, seeds, roots, berries, leaves, or flowers by a wide population. Plants naturally produce secondary metabolites such as glycosides, alkaloids, tannins, volatile oils, vitamins, and minerals, which have therapeutic qualities.[7]Nanoparticles generated from medicinal plants, such as Terminalia, are in high demand due to their potential applications in medicine, catalysis, energy, and materials research.

The scientific name for arjun is Terminalia arjuna Roxb. It is a perennial tree that ranges in height from 60 to 80 feet. Nanoparticles generated from medicinal plants, such as Terminalia, are in high demand due to their potential applications in medicine, catalysis, energy, and materials research.This plant has numerous active ingredients such as glycosides, triterpenoids, tannins, β-sitosterol, flavonoids and minerals. It has excellent therapeutic potential and has been traditionally used to cure various human illnesses.[8]

It is used to treat ulcers, hepatic and hypocholesterolemic conditions, and has antibacterial, antimicrobial, anti-cancer, antioxidant, and anti-allergic properties.[9-11] Inotropic effects is due to the presence of saponin glycosides. Anti-oxidant and vascular amplification activity is due to flavonoids/ phenolics, demonstrating the plant's multiple activities for cardio-protective function.[12-14]

This study aims to provide significant information on the phytochemical and pharmacological properties of T. arjuna Roxb. This comprehensive examination covers the taxonomy, pharmacology, morphology, and distribution of an extremely significant medicinal plant.

Methods*:*
We conducted a systematic literature search on Terminalia arjuna using PubMed, Scopus, Science Direct, Google Scholar, and Web of Science, as well as a library search for peer-reviewed journal articles and locally available books.

Terminalia arjuna Roxb.

Taxonomy:[15]

Kingdom -Plantae
Division -Magnoliophyta
Class -Magnoliopsida
Order -Myrtales
Family -Combretaceae
Genus -Terminalia
Species -T. arjuna Roxb.

Monograph: [16-18]

- **Bengali name:** Arjun, Arjhan
- **English name:** Arjunterminalia, White murda, Tropical almond, Malabar almond
- **Botanical name:** T. arjuna Roxb.
- **Family:** Combretaceae
- **Duration:** Perennial
- **Growth habit:** Tree
- **Native:** Bangladesh, India, Sri Lanka

Morphology:**[19-21]**

- Tree is 60-80 feet in high, large, drooping branches and evergreen with a spreading crown.
- Leaves are simple, borne sub-opposite coriaceous, often crenulating, oblong or elliptic.
- Petioles are 6-10 mm long, with one or two conspicuous glands at the top, just below the leaf.
- Panicles are tiny, apical, and light green while young, changing to their colour as they mature.
- Stems are buttressed and frequently fluted.
- Bark is thick, soft and smooth gray, red color from inside, irregular sheets, curved and rather flat pieces.
- Flowers are white or yellowish and arranged in bunches.
- Glabrous calyx.

- Fruit is 2.5-5 cm long drupe, that is ovoid or oblong in shape, fibrous-woody, smooth-skinned, and has five hard angles or wings.
- Seeds are hard to germinate 50-76 days [50- 60%].
- Characteristic Odour.
- Bitter in taste
- Root is superficial, shallow and spreads radially along stream banks.

Phytochemical constituents:

Part used	**Chemical constituents**	
Stem bark[15]	*Triterpenoids*	Arjunin, Arjunic acid, Arjungenin, Terminic acid, Terminoltin&Arjunolic acid
	Glycosides	Arjunetin, Arjunoside-I and II, Arjunolone, Arjunolitin, Arjunaphthanoloside, Arjunglucoside IV and V, Arjunasides A-E, Terminarjunoside I and II, Terminoside A, Termionic acid
	Flavonoids and phenolics	Arjunone, Luteolin, Baicalein, Ethyl gallate, Gallic acid, Kempferol, Oligomericproanthocyanidins, Pelargonidin, Quercetin
	Tannins	Pyrocatechols, Punicallin, Castalagin, Casuarin, Casuarinin, Punicalagin, Terchebulin, Terflavin C
	Minerals and trace elements	Calcium, magnesium, aluminum, zinc, copper, silica
	Other compounds	β-Sitosterol
Roots[24]	*Triterpenoids*	Arjunoside I-IV, Arjunolic acid, Oleanolic acid, Terminic acid, Arjunic acid
	Glycosides	Arjunetosie (3-O-β-D-glucopyranosyl-2α, 3 β, 19 α -trihydroxyolean-12-en-28-oic

		acid 28-O- β -D-glucopyranoside)
Fruits	*Triterpenoids and flavonoids*	Arjunic acid, Arjunone, Arachidic stearate, Cerasidin, Ellagic acid, Fridelin, Gallic acid, Hentriacontane, Methyl oleaolate, Myristyloleate, β -Sitisterol
Leaves and seeds[42]	*Flavonoids and glycosides*	Luteolin, 14,16-dianhydrogitoxigenin 3- β -D-xylopyranosyl-(1 > 2)-O- β -D-galactopyranoside

Pharmacological Activities:

Activity	Type of Extract	Model used & Study design	Observation	References
Anti-Ulcer Activity	Methanolic extract of Terminalia arjuna bark	Rats	Free radical scavenging activity and cytoprotective nature shows anti-ulcer activity	Devi RS, Narayan S, Vani G, Devi CS [22]
Anti-Cancer Activity	Aqueous extract of Terminalia arjuna	Mice	Anti-Cancer effect due to the increased antioxidant enzymes.	Verma N, Vinayak M [23]
Anti-diabetic Activity	Ethanolic extract of Terminalia arjuna bark	Rats	The presence of tannin, saponin, flavonoids, and other components in the bark causes anti-diabetic effect by correcting impaired liver and kidney glycolysis and reducing its gluconeogenic production, similar to insulin.	Ragavan B, Krishnakumari S[25]
	Methanolic extract of Terminalia arjuna Leaf	Rats	Anti-hyperglycemic effect is due to its antioxidant role	Biswas M et.al [26]
	Ethanolic extract of	Wistar Albino	Improves impaired baroreflex sensitivity in diabetic mice,	Khaliq F

	Terminalia arjuna bark	Rats	potentially by maintaining endogenous antioxidant enzyme activity and reducing cytokine levels.	et.al [27]
Wound Healing Activity	Hydroalcohol extract of T*erminalia arjunabark*	Rats	The astringent effect of tannins accelerates the wound healing process	Chaudhari M, Mengi S [28]
Antidyslipidemic and anti-oxidant activity	Ethanol and solvent ether fractions of T*erminalia arjuna*	Hamster	In-vivo Lipid lowering activity	Chander R et.al [29]
Cardiotonic Activity	T*erminalia arjuna*bark extract	Rats	The prophylactic and therapeutic effect of Terminalia arjuna in regulating autonomic function and preventing Left ventricular remodeling	Parveen A, Babbar R, Agarwal S, Kotwani A, Fahim M [30]
	Aqueous extract of T*erminalia arjuna* stem bark	Rats	Partially or completely restores the marker mRNAs, signaling kinases, transcription factors and total protein profile in rat heart, thereby demonstrating its efficacy in preventing Isoproterenol-induced cardiac hypertrophy	Kumar S et.al [31]
	Aqeous extract of T*erminalia arjuna*	Mice	Protective action against cardiotoxicity caused by doxorubicin via suppression of oxidative stress. Active constituents of aqeous extract of T*erminalia arjuna* contain various flavonoids and proanthocyanidins, are known to have antioxidant activities. It is a promising cardiotonic in adjuvant cancer chemotherapy	Bishop S, Liu SJ [32]
Diuretic Activity	Hydroalcoholi c extract of	Rats	A prophylactic to attenuate acute hypobaric hypoxia	Kumar K

	T*erminalia arjuna bark*		induced cerebral vascular leakage through Atrial natriuretic peptide (ANP) mediated modulation of renin-angiotensin-aldosterone system	et.al [33]
Anti-Anxiolytic Activity	Alcoholic extract of T*erminalia arjuna*	Mice	Alcoholic extract of T*erminalia arjuna* possessed an anxiolytic like activities in behavioral paradigms of mice model. T*erminalia arjuna bark* alcoholic extract was rich with many bioactive compounds and had a major role in scavenging the reactive oxygen species	Sekhar YC, Kumar GP, Anilakumar KR [34]
Anti-Atherogenic Activity	Ethanolic fraction from T*erminalia arjuna bark* powder	Rabbits	Ethanolic fraction from T*erminalia arjuna bark* powder has significant anti-atherogenic activity when administered to normal or hypercholesterolemic rabbits, due to the presence of flavonoids, tannins and plant sterols	Subramania m S et.al [35]
Anti-Hypertensive Activity	Aqueous extract of T*erminalia arjuna*	Wistar rats	Prevented MCT (Monocrotalin) -induced pulmonary hypertension which may be attributed to its antioxidant as well as its effects on pulmonary arteriolar wall thickening	Meghwani H et.al [36]
Cytoprotective and Anti-apoptotic role	Aqueous extract of Terminalia arjuna	Invitro model of Madin–Darby canine kidney (MDCK) cells	Terminalia arjuna inhibit the binding of the Calcium oxalate (CaOx) crystals to the renal epithelial surface and/or interaction of oxalate ions with calcium ions. Interference with CaOx crystallization and retention to cells, helps in prevention of recurrent stone disease. Active biomolecules of Terminalia	Mittal A, Tandon S, Singla SK, Tandon C [37]

			arjuna by blocking these interactions exhibit cytoprotective role towards oxalate-induced cell injury	
Antioxidant, anti-inflammatory &immunomodulatory	Alcoholic and aqueous extract of T. arjuna	CYP3A4, CYP2D6 and CYP2C9 enzymes in human liver microsomes	T. arjuna extracts, both alcoholic and aqueous, inhibited the enzymes CYP3A4, CYP2D6, and CYP2C9. Enzyme kinetic tests suggested that the extracts of T. arjuna demonstrated fast reversible non-competitive inhibition of all three enzymes in human liver microsomes.	Varghese A, Savai J, Pandita N, Gaud R [38]
Antioxidant and antimutagenic activity	Aqueous and ethanolic extraction of T. arjuna	Wistar rats and Swiss albino mice	The alcoholic extract of T. arjuna (ALTA) has shown potent antioxidant activity in DPPH(2,2-diphenyl-1-picrylhydrazyl) assay, superoxide radical scavenging activity and lipid peroxidation assay, respectively. In micronucleus test, ALTA showed significant reduction in both polychromatic erythrocytes and normochromatic erythrocytes.	Viswanatha GL, Vaidya S, Ramesh C, Krishnadas N, Rangappa S [39]
Anti-Oxidant Activity	T*erminalia arjunabark* extract in different solvents i.e., ethanol, acetone, water, ethyl acetate, chloroform and hexane	Biochemical estimation	Among all these extracts, ethanolic extract of T*erminalia arjuna bark* showed high phenolics, high reducing power and high free radical scavenging activity which indicated that it is the best extract to isolate antioxidant compounds	Sree TP, Kumar SK, Senthilkumar A, Aradhyam GK, Gummadi SN [40]
	Butanolic fraction of alcoholic extact of	Male Wistar albino rats	Chromic administration of butanolic fraction of alcoholic extract of T. arjuna bark has cardioprotective potential	Singh G et.al [41]

	T.arjuna bark		against Doxorubicin-induced cardiotoxicity.	
	Crude bark of Terminalia arjuna	Male albino Wistar rats	Male albino Wistar rats subjected to oxidative stress associated with in vitro ischemic reperfusion injury (IRI) T. arjuna augments endogenous antioxidant compounds of rat heart and also prevents oxidative stress associated with IRI of the heart.	Gauthaman K et.al [42]
	Ethanolic extract of T. arjuna	Male Swiss albino mice	Ethanolic extract of T. arjuna protects murine hearts from Sodium Fluoride (NaF)-induced oxidative stress via its antioxidant properties	Sinha M, Manna P, Sil PC [43]
Antimicrobial activity	Methanol, ethanol, acetone aqueous extracts from the leaves and bark of T. arjuna Acetone leaf extract	Five bacteria namely Staphylococcus aureus (Gram Positive) Acinetobacter sp., Proteus mirabilis, Escherichia coli and Pseudomonas aeruginosa (Gram negative)	Methanol, ethanol, acetone aqueous extracts from the leaves and bark of T. arjuna Acetone leaf extract was found to be best against S. aureus.Organic extract showed almost equal inhibition of all tested Gram negative bacteria except Pseudomonas aeruginosa. Aqueous extract of T. arjuna bark exhibited good activity against Staphylococcus aureus	Aneja KR, Sharma C, Joshi R [44]

Distribution:

T. Arjuna Roxb is a deciduous tree found in dry hills near water bodies like ravines, streams, and rivers. It grows abundantly in Bangladesh, Madhya Pradesh, Uttar Pradesh, Delhi, and South Bihar. It can be found in forests in Sri Lanka, Burma, and Mauritius. [22]

Side* effects of *T. arjuna Roxb:

T. arjuna Roxb has fewer side effects like mild gastritis, headache and constipation.

Conclusion:

T. arjuna Roxb. is a significant medicinal plant with numerous phytochemical and pharmacological properties, including tannins, triterpenoid, saponins, flavonoids, gallic acid, oleanolic acid, ellagic acid,and arjunic acids. Several studies have examined pharmacological action. T. arjuna Roxb. exhibits antibacterial, antiviral, anti-mutagenic, anti-inflammatory, anti-oxidant and wound healing properties.

The medicinal herb T. arjuna Roxb. has shown promising results in treating diabetes, cancer, and heart disease. This literature review supports several therapeutic properties of T. arjuna Roxb. This review can serve as a starting point for researchers to explore the therapeutic effects of T. arjuna Roxb using current techniques including NMR (Nuclear Magnetic Resonance), mass spectrophotometer analysis, High performance liquid chromatography and HPTLC (High performance thin layer chromatography).

Further research is needed to advance clinical trials and develop novel medications for treating critical diseases, drug administration, drug-drug interactions and toxicological studies.

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