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Terminalia arjuna: An indigenous ancient drug for cardio protection

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Abstract
Now a days herbal plants are used worldwide for treatment because of the less side effect and cost of treatment is also low. The *Terminalia arjuna* herbal plant contains various phytoconstituents which used in many acute and chronic disorders since ancient times. Main aim of this paper was to know the various therapeutic aspects of Terminalia arjuna. *Terminalia arjuna* is recognized as major sources of chemical constituents to treat heart diseases. Cardiovascular diseases on the top which causes majority of death worldwide. These cardiovascular diseases arise mostly due to sedentary lifestyle, food habits, pollution, etc. *Terminalia arjuna* is also used to treat lipid disorder, diabetes, any type of skin infection, purify blood, reduces vata from body, anti-inflammatory, antioxidant, etc. *Terminalia arjuna* belongs to combretaceae family. It contains arjungenin, phytosterols, luteolin, arjunone, arjunic acid, and ellagic acid these are the major phytoconstituents found in arjuna bark.

Keywords: *Terminalia arjuna*, cardio protection, phytoconstituents

Introduction
Arjuna is an ayurvedic remedy of combretaceae family that has been used in both the formulation such as traditional and modern medicine. These herbal remedies have better effectiveness, cultural preference, and available at low cost (1).
Due to increasing demand to the herbal medicine the use of herbal drug increases from (2.5 to 12 %). If plants naturally contain secondary metabolites such as tannins, alkaloids, glycoside, minerals, vitamins, volatile oils then they also have the medicinal properties. Lipid lowering, antioxidant, anti-inflammatory effect was exerted by flavonoids and cardiotonic effect was shown by glycosides. (5). We mostly use the bark of arjuna plant and powder of that bark is used in case of severe chest pain caused by insufficient blood supply to the heart. (2, 3). The phytoconstituents present in the bark shows anti-carcinogenic and antimutagenic activity. (7, 8, 9, 10). The bark is antipyretic, cardiotonic, astringent, anti-dysenteric, tonic, lithotriptic and also gives relief in hypertension and in liver cirrhosis. (4).

T. arjuna plant T. arjuna Bark

Fig 1

Role of Medicinal Plants
Medicinal plants are rich source of phytoconstituents that can be used to create various herbal, synthetic and semi synthetic formulations. Each part of plant contains various phytoconstituents so the part of plant we are using is very important to choose wisely and each part of plant is used in different diseases. If taken properly, these plants are less poisonous, have better cultural acceptance, compatibility, adaptability with human body, and have less side effects. These plants treat the root cause of diseases and not only the symptoms like modern medicine so the demand of herbal medicine is increasing now a days. Most of the drugs are derived from plants such as vinblastine from vinca, quinine from cinchona, morphine from opium, artemisinin from artemisia etc. Medicinal plants have provided humans with wide range of effective drugs to fight infections. Medicinal herbal

plants are used in case of ulcer, boils, diarrhoea, asthma, liver diseases, conjunctivitis, cancer, blood infection, kidney diseases etc.

The Most Important Marketed Dosage Forms
Arjunarishta, Arjuna Grita, Arjunadisiddha kshira, Kakubhadi kshira, Shankara vati, Kakubhadi churna, Dhatakyadi taila.

DOSES
Bark juice: 10-12 ml, Powder: 3- 6 gm, Decoction: 50-100ml

Taxonomy of Terminalia Arjuna
Botanical classification is most scientific and comprehensive. Medicinal plants are identified according to plant part used, habitat, therapeutic value etc, so the taxonomy of *T. arjuna* is as following: (19, 20)

Table 1

Kingdom	**Plantae**
Division	Magnoliophyte
Class	Magnoliopsida
Order	Myrtales
Family	Combretaceae
Genus	Terminalia
species	T. arjuna Roxb.

Table 2: Vernacular Names of *Terminalia Arjuna*

English	**Arjun**
Hindi	Arjuna, Arjun
Assamese	Arjun
Irula	Mathi
Kannada	Nirmatti, Atumaruthu, Neermaruthu
Malayalam	Vellamathi, Nirmarutu, Aatumaruthu
Manipuri	Maiyokpha
Tamil	Vella Maruda, Vella Maruthu, Marutu

Table 3: Ayurvedic Properties

Rasa	**Kashaya**
Guna	Laghu, Ruksha
Veerya	Sheeta
Prabhava	Hridaya
Doshghanata	Kaphapittashamaka
Rogaghnata	Vrana, Raktasrava, Astibhagna
Karma	Raktastambhana, Hridaya, Medohara

Botanical description of *T. Arjuna*
Biological Source
Arjuna is made out of the dried stem bark of a plant called *Terminalia arjuna Rob*, which belongs to the combretaceae family. On a dried basis, it contains at least 0.02 percent arjungenin.

Habitat
Arjuna plants can be found in Baitul, Madhya Pradesh, and Dehradun, Uttarakhand. *T. arjuna* is large perineal, naturally growing plant in dense forest. The length of plant is up to 60 to 100 feet long. It is evergreen tree with flowers which are white with short axillary spikes and Each flower has ten stamens and an ovary disc that is covered in yellow or reddish hair. Leaves are dull green above and pale brown beneath, simple, borne sub-opposite coriaceous, crenulating, oblong or elliptic. Leaves are 10 to 15 cm long and 4 to 7 cm wide. It has branches that are horizontally scattered. The bark is thick, and smooth grey on the outside, with a crimson colour on the interior, uneven sheets, and curved and flat pieces. The plant's bark has a single-layered epidermis with hairy projections and a few dispersed lenticles. Secondary phloem and periderm are present in old bark. One or two conspicuous glands are located at the apex of the petiole, immediately below the leaf. Fruits are 3 to 4 cm long, glabrous, and have five hard angles or wings. The wing lines are obliquely bent upward. The fruit is drupe-like with a notched top. Arjuna blooms from March to June and bears fruit from September to November. Seeds need 50 to 80 days to germinate. Arjuna root is shallow, superficial, and spreads radially along a stream.

Leaves of *T. arjuna* flowers of *T. arjuna* fruit of *T. arjuna*

Fig 2

Geographical Distriution

The deciduous tree is located in dry hill areas and is prevalent in the Indian peninsula. It is found in the Indo-Sub-Himalayan region of Uttar Pradesh, Bihar, and Madhya Pradesh, where it is cultivated along streams and is especially common in the Chotta Nagpur region. Near ponds and rivers, the plant is grown. It's also found in Sri Lankan forests, Burma, and Mauritius.

Macroscopy

Color: Color of outer side is greyish brown and inner side of bark is reddish brown.
Surface: Outer surface – smooth
Inner surface: finely longitudinally striated.
Odour: Characteristic.
Taste: Bitter, astringent.
Shape: Flats.
Fracture: Inner part – short
Outer part – laminated.

Microscopy

Cork has a few layers of tangentially running and radially elongated cells, phellogen, 2-4 celled thick, narrow phelloderm, and has 4-6 rows of tangentially elongated, radially arranged cells. Phloem has very broad, uniseriate medullary rays running straight and parallel, near rosette crystals, sometimes they become slightly curved. Groups of phloem fibers, lignified, thin walled, tangentially arranged, associated with idioblast containing clusters and rosettes of calcium oxalate while some cells contain starch grains.

Powder Microscopy

The uniseriate medullary rays run straight, parallel, and occasionally become slightly curved in powder microscopy of arjuna bark, and some cells contain starch grains.

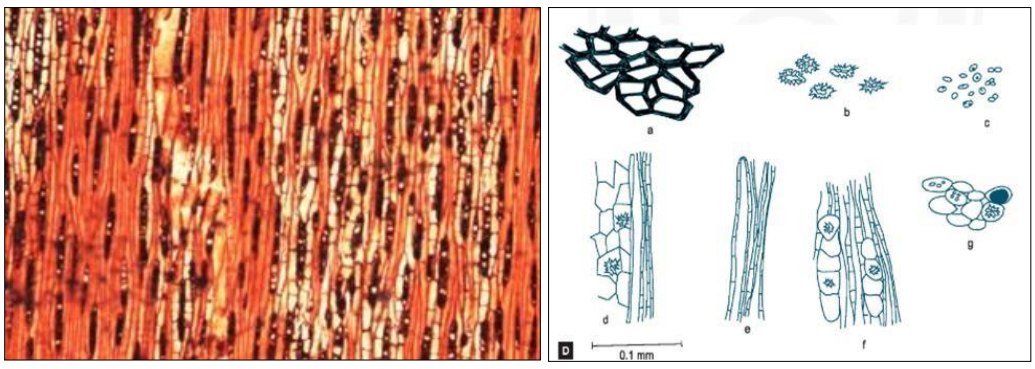

Fig 3

Microscopy of T. arjuna Bark and second image showing the characteristics of microscopy: a.) cork fragments, b.) rossets and clusters of calcium oxalate, c.) starch grains, d.) crystal fibre, e.) phloem fibre, f.) fragments of phloem region, g.) parenchyma containing rosettes of calcium oxalate, starch grains, and tannins.

Chemical Constituents

Arjuna contains 15 % of tannins. the major phytoconstituents are triterpenoids, polyphenols, flavonoids, tannins, sterol and minerals. Triterpenoid saponins, arjunolic acid, arjunic acid, and arjungenin are also found in it. Beta sitosterol, ellagic acid, and arjunic acid are also found in it. Arjunin and Arjunetin have been identified as

crystallizable compounds. Coloring matter, sugar, glycoside, carbonate of calcium, sodium and traces of chloride of alkali metals all are present in arjuna bark. Glycosides are capable of increasing force of contraction of heart. Various organic solvents like ethanol, hexane, chloroform, benzene etc. are used to isolate various chemical constituents.

1. Flavonoids/ Flavones

High level of flavonoids is present in arjuna bark such as arjunolone, flavones, bicalein, quercetin, kaempferol. luteolin possesses antimutagenic and antibacterial properties.

Arjunolone's chemical name is 6, 4-dihydroxy-7-methoxy flavone, while baicalein's chemical name is 5,6,7-trihydroxy flavone.

2. Terpenoids and Glycosides

The lactone arjunetin was isolated from the bark using benzene and alcoholic extracts. Arjunin is an oleanane triterpenoid. Arjungenin and arjunic acid is found in bark stem of the plant. Glycosides are also present in bark stem these are arjun glucoside I and arjun glucoside II. Terminic acid was also extracted from an arjuna heartwood using n-hexane extract. Arjunapthanoloside is a naphthanolycoside that has been isolated from the bark and it shows antioxidant action.

3. Tannins

Many tannins have been recovered from arjuna bark, including pyrocatechols, punicallin, punicalagin, terchebulin, and castalagin are hydrolyzed tannins. Twenty types of tannins and related chemicals have been identified from its bark. Tannins are primarily used to increase nitric oxide synthesis and relax arterial segments that have been precontracted with norepinephrine. Tannins are also known for their astringent, wound-healing, and antimicrobial properties.

4. **Minerals:** According to Dwivedi et al., the bark contains significant levels of magnesium, calcium, zinc, copper, and silica.

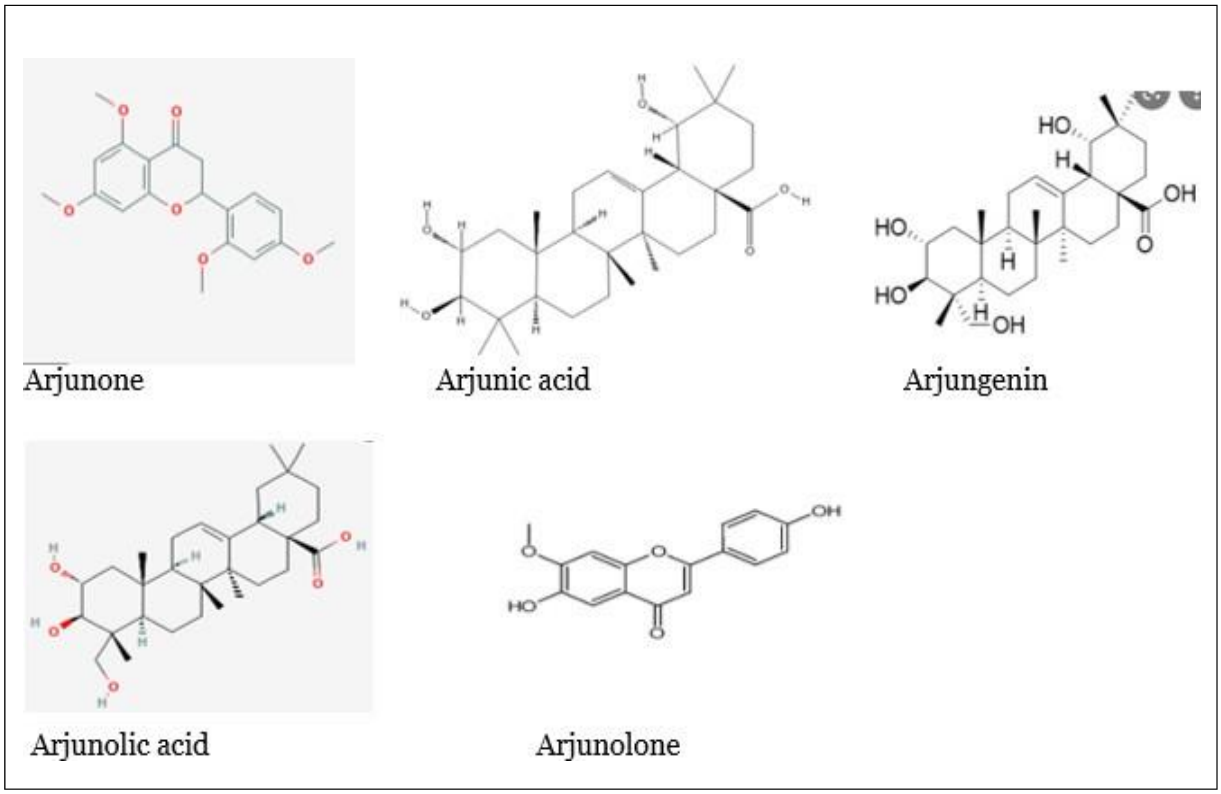

Fig 4

Total ASH

This technique is used to determine how much material is left after it has been ignited. This contains both physiological ash, which comes from plant tissue, and non-physiological ash, which is the remnant of foreign particles stuck to the plant's surface.

Procedure

In a small China dish, put roughly 2-4 gm of powdered *T. arjuna* bark. It was then put through a muffle furnace at a temperature of 500-600 degrees Celsius. When it became red hot, the weight was taken and then cooled. At a two-hour interval, a constant reading was taken.

ACID Insoluble Ash
It is the residue remaining after boiling the total ash with dilute HCL and igniting the remaining insoluble matter. This measures the amount of silica present, especially as sand and siliceous earth.

Procedure
2 gm of powdered *T. arjuna* bark were combined with 25 ml of HCL. After boiling for 5 minutes, the total ash was diluted with 25ml of HCL. On an ashless filter paper, insoluble particles were collected. Hot water was used to wash the filter paper. The crucible was ignited and then allowed to cool. It was then placed in a desiccator. The acid insoluble ash of the medication was estimated after the residue was weighed.

Determination of Moisture Content
It is used to determine the water content by removing moisture and then by measuring weight loss.

Procedure
In a tarred china dish, 2gm of powdered *T. arjuna* bark was placed. After that, the powder was dried in an oven at 100–105 degrees Celsius, then cooled in a desiccator. The loss of moisture content was then recorded. The technique was carried out for at least two readings at the same time.

Sulfated Ash
This technique is used to measure the how much amount of inorganic impurities present in organic compound.

Procedure
In a silica crucible, 2 gm of powdered *T. arjuna* were mixed with 3 ml of sulfuric acid. The powder was burnt by progressively raising the heat until it was carbon-free, and the residue was then dried in a desiccator. The percentage of sulphated ash was calculated after weighing the ash.

Water Insoluble Ash
The amount of total ash that remains after being treated with water under certain conditions.

Procedure
In a silica crucible, 2gm of powdered *T. arjuna* bark was mixed with 25ml of water. The mixture was brought to a boil. Insoluble materials were then filtered via an ashless filter paper. In a crucible, the residue was burned and then cooled. Water insoluble ash was estimated after weighing the residue.

Determination of Alcohol Content
In a tarred silica crucible, 2 gm powdered *T. arjuna* bark was placed. The powdered drug was burnt until it was carbon-free. The leftovers were chilled and stored in a desiccator. Weighing the ash and calculating the proportion of total ash.

Pharmacological and therapeutic properties

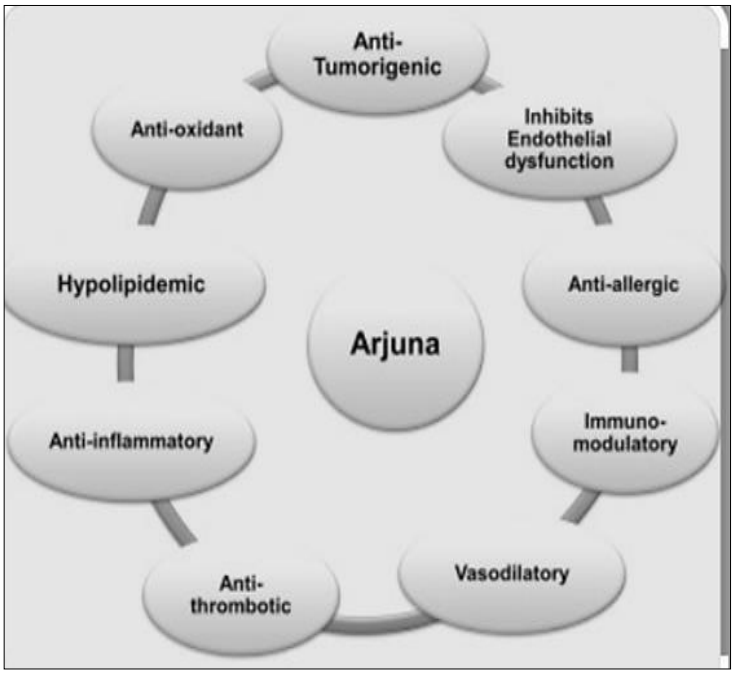

Fig 5

Clinical Uses
Arjuna has been used to treat various sorts of heart disease since the dawn of humanity. It aids in the nourishment of the heart muscles, as well as the maintenance of a normal heartbeat, contraction, and relaxation of the heart muscles. It is also particularly good at constricting blood capillaries, which is necessary for heart function and increasing blood density. It also aids in the dilatation of blood vessels, as well as the coagulation of blood in the event of an injury and the maintenance of correct blood thickness.

Mechanism
The principal effect of Terminalia appears to be better cardiac muscle function and, as a result, improved heart pumping activity. Terminalia's inotropic action is assumed to be due to the saponin glycoside, while flavonoids and OPCs provide free radical antioxidant activity and vascular strengthening was provided by flavonoids and OPCs. (11)
Two novel cardenolide cardiac glycosides were recently identified from Terminalia root and seed. The principal effect of these cardenolides is to increase force of contraction by increasing intracellular sodium and calcium levels.

Local Action
One of the most effective blood coagulants is Arjuna. It is commonly used to treat external haemorrhages because it has the ability to coagulate blood and constrict blood vessels locally to stop bleeding. It is applied directly to the wound for immediate benefits. Arjuna is also one of the most potent herbal supplements with anti-inflammatory properties. In cases of wounds and injuries, especially bone, ligament, and cartilaginous injuries, good prognoses have been observed. It's also used on wounds to speed up the healing and recuperation process.

Digestive system
It is also helpful in maintaining good health of our digestive tract. It is used in treatment of diarrhoea and dysentery due to its astringent nature. It prevents the dehydration and loose stools by regulating the peristaltic movement. Bleeding piles and dysentery is also treated by arjuna due to its Kashaya nature. It is a general health tonic and important in improving liver condition especially cirrhosis of liver.

Respiratory system
Arjuna is also thought to aid in the expulsion of excess mucus that builds up in the respiratory tract. It also aids in the toning up of the respiratory system by avoiding the formation of mucus. It also aids in the prevention of pulmonary infections and the expansion of lung capacity.

Nervous system
It's also regarded as a nervine tonic. Though it is still under investigation, promising outcomes have been observed. It helps to enhance the neurological system as well as the reflexes.

Reproductive system
Arjuna's astringent nature aids in the thickening of serum and sperm, both of which are necessary for optimal ovum fertilisation. It also aids in the increase of sperm count as well as the body's general stamina.

Endocrinal system
It is also beneficial in controlling the body's hormonal system. It is highly beneficial in maintaining healthy endocrine gland activation.

Excretory system
It aids in the treatment of polyurea as well as the regularisation of increased urine frequency. It aids in the toning of the urinary tract. It also aids in the fading of infection in the body.

Skin
It can be used to treat a wide range of skin conditions. It is particularly suggested for skin diseases due to its cool potency. Eczema, itching, rashes, scars, and serious skin disorders such as psoriasis can all be treated with Arjuna on a daily basis.
The effects of Terminalia arjuna bark extract on apoptosis in the human hepatoma cell line HepG2 were investigated. The effect of *T. arjuna* extract on human hepatoma cell line (HepG2) and its potential function in apoptosis induction were investigated, and it was discovered that *T. arjuna* produced cytotoxicity in HepG2 cells in vitro. HepG2 cell apoptosis could be caused by DNA damage and the production of apoptotic proteins. GSH depletion could be a factor.

General action
According to numerous research conducted in search of the rationale for such a feature, arjuna is also useful as an antioxidant since it has certain components that serve as scavengers in scavenging. Studies were carried out to

assess Arjuna's antioxidant qualities and compare them to those of another antioxidant, vitamin E. These studies were carried out at random and under controlled conditions.

Clinical studies

Angina/myocardial infarction

In 30 patients with stable angina/post-infarct angina, the anti-ischemic impact of bark powder was tested (500 mg tds). The authors discovered a significant drop in mean anginal frequency, as well as a significant decrease in systolic blood pressure (SBP), improvement in ECG abnormalities, and a decrease in plasma cortisol and serum cholesterol levels [12].

Arjuna has recently been demonstrated to help normal healthy people improve their cardiovascular endurance and drop their blood pressure [13].

Cardiomyopathy

Arjuna has been shown to lower LVM and improve LVEF in addition to its anti-ischemic properties [18]. A recent observational study found that when patients with dilated cardiomyopathy and low LVEF got arjuna in addition to normal medication, their left ventricular metrics and functional capability improved significantly [14].

Platelet aggregation

In 20 patients with angiographically verified CAD and 20 age- and sex-matched controls, the bark extract was found to reduce platelet activation and have antithrombotic effects in vitro. Desensitizing platelets by competing with platelet receptors or interfering with signal transduction could be one method [15].

Lipoprotein

Following the treatment of arjuna, a significant reduction in lipoprotein (a) levels of 24.71 percent was observed in a patient with -thalassemia, hyperlipoproteinemia, and metabolic syndrome [16].

Endothelial dysfunction

In a double-blind, placebo-controlled, cross-over study involving 18 healthy male smokers and an equal number of age-matched non-smoker controls, it was discovered that when given for two weeks, the hydroalcoholic extract of bark resulted in significant regression of endothelial abnormalities in smokers [17].

Thrombotic condition

The methanol extract was found to have strong thrombolytic activity in a recent study that looked into the in vitro thrombolytic and membrane-stabilizing effect of four Bangladeshi medicinal herbs, including arjuna (30.57 percent). In both hypotonic solution and heat-induced circumstances, it effectively reduced RBC haemolysis. It has mild thrombolytic activity, according to this.

Antimicrobial Activity

The antibacterial activity of flavonoids extracted from the bark of *T. arjuna* was investigated. All of the infections were resistant to both bound and free flavonoids. Both flavonoids had the greatest inhibitory impact against Agrobacterium tumefaciens and Bacillus subtilis [21].

Antimicrobial properties of *T. arjuna* leaves and bark extracts against pathogens that cause ear infections, including Staphylococcus aureus, Acinetobacter sp., Proteus mirabilis, Escherichia coli, Pseudomonas aeruginosa, and Candida albicans [22]. For the treatment of bacterial ear infections, organic extract of *T. arjuna* bark demonstrated a higher inhibitory zone than herbal drops, especially for S. aureus.

Anti-inflammatory Activity

The antioxidant activity of the extracts was measured using DPPH free radical scavenging activity and prevention of lipid peroxidation. Singh et al. investigated the anti-inflammatory properties of T. arjuna leaves in Wister albino rat models. The methanol extract of T. arjuna leaves was found to have strong anti-inflammatory properties in the studied models [23, 24].

Anti-diabetic activity

The anti-diabetic efficacy of T. arjuna aqueous stem bark extract was investigated. The haemolytic activity of the antidiabetic bioassay was assessed in human whole blood by estimating blood counts, total cellular (i.e., proteins), and free haemoglobin content in diabetic blood plasma. In diabetic human whole blood and plasma samples, the results demonstrated that the aqueous stem bark of T. arjuna has antidiabetic activity and also increases granulocyte count and decreases free haemoglobin content, including total cellular content [25].

Conclusion

Terminalia arjuna is a very important medicinal plant with a wide range of phytochemical and pharmacological capabilities, according to the findings of this study. From the above study we can conclude that *Terminalia arjuna* is very potent drug which is used from ancient times to treat the various cardiovascular disorders. It contains many beneficial phytoconstituents such as tannins (pyrocatechols, punicallin, punicalagin), flavonoids

(arjunolone, flavones, bicalein, quercetin, kaempferol), saponins (Arjunolic acid) which provide the effective actions against heart related disorders such as angiogenesis, thrombosis, hypertension, myocardial infraction etc. *T. arjuna* is beneficial in Anti-bacterial, anti-viral, anti-mutagenic, anti-inflammatory, and wound-healing properties, as well as anti-dysenteric, anti-pyretic, anti-diabetic, anti-oxidant, gastrointestinal, and reproductive properties.

This review gives an important view mainly on taxonomy of *T. Arjuna*, botanical description of arjuna, different phytochemical, physicochemical analysis and therapeutic uses and various clinical studies on the *T. arjuna* plant.

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