Review article

Medicinal properties of *Terminalia arjuna* (Roxb.) Wight & Arn.: A review

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**Abstract**

Medicinal plants have been a main source of therapeutic agents from ancient time to cure diseases. *Terminalia arjuna* (Roxb.) Wight & Arn. (*T. arjuna*) is one of the most accepted and beneficial medicinal plants in indigenous system of medicine for the treatment of various critical diseases. This comprehensive review provides various aspects of its ethnomedical, phytochemical, pharmacognostical, pharmacological and clinical significance to different diseases particularly in cardiovascular conditions. This plant has a good safety outline when used in combination with other conventional drugs. This review highlights various medicinal properties of *T. arjuna* through different studies such as antioxidant, hypotensive, antiatherogenic, anti-inflammatory, anti-carcinogenic, anti-mutagenic and gastro-productive effect.

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**1. Introduction**

Medicinal plants play an essential role in health care and are the major raw materials for both traditional and conventional medicine preparations; still most of the people choose herbal medicines than conventional medicines. They expanded attention due to their effectiveness, lack of current medical alternatives, increasing cost of modern medicines and cultural preferences. Ethnobotanical studies are most important to expose the ancient times and current culture about plants in the world and reserving original knowledge of medicinal plants. The quantitative ethnobotanical studies were used to identify the plant uses as food, human health care medicines, veterinary medicine and economically important.

Around the world, the traditional knowledge system has expanded chief importance in perspective with protection, sustainable growth and search for new utilization patterns of plant resources. Traditional medicine system includes the knowledge, skills and practices based on the presumptions, beliefs and experiences of folk communities to protect their health problems. Traditional herbal medicines are considered to be of huge importance among different rural or native communities in many developing countries. According to WHO, almost 80% of the world’s population depending on traditional medicine and in India 60% of the people in rural areas use herbal medicines. During the last few years, use of herbal supplements increased from 2.5% to 12%.[1] In recent years, there has also been an increasing demand for nanoparticles derived from medicinal plants like *Terminalia* family due to their applications in various fields of research like medicine, catalysis, energy and materials.[10–12]

In the earliest India, medicinal plants were used to prevent different critical diseases and they would be the best source to obtain a variety of drugs. The Indian traditional medicine is based on various systems such as Ayurveda, Siddha, Unanai, etc. In recent years there has been an increasing awareness about the importance of medicinal plants. Herbal drugs are easily accessible, secure, less pricey, efficient and have very rare side effects. The evaluation of new drugs, especially the phytochemical obtained materials has opened a vast area for research and helpful in making a transition from traditional to modern medicine in India. Medicinal plants contain some organic compounds which provide definite physiological action on the human body and these bioactive substances include tannins, alkaloids, carbohydrates, terpenoids, steroids, flavonoids, and phenols.[1]

Even though numerous medicinal plants have been explained in the Indian customary therapeutic system for treatment of several diseases, very few plant products are nowadays utilized in the modern medical system to treat most of the diseases,
particularly; cardiovascular diseases (CVD), ulcers, diabetes, cough, excessive perspiration, asthma, tumor, inflammation and skin disorders. Among the plants, one of the medicinal plants indigenous to India is Terminalia arjuna (Roxb.) Wight and Arn., (T. arjuna) commonly known as ‘Arjuna’, which has been used as a cardiotonic in heart failure, ischemic, cardiomyopathy, atherosclerosis, myocardium necrosis and has been used for the treatment of different human diseases like blood diseases, anemia, venereal and viral disease; and to continue excellent healthiness. It is used in the treatment of fractures, ulcers, hepatic and showed hypcholesterolemic, antibacterial, antimicrobial, antitumor, antioxidant, antiallergic and antifeedant, antiﬁlthy and anti-HIV activities.14–16 T. arjuna is reported to possess strong hydrolipidemic properties. It is trusted that the saponin glycosides in T. arjuna may be responsible for its inotropic effects, while the flavonoids/phenolics may supply antioxidant activity as well as vascular amplification activity, in this manner authenticate the multiple activities of this plant for its cardio-protective function.17–19 The aim of this review is to summarize the information and knowledge about the T. arjuna and updating available research data on the aspects of botany, ethnopharmacology, phytochemistry and clinical studies.

2. Methods

Systematic literature searches were carried out and the available information on various plants traditionally used for cardiovascular disorders was collected via electronic search (using Pubmed, SciFinder, Scopus, Scirus, ScienceDirect, Google Scholar and Web of Science) and a library search for articles published in peer-reviewed journals and also locally available books.

3. Occurrences, botanical description and ethnopharmacology

T. arjuna is an ayurvedic plant with important medicinal value. It is commonly known as Arjuna, Indradrus, Partha and Veeravriksha,20 which is known to Combretaceae family comprising of nearly 200 species distributed around the world. Nearly 24 species of Terminalia have been reported from various parts of India, some selected species are T. arjuna, Terminalia bellirica, Terminalia bialata, Terminalia catappa, Terminalia elliptica, Terminalia porphyracarpa, Terminalia mantaly etc. In India, T. arjuna is about 60–80 feet in height, buttressed trunk and horizontally spreading crown and drooping branches distributed in India, Burma, Mauritius and Sri Lanka.19,21,22 T. arjuna is distributed throughout sub Indo-Himalayan tracts of Uttar Pradesh, Punjab, Deccan, South Bihar, Orissa, West Bengal and Madhya Pradesh mainly along riverside, rivulets and ponds. It is known by its various vernacular names, the most commonly used ones are Arjuna (Common Name), Arjun (Hindi), Marudhu (Tamil and Malayalam), Tella Maddi (Telugu), Arghan (Bengali), Sadaru (Marathi), Sadado (Gujarati), Neer matti (Kannada) and some traditional formulations prescribe in the name of Arjunarishta and Arjunagbhrta.

Leaves of T. arjuna are simple, often crenulations, borne sub-opposite, shortly acute or obtuse at the apex, coriaceous and oblong or elliptic. Their upper face is pale or dark green and the lower face is pale brown. The tree bears white sessile bisexual flowers in short auxiliary spikes or in a terminal panicle arrangement. Fruits of T. arjuna are drupe, ovoid, fibrous-woody and smooth-skinned with five hard wings or angles which are oblique and curved upwards. Stem bark is simple, smooth and pinkish-gray in color in external view. An internal view, the bark is soft and reddish in color.23

4. Phytochemistry

The major constituents of T. arjuna in stem bark, root bark, fruits, leaves and seeds are well characterized (Table 1). The preliminary phytochemical analysis of existing compounds in T. arjuna was carried out according to various standard protocols as mentioned by Harbone24 in Table 2. As bark was considered to be the most important constituent from the medicinal point of view, initially reported that the bark had 34% ash content consisting entirely of pure calcium carbonate. Aqueous extract of T. arjuna is reported to have 23% calcium salts and 16% tannins. Organic extracts of T. arjuna bark were also prepared using the sequential methods with a number of organic solvents such as hexane, benzene, chloroform, acetone, dichloromethane, ethyl acetate, butanol, ethanol, methanol and ether, etc., to extract various phytochemical constituents. The chemical structures of available compounds, tannins, triterpenoids, saponins, sterols and minerals are the major constituents of T. arjuna. Such amino acids like tryptophan, tyrosine, histidine and cysteine are also the main ingredients in T. arjuna.25,26

4.1. Terpenoids, ursane triterpenoids and glycosides

At first an oleanane triterpenoid named, arjunin, and a lactone, arjunitin were isolated from the benzene and ethanolic extracts of its bark respectively (Fig. 1). Honda et al.53,54 initially confirmed that the presence of arjunic acid and arjungenin and latterly reported that two more glucosides namely arjunglucoside I and II (Fig. 1) in the stem bark of T. arjuna. Anjaneyulu and Prasad28,49 confirmed that the presence of arjunglucoside III and IV, terminalic acid, and a triterpene carboxylic acid by ethyl acetate extraction of roots of T. arjuna (Fig. 1). Hexane extraction of stem of T. arjuna authenticated that the presence of terminalic acid and β-sitosterol.26 Ali et al.16 has isolated another oleanane type triterpene, terminoside A from the acetone fraction of the ethanolic extract of T. arjuna’s stem bark. The structure of this new compound was established as olean-12β,23β-triol-12-en-28-oic acid-3β-O-glucopyranoside. It was exhibited that terminoside A inhibits nitric oxide production and decreases inducible nitric oxide synthase levels in lipopolysaccharide stimulated macrophages.35,36 Five ursane type triterpene glycosyl ester including new one, 2x, 3β-dihydroxyurs-12,18-dien-28-oic acid-28-O-β-D-glucopyranosyl ester, and four known ursane triterpene glycosyl esters namely, 2x, 3β, 23-trihydroxyurs-12,18-dien-28-oic acid-28-O-β-D-glucopyranosyl ester, 23-O-β-D-glucopyranosyl ester, quadrasonides VIII, kajiichigoside and 2x, 3β, 23-trihydroxyurs-12, 19-dien-28-oic acid-28-O-β-D-glucopyranosyl ester were isolated from bark of T. arjuna (Fig. 2).30 3-O-β-D-glucopyranosyloxy-2x, 3β, 19x-trihydroxyolean-12-en-28-oic acid, 28-O-β-D-glucopyranosyl and 2x, 19x-dihydroxy-3-oxo-olean-12-en28-oic acid 28-O-β-D-gluco-pyransides are isolated from bark of T. arjuna by Choubey and Srivastava34 and Upadhyay et al.13 through spectrochemical analysis. Pattana et al.38 using chromatography technique isolated a triterpenoid glycoside from the bark of T. arjuna and identiﬁed it as an olean-3β,22β-diol-12-en-28-O-β-D-glucopyranoside-oic acid. Alam et al.39 were isolated two more glycosides namely Termiarjunoside I (olean-1x,3β,22β-tetraol-12-en-28-oic acid-3β-O-glucopyranoside) and Termiarjunoside II (olean-3β,5α, 25-triol-12-en-23,28-dioicacid-3β-O-glucopyranoside) from the ethanolic extract of TA bark. Arjunglucoside IV and V, Arjunasides A-E were isolated from the ethanolic extract of the stem bark of T. arjuna by Wang et al.30,58
Table 1
Phytochemical constituents of various parts of *Terminalia arjuna* (Roxb.) Wight and Arn.

| Part used | Major chemical constituents | References |
|-----------|-----------------------------|------------|
| **Stem bark** | **Triterpenoids** | Row et al.²⁴ |
| | Arj unin | Honda et al.²⁵ |
| | Arjunic acid | Singh et al.²⁶,²⁷ |
| | Arjungenin | Anjaneyulu and Prasad²⁸ |
| | Terminic acid | Singh et al.²⁹ |
| | Terminoltin | Singh et al.³⁰,³¹ |
| | Arjunolic acid | | |
| **Ursane triterpenoids** | 2x,3β,12,18-oic acid 28-O-β-D-glucopyranosyl ester | Wang et al.¹⁰ |
| | 2x,3β,23-trihydroxyurs-12,18-dien-28-oic acid 28-O-β-D-glucopyranosyl ester | |
| | Qudranoside VIII | |
| | Rajichigoside F1 | |
| **Glycosides** | **Arjunetin** | Row et al.²⁴,³² |
| | **Arjunoside I, II** | Honda et al.²⁵,³² |
| | **Arjunolone** | Tripathi et al.³³ |
| | **Arjunolitin** | Ali et al.³⁴,³⁵ |
| | **Arjunaphthanoloside** | | |
| | **Arjunglucoside IV and V, Arjunasides A-E** | Wang et al.³⁶,³⁷ |
| | **Arjunoside A** | Patnaik et al.³⁸ |
| | **Arjunone** | Ahmad et al.³⁹ |
| **Roots** | **Triterpenoids** | | |
| | **Arjunoside I-IV** | Anjaneyulu and Prasad⁴⁸,⁴⁹ |
| | **Arjunolic acid** | Anjaneyulu and Prasad⁴⁶,⁴⁹ |
| | **Oleanolic acid** | Anjaneyulu and Prasad⁴⁶,⁴⁹ |
| | Terminic acid | | |
| | 2x,19α-Dihydroxy-3Oxo-Olean-12-En28-Olic acid 28-O-β-D-glucopyranoside | Choubey and Srivastava⁴⁴ |
| | Arjunic acid | Singh et al.³⁰,³¹ |
| **Glycosides** | **Arjunetoside (3-O-β-D-glucopyranosyl-2x, 3β, 19α-trihydroxyolean-12-en-28-oic acid 28-O-β-D-glucopyranoside)** | Upadhyay et al.⁵⁰ |
| **Fruits** | **Triterpenoids and flavonoids** | Rastogi and Mehrotra⁵¹ |
| | **Arjunic acid, Arjunone, Arachidic stearate, Cerasidin, Ellagic acid, Fridelin, Gallic acid, Hentriacontane, Methyl oleaolate, Myristyl oleate, β-Sitisterol** | | |
| | **Flavonoids and glycosides** | | |
| | **Leaves and seeds** | **Flavonoids and glycosides** | | |
| | **Luteolin, 14,16-dianhydrogitoxigenin 3-β-D-glucopyranosyl-(1 > 2)-O-β-D-galactopyranoside** | | |
4.2. Flavonoids and phenolics

Bark of *T. arjuna* contains a very high level of flavonoids, namely arjunolone, flavones, luteolin, baicalein, quercetin, kempferol, and pelargonidin evaluated with other medicinal plants particularly having favorable effects on cardiovascular diseases. The compound luteolin has been isolated from the butanolic fraction of *T. arjuna* and it has been found to be antimutagenic and antibacterial activity. It inhibited gram negative pathogen growth with a minimum inhibitory concentration of 12.5 µg/disc. Aqueous extract of *T. arjuna* contains 70% polyphenols having a molecular weight greater than 3.5 kDa and they are confirmed by the HPLC and LC-MS. The aqueous extract contains flavon-3-ols, such as (+)-catechin, (+)-gallocatechin and (−)-epigallocatechin; gallic acid, ellagic acid and its derivatives such as 3-O-methyl ellagic acid 4-O-β-D-xylopyranoside and 3-O-methyl ellagic acid 3-O-rhamnoside.

![Fig. 1. Structure of important terpenoids and glycosides isolated from *Terminalia arjuna*.](image)
Various studies support the fact that bioflavonoids inhibit LDL oxidation, endothelial activation and platelet aggregation. Due to the presence of free radical scavenging action of the various phenolic contents in *T. arjuna*, it acts as strong anti-proliferative and anti-oxidant agent. There is an inversely relationship between the high intake of dietary flavonoids and the risk of coronary artery disease (CAD), so possible account for intake of high flavonoids content TA is beneficial effects in CAD.

4.3. Tannins

Tannins are known to enhance the synthesis of nitric oxide and relax vascular segments pre-contracted with norepinephrine. In addition to a flavonoids variety of tannins have been isolated from the bark of *T. arjuna*. Around fifteen types of tannins and their related compounds were isolated from the bark of *T. arjuna* and their structures were elucidated with the help of spectral analysis. Hydrolyzable tannins are castalagin, casuarinin, punicalagin, pyrocatechols, punicalin, terchebulin and terflavin C were isolated from the bark of *T. arjuna*. Tannins are considered to have wound healing, astringent, hypotensive, antioxidant and antimicrobial effects.

4.4. Minerals and amino acids

The bark of *T. arjuna* contains large amount of various minerals and trace elements such as magnesium (4000 µg/g), calcium (3133 µg/g), zinc (119 µg/g) and copper (19 µg/g). It contains some amino acids such as tryptophan, tyrosine, histidine and cysteine.
5. Pharmacological and clinical studies

*T. arjuna* is a tree having an widespread medicinal potential in most of the diseases particularly cardiovascular disorders. Scientific investigations of *T. arjuna* extensively reported and discussed through various preclinical and clinical studies (Tables 3 and 4).

5.1. Pharmacological studies

Cardioprotective potential of *T. arjuna* stem bark on the molecular basis was evaluated by Kokkiripati et al., using cell cultures of human monocytic (THP-1) and human aortic endothelial cells (HAECs). Inhibitory effect of alcoholic (TAAE) and aqueous (TAWE) extracts of *T. arjuna* stem bark was assessed on human 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase, lipoprotein lipase (LpL) and lipid peroxidation in rat (Wistar) liver and heart homogenates. TAAE and TAWE inhibited the lipid peroxidation and HMG-CoA reductase. Both the extracts attenuated H$_2$O$_2$ mediated ROS generation in THP-1 cells by promoting catalase (CAT), glutathione peroxidase (GPx) activities, and by sustaining cellular reducing power. TAAE was highly effective in satisfying proinflammatory gene transcripts in THP-1 cells and HAECs, whereas the response to TAWE depended on the type of transcript and cell type. Both extracts decreased the levels of typical inflammatory marker proteins, viz. LPS induced tumor necrosis factor (TNF)-α secreted by THP-1 cells and TNF-α induced cell surface adhesion molecules on HAECs, namely vascular cell adhesion molecule-1 (VCAM-1) and E-selectin. The marked effects on cultured human monocyctic and aortic endothelial cells (HAEC) provide the biochemical and molecular basis for the therapeutic potential of *T. arjuna* stem bark against cardiovascular diseases (CVD).

Triterpenoids are essentially responsible for cardiovascular properties. Alcoholic and aqueous bark extracts of *T. arjuna*, arjunic acid, arjunetin and arjunenin were evaluated for their potential to inhibit CYP3A4, CYP2D6 and CYP2C9 enzymes in human liver microsomes by Varghese et al. They have demonstrated that...
| Pharmacological activity | Model used and study design | Type of extract | Observations | References |
|--------------------------|-----------------------------|----------------|--------------|------------|
| Antioxidant, antiinflammatory, and immunomodulatory | CYP3A4, CYP2D6 and CYP2C9 enzymes in human liver microsomes | Alcoholic and aqueous extract of *T. arjuna* at 35 μg/ml dose level | Alcoholic and aqueous extracts of *T. arjuna* showed significant inhibition activity of CYP3A4, CYP2D6 and CYP2C9 enzyme. Enzyme kinetic studies suggested that the extracts of *T. arjuna* showed rapidly reversible non-competitive inhibition of all three enzymes in human liver microsomes. Arjungenin is the most active compound than others and had moderate inhibitory effect on the process of respiratory oxyburst and its IC₅₀ value is shown 60 μg/ml. | Varghese et al⁶⁶ |
| Antioxidant | Human polymorphonuclear (PMN) cells and hypochlorous acid from human neutrophils | Methanolic extract of *T. arjuna* | *T. arjuna* was administrated orally to Wistar rat at different doses (0.42 mg/kg to 6.8 mg/kg) for 6 days/week for 4 weeks. Chromic administration of butanolic fraction of alcoholic extract of *T. arjuna* bark has cardioprotective potential against Dox-induced cardio toxicity. | Pawar and Bhutani⁶⁷ |
| Antioxidant and antimutagenic activity | Wistar rats (200–250 g) and Swiss albino mice (18–22 g) | Aqueous and ethanolic extraction of *T. arjuna* | The alcoholic extract of *T. arjuna* (ALTA) has shown potent antioxidant activity with EC₅₀ of 2.491 ± 0.160, 50.110 ± 0.150 and 71.000 ± 0.025 in DPPH assay, superoxide radical scavenging activity and lipid peroxidation assay, respectively. In micronucleus test, EC₅₀ of 2.410 ± 0.140, 40.500 ± 0.390 and 63.000 ± 0.360 in percentage of micronucleus in ALTA (100 and 200 mg/kg p.o) showed significant reduction in both polychromatic erythrocytes and normochromatic erythrocytes and also showed significant reduction in P/N ratio. | Viswanatha et al⁶⁹ |
| Anticarcinogenic and antimutagenic potential | In vitro and in vivo method | Aqueous extracts from 75 μg/ml to 200 μg/ml for lymphocyte culture for in vitro experiments Aqueous extracts from 50 mg/kg to 350 mg/kg body weight for in vivo experiments | Used human lymphocyte culture and bone marrow cells of albino mice (8–10 weeks old and weight ranges between 25–35 g) The number of sister chromatid exchanges got reduced from a higher level of 15.0 ± 1.4 per cell to 7.7 ± 0.5 per cell with S9 mix at 48 h of treatment. The replication index was enhanced from 1.33 to 1.55 in vitro. In the in vivo experiments, effective reduction in clastogenic ranging from 15.22% to 54.82% from the mutagen treated positive control and the total frequencies in aberrant cells got reduced from 429 due to AFB1 to 141 due to 5th concentration of *T. arjuna* extracts at 32 h of exposure. TAAE and TAWE inhibited the lipid peroxidation and attenuated H₂O₂ mediated ROS generation in THP-1 cells by promoting catalase, glutathione peroxidase activities and by sustaining cellular reducing power. Marked effects of *T. arjuna* steam bark on cultured human monocyte and aortic endothelial cells provide the biochemical and molecular basis for therapeutic potential of *T. arjuna* steam bark against cardiovascular diseases (CVD). *T. arjuna* augments endogenous antioxidant compounds of rat heart and also prevents oxidative stress associated with IRI of the heart. | Ahmad et al⁷⁰ |
| Antioxidant, antiinflammatory and immunomodulatory | Cell cultures of human monocytic (THP-1) and human aortic endothelial cells (HEACs) | *T. arjuna* alcoholic extract (TAAE) and *T. arjuna* aqueous extract (TAWE) from steam bark at a dose of 1–50 μg/ml | TAAE and TAWE inhibited the lipid peroxidation and attenuated H₂O₂ mediated ROS generation in THP-1 cells by promoting catalase, glutathione peroxidase activities and by sustaining cellular reducing power. Marked effects of *T. arjuna* steam bark on cultured human monocyte and aortic endothelial cells provide the biochemical and molecular basis for therapeutic potential of *T. arjuna* steam bark against cardiovascular diseases (CVD). *T. arjuna* augments endogenous antioxidant compounds of rat heart and also prevents oxidative stress associated with IRI of the heart. | Kokkiripati et al⁶⁶ |
| Antioxidant | Male albino Wistar rats (120–150 g body weight) were subjected to oxidative stress associated with in vitro ischemic reperfusion injury (IRI) | Two doses (500 and 750 mg/kg in 2% carboxy methyl cellulose (CMC)), 6 days per week for 12 weeks | Two doses (500 and 750 mg/kg in 2% carboxy methyl cellulose (CMC)), 6 days per week for 12 weeks | Gauthaman et al⁷¹ |

(continued on next page)
| Pharmacological activity | Model used and study design | Type of extract | Observations | References |
|--------------------------|----------------------------|-----------------|-------------|------------|
| Antioxidant              | Human neutrophils isolated from fresh, heparinized human blood by using Histoprep and suspended in HBSS medium containing gelatin. | Ethanolic extraction of *T. arjuna* containing arjunic acid, arjugenin, arjunetin and arjunglucoside II | Arjungenin and its glucose extracted from *T. arjuna* and are exhibited a significant free radical scavenging activity on the superoxide release from PMN cells. Arjungenin exhibit great inhibitor action on the hypochlorous acid productin from human neutrophils. *T. arjuna* bark extract improved cardiovascular autonomic neuropathy in rats having uncontrolled diabetes through maintaining endogenous antioxidant enzyme activities and decreasing cytokine levels. Ethanol extract of *T. arjuna* protects murine hearts from NaF-induced oxidative stress via its antioxidant properties. | Pawar and Bhutani<sup>64</sup> Khaliq et al<sup>67</sup> Subramaniam et al<sup>75</sup> Sinha et al<sup>73</sup> Parveen et al<sup>74</sup> |
| Antioxidant              | Male Wistar albino rats, weighing between 250 and 300 g; treated with STZ at a dose of 65 mg/kg | Therapeutic treatment through 50% ethanolic extract of *T. arjuna* at a dose of 500 mg/kg and rosuvastatin (20 mg/kg) for 30 days orally after 8 weeks of STZ treatment | Prophylactic and therapeutic treatment with *T. arjuna* improved cardiac functions and baroreflex sensitivity. It is attenuated hypertrophy and fibrosis of the LV, *T. arjuna* significantly reduced oxidative stress and inflammatory cytokine level in CHF rats Hypolipidemic and antioxidant effects of *T. arjuna* fractions were noticed as ethanol > diethyl ether > ethyl acetate. Ethanolic fraction of *T. arjuna* possesses the potent properties of antioxidant and hypolipidemic than other fractions and has therapeutic potential for the prevention of coronary arterial disease. | Kali et al<sup>72</sup> Khaliq et al<sup>67</sup> Aneja et al<sup>76</sup> Kumar et al<sup>75</sup> |
| Antioxidant              | Male Swiss albino mice treated with NaF at a dose of 600 mg/L for 1 week | Ethanolic extract of *T. arjuna* at a dose of 50 mg/kg of body weight and with vitamin C at a dose of 100 mg/kg body weight for 1 week | Ethanolic extract of *T. arjuna* protects murine hearts from NaF-induced oxidative stress via its antioxidant properties. | Khaliq et al<sup>67</sup> Sinha et al<sup>73</sup> Parveen et al<sup>74</sup> |
| Antioxidant              | Wistar rats weight between 200-240 g | Ethanolic extract of *T. arjuna* at a dose of 500 mg/kg for 15 days was administrated orally | Ethanolic extracts has great free radical scavenging properties. It contains liberal amount of flavonoid compounds. It is exhibited good antimicrobial activity against two gram negative bacteria (*E. coli* and *K. pneumonia*). Acetone leaf extract was found to be best against *S. aureus*. Organic extract showed almost equal inhibition of all tested Gram negative bacteria except *P. aeruginosa*. *T. arjuna* bark exhibited good activity against *S. aureus*. | Mandal et al<sup>77</sup> Aneja et al<sup>78</sup> |
| Antioxidant and antimicrobial activity | Poloxamer (PX)-407 induced hyperlipidemic albino Wistar rats | Three fractions diethyl ether, ethyl acetate and ethanol of *T. arjuna* exerted hypolipidemic and antioxidative effects at two different doses levels (175 and 350 mg/kg body weight) | Hypolipidemic and antioxidant effects of *T. arjuna* fractions were noticed as ethanol > diethyl ether > ethyl acetate. Ethanol fraction of *T. arjuna* possesses the potent properties of antioxidant and hypolipidemic than other fractions and has therapeutic potential for the prevention of coronary arterial disease. | Subramaniam et al<sup>75</sup> |
| Antioxidant              | Male Wistar rats treated with isoproterenol to produce LVH | Ethanolic extract of *T. arjuna* bark was evaluated at 63, 125 and 250 mg/kg given orally for antibioret and antioxidant effects in male Wistar rats given selective β-adrenoceptor agonist isoproterenol (5 mg/kg) for 28 days Captopril has given orally 50 mg/kg per day, an inhibitor of angiotensin-converting enzyme used as a standard cardioprotective drug | Ethanolic extract of *T. arjuna* significantly prevented isoproterenol-induced increase in oxidative stress and decline in endogenous antioxidant level and also prevented fibrosis. | Parveen et al<sup>74</sup> |
| Antioxidant and antimicrobial activity | DPPH methods and Agar well diffusion method | Methanol extracts | Methanolic extracts has great free radical scavenging properties. It contains liberal amount of flavonoid compounds. It is exhibited good antimicrobial activity against two gram negative bacteria (*E. coli* and *K. pneumonia*). Acetone leaf extract was found to be best against *S. aureus*. Organic extract showed almost equal inhibition of all tested Gram negative bacteria except *P. aeruginosa*. *T. arjuna* bark exhibited good activity against *S. aureus*. | Mandal et al<sup>77</sup> Aneja et al<sup>78</sup> |
| Antimicrobial activity   | Five bacteria namely *Staphylococcus aureus* (Gram Positive), *Acinetobacter sp., Proteus mirabilis, Escherichia coli* and *Pseudomonas aeruginosa* (Gram negative) were used | Methanol, ethanol, acetone aqueous extracts from the leaves and bark of *T. arjuna* | Methanol, ethanol, acetone aqueous extracts from the leaves and bark of *T. arjuna* | Aneja et al<sup>78</sup> |
| Antimicrobial activity   | NZW albino rabbits subjected to 15 min coronary artery ligation followed by 60 min of reperfusion injury | Pretreatment of bark powder of 500—750 mg/kg/day for 12 weeks before ischemic-reperfusion injury | Pretreatment of bark powder of 500—750 mg/kg/day for 12 weeks before ischemic-reperfusion injury | Gauthaman et al<sup>79</sup> |
| Anticarcinogenic potential | Adult ventricular myocytes isolated from hearts of adult male Sprague-Dawley rats (250–300 g) | Ethanolic and aqueous extract of *T. arjuna* at a dose of 0.05–100 μg/ml | Ethanolic and aqueous extract of *T. arjuna* at a dose of 0.05–100 μg/ml | Oberoi et al<sup>80</sup> |
Ethanolic extracts and its fractions of *T. arjuna* bark on DNA stand breakage assay and DNA damage protecting effect. Ethanolic extracts and its fractions of *T. arjuna* bark on free radical scavenging activity. A significant reduction in lesion index was observed in ulcer induced animals treated with *T. arjuna* + (DIC) compared to ulcerated rats (DIC). A significant reduction in per cent of micronucleus in both polychromatic erythrocytes (PCE) and normochromatic erythrocytes (NCE) and also shown a significant reduction in per cent of micronucleus in both polychromatic erythrocytes (PCE) and normochromatic erythrocytes (NCE) and also shown a significant decrease in volume of gastric juice, free and total experimental rats (male albino rats of Wistar (150–200 g) in two doses (500 and 750 mg/kg in 2% carboxy methyl cellulose (CMC)), 6 days per week for 12 weeks. The determination of baseline changes in cardiac endogenous antioxidant compounds [superoxide dismutase (SOD), reduced glutathione (GSH) and catalase (CAT)] or the hearts were subjected to oxidative stress associated with in vitro ischemic-reperfusion injury (IRI). Significant rise in myocardial thiobarbituric acid reactive substance (TBARS) and loss of SOD, GSH and CAT occurred in the vehicle-treated hearts subjected to in vitro IRI. Hearts of rats were significantly protected from oxidative stress, when subjected to in vitro IRI. The crude bark of *TA* augments endogenous antioxidant compounds of rat heart and also prevented oxidative stress associated with IRI of the heart. Vascular complications are a leading cause of mortality and morbidity in diabetic patients. Therapeutic potential of *T. arjuna* bark extract was examined in improving myocardial function in streptozotocin (STZ) induced diabetic rats. After 8 weeks of STZ administration, rats showed a decline in left ventricular pressure (LVP), maximal rate of rise and index.
| Highlights of the study | Clinical conditions | Drug formulation and dosage | Clinical outcome | References |
|------------------------|---------------------|-----------------------------|-----------------|------------|
| Idiopathic and ischemic cause | 93 patients with dilated cardiomyopathy (DCMP) of idiopathic and ischemic cause | T. arjuna capsules (500 mg at 8 hourly) | Patients with dilated cardiomyopathy with or without heart failure and reduced left ventricular ejection fraction due to either idiopathic or ischemic cause receiving combined standard therapy, and herbal medication showed significant improvement in systolic and diastolic functions as well as functional capacity in comparison to those receiving only standard therapy or only herbal medications | Bhawani et al82 |
| Heart failure | 12 patients with refractory chronic congestive heart failure | Aqueous extract from bark of T. arjuna was controlled 8 h at a dose of 500 mg | Adjuvant T. arjuna therapy in selected patients with refractory congestive heart failure, mostly related to idiopathic dilated cardiomyopathy, appeared safe and caused long lasting improvement in symptoms and signs of heart failure along with improvement in left ventricular ejection phase indices with definite improvement in quality of life | Bharani et al83 |
| Anti-ischemic effects | 40 patients with acute myocardial infarction with ischemic mitral regurgitation | Double-blind study with 500 mg thrice daily for 3 months along with conventional therapy | Reduction in mitral regurgitation jet area | Dwivedi et al84 |
| Anti-ischemic effects | 58 males with chronic stable angina (NYHA class II–III) with evidence of provokable ischemia | T. arjuna (500 mg 8 h), isosorbide mononitrate (40 mg/daily) or a matching placebo for one week each, separated by a wash-out period of three days in a randomized, double blind crossover design | Significant decrease in the frequency of angina and need for isosorbide dinitrate | Bharani et al85 |
| Hypertension | 36 hypertensive patients (stage III) with increased LV mass | Ayurvedic formulation of T. arjuna, known as ‘Arjuna Kwath’ (25 ml twice a day) | A significant decrease in both SBP and DBP (P < 0.001) in both the groups | Rao et al86 |
| Antioxidant, lowering effects of lipid and lipoprotein | 100 patients with stable CAD | In a placebo-controlled double-blind study, 500 mg of T. arjuna along twice a day in addition to receive the conventional treatment | A significant decrease in hyperlipidemia as well as in various inflammatory cytokines such as hsCRP, IL-18 (P<0.001), IL-6 and TNF-s (P < 0.05) was observed at 3 months in patients | Kapoor et al87 |
| Antioxidant activity | 30 patients with coronary artery disease | 500 mg bark powder of T. arjuna combined with conventional drugs | 16% reduction in LDL cholesterol 15% decrease in cholesterol 11% decrease in triglycerides | Khalil88 |
| Antioxidant activity | 105 patients with stable coronary heart disease (CHD) | T. arjuna bark powder at a dose of 500 mg once daily for 30 days was compared with a known antioxidant, vitamin E (400 units once daily) | Marginal decrease in nitrite levels Significant reduction in lipids (total cholesterol, LDL-cholesterol) Lowering of lipid peroxide in T. arjuna group Improvement in brachial artery flow mediated dilation | Gupta et al89 |
| Effect on endothelial dysfunction | Asymptomatic 18 health chronic smokers and 18 non-smokers | Double-blind, placebo-controlled, crossover design. 500 mg aqueous extract of T. arjuna bark powder administrated thrice daily | | Bharani et al90 |
fall in LVP (LV [dP/dt] max and LV [dP/dt] min), cardiac contractility index (LV [dP/dt] max/LVP), and a rise in LV end-diastolic pressure. Altered lipid profile, oxidative stress, and increased levels of endothelin 1 (ET-1), tumor necrosis factor-α (TNF-α), and interleukin 6 (IL-6) along with histological changes in heart and pancreas were observed in diabetic rats. T. arjuna significantly attenuated cardiac dysfunction and myocardial injury in diabetic rats. It also reduced oxidative stress, ET-1, and inflammatory cytokine levels. Sinha et al. have investigated the antioxidant properties of an ethanol extract of the bark of T. arjuna (TAEE) against sodium fluoride (NaF)-induced oxidative stress in the murine heart. NaF intoxication significantly altered all the indices related to the prooxidant—antioxidant status of the heart. In addition, the ferric reducing/antioxidant power assay revealed that TAAE enhanced the cardiac intracellular antioxidant activity. Finally, they concluded that TAAE protects murine hearts from NaF-induced oxidative stress, probably via its antioxidant properties.

Parveen et al. examined the protective effect of T. arjuna bark extract on left ventricular (LV) and baroreflex function in chronic heart failure and to elucidate the possible mechanistic clues in its cardioprotective action. Fifteen days after isoproterenol administration, rats exhibited cardiac dysfunction, hypertrophy, and LV remodeling along with reduced baroreflex sensitivity. Propylthiouracil and therapeutic treatment with T. arjuna improved LV mechanical functions and baroreflex sensitivity. It has also attenuated hypertrophy and fibrosis of the LV. T. arjuna exerts beneficial effect on LV functions, myocardial remodeling, and autonomic control in chronic heart failure possibly through maintaining endogenous antioxidant enzyme activities, inhibiting lipid peroxidation and cytokine levels. Diethyl ether, ethyl acetate and ethanol extracts of T. arjuna exerted hypolipidemic and antioxidative effects at two different dose levels of 175 and 350 mg/kg body weight in Poloxamer (PX)–407-induced hyperlipidemic albino Wistar rats. The results suggested that the ethanolic fraction of T. arjuna possesses the potent properties of being an antioxidant and hypolipidemic than other fractions. Kumar et al. evaluated the effects of T. arjuna bark extract on myocardial fibrosis and oxidative stress induced by chronic β-adrenoceptor stimulation. Because myocardial fibrosis and oxidative stress accompany a number of cardiac disorders such as hypertrophic cardiomyopathy, hypertensive heart disease and cardiac failure. Aqueous extract of T. arjuna bark was evaluated at 63, 125 and 250 mg/kg given orally for antifibrotic and antioxidative effects in rats given the selective β-adrenoceptor agonist isoproterenol for 28 days. The T. arjuna bark extract significantly prevented the isoprenaline-induced increase in oxidative stress and decline in endogenous antioxidant level and also prevented fibrosis. Gauthaman et al. studied that oral administration of T. arjuna for 12 weeks in rabbits caused augmentation of myocardial antioxidants; superoxide dismutase (SOD), catalase (CAT) and glutathione (GSH) along with induction of heat shock protein 72 (HSP72). In vivo ischemic-reperfusion injury induced oxidative stress, tissue injury of heart and hemodynamic effects were prevented in the T. arjuna treated rabbit hearts.

Alcoholic extract of T. arjuna bark and its extracts were evaluated for DNA protection, protein oxidation and free radical scavenging activity. Ethanolic extract of T. arjuna bark (TAA) and its fractions, including dichloromethane (TAD), ethyl acetate (TAE), butanol (TAB) and water (TAW) has significant antioxidant activity and potential to prevent protein oxidation, DNA damage protection by pBR 322 DNA and SCGE assay. The potent antioxidative activity and DNA protection ability of T. arjuna bark extracts might be endorsed with phenolic/flavonoid compounds. A significant correlation was also observed between free radical scavenging activity, in vitro DNA damage activity and the total phenolic/flavonoid content. Physicochemical property and inotropic effect of the aqueous extract of T. arjuna bark (TAAqE) were investigated by Oberoi et al. on adult rat ventricular myocytes in comparison with extracts prepared sequentially with organic extracts. They found that TAAqE decoctions exerted positive inotropy, accelerated myocyte relaxation and increased caffeine-induced contraction concentration dependently. TAAqE-induced cardiotoxic action via enhancing SR function, a unique action minimizing the occurrence of arrhythmias, makes TAAqE a promising and relatively safe cardiotonic beneficial to the healthy heart and the treatment for chronic heart disease.

Mandal et al. investigated antioxidative and antimicrobial properties of methanolic extract of T. arjuna bark. The antimicrobial activity showed that higher inhibition against Gram negative bacteria than gram positive bacteria and showed a promising antioxidant activity, as absorption of DPPH radicals decreased in DPPH free radical scavenging assay. Methanol extract from bark of T. arjuna exhibited medicinal as well as physiological activities. Methanol, ethanol, acetone, aqueous both hot and cold extracts from the leaves and bark of T. arjuna were tested for their antimicrobial activity against Staphylococcus aureus, Acinetobacter sp., Proteus mirabilis, Escherichia coli, Pseudomonas aeruginosa and Candida albicans, pathogens causing ear infections. Three organic solvents evaluated, alcoholic leaf extract was found to be best against S. aureus. Organic bark extract showed almost equal inhibition of all tested Gram negative bacteria except P. aeruginosa. Aqueous extract of T. arjuna bark exhibited good activity against S. aureus. Devi et al. evaluated the effect of methanolic extract of T. arjuna (100 mg/kg to 50 mg/kg body weight) on diclofenac sodium (80 mg/kg bodyweight in water, orally) induced gastric ulcer in rats. The gastroprotective effect of T. arjuna was assessed from volume of gastric juice, pH, free and total acidity, pepsin concentration, acid output in gastric juice, the levels of non-protein sulf-hydryls (NP-SH), lipid peroxide (LPO), reduced glutathione (GSH), and activities of enzymic antioxidants—super oxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), glutathione–S-transferase (GST) and myeloperoxidase (MPO) in gastric mucosa. The levels of DNA, protein bound carbohydrate complexes—hexose, hexosamine, sialic acid, fucose in gastric mucosa and gastric juice and the levels of RNA in gastric mucosa were assessed. The stomach tissues were used for adherent mucus content and also for the histological examination. A significant reduction in lesion index was observed in ulcer induced animals treated with T. arjuna (DIC + TA) compared to ulcerated rats (DIC). A significant increase was observed at pH, NP-SH, GSH, enzymic antioxidants, protein bound carbohydrate complexes, adherent mucus content, nucleic acids with a significant decrease in volume of gastric juice, free and total acidity, pepsin concentration, acid output, LPO levels and MPO activities in DIC + TA rats compared to DIC rats. It is proved that T. arjuna could act as a gastroprotective agent probably due to its free radical scavenging activity and cytoprotective nature.

5.2. Clinical studies

Recently, Kapoor et al. investigated the therapeutic potential of T. arjuna on the inflammatory markers in subjects with stable coronary artery disease (CAD). In a placebo-controlled, randomized double-blind study, 116 patients with stable CAD who were on standard cardiac medications for more than three months were enrolled and received either placebo or 500 mg of T. arjuna from Himalayan Herbal Healthcare, Bangalore, India twice a day in addition to receiving the conventional treatment. A significant decrease in serum triglycerides as well as in various inflammatory cytokines such as hsCRP, IL-18 (P < 0.001), IL-6 and TNF-α (P < 0.05) was observed at 3 months in patients who were on drug treatment.
as compared to the placebo. The effects were maintained till 6 months follow-up and showed a further reduction in hyperlipidemia and inflammatory markers with time. An observational study was conducted to find out the effects of *T. arjuna* in patients with dilated cardiomyopathy (DCMP) of idiopathic and ischemic cause. Ninety three patients with DCMP receiving standard therapy and/or bark extract of *T. arjuna* 500 mg 8 hourly were enrolled. Three groups as standard therapy (ST, Group 1), *T. arjuna* therapy (TA, Group 2) and standard therapy with *T. arjuna* (ST + TA, Group 3) were formed. At the end of the study period, patients of group 3 showed significant improvement in percentage of left ventricular ejection fraction (LVEF%) (7±1.6, P < 0.00001) compared to group 1 and 2 (P < 0.00001, P < 0.0001). Reductions in Left ventricular end systolic and diastolic diameters and volumes were most significant in group 3 (8.3 ± 4.7, P < 0.0001 and 3.1 ± 5.7, P < 0.001) and (11 ± 26, 9 ± 21 P < 0.01) respectively in comparison to other groups. Pulmonary artery pressure reduced significantly in group 1 and 3 (P < 0.0001). A similar reduction in diastolic score and mitral regurgitation (P < 0.01 and P < 0.0001) was observed in groups 1 and 3. From the results, dilated cardiomyopathy with reduced LVEF due to either idiopathic or ischemic cause receiving standard therapy with *T. arjuna* showed significant improvement in left ventricular parameters as well as LVEF%.

Bharani et al85 investigated the salutary effect of *T. arjuna* in patients with severe refractory heart failure. Twelve patients with refractory chronic congestive heart failure (Class IV NYHA), related to idiopathic dilated cardiomyopathy (10 patients); previous myocardial infarction (one patient) and peripartum cardiomyopathy (one patient), received *T. arjuna*, as bark extract (500 mg 8 hourly) or matching placebo for 2 weeks each, separated by 2 week washout period, in a double blind crossover design as an adjuvant to maximally tolerable conventional therapy (Phase I). On long term evaluation in an open design (Phase II), wherein Phase I participants continued *T. arjuna* in fixed dosage (500 mg 8-hourly) in addition to flexible diuretic, vasodilator and digitalis dosage for 20–28 months (mean 24 months) on outpatient basis, patients showed continued improvement in symptoms, signs, effort tolerance and NYHA Class, with improvement in quality of life. Dwivedi et al84 were conducted a study to evaluate the role of *T. arjuna* in ischemic mitral regurgitation (IMR) following acute myocardial infarction (AMI). 40 patients with fresh AMI showing IMR were randomly divided into 2 groups of 20 each. Two groups were observed between one and three months therapy with *T. arjuna* at a dose of 500 mg twice a day and showed significant decreases in IMR, improvement in E/A ratio and considerable reduction in angina frequency. Bharani et al85 conducted a study on the efficacy of *T. arjuna* in chronic stable angina. Fifty eight males with chronic stable angina (NYHA class II–III) with evidence of provocable ischemia on treadmill exercise test received TA (500 mg 8 hourly), isosorbide (40 mg/daily) or a matching placebo for one week each, separated by a washout period of at least three days in a randomized, double-blind, crossover design. They underwent clinical, biochemical and treadmill exercise evaluation at the end of each therapy, which were compared during the three therapy periods. *T. arjuna* therapy was associated with a significant decrease in the frequency of angina and the need for isosorbide dinitrate. *T. arjuna* bark extract, 500 mg 8 hourly, given to patients with stable angina with provable ischemia on treadmill exercise, led to improvement in clinical and treadmill exercise parameters as compared to placebo therapy. These benefits were similar to those observed with isosorbide mononitrate (40 mg/day) therapy and the extract was well tolerated and well accepted.

The effect of an Ayurvedic formulation of *T. arjuna*, known as ‘Arjuna Kwatha’ was assessed by Rao et al86 in 36 hypertensive patients at stage III with increased LV mass. The patients were divided into two groups, one group received atenolol (50 mg twice daily) and the other group ‘Arjuna Kwatha’ (25 ml twice daily) along with atenolol for 6 months. A significant decrease was observed in both SBP and DBP (P < 0.001) in both the groups. However, LV mass index was only significantly reduced in the atenolol-plus-‘Arjuna Kwatha’ group as compared to atenolol alone (P < 0.001), due to negative chronotropic and inotropic effects of the herbal preparation. Khalil87 reported that the administration of *T. arjuna* bark powder along with statins for 3 months to 30 patients with coronary artery disease resulted in a 16% in LDL-cholesterol, 15% decrease in total cholesterol and 11% in triglycerides, confirming its immense potential to correct dyslipidemia in conjunction with statins. Gupta et al88 evaluated the antioxidant and hypcholesterolaemic effects of *T. arjuna* tree bark and to compare it with a known antioxidant, vitamin E, also performed a randomized controlled trial. One hundred and five successive patients with coronary heart disease (CHD) were recruited and divided into 3 groups of 35 each in this study. Group I received placebo capsules; Group II vitamin E capsules 400 units/day, and Group III received finely pulverized *T. arjuna* tree bark-powder (500 mg) in capsules daily. Lipids and lipid peroxide levels were determined at 30 days follow-up. No significant changes in total, HDL, LDL cholesterol and triglycerides levels were seen in Groups I and II. In Group III, there was a significant decrease in total cholesterol (–9.7 ± 12.7%), and LDL cholesterol (–15.8 ± 25.6%) (paired t-test P < 0.01). Lipid peroxide levels decreased significantly in both the treatment groups (P < 0.01). This decrease was more in vitamin E group (–36.4 ± 17.7%) as compared to the *T. arjuna* group (–29.3 ± 18.9%). *T. arjuna* tree bark powder has significant antioxidant action that is comparable to vitamin E and also has a significant hypcholesterolaemic effect. A study was conducted by Bharani et al86 to determine the improvement of endothelial dysfunction in smokers. Eighteen healthy male smokers (age 28.16 ± 9.45 years) and an equal number of age-matched, non-smoker controls participated in the study. The smokers were given *T. arjuna* (500 mg, 8 h) or matching placebo randomly in a double blind crossover design for two weeks each, followed by repetition of brachial artery reactivity studies to determine various parameters including flow-mediated dilation after each period. The flow-mediated dilation showed significant improvement from baseline values after *T. arjuna* therapy.

**6. Toxicity and side effects**

*T. arjuna* has been used in the dose between 1 to 2 g per day in different clinical studies and found that this is an optimum dose in the patients particularly CAD. These doses have lesser side effect like headache, mild gastritis and constipation. There were no reports in the regards of hematological, hepatic, metabolic and renal toxicity after more than two years of its administration.89 Recently Bhawanani et al82 reported that there was no significant variation in the body and organ weights between the control and the treated group of 93 patients with dilated cardiomyopathy (DCMP) of idiopathic and ischemic cause was observed after 28 days of treatment under the treatment of *T. arjuna* capsules (500 mg at 8 h). Hematological analysis and biochemical parameters revealed no toxic effects of the extract. Pathologically, neither gross abnormalities nor histopathological changes were observed and there was no mortality recorded in 28 days. Yaidikar et al80 reported that pre-treatment with arjunolic acid from the *T. arjuna* bark effectively prevented the cerebral I/R induced oxidative damage by virtue of its antioxidant potential and supplementation of arjunolic acid may be beneficial in stroke prone population. Arjunolic acid from *T. arjuna* attenuated sodium nitrite-induced cardiac damage in rats and restored the normal balance between pro- and anti-inflammatory cytokines. Moreover, arjunolic acid protected cardiac tissues from both extrinsic and intrinsic cell death pathways.91 Parmar et al85 were observed a decrease in serum concentration of thyroid.
hormones as well as an increase in the hepatic LP0 with higher doses of T. arjuna. There is a vital need for well controlled multicentric clinical trials in a larger setup of subjects with a standardized product for exploring the true therapeutic potential of T. arjuna.

7. Conclusion

On the basis of the available literature evidences, T. arjuna is widely used for treatment of cardiovascular diseases, including heart diseases and related chest pain, high blood pressure and high cholesterol. It is also used for earaches and diseases of the urinary tract. The effectiveness T. arjuna as an anti-ischemic agent and as a potent antioxidant preventing LDL, reperfusion ischemic injury to the heart and its potential to reduce atherogenic lipid levels have been sufficiently demonstrated in different experimental and clinical studies. However, continuous research progress of using T. arjuna is very much needed in the regards of exact molecular mechanism, drug administration, drug-drug interactions and toxicological studies.

Conflict of interest statement

We declare that we have no conflict of interest.

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