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Evaluation of Chemical Constituents of *Terminalia Arjuna* Bark: As a Cardio-Protective Agent

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Abstract

In the past, the primary source of medicinal agents was herbal remedies. One such medicinal plant that is well known for its many therapeutic benefits, particularly its cardiovascular effects, is Terminalia arjuna (TA). The therapeutic effects of these substances are due to a wide range of natural chemical compounds, such as flavonoids, polyphenols, triterpenoids, tannins, glycosides, minerals, proteins, and others. These compounds work together to provide the health benefits associated with the plants or substances in question. To effectively extract pertinent phytochemicals from TA extracts, we have first described the several procedures and their parameters in this review. This review, in our opinion, may aid researchers in comprehending the significance of TA, a well-known cardioprotective medicinal plant, its biomedical qualities, its use in green nanotechnology, and the different formulations that have been investigated for encapsulating them. In addition to improving formulations to increase the stability and bioavailability of TA extracts, this review will assist researchers in creating better and more environmentally friendly nano-medicines.

Keywords: Antioxidants, cardiotonic, cardiovascular disorders, flavonoid, anti-inflammatory

INTRODUCTION

Arjuna is a member of the Combretaceae family and may have cardioprotective properties. A stang Hridayam, Sushruta Samhita, Charaka Samhita, and other ancient Indian medical writings have all referred to this ayurvedic treatment since the Vedic era. For the first time, Vagabhatta promoted the use of powdered stem bark for heart conditions [1]. In other words, ashes from the bark have been applied as a remedy for snakebites and scorpion stings, while a decoction made from the bark has been used to wash ulcers [2].

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The bark has been used to treat fractures, ulcers, leukorrhea, diabetes, anemia, cardiopathy, cirrhosis, and other conditions. It has also been classified as an astringent, demulcent, expect orant, cardiotonic, styptic, antidysenteric, and urinary astringent [3].

Habitat

The Arjuna tree typically grows to a height of 60–80 feet and is found along rivers, streams, and dry water bodies in regions, such as Uttar Pradesh, southern Bihar, Chota Nagpur, Burma, Madhya Pradesh, Delhi, and the Deccan, as well as in Sri Lanka and Mauritius. It thrives in a variety of soil but prefers humid, fertile loam or red lateritic soils. The tree is capable of withstanding partial submersion for short periods. Arjuna is propagated through seeds, which take 50–70 days to germinate, with a germination rate of 50–60%.

Pharmacogenetic Characteristics

The bark's inner surface is pinkish and features longitudinal striations, but the exterior surface is smooth. In April and May, the bark flakes off by itself [4, 5]. The adult bark may be examined under a microscope to reveal a cork made up of 9–10 layers of tangentially elongated cells, phellogen that is 2–4 cells thick, and phelloderm made up of tangentially elongated cells. The broad phloem is made up of ceratenchyma, phloem parenchyma, phloem fibers, and crystal fibers that contain calcium oxalate rosette crystals. Ancient bark contains secondary phloem and periderm [6]. The subopposite, coriaceous, oblong/elliptic leaves have a dull green upper surface and a pale brown lower surface. They are frequently unevenly sided and have ten to fifteen pairs of nerves. White, bisexual flowers with linear bracteoles are grouped in spikes. Fruits have five to seven firm angles or wings and are ovoid or oblong. The wings' lines are upward-curving and oblique (Figures 1–3) [7].

Figure 1. Tree of *T. Arjuna*.

Figure 2. Bark stem of *T. arjuna*.

Figure 3. Leaves and fruits of *T. arjuna*.

Chemical Constituents of *Terminalia Arjuna*

The plant contains various chemical constituents distributed in different parts: the stem bark, roots, leaves, fruits, and seeds are rich in triterpenoids, glycosides, flavonoids, tannins, alkaloids, steroids, and phenolic compounds. Specific compounds like arjunic acid, arjunolic acid, arjunosides, and flavonoids, such as luteolin and quercetin highlight its medicinal potential (Table 1).

Table 1. Major chemical constituents of *T. arjuna* [8–13].

Part of Plant	Major Chemical Constituents	Major Chemical Constituents
Stem bark	Triterpenoids	Arjunin, arjunic acid, arjunolic acid, arjungenin, terminic acid, ajunglucosides IV and V, arjunasides A-E, 2-alpha, 3- beta-dihydroxyurs-12,18-dien-28-oic acid 28-O-beta-dglucopyranosyl ester
	Glycosides	Arjunetin, arjunoside I, arjunoside II, arjunaphthanoloside, terminoside A
	Flavonoids	Arjunolone, arjunone, baicalein, luteolin, gallic acid, ethyl gallate, quercetin, kempferol, pelargonidin, oligomeric proanthocyanidins
	Tannins	Pyrocatechols, punicallin, punicalagin, terchebulin, terflavin C,
Roots	Triterpenoids	castalagin, casuariin, casuarinin
	Glycosides	Arjunic acid, arjunolic acid, oleanolic acid, terminic acid
	Flavonoids Alkaloids Tannins Steroids	Arjunoside I, arjunoside II, arjunoside III, arjunoside IV, 2α, 19α-dihydroxy-3-oxo-olean-12-en 28-oic acid 28-O-βd-glucopyranoside
Leaves	Phenolic Compounds Oxalic Acid Inorganic Acid	
Fruits	Glycosides	Luteolin
	Flavonoids	
Seeds	Cardenolide	14,16-dianhydrogitoxigenin-3-beta-d-xylopyranosyl (1--> 2)-O-beta-d-galactopyranoside

EXPERIMENTAL STUDIES

Numerous pharmacological effects, such as inotropic, anti-ischemic, antioxidant, blood pressure lowering, antiplatelet, hypolipidemic, antiatherogenic, and antihypertrophic, have been demonstrated for several preparations of arjuna stem bark. Therefore, we have attempted to review and provide current material relevant to the use of arjuna as a potential cardioprotective agent in this paper [14].

Cardio-Protective Effects

Studies have shown that dried and powdered bark can increase the natural antioxidant levels in the hearts of rats, helping to reduce oxidative stress caused by ischemic-reperfusion injury (a type of damage to the heart after blood flow is restored). Additionally, it has been suggested that an alcoholic extract of the Arjuna tree can trigger the production of heat shock proteins in rabbits' hearts, boosting natural antioxidants that protect the heart from damage caused by ischemic-reperfusion injury. The cardioprotective effect of Arjuna bark's active compounds have also been observed in cases of oxidative stress induced by carbon tetrachloride and sodium fluoride, likely due to its antioxidant properties. In these studies, antioxidant activity in the heart was enhanced by ethanol extracts of the bark. A more recent study showed that methanol extracts had the highest levels of phenolic compounds and flavonoids, which are strongly linked to their total antioxidant capacity. Therefore, it can be concluded that there is a direct relationship between the antioxidant activity of the extracts and their phenolic content [15–20].

Hypolipidemic and Antiatherogenic Activity

Previous studies on animals have shown that *arjuna* bark extract or powder lowers triglyceride (TG) and total cholesterol (TC) levels [20–23]. Only the ethanolic fraction significantly reduced lipid levels when the hypolipidemic properties of the bark in various solvent fractions (petroleum ether, solvent ether, ethanol, and water) were compared in hyperlipidemic rats. Both in triton and in hamster models of hyperlipidaemia fed a high fat diet (HFD), solvent ether and ethanolic fractions reduced the plasma levels of lipids. Arjuna fractions at 50–500 μg/ml were found to prevent oxidative lipid breakdown caused by metal ions in rat liver microsomes and human low-density lipoprotein (LDL) in an in vitro experiment [22].

CLINICAL USES

Angina Pectoris

Bark powder's anti-ischemic efficacy was assessed in 30 patients with postinfarct angina and stable angina (500 mg tds). Along with a considerable drop in systolic blood pressure (SBP), improvement in ECG abnormalities, and a decrease in plasma cortisol and serum cholesterol levels, the authors also noted a significant decrease in mean anginal frequency.

Congestive Heart Failure

In one of the initial studies, 10 patients with congestive heart failure (CHF) were given 4 grams of Arjuna bark powder twice a day for a month. The researchers noted improvements in the patients' functional status, reduced breathlessness, and overall better well-being. There was also a significant increase in urine output (diuresis) and a reduction in both systolic and diastolic blood pressure.

Cardiomyopathy

Arjuna has been found to lower LVM and increase LVEF in addition to its anti-ischemic properties. According to a recent observational study, patients with dilated cardiomyopathy and decreased left ventricular EF who received arjuna in addition to their usual treatment showed a notable improvement in both functional capacity and left ventricular metrics.

Toxicity and Adverse Effects

There have been reports of mild side effects, such as headache, body aches, nausea, gastritis, constipation, and insomnia. However, even after using the plant for over 24 months, no significant damage to blood, kidney, or metabolic function has been reported. Nevertheless, Parmar et al. found that while liver lipid peroxidation (LPO) increased, Arjuna injections led to decreased thyroid hormone levels in healthy rats. As a result, excessive consumption of plant extract is not recommended, as it may lead to hypothyroidism and liver toxicity. A recent acute oral toxicity study in animals, however, found that administering an ethanolic extract at a high dose of 2000 mg/kg did not result in any toxicity or animal deaths.

CONCLUSIONS

New chemical components and pharmacological activities of arjuna have been discovered because of the ongoing interest in medicinal plants. Numerous experimental and clinical research have clearly shown its effectiveness as an anti-ischemic, strong antioxidant, and antiatherogenic drug. The absence of phytochemical standardization of the extract, bioavailability tests, and carefully planned research to assess its long-term toxicity effects are some of these studies' main shortcomings. It is necessary to look into its precise function in primary and secondary coronary prevention. Furthermore, research is required to determine how arjuna affects CYP450 enzymes and how it interacts with other medications, such as βblockers, statins, aspirin, and ACE inhibitors. Raising awareness about its use as medicine can provide guidance.

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