Review Article

Medicinal Properties of Terminalia Arjuna: A Review

ABSTRACT

Terminalia arjuna, also commonly referred to as T. arjuna, is a deciduous tree that belongs to the family Combretaceae. It can be found in many regions of India. *T. arjuna* is a 60- to 80-foot-tall tree found alongside rivers and streams all over the Indo-sub-Himalayan areas of Delhi, Uttar Pradesh, Chota Nagpur, the southern part of Bihar, Madhya Pradesh and Deccan regions. It has been used to cure several ailments for as far back as the ancient times of India. It is most prevalently consumed to cure and manage several cardiac and vascular diseases, including those like CADs, Angina Pectoris, CHF/Hypertension, and Dyslipidaemia. Its extracts are used to improve cardiac muscles and thus effectively improve heart pumping, heart rate, and blood pressure. The many parts of the tree consist of several phytochemicals, including tannins, flavonoids, glycosides, and triterpenoids like Arjunolic acid, which contribute to its anti-oxidant anti-inflammatory antimicrobial, anticarcinogenic and antimutagenic properties. As of today, there have not been any reports of any harmful side effects regarding its administration. While there are various studies that support its use for a problem of diseases, further research is still required to understand its exact mechanisms. There is also a need for further research on *T. arjuna* regarding its drug interactions, its specific molecular mechanism of action, and the toxicology involved.

Keywords: Chemical constituents, Medicinal Properties, Cardiovascular, CAD, Angina Pectoris, CHF, Tannins, Flavonoids, Triterpenoids, Arjunolic Acid

INTRODUCTION

Plants with therapeutic characteristics have long been utilized to heal ailments for thousands of years. (1) WHO statistics estimate that approximately 80% of the world's population, including 60% of India's rural population, depend on these therapeutic agents. (2) The demand for herbal medicines has only increased in recent years. Due to their easy accessibility, efficiency, and rare side effects. These medicinal plants contain certain bioactive substances such as alkaloids, tannins, carbohydrates, steroids, terpenoids, phenols, and flavonoids, ensuring certain physiological effects on the body. (3)

A variety of medicinal plants have been employed in modern-day healthcare, including:

Natural Plant Source	**Name of the Drug**
Foxglove	Digitalis
Willow Bark	Salicylates
Cinchona	Quinine
Contaminated Rye	Ergotamine

Table 1: Drugs derived from plants (4)

There are a variety of medicinal plants in India which have been extensively employed in Ayurvedic practices. *T. arjuna* is one of these plants, and it has proven to be one of the most commonly acknowledged herbal medicines for the treatment of a range of disorders. (1)

T. ARJUNA: OVERVIEW

T. arjuna of the family Combretaceae. Long used as a cardioprotective agent, it was first introduced by Vagabhatta, who advocated its stem bark powder's use for heart diseases and has since been written in various ancient texts like the Sushruta Samhita, Charaka Samhita, and Ashtang Hridayam. (5)

T. arjuna is a 60- to 80-foot-tall tree found alongside rivers and streams all over the Indo-sub-Himalayan areas of Delhi, Uttar Pradesh, Chota Nagpur, the southern part of Bihar, Madhya

Pradesh, and Deccan regions. Aside from being found in various regions of India, it has also been seen in many other countries, including Sri Lanka, Burma as well as Mauritius. (6) (7). Although this plant grows on all types of soil, it has shown a preference for red lateric, fertile loam and humid soil.

The tree's bark has a smooth outer surface and an inner striated pinkish surface. (8) During April and May, the bark of this tree sheds away. (9)

Figure 1: The bark of the tree *Terminalia arjuna*

CHEMICAL COMPONENTS OF *TERMINALIA* ARJUNA

The learoots roots, fruits, ste, as well as ieeds of T.arjuna, have been used in medical practice due to their different phytoconstituents.

Table 2: Phytochemical components of various sections of *T.arjuna*. (1)

Parts of the tree that were analyzed	**Chemical components which are considered important**
Stem Bark	**Ursane triterpenoids**
	2α,3β-dihydroyurs-12,18-oic acid 28-O-β-D-glucopyranosyl ester (10)
	Kajiichigoside F1

	2α,3β,23-trihydroxyurs-12,18-dien-28-oic acid 28-O-β-glucopyranosyl ester Qudranoside VIII
	2α,3β,23-trihydroxyurs-23-trihydroxyurs-12,19-dien-28-oic acid 28-O-β-D-glucopyranosyl ester
	Triterpenoids
	Arjunin (11)
	Arjunic acid
	Arjungenin (12) (13) (14)
	Terminic acid (15)
	Arjunolic acid (13) (14)
	Terminoltin (16)
	Flavonoids and Phenolics
	Arjunone (17)
	Luteolin (18)
	Baicalein (19)
	Ethyl gallate
	Kempferol
	Gallic acid
	Pelargonidin
	Oligomeric proanthocyanidins
	Quercetin
	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
	(+)-catechin, (+)-gallocatechin and (−)-epigallocatechin (20)
	3-O-methyl ellagic acid 4′-O-α-L-rhamnophranoside (−)-epicatechin (10)
	Glycosides
	Arjunetin (11) (21) (13) (14)
	Arjunolone (17)

	Arjunoside I, II (12) (22)
	Arjunaphthanoloside (23) (24)
	Arjunolitin (25)
	Arjunasides A-E, Arjunglucoside IV and V (25) (26)
	Terminarjunoside I and II (27)
	Olean-3β, 22β-diol-12-en-28 β-D-glucopyranosie-oic acid (28)
	Terminoside A (29)
	Termionic acid
	Trace elements along with Minerals
	Magnesium, Calcium, aluminium, silica, zinc, copper (30)
	Tannins
	Pyrocatechols (31)
	Castalagin (32)
	Punicallin (33)
	Casuariin
	Casuarinin
	Punicalagin
	Terflavin C
	Terchebulin
	Other compounds
	β-Sitosterol (15)
Roots	**Glycosides**
	Arjunetosie (3-O-β-D-glucopyranosyl-2α, 3β, 19α-trihydroxyolean-12-en-28-oic acid 28-O-β-D-glucopyranoside) (34)
	Triterpenoids
	Arjunoside I-IV (35)
	Oleanolic acid

	Arjunolic acid (15)
	2α,19α-Dihydroxy-3Oxo-Olean-12-En28-Olic acid 28-O-β-D-glucopyranoside (36)
	Terminic acid
	Arjunic acid (13) (14)
Seeds and Leaves	**Glycosides and Flavonoids**
	Luteolin, 14,16-dianhydrogitoxigenin 3-β-D-xylopyranosyl-(1 > 2)-O-β-D-galactopyranoside (18) (37)
Fruits	**Flavonoids and Triterpenoids**
	Hentriacontane, Arjunic acid, Ellagic acid, Arjunone, Eridelin, Methyl oleaolate, Gallic acid, Cerasidin, Myristyl oleate, β-Sitisterol, Arachidic stearate (38)

TERPENOIDS, URSANE TRITERPENOIDS AND GLYCOSIDES

Triterpenoids are structurally diverse organic compounds which include various varieties, due to modifications in its basic backbone, including ursolic and oleanolic acid.(39)

The table above lists a number of terpenoids, ursane triterpenoids, and glycosides isolated from a variety of areas of T. arjuna.

Each type has its own pharmacodynamic effect on the body. Ali et al (24) discovered Terminoside A, an oleanane-type triterpane, from T. arjuna stem bark in a research. The Terminoside A thus extracted exhibited characteristics that prevented the synthesis of nitric oxide. In macrophages stimulated by lipopolysaccharides, it also decreased the quantity of inducible nitric oxide synthase (iNOS or simply iNOS.(20) (21)

FLAVONOIDS ALONG WITH PHENOLICS

From a medicinal point of view, *T. arjuna*'s bark is perhaps the most significant portion of *T. arjuna*'s bark is regarded the most important part of the plant. The bark contains a variety of

flavonoids such as flavones, arjunolones, kempferol, baicalein, pelargonidin and quercetin. Because of an inverse link between high dietary flavonoid consumption and the development of ischemic heart diseases (CADs), these flavonoids are particularly useful for treating cardiovascular disorders.(1)

Luteolin, a molecule isolated from the butanolic fraction, exhibits antimutagenic properties.(1) It also has a very efficient antibacterial property as it inhibits gram negative pathogenic growth with the minimum inhibitory concentration of 12.5µg/disc.

Other actions of these bioflavonoids include inhibition of oxidation of LDL molecules, activation of endothelium and aggregation of platelets.(1) (40) (41) (42) (43)

The phenolic content contributes to a free radical scavenging action which makes *T. arjuna* a strong agent against proliferation and oxidation.(1) (44)

TANNINS

Tannins are polyphenols that are water soluble and may be found in a range of plant components. Tannins possess a variety of properties. One such property is that it is an anticarcinogen along with tea polyphenols. It also has an anti-mutagenic property as well as an anti-oxidant property. There three properties are interrelated as oxygen-free radicals are produced by a variety of carcinogens and mutagens. which these tannins ultimately decrease for protecting cellular oxidative cellular damage.

Another important property of tannins is its antimicrobial activity. Studies have shown that Yeasts, fungi, bacteria, and viruses have all been found to be inhibited by tannins.

Tannins also aid in the clotting of blood, the reduction of blood pressure, the reduction of serum cholesterol levels, the production of liver necrosis, and the modulation of immune responses..(45)

PHARMACOLOGICAL ACTIVITIES OF *TERMINALIA ARJUNA*

Even though each part of *T. arjuna* has its own pharmacological effects on the body due to their varying composition, the bark of the tree is regarded to the most clinically relevant.

The bark has been shown to have astringent, expectorant, demulcent, cardiotonic, anti-dysenteric, styptic and urinary astringent effects, as well as being beneficial in the management of cirrhosis, anaemia, leukorrhea, fractures, cardiomyopathy, diabetes and ulcers..(8) (46)

Chakradatta introduced an ulcer wash made from an infusion of the bark prepared using milk and perhaps even ghee/butter in Ancient India. The ashes of the bark was employed for the management of snakebites and scorpion stings.(47)

It has been used in many forms throughout India for a variety of conditions. *T. arjuna's* bark is boiled in water and breathed in which then alleviates headaches and eliminate worms in the teeth in the Kancheepuram District of Kerala. They also use its fruit's paste as a topical agent on wounds. (48) The bark powder is mixed with rice water by tribals in the Sundargarh District of Odisha to treat haematuria (there is blood in the urine). (49)

A more detailed analysis of the same on the basis of clinical trials and experiments has been tabulated below.

Table 3: *Terminalia arjuna* – Pharmacological activities (1)

Pharmacological activity	**Chemical Constituents Responsible**	**Supporting Clinical Trial/Experiment**	**Observation in the concerned clinical trial/experiment**
Antioxidant, anti-inflammatory and immunomodulatory	Arjunic acid, arjunetin and arjungenin	Varghese et al (50)	The enzymes were shown to have strong non-competitive inhibitory and reversible action in both of *T.arjuna*'s aqueous and alcoholic extracts. The enzymes concerned are CYP344, CYP2D6 and CYP2C9 present in the human liver microsomes.(1)
Antioxidant	Oleanane triterpenoids	Pawar and Bhutani (51)	The process of respiratory oxburst is modestly inhibited by Arjungenin. Its IC50 results to be 60 µg/ml.(1)

Antioxidant activity	Butanolic fraction of *Teminalia arjuna* bark(52)	Singh et al (52)	The butanolic component of *T.* arjuna's bark's alcoholic extract shows cardioprotective activity in a patient with Doxorubicin-induced cardiotoxicity.
Antioxidant and antimutagenic activity	Alcoholic extract of *Terminalia arjuna* stem bark (ALTA)	Viswanatha et al (53)	In the DPPH assay, liquid peroxidation assay and superoxide radical scavenging activity, the alcoholic extract of T. arjuna showed significant antioxidant activity with EC50 values of 2.491 ± 0.160, 71.000 ± 0.025, and 50.110 ± 0.150 respectively. In the micronucleus test, EC50 values of 2.410 ± 0.140, 40.500 ± 0.390, and 63.000 ± 0.360 in percentage of micronucleus in T. arjuna's alcoholic extract (100 and 200 mg/kg p.o) resulted in significant reductions in both the normochromatic and polychromatic erythrocytes, as well as quite a decrease in the P/N ratio..(1)
Potential to be antimutagenic and anticarcinogenic	*Terminalia arjuna* bark has substanti al flavonoids and tannins.	Ahmad et al (54)	T. arjuna extracts were shown to be effective in reducing metaphase abnormalities. In vitro, the frequency of sister chromatid exchanges was decreased, but the replication index rose. Clastogeny was reduced in the mutagen-treated positive control and aberrant cell frequencies were

			reduced in the in vivo trials.
Anti-oxidant and antimicrobial activity	*Terminalia arjuna* bark's Methanolic extract	Mandal et al (55)	*T.arjuna*'s methanolic extracts have potent antibacterial activity as well as scanvenging of free radicals. It is a potent antibacterial agent against *K. pneumonia* and *E. coli* (gram-negative bacteria). These properties are because of the flavonoid compounds in *T. arjuna.* (56)
Antimicrobial activity	*Terminalia arjuna* leaf extract (acetonic) and bark extract (aqueous)(7)	Aneja et al (57)	The aqueous extract resulted in being an efficient antimicrobial against *S. aureus* bacteria.(58) However, the acetone extract of the leaf extract of *T. arjuna* was seen to have the most potent antimicrobial agent against *S. aureus.* (1) The organic extracts were shown to be highly efficient against the proliferation of gram-negative bacteria, with the exception of *P. aeruginosa.*
Cardio-protective potential	*Terminalia arjuna* bark powder which was used for 12 weeks before ischemic-reperfusion injury (1)	Gauthaman et al (59)	Myocardial endogenous antioxidants were boosted following chronic oral treatment of T. arjuna bark in rabbits. It also induces HSP-72 (Inducible Heat Shock Protein 72). The prevents myocardial ischemic reperfusion injuries due to protection against oxidative stress.
Anticarcinogenic	*Terminalia*	Oberoi et al (60)	*T. arjuna*'s aqueous extracts

potential	*arjuna*'s ethanolic and aqueous extracts		enhances sarcoplasmic reticular function and thus induces cardiotonic action. Arrhythmias are less likely to arise as a result of this. As a result, *T. arjuna*'s aqueous extract is seems as a safe cardiotonic that is good to heart health and may be used in conjunction with chronic health-care treatment programmes.(1)
Free radical scavenging and DNA damage protection	*Terminalia arjuna* bark's ethanolic extract along with its fractions	Phani Kumar et al (61)	*T. arjuna* bark's ethanolic extract (together with its components) protect against hydrogen peroxide-induced DNA damage. (62) The ethyl acetate fraction has especially been effective in maximally inhibiting DPPH, ABTS, metal chelation, hydroxyl and nitric oxide radicals. T. arjuna extracts have also been demonstrated to ameliorate a variety of impairments related to free radical production and DNA damage.
Gastro-productive effect	Methanolic extract of *Terminalia arjuna*	Devi et al (63)	Two groups of ulcer-induced animals were studied. One group received Diclofenac Sodium (DIC) and *T. arjuna*, whereas the other received simply Diclofenac Sodium. In comparison to merely providing DIC, the DIC + T.

			arjuna treatment plan demonstrated a considerable reduction in the lesion index..(64) *T. arjuna*'s gastroprotective effect was validated by other histological research.

CARDIOVASCULAR ROLE OF *T. ARJUNA*

The bark stem of *T. arjuna* has inotropic, chronotopic and diuretic properties.(7) Experiments on animals revealed an augmentation in coronary blood flow, which increased the force of cardiac muscle contraction, resulting in a drop in blood pressure along with heart rate as well as bradycardia with accordance with the dose administered. (65) (66) (67) (7)

Research done on rats found that pretreatment with atropine reduced the hypotensive effect of *T. arjuna* with a fraction containing tannin-related chemicals isolated from the aqueous extract. Pretreatment of the rats with propranolol had no impact, suggesting that the hypotensive effect was related to cholinergic processes..(31)

In myocardial infarction which is induced by isoprenaline, *T. arjuna* exhibited PGE2 like activity in the heart by producing vasodilatation and hypotension.(5) *T. arjuna*'s bark extract reduced the oxidative stress which upsurged on induction by isoprenaline and reduced the amount of natural antioxidants in the body... (5)

One of the triterpenoids found in T. arjuna, Arjunolic acid, prevents the decline of superoxide dismutase, glutathione peroxidase, catalase, alpha-tocopherol, ceruloplasmin, ascorbic acid, reduced glutathione (GSH), MPO (myeloperoxidase) and lipid peroxide levels, implying that Arjunolic acid's cardioprotection by Arjunolic acid is most likely due to protection against damage to heart via myocardial necrosis.(68) Another study found that arjunolic acid had cardioprotective properties through boosting the body's natural antioxidant defences.(69)

Animal experiments showed that the *T. arjuna* bark, when administered in various forms, was capable of reducing total cholesterol (TC) and triglyceride (TG) levels.(5) (70) (71) (72) (73)

When compared to the other fractions of *T. arjuna* bark, the ethanolic fraction has powerful antioxidant and hypolipidemic effects..(74) (75) The down regulation of lipogenic enzymes,

the enhances hepatic clearance of cholesterol and inhibition of HMG-CoA reductase are likely to be responsible for the hypolipidemic effect..(76)

ANGINA PECTORIS: A study was undertaken where the sample size of 30 patients suffering from stable angina were administered with 500 mg of *T. arjuna* bark extract three times a day. The bark's anti-ischemic activity was proven by a considerable reduction in the serum cholesterol levels, systolic blood pressure, plasma cortisol and the mean anginal frequency. There was also an improvement in the ECG changes.(5) (77)

CHF/ HYPERTENSION: A study was undertaken where the sample size of 10 patients suffering from Congestive Heart Failure (CHF) were given 4g of T. arjuna bark powder twice a day for a month as part of a research. With considerable diuresis, there was enhancement seen with dyspnea, functional class, and general well-being. Both the systolic as well as the diastolic blood pressures dropped significantly.(78)

TOXICITY AND SIDE EFFECTS OF *TERMINALIA ARJUNA*

Most traditional and herbal medicines like *T. arjuna* are known for producing the least amount of side effects, hence their popularity. No cases of *T. arjuna* toxicity have been documented.(19)

T. arjuna is most widely used for the cure and control of coronary artery disorders (CAD), with an ideal dose of 1-2 g per day, and 500 mg of the bark extract three times per day for congestive heart failure. The side effects reported in this treatment are rather minor like headaches, mild gastritis and constipation. After more than 2 years of this drug administration, there were no signs of haematological, hepatic, metabolic and renal toxicity.(77) (79)

A study reported that there was a reduction in thyroid hormone concentration in euthyroid animals and an increase in hepatic LPO (Lipid Peroxidation) upon the administration of *T. arjuna*. Therefore, care must be taken when consuming this plant extract as it carrier a risk of development of hypothyroidism and hepatotoxicity.(80-85)

CONCLUSION

T. arjuna, a tree seen all around India, is being utilised for hundreds of years for curing a conundrum of ailments, but more importantly for cardiac health. Its active constituents include tannins, triterpenoids, flavonoids and certain minerals like calcium, magnesium, zinc and copper.

Its extracts are used for the improvement of cardiac muscles, effectively improving heart pumping, heart rate and blood pressure.

Terminalia arjuna can be administered in a variety of conditions such as Angina Pectoris, Congestive Heart Failure, Cardiomyopathy or Post Myocardial Infarction and Hyperlipidemia.

While there are various studies which support their application in clinical practice, such studies lack the standardisation of extract to be used, well conducted studies for long term effects and the bioavailability of the drug.

There is also a need for further research on *T. arjuna* regarding its drug interactions, its specific molecular mechanism of action as well as toxicology.

NOTE:

The study highlights the efficacy of "herbal, ayurvedic,traditional" which is an ancient tradition, used in some parts of India. This ancient concept should be carefully evaluated in the light of modern medical science and can be utilized partially if found suitable.

REFERENCES

1. Amalraj A, Gopi S. Medicinal properties of Terminalia arjuna (Roxb.) Wight & Arn.: A review. J Tradit Complement Med. 2016 Mar 20;7(1):65–78.

2. World Health Organization. WHO Traditional medicine strategy Report. Document WHO/EDM/TRM; 2002.

3. Sharma J, Gairola S, Gaur RD, Painuli RM. The treatment of jaundice with medicinal plants in indigenous communities of the Sub-Himalayan region of Uttarakhand, India. J Ethnopharmacol. 2012 Aug;143(1):262–91.

4. Sen T, Samanta SK. Medicinal Plants, Human Health and Biodiversity: A Broad Review. In: Mukherjee J, editor. Biotechnological Applications of Biodiversity [Internet]. Berlin, Heidelberg: Springer Berlin Heidelberg; 2014 [cited 2021 Aug 25]. p. 59–110. Available from: http://link.springer.com/10.1007/10_2014_273

5. Dwivedi S, Chopra D. Revisiting Terminalia arjuna – An Ancient Cardiovascular Drug. J Tradit Complement Med. 2014 Oct;4(4):224–31.

6. Chopra RN, Chopra IC. Indigenous drugs of India. Academic publishers; 1994.

7. Dwivedi S. Terminalia arjuna Wight & Arn.—A useful drug for cardiovascular disorders. J Ethnopharmacol. 2007 Nov;114(2):114–29.

8. Warrier PK. Indian medicinal plants: a compendium of 500 species. Orient Blackswan; 1993.

9. Dhingra V, Dhingra S, Singla A. Forensic and pharmacognostic studies of the Terminalia arjuna Bark. Egyptian Journal of Forensic Sciences. 2013 Mar 1;3(1):15-9.

10. Wang W, Ali Z, Shen Y, Li X-C, Khan IA. Ursane triterpenoids from the bark of Terminalia arjuna. Fitoterapia. 2010 Sep;81(6):480–4.

11. Row LR, Murty PS, Rao GS, Sastry CP, Rao KV. Chemical examination of Terminalia species. XII. Isolation & structure determination of arjunic acid, a new trihydroxytriterpene carboxylic acid from Terminalia arjuna bark. Indian journal of chemistry. 1970.

12. Honda T, Murae T, Tsuyuki T, Takahashi T, Sawai M. Arjungenin, arjunglucoside I, and arjunglucoside II. A new triterpene and new triterpene glucosides from Terminalia arjuna. Bulletin of the Chemical Society of Japan. 1976 Nov;49(11):3213-8.

13. Singh DV, Verma RK, Gupta MM, Kumar S. Quantitative determination of oleane derivatives in Terminalia arjuna by high performance thin layer chromatography. Phytochem Anal. 2002 Jul;13(4):207–10.

14. Singh DV, Verma RK, Singh SC, Gupta MM. RP-LC determination of oleane derivatives in Terminalia arjuna. J Pharm Biomed Anal. 2002 May;28(3–4):447–52.

15. Anjaneyulu AS, Prasad AR. Structure of terminic acid, a dihydroxytriterpene carboxylic acid from Terminalia arjuna. Phytochemistry. 1983 Jan 1;22(4):993-8.

16. Singh B, Singh V, Pandey V, Rücker G. A New Triterpene Glycoside from *Terminalia arjuna*. Planta Med. 1995 Dec;61(06):576–7.

17. Sharma PN, Shoeb A, Kapil RS, Popli SP. ARJUNOLONE-A NEW FLAVONE FROM STEM BARK OF TERMINALIA-ARJUNA. INDIAN JOURNAL OF CHEMISTRY SECTION B-ORGANIC CHEMISTRY INCLUDING MEDICINAL CHEMISTRY. 1982 Jan 1;21(3):263-4.

18. Pettit GR, Hoard MS, Doubek DL, Schmidt JM, Pettit RK, Tackett LP, et al. Antineoplastic agents 338. The cancer cell growth inhibitory. Constituents of Terminalia arjuna (Combretaceae). J Ethnopharmacol. 1996 Aug;53(2):57–63.

19. Terminalia arjuna. Altern Med Rev J Clin Ther. 1999 Dec;4(6):436–7.

20. Jayaraman S, Saha A, Pawar V. Characterisation of polyphenols in Terminalia arjuna bark extract. Indian J Pharm Sci. 2012;74(4):339.

21. Row LR, Murti PS, Rao GS, Sastry CS, Rao KV. Chemical examination of Terminalia species. XIII. Isolation and structure determination of arjunetin from Terminalia arjuna. Indian journal of chemistry. 1970.

22. HONDA T, MURAE T, TSUYUKI T, TAKAHASHI T. The structure of arjungenin. A new sapogenin from Terminalia arjuna. Chemical and Pharmaceutical Bulletin. 1976 Jan 25;24(1):178-80.

23. Ali A, Kaur G, Hayat K, Ali M, Ather M. A novel naphthanol glycoside from Terminalia arjuna with antioxidant and nitric oxide inhibitory activities. Pharm. 2003 Dec;58(12):932–4.

24. Ali A, Kaur G, Hamid H, Abdullah T, Ali M, Niwa M, et al. Terminoside A, a new triterpene glycoside from the bark of *Terminalia arjuna* inhibits nitric oxide production in murine macrophages. J Asian Nat Prod Res. 2003 Jun;5(2):137–42.

25. Tripathi VK, Pandey VB, Udupa KN, Ru G. Arjunolitin, a triterpene glycoside fromTerminalia arjuna. Phytochemistry. 1992 Jan 1;31(1):349-51.

26. Wang W, Ali Z, Li X-C, Shen Y, Khan IA. Triterpenoids from two Terminalia species. Planta Med. 2010 Oct;76(15):1751–4.

27. Sarwar Alam M, Kaur G, Ali A, Hamid H, Ali M, Athar M. Two new bioactive oleanane triterpene glycosides from ***Terminalia arjuna*** . Nat Prod Res. 2008 Sep 20;22(14):1279–88.

28. Patnaik T, Dey RK, Gouda P. Isolation of triterpenoid glycoside from bark of Terminalia arjuna using chromatographic technique and investigation of pharmacological behavior upon muscle tissues. E-Journal of Chemistry. 2007;4(4):474-9.

29. Ahmad MU, Mullah KB, Norin T, Ulla JK. TERMINOIC ACID, A NEW TRIHYDROXYTRITERPENE CARBOXYLIC-ACID FROM BARK OF TERMINALIA-ARJUNA. INDIAN JOURNAL OF CHEMISTRY SECTION B-ORGANIC CHEMISTRY INCLUDING MEDICINAL CHEMISTRY. 1983 Jan 1;22(8):738-40.

30. Dwivedi S, Udupa N. Terminalia arjuna: pharmacognosy, phytochemistry, pharmacology and clinical use. A review. Fitoterapia. 1989;60(5):413-20.

31. Takahashi S, Tanaka H, Hano Y, Ito K, Nomura T, Shigenobu K. Hypotensive effect in rats of hydrophilic extract from Terminalia arjuna containing tannin-related compounds. Phytotherapy Research: An International Journal Devoted to Medical and Scientific Research on Plants and Plant Products. 1997 Sep;11(6):424-7.

32. Kuo P-L, Hsu Y-L, Lin T-C, Lin L-T, Chang J-K, Lin C-C. Casuarinin from the bark of Terminalia arjuna induces apoptosis and cell cycle arrest in human breast adenocarcinoma MCF-7 cells. Planta Med. 2005 Mar;71(3):237–43.

33. Lin TC, Chien SC, Chen HF, Hsu FL. Tannins and related compounds from Combretaceae plants. Chinese Pharmaceutical Journal. 2000;52(1):1-26.

34. Upadhyay RK, Pandey MB, Jha RN, Singh VP, Pandey VB. Triterpene glycoside from Terminalia arjuna. J Asian Nat Prod Res. 2001;3(3):207–12.

35. Anjaneyulu AS, Prasad AR. Chemical examination of the roots of Terminalia arjuna—the structures of arjunoside III and arjunoside IV, two new triterpenoid glycosides. Phytochemistry. 1982 Jan 1;21(8):2057-60.

36. Chouksey BK, Srivastava SK. Antifungal agent from Terminalia arjuna. Indian J Chem. B. 2001;40:354-6.

37. Yadava RN, Rathore K. A new cardenolide from the seeds of Terminalia arjuna (W&A). J Asian Nat Prod Res. 2000;2(2):97–101.

38. Rastogi R.P., Mehrotra B.N. vol. 3. CSIR; New Delhi: 1993. (Compendium of Indian Medicinal Plants).

39. Petronelli A, Pannitteri G, Testa U. Triterpenoids as new promising anticancer drugs. Anticancer Drugs. 2009 Nov;20(10):880–92.

40. Fuhrman B, Aviram M. Anti-atherogenicity of nutritional antioxidants. IDrugs Investig Drugs J. 2001 Jan;4(1):82–92.

41. Carluccio MA, Siculella L, Ancora MA, Massaro M, Scoditti E, Storelli C, et al. Olive oil and red wine antioxidant polyphenols inhibit endothelial activation: antiatherogenic properties of Mediterranean diet phytochemicals. Arterioscler Thromb Vasc Biol. 2003 Apr 1;23(4):622–9.

42. Ruf JC. Wine and polyphenols related to platelet aggregation and atherothrombosis. Drugs Exp Clin Res. 1999;25(2–3):125–31.

43. Martikainen JA, Ottelin A-M, Kiviniemi V, Gylling H. Plant stanol esters are potentially cost-effective in the prevention of coronary heart disease in men: Bayesian modelling approach. Eur J Cardiovasc Prev Rehabil Off J Eur Soc Cardiol Work Groups Epidemiol Prev Card Rehabil Exerc Physiol. 2007 Apr;14(2):265–72.

44. Bajpai M, Pande A, Tewari SK, Prakash D. Phenolic contents and antioxidant activity of some food and medicinal plants. Int J Food Sci Nutr. 2005 Jun;56(4):287–91.

45. Chung KT, Wong TY, Wei CI, Huang YW, Lin Y. Tannins and human health: a review. Crit Rev Food Sci Nutr. 1998 Aug;38(6):421–64.

46. Greco G, Turrini E, Tacchini M, Maresca I, Fimognari C. The Alcoholic Bark Extract of Terminalia Arjuna Exhibits Cytotoxic and Cytostatic Activity on Jurkat Leukemia Cells. Venoms Toxins. 2021 May 6;1(1):56–66.

47. Jain S, Yadav PP, Gill V, Vasudeva N, Singla N. Terminalia arjuna a sacred medicinal plant: phytochemical and pharmacological profile. Phytochemistry Reviews. 2009 Jun 1;8(2):491-502.

48. Muthu C, Ayyanar M, Raja N, Ignacimuthu S. Medicinal plants used by traditional healers in Kancheepuram district of Tamil Nadu, India. J Ethnobiol Ethnomedicine. 2006 Oct 7;2:43.

49. Prusti AB, Behera KK. Ethnobotanical exploration of Malkangiri district of Orissa, India. Ethnobotanical leaflets. 2007;2007(1):14.

50. Varghese A, Savai J, Pandita N, Gaud R. In vitro modulatory effects of Terminalia arjuna , arjunic acid, arjunetin and arjungenin on CYP3A4, CYP2D6 and CYP2C9 enzyme activity in human liver microsomes. Toxicol Rep. 2015;2:806–16.

51. Pawar RS, Bhutani KK. Effect of oleanane triterpenoids from Terminalia arjuna--a cardioprotective drug on the process of respiratory oxyburst. Phytomedicine Int J Phytother Phytopharm. 2005 May;12(5):391–3.

52. Singh G, Singh AT, Abraham A, Bhat B, Mukherjee A, Verma R, et al. Protective effects of Terminalia arjuna against Doxorubicin-induced cardiotoxicity. J Ethnopharmacol. 2008 Apr 17;117(1):123–9.

53. Viswanatha GL shastry, Vaidya SK, C R, Krishnadas N, Rangappa S. Antioxidant and antimutagenic activities of bark extract of Terminalia arjuna. Asian Pac J Trop Med. 2010 Dec;3(12):965–70.

54. Ahmad MS, Ahmad S, Gautam B, Arshad M, Afzal M. Terminalia arjuna, a herbal remedy against environmental carcinogenicity: An in vitro and in vivo study. Egypt J Med Hum Genet. 2014 Jan;15(1):61–7.

55. Mandal S, Patra A, Samanta A, Roy S, Mandal A, Mahapatra TD, et al. Analysis of phytochemical profile of Terminalia arjuna bark extract with antioxidative and antimicrobial properties. Asian Pac J Trop Biomed. 2013 Dec;3(12):960–6.

56. Khan AS. Trees with Antimicrobial Activities. In: Medicinally Important Trees [Internet]. Cham: Springer International Publishing; 2017 [cited 2021 Nov 13]. p. 85–108. Available from: http://link.springer.com/10.1007/978-3-319-56777-8_4

57. Aneja KR, Sharma C, Joshi R. Antimicrobial activity of Terminalia arjuna Wight & Arn.: an ethnomedicinal plant against pathogens causing ear infection. Braz J Otorhinolaryngol. 2012 Feb;78(1):68–74.

58. Verma N, Vinayak M. Effect of Terminalia arjuna on antioxidant defense system in cancer. Mol Biol Rep. 2009 Jan;36(1):159–64.

59. Gauthaman K, Banerjee SK, Dinda AK, Ghosh CC, Maulik SK. Terminalia arjuna (Roxb.) protects rabbit heart against ischemic-reperfusion injury: role of antioxidant enzymes and heat shock protein. J Ethnopharmacol. 2005 Jan 15;96(3):403–9.

60. Oberoi L, Akiyama T, Lee K-H, Liu SJ. The aqueous extract, not organic extracts, of Terminalia arjuna bark exerts cardiotonic effect on adult ventricular myocytes. Phytomedicine. 2011 Feb;18(4):259–65.

61. Kumar GP, Navya K, Ramya EM, Venkataramana M, Anand T, Anilakumar KR. DNA damage protecting and free radical scavenging properties of Terminalia arjuna bark in PC-12 cells and plasmid DNA. Free radicals and antioxidants. 2013 Apr 1;3(1):35-9.

62. Hebbani AV, Vaddi DR, Dd PP, NCh V. Protective effect of Terminalia arjuna against alcohol induced oxidative damage of rat erythrocyte membranes. J Ayurveda Integr Med. 2021 Apr;12(2):330–9.

63. Devi RS, Narayan S, Vani G, Shyamala Devi CS. Gastroprotective effect of Terminalia arjuna bark on diclofenac sodium induced gastric ulcer. Chem Biol Interact. 2007 Apr 5;167(1):71–83.

64. Prakash V, Sehgal V kumar, Bajaj VK, Singh H. To Compare the Effects of Terminalia Arjuna with Rosuvastatin on Total Cholesterol and Low Density Lipoprotein Cholesterol. Int J Med Dent Sci. 2016 Jan 17;5(1):1056.

65. Allawadhi P, Khurana A, Sayed N, Kumari P, Godugu C. Isoproterenol-induced cardiac ischemia and fibrosis: Plant-based approaches for intervention. Phytother Res PTR. 2018 Oct;32(10):1908–32.

66. Bhatia J, Bhattacharya SK, Mahajan P, Dwivedi S. Effect of Terminalia arjuna on coronary flow—an experimental study. Indian J Pharmacol. 1998;30:118.

67. Verma P, Muneesh RS, Bhutani G. Experimental Evaluation of Terminalia arjuna (Aqueous Extract) on cardiovascular system in comparison to digoxin. J Dent Med Sci. 2013;7:48-51.

68. Sumitra M, Manikandan P, Kumar DA, Arutselvan N, Balakrishna K, Manohar BM, et al. Experimental myocardial necrosis in rats: role of arjunolic acid on platelet aggregation, coagulation and antioxidant status. Mol Cell Biochem. 2001 Aug;224(1–2):135–42.

69. Mythili P, Parameswari CS, Dayana J. Phytochemical analysis of the bark extract of Terminalia arjuna and its cardioprotective effect. Indian J Innov Dev. 2012;1:40-2.

70. Tiwari AK, Gode JD, Dubey GP. Effect of Terminalia arjuna on lipid profiles of rabbits fed hypercholesterolemic diet. International Journal of Crude Drug Research. 1990 Jan 1;28(1):43-7.

71. Pathak SR, Upadhya L, Singh RN. Effect of Terminalia arjuna on lipid profile of rabbit fed hypercholesterolemic diet. International Journal of Crude Drug Research. 1990;28:48-51.

72. Khanna AK, Chander R, Kapoor NK. Terminalia arjuna: an ayurvedic cardiotonic, regulates lipid metabolism in hyperlipaemic rats. Phytotherapy Research. 1996 Dec;10(8):663-5.

73. Ram A, Lauria P, Gupta R, Kumar P, Sharma VN. Hypocholesterolaemic effects of Terminalia arjuna tree bark. J Ethnopharmacol. 1997 Feb;55(3):165–9.

74. Subramaniam S, Subramaniam R, Rajapandian S, Uthrapathi S, Gnanamanickam VR, Dubey GP. Anti-Atherogenic Activity of Ethanolic Fraction of Terminalia arjuna Bark on Hypercholesterolemic Rabbits. Evid-Based Complement Altern Med ECAM. 2011;2011:487916.

75. Subramaniam S, Ramachandran S, Uthrapathi S, Gnamanickam VR, Dubey GP. Anti-hyperlipidemic and antioxidant potential of different fractions of Terminalia arjuna Roxb. bark against PX- 407 induced hyperlipidemia. Indian J Exp Biol. 2011 Apr;49(4):282–8.

76. Patil RH, Prakash K, Maheshwari VL. Hypolipidemic effect of Terminalia arjuna (L.) in experimentally induced hypercholesteremic rats. Acta Biologica Szegediensis. 2011 Jan 1;55(2):289-93.

77. Dwivedi S, CHANSOURIA JN, Somani PN, Udupa KN. Effect of Terminalia arjuna on ischaemic heart disease. Alternative medicine. 1989;3(2):115-22.

78. Verma SK, Bordia A. Effect of Terminalia arjuna bark (arjun chhal) in patients of congestive heart failure and hypertension. J Res Educ Indian Med. 1988;7(31):e6.

79. Bharani A, Ganguly A, Bhargava KD. Salutary effect of Terminalia Arjuna in patients with severe refractory heart failure. Int J Cardiol. 1995 May;49(3):191–9.

80. Parmar HS, Panda S, Jatwa R, Kar A. Cardio-protective role of Terminalia arjuna bark extract is possibly mediated through alterations in thyroid hormones. Pharm. 2006 Sep;61(9):793–5.

81. Bittner, Vera A., Michael Szarek, Philip E. Aylward, Deepak L. Bhatt, Rafael Diaz, Jay M. Edelberg, Zlatko Fras, et al. “Effect of Alirocumab on Lipoprotein(a) and Cardiovascular Risk After Acute Coronary Syndrome.” JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY 75, no. 2 (January 21, 2020): 133–44. https://doi.org/10.1016/j.jacc.2019.10.057.
82. Garg, Mayank, and Sandip Mohale. “Prevalence of Metabolic Obesity Normal Weight (MONW) in Cardiovascular Disease Patients - A Hospital-Based Case Control Study.” JOURNAL OF EVOLUTION OF MEDICAL AND DENTAL SCIENCES-JEMDS 9, no. 34 (August 24, 2020): 2427–31. https://doi.org/10.14260/jemds/2020/528.
83. Kamble, T. K., Ankita Kapse, Sunil Kumar, Sourya Acharya, and Aiswarya Ghule. “Study of Myocardial Performance Index in Prediabetes and Its Correlation with Other Cardiovascular Risk Factors.” JOURNAL OF EVOLUTION OF MEDICAL AND DENTAL SCIENCES-JEMDS 9, no. 10 (March 9, 2020): 721–25. https://doi.org/10.14260/jemds/2020/157.
84. Acharya, Sourya, Samarth Shukla, and Anil Wanjari. “Subclinical Risk Markers for Cardiovascular Disease (CVD) in Metabolically Healthy Obese (MHO) Subjects.” JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH 13, no. 6 (June 2019): OC1–6. https://doi.org/10.7860/JCDR/2019/41317.12890.
85. Goodman, Shaun G., Philip E. Aylward, Michael Szarek, Vakhtang Chumburidze, Deepak L. Bhatt, Vera A. Bittner, Rafael Diaz, et al. “Effects of Alirocumab on Cardiovascular Events After Coronary Bypass Surgery.” JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY 74, no. 9 (September 3, 2019): 1177–86. https://doi.org/10.1016/j.jacc.2019.07.015.
86. Singh, A., Lodha, P. and Sharma, A. (2021) “Terminalia arjuna Leaf Gall: The Possible Treatment for Sickle Cell Anaemia”, Journal of Pharmaceutical Research International, 32(41), pp. 64-75. doi: 10.9734/jpri/2020/v32i4131044.