



International Journal of Medicine and Pharmaceutical Research

Journal Home Page: www.pharmaresearchlibrary.com/ijmpr



Review Article

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A Phytochemical and Pharmacological review on *Terminalia arjuna*

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ABSTRACT

Medicinal plants have been a major source of therapeutic agents to cure human diseases, since ancient time. *Terminalia arjuna* is one kind of widely used medicinal plant used in various indigenous system of medicine like Ayurveda, Siddha and Unani. This review has been conducted to pile up phytochemical as well as pharmacological information that is available in different scientific literatures. This plant has been reported to contain phytochemical constituents like Triterpenoids (arjunolic acid, arjunic acid, arjunin, terminic acid, etc.), Glycosides (arjunetin, arjunosides, arjunglycosides etc.), Flavonoids (Arjunone, arjunolone etc.), Tannins (casuarinin, gallic acid, pyrocatechols etc.), -Sitosterol, Minerals (calcium, magnesium, zinc, copper etc.). Which exhibit various pharmacological activities like Antimicrobial, Anti cancer, Cardioprotective, Anti fungal, Anti diabetic, Antioxidant, Anti inflammatory, Hypolipidemic, Anthelmintic, Insecticidal, Wound healing, Anti acne, Gastroprotective etc. The present comprehensive review is therefore an effort to give detailed information on phytochemical and pharmacological studies of *T. arjuna*.

Keywords: *Terminalia arjuna*, Phytochemical, Pharmacological activities

ARTICLE INFO

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Article History: Received 28 December 2014, Accepted 10 January 2015, Published Online 10 April 2015

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 Manuscript ID: IJMPR2493



PAPER-QR CODE

Citation: Bariya Aditi Hemrajbhai, et al. A Phytochemical and Pharmacological review on *Terminalia arjuna*. *Int. J. Med. Pharm. Res.*, 2015, 3(2): 1011-1019.

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1. Introduction

The revival of interest in natural drugs started in last decade mainly because of the wide spread belief that green medicine is healthier than synthetic products. Nowadays, there is manifold increase in medicinal plant based industries due to the increase in the interest of use of medicinal plants throughout the world which are growing at a rate of 7-15% annually. Despite the major advances in the modern medicine, the development of new drugs from natural products is still considered important. This seems to be even more relevant for the developing countries, where the cost to develop a drug is prohibitive. Since 1980, the World Health Organization has been encouraging countries to identify and exploit traditional medicine and phytotherapy. The main Indian Traditional System of Medicine namely Ayurveda and Siddha are primarily plant based system. The evaluation of new drugs especially phytochemically obtained materials has again opened a vast area for research and development. As per WHO, about 80% of the population in the world relays on the traditional medicine for the treatment of various diseases. Therefore, the evaluation of rich heritage of traditional medicine is essential.⁰¹ In this regard, one such plant is *Terminalia arjuna* (Roxb.) Wt. and Arn. which is a deciduous and evergreen tree distributed throughout India growing to a height of 20-30m above ground level. In the Indian system of medicine, *T. arjuna* bark is used for many complications. The aim of present review is to highlight the phytochemical and pharmacological investigation carried out on the plant so that more pharmacological studies could be conducted to investigate the unexploited potential.

Plant Profile

Botanical Name:

Terminalia arjuna (belongs to Combretaceae family)

Common Name: Arjuna, Dhavala, Kakubha, Nadisarja, Veeravriksha, Partha, Indradru. [02]

Parts Used: Bark, Roots, Leaves and Fruits

Taxonomical/ Scientific classification: [03]

- **Kingdom:** Plantae - Plants
- **Subkingdom:** Tracheobionta - Vascular plants
- **Subkingdom:** Spermatophyta- Seed plants
- **Division:** Magnoliophyta - Flowering plants
- **Class:** Magnoliopsida - Dicotyledons
- **Subclass:** Rosidae
- **Order:** Myrtales
- **Family:** Combretaceae- Indian Almond family
- **Genus:** Terminalia L.
- **Species:** arjuna

Habitat

Terminalia arjuna Wight & Arn. is a deciduous and evergreen tree, standing 20–30m above ground level. It belongs to Combretaceae family. It is found in abundance throughout Indo-sub-Himalayan tracts of Uttar Pradesh, South Bihar, Madhya Pradesh, Delhi and Deccan region near ponds and rivers. It is also found in forests of Sri Lanka, Burma and Mauritius. *Terminalia arjuna* was introduced in Mauritius by early Indian migrants. Remarkably the tree is pest and disease free.⁰⁴

2. Phytochemical Profile

Table 1

Plant part	Chemical constituents	References
Stem bark	Triterpenoids: arjunolic acid, arjunic acid, arjunin, arjugenin, Ursane triterpenoids	5, 6
	Arjunahomosesquiterpenol & Stigmasteryl digalactoside	7
	oleaterminaloic acid A, B & C, oleaterminolide and termiarjunoside I	8
	Glycosides: arjunetin, arjunoside II, arjunoside I, arjunaphthanolside, terminoside A	5, 9, 10, 11,
	Arjunasides A-E Arjunetoside, Ajunglycosides IV and V, Termiarjunoside I and II	12, 13
	-Sitosterol	5
	Flavonoids: arjunone, bicalein, arjunolone, luteolin, ethyl gallate, gallic acid, kempferol, pelargonidin, quercetin, oligomeric proanthocyanidins	5
Stem bark	Tannins: terflavin C, castalagin, punicallin, punicalagin, terchebulin, casuarinin, pyrocatechols, arjunin, gallic acid, ellagic acid	5, 14, 15
	Trace elements/Minerals: zinc, copper calcium, aluminium, silica, magnesium	5
Roots	-Sitosterol	5
	Triterpenoids: terminic acid, arjunic acid, oleanolic acid, arjunolic acid	
	Glycosides: arjunoside I, arjunoside II, arjunoside III, arjunoside IV, 2,19-dihydroxy-3-oxo-olean-12-en-28-oic acid 28-O-d glucopyranoside	
Leaves and fruits	Glycosides	5
	Flavonoids: luteolin	

	Tannins: Ellagic acid, Gallic acid, Corilagin, Chebulagic acid, etc.	16
	Chebuloside II and Bellericoside	
	Dietary minerals of Calcium, Magnesium, Zinc, and Copper	

3. Pharmacological Activities

1. Antimicrobial activity:

When total 34 plant species belonging to 18 different families were assayed for antibacterial activity against *Escherichia coli*, *Klebsiella aerogenes*, *Proteus vulgaris*, and *Pseudomonas aerogenes* (gram-negative bacteria) by the disc diffusion method, about

16 plants showed activity. Among them *Terminalia arjuna* showed significant antibacterial activity against the tested bacteria [17]. Antimicrobial activity of different solvent extracts from *T. arjuna* reported previously are summarized in below Table.

Table 2

Extracts used	Organisms used	Extracts conc. used	Highest active extract	Reference
Methanol, Ethanol, Acetone, Hot & Cold aqueous	<i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> , <i>Proteus mirabilis</i> , <i>Escherichia coli</i> , <i>Acinetobacter sp.</i> <i>Candida albicans</i>	50 mg/mL	Acetone	18
Aqueous, Methanol	<i>Staphylococcus aureus</i> , <i>Bacillus cereus</i> , <i>Escherichia coli</i> , <i>Vibrio cholerae</i> , <i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i>	Aqueous 2gm/20 mL Methanol 30 mg/mL	Methanol	19
Ethanol	<i>Staphylococcus aureus</i> , <i>Streptococcus faecalis</i> , <i>Coliform spp.</i> , <i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , <i>Pseudomonas aeruginosa</i>	25 µg/mL, 50 µg/mL, 100 µg/mL, 200 µg/mL	Ethanol (200 µg/mL)	20
Aqueous, Methanol	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i> ,	10%, 15%	15% Methanol	21
Aqueous, Methanol, Chloroform	<i>Bacillus subtilis</i> , <i>Enterococcus faecalis</i> , <i>Micrococcus luteus</i> , <i>Staphylococcus aureus</i> , <i>Staphylococcus saprophyticus</i> , <i>Acinetobacter baumannii</i> , <i>Citrobacter freundii</i> , <i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , <i>Klebsiella oxytoca</i> , <i>Moraxella catarrhalis</i> , <i>Proteus mirabilis</i> , <i>Proteus vulgaris</i> , <i>Pseudomonas aeruginosa</i> ,	10 mg/mL	Aqueous	22
Hydroalcoholic extract (1:1)	<i>Staphylococcus aureus</i> , <i>Bacillus coagulans</i> , <i>Escherichia coli</i> , <i>Aspergillus niger</i> , <i>trichoderma viride</i> and <i>Fusarium oxysporum</i>	40%, 60%, 80%, 100%	Hydroalcoholic 100%	23
Aqueous extracts of bark, root, leaves and fruits.	<i>Micrococcus glutamicus</i> , <i>Lactobacillus bulgaris</i> , <i>Streptococcus faecalis</i> , <i>Staphylococcus aureus</i> , <i>Bacillus stearothermophilus</i> , <i>Staphylococcus pyogenes</i> , <i>Micrococcus luteus</i> , <i>Bacillus cereus</i> , <i>Escherichia coli</i> and <i>Pseudomonas aeruginosa</i>	1.0 mg/disc 5.0 mg/disc	Bark aqueous extract 5.0 mg/disc	24
Ethanol	<i>Vibrio cholerae</i>	1 mg/disc, 2 mg/disc, 3 mg/disc, 4 mg/disc 5 mg/disc.	5 mg/disc	25

2. Anticancer activity:

Different types of cancer reported to treat by *T. arjuna* extracts are compiled in a Table. Herbal extracts of *T. arjuna* reported to enhance

increased percentage of life span of experimental animals.

Table 3

Type of cancer	Used extract	Treated organisms/cells	Reference
Mutagenic cancer	Dried bark	<i>Salmonella typhimurium</i>	26
Human breast, colon, intestine, lung and leukaemia	Leaf	<i>Pestalotiopsis terminaliae</i>	27
Ehrlich ascites carcinoma (EAC)	Methanolic extract of leaves	Mice	28
Human breast	Bark	Human breast adeno-carcinoma MCF-7 cell	29
BT- human breast	Ethanolic extract of leaves	BT-human breast carcinoma cells	14
Chronic myeloid leukemia	Methanolic extract of leaves	Human K562 leukemic cell line	30
Human hepatocellular carcinoma	Ethanolic extract of bark	Human hepatoma cell line (HepG2)	31
Dalton's Lymphoma Ascites (DLA) tumour	Ethanolic extract of bark	Mice	32
Hepatocellular carcinoma	Ethanolic extract of bark	Liver of rat	33
Lung, Breast and ovarian cancer	Leaves	A549>MCF7>PA respective cell line	34

3. Cardioprotective activity:

There are different types of therapeutic use of *T. arjuna* for cardiac disease that based on empirical explanation recorded in various treatment of ancient medicine.

(a) Cardiotonic activities:

Arjunolic acid is used as a cardiac tonic in ayurvedic medicine for centuries and it has been first isolated from *T. arjuna*. The bark extracts have major component triterpenoid saponin is an arjunolic acid. [35] Besides Arjunolic acid, Arjungenin was also found to be most active as direct free radical scavenger and inhibitor for the hypochlorous acid production followed by its glucoside that was almost 50% active resulting in cardioprotective action. [36] The aqueous extract of the bark is isolated from rat atria that confirmed positive inotropic activity. [37, 38] *Terminalia arjuna* (Aqueous Extract) increased the force of contraction of cardiac muscle in frog's heart in situ, hypodynamic frog's heart in situ and isolated perfused rabbit heart. [39]

(b) Anti anginal effects & Myocardial infarction:

Treatment with *T. arjuna* is fairly effective in patients with symptoms of stable angina pectoris. However, it has a limited role in

unstable angina. [40] *Terminalia arjuna* ethanol extract (TAEE) and *Terminalia arjuna* aqueous extract (TAAE) both produced significant cardioprotection in isoproterenol induced myocardial infarction in animals. [41,42,43]

(c) Coronary flow:

Terminalia arjuna (Aqueous Extract) increased the coronary flow at a 400 µg dose in isolated perfused rabbit heart along with dose dependent bradycardia. However the doses required were high as compared to digoxin so the agent proved to be less potent as compared to digoxin. [39] The coronary flow was significantly enhanced with 1024 µg/ml dose of TA extract on the isolated perfused rabbit heart. [44]

(d) Hypotensive effects:

Intravenous injection of alcoholic and aqueous extract of bark causes dose-dependent persistent bradycardia and hypotension. [45] 70% alcoholic extract of *Terminalia arjuna* produced hypotension of peripheral origin which may be due to adrenergic 2-receptor agonistic and/or direct action on the heart.[46]

4. Antifungal activity:

The organic extracts of five *Terminalia* species (*T. arjuna*, *T. chebula*, *T. bellerica*, *T. catappa*

and *T. alata*) were tested with plant pathogenic fungi i.e. *A. flavus*, *A. alternata*, *A. niger*, *A. brassicicola*, and *H. tetramera*. The leaves extracts of all five plants found to inhibit these plant pathogens. [47] The polar extracts of *T. arjuna* demonstrated strong anti fungal activity against eight species of *Candida*. [22] The antifungal activities of *Terminalia arjuna* leaves extract (40, 60, 80, 100 %) were tested against three fungal strains. *Aspergillus niger*, *Trichoderma viride* and *Fusarium oxysporum* which showed remarkable inhibition of fungi growth.²³ The bark extracts were more effective than fungicide (control) used in this antifungal test. Moderate antifungal activity against *C. albicans*, *C. krusei* and *C. parapsilosis* was exhibited by a mixture of arjunolic acid with minimum inhibitory concentration (MIC) values in the range of 50-200 µg/ml. [35]

5. Antidiabetic activity:

The *T. arjuna* extracts have potential effects on diabetes. *T. arjuna* bark extracts cause a significant reduction in liver and kidney markers such as alkaline phosphatase (ALP), acid phosphatase (ACP), alanine amino transferase (ALT), aspartate amino transferase (AST) and lactate dehydrogenase (LDH) as well as significant decrease in the activities of glucose-6-phosphatase, fructose-1,6-disphosphatase, aldolase and an increase in the activity of phosphoglucosomerase and hexokinase in tissues and also cause a significant ($P < 0.05$) increase in superoxide dismutase, catalase, glutathione peroxidase, glutathione-s-transferase glutathione reductase and glucose-6-phosphate dehydrogenase, reduced glutathione, vitamin A, vitamin C, vitamin E, total sulfhydryl groups (TSH) and non protein sulfhydryl groups (NPSH) in liver and kidney of alloxan induced diabetic rats, which clearly shows, the anti diabetic and antioxidant property of *T. arjuna* bark. [48, 49, 50]. Aqueous Bark Extracts of *Terminalia Arjuna* Stimulates Insulin Release, Enhances Insulin Action and Inhibits Starch Digestion and Protein Glycation in Vitro [51]. The organic extracts (Ethanol, methanol and acetone) of *T. arjuna* leaves and bark possess significant hypoglycaemic and anti-diabetic activity due to the presence of the phytochemicals (flavonoids, tannins, glycosides, alkaloids, terpenoids) in it which are strong antioxidants. [52, 53, 54]

6. Antioxidant activity:

The extracts of *Terminalia arjuna* may be explored as a potential source of antioxidants for their use in food and pharmaceutical industries. [55] The extracts from barks of investigated trees: *A. indica*, *T. arjuna*, *A. nilotica*, and *E. jambolana* Lam., exhibited outstanding antioxidant activity as measured by

various antioxidant assays.⁵⁶ Because of antioxidant activity of *Terminalia arjuna*, it could be very well used as hepatoprotectant.⁵⁷ *Terminalia arjuna* shows potential antioxidant and free radical scavenging activity due to presence of more amount of flavonoid and phenolic content. [58]

7. Anti-inflammatory:

The methanol extract of the leaves of *Terminalia arjuna* demonstrated significant analgesic and acute anti-inflammatory activities in the tested models. [59] *T. arjuna* has anti-inflammatory potential against some phlogistic agents, immunomodulatory effect and also has anti nociceptive action probably mediated via opioid receptors. [60]

8. Lipid lowering activity

The rats receiving *Terminalia arjuna* had a marked reduction in total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol as well as an increased HDL cholesterol when compared to the induced animals. Thus, *Terminalia arjuna* was observed to be the most potent hypolipidemic & hypotriglyceremic agent. [61] *T. arjuna* significantly decreases Total Cholesterol, LDL and Triglyceride levels and increases HDL and lessens atherosclerotic lesion in aorta. Hence *T. arjuna* extract can effectively prevent the progress of atherosclerosis. This is likely due to the effect of *T. arjuna* on serum lipoproteins and its antioxidant and anti-inflammatory properties. [62] Arjuna bark acts as a hypolipidemic, hypocholesterolemic and oxidative stress lowering agent induced by high fat high cholesterol diet in rats. [63]

9. Anthelmintic activity:

Crude methanolic extracts of *T. arjuna* bark exhibited anthelmintic activity both in vitro and in vivo studies which may be mainly attributed to its tannin content. [64, 65] All extracts showed effective anthelmintic activity at 20 mg ml⁻¹ concentration. [66]

10. Insecticidal property:

Arjunolic acid isolated from the stem of *T. arjuna* exhibits significant inhibitory activity towards fourth instar larvae of *Spilarctia obliqua*. [35]

11. Wound healing activity:

The hydroalcoholic extract of *T. arjuna* bark phytoconstituents was reported to be used in topical application on healing rat dermal wounds. [35] *T. arjuna* has capability to complete epithelisation of excision wounds and increased tensile strength of incision wounds. [67]

12. Against ear infection:

T. arjuna plants extracts having a great potential to be developed as herbal ear drop to control the bacterial ear infections. All the organic *T. arjuna* extracts (acetone, ethanol or methanol) have

shown good activity against both the Gram positive and Gram negative ear pathogens, the inhibition being higher in Gram positive bacteria than the Gram negative bacteria. [18]

13. Anti acne activity:

Herbal anti-acne cream is non-toxic, safe, effective and improves patient compliance by the utilization of herbal extracts from *T. arjuna* would be highly acceptable. [68]

14. Gastroprotective effect:

Hydro alcoholic extract of TA was found to possess anti-ulcerogenic as well as ulcer healing properties, which might be due to anti-secretory activity. [69] *T. arjuna* acts as an gastroprotective agent probably due to its free radical scavenging activity and cytoprotective nature. [70]

15. Anti asthmatic activity:

Arjunolic acid and alcoholic extract of *T. arjuna* have significant mast cell stabilization activity

and specifically, arjunolic acid exhibits comparatively better stabilization activity than alcoholic extract of TA.⁷¹ The antiasthmatic and antianaphylactic activity may be due to the mast cell stabilizing potential and inhibition of antigen induced histamine and acetylcholine release. [71, 35]

16. Decrease arsenic-induced toxicity:

Arsenic, one of the environmental pollutants, causes tissue damage. Its exposure occurs from inhalation, absorption through the skin and by ingestion of contaminated food and drinking water. An impaired antioxidant defence mechanism followed by oxidative stress is the major cause of arsenic induced toxicity. Arjunolic acid has been shown to protect against arsenic induced cytotoxicity probably due to its free radical scavenging as well as metal chelating properties. [72]

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