
Scientific Name: *Aegle marmelos* (L.) Corr.
Synonym: *Crataeva marmelos* L.
Family: Rutaceae
Genus: Aegle
Species: marmelos
Common Name: Bael fruit tree, Holy fruit, Stone Apple, Bela, Bengal quince, golden apple.
Parts used: fresh pulp of unripe or half ripe fruit

Plant Description:
A spinous, deciduous, small to medium sized aromatic tree, about 12-20 m high. Spines straight, strong, axillary, single or paired about 2.5 cm long. Leaves alternate, usually 3 foliate, sometimes 5 foliate. Leaflets ovate-lanceolate, entire or crenate, glabrous, lateral, sub-sessile, terminal long petiolated, acuminate, cuneate to obtuse at base. Terminal one 4.5 × 2.5 cm, lateral ones smaller. Flowers in few flowered short axillary panicles, greenish-white, sweet-scented about 2.5 cm across. Calyx flat, pubescent, 4-lobed; lobes rounded sometimes obscure. Petals 4-5, spreading, oblong, thick, gland-dotted, much exceeding the sepals, imbricate. Stamens numerous; anthers elongate, apiculate; filaments free, inserted round an inconspicuous disk. Ovary ovoid, 8-20 carpelled; style terminal, short, deciduous; stigma capitate; ovules numerous, 2-seriate. Fruit 8-20 cm diameter, globose, ovoid or pyriform. Rind smooth grey or greyish yellow, woody; pulp orange, sweet and aromatic. Seeds numerous in aromatic oulp, oblong, compressed; testa woody and mucilaginous.

Chemical Constituents
β-sitosterol, amino acids, dictamine, marmesin, marmin, umbelliferone, skimmianine, carbohydrate, carotene, fat, tannins, and vitamins; imperatorin and its isomers alloimperatorin and marmelide, psoralen, tannic acid, α-d- phellandrene, N-2-methoxy 2-(4-methoxyphenyl)-ethylcinnaminimide, aurapten, isoimperatorin, isopimpinellin, marmelin and its methyl ether, osthol, scoparone, xanthotoxol, xanthotoxin, arabinose, galactose, D-galacturonic, rhamnose, linoleic, linolenic, oleic, palmitic and stearic acid, caryophyllene, ethyl-n-amylketone, methyl-n-heptylketone, eugenol, methyleugenol, d-limonene and linalool; N-2-ethoxy-2-(4-methoxyphenyl)-ethylcinnamaides, N-2-methoxy-2-[4-(3’,3’-dimethylallyloxy)phenyl]-ethylcinnamamide, 0-(3,3-dimethylallyl)-halfordinol, aegeline, aegelenine, anthocyannins and leuco-anthocyanins, flavan-3-ols, flavone glycosides, γ-fagarine.
Structures of chemical constituents of *Aegle marmelos* (L.) Corr.

Figure: Active chemical constituents of *Aegle marmelos* Corr-ex-Roxb.
Preparations
Homeopathic mother tincture of \textit{Aegle marmelos} Corr-ex-Roxb., 3X, 6, 30, 200; Compounded preparations include Murraba Bael, Murabba Belgari, Ma'jun Bawasir, Sherbet Bael Giri.

Dosage
2-3g (in powdered form), in infusion 3-5 g. (approximately).
Decoction Belae BPC 1 in 2 ½: dose, ½ to 2 oz; Fluid extract, ½ to 2 drachms.

Pharmacological actions
Restorative, astringent, laxative, digestive, stomachic. Mucilaginous (glutinous), alterative, haemostatic, stomach tonic, anti-dysenteric, brain and cardiac tonic. The bark is regarded as antipyretic.

Medicinal uses: bleeding piles, diarrhea, dysentery, fever with dropsy, impotency.

Physicochemical standardization
The various Physico-chemical parameters (ash values, extractive values, loss on drying) of \textit{A. marmelos} leaves were evaluated according to the Pharmacopoeial method. See Tables below:

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
\textbf{Sr. No.} & \textbf{Parameter} & \textbf{Values (\%w/w)} \\
\hline
1. & Ash value: & \\
& A. Total ash value & 5.80 \\
& B. Water soluble value & 1.30 \\
& C. Acid insoluble value & 2.50 \\
\hline
2. & Extractive value: & \\
& A. Pet. Ether soluble extractive value & 6.30 \\
& B. Chloroform soluble extractive value & 5.20 \\
& C. Alcohol soluble extractive value & 8.00 \\
& D. Acetone water (70:30) soluble extractive value & 4.20 \\
& E. Water soluble extractive value & 3.10 \\
\hline
3. & Loss On Drying & 0.63 \\
\hline
\end{tabular}
\caption{Physio-chemical evaluation of \textit{A. marmelos} leaf}
\end{table}


Fluorescence analysis of \textit{A. marmelos} leaf
Florescence analysis of \textit{A. marmelos} was carried out using different chemical reagents and UV light 254nm and 366nm respectively.
Table: Fluorescence analysis of *A. marmelos* leaf

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Treatment</th>
<th>Day light</th>
<th>UV light 254 nm</th>
<th>UV light 366 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Powder as such</td>
<td>Green</td>
<td>Dark green</td>
<td>Green</td>
</tr>
<tr>
<td>2.</td>
<td>Powder treated with distilled water</td>
<td>Light green</td>
<td>Dark green</td>
<td>Black</td>
</tr>
<tr>
<td>3.</td>
<td>Powder treated with Petroleum ether</td>
<td>Dark green</td>
<td>Green</td>
<td>Dark green</td>
</tr>
<tr>
<td>4.</td>
<td>Powder treated with Chloroform</td>
<td>Dark green</td>
<td>Dark green</td>
<td>Dark green</td>
</tr>
<tr>
<td>5.</td>
<td>Powder treated with conc. HCl</td>
<td>Dark green</td>
<td>Radish brown</td>
<td>Greenish black</td>
</tr>
<tr>
<td>6.</td>
<td>Powder treated with HNO₃</td>
<td>Light brown</td>
<td>Dark green</td>
<td>Dark violet</td>
</tr>
<tr>
<td>7.</td>
<td>Powder treated with H₂SO₄</td>
<td>Green</td>
<td>Black</td>
<td>Blue</td>
</tr>
<tr>
<td>8.</td>
<td>Powder treated with Glacial acetic acid</td>
<td>Yellow</td>
<td>Dark yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>9.</td>
<td>Powder treated with 1N NaOH in water</td>
<td>Greenish brown</td>
<td>Greenish black</td>
<td>Brown</td>
</tr>
<tr>
<td>10.</td>
<td>Powder treated with Ammonia</td>
<td>Light green</td>
<td>Dark green</td>
<td>Greenish brown</td>
</tr>
<tr>
<td>11.</td>
<td>Powder treated with Ferric chloride</td>
<td>Green</td>
<td>Radish black</td>
<td>Greenish brown</td>
</tr>
</tbody>
</table>


**Phytochemical analysis of *A. marmelos***

Phytochemical analysis of *A. marmelos* decoction was carried out for assaying presence of carbohydrates, glycosides, proteins, amino acids, phytosterols, saponins, flavonoids, alkaloids and tannins.

**High Performance Thin-layer Chromatography of *A. marmelos***

High performance thin layer chromatography (HPTLC) fingerprinting of the methanol soluble fraction of the *A. marmelos* decoction was carried out with the solvent system n-Hexane-Ethyl acetate-Acetic acid (40:60:0.5). Marmelosin was used as a phytochemical reference standard for fingerprinting.

Figure: HPTLC of *A. marmelos* decoction (A) Methanolic fraction of *A. marmelos*; (B) Marmelosin.

Microscopic features

Powder drug study: It contains oval, elongated parenchymal cells containing granular, oil inclusions, numerous lignified, multi-cellular fibers up to 10-14 cells wide. Numerous elongated multi-cellular hairs above the seeds each up to 9 cells wide, made of lignified walls containing cup-like and simple pits. Numerous, large, highly, sinuous, lignified cells are present below the hairs, each containing pits on walls, polygonal cells; numerous rhomboidal crystals scattered in seed cell walls.

![Diagnostic microscopic features of A. marmelos](image)

Figure: Diagnostic microscopic features of A. marmelos: A, Parenchyma with oil globules; B, Hairs; C, Fibres; D, Epidermal cells of the testa with calcium oxalate crystals; E, Oil glands; F, Epidermis and palisade of the cotyledons in sectional view; G, Parenchyma of the cotyledons.


Transverse section study of A. marmelos:

Transverse section of leaf revealed upper and lower epidermis consisting of round to oval cells in lamina portion. Epidermis is single-layered, having thick layer of cuticle consisting of sunken stomata and covering trichomes. Upper epidermis contains more stomata as compared to lower epidermis. Palisade tissue is found beneath epidermis layer and consists of closely packed oval cells. Below palisade tissue spongy parenchyma was observed containing clusters of calcium oxalate crystals and fewer chloroplasts in comparison to palisade cells. Strips of collenchyma were found above lower epidermis and beneath upper epidermis. Xylem and phloem were arranged in an arc in the mid-rib portion. See figure below.

![Transverse section of A. marmelos leaf](image)

Ant diabetic Activity
A. marmelos leaves aqueous extract exhibited significant anti-diabetic activity in alloxon-induced diabetes in male albino rats and in streptozotocin-induced diabetes in wistar rats in two separate studies.

Hepato-protective activity
Leaf extract of Aegle marmelos Corr-ex-Roxb. showed significant hepato-protective activity against alcohol induced liver injury in albino rats. Aqueous extract of A. marmelos fruit pulp and seeds were found to effectively prevent and treat CCl4 induced hepatic toxicity.

Anti-bacterial activity
A. marmelos exhibited significant anti-bacterial activity against E. coli, S. typhi, P. aeruginosa, A. hyydrophyla and Vibrio species.

Anti-inflammatory activity
The leaves extract of A. marmelos exhibited significant anti-inflammatory activity by inhibition of carrageenan-induced paw oedema and cotton-pellet granuloma in rats.

Analgesic activity
A. marmelos extract revealed significant analgesic activity by decrease in early and late phase of paw licking in mice. In another study, 200 and 300mg/kg of methanolic extract of A. marmelos exhibited significant analgesic activity in acetic acid induced writhing and tail-flick tests in mice.

Anti-fungal activity
Oil extracted from A. marmelos showed significant anti-fungal activity.

Cytotoxic activity
Anti-cancer activity of A. marmelos was evaluated using brineshrimp lethality assay, sea urchin eggs assay and MTT assay using tumor cell lines.

Radio-protective effect
A. marmelos extract revealed significant radio-protective effect in different doses in mice.

Anti-ulcer activity
Pyranocoumarin isolated from A. marmelos seeds exhibited protective effect against pylorus-ligated and aspirin-induced gastric ulcers in rats and cold restraint stress-induced gastric ulcers in rats and guinea pigs.

Anti-thyroid activity:
Scopoletin isolated from A. marmelos leaves exhibited significant anti-thyroid activity and showed superior therapeutic efficacy incomparison with the standard anti-thyroid drug, Propylthiouracil.

Toxicity Studies:
Alcoholic, aqueous and methanolic A. marmelos leaves extracts at the dose of 50mg/kg were administered in rats intra-peritoneally for 14 days. No histo-pathological changes revealed high margin of safety of A. marmelos.

Anti-oxidant activity:
Aqueous and methanolic fruit pulp extracts of A. marmelos extract revealed significant anti-oxidant activity by using following assay methods: DPPH radical scavenging method, reducing power assay, nitric oxide scavenging assay, superoxide radical scavenging assay, ABTS radical scavenging assay and H2O2 radical scavenging assay.

Anti-arthritis activity
A. marmelos leaves extract showed significant anti-arthritis activity against collagen-induced arthritis in Wistar rats. Methanolic extract reduced paw swelling and arthritic index along with reduced radiological and histo-pathological changes.
**Anti-diarrheal activity of A. marmelos**

The *A. marmelos* unripe fruit pulp decoction is effective against bacterial colonization to gut epithelium as well as inhibits the production and activity of certain enterotoxins, thereby validating the therapeutic efficacy of *A. marmelos* in the treatment of infectious forms of diarrhea.

**Clinical Study on effectiveness of A. marmelos in treatment of non-insulin dependent diabetes mellitus**

In a study carried out on non-insulin dependent diabetes mellitus patients for 16 weeks 5gm *A. marmelos* powder individually once daily orally were found to have anti-diabetic effect. *A. marmelos* and *T. foenum-graecum* can be combined in high dose with oral hypoglycemic agents to bring the blood glucose to normal levels in patients whose diabetes is not controlled with these agents or in those patients in whom these drugs produce adverse effects on dose increments. A randomized, double-blind, placebo-controlled study was conducted for three months to assess the effectiveness of *A. marmelos* supplementation on blood sugar, glycosylated hemoglobin (HbA1C) and blood pressure levels in 150 patients with type 2 diabetes mellitus. Patients were divided in to three group *A. marmelos* (250mg/day), *A. marmelos* (600mg/day) and placebo. *A. marmelos* in both the administered doses effectively controlled hyperglycaemia and blood pressure without exhibiting any adverse effects.

**References:**


