Phytochemistry and Pharmacological Potential of *Terminalia arjuna* L.

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Abstract

To cure human diseases, medicinal plants have been a major source of therapeutic agents since ancient time. *Terminalia arjuna* is one kind of widely used medicinal plant throughout Bangladesh and used in various indigenous system of medicine like Ayurveda, Siddha and Unani. This plant has been reported to contain active constituents including arjunolic acid, gallic acid, terminic acid, pyrocatechols, β-Sitosterol, calcium, magnesium, zinc, copper etc. which proved to be effective pharmacological agents as antimicrobial, anticancer, antidiabetic, antiacne, antihelmintic, antiinflammatory, anticholinesterase, antioxidant, antiasthmatic as well as wound healing, cardioprotective and insecticidal activities. It is considered to be an ideal agent for treating cancer, coronary artery disease, hypertension and ischemic cardiomyopathy. The present comprehensive update review is therefore an effort to give detailed information on phytochemical and pharmacological studies of *T. arjuna*.

Keywords *Terminalia arjuna*; Arjunolic acid; Phytochemistry; Cardio-protective activity; Antimicrobial activity

Background

*Terminalia arjuna* is a native Bangladeshi tree with simple leaf, smooth and thick bark belonging to the family Combretaceae. Flowers are small, regular, sessile, cup-shaped, polygamous, white, creamy or greenish-white and robustly honey-scented and flowering from April to July. The inflorescences are short axillary spikes or small terminal panicles and fruits are obovoid-oblong, dark brown to reddish brown fibrous woody, indehiscent drupe and ripening from February to May (Orwa et al., 2009; Bhat et al., 2003). All the parts of the plant have been used for their therapeutic beneficiary effect from ancient times. *T. arjuna* helps to maintain a healthy heart and decrease the effects of stress and anxiety (Emran et al., 2011). It has antibacterial (Perumalsamy et al., 1998), antimutagenic, hypolipidemic, antioxidant and hypocholesterolaemic and anti-inflammatory effects (Tripathi et al., 2005). *T. arjuna* have the capability to protect the liver and kidney tissues against CCl4-induced oxidative stress by increasing antioxidative defense activities (Manna et al., 2006). Its chemical constituents act as a gastro-protective agent (Devi et al., 2007). Different types of bioactive compound have been isolated from this medicinal plant possesses enormous value in medicine among them arjunolic acid is very well known. The aim of the present study was to deliver the literal studies of *T. arjuna* with its phytochemical and pharmacological characteristics.

Phytochemistry

It was initially reported that the bark had 34% ash content consisting entirely of pure calcium carbonate. The water extract existence 23% calcium salts and 16% tannins, whereas the alcoholic extract contained very little coloring matter and tannins (Dymock et al., 1891). The chemical analysis of the bark showed confirmation of sugar, tannins (12%), coloring matter, glycoside, and carbonates of calcium, sodium and traces of chloride of alkali metals (Ghoshal, 1909). The chemical constituents of *T. arjuna* are shown in Table 1.

Bioactive compounds

*T. arjuna* has medicinal and economic value due to the presence of different bioactive compounds showing biological activities in human and animal body (Zaidi, 1998). Some bioactive compounds showing biological activities reported so far are summarized in Table 2.
Table 1 Major chemical constituent in different parts of T. arjuna

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Stem/ bark</th>
<th>Root</th>
<th>Activity of compounds</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triterpenoids</td>
<td>Arjunin, arjunic acid, arjunolic acid, arjunigenin, terminic acid</td>
<td>Arjunic acid, arjunolic acid, oleanolic acid, terminic acid</td>
<td>Antifungal, cardioprotective</td>
<td>Zhou et al., 2011a; Dwivedi, 2007</td>
</tr>
<tr>
<td>Sitosterol</td>
<td>Sitosterol</td>
<td>Sitosterol</td>
<td>Antimitagentic, anti-inflammtory, antitussive</td>
<td>Zhou et al., 2011d and Dwivedi, 2007</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Arjunolone, Arjunone, Bicalein, Luteolin, Gallic acid, Ethyl gallate Kempferol, Proanthocyanidins, Quercetin, Pelargonidin,</td>
<td></td>
<td>Antiallergic, antibacterial, cytotoxic, antiasthmatic, antifungal, antioxidant</td>
<td>Zhou et al., 2011b,c,d and Dwivedi, 2007</td>
</tr>
<tr>
<td>Tannins</td>
<td>Pyrocatechols, Casurin, Casurin, Punicillin, Punicalagin, Castalagin, Terchebulin, Terflavin C,</td>
<td></td>
<td>Astringent, wound healing and antimicrobial</td>
<td>Dwivedi, 2007</td>
</tr>
<tr>
<td>Trace elements</td>
<td>Calcium, Aluminium, Magnesium, Silica, Zinc, Copper</td>
<td></td>
<td>To fill up ion requirement</td>
<td>Dwivedi, 2007</td>
</tr>
</tbody>
</table>

Table 2 Individual functions and properties of some compounds isolated from T. arjuna

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Biological activity</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arjunolic acid (C_{30}H_{48}O_{5}, MW: 488.71)</td>
<td>Antifungal, cardioprotective</td>
<td>Zhou et al., 2011a</td>
</tr>
<tr>
<td>Arjunic acid (C_{30}H_{48}O_{5}, MW: 488.71)</td>
<td></td>
<td>Zhou et al., 2011a</td>
</tr>
<tr>
<td>Arjunoglucoside I (C_{36}H_{58}O_{11}, MW: 666.86)</td>
<td></td>
<td>Zhou et al., 2011a</td>
</tr>
<tr>
<td>Arjunogenin (C_{36}H_{48}O_{6}, MW: 504.71)</td>
<td></td>
<td>Zhou et al., 2011a</td>
</tr>
<tr>
<td>Castalagin (C_{41}H_{34}O_{26}, MW: 934.65)</td>
<td>Antihypertensive, cytotoxic</td>
<td>Zhou et al., 2011a</td>
</tr>
<tr>
<td>Ethyl gallate (C_{8}H_{18}O_{3}, MW: 198.18)</td>
<td>Antiinflammatory, platelet aggregation inhibitor, collagenase inhibitor, analgesic</td>
<td>Zhou et al., 2011b</td>
</tr>
<tr>
<td>Gallic acid (C_{7}H_{6}O_{5}, MW: 170.12)</td>
<td>Antiallergic, antibacterial, antineoplastic, cytotoxic, antifungal, anti-inflammatory, antimutagenic, antiviral, astringent, antiasthmatic; choleretic, antioxidant cell growth inhibitor, control phosphoramidon</td>
<td>Zhou et al., 2011b</td>
</tr>
<tr>
<td>Luteolin (C_{15}H_{10}O_{5}, MW: 286.24)</td>
<td>Antiallergic, antibacterial, antineoplastic, cytotoxic, antifungal, anti inflammatory, antispasmodic, antitussive, immunoenhancer, increases coronary flow, protein kinase C inhibitor, succinic oxidase inhibitor, antihypercholesterolemic</td>
<td>Zhou et al., 2011c</td>
</tr>
<tr>
<td>Kaempferol (C_{15}H_{10}O_{6}, MW: 286.24)</td>
<td>Anti-HIV-1, antibacterial, antitussive to cure trachitis, antioxidant, iodinate thyrone deiodinase inhibitor, aldos reductase inhibitor, anti-inflammtory</td>
<td>Zhou et al., 2011c</td>
</tr>
<tr>
<td>B-Sitosterol (C_{20}H_{30}O, MW: 414.72)</td>
<td>Antineoplastic, antimutagenic anti-inflammatory, antitussive, antihypercholesterolemic</td>
<td>Zhou et al., 2011d</td>
</tr>
<tr>
<td>Chebulinic acid (C_{41}H_{34}O_{28}, MW: 974.75)</td>
<td></td>
<td>Singh, 2002</td>
</tr>
<tr>
<td>Proanthocyanidin B_{2} (C_{30}H_{26}O_{12}, MW: 578.53)</td>
<td>Anticomplement activity, antihypertensive, protein kinase C inhibitor, reverse transcriptase inhibitor, antioxidant</td>
<td>Zhou et al., 2011d</td>
</tr>
<tr>
<td>Terchebulin (C_{48}H_{32}O_{30}, MW: 1084.74)</td>
<td></td>
<td>Zhou et al., 2011e</td>
</tr>
<tr>
<td>Terminoid acid (C_{30}H_{48}O_{3}, MW: 488.71)</td>
<td></td>
<td>Zhou et al., 2011e</td>
</tr>
</tbody>
</table>
Pharmacological Values

A number of previous studies reported a wide number of pharmacological activities of *T. arjuna*. It can be used to treat diabetics, heart diseases as well as for the treatment of wound. It has antiviral, antibacterial, anticancer and other potential anti-ailment properties.

(i) Antimicrobial activity: Perumalsamy et al (1998) reported that the aqueous extracts of *T. arjuna* bark holds major antimicrobial activity against *Proteus vulgaris, Klebsiella aerogenes, Escherichia coli* and *Pseudomonas aerogenes*. The presence of antibacterial activity in the bark of *T. arjuna* exhibiting selectively maximum activity against *S. epidermidis* (Singh et al., 2008). Antimicrobial activity of different solvent extracts from *T. arjuna* reported previously are summarized in Table 3.

Table 3 Antimicrobial activity of different solvent extracts from *T. arjuna*

<table>
<thead>
<tr>
<th>Solvents, Methanol, Ethanol, Acetone, Hot aqueous, Cold aqueous</th>
<th>Organisms</th>
<th>Extracts concentration</th>
<th>Highest activity showed extract</th>
<th>Maximum zone of inhibition (mm)</th>
<th>Highest sensitivity showed organisms</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol, Ethanol, Acetone, Hot aqueous, Cold aqueous</td>
<td><em>Staphylococcus aureus, Pseudomonas aeruginosa, Proteus mirabilis, Escherichia coli, Acinetobacter sp. Candida albicans</em></td>
<td>50 mg/mL</td>
<td>Acetone</td>
<td>28</td>
<td><em>Staphylococcus aureus</em></td>
<td>Aneja et al., 2012</td>
</tr>
<tr>
<td>Aqueous, Methanol</td>
<td><em>Staphylococcus aureus, Bacillus cereus, Escherichia coli, Vibrio cholerae, Klebsiella pneumoniae Pseudomonas aeruginosa</em></td>
<td>Aqueous 2 gm/20 mL, Methanol 30 mg/mL</td>
<td>Methanol</td>
<td>0.625±0.016</td>
<td><em>Escherichia coli</em></td>
<td>Dey et al., 2010</td>
</tr>
<tr>
<td>Methanol, Ethanol acetate, Acetone, Gemmo-modified Water</td>
<td><em>Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pasteurella multocida</em></td>
<td>250µg/disc, 500 µg/disc, 750 µg/disc, 1000 µg/disc</td>
<td>1000 µg/disc (Gemmo-modified)</td>
<td>38±1.0</td>
<td><em>Bacillus subtilis</em></td>
<td>Jahan et al., 2011</td>
</tr>
<tr>
<td>Crude and Methanol</td>
<td><em>Streptococcus pneumoniae, Staphylococcus aureus, Salmonella typhi, Escherichia coli, Pseudomonas aeruginosa, Yersinia enterocolitica, Candida albicans</em></td>
<td>0.5 mg/disc, 1 mg/disc</td>
<td>Methanol</td>
<td>30</td>
<td><em>Staphylococcus aureus</em></td>
<td>Elizabeth, 2005</td>
</tr>
<tr>
<td>Ethanol</td>
<td><em>Staphylococcus aureus, Streptococcus faecalis, Coliform spp., Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa.</em></td>
<td>25 µg/mL, 50 µg/mL, 100 µg/mL, 200 µg/mL</td>
<td>Ethanol (200 µg/mL)</td>
<td>20</td>
<td><em>Coliform spp</em></td>
<td>Emran et al., 2011</td>
</tr>
<tr>
<td>Ethanol</td>
<td><em>Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, Salmonella typhi</em></td>
<td>0.5 mg/disc, 1 mg/disc</td>
<td>Ethanol (0.5 mg/disc)</td>
<td>16</td>
<td><em>Staphylococcus epidermidis</em></td>
<td>Kannan et al., 2009</td>
</tr>
<tr>
<td>Aqueous, Methanol</td>
<td><em>Staphylococcus aureus, Escherichia coli,</em></td>
<td>10%, 15% Aqueous; 10%, 15% Methanol</td>
<td>15% Methanol</td>
<td>13</td>
<td><em>Staphylococcus aureus</em></td>
<td>Seniya et al., 2011</td>
</tr>
</tbody>
</table>
Methanol

(ii) Anticancer activity: Different types of cancer reported to treat by *T. arjuna* extracts are compiled in Table 4. Herbal extracts of *T. arjuna* reported to enhance increased percentage of life span of experimental animals induced with DLA (Dalton’s Lymphoma Ascites) tumour cells and in some cases induced with carcinogens (Muthuchelian et al., 2010). Arjuna extract inducing DNA damage in HepG2 cells indicated that *T. arjuna* extract induces ROS production in HepG2 cells and consequently causes apoptosis (Sarveswaran et al., 2006).

<table>
<thead>
<tr>
<th>Types of cancers</th>
<th>Used extracts</th>
<th>Active compounds</th>
<th>Treated organisms/cells</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutagenic cancer</td>
<td>Dried bark</td>
<td>Tannin</td>
<td><em>Salmonella typhimurium</em></td>
<td>Kaur et al., 2000</td>
</tr>
<tr>
<td>Human breast, colon, intestine, lung and leukaemia.</td>
<td>Leaf</td>
<td>Taxol</td>
<td><em>Pestalotiopsis terminaliae</em></td>
<td>Gangadevi et al., 2009</td>
</tr>
<tr>
<td>Ehrlich ascites carcinoma (EAC)</td>
<td>Methanolic extract of Leaves</td>
<td>–</td>
<td>Mice</td>
<td>Biswas et al., 2012</td>
</tr>
<tr>
<td>Human breast</td>
<td>Bark</td>
<td>Casuarinin</td>
<td>Human breast adenocarcinoma</td>
<td>Kuo et al., 2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MCF-7 cell</td>
<td></td>
</tr>
<tr>
<td>Age related cancer</td>
<td>Aqueous bark extract</td>
<td>Catalase, superoxide dismutase and glutathione S transferase</td>
<td>Lymphoma bearing mice</td>
<td>Verma et al., 2005</td>
</tr>
<tr>
<td>BT- human breast</td>
<td>Ethanolic extracts of leaves</td>
<td>Ellagenatin (arjunin)</td>
<td>BT-human breast carcinoma cells</td>
<td>Kandil et al., 1998</td>
</tr>
</tbody>
</table>

(iii) Against ear infection: *T. arjuna* plants extracts having a great potential to be developed as herbal ear drop to control the bacterial ear infections. Aneja et al (2012) reported the leaves and bark extracts as potent and effective medicine against tested bacteria responsible for ear infections than that of standard ear drop.

(iv) Antifungal activity: The organic extracts of five *Terminalia* species (*T. arjuna, T. chebula, T. bellerica, T. catappa* and *T. alata*) were tested with plant pathogenic fungi i.e. *A. flavus, A. alternata, A. niger, A. brassicicola, and H. tetramera*. The leaves extracts of all five plants found to inhibit these plant pathogens (Shinde et al., 2011). The bark extracts were more effective than fungicide (control) used in this antifungal test. Moderate antifungal activity against *C. albicans, C. krusei* and *C. parapsilosis* was exhibited by a mixture of arjunolic acid with minimum inhibitory concentration (MIC) values in the range of 50-200 µg/ml (Puvanakrishnan et al., 2010).

(v) Antidiabetic activity: *The T. arjuna* extracts have potential effects on diabetic. In the experimental diabetic rats model treated with *T. arjuna* extracts showed two enzymes (glucose-6-phosphatase, fructose-1, 6- diphosphatase) significantly reduced in liver and kidney. This has effects on increasing insulin secretion which can effects on repression of the gluconeogenic key enzymes (glucokinase and phosphofructokinase) (Ragavan et al., 2006). *Terminalia arjuna* bark extract exhibited antidiabetic activity by enhancing the peripheral utilization of glucose which have the ability to kidney glycolysis and correcting the impaired liver and by decreasing its gluconeogenic formation as like as insulin. This effect may be due to the presence of tannin, saponin, flavonoids and other constituent’s presence in the bark, which could act synergistically or independently in enhancing the activity of glycolytic and gluconeogenic enzymes (Ragavan et al., 2006). Manna et al (2009a; 2009b) have investigated the prophylactic role of arjunolic acid against streptozotocin (STZ) induced diabetes in the pancreatic tissue of Swiss albino rats. STZ administration (at a dose of 65mg/kg body wt, injected into the tail vein) causes an increase in the production of both ROS and reactive nitrogen species (RNS) in the pancreas of experimental animals. Formation of these reactive intermediates decreases the intracellular antioxidant defense, increases the levels of lipid peroxidation, protein carbonylation, serum glucose and TNF-α (Puvanakrishnan et al., 2010).
(vi) Antiacne activity: Topical formulations (cream) of *T. arjuna* extract containing flavonoid (FF-I to III) and tannin fraction (TF-I to III) have been developed, which were examined for antimicrobial activity against *Propionibacterium acnes* and *Staphylococcus epidermidis*. The formulation of FF-III (cream containing 2% flavonoid fraction) has showed higher antibacterial activity against *P. acnes* (zones of inhibition >17 mm) and *S. epidermidis* (zones of inhibition >20 mm) than other formulations and which is comparable to that of standard marketed topical herbal preparation (Vijayalakshmi et al., 2011). Herbal anti-acne cream is non-toxic, safe, effective and improves patient compliance by the utilization of herbal extracts from *T. arjuna* would be highly acceptable (Vijayalakshmi et al., 2011).

(vii) Anthelmintic activity: Crude methanolic extracts of *T. arjuna* bark exhibited anthelmintic activity both in vitro (eggs, larvae and adult of *Haemonchus contortus*) and in vivo studies against mixed gastrointestinal trichostrongylid nematodes of sheep (Bachaya et al., 2009). Anthelmintic activity of *T. arjuna* bark may be mainly attributed to its tannin content that binds with a free protein existing in the tubes for larval nutrition and reduced nutrient availability resulting in larval starvation or decreased gastrointestinal metabolism by directly inhibiting the oxidative phosphorylation thereby causing larval death (Bachaya et al., 2009).

(viii) Wound healing activity: The hydroalcoholic extract of *T. arjuna* bark phytoconstituents was reported to be used in topical application on healing rat dermal wounds. Wounds created on the back of rats under anesthesia have been treated with various fractions applied topically as simple ointment. Results prove that fraction III prepared as 1% simple ointment shows complete epithelialization on day 20, whereas fraction I show complete epithelialization on day 9, which essentially consists of tannins (Puvanakrishnan et al., 2010). Mengi et al (2003) reported the capability of *T. arjuna* to complete epithelisation of excision wounds and increased tensile strength of incision wounds.

(ix) Cardioprotective activity: There are different types of therapeutic use of *T. arjuna* for cardiac disease that based on empirical explanation recorded in various treatment of ancient medicine.

(a) Cardiotoxic activities: Arjunolic acid is used as a cardiac tonic in ayurvedic medicine for centuries and it has been first isolated from *T. arjuna*. The bark extracts have major component triterpenoid saponin is an arjunolic acid (Puvanakrishnan et al., 2010). Physiological studies carried on the isolated rabbit and frog heart exposed that *T. arjuna* bark had cardiotoxic and stimulatory effect (Ghosh, 1909). It was consequently found that intravenous administration of the glycoside, obtained from the bark of *T. arjuna*, resulted in rise in blood pressure (Ghosh, 1926). It was indicated that the bark powder has a cardiotoxic property, also possessed diuretic properties. Consequent experimental studies in isolated frog heart exposed that the aqueous extract of the bark had chronotropic and inotropic activities. The aqueous extract of the bark is isolated from rat atria that confirmed positive inotropic activity (Radhakrishnan et al., 1993). Aqueous extract of the bark was isolated from rat atria that was again confirmed in consequent work where produced inotropic action which was abolished by propanolol and cocaine (Karamsetty et al., 1995). The new compound 16,17-Dihydroneridienone, 3-O-β-D-glucopyranosyl-(1-6)-O-β-D-galactopyranoside is isolated from arjuna root and used as a cardiotoxic (R.N. Yadav et al., 2001).

(b) Coronary flow: Bhatia et al. (1998) reported to inject aqueous extract of the bark injection into isolated rabbit heart (Langendorff’s) to increase in coronary flow. The dose was 1024 µg/ml that causes highest increase in coronary flow.

(c) Hypotensive effects: Singh et al. (1982) reported intravertebral and intracerebro-ventricular injection of alcoholic and aqueous extract of bark that was dose-dependent persistent bradycardia and hypotension. Further the alcoholic extract causes the hypotensive effect in dogs was abolished by pre-treatment with atropine. In another study the observation in dogs where intravenous administration of aqueous extract of *T. arjuna* resulted in dose-dependent fall in blood pressure (Srivastava et al., 1992).
(d) Effect on aortic prostaglandins: Aortic prostaglandin E2 like activity was enhanced in those rabbits that were administered *T. arjuna* compared to those who were on placebo. The finding of raised PGE2 like activity was significant because PGE2 is known to produce coronary vasodilation. This may possibly explain the pharmacological basis of the increased coronary flow following *T. arjuna* infusion (Bhatia et al., 1998). This may also be contributing to the beneficial effect of *T. arjuna* in coronary artery disease (CAD) patients.

(x) Anti-inflammatory: Sharma et al. (2010) state combined crude ethanolic extract of *Datura stramonium* (leaves) *Terminalia arjuna* (bark) and *Withania somnifera* (root) that results polyherbal formulation have anti inflammatory effect to inhibit the enzyme cyclooxygenase (COX) leading to inhibition of prostaglandin synthesis causing inflammation at the third stage. From the results of the study, it can be accomplished that polyherbal formulation showed significant anti inflammatory and analgesic activities (Puvanakrishnan et al., 2010).

(xi) Insecticidal property: Arjunolic acid isolated from the stem of *T. arjuna* exhibits significant inhibitory activity towards fourth instar larvae of *Spilarctia obliqua*. Effective concentration to reduce feeding and growth of the larvae has been found to be 617.8 and 666.9 ppm, respectively (Puvanakrishnan et al., 2010).

(xii) Antioxidant activity: In antioxidant activity test, the methanol extract of *T. arjuna* bark exhibited significant antioxidant activities with the IC50 value of 7.05 µg/ml. Methanol extract of *T. arjuna* has intense antioxidant activity and may have potential use in medicine (Rahman et al., 2011).

(xiii) Antiasthmatic activity: Arjunolic acid and alcoholic extract of *T. arjuna* have significant mast cell stabilization activity and specifically, arjunolic acid exhibits comparatively better stabilization activity than alcoholic extract of TA (Prasad et al., 2004). The antiasthmatic and antianaphylactic activity may be due to the mast cell stabilizing potential and inhibition of antigen induced histamine and acetylcholine release (Prasad et al., 2004; Puvanakrishnan et al., 2010).

(xiv) Gastroprotective effect: *T. arjuna* acts as an gastroprotective agent probably due to its free radical scavenging activity and cytoprotective nature (Devi et al., 2007).

(xv) Decrease arsenic-induced toxicity: Arjunolic acid acting a preventive role against arsenic-induced cellular oxidative stress (Sil et al., 2007).

**Traditional use**

*T. arjuna* is widely used and known as ayurvedic plant. Physicians used it for its curative properties in different types of heart problems including hypertension, angina and blocks in arteries. It is also very useful in the treatment of any sort of pain in heart such as falls, spermatorrhoea, eczynmosis and sexually transmitted diseases as gonorrhrea and thought to be a useful astringent, cooling, aphrodisiac, cardio-tonic, and is used for ulcers, leucorrhoea, diabetes, cough, tumor, excessive perspiration, asthma, inflammation and skin disorders etc (Parakh, 2010).

**In vitro Propagation of T. arjuna**

There are different types of species that are being threatened and are endangered (IUCN 2011) because of logging practices, non-optimal management strategies, exchange to agricultural lands and generally deforestation rates that cannot keep up with natural regeneration of native forests. *In vitro* propagation of arjuna from different parts has been reported by Pijut et al. (2012). Arjun was propagated from nodal explants of a mature tree on half-strength MS medium with 4.44 µM BA and 0.53 µM NAA. Seasonal variations were found to affect the proliferation rates with the best rate obtained from material collected during April or May. Rooting was obtained on medium with 4.92 µM IBA and plants were acclimatized (Pandey et al., 2006).

**Conclusion**

The present review reveals that *T. arjuna* is a very important plant for its large number of phytochemical and pharmacological properties as well as medicinally important chemicals. The plant was found to be very useful in antibacterial, antiviral, antimutagenic,
anti-inflammatory and wound healing activities. The most exciting aspects of the plant were treatment of diabetics, cancer and heart diseases. This compendium literature supports various potential medicinal characteristics of *T. arjuna*. Thus this review can be a preliminary authentic source for the researchers willing to carry out further research and systematic study to develop herbal and poly-herbal drugs from *T. arjuna*.

**Authors’ contributions**

Khan ZMH and Faruquee HM conceived the work; Shaik MM designed the project; Shaik MM and Faruquee HM analyzed the data; Shaik MM, Faruquee HM and Khan ZMH wrote the paper.

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