Terminalia arjuna Roxb.

Scientific name: Terminalia arjuna Roxb.
Synonyms: Pentaptera arjuna, Pentaptera glabra, Terminalia bellirica, Myrobalanus bellirica, Terminalia chebula.
Family: Combretaceae
Genus: Terminalia
Species: arjuna
Common name: White marudah, tropical almond, arjun, Malabar almond, arjuna
Parts used: Barks, stems, leaves

Plant Description: The bark of Terminalia arjuna is thin, smooth, shiny, and greenish-grey and peels off regularly. The leaves are simple (undivided), oblong-elliptic, 7-18 (-25) cm long with short petioles, arranged opposite (sub-opposite) on the stem and often coriaceous (leathery) at maturity. Each leaf has a pair of knob-like glands on the dorsal (lower) side at the junction between the petiole and the lamina. The dorsal surface has downy hair but the ventral surface is smooth. The flowers are greenish white or creamy and have a sweet scent. They are borne at the ends of shoots or in the axils of leaves in inflorescences. Lacking pedicels (and hence sessile), they are directly attached to the inflorescence axis. The calyx is cuplike, 5-lobed and constitutes the most prominent component of the flower. There are no petals. The 10 stamens are attached to the calyx cup. The ovary is encased in a disc with yellowish or reddish hairs. Flowers have a sweet scent. The fruit is ovoid, up to 6 cm long, and at maturity, hard and woody. It has five wings in which the veins curve upwards from the axis.

Chemical constituents:
The bark of Arjuna tree is used for medicinal purposes and it has been found to contain minerals such as calcium, magnesium, aluminium, and tannins (gallic and ellagic acid), flavonoids (arjunone, arjunolone, luteolin), saponin glycosides (arjunic acid, arjunolic acid, arjungenin, arjunglycosides) and phytosterols. The bark also contains crystalline compounds such as arjunine, arjunetin, essential oils and reducing sugars. Triterpenoid saponins (with aglycones: arjunolic acid, etc.), minerals (magnesium, zinc copper and very rich in calcium), flavonoids (methoxy-flavones, -flavanones, -chalkones), tannins (rich), phytosterols (5-sterols: 13-sitosterol, etc.), oligo-mericpro-anthocyanidins (OPCs).

Isolated active chemical constituents of T. arjuna

Arjunic acid
Arjunolic acid
Arjugenin
**Medicinal Uses:** Treating chest pain (angina) after a heart attack, and congestive heart failure (CHF) when used with conventional medications.  
*T. arjuna* has been widely used in Ayurvedic medicine for the treatment of cancer, dermatological and gynaecological complaints, heart diseases and urinary disorders. The bark is acrid, an astringent and tonic, and is useful in treatment of high blood pressure and ulcers. The cancer cell growth inhibitory constituent (luteolin) has been isolated from bark, stem and leaves of *T. arjuna*. Luteolin has also been shown to have specific anti-bacterial activity against *Neisseria gonorrhoea*. It can also be used as alexiteric, styptic, tonic and anthelmintic and it is useful in fractures, inflammation and wounds and ulcers.

**Actions of the herb:** anti-inflammatory, diabetes reducing agent, controls cholesterol, treats asthma, fractures and other injuries. Cardiac stimulant, Rejuvenative, Astringent, Hemostatic

**Contraindications:** Pregnancy, lactation, patients with kidney stones or prone to kidney stone formation.

**Dosages:** For treating chest pain after a heart attack along with conventional treatments: 500 mg of the powdered bark of *Terminalia arjuna* every 8 hours daily. For congestive heart failure: 500 mg of the powdered bark of *Terminalia arjuna* every 8 hours daily. Herbalists usually recommend; 500 - 1,500 mg per day.

**Incompatibilities with other medications:** Arjuna appears to have some effects on cardiovascular function, which may lead to interactions with conventional drugs used for similar indications. However, if anything, these interactions may be beneficial. Arjuna may also affect thyroid function, which could alter the control of both hyper and hypothyroidism. Tetracyclines should be taken about 2 hours apart from arjuna as it may impair their absorption.

**Evaluation of physico-chemical parameters of *T. arjuna* stem bark**
Physico-chemical analysis of *T. arjuna* stem bark was carried out by Krishna and Singh (2012). See the table below.

<table>
<thead>
<tr>
<th>NO.</th>
<th>Physico-Chemical Test</th>
<th>Shade drying</th>
<th>Sun drying</th>
<th>Oven drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Loss on drying at 105°C</td>
<td>5.12</td>
<td>6.28</td>
<td>7.32</td>
</tr>
<tr>
<td>2.</td>
<td>Total ash</td>
<td>12</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>3.</td>
<td>Acid-insoluble ash</td>
<td>1.2</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>4.</td>
<td>Alcohol soluble extractive</td>
<td>12.02</td>
<td>14.63</td>
<td>16.05</td>
</tr>
<tr>
<td>5.</td>
<td>Water soluble extractive</td>
<td>17.45</td>
<td>21.30</td>
<td>19.22</td>
</tr>
</tbody>
</table>


**Phytochemical screening of *T. arjuna*:** Phytochemical screening of *T. arjuna* bark methanolic extract was carried out by Mandal et al. (2013)

<table>
<thead>
<tr>
<th>Phytoconstituents</th>
<th>Tests</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytosterols</td>
<td>Salkowski reaction</td>
<td>++</td>
</tr>
<tr>
<td>Triterpenoids</td>
<td>Liebermann–Burchard’s test</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>Foam test</td>
<td>+</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>Dragendorff’s test</td>
<td>+</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>Molisch’s test</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Lead Acetate test</td>
<td>++</td>
</tr>
<tr>
<td>Lactones</td>
<td>Legal’s test</td>
<td>++</td>
</tr>
<tr>
<td>Phenolic Compounds and Tannins</td>
<td>5% Fec, Test</td>
<td>++</td>
</tr>
<tr>
<td>Proteins</td>
<td>Ninhydrin test</td>
<td>+</td>
</tr>
<tr>
<td>Glycosides</td>
<td>Keller–Kiliani test</td>
<td>++</td>
</tr>
</tbody>
</table>

*: Present in low concentration; **: Present in high concentration.

Microscopic examination of *T. arjuna* bark
Dhingra et al. (2013) carried out microscopic examination of the mature bark. The study revealed that a cork consisted of 9–10 layers of tangentially elongated cells. Phellogen was found to be 2–4 cells thick, phelloderm was narrow and consisted of 4–6 rows of tangentially elongated and radially arranged cells. Phloem was observed to be broad, traversed by uniseriate medullary rays that run straight and parallel, sometimes becomes slightly curved near the rosette crystals. Group of phloem fibers were lignified, thin walled, tangentially arranged, associated with idioblasts that comprised of clusters and rosettes of calcium oxalate. Some parenchymatous cells of cortex and secondary phloem contain reddish brown pigment whereas some cells contain starch grains. See the figures

![Tangential section of T. arjuna bark](image1)
![Radial section of T. arjuna bark](image2)


Microscopic examination of stem bark powder of *T. arjuna*

Microscopic examination of *T. arjuna* stem bark was carried Krishna and Singh (2012). Following diagnostic characters were observed in *T. arjuna* powder sample: phloem fiber, phloem parenchyma, rosette and micro rosette calcium oxalate crystals.

![Figure: Microscopic characters of T. arjuna stem bark](image3)

Thin-layer chromatography analysis of anti-oxidative constituents of *T. arjuna*
Thin-layer chromatography of anti-oxidant constituents of *T. arjuna* was carried out by Mandal et al. (2013) using solvent system methanol: chloroform: hexane (7: 2: 1) and 0.05% DPPH as spray reagent.

Figure: TLC profile of test solution of *Terminalia arjuna* Stem bark (Test solution derivatiged with ferric chloride solution Elaagic Acid Standard)


**Thin-layer chromatography analysis of flavonoid constituents of *T. arjuna***

Thin-layer chromatography analysis of flavonoid constituents of *T. arjuna* was carried out by Mandal et al. (2013) using chloroform: toluene: methanol (4:4:1) solvent system and anisaldehyde-sulphuric acid was used as a spray reagent.

Table: Thin-layer chromatography of flavonoid constituents of *T. arjuna*

<table>
<thead>
<tr>
<th>Extract</th>
<th>Solvent system</th>
<th>Revealing reagent</th>
<th>No. of Spot</th>
<th>R&lt;sub&gt;f&lt;/sub&gt; value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>Chloroform: Toluene; Methanol (4:4:1,v/v/v)</td>
<td>Anisaldehyde sulfuric acid</td>
<td>3</td>
<td>a. 0.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b. 0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>c. 0.38</td>
</tr>
</tbody>
</table>

Figure: Thin-layer chromatogram of flavonoid content of *T. arjuna* methanolic bark extract.

Antimicrobial activity of *T. arjuna* methanolic bark extract

Anti-microbial activity of *T. arjuna* methanolic bark extract was assessed by Mandal et al. (2013). The results of the study revealed more significant anti-microbial activity against gram negative bacteria as compared to the gram positive bacteria. See the table below.

Table: Anti-microbial activity of *T. arjuna* methanolic bark extract

<table>
<thead>
<tr>
<th>Extract</th>
<th><em>S. aureus</em></th>
<th><em>S. mutans</em></th>
<th><em>K. pneumoniae</em></th>
<th><em>E. coli</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanolic</td>
<td>11</td>
<td>5.2</td>
<td>16</td>
<td>5.8</td>
</tr>
<tr>
<td>Chloramphenicol (std)</td>
<td>18</td>
<td>10</td>
<td>20</td>
<td>12</td>
</tr>
</tbody>
</table>


Thin-Layer Chromatography of *T. arjuna* stem bark

Thin-layer chromatography of *T. arjuna* stem bark methanolic extract was assessed by Mandal et al. (2013). The shade drying sample showed nine major spots at Rf 0.08 (grey), 0.19 (pinkish-blue), 0.23 (dark blue), 0.32 (blue), 0.42 (dark blue), 0.45 (grey), 0.65 (grey), 0.71 (grayish blue) and 0.80 (dark pink) while as sun and oven drying samples showed eight spots. The spot at Rf 0.08 (grey) was absent on sun drying samples and spot at Rf 0.19 (grey) was absent on oven drying samples. See the figure below.

*Figure: Thin-layer chromatography of stem bark of *T. arjuna*

Anti-hypertensive activity of *T. arjuna* extract

Nammi et al. (2003) studied the anti-hypertensive effect 70% alcoholic extract of *T. arjuna* on anaesthetized dog blood pressure. Dose-dependent hypotensive effect produced by *T. arjuna* 70% alcoholic extract supports the use of *T. arjuna* extract in various cardiovascular disorders in traditional system of medicine.

![Figure: Effect of 70% alcoholic extract of *T. arjuna* on dog blood pressure.](image)

TAE – 70% alcoholic extract of *T. arjuna*. Ach – Acetylcholine, H – Histamine, IP – Isoprenaline, M – Mepyramine, PG – Propanolol


Insecticidal activity of *T. arjuna*

*T. arjuna* extract exhibited significant insecticidal activity against fourth instar larvae of *Spilarctia obliqua* in the research work carried out by Puvanakrishnan et al. (2010).

Anti-oxidant activity of *T. arjuna*

Shahriar et al. (2012) evaluated anti-oxidant activity of *T. arjuna* methanolic, ethanolic, petroleum ether and n-hexane extracts using DPPH free radical scavenging assay, hydrogen peroxide scavenging assay, nitrogen oxide scavenging capacity assay, reducing power capacity assessment, cupric reducing anti-oxidant capacity, total anti-oxidant capacity, total phenolic count and total flavonoid count.
Figure: Comparative DPPH radical scavenging activity of *T. arjuna* bark extracts, ascorbic acid and butylatedhydroxytoulene (BHT)

Figure: Comparative Hydrogen peroxide scavenging activity of *T. arjuna* bark extracts, ascorbic acid and butylatedhydroxytoulene (BHT)
Figure: Comparative Nitric oxide scavenging activity of *T. arjuna* bark extracts, ascorbic acid and butylatedhydroxytoulene (BHT)


Figure: Comparative reducing power of *T. arjuna* bark extracts, ascorbic acid and butylatedhydroxytoulene (BHT)

Figure: Comparative cupric reducing anti-oxidant capacity of *T. arjuna* bark extracts, ascorbic acid and butylated hydroxytoluene (BHT)


Figure: Total anti-oxidant capacity of different extracts of *T. arjuna*


Figure: Total phenolic content of the different extracts of *T. arjuna*

Effect of *T. arjuna* as healing agent

Giri et al. (2012) studied the effect of ethanolic extract of *T. arjuna* on the healing process of experimentally fractured tibia of rats. The results of the study revealed significant fracture healing effect of *T. arjuna* ethanolic extract.

<table>
<thead>
<tr>
<th>Table: Fracture healing effect of <em>T. arjuna</em> ethanolic extract</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>1st Week</th>
<th>2nd Week</th>
<th>3rd Week</th>
<th>4th Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td>Fracture line</td>
<td>Fracture gap</td>
<td>Callus appearance</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>Totally visible</td>
<td>+++</td>
<td>No</td>
</tr>
<tr>
<td><em>Terminalia arjuna</em></td>
<td>Totally visible</td>
<td>+++</td>
<td>No</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>Totally visible</td>
<td>+++</td>
<td>No</td>
</tr>
<tr>
<td><em>Terminalia arjuna</em></td>
<td>Partly visible</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>Totally visible</td>
<td>+++</td>
<td>No</td>
</tr>
<tr>
<td><em>Terminalia arjuna</em></td>
<td>Partly visible</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>Totally visible</td>
<td>+++</td>
<td>No</td>
</tr>
<tr>
<td><em>Terminalia arjuna</em></td>
<td>Absent</td>
<td>Not seen</td>
<td>+++</td>
</tr>
</tbody>
</table>

Anti-diabetic activity of *T. arjuna*

Clinical study was carried out by Deogade et al. (2013) to evaluate the anti-diabetic activity of *T. arjuna* extract on 40 patients. The results of the study justified the effectiveness of *T. arjuna* extract in treatment of diabetes.

Hepato-protective effect of *T. arjuna* extract

Doorika and Ananthi 2012 evaluated the hepato-protective effect of *T. arjuna* extract against Isoniazid induced hepato-toxicity.
Cytotoxicity screening of *T. arjuna*

Cytotoxicity screening of *T. arjuna* extract was carried out using Brine shrimp bioassay by Akhter et al. (2012). Vincristine sulphate was used as a positive control. Dose-dependent increase in percentage mortality of brine shrimp nauplii was observed.

![Graphs showing LC50 determination](image)

Figure: Determination of LC50 of A) Vincristine sulphate, B) methanol extract, C) ethanol extract, D) petroleum ether extract, E) chloroform extract, F) n-hexane extract of *T. arjuna* against brine shrimp nauplii.


Cardiotonic effect of *T. arjuna*

Cardiotonic effect of *T. arjuna* was evaluated by Verma et al. (2013) by comparing the efficacy of aqueous *T. arjuna* extract with Digoxin. The results showed that *T. arjuna* extract increased coronary flow in frog’s heart in situ as well as hypodynamic frog’s heart in situ. *T. arjuna* extract (400µg) also increased coronary flow in isolated perfused rabbit heart.
Hypolipidemic activity of T. arjuna

Hypolipidemic activity of 50% ethanolic extract of T. arjuna was assessed in rats by Patil et al. (2011). The results of the study revealed significant lowered levels of total cholesterol, triglycerides, LDL cholesterol and elevated level of HDL cholesterol in experimental group as compared to hypercholesterolemic group.

References


Tripathi YB. Terminalia arjuna extract modulates the contraction of rat aorta induced by KCl and norepinephrine. Phytother Res. 1993;7:320-322.
