IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Medicinal Properties Of Terminalia Arjuna

Mr. Irfan Mustafa Pathan*[1]

Mr. AjinkyaShridhharraoDeshmukh*[2]

Mr. Bhaiyyasaheb Vishvanath Kokare*[3]

Mr. Sanskar Ramrao Biradar*[4] Mr. Aryan Dayanand Chavan*[5]

Mr. Anil B. Panchal*[6]

Al-Ameen Collage's Education and Medical Foundation's Delight Collage of Pharmacy ,Koregaon Bhima

ABSTRACT

Since ancient times, the medicinal herb Terminalia arjuna has been utilized in traditional medicine to treat a variety of illnesses and disorders. This study used contemporary medication techniques to empirically validate the folkloric method. Examining the pharmacological properties of the native medicinal plant Terminalia arjuna was the primary goal of this review. Given that green medicine is healthier than manufactured goods, medicinal plants have been identified as a significant source of therapeutic compounds to treat human illness. Vagbhata (c. 7th century CE) brought the Arjuna into Ayurveda as a remedy for cardiac ailments. Traditionally, a milk decoction is made of it. Arjuna was used for thousands of years as a medicinal herb; in the ancient Indian Vedas, Vagbhata describes Arjuna's use for treating wounds, hemorrhages, and ulcers, topically administered as a powder.

Keywords: Flavonoids, Triterpenoids, Terminalia arjuna, Cardiovascular diseases, and Coronary prevention.

1. Introduction

Arjuna, a member of the Combretaceae family, is recognized for its potential cardioprotective properties. Referenced in ancient Indian medical texts such as Astang Hridayam, Sushruta Samhita, and Charaka Samhita since the Vedic era, this Ayurvedic medicine saw its first recommendation for cardiac conditions using stem bark powder by Vagabhatta.

The primary objective of this study was to develop and assess a nutrition chocolate infused with a natural heart tonic. Memories shape our uniqueness; each individual carries distinct recollections of shared experiences. Herbal formulations, whether singular or in combination with other herbs, constitute the basis of herbal preparations. Due to the health benefits attributed to cocoa, chocolate-based products have served as

medicinal remedies across various cultures for centuries. These benefits are largely attributed to flavonoids, acting as antioxidants and regulating specific hormones while also lowering blood pressure. Dark chocolate, in particular, boasts a higher concentration of antioxidants compared to milk or white chocolate, thus offering superior health advantages.

Chocolate, available in various forms including liquid, paste, or solid blocks, is derived from roasted and ground cacao seeds and can also be used as a seasoning in other dishes. The three main types of chocolate are milk chocolate, dark chocolate, and white chocolate, with cocoa butter, a component of dark chocolate, exhibiting mood-enhancing, energy-boosting, stress-alleviating, cognitive-improving, and cardiovascular health-promoting properties.

The development and evaluation of a holistic chocolate incorporating powdered arjuna bark, aimed at enhancing memory and learning without adverse effects, is the focal point of this study. Medicated chocolate is created by blending medication with a chocolate base, employing the "chocolate drug delivery system" for effective drug administration, especially in children.

Native to Bangladesh, the Terminalia arjuna tree is both deciduous and evergreen, reaching heights of 20 to 30 meters. Belonging to the Combretaceae family, it thrives near ponds and rivers across regions such as the Deccan, South Bihar, Madhya Pradesh, Delhi, and Uttar Pradesh. Traditional Indian medicine utilized powdered tree bark from Terminalia arjuna to treat heart ailments including angina, while all parts of the plant have been medicinally utilized since ancient times. T. arjuna exhibits stress and anxiety-reducing properties while promoting heart health, owing to its glycosides, abundant flavonoids, tannins, and minerals present in its stem bark. Distinguished from other medicinal plants, Terminalia arjuna stands out for its anti-inflammatory, antioxidant, lipid-lowering flavonoids, and cardiotonic glycosides properties.

Furthermore, its fruits serve as tonics, fruit juice acts as an antacid, and inhaling boiling bark powder in water is believed to alleviate migraines and toothaches.

The Terminalia arjuna tree has a conical shape with elliptic leaves that point in different directions and white bark. Its sap is milky white, while its flowers are yellowish and its fruits are smooth, fibrous, and woody. The bark of Terminalia arjuna is commonly marketed as a herbal preparation for treating and preventing various cardiovascular diseases, although concerns exist regarding the quality of these products. This study aims to compare reference data with selected samples of commercially available Terminalia arjuna bark products in terms of various pharmacognostic parameters. Such standards are crucial for forensic detection, authenticity assessment, and identification of adulterants in pharmaceuticals.

Chocolate, as a culinary medium, offers the opportunity to create unique textures and flavors. Due to its anhydrous nature, chocolate resists microbial growth and hydrolysis of water-sensitive active ingredients. Chocolate comprises various compounds including sterols, saturated fat, and polyphenols. Medicinal chocolate involves blending a chocolate base with drugs, a process known as the 'chocolate drug delivery system', which proves effective especially for administering medications to children. This study endeavors to develop a herbal chocolate with cardiotonic properties, assessing its physiochemical parameters for standardization and commercialization.

Ayurveda, the world's oldest complete medical system still in use, traces its 5000-year origin to its Sanskrit roots 'ayus' (life) and 'ved' (knowledge), offering a holistic approach to health. Despite its ancient wisdom, further research is warranted to validate Ayurvedic treatments for various diseases.

In the context of prevalent global health issues like diabetes, hypertension, and cardiovascular diseases, allopathic medications are commonly used but may entail side effects such as weight gain, lactic acidosis, and organ damage. Consequently, there is a growing interest in natural products, driving the rapid expansion of herbal medicine due to their low side effects, therapeutic benefits, and natural origin. Among medicinal plants, Terminalia species, including Terminalia arjuna, are renowned for their medicinal properties.

Terminalia arjuna is also significant in sericulture, as the Anthrerae mylitta feeds on it, yielding tasar silk. Its various parts, including leaves, bark, fruit, flowers, roots, and seeds, are used in traditional medicine to treat diverse ailments ranging from cardiovascular issues to epilepsy. Recent research has identified two novel cardenolide cardiac glycosides from Terminalia seeds and roots, which increase intracellular calcium and sodium levels, enhancing cardiac contraction force. The pharmacognostic standards of Terminalia arjuna bark are investigated in this study.

DRUG PROFILE

Figure 1: Arjuna fruit

1. Botanical Name: Terminalia arjuna W & A

2. Synonym: T. glabra W & A

3. Common Name: Arjun , Arjuna

4. Biological Source: Arjuna is made up of the dried stem bark of the terminalia Arjuna Rob plant. Itcontains more than 0.02 percentage of arjungenin on dried basis.

5. Geographical Source: This is a common tree on the Indian Peninsula. It is widely grown in theChotta Nagpur region and is grown alongside streams.

3.1. Classification of Arjuna

1. Charaka: Udarda Prashamana, Kashaya-skandha

2. Sushruta: Salasaradi, Nyagrodhadi

3. Vargbhatt: Virtarvadi, Nyagrodhadi

4. Vatadi: Nighantu Bhavaprakash

5. Bhavaprakash: Salasardi, Nagrodhadi
6. Amradi, Swati Nakshatra Vriksha: Dhanvantari Nighantu

3.2. Properties of action of arjuna

1. The Rasa: Kshaya

2. Guna: Ruksha, Laghu

3. Venera: Sheeta

4. Katu: Vipaka

5. Hridya Doshaghnata Prabhava: The Phaghattashamaka

4. Arjuna Bark

Various extracts from the stem bark of Arjuna have demonstrated numerous pharmacological characteristics, including inotropic, anti-ischemic, antioxidant, blood pressure-lowering, antiplatelet, hypolipidemic, antiatherogenic, and antihypertrophic effects. This article aims to review and present current information relevant to the use of Arjuna as a potential cardioprotective agent based on these demonstrated pharmacological properties.

Figure 2: Arjuna Bara

Medicinal Uses

1. The bark of Arjuna has been recognized for its diverse medicinal properties, including being described as an astringent, demulcent, expectorant, cardiotonic, styptic, antidysenteric, and urinary astringent. It has shown effectiveness in treating conditions such as fractures, ulcers, leukorrhea, diabetes, anemia, cardiopathy, and cirrhosis.

2. Chakradatta, a renowned ancient physician, recommended Arjuna bark to be consumed as a decoction with milk or prepared as a ghrita (a mixture with ghee or butter).

3. The decoction of Arjuna bark has been utilized as a wash for ulcers, while the ashes of the bark have been prescribed for the treatment of snakebites and scorpion stings.

4. Traditional healers from the Kancheepuram district in Tamil Nadu boil Arjuna bark powder with water and inhale it to alleviate headaches and eliminate tooth worms. Additionally, they apply a paste made from the fruit topically on wounds.

5. The fresh juice of Arjuna leaves is used by the Malabar tribe in Kerala to relieve earaches, while bark powder is employed for the treatment of heart ailments.

6. Tribals residing in the Sundargarh District of Orissa utilize dried Arjuna bark powder along with rice-washed water to address issues such as blood in urine, while tribes in the Malkangiri district chew the fresh bark and ingest the juice as an antacid.

Table 1

Major Chemical Constituents

Part used	Major chemical constituents	References
Stem bark	**Triterpenoids**	
	Arjunin	Row et al[24]
	Arjunic acid	
	Arjungenin	Honda et al[25]
		Singh et al[26,27]
	Terminic acid	Anjaneyulu and Prasad[28]
	Terminoltin	Singh et al[29]
	Arjunolic acid	Singh et al[26,27]
	Ursane triterpenoids	
	2α,3β-dihydroyurs-12,18-oic acid 28-O-β-D-glucopyranosyl ester	Wang et al[30]
	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	
	Glycosides	
	Arjunetin	Row et al[24,31]
		Singh et al[26,27]
	Arjunoside I, II	Honda et al[25,32]
	Arjunolone	Sharma et al[33]
	Arjunolitin	Tripathi et al[34]
	Arjunaphthanoloside	Ali et al[35,36]
	Arjunglucoside IV and V, Arjunasides A-E	Wang et al[34,37]
	Olean-3β, 22β-diol-12-en-28 β-D-glucopyranosie-oic acid	Patnaik et al[38]
	Terminarjunoside I and II	Alam et al[39]
	Terminoside A	Ahmad et al[40]
	Termionic acid	
	Flavonoids and phenolics	
	Arjunone	Sharma et al[33]
	Luteolin	Pettit et al[41]
	Baicalein	Anonymous[42]
	Ethyl gallate	
	Gallic acid	
	Kempferol	
	Oligomeric proanthocyanidins	
	Pelargonidin	
	Quercetin	
	(+)-catechin, (+)-gallocatechin and (−)-epigallocatechin	Saha and Pawar[43]
	Gallic acid, ellagic acid and its derivatives such as 3-O-methyl-ellagic acid 4-O-β-D-xylopyranoside, 3-O-methyl ellagic acid 3-O-rhamnoside	
	3-O-methyl ellagic acid 4′-O-α-L-rhamnophranoside	Wang et al[30]
	(−)-epicatechin	
	Tannins	
	Pyrocatechols	Takahashi et al[44]
	Punicallin	Lin et al[45]
	Castalagin	Kuo et al[46]
	Casuariin	
	Casuarinin	
	Punicalagin	
	Terchebulin	
	Terflavin C	
	Minerals and trace elements	
	Calcium, magnesium, aluminum, zinc, copper, silica	Dwivedi and Udupa[47]
	Other compounds	
	β-Sitosterol	Anjaneyulu and Prasad[28]
Roots	**Triterpenoids**	
	Arjunoside I-IV	Anjaneyulu and Prasad[48,49]
	Arjunolic acid	Anjaneyulu and Prasad[28]
	Oleanolic acid	
	Terminic acid	
	2α,19α-Dihydroxy-3Oxo-Olean-12-En28-Olic acid 28-O-β-D-glucopyranoside	Choubey and Srivastava[50]
	Arjunic acid	Singh et al[26,27]
	Glycosides	
	Arjunetosie (3-O-β-D-glucopyranosyl-2α, 3β, 19α-trihydroxyolean-12-en-28-oic acid 28-O-β-D-glucopyranoside)	Upadhyay et al[51]
Fruits	**Triterpenoids and flavonoids**	
	Arjunic acid, Arjunone, Arachidic stearate, Cerasidin, Ellagic acid, Fridelin, Gallic acid, Hentriacontane, Methyl oleaolate, Myristyl oleate, β-Sitisterol	Rastogi and Mehrotra[52]
Leaves and seeds	**Flavonoids and glycosides**	
	Luteolin, 14,16-dianhydrogitoxigenin 3-β-D-xylopyranosyl-(1 > 2)-O-β-D-galactopyranoside	Pettit et al[41]
		Yadava and Rathore[53]

1. Anti diuresis

T. arjuna demonstrated anti-diuretic effects by mitigating the decrease in glomerular filtration rate induced by acute hypobaric hypoxia ($p < 0.5$), increasing total urine output ($p < 0.5$), and preventing cerebral vascular leakage in hypoxic rats. Animals treated with T. arjuna also exhibited a decrease in serum levels of renin ($p < 0.001$) and angiotensin-II ($p < 0.5$) compared to those treated with a placebo. Administration of T. arjuna attenuated acute hypobaric hypoxia-induced oxidative stress, improved aldosterone levels, and altered electrolyte balance in animals through an atrial natriuretic peptide (ANP) dependent mechanism.

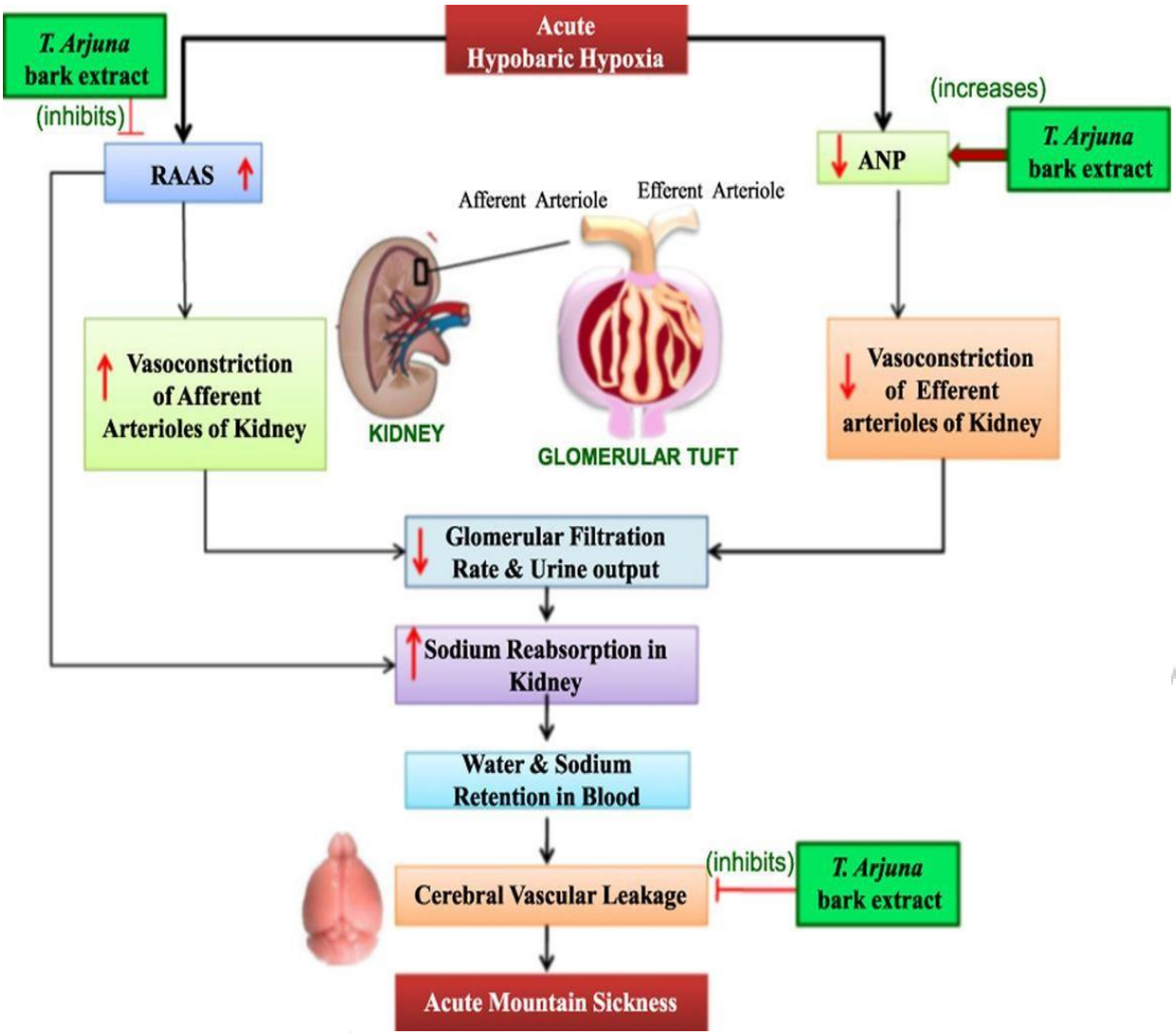

Figure 3
M.O.A Anti Diuresis Activity

2. Hepatoprotective activity:

Several studies have highlighted the hepatoprotective activity of Terminalia arjuna:

- Arjunolic acid, a component of Terminalia arjuna, has shown preventive effects against arsenic-induced cytotoxicity in isolated murine hepatocytes.
- The aqueous extract of T. arjuna bark has demonstrated protective effects on liver and kidney tissues against oxidative stress induced by carbon tetrachloride (CCl4).
- T. arjuna bark extracts have exhibited hepatoprotective potential against liver damage induced by paracetamol/CCl4 in Wistar albino rats. These extracts significantly reduced serum markers of liver damage (SGPT, SGOT, SALP, SB) and showed histopathological improvements comparable to silymarin, a standard hepatoprotective agent.
- T. arjuna bark extract has been shown to reverse the toxic effects of cadmium, indicating its hepatoprotective and antioxidant properties.

- Aqueous bark extract of T. arjuna has demonstrated therapeutic potential against alcohol-induced oxidative/nitrosative stress-mediated liver and kidney damage in rats. It restored plasma concentrations of nitrogenous compounds, reduced lipid peroxidation, and restored antioxidant levels in the liver.
- Methanolic extract of Terminalia arjuna stem bark and its flavonoids (baicalein and quercetin) have exhibited hepatoprotective effects against CCl4-induced hepatic damage. Quercetin showed more protective effects than baicalein.
- Arjunolic acid, a major active constituent of Arjuna, has shown promising results in treating non-alcoholic fatty liver disease by reducing lipid levels and markers of liver damage in cell and animal models.

These findings collectively indicate the potential of Terminalia arjuna as a hepatoprotective agent against various liver injuries induced by toxins, chemicals, and alcohol.

3 Anti-inflammatory and analgesic activity:

The bark of Terminalia arjuna exhibits significant anti-inflammatory and analgesic properties:

- Research conducted by Halder et al. investigated the anti-inflammatory activity of T. arjuna bark powder. Constituents from the stem bark demonstrated potent antioxidant activity and inhibited the production of Nitric Oxide (NO) in lipopolysaccharide (LPS) stimulated rat peritoneal macrophages.

- A polyherbal formulation containing ethanolic extracts of Datura stramonium (leaves), Terminalia arjuna (bark), and Withania somnifera (root) displayed anti-inflammatory effects by inhibiting the enzyme cyclooxygenase (COX), thus suppressing prostaglandin synthesis during inflammation. This formulation exhibited significant anti-inflammatory and analgesic activity.

- In studies using the Carrageenan-induced paw edema method, Terminalia arjuna extract significantly reduced the formation of edema induced by Carrageenan, indicating its anti-inflammatory properties.

- The extract of Terminalia arjuna was also evaluated for its analgesic potential using various models including formalin, hot plate, and acetic acid-induced writhing tests in mice. Significant analgesic activity was observed at oral doses of 250 and 500 mg/kg body weight in these models.

- Arjuna Kaseera paka, an Ayurvedic formulation of T. arjuna prepared in cow milk, was compared with a hydroalcoholic extract for its anti-inflammatory activity. The study found that Arjuna Kaseera paka exhibited higher efficacy, possibly due to the presence of milk solids acting as adjuvants to T. arjuna phytoconstituents, enhancing their sustained bioavailability and efficacy at lower drug concentrations.

These findings highlight the potential of Terminalia arjuna as a natural remedy for inflammation and pain relief, supporting its traditional use in Ayurvedic medicine.

Anti-tumor and cytotoxic activity:

Terminalia arjuna demonstrates significant anti-tumor and cytotoxic activities:

- The bark extract of Terminalia arjuna has been shown to protect DNA against damage induced by adriamycin (ADR), an environmental carcinogen.

- Aqueous extracts of T. arjuna stem bark exhibit antioxidant properties, which contribute to their anti-carcinogenic activity by reducing oxidative stress and inhibiting anaerobic metabolism.

- Arjunic acid, a compound found in Terminalia arjuna, has been found to activate significantly against human oral, ovarian, and liver cancer cell lines, suggesting its potential role in cancer treatment.

- Ethanolic extracts of T. arjuna bark demonstrate significant analgesic and cytotoxic effects.

- Arjunolic acid, isolated from Terminalia arjuna, exhibits cytotoxic activity against carcinoma and lymphoma

cancer cell lines.

- Terminalia arjuna extract has shown anti-carcinogenic and anti-mutagenic potential both in vivo and in vitro.

- Singh et al. studied the anti-cancer potential of T. arjuna bark extract against various human cancer cell lines.

- Methanolic extracts of Terminalia arjuna bark, rich in flavonoids, demonstrate antiproliferative effects.

- Phytosome complexes of methanolic extracts of T. arjuna bark exhibit antiproliferative effects on human breast cancer cell lines (MCF-7) compared to methanolic extract alone.

These findings collectively suggest that Terminalia arjuna holds promise as a natural anti-cancer agent, with its bark extracts and compounds showing potential for use in cancer treatment and prevention.

4 Gastric activity:

Terminalia arjuna exhibits notable gastric activity:

- Methanolic bark extract of T. arjuna has shown a significant increase in the adherent mucus of the gastric wall and in the protein-bound carbohydrate complexes of gastric juice in rats treated with diclofenac sodium. This suggests a protective effect against gastric damage induced by diclofenac sodium.

- The anti-ulcer effect of methanol extract of T. arjuna against Helicobacter pylori lipopolysaccharide-induced gastric damage in rats was evaluated by Devi et al. The findings suggest that Arjuna has the ability to combat factors that damage the gastric mucosa, indicating its potential as a gastroprotective agent.

These results indicate that Terminalia arjuna may possess properties beneficial for gastric health, including the protection of gastric mucosa and the prevention of ulcer formation induced by various factors.

5 Wound healing activity:

Terminalia arjuna exhibits wound healing activity:

- The topical application of hydroalcoholic extract of T. arjuna bark on rat dermal wounds using in vivo models demonstrated the wound healing capacity of T. arjuna. The beneficial effect was attributed to its tannin content.

- A herbal formulation containing T. arjuna extract, known as Himax ointment and lotion, was evaluated for its wound healing potential. The results were comparable to the standard drug nitrofurazone, indicating the efficacy of T. arjuna in promoting wound healing.

- T. arjuna bark powder mixed with coconut oil was found to be potentially effective against chronic wounds, further highlighting its wound healing properties.

These findings suggest that Terminalia arjuna holds promise as a natural remedy for promoting wound healing and may be beneficial in the management of various types of wounds.

6 Antibacterial activity:

Terminalia arjuna demonstrates significant antibacterial activity:

- Methanol extracts of T. arjuna have shown strong antibacterial activity against multi-drug-resistant Salmonella typhi. This suggests the potential development of T. arjuna plant extracts as herbal ear drops to control bacterial ear infections. Additionally, the leaves and bark extracts were found to be more potent and effective against bacterial strains responsible for ear infections compared to standard ear drops.

- Antibacterial and cytotoxic activities of T. arjuna bark aqueous and methanolic extracts were evaluated against various bacterial strains including Escherichia coli, Klebsiella sp., Pseudomonas sp., and Staphylococcus sp. Both aqueous and methanolic extracts demonstrated inhibition against these organisms in a dose-dependent manner.

- Javed et al. conducted experiments to assess the antibacterial, antifungal, brine shrimp lethality, and phytotoxic effects of Terminalia arjuna. The methanolic extract of T. arjuna leaves exhibited moderate antifungal activity against Microsporum canis, while the fruit extract showed good antibacterial activity against Staphylococcus aureus and Pseudomonas aeruginosa. Additionally, the dichloromethane extract of T. arjuna bark and fruit showed moderate phytotoxic activity.

- Recent studies have reported strong antimicrobial activity of ethanolic extracts of T. arjuna bark and leaves, as well as its different solvent fractions, against various bacterial strains including Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Klebsiella pneumonia, Pseudomonas aeruginosa, and Salmonella typhi.

These findings collectively suggest that Terminalia arjuna possesses potent antibacterial properties, making it a promising candidate for the development of herbal remedies to combat bacterial infections.

Antioxidant activity:

Terminalia arjuna exhibits significant antioxidant activity:

- Various studies have investigated the antioxidant and free radical scavenging capacity of Terminalia arjuna. Kumar et al. conducted a comparative study on the antioxidant potential of T. arjuna bark and leaves ethanolic extracts and their different solvent fractions. The study demonstrated that the antioxidant properties are attributed to the presence of flavonoids, tannins, and oligomeric proanthocyanidins.

- Arjunic acid and aglycone isolated from the fruit of Terminalia arjuna were found to be strong antioxidants or free radical scavengers, even more potent than ascorbic acid.

- Casuarinin, extracted from Terminalia arjuna, has been shown to protect cultured Madin Darby Canine Kidney (MDCK) cells against H2O2-mediated oxidative stress. It decreases DNA oxidative damage and prevents the depletion of intracellular glutathione (GSH) in MDCK cells.

These findings highlight the antioxidant properties of Terminalia arjuna, indicating its potential therapeutic use in combating oxidative stress-related diseases and promoting overall health.

7 Ant diabetic activity:

Terminalia arjuna exhibits significant anti-diabetic activity:

- The anti-diabetic activity of Terminalia arjuna has been studied extensively. In one study, the effect of ethanol extract of T. arjuna bark was investigated in alloxan-induced diabetic rats. The study evaluated its effect on lipid peroxidation and enzymatic and non-enzymatic activities in liver and kidney tissues. The results confirmed the traditional use of this plant in diabetic animals, suggesting its potential in managing diabetes.

- Borde et al. studied the anti-diabetic effect of T. arjuna in experimental models of myocardial infarction co-existing with cardiovascular disease. The results demonstrated the beneficial effects of T. arjuna in this context, indicating its potential in managing diabetes in individuals with cardiovascular complications.

These findings support the use of Terminalia arjuna as a potential therapeutic agent for managing diabetes and its complications, highlighting its importance in traditional medicine and its potential in modern medical treatments.

8 Anti-viral activity:

Terminalia arjuna exhibits antiviral activity:

- Casuarinin, extracted from the bark of Terminalia arjuna, has been investigated for its antiviral activity against Herpes simplex type II in vitro. The results of the study demonstrated that casuarinin exhibits virucidal properties and possesses anti-herpesvirus activity by inhibiting viral attachment and penetration.

These findings suggest the potential of Terminalia arjuna and its constituents, such as casuarinin, as natural antiviral agents, particularly in the context of herpesvirus infections. Further research may explore the mechanisms of action and potential therapeutic applications of Terminalia arjuna in combating viral infections.

9 Anthelmintic activity:

Anthelmintic activity of T. arjuna methanol extract against the hatched egg and larvae of Haemonchus contortus were found to be toxic at 645.65 and 467.65 µg mLG1 of dose, respectively. The data revealed dose dependents antihelmintic activity both in vitro and in vivo studied, thus justifying its use in the traditional medicine system90. Anthelmintic activity of T. arjuna may be only attributed to its tannin content. Antihelmintic effect of T. arjuna bark was also studied on Pheretima posthuma. The effectiveness of drug was judge on the basis of loss of spontaneous movement and death of trematode. Terminalia arjuna demonstrates anthelmintic activity:

- The methanol extract of Terminalia arjuna has been shown to exhibit anthelmintic activity against the hatched eggs and larvae of Haemonchus contortus. Toxicity was observed at doses of 645.65 µg/mL for eggs and 467.65 µg/mL for larvae. The data indicate a dose-dependent anthelmintic activity both in vitro and in vivo, supporting its traditional medicinal use.

- The anthelmintic activity of Terminalia arjuna may primarily be attributed to its tannin content.

- Additionally, the anthelmintic effect of T. arjuna bark was studied on Pheretima posthuma. The efficacy of the drug was assessed based on the loss of spontaneous movement and death of the trematode.

These findings underscore the potential of Terminalia arjuna as a natural anthelmintic agent, suggesting its usefulness in traditional medicine systems for treating parasitic infections.

10 Molluscicidal activity:

Terminalia arjuna exhibits molluscicidal activity:

- Studies conducted by Soni and Singh investigated the molluscicidal activity of Terminalia arjuna bark and its various organic extracts against the snails Lymnaea acuminata and Indoplanorbis exustus, which are vectors for fasciolosis. The results demonstrated that the column-purified fraction exhibited higher toxicity compared to other treatments, with 96-hour LC50 values of 3.12 mg/L for L. acuminata and 14.53 mg/L for I. exustus. The presence of arjunolic acid in the column-purified fraction was identified through TLC analysis, which was attributed to its molluscicidal activity.

- Further studies by Soni et al. investigated the in vivo and in vitro mode of action of the molluscicidal component on key enzymes, including acetylcholinesterase (AChE), acid phosphatase (ACP), and alkaline phosphatase (ALP) activities in the nervous tissue of L. acuminata. The results showed concentration-dependent inhibition of these enzymes, with the maximum inhibition observed in snails exposed to 80% of the 96-hour LC50 of arjunolic acid. The kinetics of inhibition of AChE, ACP, and ALP by the column-purified fraction and arjunolic acid of T. arjuna bark were also studied, revealing non-competitive inhibition of AChE, uncompetitive inhibition of ACP, and competitive-non-competitive inhibition of ALP.

- Evaluation of the safety of this plant-derived molluscicidal drug against non-target aquatic biota, specifically fish (Colisa fasciatus), indicated that toxic concentrations of arjunolic acid and the column-purified fraction did not exert any adverse effects on the nervous tissue of fish.

These findings suggest the potential of Terminalia arjuna as a natural molluscicide for controlling snail populations that act as vectors for various diseases, while also highlighting its safety for non-target aquatic organisms.

11 Apoptosis:

Terminalia arjuna induces apoptosis in human hepatoma cell line HepG2:

- Studies have investigated the effects of Terminalia arjuna bark extract on apoptosis in the human hepatoma cell line HepG2. It was observed that T. arjuna induced cytotoxicity in HepG2 cells in vitro.

- The apoptotic effect of T. arjuna on HepG2 cells may be attributed to several mechanisms, including DNA damage and alterations in the expression of apoptotic proteins. Additionally, the depletion of glutathione (GSH) may be involved in the induction of apoptosis in HepG2 cells.

These findings suggest the potential of Terminalia arjuna as a natural agent for inducing apoptosis in hepatoma cells, highlighting its possible utility in cancer therapy. Further research may elucidate the specific mechanisms underlying its apoptotic effects and its potential application in cancer treatment strategies.

CONCLUSION

In conclusion, Terminalia arjuna holds significant ethnopharmacological value, with various parts of the plant exhibiting a wide range of traditional and pharmaceutical applications. This is attributed to the presence of numerous bioactive chemical constituents. Experimental studies have demonstrated the plant's potential therapeutic effects in various areas, including:

- Cardio-protection
- Hepatoprotection
- Antioxidant activity
- Anticancer properties
- Anti-inflammatory effects
- Analgesic properties
- Antidiabetic activity
- Anthelmintic properties
- Antimicrobial and antiviral activity
- Molluscicidal effects

Despite these promising findings, further detailed clinical research is necessary to fully explore the therapeutic potential of Terminalia arjuna. Establishing it as a standard drug will require rigorous investigation into its efficacy, safety, and optimal usage in clinical settings. Continued research efforts can help unlock the plant's full therapeutic benefits and enhance its integration into modern medical practice.

References

1. WHO. World Health Organization, Traditional Medicine Strategy Report, Document WHO/EDM/TRH/2002.1. 2002.
2. Heinrich M. Ethnobotany and its role in drug development. Phytother Res. 2000;14:479e488.
3. Tabuti JRS, Lye KA, Dhillion SS. Traditional herbal drugs of Bulamogi, Uganda: plants, use and administration. JEthnopharmacol. 2003;88:19e44.
4. Pieroni A. Evaluation of the cultural significance of wild food botanicals traditionally consumed in NorthwesternTuscany, Italy. J Ethnobiol. 2001;21: 89e104.
5. Kim H, Song MJ. Ethnomedicinal practices for treating liver disorder of local communities in the southern regions of Korea. J Evid Based Complement Altern Med. 2013. http://dx.doi.org/10.1155/2013/869176.
6. Upadhyay B, Singh KP, Kumar A. Ethnoveterinary uses and informants consensus factor of medicinal plants ofSariska region, Rajasthan, India. J Ethnopharmacol. 2011;133:14e25.
7. Reyes-Garcia V, Huanca T, Vadez V, Leonard W, Wilkie D. Cultural, practical, and economic value of wild plants: aquantitative study in the Bolivian, Amazon. Econ Bot. 2006;60:62e74.
8. Gosh A. Herbal folk remedies of Bantura & Medinipur districts, West Bengal (India). Indian J Tradit Knowl.2003;2:393e396.
9. Stickel F, Schuppan D. Herbal medicine in the treatment of liver diseases. Dig Liver Dis. 2007;39:293e304.
10. Gopinath K, Venkatesh KS, Ilangovan R, Sankaranarayanan K, Arumugam A. Green synthesis of gold nanoparticlesfrom leaf extract of Terminalia arjuna, for the enhanced mitotic cell division and pollen germination activity. Ind CropProd. 2013;50:737e742.
11. Wani, M.R. and S.S. Singh, 2016. Variation in leaf morphological traits of Terminalia arjuna Roxb. in natural population of lower parts of Achanakmar Amarkantak Biosphere Reserve (AABR) of Central India. Int. J. Adv. Res., 4:484-491.
12. Singh, D.V., R.K. Verma, M.M. Gupta and S. Kumar, 2002. Quantitative determination of oleane derivatives inTerminalia arjuna by high performance thin layer chromatography. Phytochem. Anal.,
13. 13: 207-210. 13. Singh, D.V., R.K. Verma, S.C. Singh and M.M. Gupta, 2002. RP-LC determination of oleane derivativesin Terminalia arjuna. J. Pharmaceut. Biomed. Anal., 28: 447-452.
14. Chitlange, S.S., P.S. Kulkarni, D. Patil, B. Patwardhan and R.K. Nanda, 2009. High-performance liquid chromatographic fingerprint for quality control of Terminalia a rjuna containing Ayurvedic churna formulation. J.AOAC Int., 92: 1016-1020.
15. Kokkiripati, P.K., R.V. Kamsala, L. Bashyam, N. Manthapuram and P. Bitla et al., 2013. Stem-bark of Terminalia arjuna attenuates human monocytic (THP-1) and aortic endothelial cell activation. J. Ethnopharmacol., 146: 456-464.
16. Mandal, S., A. Patra, A. Samanta, S. Roy and A. Mandal et al., 2013. Analysis of phytochemical profile of Terminalia arjuna bark extract with antioxidative and antimicrobial properties. Asian Pac. J. Trop. Biomed., 3: 960-966.
17. Kandil, F.E. and M.I. Nassar, 1998. A tannin anti-cancer promotor from Terminalia arjuna. Phytochemistry,
18. 1567-1568.
19. Tripathi, V.K., V.B. Pandey, K.N. Udupa and G. Ru, 1992. Arjunolitin, a triterpene glycoside from Terminaliaarjuna. Phytochemistry, 31: 349-351.
20. Sharma, P.N., A. Shoeb, R.S. Kapil and S.P. Popli, 1982. Arjunolone: A new flavone from stem bark of Terminaliaarjuna. Indian J. Chem., 21: 263-264.
21. Anjaneyulu, A.S. and A.V. Prasad, 1982. Chemical examination of roots of Terminalia arjuna (Roxb) Wright andArnot. Part I. Characterization of two new triterpenoid glycosides. Indian J. Chem., 21: 530-533.
22. Row, L.R., P.S. Murty, G.S.R. Subba-Rao, C.S.P. Sastry and K.V.J. Rao, 1970. Chemical examination of Terminaliaarjuna: Part-XII: Isolation and structure determination of arjunetin from Terminalia arjuna bark. Indian J. Chem., 8:772-775.
23. Verma, S.C., C.L. Jain, M.M. Padhi and R.B. Devalla, 2012. Microwave extraction and rapid isolation of arjunic acidfrom Terminalia arjuna (Roxb. ex DC.) stem bark and quantification of arjunic acid and arjunolic acid using HPLC-PDA technique. J. Sep. Sci., 35: 1627-1633.
24. Amalraj, A. and S. Gopi, 2017. Medicinal properties of Terminalia arjuna (Roxb.) Wight & Arn.: A review. J. Tradit.Complement. Med., 7: 65-78.

25. Soni, N. and V.K. Singh, 2015. Molluscicidal activity of Tamarindus indica and Terminalia arjuna againstIndoplanorbis exustus: A causative agent of trematodiasis. Sci. Agric., 12: 163-170.
26. Soni, N. and V.K. Singh, 2017. Screening of molluscicidal potential of indigenous medicinal plants Terminalia arjuna and Tamarindus indica against fasciolosis vector: Lymnaea acuminate. Asian J. Sci. Technol., 8: 5256-5261.
27. Kuo, P.L., Y.L. Hsu, T.C. Lin, L.T. Lin, J.K. Chang and C.C. Lin, 2005. Casuarinin from the bark of Terminalia arjunainduces apoptosis and cell cycle arrest in human breast adenocarcinoma MCF-7 cells. Planta Medica, 71: 237-243.
28. Rastogi, R.P. and B.N. Mehrotra, 1993. Compendium of Indian Medicinal Plants. Vol. 2, CSIR, New Delhi, India.
29. Wang, W., Z. Ali, Y. Shen, X.C. Li and I.A. Khan, 2010. Ursane triterpenoids from the bark of Terminalia arjuna.Fitoterapia, 81: 480-484.
30. Rastogi, R.P. and B.N. Mehrotra, 1993. Compendium of Indian Medicinal Plants. Vol. 1, CSIR, New Delhi, India.
31. Ahmad, M.U., K.B. Mullah, T. Norin and J.K. Ulla, 1983. Terminoic acid, a new trihydroxytriterpene carboxylic acidfrom bark of Terminalia arjuna. Indian J. Chem., 22: 738-740.