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An Overview on "*Boswellia serrata*"

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Abstract

"*Boswellia serrata*" is a herb used for ages in the Indian system of medicine and other systems of medicines across the world. It comes under the family "Burseraceae". The *Boswellia serrata* is called by various local names in different regions, out of which "Kundur" "salai" "guggul" "Shallaki" are very prominently used. "Shallaki" is a widely used active ingredient in the "Unani" "Siddha" and "Ayurvedic" medicines oriented for the treatment of inflammation and pain. It is also used as a component to add fragrance to the products. *Boswellia serrata* plant contains oleo-gum resins and the ASU drug manufacturer mostly use this resin to prepare Boswellia-oriented drugs and this practice of using resin as the key component of drugs is very old and effective. In ancient ayurvedic texts, particular methods describe the extraction, purification, and usage of this oleo gum resin. Now in the modern era, when a lot of research has been done on this plant and its parts, this plant has come out to be even more important as it is found to be showing specific characteristics beneficial for treating illnesses such as dysentery, urinary tract disorders, hemorrhoids, ulcers, and dyspepsia. The present review provides an overview of some pharmacological activities and the importance of "Salaiguggal" or "*Boswellia serrata*". "Salai guggal" is rich in essential oils, and therefore, it becomes important for the perfume industries as its essential oils are soothing to smell and show therapeutic effects. The essential oils of *Boswellia serrata* are a mixture of different boswellic acids such as "mono-terpenes", "di-tepenes" and "sesqui-terpenes". Whereas the oleo gum resin of " *Boswellia serrata* " comprises monosaccharides such as pentose and hexose sugars. The oleo gum resin of this plant is highly recommended by almost every medical practitioner who deals in herbal medicines as it has shown a huge range of effective characteristics in asthma, cancer, microbial/fungal infections, inflammation, arthritis, diarrhea, and also as an analgesic. A proper systematic literature review was done using different databases that were available online like Google Scholar, PubMed, and ScienceDirect.

Keywords: *Boswellia serrata,* Shallaki, Salai guggul, Guggul, Anti-inflammation

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Introduction

Ayurveda is one of the world's most seasoned therapeutic frameworks. It started in India and has developed there over many years.[1-2] The word "Ayurveda" is made out of two Sanskrit terms, "Ayus" means life and "Veda" means the knowledge, and taken together, it implies the "study of life" or "the study of the drug" or "Intelligence of life", Ayush implies the conjunction of body, psyche, organs, sense, and self is known by the equivalent words dhari, jivita, nityaga and anubandha. Ayurveda is arrangements with great, terrible, glad, and despondent life, which means good, bad, happy, and unhappy. The target of Ayurveda is to secure the strength of sound individuals and to lighten issues in the ailing person. Ayurveda is a medicinal science as well as it is a study of life. It is additionally called holistic science as every one of the parts of life, mind, body, soul, and sense organs.[3] The birth place of Ayurveda as an oral convention is taken to be 6000 BC. The term Vedic period applies to that period of Aryan human advancement during which the four Vedas were created. They are: - Rig Veda, Sam Veda, Yajur Veda, Atharva Veda. Learning of Vedic drugs is chiefly obtained from two Vedas the Rig Veda and the Atharva Veda.[2,4]

"*Boswellia serrata*" is commonly known as "Salai guggal" "Shallaki" "guggul" and "kundur" is a medium height plant of about 6m-8m and has a circumference ranging from 1.2 to 3 m. It belongs to the "Burseraceae" family. This plant is found is the regions of countries like Saudi Arabia, Oman, and Yemen. When talked particularly about the availability of this plant in India, the Western Himalayas, MP, Gujarat, Orissa, Rajasthan, Bihar, and Maharashtra are the areas where it is widely distributed. The bark of this tree is very thin almost 0.2 mm in width, and can be easily taken off from the trunk or branch when dried. On drying, the bark changes its color where the fresh bark is yellowish-green in color the dried bark changes its color to ash gray color. For the collection of the resin incisions are made on the trunk and branches of the tree. After incisions are made, exudate begins to come out in the form of yellow lumps.[5,6] This yellow-colored compound is the oleo gum resin that is later dried and purified to make it compatible for its use in medicinal formulations. Whereas, in scent industries, the resin is used in raw conditions without purification. This aromatic oleo gum resin smells like vinegar and is bitter when tasted. In, Indian traditional system of medicine, i.e., Ayurveda, the gum resin is used for treating several skin inflammation and gastrointestinal tract inflammations.

Along with this, the medicated smoke of this resin is also helpful in treating certain respiratory disorders such as asthma, bronchitis, and laryngitis and because of this, it has been an integral part of hawan samagri *dhoop* in Hindu traditional rituals since ages.[7] The oleo-gum resin of *B. serrata* has essential oil as its main chemical constituent. Monosaccharides or simple sugars with different digestive enzymes are found

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in the composition of gum. Two types of acids are majorly present in all Boswellia species: boswellic acid (BA) and pentacyclictriterpene acid.[8,9] Boswellic acids have been a hot research topic because of its usefulness and therefore a lot of work has been done. Those researches prove it to be extremely beneficial in managing various chronic inflammatory diseases which include chronic ulcerative colitis, rheumatoid arthritis, and bronchial asthma along with its anti-depressive, anti-anxiety, and beneficial effects in brain tumor patient are complementary.[10]

Historical/Traditional Applications

B. serrata is one of the precious herbs in Ayurveda. It is also identified by the name "Gajabhakshya" in Sanskrit, which means that the *gaj* means the elephants choose this plant as their food over other herbs or plants i.e., they enjoy eating this plant. The three main literary works of classical ayurvedic sciences, Charak Samhita, Sushruta Samhita, and Asthang hridya and Sangraha have described and mentioned this herb several times in detail. Charak Samhita and Sushruta Samhita have described the resin of *B. serrata* as a drug for arthritis or as an anti-rheumatic drug. Along with its use for arthritis, the oleo gum resin of *B. serrata* is also considered effective medicine for dysentery, skin inflammations, reducing fevers, neutralizing asthma and cough, heart-related disorders, liver disorders, diarrhea, and various others. At the same time, the modern medicinal sciences focus on using *B. serrata* as a medicine for arthritis, inflammations, pain-relieving and liver disorders.

Pharmacognostical Characteristics of Indian Boswellia

- When examined Macroscopically, the oleo-gum resin is transparent, brownish-yellow, 2 to 3 cm thick, stalactite type formation that constitutes masses of different sizes and shapes, fracture is quick and brittle, and is aromatic like vinegar.[11]

Microscopically, debris of fibers, boxy cork, yellowish-brown oil globules, and a large number of crystalline fragments of somewhat spherical shape and size ranging:

- from small to large can be seen.[12]
- Generally, the medical part used of *B. serrata* are bark and oleo-gum resins.[13]
- In India, it is one of the most common trees found in some parts of Deccan and another neighboring region.[14]
- It is indigenous to Andhra Pradesh, Tamil Nadu, and Karnataka.[15]
- It is also found in dry hilly forest regions of malwa region present-day Madhya Pradesh, Rajputana region present-day Rajasthan, Haryana, and some parts of Punjab, Bihar, Orissa, and Assam.[16]

Phytochemistry

Many pharmacologically relevant phytochemicals are contained in the mixture of oleo-gum resin. These include mucus, pure resin, and essential oils.[17] The amount of content and their composition varies from species to species of oleo-gum resin depending on resin's quality, age, and atmospheric conditions.[18] The resins of Boswellia species mainly contain higher terpenoids like pentacyclictriterpenes and tetracyclic triterpenes, and these terpenoids are responsible for the resin's pharmacological effects of this plant shows.[17,19] The bosewellic acids, namely alpha and beta boswellic acids (9–22%), KBA (3.5–6.5%), acetylated alpha and beta boswellic acids (0.06–7%), and 3-o-AKBA (0.1–2.9%) are the six major BAs that are present in the oleo-gum resin. The Percentage of Boswellic acid in standardized extract available in the market is found between 38.5 to 66%.[20] The dried extract of Boswellia serrata contains approximately 50–60% of various alpha and beta boswellic acids. Among all the Boswellic acids of Boswellia species, the two BAs that are highly potent and have great anti-inflammatory properties are keto boswellic acid and acetyl keto boswellic acid.[21,22]

Table 1: Botanical names and vernacular names (Alam, Khan, Samiullah, & Siddique, 2012; Sultana & Padmaja, 2013)

Botanical origin	*Native names*
Species–"Serrata"	English–"Indian frankincense"
Genus–"Boswellia"	Hindi–"Sallai", "Kundoor"
Family–"Burseraceae"	Gujarati–"Guggali", "Dhoop"
"Class"–"Anacardiales"	Sanskrit–"Kundaru", "Ashavamurti", "Shaallaki"
"Over-class"–"Rutanae"	Tamil–"Sambrani", "Paraangi"
"Subtribe"–"Rosidae S. lat."	Malayalam–"Sambhrani", "Parangi"
"Tribe"–"Rosopsida"	Telugu–"Sambrani", "Phirangi"
"Sub-division"–"Angiospermae"	Kannada-"Gugguladhoop", "Chita"
"Division"-"Spermatophyte"	Bengali-"Sallai", "Kundoor"

Effect of Boswellic Acids on Various Organs

BAs act differently on multiple targets or various organs of the body and are characterized by these abilities. Their effects on various organs are compiled in Table 2.

Pharmacological Profile

Antiarthritic and Anti-inflammatory Activity

- The widely utilized compounds for the induction of "paw edema for screening of anti-inflammatory" action of drugs are "Carrageenan and dextran".[23]
- When rats were given the extract of *B. serrata* orally, it was seen that it was effective in inhibiting the edema in rat induced using carrageenan and dextran. Moreover, many scientific reviews have been done on the anti-inflammatory capability of *B. serrata,* and it has proved itself right as an anti-inflammatory drug.[23,24]

Analgesic Effect

- *B. serrata* is widely used to treat arthritic and muscular pain in different systems of medicine like Ayurveda, Unani and Homeopathy.[19]
- The "non-phenolic fraction of Boswellia serrata possesses" extraordinary "analgesic and sedative" effects. It is also revealed that after treatment with *Boswellia* there is a significant reduction in the spontaneous locomotor activity.[25]
- The "analgesic activity" of various fractions of *B. serrata* distinctly by "formalin test, acetic acid-induced writhing",

Table 2: Uses of "Salai guggul"

"Organ and functional system"	*Effects*
"Cardiovascular system"	Tonic for heart
"Gastrointestinal tract"	Relieves flatulence Anti-parasitic effect Aids and stimulates digestion
"Nervous system"	Tonic for brain Relieves pain
"Fever"	Reduce body temperature
"Skin"	Increases sweating Aids in healing of wounds
"Urogenital system"	Diuretic
"Whole body"	Reduces inflammation Antiseptic

"hot plate methods, and tail immersion model of analgesia in rats was investigated".[26]

- "Tail immersion methods and acetic acid-induced abdominal constriction measured central and peripheral activity, respectively, whereas the formalin test measured both". The hot plate method was used to elucidate Peripheral effects.[27]

Antifungal Activity

- The extract of *Boswellia serrata* was prepared using water, ethanol, and chloroform, and "ethanolic extract" of the plant was found much more efficient than "chloroform and water extract".[28]
- A study using the agar well diffusion method was carried out to study the anti-fungal activity of "*B. serrata*" and it was found that *Boswellia serrata* is capable of inhibiting the growth of *Colletotrichum falcatum*, which is a fungus and it causes red dot disease in plants.
- The "antifungal activity of Boswellia serrata" was studied and it was found that 0.6% of essential oil is produced on performing hydrodistillation.[29]
- The essential oil obtained from hydrodistillation of the resin of *B. serrata* was incapable of showing remarkable effects against human pathogens whereas it showed remarkable effects against plant pathogens as it can inhibit the growth of *Phytophthora parasitica* which was taken as a test organism. This shows that certain naturally occurring chemical components in *B. serrata* contribute to the plant's natural defense system.[30]

Antidiarrhoeal Activity

- When the effects of *B. serrata* on treating diarrhea were studied, it was found that it is capable of treating diarrhea and also the inflammatory syndrome and the plus point of using *B. serrata* for treating diarrhea is that it does not cause any after problems like constipation.[31]
- Also, its effect was studied on mice model when diarrhea was induced in the mice by castor oil and it was found that the extract is capable of increasing the time duration of food in colon and hence effective against diarrhea in mice too.[31]

Antidepressant Activity

- "*B. serrata*" is efficient in the acute model of depression. It was seen that at a dose of "100 mg/kg", "*B. serrata*" has remarkable "antidepressant activity" in acute models of depression.[32]

Anti-asthmatic Activity

- Important phytocompound resins of *Boswellia serrata* have been found to inhibit the "leukotriene biosynthesis" and have a beneficial and positive effect on "respiratory disorders". It is used in massages, baths, and treatment of "cough", "excessive discharge or buildup of mucus" in the nose or throat, asthma, and "bronchitis".[33]
- It was seen that "alcoholic extract" of "*Boswellia serrata*" has a notable effect on "asthma". A double-blind placebo control clinical study was conducted and it was found to show a promising "anti-asthmatic effect". Furthermore, out of the total patients that were made to administer the ethanolic extract of Salaiguggal guggal orally the 68% of the patients showed recovery in physical symptoms and signs of "bronchitis".[33,34]

Hypoglycemic Activity

- It has been studied that the formulations having "*B. serrata*" as one of the ingredients can produce anti-diabetic effect against. Diabetes mellitus (DM) is independent of insulin induced in a rat with the help of streptozocin.[35,36]

Branded Formulations Containing *B. serrata* [1]

Apart from it being used in spiritual ceremonies, has been used as an important adhesive in "lotions", "creams", "perfumes", with an old-school note in its scent, in prominent products of the perfume and "cosmetic industry". Many preparations with "*B. serrata*" are available in the markets which are mentioned below[37]:

Bonoset Plus is a capsule formulation for oral ingestion, manufactured by Nature's Ayurveda Co., Haryana. It has powdered extract of "*B. serrata*", "*Cissus quadrangularis*", "*Withania somnifera*" as its active ingredients in its composition. It has certified action of reducing inflammations in joints, accelerates the healing process of bones, and strengthens them.

Niltan Is a "cream formulation" for external use only, manufactured by "Dr. Reddy's Laboratories Limited", Hyderabad. It is a product made up of active herbal extracts ("Arbutin", "Boswellin", "Coriander" Seed oil, and "Liquorice" extract in a semisolid base). It shows its action by reducing the "enzyme tyrosinase" in the skin and reducing the level of melanin, which causes dark skin.

Shallaki Each capsule consists of 125 mg *B. serrata*. It has certified anti-inflammatory and analgesic effects to relieve joint pains, produced by "Himalayan Drug Company", Makali, Bengaluru.

Rheumatic-X Consists of 20 mg "Shallaki" along with several ingredients, produced by "Sunrise Herbals", Banaras (Uttar Pradesh, India), and prescribed for "osteoarthritis", "gout", "rheumatoid", and pain.

Conclusion

The present literature review provides the path to understanding the various pharmacotherapeutic properties of *B. serrata,* an ancient medicinal plant. After a detailed literature review, it was noteworthy that the plant's activities mentioned by classical

literature were found when it was investigated through the latest pharmacological tools and subjected to preclinical studies. Hence, the present review gives the path to future clinical research and active phytoconstituents in the plant.

References

1. Baghel DS, Chopra S, Bhatia A, Tamilvanan S. Amalgamation of Ayurvedic concept with modern medical practice to manage kideny stone (Urolithasis): An abbreviated review. Indian Drugs. 2018;55 (11):7-18
2. Sharma S, Baghel DS. Ayurceuticals: A progressive opportunity in wellness and medical tourism. Journal of Pharmacy Research. 2017;11(7):903-11.
3. Kaur S, Sabharwal S, Anand N, Singh S, Baghel DS, Mittal A. An overview of Tulsi (Holy basil). European Journal of Molecular & Clinical Medicine. 2020;7(7):2833-9
4. Chatterjee A, Baghel DS, Mittal A, Singh S, Kumar B, Chaudhary AK. In-Vitro Anti-inflammatory and Anti-oxidant Activities of Hinguleswara Rasa-Based Herbomineral Formulations. Asian J Pharm Clin Res. 2018;11 (Special issue 2):24-27
5. Kumar A, Kumar B, Singh S, Kaur B, Singh S. A review on phytosomes: novel approach for herbal phytochemicals. Asian J Pharm Clin Res. 2017;10(10):41-7
6. Prabhakar P, Nath D, Singh S, Mittal A, Baghel D. Formulation and evaluation of polyherbal anti-acne combination by using in-vitro model. Biointerface Res Appl Chem. 2020;10(1):4747-51
7. Siddiqui M. Boswellia serrata, a potential antiinflammatory agent: an overview. Indian journal of pharmaceutical sciences. 2011;73(3):255. Available from: 10.4103/0250-474X.93507
8. Hamidpour R, Hamidpour S, Hamidpour M, Shahlari M. Frankincense (乳香 Rǔ Xiāng; Boswellia species): from the selection of traditional applications to the novel phytotherapy for the prevention and treatment of serious diseases. Journal of traditional and complementary medicine. 2013;3(4):221-6
9. Shah BA, Qazi GN, Taneja SC. Boswellic acids: a group of medicinally important compounds. Natural Product Reports. 2009;26(1): 72-89.
10. Zhang Y, Ning Z, Lu C, Zhao S, Wang J, Liu B, et al. Triterpenoid resinous metabolites from the genus Boswellia: pharmacological activities and potential species-identifying properties. Chemistry Central Journal. 2013;7(1):1-16. Available from: doi.org/10.1186/1752-153X-7-153
11. Du Z, Liu Z, Ning Z, Liu Y, Song Z, Wang C, et al. Prospects of boswellic acids as potential pharmaceutics. Planta medica. 2015;81(04):259-71
12. Ammon H. Modulation of the immune system by Boswellia serrata extracts and boswellic acids. Phytomedicine. 2010;17(11):862-7
13. Herrmann A, König S, Lechtenberg M, Sehlbach M, Vakhrushev SY, Peter-Katalinic J, et al. Proteoglycans from Boswellia serrata Roxb. and B. carteri Birdw. and identification of a proteolytic plant basic secretory protein. Glycobiology. 2012;22(11):1424-39
14. Ammon H. Boswellic acids in chronic inflammatory diseases. Planta medica. 2006;72(12):1100-16
15. Birkner KM. Boswellia, the pain herb. Pain and Stress Publications. 2006;1(1):60-1
16. Upaganlawar A, Ghule B. Pharmacological activities of Boswellia serrata Roxb.-mini review. Ethnobotanical leaflets. 2009;2009(6):10
17. Singh S, Chauhan MG, Kaur B, Kumar B, Gulati M, Singh SK. Characterization, organoleptic evaluation and standardization of aqueous extracts of antidiabetic herbs Trigonella foenum, Allium sativum, Aloe vera, Phyllanthus niruri. J. Pharm. Res. 2017;11:1370-5.
18. Gerbeth K, Meins J, Kirste S, Momm F, Schubert-Zsilavecz M, Abdel-Tawab M. Determination of major boswellic acids in plasma by high-pressure liquid chromatography/mass spectrometry. Journal of pharmaceutical and biomedical analysis. 2011;56(5):998-1005
19. Al-Harrasi A, Al-Rawahi A, Hussain J, Ali L, Hussain H, Rehman NU, et al. First in vitro lipid peroxidation and in vivo anti-inflammatory activity of the Omani frankincense of Boswellia sacra Flueck. International Journal of Phytomedicine. 2013;5(1):73
20. Al-Harrasi A, Ali L, Rehman NU, Hussain H, Hussain J, Al-Rawahi A, et al. Nine triterpenes from Boswellia sacra Flückiger and their chemotaxonomic importance. Biochemical Systematics and Ecology. 2013(51):113-6
21. Sterk V, Büchele B, Simmet T. Effect of food intake on the bioavailability of boswellic acids from a herbal preparation in healthy volunteers. Planta medica. 2004;70(12):1155-60. Available from: 10.1055/s-2004-835844
22. Sterk V. Bu chele B., Simmet T. Simultaneous food intake enhances the bioavailability of frankincense-based phytopharmaceuticals. Zeitschrift fur Phytotherapie. 2005;26:174-80
23. Singh G, Atal C. Pharmacology of an extract of salai guggul ex-Boswellia serrata. Indian J Pharmacol. 1984;16:51
24. Poeckel D, Werz O. Boswellic acids: biological actions and molecular targets. Current medicinal chemistry. 2006;13(28):3359-69
25. Mothana RA. Anti-inflammatory, antinociceptive and antioxidant activities of the endemic Soqotraen Boswellia elongata Balf. f. and Jatropha unicostata Balf. f. in different experimental models. Food and Chemical Toxicology. 2011;49(10):2594-9
26. Sharma A, Bhatia S, Kharya M, Gajbhiye V, Ganesh N, Namdeo A, et al. Anti-inflammatory and analgesic activity of different fractions of Boswellia serrata. International Journal of Phytomedicine. 2010;2(1).
27. Menon M, Kar A. Analgesic and psychopharmacological effects of the gum resin of Boswellia serrata. Planta medica. 1971;19(02): 333-41
28. Vongtau H, Abbah J, Ngazal I, Kunle O, Chindo B, Otsapa P, et al. Anti-nociceptive and anti-inflammatory activities of the methanolic extract of Parinari polyandra stem bark in rats and mice. Journal of Ethnopharmacology. 2004;90(1):115-21. Available from: doi.org/10.1016/j.jep.2003.09.038
29. Chaurasia A, Gharia A. Antifungal activity of medicinal plant Boswellia Serrata. JUC. 2017;13(4):88-90
30. Garg S. Antifungal activity of some essential oils. INDIAN J PHARM. 1974;36(2):46-7
31. Borrelli F, Capasso F, Capasso R, Ascione V, Aviello G, Longo R, et al. Effect of Boswellia serrata on intestinal motility in rodents: inhibition of diarrhoea without constipation. British journal of pharmacology. 2006;148(4):553-60
32. Prabhakar A, Chandrashekar R, Rao S. Evaluation of antidepressant activity of Boswellia serrata in Swiss albino mice by forced swim test. International Journal of Universal Pharmacy and Bio Sciences. 2013;2(3):417-24
33. Gupta I, Gupta V, Parihar A, Gupta S, Lüdtke R, Safayhi H, et al. Effects of Boswellia serrata gum resin in patients with bronchial asthma: results of a double-blind, placebo-controlled, 6-week clinical study. European journal of medical research. 1998;3(11):511-4
34. Badria FA, Mohammed EA, El-Badrawy MK, El-Desouky M. Natural leukotriene inhibitor from Boswellia: a potential new alternative for treating bronchial asthma. Alternative & Complementary Therapies. 2004;10(5):257-65
35. Sagar, Mittal A, Baghel DS, Singh S, Singh A, Chaudhary AK, Chopra S, et al. An survey on obesity stigma and its assessment with update: a review. Plant Archives. 2019;19(2):2153-61
36. Sultana A, Padmaja A. Boswellia serrata Roxb. a traditional herb with versatile pharmacological activity: a review. International Journal of Pharmaceutical Sciences and Research (IJPSR). 2013;4(6):2106-17. Available from: 10.13040/IJPSR.0975-8232.4(6).2106-17
37. Singh S, Chauhan MG, Machawal L. Trichosanthes dioica Roxb.: Pharmacognostic standardization of the female leaves with special emphasis on the microscopic technique. Journal of Pharmacy And Bioallied Sciences. 2011 Apr;3(2):249. Available from: 10.4103/0975-7406.80780
38. Alam M, Khan H, Samiullah L, Siddique K. A review on phytochemical and pharmacological studies of Kundur (Boswellia serrata Roxb ex Colebr.)-A Unani drug. J Appl Pharm Sci. 2012;2(3):148-56
39. Singh S, Singh SK, Kumar B, Kaur B, Khursheed R, Gulati M, Pandey NK, Prabhakar PK, Baghel DS, Porwal O, Awasthi A. Effect of Co-Administration of Herbal Extracts with Copper Nanoparticles: A Novel Two-Pronged Approach in Treating Type 2 Diabetes. Recent Innovations in Chemical Engineering (Formerly Recent Patents on Chemical Engineering). 2020 Nov 1;13(5):366-78. Available from: doi.org/10.2174/2405520413999200719140819