



## PHARMACOGNOSY, PHYTOCHEMISTRY AND PHARMACOLOGICAL PROFILE OF *Saraca Asoka*

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### ABSTRACT

Asoka scientific name is *Saraca asoka* which is a popular ancient plant with aurvedic importance. Since ages asoka is used in traditional medicine and folklore medicine. Natural medicinal systems like Ayurveda and Unani also have emphasized and formulated important formulations and cured ailments related to women. In the present article emphasis is given more to the pharmacognostic, phytochemical and pharmacological aspects of asoka.

### Key words:

Asoka, *Saraca asoka*, *Sita asoka*,

### INTRODUCTION

*Saraca asoka* (Roxb.) wild is also known as *Saraca indica* L. Which belongs to the family Caesalpiniaceae. It is medium sized handsome evergreen tree.<sup>1</sup> The *Saraca asoka* tree has fragrant flowers and leaves with 30-60 cm in length. The bark of *Saraca asoka* is bitter, acrid, refrigerant, astringent. The flowers are in orange - yellow in colour and found in dense corymbs. The 2-3 pairs of lanceolate leaflets are found.<sup>1</sup> It also belongs to the family Fabaceae and used in large quantities in Ayurvedic industry.<sup>2</sup> It is found in the (or) widely distributed in ever green forests of India up to 750m. The fruits are pod and flat, leathery with 4 to 8 ellipsoid oblong in shape and compressed of many seeds.<sup>3</sup> The *Saraca asoka* is a small, evergreen tree found in rain forest throughout the India, especially in the Himalayan region, Kerala and Bengal. It has listed in the vulnerable species which was reported by the International Union for Conservation of Nature (IUCN).<sup>4</sup>

The phytoconstituents of *Saraca asoka* can treat diseases like dyspepsia, thirst, polydipsia, blood disorders, biliousness, weariness, tumours, colic, bloody uterine, ulcers and discharges.<sup>4</sup> The *Saraca asoka* is a medicinal plant, in which the whole part of the tree or plant is used to cure so many diseases. The bark of *Saraca asoka* is an important raw drug for Ashokaristha. The bark of this tree is to provide the astringent activity for halting excessive menstrual bleeding, bleeding hemorrhoids, bleeding ulcers and hemorrhagic dysentery.<sup>5</sup> It also helps to get rid of the

toxins from the body and is effective in purifying the blood naturally and in preventing skin allergies. Seeds are used to treat bone fracture and vesicle calculi. The plant is used in the treatment of dyspepsia, indigestion, blood disorders, tumours etc. There are various indigenous preparations available with Ashoka as a major constituent, of which the important ones include Ashokaristha, Ashokaghrita, Ashoka kwath.<sup>6</sup>

### HISTORY

The *Saraca Asoka* or *Asoka* is the Sanskrit word, that means "Without sorrow". *Asoka* is especially sacred to Hindu god of love, Kamadeva for whom it is worshiped every year on December 27; it is mentioned in Hindu mythology. That the Indian philosopher and founder of Buddhism, Gautama Siddhartha (c.563-483 B.C.) was said to have been born under this tree. In mahakavya, or Indian epic poetry the Ashoka tree mentioned in the Ramayana in reference to the „Ashoka Vatika“, where Hanuman first meets Sita.

In classical Ayurvedic text Ashoka has been mentioned in vedanasthapana mahakasha and Kashayaskandha by aacharya Charaka. Aacharya Sushruta included *Ashoka* in Rodhradigana. As we all know *Ashoka* is the drug of choice in Raktapradara (dysfunctional uterine bleeding) but this action of *Ashoka* was not mentioned in Ayurvedic text like Charaka Samhita, Sushruta Samhita and in Nighantus. Vrundamadhava was the first who described

use of *Ashoka* in Raktapradara . Ashoka is the famous drug for feminine disorders, in spite of these aacharya Sushruta has been mentioned the use of Ashoka in Kalyanaka lawana of Vatvyadhi chikitsa, in Tilvakasarpī , Vran avachhoonan, krushabha agada , Dundubhiswaniya chapter, in eye disorder (specially pitta-kaphaj), in Mahakalyanaka ghruta. Also aacharya Vagbhata has been mentioned the use of *Ashokaghruta* .<sup>7</sup>

There are so many ethnic beliefs associated with *Saraca asoca*. In Hindu culture, it is worshiped every year on December 27 for the God of love, Kamadeva. Ashoka flower was included among kamadeva's quiver of five

flowers. Ashoka flower represents seduction. It is said that Gautama Siddhartha, who is an Indian Philosopher and founder of Buddhism, was born under Ashoka tree. In Hindu culture, Ashoka flowers are used for worshipping Lord Vishnu, and these are also used on the occasion of Durga Ashtami. In Hindu culture, married women eat Ashoka buds on "*Ashoka Shashti day*" to protect their children from negativity, grief, and sorrow. Apart from its ethnic view, Ashoka is a well-known medicinal plant used in traditional medicines like Ayurveda, Siddha, Unani and folk medicine system.<sup>8</sup>

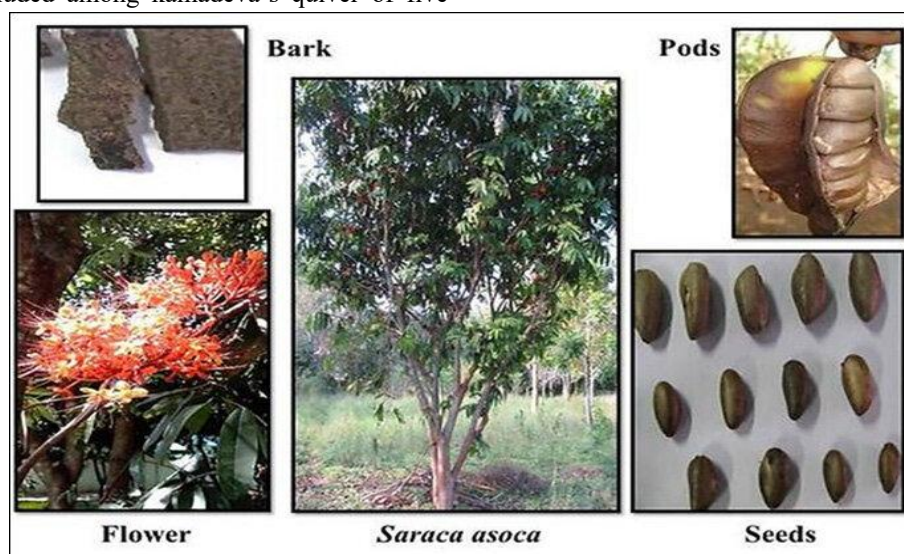


**Fig: 3 Whole Parts of *Saraca Asoka***

#### Vernacular Names

Vernacular names of *Saraca Asoca* is given below in table 1.

| Language                | Vernacular names                                                                                                             |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>Sanskrit</b>         | Kankeli, Asoka; Gandhpushpa, SitaAshoka                                                                                      |
| <b>English</b>          | Asoka tree                                                                                                                   |
| <b>Hindi</b>            | Ashoka, Anganpriya, Vandichitra, Ashokadamara, Sitaashoka, Ashopalava, Asupala, Hempushpa, Pindpushpa, Vishoka and Vichitra. |
| <b>Marathi</b>          | Ashoka, Jasundi                                                                                                              |
| <b>Bengali</b>          | Ashoka, Oshok                                                                                                                |
| <b>Gujrati</b>          | Asupala, Ashopalav                                                                                                           |
| <b>Telugu</b>           | Asok                                                                                                                         |
| <b>Tamil &amp; Mal.</b> | Asogam                                                                                                                       |
| <b>Cannad</b>           | Asokada, Kankelimara                                                                                                         |
| <b>Panjabi</b>          | Ashok                                                                                                                        |
| <b>Assamese</b>         | Ashoka                                                                                                                       |
| <b>Kashmiri</b>         | Ashok                                                                                                                        |
| <b>Malayalam</b>        | Asokam                                                                                                                       |
| <b>Kannada</b>          | Ashanke, Kenkalimara                                                                                                         |
| <b>Urdu</b>             | Ashoka                                                                                                                       |
| <b>Arabic</b>           | Shabuqa                                                                                                                      |

**Table 1: Vernacular names of *Saraca asoka***

**Traditional uses in Ayurveda****Rasa:** Kashaya, tikta**Veerya:** Sheeta**Vipaka:** Katu**Guna:** Laghu, Ruksha

**Karma:** Kaphapittashamaka (alleviates kapha and pitta), varnya (improves complexion of skin), sothaghna (anti-inflammatory), kusthagana (cure skin diseases), rasayan (rejuvenating), stambhana (astringent), shonitsthapana (antihaemorrhages), vrsya (aphrodisiac), artavjannan (improve ovulation), krimighna (antihelmintic), pramehaghna (anti-diabetic).

The earliest records of this tree can be found in ancient Indian Ayurvedic texts. The *Charaka Samhita* (circa 100 A.D.) recommends the plant for the treatment of various gynecological disorders. Similarly, in another renowned treatise, the *Bhavaprakasha Nighantu*, the plant is described as a uterine tonic known for its effectiveness in regulating menstrual disorders.<sup>9</sup> The tradition of tree worship dates back to the Harappan civilization, as evidenced by significant archaeological findings such as terracotta seals and other artifacts. Scholars now suggest that the people of the Indus Valley civilization revered trees, particularly the *āśvattha adhiṣṭhātṛī devatā*. By the time of the *Purāṇas*, this tradition had gained substantial momentum and evolved into a recognized religious practice. The *Purāṇas* extol trees for their multifaceted roles in five types of sacrifices (*Pañcayajña*).<sup>10</sup>

Trees provide shade, food, medicine, and fuel for ritual offerings (*agnihotra*), and serve as nesting places for birds. These diverse benefits led early Indians to actively promote the planting of trees. As a medicinal plant, the usefulness of *āśoka* was first acknowledged in the *Agniveśa Caraka Samhitā*, believed to have been compiled around 1000 B.C. This ancient Ayurvedic text discusses the therapeutic value of *āśoka* across centuries, both before and after the Common Era. While many legends—cultural and scientific—are associated with *āśoka*, its specific application in treating female health issues was not fully recognized until the ninth century A.D. Today, Ayurvedic practitioners continue to use *āśoka* in the treatment of various gynecological disorders, especially those affecting the uterus.

**CLASSIFICATIONS**Scientific Classification of *Saraca asoca*<sup>11,12</sup>**Kingdom:** Plantae**Clade:** Angiosperms**Clade:** Eudicots**Order:** Fabales**Family:** Fabaceae (formerly Caesalpinaceae)**Genus:** *Saraca***Species:** *Saraca asoca* (Roxb.) Willd**PHARMACONGNOSY**

The Pharmacongny is studied by the Macroscopical and Microscopical.<sup>13-15</sup>

**Morphological Characteristics of *Saraca asoca***

**Habit:** A medium-sized, evergreen tree reaching heights of 6–9 meters, characterized by glabrous (smooth and hairless) branches.

**Leaves:** Paripinnate (evenly pinnate) leaves measuring 15–25 cm in length. Each leaf comprises 4–6 pairs of oblong-lanceolate leaflets, each 10–20 cm long and 3–5.7 cm wide. The leaflets are glabrous, with rounded or cuneate bases.

**Stipules:** Intrapetiolar (located between the petiole and stem), completely united, measuring approximately 10–13 mm by 6 mm. They are ovate, oblong, obtuse, and parallel-nerved.

**Bark:** The bark is brown, grey, or nearly black with a warty surface. It is rough and uneven due to the presence of rounded or projecting lenticels. Upon fracture, the bark splits to expose a striated surface with a thin, whitish, continuous layer beneath the cork.

**Flowers:** Fragrant and numerous, the flowers are arranged in dense axillary corymbs measuring 7.5–10 cm across. They exhibit actinomorphic (radially symmetrical) or slightly irregular shapes. The calyx transitions in color from yellow to orange and finally red, with a tube length of 1.3–2 cm. Notably, petals are absent. There are 7 or 8 stamens with filiform filaments thrice as long as the calyx segments; anthers are purple. The ovary is pubescent, especially along the sutures, and the style is curved into a ring.

**Fruit (Pods):** The pods are black, linear-oblong, measuring 10–25 cm in length and 4.5–5 cm in width. They taper at both ends, are compressed, glabrous, and veined. Each pod contains 4–8 ellipsoid-oblong seeds, approximately 3.8 cm long and slightly compressed.

**Pharmacognostical Characteristics of *Saraca asoca*****1. Bark (Transverse Section)**

**Periderm:** Comprises a broad layer of cork with radially flattened cells, a narrow cork cambium, and a wide secondary cortex.

**Stone Cells:** One or two continuous layers present, along with numerous patches of sclereids.

**Parenchyma:** Contains yellow masses and prismatic crystals.

**Secondary Phloem:** Consists of phloem parenchyma, sieve tubes with companion cells, and groups of phloem fibers. Crystal fibers are also observed.

**2. Stem (Transverse Section)**

**Outline:** Circular with small, rounded to oval lenticels on the surface.

**Epidermis:** Single-layered with a thin cuticle.

**Cork:** Composed of 5–6 layers beneath the epidermis.

**Cortex:** 12–16 layers, with 3–5 layers of stone cells in the middle region.

**Phloem:** Distinct, containing tannin cells.

**Cambium:** Clearly visible, 2–3 layers thick.

**Xylem:** Predominantly tracheids with a few vessels; primary xylem is prominent.

**Pith:** Composed of thin-walled parenchyma; many cells contain polygonal calcium oxalate crystals.

**3. Root (Transverse Section)**

**Outline:** Approximately circular.

**Cork:** 8–10 layers of tangentially elongated, thick-walled cells.

**Phellogen:** Not distinctly observed.

**Secondary Cortex:** Two zones—upper zone with 5–7 layers of thin-walled parenchyma (some containing small, rounded starch grains); lower zone with 3–5 layers of mechanical cells (outer layer sclerenchymatous, inner layers stone cells).

**Phloem:** Broad zone of primary and secondary phloem with thin-walled, polygonal parenchyma cells.

**Cambium:** 4–6 layers, prominently visible.

**Secondary Xylem:** Tracheids, vessels, and parenchyma arranged in alternating patches; ray cells filled with starch grains.

**Primary Xylem:** Groups aligned with medullary rays towards the center.

**4. Powder Characteristics**

**Color:** Brown.

**Microscopic Features:** Presence of tracheids, numerous fibers, stone cells, parenchyma cells, sieve tube fragments, and various unidentified cells.

**PHYTOCHEMISTRY**

Phytochemical profile of *saraca asoka* is well established.<sup>31-32</sup> The medicinal properties, traditional uses, and cultivation challenges associated with *Saraca asoca* (Ashoka tree).<sup>16,17</sup>

*Saraca asoca* is renowned for its rich phytochemical profile, which contributes to its therapeutic efficacy. Key compounds identified include:

**Flavonoids:** Notably, (+)-catechin, (+)-epicatechin, and (–)-epigallocatechin, which exhibit strong antioxidant and antimicrobial properties.

**Flavanol Glycosides:** Compounds such as 3'-deoxyepicatechin-3-O-β-D-glucopyranoside and 3'-deoxycatechin-3-O-α-L-rhamnopyranoside have demonstrated significant anti-inflammatory activities.

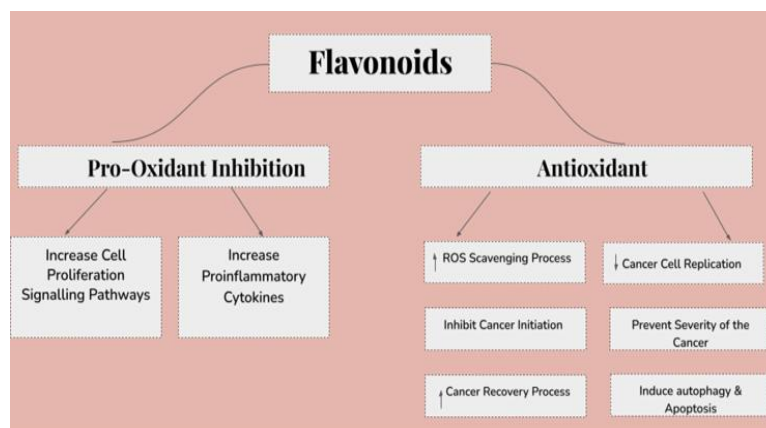
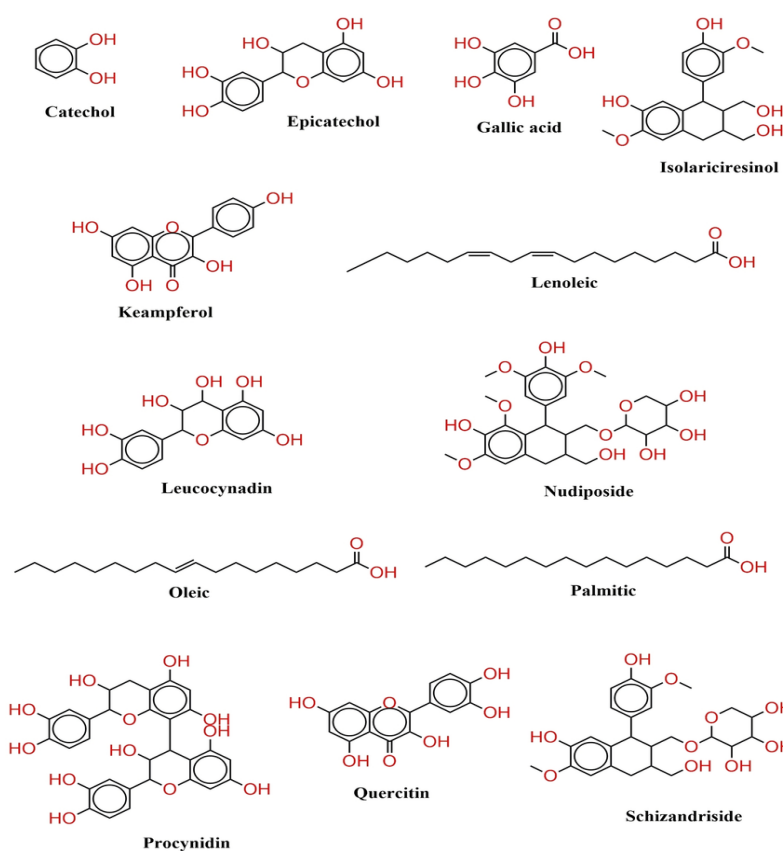
**Phenolic Acids:** Including gallic acid, which contributes to the plant's antioxidant capacity.

**Saponins and Tannins:** These compounds are known for their astringent and antimicrobial effects.

**Other Constituents:** Essential oils and hematoxylin further enhance the plant's medicinal profile

| Plant part | Phytoconstituents                                                                                                                                                                                                                                                                                                                                  |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Flower     | Oleic, linoleic, palmitic and stearic acids sitosterol, quercetin, kaempferol, quercetin, apigenin- 7-0-p-D-glucoside, Pelargonidin- 3, 5- diglucoside, cyanidin-3, 5- diglucoside, palmitic, stearic, linolenic, leucocyanidin and gallic acid. Procyanidin, epicatechin, 11'- deoxyprocyanidin B, catechin, leucopelargonidin and leucocyanidin. |
| Bark       | Glycosides, lyoniside, nudiposide, 5-methoxy- 9- βxylopyranosyl, isolariciresinol, and schizandriside, and three lavonoids, epicatechin, epiafzelechthin-(4β→8)- epicatechin and procyanidin B2, together with βsitosterol glucoside                                                                                                               |
| Dried bark | Oleic, linoleic, palmitic and stearic acids,                                                                                                                                                                                                                                                                                                       |
| Seeds      | catechol, (-) epicatechol and leucocyanidin.                                                                                                                                                                                                                                                                                                       |
| and pods   |                                                                                                                                                                                                                                                                                                                                                    |

**Table 2: Phytoconstituents of *Saraca asoca***

Fig 4: Benefits of flavonoids of *Saraca asoca*Fig 5: Structures of *Saraca asoca*

## PHARMACOLOGY ALONG WITH MEDICINAL VALUE

*Saraca asoca* (Ashoka tree) exhibits a wide array of pharmacological activities, substantiated by various scientific studies.<sup>18-20</sup>

**Antimicrobial Activity:** Extracts from *S. asoca* have demonstrated antibacterial properties against various pathogens, including enteric bacteria. Methanolic extracts of *Saraca asoca* stem bark exhibited strong antimicrobial activity against various bacterial and fungal strains,

including *Staphylococcus aureus* and *Candida albicans*. Phytochemical analysis revealed the presence of compounds like tannins, flavonoids, and saponins, contributing to its antimicrobial properties.<sup>18</sup>

**Anticancer Activity:** Studies have shown that *S. asoca* bark extract exhibits in vitro antioxidant and anti-breast cancer activities without toxicological effects. Ethanol extracts of *Saraca asoca* flowers inhibited lung cancer cell proliferation in vitro, inducing apoptosis in a dose-dependent manner. The IC<sub>50</sub> was observed at 60 µg/ml concentration.<sup>18</sup>

**Analgesic and Anti-inflammatory Activity:** Various extracts of *S. asoca* have demonstrated analgesic properties and the ability to reduce inflammation. The stem bark decoction of *Saraca asoca* showed significant analgesic effects in female Wistar albino rats using the acetic acid-induced writhing method, confirming its traditional use in pain management. Ethanolic extracts of *Saraca asoca* have shown significant anti-inflammatory effects, reducing paw edema in animal models, supporting its traditional use in inflammatory conditions.<sup>18</sup>

**Antipyretic Activity:** Acetone extracts of *S. asoca* seeds have shown significant antipyretic effects in yeast-induced pyrexia models in rats. Acetone extracts of *Saraca asoca* seeds demonstrated significant antipyretic effects in Brewer's yeast-induced pyrexia models in rats, with the 500 mg/kg dose showing effects comparable to aspirin.<sup>18</sup>

**Antioxidant Activity:** The presence of flavonoids and polyphenols in *S. asoca* contributes to its significant antioxidant properties. The presence of polyphenolic compounds such as catechins and flavonoids in *Saraca asoca* contributes to its antioxidant properties, aiding in the reduction of oxidative stress.<sup>19</sup>

**Estrogenic and Uterotrophic Effects:** Ethanolic extracts of *Saraca asoca* flowers exhibited estrogenic activity in ovariectomized rats, improving uterine weight and histoarchitecture, and modulating hormone levels. Phytochemical analysis identified compounds like quercetin and kaempferol contributing to these effects.<sup>19</sup>

**Larvicidal Activity:** Extracts of *S. asoca* have shown effectiveness against larvae of mosquito species, indicating potential as a natural larvicide. *Saraca asoca*, the pet ether extract of the leaf and the chloroform extracts of the bark were effective against the larva of *C. quinquefasciatus* with respective LC<sub>50</sub> value. The Larvicidal bioassay followed the WHO standard protocols for experimental treatment, 1ml of plant extract dissolved in absolute ethanol was added to 99 ml of distilled water in 150 ml disposable wax coated paper cup, which was shaken lightly to ensure a homogeneous test solution.<sup>19</sup>

**Aphrodisiac and Sexual Function Enhancement:** In male Wistar rats, daily oral administration of 100 mg/kg of *Saraca asoca* bark extract over 54 days enhanced sexual behavior without affecting sperm parameters, indicating its potential as a safe aphrodisiac.<sup>19</sup>

**Antimenorrhagic Activity:** Traditionally used to manage excessive menstrual bleeding, *S. asoca* has been documented for its efficacy in treating menorrhagia. An antihemorrhagic is a systemic or local hemostatic agent that works to prevent or control bleeding. Systemic antihemorrhagics, particularly antifibrinolytic agents, inhibit the breakdown of fibrin clots by blocking the

activity of plasmin, thereby stabilizing clots and reducing bleeding.<sup>20</sup>

**Anthelmintic Activity:** Methanolic extracts of *S. asoca* leaves have been reported to paralyze and kill the adult Indian earthworm, indicating potential anthelmintic properties. Anthelmintic activity refers to the ability of a substance to eliminate parasitic worms (helminths) from the body, either by killing them or expelling them through paralysis or disruption of their metabolism. Anthelmintic drugs are designed to target the worms selectively, minimizing harm to the host organism.<sup>20</sup>

**Antitumor Activity:** The bark extract has been studied for its chemopreventive effects against two-stage skin cancer in vivo. Antitumor activity refers to the capacity of a substance, compound, or treatment to inhibit the growth, proliferation, or survival of tumor cells. It indicates the potential to prevent, suppress, or destroy cancerous growths, making it a critical property in cancer therapy.<sup>20</sup>

**Neuroprotective Activity:** Methanolic extracts of *Saraca asoca* bark have demonstrated significant neuroprotective effects against doxorubicin-induced neurotoxicity in rats. The extract improved episodic memory and reduced oxidative stress markers in the hippocampus and frontal cortex. Neuroprotective activity refers to the capacity of a substance or treatment to safeguard neurons from injury, dysfunction, or degeneration. By preserving or restoring the structure and function of nerve cells, neuroprotective agents aim to slow, halt, or potentially reverse the progression of neurodegenerative disorders and other neurological conditions.<sup>20</sup>

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## MISCELLANEOUS

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### Toxicity

*Saraca asoca* (Ashoka tree) is widely recognized in traditional medicine for its therapeutic benefits. However, scientific studies have explored its safety profile to identify potential toxic reactions.

#### Acute and Subacute Toxicity Studies

**Acute Toxicity:** In studies adhering to OECD guidelines, a single oral dose of 2000 mg/kg of aqueous bark extract administered to female rats showed no mortality. However, some behavioral changes were observed.

**Subacute Toxicity:** Rats given daily doses of 250, 500, and 1000 mg/kg over 28 days exhibited no significant changes in body weight, temperature, food and water intake, or urine parameters. Nonetheless, higher doses led to notable alterations in hematological and serum biochemical parameters, as well as variations in the relative weights of the liver, spleen, and kidneys.<sup>21</sup>

#### Observations from Seed Extract Studies

An investigation into the acetone extract of *Saraca asoca* seeds involved administering doses ranging from 100 to 1000 mg/kg to mice. No mortality was observed over a 14-day period. However, at higher doses, some animals exhibited symptoms such as muscle spasms, tremors, and behavioral changes.<sup>22</sup>

#### Human Considerations and Precautions

**Dosage Sensitivity:** While *Saraca asoca* is generally safe when used appropriately, excessive intake may lead to digestive discomfort, including constipation, abdominal heaviness, and nausea, especially in individuals with gastrointestinal sensitivities.

**Cardiac Concerns:** Due to its cardiotonic properties, individuals with heart conditions should consult healthcare professionals before using *Saraca asoca* preparations.

**Pregnancy and Lactation:** There is insufficient data on the safety of *Saraca asoca* during pregnancy and breastfeeding. Therefore, its use is not recommended for

pregnant or lactating women without medical supervision.<sup>23</sup>

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### MARKET VALUE

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The market value of *Saraca asoca* (Ashoka tree) varies based on its form such as bark, powder, or live plants and the quantity purchased. Here's an overview of current pricing in India.

#### Ashoka Bark (*Saraca asoca*) Pricing

##### Market Insights

**Demand Factors:** The demand for *Saraca asoca* is driven by its applications in traditional medicine, especially for women's health.

**Supply Challenges:** Overharvesting and slow growth rates have led to concerns about sustainability, potentially impacting future availability and pricing.

If you're interested in sourcing *Saraca asoca* for personal use or commercial purposes, it's advisable to consider certified suppliers to ensure quality and sustainability.<sup>27</sup>

## SUMMARY TABLE

The Summary Table of *Saraca asoca* is given in table 3<sup>28-30</sup>

| S.No | Plant part | Activity          | Extract                  | Model                               | Standard Drug                                         | Dose           | Parameters                                                                                              | Mechanism                | Stats p value      | Author year                                |
|------|------------|-------------------|--------------------------|-------------------------------------|-------------------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------|--------------------------|--------------------|--------------------------------------------|
| 1    | Bark       | Antidepressant    | Soxhlet Extraction       | Forced Swim Test                    | Nitrofurazone                                         | 15 mg/kg       | Inhibits bacterial enzymes involved in DNA, RNA, and protein synthesis                                  | Cytokine inhibition      | p < 0.001          | Meghna Gill 2018 <sup>{28}</sup>           |
| 2    | Bark       | Antioxidant       | Aqueous Extraction       | DPPH Assay                          | <b>Ethinyl estradiol</b> or <b>Estradiol valerate</b> | 100 mg/kg      | Binds to estrogen receptors (ER $\alpha$ , ER $\beta$ ), modulates gene expression                      | Free radical scavenging  | p < 0.001          | Manas Kinra 2018 <sup>{28}</sup>           |
| 3    | Flower     | Anticancer        | Maceration               | In vitro assays                     | Estradiol valerate                                    | 400 mg/kg      | Prodrug $\rightarrow$ hydrolyzed to 17 $\beta$ -estradiol                                               | Tumor suppression        | p < 0.001          | Mohan Ch 2016 <sup>{29}</sup>              |
| 4    | Flower     | Antioxidant       | Phytochemicals Extracted | In vitro assays                     | Vitamin E or Ascorbic acid                            | 250 mg/kg      | Antioxidant; cofactor for collagen synthesis, immune support, and iron absorption                       | Flavonoid neutralization | <b>p &lt; 0.05</b> | Kistamma S. 2016 <sup>{29}</sup>           |
| 5    | Leaves     | Antibacterial     | Soxhlet Extraction       | Disk Diffusion Method               | Methicillin or Ciprofloxacin                          | 100 $\mu$ g/mL | Inhibits bacterial cell wall synthesis by binding penicillin-binding proteins                           | Transcription blocker    | P = 0.028          | Chandrakant P. Rathod 2021 <sup>{30}</sup> |
| 6    | Leaves     | Antioxidant       | Maceration               | DPPH Assay                          | Amoxicillin-clavulanic acid                           | 50 $\mu$ g/mL  | Amoxicillin inhibits bacterial cell wall synthesis; clavulanic acid inhibits $\beta$ -lactamase enzymes | <i>Catechin action</i>   | <b>P= 0.35</b>     | Mahavir H.Ghante 2021 <sup>{30}</sup>      |
| 7    | Seeds      | Antipyretic       | Acetone Extraction       | Brewer's Yeast-Induced Pyrexia      | <b>Paracetamol</b> or <b>Aspirin</b>                  | 500 mg/kg      | Irreversible COX inhibition                                                                             | Prostaglandin inhibition | P = 0.011          | Mohan Ch 2016 <sup>{29}</sup>              |
| 8    | Seeds      | Anti-inflammatory | Methanol Extraction      | Freund's Adjuvant-Induced Arthritis | Diclofenac                                            | 1000 mg/kg     | <b>Non-selective COX inhibition</b> $\rightarrow$ reduces prostaglandins                                | IL-2 induction           | <b>P= 0.05</b>     | Laxminarain Misra 2016 <sup>{16}</sup>     |

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