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# Brihatpanchmoola: An Overview of Morphological, Phytochemical and Biological Profiles

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## ABSTRACT

**Introduction:** Brihatpanchmoola is an integral part of Dashmoola herb which is a combination of ten ayurvedic herbs which are *Aegle marmelos* (L) Correa, *Clerodendrum phlomidis* L.f., *Oroxylum Indicum* (L) Benth. Ex. Kurz, *Stereospermum. suaveolens* (Rox.) DC, *Gmelina Arborea* Roxb., *Solanum Indicum* auct. Non-L, *Solanum xanthocarpum* Schrad & H., *Desmodium gangeticum* (L) DC., *Uraria picta* (Jacq) DC and *Tribulus Terrestris*. The above-mentioned first five herbs of Dashmoola are collectively called Brihatpanchmoola and it is used traditionally in various ayurvedic formulations like Dashmolarishta, Dashmool ghritam, Chywanprash, Mahanarayan Tail etc.

**Aim:** The present review aims to put together various published reports on Brihatpanchmoola and analyse them critically.

**Methodology:** Various published literature and researches on individual plants of Brihatpanchmoola species are studied deeply in detail covering their morphological parameters, geographical distribution, chemical constituents and Pharmacological activities. This is perhaps the first such compilation of all the species of Brihatpanchmoola in a single article.

**Result and Conclusion:** The enormous medical significance of Brihatpanchmoola species has resulted in huge demand which has increased the pressure on the natural/wild resources. There is an immediate need to reexamine this species using appropriate scientific procedures.

**Key Words:** Brihatpanchmoola, Chywanprash, Dashmoola, Herb, Rutaceae, Bignoniaceae

## INTRODUCTION

Brihatpanchmool constitutes a significant part of Dashmoola which includes a mix of roots of ten plants. The species of Dashmoola are referred to individually in Charakh Samhita, however their grouping into Dashamoola and sub-groups laghu and Brihatpanchamoola was done by Sushruta Samhita for the first time. The two subgroups are classified as Brihatpanchmoola which incorporates *Aegle marmelos*, *Clerodendrum phlomidis*, *Oroxylum Indicum*, *Stereospermum suveolens*, *Gmelia Arborea* while laghu panchmool incorporates; *Solanum Indicum*, *Solanum xanthocarpum*, *Uraria picta*, *Desmodium gangeticum* and *Tribulus Terrestris*.<sup>1</sup> This ayurvedic formulation have a balancing action on Kapha, Pitta and Vata doshas, and useful for Vata vyadhi.<sup>1</sup>

It is utilized in different ayurvedic cures like fortifying and detoxification of the body, tonic for liver and kidney, in rest-

lessness, uterine tonic, utilized for anorexia, oedema, iron deficiency, powerful cancer prevention agent and in different diseases of nerves, bones, joints and muscles.<sup>2,3</sup> Most of the plants of Brihatpanchmool has been marked as red listed species which is near to eradication.<sup>4</sup>

## PLANT DESCRIPTION OF BRIHATPANCHMOOLA

### I. *Aegle marmelos*

**Natural Source:** *Aegle marmelos* (L.) Corr ex Roxb, belongs to family Rutaceae.

**Geological Source:** Bael (*Aegle marmelos*) is a fruit-bearing tree native to dry woodlands on slants and fields of central and southern India, Myanmar, Pakistan, Bangladesh, Nepal

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and Cambodia. It is grown all over India, in Sri Lanka, northern Malaya, Java and Philippines.<sup>5, 6,7</sup>

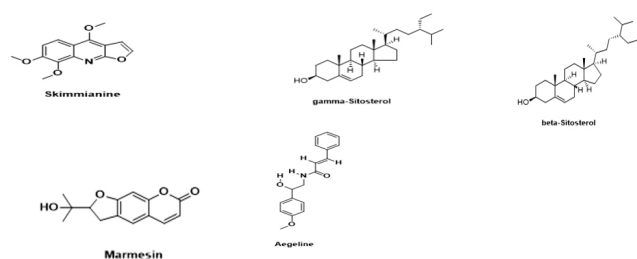
### Morphological characters

*Aegle marmelos* is deciduous with 6–8 meters in height and trifoliate fragrant leaves. Long straight spines are present in branches. The bark is corky and shallowly wrinkled. The flowers are bisexual and around 2 cm wide, in gatherings, are greenish-white with a pleasant smell. Calyx is shallow and has 5 short sepals and apparently pubescent. The petals are oval and ovoid, thick and pale greenish-white in colour with oil organs. Stamens are present in groups. Ovaries are lengthened ovoid, fairly fixing, center wide, cells different (8–20), minimal organized around with ovules which are different in each cell. Fruits are 5–8.0 cm in length, globose shape, lengthened pyriform, skin dull and yellow-orange to brown in shade. Woolly hairs are present in the seeds which are arranged in the cells.<sup>8</sup>

**Parts Used:** Fruits, Pulp, unripe fruit, ripe fruit, and skin of ripe fruit, bark, root and root bark.

### Phytochemical Constituents

Various chemical constituents viz., alkaloids, coumarins and steroids are reported in different parts of the Bael tree like aegelin ( $C_{18}H_{18}O_4$ ), skimmianine, aegelenine ( $C_{14}H_{10}O_2N_2$ ), Y-sitosterol ( $C_{29}H_{50}O$ ), myrlene, p-menth-1-en-3 beta, N-2 (4 (3',3' dimethylalloxy) phenyl) ethyl cinnamide, N-hydroxy-2 (4-(3', 3' dimethylallyloxy) phenyl) ethyl cinnamide, 5 betadiol, N-4 methoxystyryl cinnamide, N-2-hydroxy-2 (4 hydroxyphenyl) ethyl cinnamide, lupeol, sitosterol, allo-imperatorin, imperatorin,  $\beta$ -sitosterol, marmesin ( $C_{14}H_{11}O_4$ ), Dietamine ( $C_{12}H_9NO_2$ ), Marmin ( $C_{19}H_{26}O_5$ ), umbelliferone, marmelosin ( $C_{13}H_{12}O_3$ ) and lupeol (**Figure 1**). The leaves contain 0.6 % essential oil, mostly contain d – limonene. The pulp of the fruit contains around 50 % moisture. The pulp is acidic, contains sugars and tannins. The content of pectin is around 2.5 %. The fruit is a rich source of protein and contains minerals like potassium, calcium, phosphorus, magnesium etc.<sup>9</sup>



**Figure 1:** Phytochemical constituents of *Aegle marmelos*.

### Pharmacological activities of *Aegle marmelos*

#### Antidiarrhoeal activity and irritable Bowl Syndrome

An Ayurvedic formulation comprising of *Aegle marmelos* and *Bacopa monnieri* was compared with standard treatment (clidinium bromide with chlordiazepoxide and isabgula) and matching placebo, in a randomized experiment for about one and half months. 34 % of patients showed improvement with the therapy, 36 % of patients with the standard treatment and 31 % patients with the placebo treatment. The Ayurvedic formulation was the most valuable in the loosening of the bowels when compared with placebo. Long haul treatment (longer than a half year) demonstrated that placebo was best in limiting relapse.<sup>10</sup>

Agar dilution and disc diffusion techniques were used to evaluate the *in vitro* antidiarrhoeal activity of chloroform root extract of *Aegle marmelos*. The concentrate was found to be most active against the strains of *Vibrio cholerae*, followed by *Escherichia coli* and *Shigella* spp and the effect was seen as identical to ciprofloxacin. Critical inhibitory action against castor oil-induced diarrhoea was observed in *Aegle marmelos* root extract (AMRE) treated rodents.<sup>10</sup>

#### Antiulcer action

The isocoumarins; bergenin and norbergenin isolated from leaves and roots of *Flueggea microcarpa* and a pyranocoumarin; luvangetin, isolated from the seeds of *Aegle marmelos*, showed good activity against pylorus-ligated and aspirin-induced gastric ulcers in rodents and cold restraint stress-induced gastric ulcers in rodents and guinea pigs. The examination on prostaglandins released by human colonic mucosal incubates exhibited a concentration-dependent (1-10 micrograms/ml) stimulatory effect of bergenin and norbergenin, while luvangetin (1-10 micrograms/ml) didn't show any effect.<sup>11</sup>

#### Anti-diabetic activity

The *Aegle marmelos* was studied against experimental diabetes as well as for antioxidant potential. Blood sugar in alloxan diabetic rats was found to be reduced by using a methanolic extract of *Aegle marmelos*. The oxidative stress produced by alloxan was remarkably lowered by the administration of *Aegle marmelos* extract and led to a reduction in blood sugar.<sup>12</sup>

The aqueous seed extract of *Aegle marmelos* showed anti-diabetic and hypolipidemic effects in diabetic rats. The aqueous extract of *Aegle marmelos* seeds was administered orally at different doses (100, 250 and 500 mg/kg) to normal as well as sub (fasting blood glucose (FBG) normal; glucose tolerance abnormal) and mild (FBG 120-250 mg/dl) diabetic rats. The dose of 250 mg/kg was the most effective dose with decreased blood glucose level (BGL) by 35.1% in normal healthy rats after 6h of administration. It also showed a marked re-

duction in BGI of 41.2% in sub and 33.2% in mild diabetic rats in glucose tolerance test (GTT) after 2 h. There was also a fall in the level of total cholesterol (TC) by 25.49% with an increase of 33.43% in high-density lipoprotein (HDL) and a decrease of 53.97 and 45.77% in low-density lipoprotein (LDL) and triglyceride (TG), respectively.<sup>13</sup>

### Anti-inflammatory Activity

Various extracts of the leaves of *Aegle marmelos* investigated for anti-inflammatory, analgesic and antipyretic properties lead to a remarkable inhibition of the carrageenan-induced paw oedema, cotton-pellet granuloma in rats, reduction of the early and late phases of paw licking in mice and reduction in hyperpyrexia in rats.<sup>14</sup>

### Wound healing activity

The topical and intraperitoneal administration of methanolic extract of *Aegle marmelos* ointment and injection were studied on two types of wound models in rats (i) the excision and (ii) the incision wound model. In the excision model, the extract-treated wounds were found to epithelialise at a faster rate and the rate of wound contraction was also higher, as compared to control wounds. The extract facilitated the healing process as proved by an increase in the tensile strength in the incision model. The results were comparable to nitrofurazone.<sup>15</sup>

### Immunomodulatory Activity

A C-glucosylated propylargenonidin from the aqueous extract of the pulp of the unripe fruit of *A. Marmelos* exhibited moderate inhibition of the classical pathway of complement activation and luminol-enhanced chemiluminescence by zymosan activated polymorphonuclear leucocytes. It did not affect the alternative pathway of complement activation.<sup>16</sup>

## 2. *Oroxylum Indicum*

**Biological Source:** *Oroxylum Indicum* (L.) Corr ex Roxb belongs to the family Bignoniaceae.<sup>17</sup>

**Geographical Source:** *Sona Chhal* (*Oroxylum Indicum*) is a native of the Indian subcontinent. It is found in the Himalayas and its ranges spreading over to Bhutan and southern China, Indo-China and the Malaysia ecozone. It has also been discovered in the forests of Manas National Park, Assam, India. It has been also seen in Sri Lanka (Ceylon), Vietnam, Thailand, Philippines, Laos, Cambodia Yunnan, Taiwan, Sichuan, Guizhou, Guangxi, Guangdong, Fujian, Nepal, Myanmar and Malaysia.<sup>16</sup>

### Morphological Characteristics

It is a small tree that is 8-15 metres in height, branched at the top, has a light brown bark that is soft with green juice and often has numerous corky lenticels. Its leaves are 3-7 cm long, 2-3 pinnate with opposite pinnae, rachis stout, cylindrical,

leaflets 2-4 pairs, 6-12 cm in length and are 4-10 cm broad, ovate or elliptic, acuminate, glabrous, base rounded, sometimes cordate; petioles of the lateral leaflets 6-15 mm long. Flowers numerous, foetid, in large erect racemes, 0.3-0.6 meter long, pedicels 6-30 mm long. Calyx 4 cm long, leathery, oblong-campanulate and glabrous. Corolla usually lurid-purple, 10 cm long, lobes are fleshy, about 4 cm long with crisped margins. Stamens 5 slightly exerted beyond the corolla tube, one of them a little shorter than the other 4, filaments cottony at the base. Capsules 0.3-0.6-meter-long and 5-9 cm broad, straight, tapering at both ends, flat, hardly 8 mm thick, acute, valves semi-woody. Seeds numerous, 6 cm long, winged all round except at the base.<sup>18,19,20</sup>

### Chemical Constituents

- The essential oils present in the plant imparts an aromatic odour. The constituent of this essential oil are phenols, fatty acids and aldehydes, also contain polyphenolics, flavonoids and alkaloids.<sup>21,22</sup>
- The leaves contain flavonoids mainly chrysin, oroxylin-A, scutellarin, baicalein, quercetin-3-O- $\alpha$ -L-arabinopyranoside, 1-(2-hydroxyethyl) cyclohexane-1,4-diol and apigenin.<sup>23</sup>
- Seeds contain ellagic acid.<sup>25</sup>
- Root bark consists of chrysin, baicalein, biochanin-A and ellagic acid.<sup>20</sup> Two flavonoids 2, 5-dihydroxy-6, 7-dimethoxy flavone and 3, 7, 3', 5'-tetramethoxy-4'-hydroxyflavone are also reported.<sup>26</sup>
- The stem bark contains ellagic acid, chrysin, oroxylin-A, scutellarin, baicalein, 5-hydroxy 8-methoxy 7-O- $\beta$ -D-glucopyranuronosyl flavone, stigmast-5-en-3-ol, pratensol, 3-(4-hydroxy phenyl) 2-propenoic acid and flavonoid 3,4',5,7-tetrahydroxy flavonol, 5-hydroxy 4',7-dimethoxy flavone, 7-O-methylchrysin, dihydrooroxylin-A, methyl-3,4,5-trihydroxy-6-(5-hydroxy-6-methoxy-4-oxo-2-phenylchroman-7-yloxy)-tetrahydro-2H-pyran-2-carboxylate, 5-hydroxy-7-methoxy-2-(2-methoxy-6-(3,4,5-trihydroxy-6-(hydroxymethyl) tetrahydro-2H-pyran-2-yloxy) phenyl)-4H-chromen-4-one. Wood contains prunetin and sitosterol.<sup>27</sup>
- Fruits contain chrysin, ursolic acid, oroxylin A and aloe-emodin (Figure 2).<sup>28,29</sup>
- Seed oil contain lauric, myristic, caprylic, palmitic, palmitoleic, stearic, oleic, and linoleic acids.<sup>30</sup>

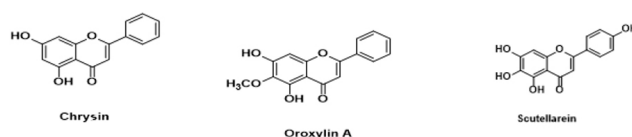


Figure 2: Phytochemical constituents of *Oroxylum Indicum*.

### Pharmacological action

### Antibacterial Activity

The methanolic, ethyl acetate and ethanolic extracts of stem bark of *Oroxylum Indicum* possess significant antibacterial activity against both gram-positive and gram-negative bacteria namely *Bacillus subtilis*, *E. coli*, and *Pseudomonas aeruginosa*.

The crude petroleum ether, methanolic and ethyl acetate extracts of root bark possess moderate to good antimicrobial and antifungal activity.

Dichloromethane extract of *Oroxylum Indicum* showed significant antifungal activity.<sup>31</sup>

### Anti-inflammatory Activity

The root bark of *Oroxylum Indicum* has shown potent anti-inflammatory activity in rats. The aqueous stem bark extract of *Oroxylum Indicum* has shown positive results against ear swelling in mice. The aqueous extract of leaves of *Oroxylum Indicum* provided relief to rats against carrageenan-induced rat paw oedema.<sup>32,33,34</sup>

### Analgesic activity

Butanol extract of root bark of *Oroxylum Indicum* was employed to detect analgesic activity in tail-flick and acetic acid-induced writhing response models in mice. Oral administration of n-butanol fraction significantly reduced the number of writhing by 75.93 % as compared to aspirin 87.05 %. The analgesic activity has been attributed to the presence of flavonoids such as baicalein, ellagic acid, biochanin-A.<sup>35</sup>

### Antioxidant activity

Antioxidant activity of methanolic extracts of different parts viz. root bark, root, stem bark and stem, leaves and fruits were determined by performing DPPH, nitric oxide, superoxide anion and hydroxyl radical scavenging activity than bark, stem and fruit extract.<sup>36</sup>

### Hepatoprotective activity

Different extracts of leaves of *Oroxylum Indicum* showed significant hepatoprotective activity against CCl<sub>4</sub> induced hepatotoxicity in Wistar albino rats.

The aqueous root bark extract of *Oroxylum Indicum* has a protective effect against paracetamol-induced liver damage in experimental rats.<sup>37</sup>

### Nephroprotective activity

The ethanolic root extracts of *Oroxylum Indicum* has shown a protective effect against cisplatin-induced renal injury in Wistar male albino rats<sup>[38]</sup>.

### Antihyperlipidemic activity

The *Oroxylum Indicum* root bark extract has been examined

in the cholesterol induced hyperlipidemic albino Wistar rat model. There was a significant reduction in total cholesterol, total triglycerides, LDL-C, VLDL-C levels and a remarkable increase in the level of HDL-C. The levels of SGOT and SGPT were found to be significantly less than that of the hyperlipidemic control group.<sup>39</sup>

### Antidiabetic activity

Oral administration of ethanolic and water extracts of roots of *Oroxylum Indicum* showed a significant reduction in the serum glucose, triglycerides, total cholesterol levels and significant increase in the liver and muscle glycogen levels when compared with diabetic control groups. The methanolic and aqueous extracts of leaves of *Oroxylum Indicum* have also been found to have antidiabetic activity against alloxan-induced diabetes in rats.<sup>40</sup>

### 3. *Clerodendrum phlomidis*

**Biological Source:** *Clerodendrum phlomidis* linn.f belongs to the family Lamiaceae.<sup>41</sup>

**Geographical Source:** It is a shrub found in arid plains, tropical deserts and low hills. It is found in India in various regions like Delhi, Uttar Pradesh, Diu island, Haryana, Gujarat, Madhya-Pradesh, Bihar, Rajasthan, Punjab, Tamilnadu, Pakistan (Baluchistan, North-eastern provinces and Sindh), Sri Lanka, Myanmar and Southeast Asia.<sup>42</sup>

### Morphological Characteristics

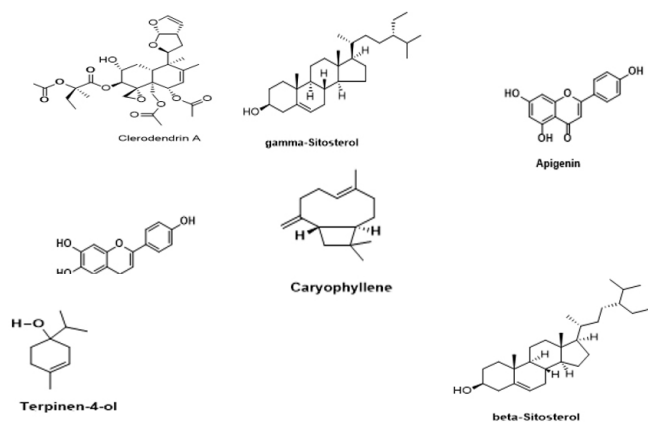
*Clerodendrum phlomidis* linn.f. [Syn. *C. multiflorum* (Burm.f.) O.kuntze, *Clerodendrum phlomoides* Linn.f., *Clerodendron phlomoides* Willd] is bush or tree, 9-10 m. high, with branches having pubescent branching. Leaves are 4.0-7.0 cm by 3.0-4.0 cm., subrhomboid or ovate, acute, coarsely subentire, crenate-dentate, glabrous, undulate, puberulous beneath, base subcordate or truncate, petioles 5-20 mm in length. Flowers moderate-sized, fragrant, arranged as dichotomous Auxillary comes to form rounded terminal panical; obovate bracts and acute leafy lanceolate. Calyx 1-2 cm long, glabrous, divided halfway down, veined. White or pinkish corolla, 2-3 cm long tube, glabrous inside and slightly pubescent outside, nearly equal lobes, 6-7 mm long, obtuse, elliptic, veined and obtuse. Slightly pubescent filaments below. Glabrous style and ovary. Drupe is around 6-7 mm long, obovoid broadly, depressed and persistent calyx-lobes.<sup>42, 43</sup>

### Chemical Constituents

Roots contain  $\gamma$ -sitosterol,  $\beta$ -sitosterol, clerodin, clerodendrin-A,  $\alpha$ -1-rhamnopyranosyl-(1 $\rightarrow$ 2)- $\alpha$ -D-glucopyranosyl-7-O-naringin-4'-O- $\alpha$ -D-glucopyranoside-5- methyl ether. The stem contains  $\beta$ -D-glucoside,  $\beta$ -sitosterol and ceryl alcohol. Aerial parts contain tetratriacontanol, lup-20(29)-en-3-triacontanoate (C<sub>60</sub>H<sub>10</sub>8O<sub>2</sub>), and 24 $\beta$ -ethylcholesta-5, 22E,



25-triene-3 $\beta$ -ol. Leaves contain a non-glucoside bitter compound (C<sub>17</sub>H<sub>16</sub>O<sub>6</sub>),  $\beta$ -sitosterol, ceryl alcohol, palmitic acid,  $\gamma$ -sitosterol, cerotic acid, an unidentified sterol (C<sub>28</sub>H<sub>48</sub>O), scutellarein (5,6,7,4'-tetrahydroxy flavones. Pectolinarigenin (6, 4'-dimethoxy scutellarein). 7-hydroxy flavone and 7-hydroxy flavanone and 7-O-glucoside. Flowers contain pectolinarigenin, hispidulin, 6, 4'-dimethyl-7-acetoxyscutellarein apigenin chalcone glycoside (4, 2', 4'-trihydroxy-6'-methoxychalcone-4, 4' $\alpha$ -D-diglycoside, C<sub>28</sub>H<sub>34</sub>O<sub>15</sub>) and luteolin. Saponins, alkaloids and tannins were also reported in stem, leaf and flowers. Terpinen-4-ol (25.92%); caryophyllene (26.71%) and beta-bisabolene (18.10%) are the major and phytol (5.08%) are the minor constituents from leaf oil. <sup>44</sup>



**Figure 3:** Phytochemical constituents of *Clerodendrum phlomidis*.

## Pharmacological Action

### Anti-inflammatory activity

In the carrageenan-induced paw oedema model, *clerodendrum phlomidis* aerial parts at the dose of 200 and 400 mg/kg caused significant inhibition of paw oedema by 34.02 % and 26.80 % respectively 4 hours after carrageenin administration. The study shows that chloroform extract of *Clerodendrum phlomidis* exhibits significant anti-inflammatory effects in albino rats. Significant anti-inflammatory action was also reported in an aqueous extract of root bark. <sup>45</sup>

### Analgesic activity:

Methanolic and ethyl acetate extract of aerial part of *Clerodendrum phlomidis* showed significant analgesic activity in the hot plate test (200mg/kg), and acetic acid-induced abdominal constriction test (200 mg/kg). The flavonoids act by inhibiting the cyclooxygenase responsible for the synthesis of inflammatory prostaglandins. <sup>46</sup>

### Antiarthritic activity:

The anti-arthritic effect of oral administration of ethanolic extracts of *Clerodendrum phlomidis* on Freund's adjuvant-

induced arthritis has been studied in Wistar albino rats. The swelling of the paws during the secondary lesions was markedly reduced on treatment with ethanolic extracts of *Clerodendrum phlomidis*. The hind limb bone mass was significantly reduced on treatment with ethanolic extract (250 and 500 mg/kg body weight) of *Clerodendrum phlomidis* and standard drug indomethacin (10 mg/kg). <sup>47</sup>

### Antiobesity activity

Methanolic extract of *Clerodendrum phlomidis* showed a strong anti-obesity effect when evaluated by feeding a high-fat diet for 13 weeks to C57Bl/6J female mice.

Various extracts of *C. phlomidis* also possess antihepatotoxic, antifertility, anti-amnesic, anti-asthmatic, antioxidant, hypoglycemic and immuno-modulator activities. <sup>48</sup>

## 4. *Stereospermum suaveolens* (Roxb.) DC

**Biological Source:** *Stereospermum suaveolens* (Roxb) DC belongs to the family Bignoniaceae. <sup>49</sup>

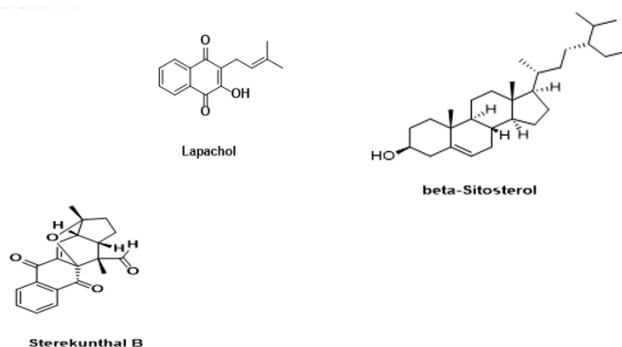
**Geographical Source:** *Stereospermum suaveolens* is found in the subhimalayan tract, central India, outer hills, Bangladesh, Burma, western Peninsula, and the English Forest. <sup>50</sup>

## Morphological Characteristics

It is a large deciduous tree having greyish /dark brown coloured bark. The plant has leaves that are imparipinnate and elliptic. Flowers are purplish-yellow, fragrant, in large lax panicles, straight capsules, cylindrical, greyish with white dots. <sup>52</sup>

## Chemical Constituents

The plant bark contains sterekunthal B, stereochenols A and B, lapachol, dehydro- $\alpha$ -lapachone, apigenin and leaves contain scutellarein, stereolensin, dinatin (4, 5, 7-trihydroxy-6-methoxy-flavone) and dinatin-7 glucuroniside (**Figure 4**). Seeds contain non-drying oil, bitter substances, sterols, glycosides and glycol alkaloids. <sup>53-55</sup>



**Figure 4:** Phytochemical Constituents of *Stereospermum suaveolens* (Roxb.) DC.

## Pharmacological action

### Antihyperglycemic and antioxidant activities

The ethanol extract of *Stereospermum suaveolens* bark was evaluated for its antihyperglycemic in addition to antioxidant effects in streptozotocin (STZ)- induced diabetic rats by acute and subacute models at dose level of 200 and 400 mg/kg body weight, given orally. The ethanol extract of the bark reported a significant reduction in fasting blood glucose levels when compared to the standard drug, oral Glibenclamide (0.5 mg/kg body weight). It also showed a marked antioxidant effect evaluated the serum of rats shows decreased levels of serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase, serum alkaline phosphate, creatinine, bilirubin, urea, total cholesterol, triglycerides, and increased level of total proteins after treatment with ethanolic extracts.<sup>56</sup>

### Anti-inflammatory activity

Ethanol extract of *stereospermum suaveolens* (roxb.) DC bark was evaluated in rats at the dose of 200 and 400 mg/kg body weight using carrageenan, dextran, and histamine-induced hind paw oedema, and cotton pellet induced granuloma formation models. Indomethacin was used as a standard drug at the dose of 10 mg/kg body weight. The extract of the dose level of 400 mg/kg body weight showed maximum inhibition of oedema i.e. 64.6, 53.48 and 50.06 % at the end of 3 h with carrageenan, dextran and histamine-induced rat paw oedema, respectively. The extract (400 mg/kg) exhibited a significant reduction (34.77%) in granuloma weight in the cotton pellet-induced granuloma model.

### Anticancer activity

Lapachol [2-hydroxy-3-(3-methyl-2-butenyl)-1, 4-naphthoquinone] present in the bark of the plant is a vitamin K antagonist with antitumor activity. A single oral administration of a highly toxic dose (80-100 mg/kg) 6h before IV injection of tumour cells promoted metastasis drastically. In vitro treatment of B16 cells with lapachol promoted metastasis primarily by affecting host factors other than T cells and NK cells. On the other hand, serial oral administration of low nontoxic doses of lapachol (5-20 mg/kg) significantly suppressed metastasis by an unknown mechanism which suggests, the possible use of lapacholas anti-metastatic agents.<sup>58</sup>

### Hepatoprotective activity:

Hepatoprotective activity is studied by carbon tetrachloride (CCl<sub>4</sub>) induced liver damage in albino rats by serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT), alkaline phosphate (ALP), total bilirubin, LDL-cholesterol, total thiols, Nitrous oxide (NO), and lipid peroxidation in liver tissue homogenate. The methanol extract of stem bark produced significant hepatoprotection against CCl<sub>4</sub> induced liver damage by decreasing

the activities of serum enzymes, bilirubin and lipid peroxidation.<sup>59</sup>

## 5. *Gmelina Arborea*

**Biological Source:** Gambhari (*Gmelina Arborea* Roxb.) belongs to the family Verbinaceae<sup>60</sup>

**Geographical Source:** It is found throughout greater parts of India, Western Ghats, and from the foot of North-West Himalaya to Chittagong & throughout the Deccan Peninsula.<sup>61</sup> It befalls at altitude 5°- 30° north and latitudes 70° -110° east and altitude range is 50-1300 meters. It is found in the rain forest, dry deciduous forest and occurs from sea level up to 1200 m and rainfall 750-5000 mm.<sup>61,62</sup>

### Morphological Characteristics

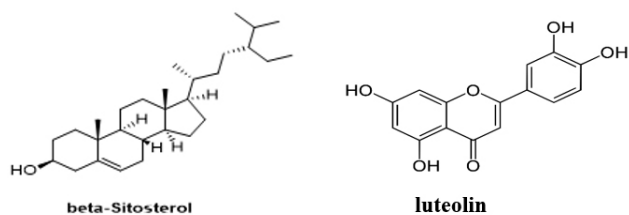
The plant attains a height of about 40 m and 140 cm in breadth<sup>[5]</sup>. The bark is greyish-yellow, rather corky. leaves are around 11-20 cm by 7.0-15 cm, acuminate, entire, glabrous above when mature, broadly ovate, stellately fulvous-tomentose underneath, base cordate, in some cases truncate and at short times cuneate. Petioles are around 4 -8.0 cm long, cylindrical, glandular at top and puberulous. Flowers show up with or sometimes before the young leaves, usually in little cymes of around 3 flowers arranged along the branches of thickly fulvous, hairy panicle around 30cm long. Buds are angular and clavate. Bracts are 8mm long, linear-lanceolate. Calyx 5mm long, broadly campanulate, thickly fulvous-hairy. Corolla brown-yellow, thickly hairy outside almost 3.8cm long, 5 lobed, 2 lipped. The upper lip is more than 1 cm long, profoundly divided into 2 oblong, obtuse lobes. lower lip almost 2.5cm long, 3 lobed, the middle lobe projecting forward, ovate, sub-obtuse, with the irregular crenulate edge, any longer and broader than the obovate rounded lateral lobes. Fruits are drupes 2-2.5cm long ovoid or pyriform or obovoid-elliptical, 1-1.5cm long, green when unripe, orange-yellow or blackish when ready, generally 1 or 2 seeded.<sup>63</sup>

### Chemical Constituents

The bark of *G. Arborea* has been reported to contain flavonoids, saponins, terpenoids and cardiac glycosides.<sup>63</sup>

Roots contain n-octacosanol, gmelinol, cluytylferulate, arboreol, 2-0- methyl arboreal, 2-0-ethylarboreol, isoarboreol, gmelanone, β-sitosterol, paulownin, 6''-bromoisoarboreol, 4- hydroxysesamin, 4,8-dihydroxysesamin, 1,4- dihydroxysesamin (gummadiol), 2-piperonyl-3- (hydroxymethyl)-4 (α-hydroxy-3-,4-methylenedioxybenzyl)-4-hydroxy tetrahydro furan (I), 4-epigummadiol-4-0-glucoside, 1,4-dihydroxy-2,6-dipiperonyl-3,7-dioxabicyclo [3,3,0]- octane, gmelanone, palmitic, oleic and linoleic acids, stigmaterol, stigmastanol, campesterol, α-2-sitosterol, butulinol. Leaves contain luteolin, apigenin, quercetin, hentricontanol, β-sitosterol, quercetogenin and other flavans. Fruits

are reported to contain butyric and tartaric acids, saccharine substances,  $\beta$ - sitosterol, ceryl alcohol, gmelinol, arborone, arboreal, luteolin, apigenin, quercetin, hentriacontanol and quercetogenin.



**Figure 5:** Phytochemical constituents of *Gmelina Arborea*.

## Pharmacological actions

### Antioxidant activity

Methanolic extracts of stem bark of *Gmelina Arborea* Roxb possess potent antioxidant activity using various *in vitro* assay methods which showed free radical scavenging activity by more than 80 % against the standard ascorbic acid.<sup>64</sup>

### Anthelmintic activity

Alcoholic and aqueous leaf extracts of *Gmelina Arborea* Roxb exhibited potent anthelmintic activity in a dose-dependent manner giving the shortest time of paralysis compared to piperazine citrate.<sup>64</sup>

### Anti-microbial activity

The crude leaf and stem bark extracts of *Gmelina Arborea* roxb. showed potent anti microbial activities against gram-positive and gram-negative bacteria. *In vitro* study had shown significant activity against *E. coli*, *K. pneumoniae*, *P. dysenteria* and *S. Typhi*.<sup>64</sup>

### Diuretic activity

*Gmelina Arborea* roxb. the methanolic extract has shown significant diuretic activity on albino rats. Extracts were given at the dose of 250 mg/kg and 500 mg/kg body weight. Sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ) and chloride ( $\text{Cl}^-$ ) output in urine markedly increased as compared to normal saline. The diuretic activity is due to the synergistic action of ( $\text{HCO}_3^-/\text{Cl}^-$ ), ( $\text{HCO}_3^-/\text{H}^+$ ) exchange and the ( $\text{Na}^+/\text{H}^+$ ) antiporter by inhibiting tubular reabsorption of water and accompanying anions to cause diuresis. There was an increase in the ratio of the concentration of excreted sodium and potassium ions after treatment with the methanolic extract.<sup>64</sup>

### Cardioprotective

Ethanollic extract of *Gmelina Arborea* Roxb has shown potential protective effects against doxorubicin (DOX) induced cardiotoxicity by increasing cardiac markers activities in

plasma. It significantly increased the activities of cardiac markers such as SGOT, SGPT and ALP in plasma of DOX (20mg/kg) treated rats might be due to enhanced susceptibility of the myocardial cell membrane to the isoproterenol mediated peroxidation damage resulting in increased release of this diagnostic marker enzyme into the systemic circulation.<sup>65</sup>

### Anti-diabetic activity

Ethanollic extract of *Gmelina Arborea* Roxb bark at the dose of 420 mg/kg and chlorpropamide at the dose of 200 mg/kg was found to reduce the increase of blood sugar in streptozotocin (50mg/kg) induced diabetes due to the increased blood GSH (glutathione) levels reinforcing the role of GSH as free radical scavenging and in the repair of free radical caused biological damage.<sup>66,67</sup>

### Immuno modulatory activity

Methanolic extract of *Gmelina Arborea* Roxb and ethyl acetate fraction of methanolic extract have been found to increase the total WBC count, which was lowered by cyclophosphamide, a cytotoxic drug. The results indicate that the *Gmelina Arborea* Roxb can stimulate bone marrow activity. As the drug is capable of reducing cyclophosphamide-induced toxicity, it can be useful in cancer therapy also.<sup>68</sup>

### Antipyretic and analgesic activity

*Gmelina Arborea* Roxb bark extract was evaluated and the ethanollic and aqueous extract found to reduce the hyperthermia at the rate of 420 mg/kg body weight 1 hrs after the administration and its effect is comparable to that of the standard antipyretic drug paracetamol at the dose of 50 mg/kg body weight whereas chloroform and benzene extract reduces the temperature 3h after their administration but have mild effects. However, the analgesic activity of ethanol and aqueous extract (test compound) was found to be more significant on the acetic acid-induced test than tail-flick test as compared to standard diclofenac sodium at a dose of 25 mg/kg and thus it appears that the test compounds inhibit predominantly the peripheral pain mechanism.<sup>69</sup>

## Brihatpanchmoola as a Fixed-dose Combination

The Brihatpanchmoola species are referred to individually in Charaka Samhita, however, their classification as Dashmoola and further into subgroups: laghu and Brihatpanchmoola were mentioned in Sushrita Samhita for the first time. Brihatpanchmoola species as a fixed-dose combination is used in several Ayurvedic formulations like Chywanprash, Mahanarayan Tail, Dashmoolarishta, Dasmularishta Kwath etc. Although there is no scientific evidence available, it is assumed that the combination is aimed to optimize biological activities.

## DISCUSSION

In the present review, an attempt has been made to describe individually each plant species of Brihatpanchmoola in detail covering their morphological parameters, geographical distribution, chemical constituents and Pharmacological activities. This is perhaps the first such compilation of all the species of Brihatpanchmoola in a single article.

## CONCLUSION

Annual consumption of Brihatpanchmoola species range between 2000-5000 MT per annum in Ayurvedic formulations.<sup>70</sup> As mentioned in Ayurvedic Pharmacopeia of India, the root bark of these 5 tree species is required to be used as Brihatpanchmoola. Due to sustainability issues, over some time, the usage of stem bark came into vogue. Both these practices are associated with high-degree conservation concerns due to the destructive nature of collecting root bark and stem bark. Therefore, there is an immediate necessity to re-examine the species using the most appropriate scientific studies.

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None

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### Contribution of Individual Author

Pasrija Anubhuti: Collection and compilation of all the data and writing of the paper.

Popli Harvinder: Reviewed the paper critically and provided comments.

Mitra Ranjan: Reviewed the paper critically and suggested improvements in the paper.

Chitralkha: Formatting and corrections

Singla Chhavi: Worked on the word count and overall formatting

Dhiman Anju: Final revisions in the paper

Jain Kajal: Formatting and corrections

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