STM JOURNALS

Research & Reviews: A Journal of
Ayurvedic Science, Yoga & Naturopathy

ISSN: 2395-6682
Volume 12, Issue 3, 2025
September–December
DOI (Journal):10.37591/RRJoASYN

https://journals.stmjournals.com/rrjoasyn

Review RRJOASYN

Terminalia arjuna: The Medicinal Tree

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Abstract

Over 85% of the medications used in both conventional and alternative medical systems come from plant sources. The stem bark of Terminalia arjuna (T. arjuna) is rich in minerals, flavonoids, and glycosides. T. arjuna bark is unique because flavonoids have been shown to have anti-inflammatory, lipid-lowering, and antioxidant properties, and glycosides are cardiotonic. A variety of topics related to its ethnomedical, phytochemical, pharmacological, and clinical significance to different medical conditions have been attempted to be covered in this review. After superfluous information was removed, 60 articles were found in all. Most of the research, including both clinical and experimental studies, has indicated that T. arjuna bark has hypolipidemic, antioxidant, and anti-ischemic properties. Among its advantageous phytoconstituents are triterpenoids, flavonoids, glycosides, tannins, phenolics, and arjunolic acid. Experimental studies have demonstrated the potent antioxidant and cardioprotective properties of T. arjuna bark. Here is an extended version of your abstract with ~100 more words added in continuation, keeping the flow and scientific tone intact: Over 85% of the medications used in both conventional and alternative medical systems come from plant sources. The stem bark of T. arjuna is rich in minerals, flavonoids, and glycosides. T. arjuna bark is unique because flavonoids have been shown to have anti-inflammatory, lipid-lowering, and antioxidant properties, and glycosides are cardiotonic. A variety of topics related to its ethnomedical, phytochemical, pharmacological, and clinical significance to different medical conditions have been attempted to be covered in this review. After superfluous information was removed, 60 articles were found in all. Most of the research, including both clinical and experimental studies, has indicated that T. arjuna bark has hypolipidemic, antioxidant, and anti-ischemic properties. Among its advantageous phytoconstituents include triterpenoids, flavonoids, glycosides, tannins, phenolics, and arjunolic acid. Experimental studies have demonstrated the potent antioxidant and cardioprotective properties of T. arjuna bark. Furthermore, several clinical investigations have reported its beneficial effects in managing hypertension, coronary artery disease, and heart failure. The bark extracts have been observed to improve endothelial function, reduce oxidative stress, and enhance myocardial efficiency. In addition, studies suggest its potential role in modulating lipid metabolism and reducing serum cholesterol levels, thereby lowering cardiovascular risk factors. Its traditional use in Ayurveda as a heart tonic is now supported by increasing pharmacological evidence, making it a promising natural therapeutic agent. With rising interest in plant-based medicines, T. arjuna continues to gain attention as a safe, well-tolerated, and effective herbal option in cardiovascular health management.

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Received Date: July 15, 2025
Accepted Date: August 20, 2025
Published Date: August 21, 2025

Citation: Shreya V. Chaudhari, Sunil A. Patil, S.P. Pawar. *Terminalia arjuna*: The Medicinal Tree. Research & Reviews: A Journal of Ayurvedic Science, Yoga & Naturopathy. 2025; 12(3): 27–34p.

Keywords: *Terminalia arjuna* bark contains flavonoids, antioxidants, cardioprotectants, ayurvedic medicine, heart health

INTRODUCTION

Arjun tree, Arjuna, Koha, Kahua, Arjan, White Maroondah, White Murdh, Arjuna Myrobalan, Orjun, Yerra Maddi, Sadada, and Sadaru are other names for *Terminalia arjuna* (*T. arjuna*), a tree belonging to the Combretaceae family. This deciduous riparian tree is indigenous to India and can also be found in Pakistan, Sri Lanka, Myanmar, and a few other Asian countries.

The Latin term "terminalis" or "terminus," meaning "ending," is the source of the name Terminalia. Stated differently, it refers to the tendency of this plant's leaves to be densely packed near the terminals of the shoots. The Rig-Veda and Atharvaveda, two ancient Indian scripts, both give a detailed description of the name "Arjuna." Something that is "white," "bright," or most likely the glistening quality of its (Chaal) bark is referred to here. Terminalis has been employed in the ancient Ayurvedic medicinal system since the 7th century. The entire plant is used, usually as an infusion of milk. Terminalis is typically used by Ayurvedic practitioners to treat blood problems and cardiovascular issues. Tassar silk, often referred to as Tussah, is a form of wild silk with substantial commercial value that is produced by the Antheraea paphia moth, which consumes the leaves of this tree. The tree is often planted to provide shade, especially in coffee fields.

Medicinal plants have long been the primary source of therapeutic compounds used to treat human illnesses. Many traditional medical systems, including Ayurveda, Siddha, and Unani, use *T. arjuna*, a common therapeutic herb.

This review was carried out to compile pharmacological and phytochemical data that may be found in various scientific publications. Numerous phytochemical constituents have been reported to be present in this plant, including β-Sitosterol, flavonoids (Arjunone, arjunolone, etc.), tannins (casuarinin, gallic acid, pyrocatechols, etc.), triterpenoids (arjunolic acid, arjunic acid, arjunin, terminic acid, etc.), and glycosides (arjunetin, arjunosides, arjunglycosides, etc.). that display a range of pharmacological properties, including those that are antimicrobial, anticancer, cardioprotective, antifungal, antidiabetic, antioxidant, anti-inflammatory, hypolipidemic, anthelmintic, insecticidal, wound-healing, anti-acne, and gastroprotective [1].

DESCRIPTION

Plant Profile

- *Kingdom:* Plantae.
- *Division:* Magnoliophyta.
- *Class:* Magnoliopsida.
- *Order:* Myrtales.
- *Family:* Combretacea.
- *Genus:* Terminalia [2].
- *Bark of T. arjuna:* On the outside, it is smooth, drab, and basic (Figure 1). From the inside out, the bark is red, velvety, and thick [2, 3].

Figure 1. Bark of *Terminalia arjuna*.

- *Habitate:* Arjuna plants can be found all throughout the Indian subcontinent, including in Bihar, Madhya Pradesh, Bengal, and the foothills of the Himalaya. Huge arjuna plants grow [2, 3].
- *Plant Description:* The enormous deciduous tree is called Arjuna. The Arjuna tree has a 100-foot growth potential. It is evergreen with golden blooms and conical leaves. Its bark is smooth and gray. The fruit has five stiff wings, is spherical, woody, striped, and is 2.5–3.5 cm in length. It also contains many twisted veins. A buttressed stem supports a wide, spreading crown from which its branches grow. Its leaves are dull green on top and pale brown below. Arjuna flowers from September to November [2, 3].
- *Leaves:* These leaves, which are 4–6 inches long and 2–3 inches wide, are glabrous, oblong, subopposite, and often inequilateral, just like guava leaves. Two glands are located near the base of the petiole. The apex of the crenulate margin is an obtuse or subacute angle. The base is rounded or cordate. Petioles are between 0.5 and 1.3 cm long [2, 3].
- *Flowers:* Clusters of yellow or white blooms are seen. After flowering in the summer, fruits are produced in the winter or spring [2, 3].
- *Fruits:* The fruits are 1–1.5 inches in diameter and contain 5–7 longitudinal lobes. They have 5–7 wings and are glabrous, woody, and fibrous. Fruit is drupe-shaped, frequently has a notch at the top, and has striations that curve upward and obliquely [2, 3].
- *Chemical constituents:* Terpenoids, ursane riterpenoids, and glucosides – Triterpenoids are chemical compounds with varying structural diversity, resulting from alterations to their basic backbone. Examples of these variations include ursolic and oleanolic acid [4, 5].
- *Flavonoids along with phenolics:* Regarding its medicinal value, the bark of *T. arjuna* is the most significant component of the plant. Numerous flavonoids, including flavones, arjunolones, kempferol, baicalein, pelargonidin, and quercetin, are found in the bark. Due to a negative correlation between increased intake of dietary flavonoids and the onset of ischemic heart diseases (CADs), these flavonoids are especially beneficial in the treatment of cardiovascular conditions [6].
- *Tannins:* Many different plant components contain water-soluble polyphenols called tannins. Tannins have many different qualities. One of these qualities is that like tea polyphenols, it is an anticarcinogen. In addition, it possesses antioxidant and antimutagenic properties [7].

GEOGRAPHICAL CHARACTERISTICS

- *Distribution:* Most India's mixed dry deciduous tropical forests are home to this species. It grows as an avenue tree in other places and is frequently found along water courses. It is a typical avenue tree in many places, including Delhi.
- *Climate and Soil:* The plant grows naturally in the country's tropical and subtropical moist regions. Alluvial loamy or black cotton soils are preferred by the tree because they are loose, moist, productive, and have good drainage and water-holding capacity. Its native habitat consists of ravines, streams, and riverbank soils. Additionally, the plant endures in wide, sunny regions with little rainfall.
- *Planting Material:* Seeds are the ideal medium through which to propagate an idea. Early summer from trees older than 6 years old are good places to gather the seeds. Ripe fruits are gathered in March by mowing the branches or by sweeping the already cleared land. When kept in sealed containers, the seeds can be planted and kept for at least a year [8].

ROLE OF *T. ARJUNA* IN VARIOUS DISEASES

The primary active ingredients in *T. arjuna* are calcium, magnesium, zinc, copper, terminic acid pyrocatechols, gallic acid, arjunolic acid, and α-sitosterol. Together with wound healing, cadioprotective, and insecticidal properties, they are all valuable therapeutic substances with anticancer, antibacterial, antiacne, antidiabetic, antianthelmintic, anticholinesterase, anti-inflammatory, antioxidant, and antiasthmatic properties. Typically, *T. arjuna* is used to treat hypertension, cardiomyopathy, and cancer. It is also utilized as an antioxidant, hypolipdemic, antimutagenic, hypocholesterdamic, and to lessen the effects of stress and anxiety. Additionally, it can shield liver and kidney tissue from oxidative damage caused by CCl_4 [9].

EXPERIMENTAL EVIDENCE

- *Effect on CCl_4-induced hepatic and renal disorders:* Because carbon tetrachloride produces free radicals, it causes hepatotoxicity and nephrotoxicity, which damage the liver and kidneys. The production of chlorine and trichloromethane free radicals is caused by the metabolic activation of carbon tetrachloride. When oxygen and free radical trichloromethane combine, more reactive free radical CCl_3OO is produced. This could result in oxidative stress, which lowers the amount of glutathione inside cells and inhibits the actions of antioxidants, like catalase and superoxide dismutase. It can also lessen the detoxification that glutathione-s-transferase produces. Lipid peroxidation in the liver and kidneys increases when antioxidant activity declines. The aqueous extract of *T. arjuna* possesses antioxidant properties that safeguard the kidney and liver's antioxidant machinery by elevating the levels of catalase, glutathione-S-transferase, and superoxide dismutase while lowering lipid peroxidation [10].
- *Effect on diclofenac sodium induced gastric ulcer:* An NSAID called diclofenac sodium is used to treat rheumatoid arthritis and osteoarthritis, but it also has hazardous side effects that include stomach perforation, bleeding, and ulceration. During long-term nonsteroidal anti-inflammatory medication therapy, stomach ulceration affects 10–25% of patients. *T. arjuna* is an herb used to cure ulcers brought on by nonsteroidal anti-inflammatory drugs. Many substances, including tannin, saponin, steroids, phenol, flavonoids, etc., are present in *T. arjuna*. Tannin inhibits the development of ulcers by vasoconstriction and protein precipitation. Additionally, flavonoids lessen lesions caused by necrotic agents. Acid is the primary cause of both acute and chronic gastric mucosal lesions after *T. arjuna* treatment for gastric ulcers [11].
- *Effect of arjunolic acid on arsenic-induced hepatic disorder:* Arsenic damages almost every organ, but primarily the liver. Arsenic produces reactive oxygen species, including superoxide anion radicals, hydroxyl radicals, and hydrogen peroxide.

These free radicals cause a reduction in the number of antioxidants, like glutathione and thiols, as well as an increase in lipid peroxidation, protein carbonyl content, and deoxyribonucleic acid fragmentation. Pretreatment with arjunolic acid prevents all of these alterations without having any adverse consequences.

Arsenic-induced toxicity was inhibited by a five-membered chelate complex consisting of arsenic and arjunolic acid. Cells are shielded from oxidative stress by the polyhydroxyl groups in arjunolic acid, which interact with ROS and can scavenge free radicals. Arjunolic acid's chelating and free radical scavenging properties are likely to contribute to its protective effect against hepatic diseases [12].

ROLE OF TISSUE CULTURE IN *T. ARJUNA*

- *Direct organogenesis:* Direct organogenesis is the *in vitro* process by which adventitious shoots develop directly from plant somatic tissue.
- *Explant collection and preparation:* It was found that cotyledonary nodes, seedling nodal explants, and nodal explants from trees can be used to directly organogenize *T. arjuna*. It is well known that elder shoots may contain chemicals with inhibitory properties, hidden microbes that could hinder a plant's development and eventually destroy the explants. Furthermore, Arjuna Terminalia branches that were both trimmed and untrimmed were used to gather the transplants. the month of the surgical procedure. The collection influences the in vitro reaction as well. The group of transplants that came together in April and May was quite acceptable. In relation to the proliferation of shoots. 2% (v/v) cetrimide or tween-20 was first applied to the transplants to eliminate dust particles. Sodium hypochlorite [4% (w/v) accessible chlorine] or 0.05–0.1% $HgCl_2$ was used for surface sterilization. Occasionally, soaking the nodal explants for 30 seconds in 70% alcohol assisted in the elimination of impurities. The primary issue with *T. arjuna* was the browning of the culture media, which increased the likelihood of microbial infection and necrosis in the explants. By shaking the explants in a prechilled solution containing ascorbic acid, citric acid, and PVP or adding ascorbic acid and PVP to the medium with activated charcoal, the issue of phenolic exudation during culture establishment was resolved [13].

- *In vitro shoot proliferation:* Any plant species' hormonal needs are determined by the hormone's endogenous level. Auxins Naphthaleneacetic Acid, Indole-3-butyric Acid, and Indole Acetic Acid as well as cytokinins BAP (6-Benzylaminopurine), Kinetin, and Thidiazuron, were among the plant growth regulators that affected the in vitro shoot proliferation. Out of all these PGRs, 8.86 μM BAP was found to be the most potent plant growth regulator for bud break response. Bud rupture is also encouraged in some plants by the interplay of auxin and cytokinin [14].
- *Organogenesis by indirect means:* After a callus phase, plant organs can potentially grow again from the somatic tissue through indirect organogenesis.
- *Explant collection and preparation:* Indirect organogenesis made use of a range of explants, including leaves, cotyledons, hypocotyls, and epicotyls. After giving these explants a liquid soap wash, they were surface sterilized for 1 minute with 70% ethanol and then for 5 minutes with 0.1% HgCl2. The explants were divided into pieces and cultivated on MS-medium supplemented with varying concentrations of 2, 4-D, glycine, myoinositol, pyridoxine HCl, thymine HCl, nicotinic acid, and 3% sucrose. The medium was set with 0.7% agar-agar [15].
- *Induction of callus:* The effectiveness of callus induction depends on the kind of explants used. Although many explants can develop calluses at the site of damage, actively mitotic cells are the most effective at doing so. In *T. arjuna*, cotyledon, hypocotyl, epicotyl, and leaves were used as explants. The leaf was shown to be the most effective explant for callus induction, followed by the epicotyl. used internodes, young leaves, and leaf petioles as explants to induce callus and found that the internodes worked best. The least susceptible was the cotyledon explant [16].

PHARMACOLOGICAL ACTIVITIES

- *Antimicrobial activity:* About 16 of the 34 plant species that were tested using the disc diffusion method for their antibacterial activity against gram-negative bacteria, including Escherichia coli, Klebsiella aerogenes, Proteus vulgaris, and Pseudomonas aerogenes, showed action. These species belong to 18 different families. Of these, *T. arjuna* exhibited noteworthy antimicrobial efficacy against the microorganisms under investigation.
- *Antifungal action:* The organic extracts of five Terminalia species were evaluated using plant pathogenic fungus, specifically *A. flavus*, *A. alternata*, *A. niger*, *A. brassicicola*, and *H. tetramera*. All five plants' leaf extracts were shown to suppress various plant diseases. *T. arjuna* polar extracts showed potent antifungal action against eight different types of Candida. Three fungus strains were evaluated to determine the antifungal properties of extract from *T. arjuna* leaves (40, 60, 80, and 100%).
- *Antidiabetic activity:* There may be effects on diabetes from *T. arjuna* extracts. Alkaline phosphatase, acid phosphatase, alanine aminotransferase, aspartate aminotransferase, lactate dehydrogenase, and the activities of glucose-6-phosphatase, fructose-1,6-disphosphatase, and aldolase are significantly reduced in tissues when *T. arjuna* bark extracts are applied. Phosphoglucoisomerase and hexokinase are also significantly increased.
- *Activity of antioxidants:* Extracts from *T. arjuna* might be used to supply antioxidants to the food and pharmaceutical sectors. *T. arjuna* may have antioxidant and free radical scavenging qualities due to its greater flavonoid and phenolic content.
- *Reduce the toxicity caused by arsenic:* Arsenic is one of the environmental pollutants that causes tissue damage. Exposure occurs by inhalation, skin absorption, and consumption of tainted food and water. The primary source of arsenic-induced toxicity is oxidative stress, which is followed by a compromised antioxidant defense system. It has been demonstrated that arjunolic acid guards against cytotoxicity caused by arsenic, most likely because of its ability to chelate metals and scavenge free radicals.
- *Cardioprotective activity: T. arjuna* is used therapeutically in a variety of ways for heart disease, depending on the empirical explanation found in traditional medical treatments.
- *Cardiotonic activities:* Since it was initially isolated from *T. arjuna*, arjunolic acid has been utilized for centuries in ayurvedic medicine as a heart tonic. Bark extracts primarily contain arjunolic acid, a triterpenoid saponin. In addition to arjunolic acid, arjungenin was also discovered to be highly

effective in scavenging free radicals and inhibiting the generation of hypochlorous acid. Its glucoside, which was over 50% active and had a cardioprotective effect, was found to be secondary in activity. Rat atria were used to extract the bark's aqueous extract, which demonstrated positive inotropic action. *Terminalia arjuna* (aqueous extract) increased the force of contraction of the cardiac muscle in the isolated perfused rabbit heart, the hypodynamic frog's heart in situ, and the frog's heart in situ.

- *Anti-anginal effects & Myocardial infarction:* Patients with stable angina pectoris symptoms respond quite well to *T. arjuna* treatment. It does, however, only play a minor part in unstable angina. When isoproterenol was used to induce myocardial infarction in mice, *Terminalia arjuna* ethanol extract (TAEE) and *Terminalia arjuna* aqueous extract (TAAE) both significantly reduced heart damage.
- *Coronary flow:* In an isolated perfused rabbit heart, 400 μg of TAAE increased coronary flow and caused dose-dependent bradycardia. Nevertheless, the drug turned out to be less powerful than digoxin since higher doses were needed. On the isolated perfused rabbit heart, a 1024 μg/ml dosage of TA extract considerably improved the coronary flow [17].

CLINICAL USES

- *Angina/myocardial infarction:* Bark powder's anti-ischemic efficacy was assessed in 30 patients with post-infarct angina and stable angina (500 mg tds). The authors observed a significant drop in mean anginal frequency, along with a significant decrease in systolic blood pressure (SBP), improvement in ECG abnormalities, and a decrease in plasma cortisol and serum cholesterol levels [18].
- *Hypertension and CHF:* Ten CHF patients were given 4 g of arjuna bark powder twice a day for a month in one of the first investigations. Significant diuresis, a decrease in both systolic and diastolic blood pressure, and improvements in functional class, dyspnea, and general health were noted by the researchers [19].
- *Heart disease caused by rheumatism:* Arjuna's efficacy in treating decompensated rheumatic heart disease was examined in a double-blind study. Arjuna 200 mg was administered three times a day to thirty individuals with congestive heart failure and rheumatic valvular heart disease [20].
- *Heart disease:* It has been demonstrated that arjuna lowers LVM and increases LVEF in addition to having anti-ischemic effects. A recent observational study found that those with dilated cardiomyopathy and decreased LVEF who took arjuna in addition to their regular prescription exhibited a significant improvement in their left ventricular measures and functional ability [21].
- *Stress from oxidation and dyslipidemia:* One study found that after taking one gram of bark powder twice a day with milk for four months, the lipid profiles of twenty-one people with coronary heart disease improved. Additionally, people experienced clinical relief after a month of medication [22].

Toxicity and Side Effects of *T. arjuna*

Most herbal and traditional remedies, including *T. arjuna*, are well known for having the fewest negative effects, which accounts for their appeal. There are no known cases of *T. arjuna* poisoning [23].

The most common application for *T. arjuna* is the treatment and management of coronary artery diseases (CAD); an optimal dosage for this condition is 1–2 g daily, and for congestive heart failure, 500 mg of the bark extract three times a day is recommended. Constipation, moderate gastritis, and headaches are among the treatment's relatively minor adverse effects that have been documented. Following the use of this medication for over 2 years, no indications of hepatic, renal, metabolic, or hematological damage were observed [24, 25].

CONCLUSIONS

Arjuna offers a plethora of health benefits, but what is even more alluring about this natural health food is that it hardly has any negative effects. With a few notable exceptions, it is safe for most individuals to consume. The present review states that *T. arjuna* is utilized to cure a variety of common ailments. We have gathered information about botanical, phytochemical, and pharmacological studies

in the current review. Numerous pharmacological activities of the plant have been investigated, including antioxidants, anthelmintics, antihyperglycemic, antihyperlipidemic, cardioprotective, immunomodulatory effects, hepatoprotective, and studies on analgesic and anti-inflammatory, hepatoprotective, hyperthyroidism, hyperglycemia, and lipid peroxidation. For this reason, it is essential to fully utilize its potential in the fields of pharmaceutical and medical sciences to produce innovative and successful. *Terminalia arjuna* (Roxb.) Wight & Arn. has been used as a traditional medicinal plant to cure a variety of ailments since ancient times. In medicine, almost every component is used. Indigenous people have utilized various portions of *T. arjuna* directly to treat a wide range of ailments, including headache, ulcers, snakebite, ear pain, eye infection, cough, chest pain, heart pain, and bone fractures. The plant is rich in phytosterol, natural oxidants, tannin, saponins, flavonoids, ellagic acid, arjunolic acid, phytosterol, and reducing sugar in addition to a variety of minerals, like magnesium, zinc, calcium, and cobalt. It has been determined that *T. arjuna* possesses qualities such as immune modulatory, cardiotonic, hypatoprotective, insecticidal, antioxidant, antidysenteric, antidiabetic, antibacterial, and antimutagenic. It is mostly used to treat conditions linked to the heart.

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