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Arjuna Bark (Terminalia arjuna): A Comprehensive Review of Its Pharmacological Properties and Therapeutic Potential

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ABSTRACT:

***Background*:** This review provides an in-depth look at terminalia arjuna bark, covering their taxonomy, phytochemistry, medicinal uses, and pharmacological action. It highlights the presence of bioactive compounds like Arjunin , Arjunic acid, Arjungenin, Terminic acid, Terminoltin, Arjunolic acid and explores their traditional and modern uses in treating various diseases. The review showcases the potential of terminalia arjuna for pharmaceutical applications and calls for further research to fully utilize their benefits.

***Methods*:** Literature has been collected through SciFinder, Web of Science, Google Scholar, PubMed, and a library. This review shares updated information on the botany, distribution, health benefits, phytochemistry and pharmacology of terminalia arjuna .

***Result*:** Bioactive components of arjuna bark exhibited a wide array of activities such as Anti-inflammatory, anti-microbial, antioxidant, antihypertensive and in cardiovascular diseases . This curative potential highlighted its various beneficial outcomes in the field of drug research and increasing scientific interest in the identification of bioactive compounds responsible for various pharmacological activities. .

***Conclusion*:** Existing literature authenticates the potential benefits of arjuna bark for cardiotonics as well as medicinal perspective. This barks needs to be explored for identification, isolation, and characterization of bioactive compounds against varied ailments.

Keywords: terminalia arjuna , cardiaovascular disease , hypertension , arjunolic acid.

1.INTRODUCTION

The bark of the Terminalia arjuna (Roxb.) tree is commonly used in Indian medicine (Ayurveda) to treat a variety of cardiovascular conditions. The bark has been shown to contain a number of bioactive chemicals. Many experimental investigations have demonstrated its antioxidant, anti-ischemic, antihypertensive, and antihypertrophic properties, which are relevant to its therapeutic potential in cardiovascular disorders in people[1]. Ancient physicians believed that the bark stem powder of this tree may help with "hritshool" (angina) and other cardiac disorders[2]. It is an evergreen tree endemic to India. The bark stem powder of the Arjuna has been utilized in the case of "hritshool" i.e. acute discomfort in the chest caused by a lack of blood flow and other cardiac illnesses by the ancient physicians. Terminalia arjuna's principal phytoconstituents include arjunic acid, arjunolic acid, arjungenin, arjunone, arjunolone, and luteolin, gallic acid, ellagic acid, oligomeric proanthocyanidins (OPCs), and phytosterols[3]. Nearly 24 Terminalia species have been reported in India, including well-known species such as T. arjuna, T. bellerica, T. chebula, T. tomentosa, T. catappa, T. elliptica, T. porphyrocarpa, and T. mantaly.T. arjuna (Roxb) Wight and Arnot's bark is called as "Arjuna" in India. It is utilized for cardiovascular disorders such as heart failure, ischemia, cardiopathy, atherosclerosis, and myocardial necrotic diseases[4]. Terminalia arjuna (T. arjuna) is a huge, deciduous fluted tree that can grow to be 30 meters tall and 2-2.5 meters in diameter at breast height, with a trunk that is frequently buttressed. T. arjuna (Combretaceae), a huge tree, is distributed throughout the South Asian region[5]. Ayurvedic literature describes the bark of Terminalia arjuna as having heart-health advantages[6].

After 30 days of oral administration of an ethanolic extract of bark (250 and 500mg/kg body weight), blood glucose levels decreased from 302.67±22.35 to 82.50±04.72. Additionally, the activities of glucose-6-phosphatase, fructose-1,6-disphosphatase, aldolase decreased, while phosphoglucoisomerase and hexokinase increased in tissues[7]. T. arjuna bark contains 34% ash, all of which is calcium carbonate. The alcoholic extract was confined to coloring matter and tannins, while the aqueous extract included 23% calcium salts and 16% tannins. Later, bark contained sugar, tannins (12%), coloring matter, a glycoside, calcium and sodium carbonates, and traces of alkali metal chloride. Afterward, the presence of an alkaloid and a glycoside was established[8]. Arjuna contains Beta-sitosterol, a phytosterol that reduces cholesterol levels in blood serum by inhibiting absorption due to its increased solubility in bile salt micelles[9]. Recent experimental and clinical research have demonstrated that the dried bark powder of Terminalia arjuna has considerable preventive effects in ischemic heart disease[10]. The bark of Terminalia arjuna, a plant in the Combretaceae family, was chosen for the study due to its traditional use as astringent, wound healer, cardiac stimulant, hemoptysis, lithontriptic, and treatment for bilious infections, diarrhea, and acne. The use of flavonoids

and tannins to treat ailments predates the understanding of chemistry. Flavonoids have several biological actions, including anti-oxidant, anti-cancer, anti-inflammatory, ulcer, hepatoprotective, and anti-microbial. Tannins have cytotoxic, antitumor, astringent, anti-hemorrhagic, antioxidant, and anti-bacterial properties[11]. Given these findings, the current investigation was undertaken to examine whether an aqueous extract of the stem bark of Terminalia arjuna could be useful in reducing monocrotaline-induced pulmonary hypertension in rats[12].

2. TAXONOMY

2.1 Taxonomical classification of Terminalia arjuna

Kingdom Plantae

Division Magnoliophyta

Class Magnoliopsida

Order Myrtales

Family Combretaceae

Genus Terminalia

Species Terminalia arjuna

Common Name Arjuna

2.2 Vernacular Names of Terminalia arjuna

English Arjun

Hindi Arjuna, Arjun

Assamese Arjun

Irula Mathi

Kannada Aatumaruthu, Nirmatti, Neermaruthu

Malayalam NeerMarudhu, Aatumaruthu, Nirmarutu, Vellamathi

Manipuri Maiyokpha

Tamil Vella Maruda, Vella maruthu, Kula maruthu, Marutu

3.GEOGRAPHICAL DISTRIBUTION

T. arjuna is found in Indo-subHimalayan regions including Uttar Pradesh, South Bihar, Madhya Pradesh, Delhi, and Deccan. The plant grows around ponds and rivers. It is abundant in the woods of Sri Lanka, Burma, and Mauritius. Indian immigrants introduced Terminalia arjuna in Mauritius[3].

4.TRADITIONAL USES

This medicinal plant has been in use since the Vedic period. In Ayurvedic literature, the plant is known by synonyms such as Arjun, the Hero of the famous epic Mahabharata. Arjuna is mentioned in several ancient Indian medicinal texts, including Charaka Samhita, Sushruta Samhita, and Astang Hridayam. Vegabhatta was the first to use Arjuna stem bark powder to treat cardiac diseases. In Ayurveda, it is referred to as Hridya (cardiac tonic). Arjuna bark powder is used to cure a variety of ailments, including kshata (injury or wound), kshaya (emitiated condition), visha (poison), raktavikara (styptic), medaroga (diabetes), prameha (urinary diseases), and vrana (ulcer/wound)[3].

5. PHYTOCONSTITUENTS OF ARJUNA BARK

The major phytoconstituents present in the bark of Terminalia arjuna include tannins, arjunic acid, arjunolic acid, Arjungenin, arjunoglycosides, flavonoids, ellagic acid, Gallic acid, oligomeric proanthocyanins (OPCs) phytosterols, calcium, magnesium, zinc and copper[13].Arjunin, Terminic acid, Terminoltin, 2α,3β-dihydroyurs-12,18-oic acid 28-O-β-D-glucopyranosyl ester, 2α,3β,23-trihydroxyurs-12,18-dien-28-oic acid 28-O-β-glucopyranosyl ester, Qudranoside VIII, Kajiichigoside F1, 2α,3β,23-trihydroxyurs-23-trihydroxyurs-12,19-dien-28-oic acid, 28-O-β-D-glucopyranosyl ester, Arjunetin, Arjunoside I, II,. Arjunolone, Arjunolitin, Arjunaphthanoloside, Arjunglucoside IV and V, Arjunasides A-E, Olean-3β, 22β-diol-12-en-28 β-D-glucopyranosie-oic acid, Terminarjunoside I and II, Terminoside A, Termionic acid, Luteolin, Baicalein,[8].

6. PHARMACOLOGICAL EFFECT OF ARJUNA BARK

6.1 Antimicrobial Activity

Flavonoids extracted from T. arjuna bark were found to have antibacterial properties.The study looked at the bark of T. arjuna for Several bioactive chemicals. Both confined and free. Flavonoids demonstrated efficacy against all infections. The strongest inhibitory effect was seen against Agrobacterium tumefacient and Bacillus subtilis, both the flavonoids. T. arjuna leaves and bark extracts have antibacterial properties against several infections, including Staphylococcus aureus. Acinetobacter sp., Proteus mirabilis, and Escherichia coli Pseudomonas aeruginosa, Candida albicans microorganisms that cause ear infections. Organic Extract of T. arjuna bark had a larger inhibitory zone than the Herbal drops for treating bacterial ear infections. Especially S. aureus [3].

6.2 Anti-inflammatory Activity

Polyphenolic substances can alleviate oxidative stress by scavenging free radicals and inhibiting their formation by enzymes or trace element chelation. Polyphenols have been shown to have anti-inflammatory properties, both in vitro and in vivo. Plant polyphenols can lower inflammation biomarkers and proinflammatory cytokines while increasing the synthesis of antiinflammatory mediators.[14]. This suggests that the extract may have an inhibitory effect on carrageenan-induced inflammation. Because of the suppression of enzyme Cyclooxygenase leads to inhibition of Prostaglandin synthesis. This study found that the methanol extract from Terminalia arjuna leaves demonstrated analgesic and immediate anti-inflammatory effects[15]. According to Ayurvedic standards, arjuna ksheerapaka was made in cow milk and compared to a typical hydroalcoholic decoction of T. arjuna. The extracts were analyzed for phytoconstituent levels and antioxidant activity, including DPPH free radical scavenging and lipid peroxidation inhibition. The overall extraction yield of Arjun Ksheera Paka was two times that of hydroalcoholic extract. This means that the phytoconstituents in Arjun Ksheera Paka were diluted by a factor of 0.5. The study revealed that the hydroalcoholic extract has better antioxidant activity than Arjun Ksheera Paka. The study examined the anti-inflammatory properties of T. arjuna leaves in Wister albino rat models. Arjuna leaves were dried and crushed before extracting with petroleum ether and methanol. Animal models were tested for anti-inflammatory activity using methanol extract at doses of 100mg/kg and 200mg/kg body weight. In Wister albino rats, acute anti-inflammatory activity was assessed using carrageenan, histamine, and dextran-induced paw oedema. Aspirin and indomethacin were the medications recommended for anti-inflammatory investigations. In the examined models, the methanol extract of T. arjuna leaves shown considerable anti-inflammatory activity[3].

6.3 Cardiovascular Activity

Its bark decoction has long been used in the Indian subcontinent to treat anginal discomfort, hypertension, congestive heart failure, and dyslipidemia, according to traditional physicians. Arjuna is a possible cardioprotective agent from the Combretaceae family. It is an ayurvedic medicine referenced in numerous ancient Indian medicinal works, such as Charaka Samhita, Sushruta Samhita, and Astang Hridayam, dating back to the Vedic period. Vagabhatta was the first to recommend the use of stem bark powder for cardiac diseases. Arjuna's cardioprotective activity was comparable to that of fluvastatin. Arjuna bark extract provides a considerable preventive and therapeutic benefit in protecting the heart against catecholamine-induced CHF, probably through preserving endogenous antioxidant enzyme activities and lowering LPO and cytokine levels[16]. T. arjuna bark has been shown in tests to have considerable inotropic and hypotensive effects, including increased myocardial contractility, coronary artery flow, and protection against ischemia damage. T. arjuna can protect myocardium and improve various cardiac injuries[17]. Arjunolic acid has been utilized as a heart tonic in Ayurvedic medicine for ages, and it was initially discovered in Terminalia arjuna. Bark extracts contain a wide range of components, including triterpenoid saponin, which is an arjunolic acid. Physicochemical studies on the experimental rabbit and frog hearts revealed that Terminalia Arjuna bark possessed cardiotonic properties.As a result, it was observed that intravenous administration of the glycoside derived from Terminalia Arjuna bark caused a rise in blood pressure. The bark powder was shown to have cardiotonic and diuretic properties. The analysis of the isolated frog heart revealed that the water-based bark extract displayed chronotropic and inotropic actions. The bark's aqueous extract was isolated from rat atria and tested positive for inotropy. A water-based extract of bark from rat atria generated inotropic activity, as demonstrated by propanolol and cocaine. Arjuna root contains the novel element 16, 17-Dihydroneridienone, 3-O-β-D-glucopyranosyl-(1-6)-O-β-D-galactopyranoside, which can be used as a cardiotonic agent[18].

Coronary Flow

To maximize coronary flow, aqueous extract from bark was injected into an isolated rabbit heart. The dose of 1024 µg/ml results in the largest increase in coronary flow[18].

Hypotensive Effects

The injection of alcoholic and aqueous extracts into intravertebral and intracerebroventricular extracts of bark resulted in dose-dependent sustained bradycardia and hypotension. Although the alcoholic extract showed a hypotensive effect in dogs, it was obtained after pretreatment with atropine. In dogs, intravenous administration of aqueous extract of Terminalia Arjuna led to dose-dependent decreases in blood pressure[18].

6.4 Antioxidant Activity

Antioxidant substances such as phenolic acids, polyphenols, and flavonoids scavenge free radicals including peroxide, hydroperoxide, and lipid hydroxyl, preventing oxidative mechanisms that cause degenerative illnesses . Although hydrogen peroxide is not very reactive, it can be hazardous to cells due to the formation of hydroxyl radicals. Extracts' ability to scavenge H2O2 may be due to their phenolic content, which donates electrons and neutralizes it with water. The extracts effectively scavenged hydrogen peroxide at varying concentrations. When NO reacts with oxygen, it produces stable nitrate and nitrite, which can be measured using the Griess reagent. Scavenging test compounds reduce nitrous acid levels, which can be detected at 546 nm.

T. arjuna bark extracts in methanol and ethanol exhibit high nitric oxide scavenging action. [19].

6.5 Antidiabetic effect

Traditional healers claim that the stem bark of the plant has anti-diabetic properties.[20]

6.6 Hypolipidemic effect

Experiments and clinical research show that the dried bark powder of this plant has significant hypolipidemic and cardioprotective properties.T. arjuna fractions (50-500 pg/ml) reduced Cu 247-mediated lipid peroxidation of LDL in a concentration-dependent manner.[21]

6.7 Antinalgesic effect

Most popular Nighantus, including Dhanvantari, Kaiyadeva, Raja, and Bhavaprakash, ascribe the drug's wound-healing properties.To relieve pain in the lower limbs, five grams of finely powdered T. arjuna stem bark are used twice daily for three days.A critical analysis of previous research studies on Arjuna reveals that the bark was not examined for its analgesic properties. Keeping this in mind, the current study was designed and carried out based on tribal claims to investigate analgesic effectiveness in Swiss albino mice using the tail flick method, acetic acid-induced writhing response, and formaldehyde-induced paw licking method.[22]

6.8 Anti acne properties

Acne vulgaris is a common skin ailment of the Pilosebaceous unit, affecting areas with the most oil glands, such as the face, back, and trunk.The condition is characterized by seborrhea, comedones, inflammatory lesions, and bacteria. Propionibacterium acnes, Staphylococcus epidermidis, and Malassezia furfur are found in the follicular canal and contribute to sebum production.Propionibacterium acnes is considered an obligatory anaerobic bacteria. It contributes to inflammatory acne by activating complements and converting sebum triglycerides into fatty acids that attract neutrophils.Terminalia arjuna, a member of the Combretaceae family, has traditional uses as an astringent, wound healer, heart stimulant, hemoptysis, lithontriptic, and treatment for bilious infections, diarrhea, and acne.This study examines the creation and assessment of herbal anti-acne creams using flavonoid and tannin fractions from Terminalia arjuna bark. The herb has been used to treat wounds and acne.The results indicate that integrating flavonoids and tannins from Terminalia arjuna bark could be an alternate treatment for acne.[11]

6.9 Antimutagenic

T. arjuna acetone and methanol fractions shown antimutagenic activity against Acid Black dye, NPD, and 2AF (promutagen).Both pre-incubation and co-incubation showed similar inhibitory effects at varying fraction concentrations. Both fractions effectively suppressed 2AF-induced revertants, outperforming direct-acting mutagens. In pre-incubation mode, acetone and methanol fractions inhibited 2AF-induced mutations by 99.49 and 99.80%, respectively. In the presence of S9, the methanol fraction inhibited acid black dye-induced revertants more effectively than the acetone fraction[23]. Previously, tannins and flavonoids were found to have anticancer effects.Plants may include chemical compounds that serve as anticarcinogens or antimutagens by preventing or trapping carcinogen electrophiles in a nucleophilic process, resulting in harmless products. The bark of T. arjuna contains 60-70% polyphenols, including flavonoids, tannins, and triterpenoids. These components are primarily responsible for anticancer action[24].Terminalia arjuna is a widely known medicinal herb.Plants have several secondary metabolites that exhibit antimutagenic activity[25].

USES OF TERMINALIA ARJUNA IN MANY OTHER DISEASES

Terminalia arjuna (Roxb. ex DC.) Wight & Arnot (Combretaceae) is a widely used medicinal tree in Indian traditional medicine[26].Terminalia arjuna is a prominent Indian medicinal plant, and its bark has been used for ages as a cardiotonic[27].Terminalia arjuna (Roxb. ex DC.) Wight & Arn. (T. arjuna) is widely used in traditional Ayurvedic medicine as a cardioprotectant and for acute and chronic renal disorders, indicating its ethnopharmacological use[28].We infer that arabinogalactan is an important component of Terminalia arjuna that contributes to its antitussive activity[29].AgNPs' antibacterial activity was tested against Gram-positive (Staphylococcus aureus), Gram-negative (Escherichia coli), and pearl millet blast disease-causing fungi (Magnoporthe grisea)[30].The findings suggest that the extract can protect hepatic and cardiac tissues from Cd-induced oxidative stress-mediated damage via an antioxidant mechanism(s)[31].Several clinical trials have also shown that it is useful in individuals with chronic stable angina, endothelial dysfunction, heart failure, and even ischemic mitral regurgitation[32].The thermodynamic analysis demonstrated the spontaneity of the physisorption

process[33].This study revealed the composition, antibacterial activity, antioxidant activity, and cytotoxicity of bark oil from Terminalia arjuna (Roxb.)[34].Terminalia arjuna is indigenously used in India for curing several diseases, and its pharmacological activities are being revisited in recent drug-repurposing research[35].The bio-reduction properties of the T. arjuna (TA) bark extract were used to produce selenium nanoparticles[36].Polyphenols have antioxidant characteristics and are well-known health actives. It is vital to characterize polyphenols in Terminalia arjuna[37].In the present investigation, we used high-throughput sequencing of mRNA from control and treated rat hearts to confirm its efficiency[38].PH's key pathological hallmarks include pulmonary vascular smooth muscle enlargement and increased oxidative stress[39].Herb-drug interactions (HDI) are one of the most significant clinical problems in the concurrent ingestion of herbs and prescription medications[40].Terminalia arjuna stem bark, which has been used in folk medicine since antiquity, was tested for piscicidal efficacy[41].The current study was carried out to evaluate the antidiabetic effect of T. arjuna stembark extract and to study the activities of hexokinase, aldolase, and phosphoglucoisomerase, as well as gluconeogenic enzymes such as glucose-6-phosphatase and fructose-1,6-diphosphatase in the liver and kidney of normal and alloxan[42].After one month of T. arjuna medication, reflex bradycardia improved dramatically, while reflex tachycardia did not.[43] Powders and extracts made from them are commonly used to treat liver illnesses such cirrhosis, hepatitis, and loss of appetite[44] Prolonged dosing of T. arjuna had no detrimental effect on renal, hepatic, or hematological parameters[45] Terminalia arjuna (Ta) bark contains several natural antioxidants and has been utilized to protect animal cells from oxidative stress[46] T. arjuna bark will work as a cryoprotectant and a superb zinc supplement for smokers to maintain sperm motility and morphology[47] T. arjuna bark extract has been shown to be an effective heart stimulant in treating angina.[48] For millennia, the bark of Terminalia arjuna (TA) has been utilized in Ayurvedic medicine as a cardiotonic to treat cardiac diseases[49] Atherosclerosis, which comes from the progressive accumulation of lipids in medium and large arteries, is a leading cause of death globally. Terminalia arjuna is a herb from the Combretaceae family that includes hypolipidemic chemicals and flavonoids with strong antioxidant effects[50] Pentacyclic triterpenoids increase the epidermal barrier function and stimulate collagen synthesis[51] The aqueous extract of Terminalia arjuna (TA) bark (TAAqE) was found to have a direct inotropic impact on ventricular myocytes[52] The level of oxidative damage produced by alcohol to erythrocytes was assessed, as well as the protective capacity of T. arjuna bark powder aqueous extract (AETA)[53] For ages, the Indian subcontinent has used aqueous bark extract of Terminalia arjuna (TA) as an ethnomedicine to treat cardiovascular diseases. Studies utilizing hemodynamic, ROS scavenging, and anti-inflammatory parameters in animal models have proven its anti-atherogenic, hypotensive, inotropic, and anti-inflammatory properties[54] T. arjuna and oxalate-induced damage to renal tubular epithelial cells. Madin-Darby canine kidney. T. arjuna bark has cytoprotective properties, and based on our findings, it could be a promising natural plant source for urolithiasis treatment[55] The principal bioactive components of Terminalia arjuna stem bark are arjunic acid and arjunolic acid, which have been linked to a variety of biological activities[56] The antibacterial activity of TA-AgNPs was tested against Escherichia coli[57] Terminalia arjuna is a medicinal plant that is well-known in the Ayurvedic medical system for its cardiotonic properties.[58] T. arjuna bark extract has a strong preventive and therapeutic positive effect on protecting the heart from ISO-induced CHF, probably by preserving endogenous antioxidant enzyme activity.[59] Low dosage of the herbal extract residue was effective to control the tumor volume 35.1% and 32.9% increase in the lifetime was observed at both high and low dosages, respectively[60] For decades, numerous societies have employed herbal treatments to alleviate ailments. These medicinal plants were discovered to possess a variety of phytochemical substances that can help cure mild to severe ailments.[61] The bark of the Terminalia arjuna tree has a long history of usage as a cardiac tonic, with indications for treating coronary artery disease, heart failure, hypercholesterolemia, and anginal discomfort.[62] Terminalia chebula and Terminalia arjuna were frequently utilized in traditional medicine to treat memory loss, inflammatory problems, and anti-aging properties[63] Chronic heart failure (CHF) is defined as left ventricular (LV) dysfunction along with compromised autonomic regulatory systems. Herbal medications are increasingly being used to treat cardiovascular disease[64] Terminalia arjuna (TA) has been utilized as folk medicine since antiquity. Aside from its medicinal qualities, it exhibits anti-spermatogenic activity; nevertheless, its effectiveness and manner of action on male gonadal activity are unknown[65]The influence of acetone and methanol extracts of a medicinal plant, Terminalia arjuna, on the proliferation of human normal fibroblasts (WI-38), osteosarcoma (U2OS), and glioblastoma (U251) cells[66] Arjunetoside, a novel triterpene glycoside, as well as oleanolic and arjunic acids, were isolated from Terminalia arjuna root bark.[67]Terminalia arjuna bark, an indigenous herb used in Ayurvedic medicine in India, particularly as a cardiotonic, is also used to treat diabetes, anemia, tumors, and hypertension[68] Arjun bark (Terminalia arjuna) is a natural herbal colorant used in cotton dyeing that is environmentally benign. This is owing to a surge in global demand for natural dyes for therapeutic, food, textile, agricultural, engineering, and medical applications[69] Arjunic acid (AA) is one of the main active components of Terminalia arjuna and is known for its health benefits[70].

Toxicological studies of terminalia arjuna

Numerous clinical research have found that the optimal dose of T. arjuna for patients with coronary artery disease (CAD) is between 1 and 2 grams per day. The supplied dose caused a few side effects, including headache, mild gastritis[4]. The treatment with TA Bark extract restored the activity of antioxidant enzymes. These data indicate that TA bark extract can alleviate the negative effects of lead acetate-induced toxicity and can be employed as a therapeutic intervention against metal toxicity[71].

CONCLUSION

The arjuna bark is used in many diseases but mainly used as a cardiotonics and it contain mainly chemical constituents like tanins polyphenols flavanoids etc. It is also used in acne. It has more widely used in cvs and it is herbal so it has no side effects.

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