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Review Paper

Phytochemical Profile and Pharmacological Efficacy of Terminalia Arjuna: A Detailed Pharmacognostic Review

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ABSTRACT

Terminalia arjuna, well-known medicinal plant in Ayurveda, has been used for a variety of health issues, especially those related to the heart. This review thoroughly examines the pharmacological attributes and therapeutic uses of *T. arjuna*, placing emphasis on its possible advantages for heart health. The plant's phytochemical profile, which includes flavonoids, tannins, and triterpenoids, is analyzed in relation to its biological functions. The review investigates the underlying mechanisms that contribute to the cardioprotective properties of *T. arjuna*, such as its antioxidant, anti-inflammatory, and antihyperlipidemic effects. Furthermore, its possible therapeutic roles in managing diabetes, obesity, and other metabolic disorders are also examined. The aim of this review is to offer an extensive summary of the scientific evidence that supports the traditional applications of *T. arjuna* and to emphasize its potential as a beneficial natural therapeutic agent.

INTRODUCTION

Historically, individuals predominantly turned to the plant kingdom for medicinal purposes to address a range of illnesses. Data from the World Health Organization (WHO) indicates that around 80% of the global population still utilizes traditional herbal supplements and medications. Medicinal herbs are largely accessible, especially

in low-income countries, and are generally viewed as non-toxic, posing fewer side effects compared to synthetic drugs. Consequently, they are often the preferred treatment option, particularly in less developed nations. With the advent of vertical farming and technological advancements, there is significant potential for these therapeutic plant-based systems to gain popularity in industrialized

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regions in the near future. Currently, pharmaceutical companies are starting to incorporate these medicinal plants into culinary preparations^[1,2]. *Terminalia arjuna* boasts a high concentration of active phytoconstituents, and it has been traditionally employed in medical formulations to treat a range of disorders. The bark is utilized as an astringent, cooling aphrodisiac, cardiogenic, and in the remedy of diabetes, ulcers, spermatorrhea, leucorrhea, cough, tumors, asthma, inflammation, and skin problems in ancient Indian medicine. Most importantly, utilizing drugs derived from Arjuna bark helps ensure that the heart beats regularly, strengthens the heart muscles, promotes platelet activity, and assists in maintaining stable blood pressure. To facilitate proper fertilization of the ovum, Arjuna enhances the thickness of both sperm and serum. Among its benefits are increased sperm count, treatment of polyuria, regulation of frequent urination, and addressing obesity, hypertension, and hyperglycemia. This comprehensive analysis aims to highlight the efficacy of *Terminalia arjuna* and its advancements in herbal medicine research across pharmacological, phytochemical, and ethnomedical fields^[3,4].

Scientific Classification:

1. Kingdom – Plantae
2. Sub kingdom – Tracheobionta
3. Division – Magnoliophyta
4. Sub division – Spermatophyta
5. Class – Magnoliopsida
6. Order – Myrtales
7. Family – Combretaceae
8. Genus – *Terminalia*
9. Species – *arjuna*

Habitat:

This tree is quite large, reaching heights between 60 and 80 feet. It is an evergreen species, characterized by its drooping branches and wide-spreading crown. New leaves emerge during the warm spring months from February to April. In

India, this tree is regarded as exotic and can be found in regions such as South Bihar and Uttar Pradesh. It also thrives in Madhya Pradesh, Delhi, and the Deccan area, often located near rivers, ponds, and stream banks. In the village of Manipur in Jammu and Kashmir, two trees have been recorded with girths of 26 and 32 feet at a height of five feet above the ground^[5].

Cultivation:

Terminalia Arjuna, commonly called the Arjuna tree, is a significant medicinal plant indigenous to India. Its bark, leaves, and fruit are utilized in traditional Ayurvedic medicine for various health benefits. The tree requires deep, well-drained, and fertile soil to develop properly. The germination rates are typically high. It is best to plant seedlings or cuttings during the rainy season, which spans from June to August. This tree favors tropical and subtropical climates that experience moderate rainfall^[6].

Macroscopic Characteristics:

Leaves:

- **Appearance:** The leaves of the Arjuna tree are simple, green, and oblong, measuring approximately 10-15 cm in length.
- **Texture:** They have a smooth feel and a slightly leathery quality.
- **Uses:** Though not as frequently utilized in traditional medicine as the bark, the leaves do have medicinal benefits. They are occasionally employed in the treatment of wounds and ulcers because of their antibacterial and anti-inflammatory properties.

Bark:

The bark of the Arjuna tree has a greyish-brown or reddish-brown hue (Figure No. 1), with a rough and fibrous texture. It is the most valuable component of the tree for medicinal purposes, enriched with tannins that offer astringent, anti-inflammatory, and cardioprotective effects. Traditionally, the bark is used to address heart conditions, diabetes, and digestive issues.





Fig. No. 1: Dried Bark of T. Arjuna

Flower:

The flowers are small and greenish-white in colour, arranged in clusters known as spikes. They typically bloom in the spring or early summer.

Fruit:

The fruits measure about 2-3 centimetres in length, featuring a winged, drupe-like shape (Figure No.

2). They start off green when unripe, shifting to brown or reddish-brown as they mature. While the bark is the main medicinal component, the fruits also have some uses. They contain tannins and various bioactive compounds that might offer health advantages^[7,8,9].



Fig No. 2: Fruit of T. Arjuna

Allopathy Formulation:

Allopathic formulations of Terminalia arjuna are available in several forms that is Arjuna Capsules/Tablets, Arjuna Syrup, Arjuna Extract, Arjuna Combination Formulation, Arjuna Powder, Arjuna Ointments/Creams, Arjuna Lozenges^[10].

Arjuna Capsules/Tablets:

These formulations typically contain standardized extracts from Arjuna bark, which can be concentrated for enhanced potency. They are often used to support heart health and address cardiovascular issues^[11].



Figure No. 3: Marketed Tablets of Arjuna

Arjuna Syrup:

Arjuna syrups are usually made for easy consumption, especially suitable for children or those who have trouble swallowing pills or

capsules. This syrup often includes Arjuna extract along with other ingredients for flavour and preservation (Figure no. 4).



Figure No. 4: Marketed Syrup of Arjuna

Arjuna Extract:

Liquid extracts of Arjuna are concentrated forms of the herb, often utilized in various allopathic products. They can be mixed with other medications or formulas to amplify their heart health benefits.

Arjuna Combination Formulations:

Arjuna is sometimes combined with other herbs or compounds that support heart health, such as coenzyme Q10, Hawthorn, or Omega-3 fatty acids. These mixtures aim to provide comprehensive cardiovascular support^[12].

Arjuna Powder:

Though less common in allopathic products, Arjuna powder can be included in specific formulations or compounded medications. It can be dissolved in water or other liquids for consumption.

Arjuna Ointment/Creams:

In some cases, Arjuna extracts are added to topical ointments or creams for local application. These formulations can be used to address skin conditions or facilitate wound healing (Figure No.5).



Figure No. 5: Ointment of Arjuna

Arjuna Lozenges:

Arjuna lozenges are another type of allopathic formulation created for convenient intake, especially for those experiencing throat discomfort or swallowing difficulties^[12].

USES OF TERMINALIA ARJUNA:

A study was conducted on the free and bound flavonoids present in the bark of *T. arjuna* using antimicrobial screening. The research focused on specific bioactive compounds in *T. arjuna* bark. All selected pathogens showed activity against both free and bound flavonoids, with *Agrobacterium tumefaciens* displaying the largest inhibition zone.

Antimicrobial Property:

T. arjuna leaf and bark extracts were assessed for their effectiveness against *Staphylococcus aureus* and other pathogens responsible for ear infections, such as *Acinetobacter* sp., *Proteus mirabilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans*, comparing their efficacy to commonly available ear drops. Extracts from *T. arjuna* bark and leaves can be developed into a natural remedy for bacterial ear infections, particularly those caused by *S. aureus*, which has been shown to have larger inhibition zones than herbal drops^[13].

Antioxidant Property:

An investigation was conducted on the ethanolic extract of *T. arjuna* bark and its various fractions—dichloromethane (TAE), butanol (TAB), and

water (TAW)—to assess their ability to prevent DNA damage, protein oxidation, and combat free radicals. The TAE fraction demonstrated the most significant inhibition against radicals such as DPPH, hydroxyl, ABTS, nitric oxide, and showed capacity for metal chelation. This study indicated that extracts from *T. arjuna* bark enhance conditions associated with DNA damage and the generation of free radicals^[14].

Anti-inflammatory Effects:

Following traditional Ayurvedic procedures, cow milk was utilized to create Arjun ksheers paka, which was then put up against a standard hydroalcoholic extract of *T. arjuna*. The levels of gross phytoconstituents were evaluated for both extracts, and their antioxidant activity was assessed through DPPH free radical scavenging and lipid peroxidation inhibition. The extraction yield of Arjuna ksheera paka was found to be double that of the hydroalcoholic extract, indicating a dilution of the phytoconstituents in the former by a ratio of 0.5. In contrast, the hydroalcoholic extract contained a 3.8-fold higher total polyphenol content and showed superior antioxidant capabilities.

Cardiovascular Activity:

The study aimed to examine the effects of various significant antioxidant and free radical scavenging extraction yields of *T. arjuna* extracts. The dry weight showed that arjuna extracts contained between 2 and 11.00 g/100 g of gallic acid, with

TFC ranging from 1.75 to 5.96. Serum biochemistry was assessed in broiler chicks following scheduled administrations of *T. arjuna* bark powder. A total of 72-day-old Arbor-Acres chicks were included in this research, where four levels of Arjuna bark powder (0.00%, 0.50%, 0.75%, and 1%) were integrated into the basal diet for five weeks, with the feeding duration extending up to 35 days.

Antihyperglycemic and Lipid-Lowering Effect:

The study explored the lipid-lowering and antihyperglycemic effects in a Type 2 diabetes model using rats, employing an in vitro model for oxidative stress. The aqueous extract from *T. arjuna* bark notably reduced lipid peroxidation, glutathione levels, and protein content in ascorbate-treated red blood cells. Furthermore, this extract was shown to protect key antioxidant enzymes such as catalase and superoxide dismutase (SOD). *T. arjuna* bark's aqueous extract demonstrated the ability to chemically neutralize hydroxyl radicals, while superoxide anion radical activity was observed following a single intraperitoneal injection of streptozotocin (STZ) in diabetic subjects. Research confirmed that STZ induces free radicals and causes tissue damage. The potent antioxidant properties of *T. arjuna*'s ethanol extract was evaluated, particularly against hydroxyl and superoxide radicals, as well as lipid peroxidation. High concentrations of certain arjunic acid derivatives, including ellagic acid and various arjunoglycosides, were found to significantly diminish hepatic lipid peroxidation and free radical destruction. The anti-diabetic effects of *T. arjuna*'s ethanol extract was identified after a 21-day period.

Lipid-Lowering Effect:

The study covering lipid-lowering and antihyperglycemic effects was conducted over a 33-day period using Type 2 model rats.

Anti-cancer Activity:

Evidence suggests that *T. arjuna* possesses anti-cancer properties. An endophytic fungus, *Pestalotiopsis terminalia*, was isolated from the leaves of *T. arjuna* and studied for its capacity to produce the anticancer drug Taxol. The fungus yielded a significant amount of Taxol at 211.1 µg/litre. The apoptotic activity of the Taxol sourced from the organic extract of the fungal culture demonstrated considerable cytotoxic effects against various human cancer cells, including BT220, H116, Int 407, HL 251, and HLK 210, when tested in vitro.

Hepatoprotective Activity:

Manual investigated the protective role of arjunolic acid against arsenic-induced toxicity in isolated mouse hepatocytes. The aqueous extract of *T. arjuna* bark appeared to protect liver and renal tissues from CCl-Induced oxidative stress, potentially through the enhancement of antioxidant defines mechanisms. Another study evaluated the antioxidative capacity of *T. arjuna* bark against DEN-induced liver cancer. The hepatoprotective efficacy of both aqueous and ethanol extracts of *T. arjuna* bark was shown against paracetamol and CCl-induced liver damage in Wistar albino rats. Rats pre-treated with the ethanol and aqueous extracts exhibited markedly lowered serum levels of GPT, GOP, alkaline phosphatase (ALP), and bilirubin levels, closely resembling those of silymarin, a typical hepatoprotective agent. Histological examinations were conducted on both treated and control rats to confirm the hepatoprotective effects. Additionally, the hepatoprotective and antioxidative properties of *T. arjuna* bark were investigated concerning cadmium toxicity. The results illustrated the significant antioxidative and hepatoprotective capabilities of *T. arjuna* at a dosage of 200 mg/kg, which effectively countered the adverse impacts of cadmium. The aqueous extract of arjuna bark showed therapeutic potential against alcohol-induced oxidative and nitrosative stress, which led

to hepatotoxicity and nephrotoxicity in rats. Alcohol administration prompted a substantial increase in plasma concentrations of nitrogenous compounds alongside elevated activity of enzymatic markers for alcohol metabolism.

Cytotoxic and Anti-tumour Properties:

T. arjuna bark extract protects DNA from damage induced by adrenergic compounds, qualifying it as an herbal approach to address environmental carcinogenicity. By reducing oxidative stress and inhibiting anaerobic metabolism, the aqueous extract of the stem bark demonstrated antioxidant effects that contribute to its anti-carcinogenic properties. The involvement of arjunic acid in cancer therapy was indicated by its considerable activation against human cell lines linked to liver, ovarian, and oral cancers. Reports noted that the ethanol extract of *T. arjuna* bark showed strong analgesic and cytotoxic effects. The cytotoxicity of arjunolic acid against lymphoma and carcinoma cell lines was also assessed. Moreover, the extract's anti-mutagenic and anti-carcinogenic properties were studied both in vivo and in vitro. Singh et al. examined the anti-cancer activity of *T. arjuna* bark extract against several human cancer cell lines, attributing the antiproliferative effects of Arjuna to its high flavonoid content in the methanolic extract. Furthermore, it was demonstrated that the Phyto some complex derived from Terminalia arjuna bark's methanolic extract had a more significant antiproliferative effect on MCF-7 human breast cancer cell lines when compared to standard methanolic extracts^[15].

Wound Healing Activity:

Topical application of Arjuna has the potential to enhance the healing of wounds. An evaluation of *T. arjuna*'s wound-healing properties was conducted using a hydroalcohol extract from its bark on skin wounds in rats, employing in vivo models. The results clearly indicated that the concentration of tannins was responsible for the

positive effects observed. When the wound-healing efficacy of Himax ointment and lotion, which contain *T. arjuna* extract, was tested, the results were comparable to those of the prescription drug nitrofurazone. Additionally, the combination of *T. arjuna* bark powder and coconut oil was found to be beneficial in treating chronic wounds^[16].

Antioxidant Property:

T. arjuna is recognized for its anti-diabetic properties. Research focused on the ethanol extract of *T. arjuna* bark in the context of alloxan-induced diabetes in rats, examining both enzymatic and non-enzymatic lipid peroxidation activities in liver and kidney tissues. The study findings strongly support the traditional use of this plant in diabetic models. Moreover, Borde et al. investigated the anti-diabetic effects of *T. arjuna* in patients also suffering from cardiovascular conditions. The results revealed that *T. arjuna* had a positive impact on animal models of myocardial infarction along with simultaneous cardiovascular issues^[17].

Anti-Diabetic Action:

T. arjuna has been shown to possess anti-diabetic properties. Research analysed the lipid peroxidation activities, both enzymatic and non-enzymatic, of *T. arjuna* bark ethanol extract in the liver and kidney tissues of rats with alloxan-induced diabetes. The conclusions from this study reaffirm the traditional usage of this herb for treating diabetes. In a separate investigation by Borde et al., the anti-diabetic efficacy of *T. arjuna* was examined in individuals concurrently dealing with cardiovascular disease. The findings demonstrated that *T. arjuna* was beneficial in an experimental model of myocardial infarction associated with cardiovascular complications^[17,18].

Antiviral Activity:

The antiviral properties of *Arjuna* extract containing casuarinin were studied in vitro against Herpes simplex type II. The results indicated the



virucidal and anti-herpesvirus capabilities of casuarinin, preventing the virus from attaching and penetrating host cells.

Anthelmintic Activity:

The methanol extract of *T. arjuna* demonstrated toxicity at dosages of 645.65 and 467.65 $\mu\text{g mL}^{-3}$ when tested on the hatched eggs and larvae of *Haemonchus contortus*, respectively. This evidence supports the use of the substance in traditional medicine by showing a dose-dependent anthelmintic effect in both in vitro and in vivo experiments. It is likely that the tannin concentration in *T. arjuna* contributes to its anthelmintic properties. The study utilized *Pheretima posthuma* to investigate the anthelmintic effects of *T. arjuna* bark. The effectiveness of the drug was assessed by observing the death of the trematode and the cessation of spontaneous movement^[19].

Toxicity/Side Effects:

Daily dosages of *T. arjuna* ranging from one to two grams have been tested, revealing it to be the optimal amount for patients, particularly those with coronary artery disease (CAD). At these levels, side effects are rare, possibly resulting in mild headaches, gastritis, or constipation. After more than two years of treatment, no patients reported any issues related to blood, liver, metabolic, or kidney function. Even beyond 24 months, there have been no observed cases of damage to the liver, kidneys, metabolic processes, or blood parameters^[20].

Precautions:

1. Pregnancy: Some studies suggest that *T. arjuna* may be potentially unsafe during pregnancy. There is insufficient reliable data to confirm the safety of the other two species in pregnant women.

2. Surgery: *Terminalia Arjuna* could heighten the risk of bleeding during surgical procedures. It is advisable to discontinue use at least two weeks prior to any planned surgery.

3. Bleeding Disorders: *T. arjuna* might impede blood clotting, which could elevate the likelihood of bruising and bleeding. It is recommended to avoid this extract if you have a bleeding disorder.

4. Heart Conditions: Although often recommended for heart health, individuals with certain heart issues should consult their physician before using *Terminalia Arjuna*.

5. Allergic Reactions: Some individuals may have allergies to *Terminalia Arjuna*. If you experience any negative reactions, stop using it and seek medical help.

6. High doses could potentially harm the liver.

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