



***Boswellia serrata* Roxb. Ex Coleb.: A Threatened Tree**

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Authors' contributions

This work was carried out in collaboration between both authors. Author KCSW managed the conceptualization and wrote the manuscript. Author SM managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Boswellia serrata Roxb. ex Coleb. is commonly known as Indian Olibanum or Indian Frankincense tree. It belongs to the family Burseraceae. The tree is confined to Tropical Dry Deciduous Forest of India. It grows at altitudes up to 1,150 m in regions with annual temperatures between 0-45°C and annual rainfall between 500-2,000 mm. *B. serrata* has been listed in the threatened species of India. The principal threats of this species are slow growth coupled with poor regeneration. However, the population trends and habitat trends are stable. Due to its exudations of volatile oil, resin and gum, the tree has attained commercial significance. The oil obtained from this tree is very similar to turpentine oil and found suitable for paint making, varnish and used as printing ink in textile industries and in making distempers. It is a unique non coniferous source of turpentine employed for the manufacture of paints and varnishes. The resin obtained from this tree is used for preparation of varnishes. The tree exudes of *B. serrata* resembles Canada balsam in colour and consistency. It is mainly used for medicinal purposes and incense. A detailed review covering its taxonomy and nomenclature, distribution in India, reproductive biology, wood properties, processing and harvesting, genetic resources available, reasons for its deterioration, and its uses is presented in this article.

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Keywords: *Boswellia serrata*; wood properties; genetic resources; threatened species.

1. INTRODUCTION

1.1 Taxonomy and Nomenclature

Boswellia serrata Roxb. ex Coleb. commonly known as Indian Olibanum or Indian Frankincense Tree belongs to the family Burseraceae has a chromosome number of $2n=44$ [1]. The vernacular names are Shallaki, Salai (Hindi), Kungilyam (Malayalam) and Parangisambrani (Tamil). The word Olibanum is derived from the Arabic 'al-luban' and it means 'the milk' [2].

Table 1. Taxonomy and nomenclature of *Boswellia serrata*

Kingdom	Plantae
Sub kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Sapindales
Family	Burseraceae
Genus	<i>Boswellia</i>
Species	<i>Boswellia serrata</i> Roxb. ex Coleb

1.2 Botanical Descriptions

Boswellia serrata is a deciduous tree. It grows up to height of 20m. The bark is yellowish-white with dark blotches. Its exfoliations are thin, papery and in smooth flakes. The leaves are imparipinnate, arranged in an alternating manner and apically clustered. The leaflets can vary from 15 to 31cm. The flowers of the tree are bisexual, small and white. The flowers are arranged in axillary or sub terminal fascicled racemes with five to seven lobes and petals [3]. Flowers appear from the end of January to March and the fruit ripen in May-June [4]. The species is self-incompatible and cross-pollinated flowers allows normal pollen germination [5].

1.3 Distribution and Environmental Conditions

Distribution is in Tropical Dry Deciduous Forest of India. The tree is found in dry, rocky ridges and slopes, as well as flat terrain. It grows at altitudes up to 1,150 m in regions with annual temperatures between 0-45°C and annual rainfall between 500-2,000 mm [6]. Occurrence of *B.*

serrata has been reported in the natural forests of following states namely, Andhra Pradesh, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal [7,8]. In addition, the species has been planted as part of Trees Outside Forests programme in the states of Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Nagaland, Odisha and Rajasthan [7].

B. serrata is widely distributed in 17 out of the 28 states of which India is composed, and climatic suitability for the species prevails in ca. 22% of the overall Indian territory. Detailed population assessments have been made in seven states. The total species count in these seven states is estimated at 44 million individuals [9].

1.4 Distribution in Kerala

- Palakkad Division: Dhoni and Sappal Catchment, Parapetty Catchment Olavakkode Range [10].
- Idukki District [11,12].
- 250 mature individuals in the dry deciduous track of Chinnar Wildlife Sanctuary of Munnar Wildlife Division

1.5 Distribution in Tamil Nadu

- Coimbatore, Dharmapuri, Dindigul, Salem, Tiruchchirappalli, Tiruvannamalai, Viluppuram [11].
- Dindigul [12].
- Nilgiris South Division [13].

[14] reported that *B. serrata* is able to grow in approximately 21.95% of the geographical area in India. Substantial distribution of this species is found in the states of Madhya Pradesh, Uttar Pradesh, Karnataka, Rajasthan, Maharashtra, Haryana, Chhattisgarh, and Jharkhand. It is also adapted to the states of Uttarakhnad, Gujarat, Tamil Nadu, Himachal Pradesh, Bihar, Punjab, Andhra Pradesh, Jammu & Kashmir, and Kerala. This prediction is based on MaxEnt model (MaxEnt software ver. 3.4.1). However, it is predicted that substantial area in peninsular India is expected to lose climatic suitability by 2050. It is suggested that prioritization may be undertaken for long term conservation strategies for this species to retain climatic suitability.

Table 2. State wise estimated number of stems of *Boswellia serrata* in Forest at Country level (in '000') [7]

State	Diameter Class (cm)			Total
	10-30	30-60	60+	
Andhra Pradesh	5179.966	1249.114	0.000	6429.079
Bihar	2135.314	318.985	0.000	2454.299
Chhattisgarh	7402.115	12659.830	694.038	20755.983
Goa	20.134	0.000	0.000	20.134
Gujarat	2182.300	188.058	0.000	2370.358
Haryana	97.402	0.000	0.000	97.402
Jharkhand	5463.006	695.735	82.271	6241.012
Karnataka	169.378	169.378	0.000	338.755
Madhya Pradesh	9947.954	12527.338	295.321	22770.613
Maharashtra	9370.200	7029.736	0.000	16399.935
Meghalaya	179.047	0.000	0.000	179.047
Odisha	2787.052	2068.289	0.000	4855.341
Rajasthan	7288.921	2772.845	0.000	10061.767
Tamil Nadu	792.471	426.715	0.000	1219.186
Telangana	3125.509	4475.791	71.012	7672.311
Uttar Pradesh	640.679	439.315	0.000	1079.994

Table 3. State wise estimated number of stems of *Boswellia serrata* in TOF at Country level (in '000') [7]

State	Diameter Class(cm)			Total
	10-30	30-60	60+	
Bihar	0.000	6.958	0.000	6.958
Chhattisgarh	29.074	11.879	0.000	40.953
Gujarat	56.070	0.000	0.000	56.070
Jharkhand	91.758	33.887	0.000	125.645
Karnataka	0.139	6.291	0.000	6.430
Madhya Pradesh	46.002	15.004	0.000	61.006
Maharashtra	32.888	0.000	0.000	32.888
Nagaland	0.000	37.184	0.000	37.184
Odisha	97.027	32.129	0.000	129.156
Rajasthan	317.930	10.684	0.000	328.614

Table 4. Estimated number of stems and diameter class in the forest areas in India. (in '000') [7]

Diameter Class(cm)			Total	Percentage
10-30	30-60	60+		
56,781	45,021	1,143	1,02,945	0.75

Table 5. Estimated volume and diameter class in forest areas in India. (in million cum) [7]

Diameter Class(cm)			Total	Percentage
10-30	30-60	60+		
11.05	41.93	3.65	56.63	1.33

1.6 Reproductive Biology and Breeding System

Boswellia regenerates naturally from the seeds. The tree is a dioecious species. These trees are self-incompatible and thus depends on

outcrossing. The rate of natural regeneration of *B. serrata* is too slow. Older trees can be propagated through root suckers. However, the root sucker propagation methods have not been standardized commercially. Viable seeds are produced very little and fruit setting is also poor

(2.6 to 10 %). Seed germination is scanty (10–20 %). All these factors contribute towards the natural sources being scanty [15]. Conventional method of propagation of *Boswellia serrata* is by stem and root cuttings. These methods are season dependent and time consuming [16]. [17] reported that cotyledonary node segments could be used for micropropagation.

1.7 Seed Production

The fruits of *B. serrata* are 1.3 cm long, trigonous, with three valves and three heart-shaped, 1-seeded pyrenes, winged, along the margins. Reported weights for seed range from 13,400-25,600 seeds per kilogram. Seeds are collected manually by hand picking. Seeds cannot be stored more than 6 to 9 months. They can be stored in dry tins. [18].

1.8 Threatened Status

Boswellia serrata has been listed in the threatened species of India [19]. Major threats are slow growth coupled with poor regeneration. However, stable trends have been reported in its population habitat [20]. Indiscriminate exploitation for its high economic value, the tree has been identified by the government of India for its genetic improvement. There are several constraints in the cultivation of *Boswellia serrata* under natural conditions. Seed viability is very poor and germination percentage is very low (10-12%). The seeds require high humid conditions for germination. In India, changing climate, and soil conditions, dwindling habitats, degradation of forests and over-exploitation, are major threats faced. Over-tapping to meet the international demand has been reported [9].

1.9 Reasons for Deterioration

Reduction in the distribution range of *B. Serrata* has been reported during intensive population assessments. Changes in the natural regeneration of this species are due to over-exploitation for traditional medicines, shrinking habitats, forest degradation, climate change, changes in soil properties and grazing of saplings by wild animals like boar [14].

1.10 Wood Properties

B. serrata is also a timber yielding tree. The sapwood is soft and moderately value [16]. The species could be used for making paper pulp due

to its suitable fiber length and fiber wall thickness. Mechanical strength of the wood is also good. The wood fiber length of the species ranged between 0.803 mm to 1.397 mm with average of 0.968 ± 0.11 mm and the wood fiber width of the species ranged between 0.019 mm to 0.030 mm with average of 0.025 ± 0.002 mm [21]. For national consumption and international trade, the total demand for *B. serrata* is estimated at 745 tonnes per annum. It is mainly used in Ayurvedic industries. The annual exports have been estimated at approximately 90 tonnes [20].

1.11 Genetic Resources and Tree Improvement

Seed Production Areas of this tree species is being maintained by the research wing of Maharashtra Forest Department. For seed collection a seed stand of 5 Ha has been established at Palaskheda (Jalgaon) having 173 trees by the forest department. The territorial wing receives the seeds for raising plantations. The forest department of Maharashtra is also entrusted with raising of its saplings on a regular basis. Collaborative research are being conducted with Tropical Forest Research Institute, Jabalpur for sustainable harvesting of gum. 147 occurrences of this tree have been recorded from various regions of India [14].

1.12 Economic Importance

Boswellia serrata is valued for its volatile oil, resin and gum. The oil obtained from salai is very similar to turpentine oil. The oil has been found suitable for paint making, varnish and used as printing ink in textile industries and in making distempers. It is a unique non coniferous source of turpentine employed for the manufacture of paints and varnishes. The resin obtained from salai is used for preparation of varnishes. The tree exudes of *B. serrata* resembles Canada balsam in colour and consistency.

2. USES OF *B. serrata* IN INDIA

2.1 Medicinal Uses

In Ayurveda, the gum is being used for treating inflammatory diseases affecting skin, eye, gums and gastrointestinal tract. It is also effective in the treatment of respiratory and inflammatory disorders [22]. *B. serrata* bark is used for the treatment of dysentery, diarrhoea and fractured

Table 6. Uses of plant parts or products [20]

Plant part or plant product	Uses
Bark	Cordage
Boswellic acids	Used for pharmaceutical therapeutic applications. <i>B. serrata</i> extract for the export market is being produced by Indian herbal extraction companies mainly for the countries like Japan, Singapore, UAE and USA
Exudate, Oleogum resin	The tree is the only non- coniferous source of turpentine and resin in India. It is being used by the traditional Ayurvedic and Unani medicinal formulations for treatment of asthma, arthritis and for the treatment of renal disorders
Extracted gum	Binding agent in tablets.
Fodder	Fodder relished by buffaloes.
Green leaf twigs	Used as fodder in the Sariska tiger Reserve.
Tree	Utilized as a lac host in West Bengal. Also used for making charcoal suited for iron smelting.
Wood	Mixed with bamboo (25-40%) the wood is used for making paper pulp. The wood is also suitable for making furniture, packing cases, matches, veneers and plywood.

bones. The resin has application in curing diseases like haemorrhage, pulmonary infections cough, dyspnoea, cardiac diseases, polyuria, leucorrhoea, boils and wounds, skin diseases, urinary disorders, urethritis, piles, ulcers, diabetes and dysentery [23].

2.2 Olibanum

Tapping in the bark of *Boswellia* trees yields a natural oleo gum resin called Olibanum. A complex mixture composed of about 5-9% highly aromatic essential oil, 65- 85% alcohol- soluble resins and the remaining water-soluble gums yields frankincense [16].

3. HARVESTING / COLLECTION OF GUM RESIN

3.1 Method of Harvesting/Tapping

Gum resin is obtained by tapping of trees of 90 cm girth and above at 1.37m from the ground level. It is not advisable to tap from the trees of lower girth classes. This may adversely affect their growth. From the trunk of a tree, a thin band of bark of about 30 cm in length and 20 cm wide is shaved at a reasonable height from the ground thereby exposing the reddish phloem. Every fourth or fifth day the blaze is freshened. After

two weeks the first collection of the gum-resin starts. A scraper is used for collection keeping a tray having a semicircular edge around the blazed surface. The blaze is freshened from time to time thereby widening the original blaze [20].

3.2 Period of Harvesting

Boswellia trees are tapped and used for collection of gum generally from the month of November. It is usually continued up to end of May. By the onset of monsoon the tapping is stopped. The gum is usually collected after a month of blazing. Fortnightly freshening of the blazes and collection may be done subsequently [24].

3.3 Yield

Approximately 1 kg of *Boswellia* gum is collected per tree and a tree may yield up to 2 to 2.5 kg of resin in a year. According to season, locality and size of the tree the yield of the gum may vary. Larger trees yield better yield. In wet or moist areas, the yield has generally been found to be poor. Older trees with black bark or dwarfed and suppressed trees yield less. Better yields have been noticed from middle aged, sound and vigorous trees [24].

4. PROCESSING AND VALUE ADDITION

The gum-resin of *Boswellia* is collected in a semi-solid state. The bark and other impurities are removed manually after collection. The crude gum-resin is collected in a bamboo basket for up to a month. The fluid portion locally known as 'ras', flows out during this period. The 'ras' is being used as a raw material for manufacturing paints and varnishes. The semi-solid to solid part remaining is the gum resin. This is dried thoroughly and treated with soapstone powders often to make it brittle. Wooden mallet or chopper is used to break it into small pieces. Bark and other impurities are again removed manually during this process. Based on the colour and impurities, the gum-resin is then graded. Four grades are categorized in the market as follows [24].

Table 7. Different grades of *Boswellia serrata* gum-resin

Grade	Colour	Appearance
Superfine	Light yellow	Translucent
Quality-I	Brownish yellow	Translucent
Quality-II	Brown	Semi-translucent
Quality-III	Dark brown	Opaque

4.1 Active Constituents

Essential oils, gum, and terpenoids are contained in the gum oleoresin. The active constituent of *Boswellia serrata* is boswellic acid which is present in the terpenoid portion [12].

4.2 Properties of Gum

Depending on the season of collection and the impurities present, the colour of *Boswellia* gum varies from transparent golden brown to dark brown or dark greenish brown. The content of the gum is as follows:

Moisture	10-11 %
Volatile essential oil	8-10 %
Resin	45-50 %
Gum	30-35 %
Insoluble matters	4-5 %

One of the principal constituents of the gum-resin is Boswellic acid. It has shown anti-inflammatory atherosclerotic and anti-arthritis activities. Most of the organic solvents dissolves it. Its softening point varies from 65-72°C and melting point from 73-78°C. The resin burns readily and diffuses a

pleasant aroma. The resin portion has the following properties:

Specific gravity	0.91
Acid value	1.87
Saponification value	65.00
Ester value	63.14
Iodine value	Around 200

Pentose with a high proportion arabinose is contained in the gum [12].

5. INDUSTRIAL APPLICATIONS

Because of its unique fragrance, *Boswellia* gum resin is traditionally used as incense.

It is extensively used in Ayurvedic medicines for treating asthma and arthritis. *Boswellia* gum has been reported to be better than drugs like Phenylbutazone. It also finds a place in various indigenous medicine especially for the treatment of rheumatism, nervous diseases and as diaphoretic and astringent. Certain ointments contain its formulations. *Boswellia* gum also has a usage for lighting fires.

6. CONCLUSIONS

Since time immemorial, *Boswellia serrata* resin has been used as incense in cultural and religious ceremonies. Its medicinal properties are also highly valued. It is used in indigenous medicines and Ayurvedic formulations. In India, *B. serrata* has been listed in the threatened species list. The major threats to its survival are slow growth and poor regeneration. However, the population trends and habitat trends are stable. The available literature warrants a thorough study of this species as gaps still exist between the scientific data published and knowledge of the traditional uses of the resin.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ram H, Sharma SK, Kumar A, Rao SR. Male meiotic studies in some accessions of *Boswellia serrata* (Roxb.) Ex. from the Aravali Region of Rajasthan, India. The Japan Mendel Society. 2014;79(1): 41-47.

2. Sultana A, Rahman KU, Padmaja AR, Rahman SU. *Boswellia serrata* Roxb. A traditional herb with versatile Pharmacological activity: a review. International Journal of Pharmaceutical Sciences and Research. 2013;4(6):2106-2117.
3. Al-Harrasi A, Khan AL, Asaf S, Al-Rawahi A. Biology of genus *Boswellia*. Springer Nature. 2019;25.
4. Troup RS. The silviculture of Indian trees. Oxford University Press. 1921; 1:174-176.
5. Sunnichan VG, Ram MHY, Shivanna KR. Reproductive biology of *Boswellia serrata*, the source of salai guggul, an important gum-resin. Botanical Journal of the Linnean Society. 2015;147: 73–82.
6. Brendler T, Brinckmann JA, Schippmann U. Sustainable supply, a foundation for natural product development: the case of Indian frankincense (*Boswellia serrata* Roxb. ex Colebr.), Journal of Ethnopharmacology. 2018; 225:279-286.
7. India State of Forest Report. Forest survey of India, Ministry of Environment, Forest & Climate Change, Government of India. 2019; 1:179-180.
8. Cutcheon AM. Adulteration of *Boswellia serrata*. Austin, TX: Botanical adulterants prevention program. Botanical Adulterants Bulletin. 2018;1-7.
9. CITES. Trade in *Boswellia* spp, Convention on international trade in endangered species of wild fauna and flora. 2019;15.
10. Bonaventure BAM, Singh L, Sinha VK. Working plan for Palakkad Forest Division (2009-10 to 2018-19) volume-I, Forests and Wildlife Department, Government of Kerala. 2009;331.
11. India Biodiversity portal; 2020. Available:<https://indiabiodiversity.org/species/show/31115> Accessed on 03.08.2022.
12. Indian Medicinal Plant Database; 2020. Available:<http://www.medicinalplants.in/distributionmaps> Accessed on 03.08.2022.
13. Rampati, Varadharajulu S, Harikrishnan M. Working plan for Nilgiris South Forest Division, (1996-2006), Working plan Division, Government of Tamil Nadu. Part-III. 1996;65.
14. Rajpoot R, Adhikari D, Verma S, Saikia P, Kumar A, Grant KR, Dayanandan A, Khare PK, Khan ML. Climate models predict a divergent future for the medicinal tree *Boswellia serrata* Roxb. in India. Global Ecology and Conservation. 2020;23:1040.
15. Nikam TD, Ghorpade RP, Nitnaware KM, Ahire ML, Lokhande VH, Chopra A. Micropropagation and non-steroidal anti-inflammatory and anti-arthritic agent boswellic acid production in callus cultures of *Boswellia serrata* Roxb. *Physiol Mol Biol Plants*. 2013;19(1):105–116.
16. Manjula P. Micropropagation phytochemical analysis and molecular characterization of *Boswellia Serrata* Roxb and *Boswellia ovalifoliolata* Bal and Henry. PhD thesis, Department of Botany, Osmania University. 2015;13-15.
17. Purohit SD, Tak K, Kukda G. *In vitro* propagation of *Boswellia serrata* Roxb. *Biol Plant*. 1995; 37:335–340.
18. Maharashtra Forest Department. Prioritised plants brochure *Boswellia serrata* Roxb. (Salai); 2020. Available: <https://mahaforest.gov.in/fckimagefile/Salai-%20Boswellia%20serrata.pdf> accessed on 01/12/2022
19. Barik SK, Tiwari ON, Adhikari D, Singh PP, Tiwary R, Barua S. Geographic distribution pattern of threatened plants of India and steps taken for their conservation. *Current Science*. 2018; 114(3):470-503.
20. CITES. Response of India to the questionnaire on *Boswellia* trees. Convention on international trade in endangered species of wild fauna and flora. 2020;18.
21. Vaishnav V, Mahesh S, Kumar P. Assessment of genetic structure of the endangered forest species *Boswellia serrata* population in central India. *Journal of Tropical Forest Science*. 2019; 31(2): 200–210.
22. Iram F, Khan SA, Husain A. Phytochemistry and potential therapeutic actions of Boswellic acids: A mini review. *Asian Pacific Journal of Tropical Biomedicine*. 2017;1–11.
23. Reddy GVR, Rao DM. Phytomorphological and medicinal properties of *Boswellia ovalifoliolata* Bal. & Benry and *boswellia serrata* Roxb. ex Colebr. *Research*

Journal of Life Sciences, Bioinformatics,
Pharmaceutical and Chemical Sciences.
2019;5(5):65.
24. Vikaspedia; 2020.

Available:<https://vikaspedia.in/agriculture/post-harvest-technologies/natural-resins-and-gums-of-commercial-importance/salai>
Accessed on 03.08.2022.

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