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A REVIEW ON PHYTOCHEMISTRY AND PHARMACOLOGICAL ACTIVITIES OF *BOSWELLIA SERRATA*: A NATURAL REMEDY

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Anti-arthritic activity, Anti-asthmatic Activity, Anti-rheumatic activity, Immuno-modulatory activity, *B. serrata*

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ABSTRACT: Before discovering synthetic drugs, peoples were dependent completely on the herbal medicinal plants for the prevention and treatment of various diseases or ailments. This is the era where a large number of synthetic drugs have been discovered for the treatment of various diseases and better health care for people suffering from various diseases. However, herbal drugs are still the choice for treating many diseases. They are preferred over synthetic drugs as they are pharmacologically very active and have no side effects or low side effects when used for the treatment of diseases. *B. serrata* is one of the medicinal plants amongst many other plants used traditionally to treat various ailments or diseases. The medicinal plant has a long-range of reported pharmacological activities *viz.* anti-inflammatory activity, anti-arthritic activity, anti-rheumatic, analgesic activity, antimicrobial activity anti-oxidant activity, anticancer activity, antitumor activity, anti-asthmatic activity, anti-diarrhoeal activity, immunomodulatory activity, hypo-lipidaemic and hepatoprotective activity, anti-complementary activity, antifungal, anti-convulsant activity, anti-obesity, cardiotoxic activity and anti-ulcer activity. The Oleo-gum-resin of the plant *B. serrata* is traditionally used to treat arthritis, osteoarthritis, gout, joint pain, skeletal muscle pain, back pain, and diarrhoea. The plant is also used to treat bronchitis, asthma, jaundice, cough, bad throat and various intestinal infections. All the reported activities are suggested due to the presence of various secondary metabolites present in their chemical composition. This review paper provides information related to the phytochemical properties and pharmacological activities of *B. serrata*.

INTRODUCTION: Nowadays, herbal medicines have become the most frequently used remedy for the treatment and a preventive measure against a variety of diseases. Herbal medicines play an important role in the traditional system of medicines as well as in a modern system of medicines.

Boswellia serrata Roxb belonging to the family Burseraceae is commonly known as salai guggal, white guggal, loban, kundur, dhup, and Indian olibanum or more commonly known as shallaki in Sanskrit, is the most important herbal medicines used to treat various ailments or diseases^{1,2,3}.

Seldom is the plant also called as “Gajabhakshya” a Sanskrit name used for *Boswellia serrata* describes that elephants enjoy this herb as a part of their diet^{4,5}. It is also known as Indian Frankincense; Frankincense is a French word that means “pure incense^{6,7}”. The word olibanum is derived from the Arabic word “al- Luban” meaning the milk or white⁸. *Boswellia serrata* tree has been used in

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couple of countries in the traditional system of medicine for the treatment of various diseases⁹. Besides *Boswellia serrata*, *Boswellia* genus is comprised of nearly 25 different species; some of the important species are *Boswellia sacra*, *Boswellia carterii*, *Boswellia papyrifera*, *Boswellia neglecta*, *Boswellia frereana*, *Boswellia rivae*, *Boswellia ovalifoliolata*^{10, 11, 12, 13}.

The plant formulation is useful when applied externally in conditions like stiffness of vessels, joint pain, inflammatory conditions, pain in legs, pus formation and various types of wound and stomach problems. The drug is also used in the treatment of cancer in eyes¹⁴. *Boswellia serrata* has also been used in various diseases of the eye, tooth, tongue, and prevention of the contamination of the birth canal¹⁵. Many previous phytochemical studies of *Boswellia species* shows the presence of a number of secondary metabolites like tannins, saponins, flavonoids, terpenoids, cardiac glycosides, reducing sugars, carbonyls, steroids, phenols, but there is no alkaloid reported as their chemical composition, which is responsible for the above mentioned pharmacological activities of the *Boswellia species*¹⁶. This paper reviews the chemical constituents and pharmacological activities of *Boswellia serrata* or salai guggal.

Geographical Source: *Boswellia serrata* plant is commonly found in West Asia, South Africa, Southern Arabia, Oman, and many parts of India. In India, the *Boswellia serrata* tree is found mainly in Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Orissa, Western Himalayas and Bihar, and other dry hilly regions of India¹⁷.

Morphology: *Boswellia serrata* is a medium to large, deciduous tree usually with papery bark. Leaves are alternate, crowded at the ends of branches, imparipinnate with opposite leaflets and usually serrate. Flowers are hermaphrodite, small in size and white in axillary racemes. The flowers petals are 3-5 in number, deciduous and imbricated. Fruits are indehiscent containing 2, 5- pyrenes or pseudo capsular dehiscent rarely.

Seeds are pendulous. Flowers grow in March-April, and fruit grow in winter. The tree remains leafless during the entire period of flowering and fruiting¹⁸. *Boswellia serrata* is a medium to large, deciduous

plant, up to 18 meters in height and 2.4 meters in girth. The bark of the plant is thin, greenish-grey to yellow or red, which ultimately turn into an ash color. The bark peels off in smooth, exfoliates in papery flakes, blazing pinkish, and exudes small resin drops. The oleo gum resin is obtained as exudate after an injury or natural crack in the bark. The oleo gum resin obtained is fragrant, transparent, and golden yellow, turning into brownish yellow tears or drops and crusts¹⁹.

Vernacular Name:

Hindi	:	Kundur, Salai, Luban ²⁰
Kanada	:	Shallaki, Chitta, Gugul, Dhupa, Adimar, Tallaki, Maddi ²¹
Tamil	:	Parangisambrani ²¹
Telugu	:	Anduga, Kondagugi, Tamu ²²
Sanskrit	:	Ashwamuthri, Kunduru ²³
Urdu	:	Kundur ²⁴
Arabic	:	Luban, Kundur ²⁵
Persian	:	Kunduri ²⁶
Bengali	:	Kundur, Salai ²⁷
Gujarati	:	Dhup, Gugali ²⁷
Malayalam	:	Parangi, Saambraani ²⁷

Taxonomical Classification²⁸:

Kingdom	:	Plantae
Subkingdom	:	Tracheobionta
Superdivision	:	Spermatophyta
Division	:	Magnoliophyta
Order	:	Sapindales
Class	:	Angiosperms
Subclass	:	Eudicots
Family	:	Burseraceae
Genus	:	<i>Boswellia</i>
Species	:	<i>Serrata</i>

Phytochemistry and Medicinal Uses:

Phytochemistry: The phytochemical screening of various extracts of the plant *Boswellia serrata* reveals the presence of various chemical constituents as major active chemical compositions like essential oil, gum, and resin. Essential oil is suggested to be a mixture of monoterpene, diterpene, and sesquiterpenes. Gum portion on phytochemical screening suggested that it consists of pentose and hexose sugar and some digestive and oxidizing enzymes. The resin portion of *Boswellia serrata* mainly consists of pentacyclitriterpenic acid; *Boswellic acid* is the

most active constituent of pentacyclic terpenes amongst other²⁹. The major phytochemicals of the resinous part is recognized as a monoterpene (α -thujene), diterpenes (e.g., incensole, incensole oxide and iso- incensole oxide), diterpene alcohol known as serratol, triterpenes (e.g., α - amyrin and β - amyrin), pentacyclitriterpenic acid (e.g., boswellic acids), tetracyclic triterpenic acids (e.g., tirucall-8, 24-dien-21-oic acids)^{30, 31}. The gum resin of *Boswellia serrata* is a mixture of pentacyclic triterpenoids and sugar moieties, and approximately 200 other substances are also present along with them³². The major composition of the lipophilic portion of the oleo gum resin is pentacyclitriterpenoidal derivatives, e.g., Boswellic acids, major constituents of the plant *Boswellia serrata*, are considered as the pharmacologically active constituents of the plant³³.

The gum of *Boswellia serrata* is reported to contain arabinose, rhamnose, glucose, galactose, Fructose, galacturonic acid, and β sitosterol, and the essential oil obtained from the gum is reported to contain phenol-o-cresol, m-cresol, p-cresol, thymol and carvacrol and carboxylic acid- α -campholenic acid 2,2,4-trimethylcyclopent-3-en-1-yl acetic acid and campholytic acid^{34, 35, 36, 37}.

The oil of the gum resin of the plant *serrata* reported containing monoterpenes *Boswellia* in high portion (97.3%) in which E- β -ocimene and limonene were reported as major constituents. The remaining 2.7% was accounted for sesquiterpenes, in which E-caryophyllene was reported as major constituents³⁸.

The monoterpenes of the oil were identified as a 2- β -pinene, α -thujene, E- β -ocimene, 2,4(10)-thujadiene, camphene, sabinene, 1- β -pinene, myrcene, 2-carene, limonene, pinene, Z- β -ocimene, γ -terpinen, terpenoline, p-cymene, 1,4-cyclohexadiene, perillene, isopentyl-2-methyl butanoate, isomylvalerate, 1,3,6-trimethylenecycloheptane, β -thujone, α -camphlene aldehyde, allo-ocimene, trans-pinocarveol, p-mentha-1,5-dien-8-ol, 4-terpineol, sabinyl acetate, myrtenal, verbenone, carvone, α -phellandrene epoxide and bornyl acetate³⁸.

Sesquiterpenes were reported as α -cubebene, α -copaene, β -bourbonene, β -elemene, α -gurjunene,

E-caryophyllene, α -humulene, allo-aromadendrene, α -amorphenone, germacrene D, β -selinene, α -selinene, α -murolene, γ -cadinene, caryophyllene oxide and γ -murolene³⁸.

Medicinal Uses: Traditionally, *Boswellia serrata* gum resin is used as an antiseptic, antifungal, and antimicrobial³⁹, anti-arthritic⁴⁰, anti-inflammatory⁴¹, anti-obesity⁴², anti-asthmatic⁴³, anticonvulsant⁴⁴, and as a cardiotoxic⁴⁵. *Boswellia serrata* is traditionally used to treat bronchitis, asthma, cough, bad throat, and treat various intestinal problems^{46, 47, 48, 49}.

Traditionally *Boswellia serrata* is used for the treatment of rheumatoid arthritis, osteoarthritis, gout, joint pain, skeletal muscle pain, and back pain⁵⁰. *Boswellia serrata* is used to treat various types of syphilitic and pulmonary disorders because it possesses diaphoretic and astringent properties. Boswellic acid, one of the most important active constituents of *Boswellia serrata* has been reported to possess stomachic, diuretic, expectorant, and stimulant properties. Boswellic acid is a well-known therapeutic agent for treating hemorrhoids, dysentery, diarrhea, and jaundice. The herbal formulation of the plant is used for the treatment of ulcers. The plant is used as a skin irritant for better flow of blood and stimulation of menstruation^{51, 52, 53}.

Pharmacological Activities: *Boswellia serrata* plant is known for its various pharmacological activities. Some of the activities are discussed below;

Anti-inflammatory Activity: *Boswellia serrata* is an ancient medicine, reported to possess potent anti-inflammatory activity and anti-atherosclerosis activity in numerous scientific studies^{54, 54, 56}. *Boswellia serrata* was reported to possess anti-inflammatory activity when tested on the papaya latex model; the test showed significant activity with mean 35% inhibition of inflammation. The activity reported is suggested due to the Boswellic acid, the most important chemical composition of *Boswellia serrata*⁵⁷. *Boswellia serrata* reported to possess significant activity against ulcerative colitis; the activity is suggested because it blocks leukotriene biosynthesis in neutrophilic granulocytes. The activity is directed non- redox

and non-competitive inhibition of 5- lipoxygenase⁵⁸. *Boswellia serrata* was reported to possess prominent anti-inflammatory activity without side effects in 88% of patients with inflammatory diseases⁵⁹. *Boswellia serrata* is used in traditional Ayurvedic medicine of India for the treatment of inflammatory diseases like chronic polyarthritis, especially in the treatment of rheumatoid arthritis and osteoarthritis^{60, 61, 62, 63}. *Boswellia serrata* was reported to possess anti-inflammatory and anti-arthritic activity when tested against the carrageenan-induced paw edema adjuvant in rats. The inhibitory activity was reported as 39.75% and 65-73% administered orally in dose of 50-200 mg per kg and intraperitoneal in dose of 50-100 mg per kg, respectively. The inhibitory activity is compared with phenylbutazone, used as a standard drug in the dose of 50 mg per kg for the anti-inflammatory activity study of *Boswellia serrata*, which shows 47% inhibitory action^{64, 65}.

Analgesic Activity: Gum resin of *Boswellia serrata* was reported to possess significant analgesic activity in an experimental animal in addition to its sedative effect. The effect reported was reduced on spontaneous motor activity and caused Ptosis in rats⁶⁶.

Anti-arthritic Activity: *Boswellia serrata* showed prominent anti-arthritic activity when an anti-arthritic activity study was carried out on Mycobacterium adjuvant-induced polyarthritis in rats. The inhibition of paw swelling was reported 34% and 49% in the dose of 50 mg/kg and 100 mg/kg, respectively, when compared with control⁶⁷. *Boswellia serrata* exhibited marked anti-arthritic activity (45%-67%) in the dose range of 50-100 mg/kg when the chronic test of formaldehyde was performed. The drug was shown to be effective against both adjuvant arthritis (35-59%) and established arthritis (54-84%)⁶⁸.

Anti-asthmatic Activity: Gum resin of *Boswellia serrata* was reported to possess vivid anti-asthmatic activity when it was tested by a double-blind, placebo-controlled study on 40 patients (23 males and 17 females) in the age range of 18-75 years having a mean duration of bronchial asthma. The patients were treated with gum resin preparation of 300 mg thrice a day, daily for a period of 6 weeks. 70% of patients were reported to show

improvement of disease as evidenced by the disappearance of physical symptoms and sign like dyspnea, rhonchi, a number of attacks, increase in forced expiratory volume (FEV) subset 1, forced vital capacity (FVC), and peak expiratory flow rate (PEFR) as well as a reduction in the eosinophilic count and ESR⁶⁹.

Immuno-modulatory Activity: Gum resin extract of the *Boswellia serrata* was reported to possess a prominent immuno-modulatory activity when evaluated for anti-anaphylactic activity and mast cell stabilizing activity against passive paw anaphylaxis and compound 48/80 induced degranulation of the mast cell. The test was carried out in rats in a dose-dependent manner by using dexamethasone (0.27 mg/kg) as control^{70, 71}.

Anticancer Activity: Alcoholic extract of Oleo gum resin of *Boswellia serrata* was reported to possess marked anticancer activity when tested against the anti-carcinogenicity in mice with ehrlic ascites carcinoma and S-180 tumor; test result showed a prominent inhibition of tumor growth and the proposed mechanism of inhibition was inhibition of cell proliferation and cell growth caused by the interference with the biosynthesis of DNA, RNA and Proteins⁷². *Boswellia* is reported as the most important and potent anticancer agent that occurs naturally. Methanolic extract of the gum resin of *Boswellia serrata* contains β - Boswellic acid and its derivatives, which were reported to possess significant anti-carcinogenic, antitumor, and anti-hyperlipidemic activities⁷³. *Boswellia serrata* was reported to possess inhibitory effects against the growth of prostate cancer cells. The anticancer activity was reported due to the presence of the boswellic acids in its composition, boswellic acids are pentacyclic triterpenoids. Amongst all boswellic acids, Acetyl-11-keto- β -Boswellic acid (AKBA) exerts an inhibitory effect on prostate cancer by suppressing vascular endothelial growth factor receptor⁷⁴. Boswellic acids, the most active chemical composition of the gum resin of the plant *Boswellia serrata* reported to show promising anticancer activity when prepared nanoparticles formulation of the boswellic acid was used in the treatment of prostate cancer. The proposed mechanism was that boswellic acid nanoparticles cause apoptosis and DNA fragmentation^{75, 76}.

Hypolipidemic and Hepatoprotective Activity:

Water-soluble extract of the plant *Boswellia serrata* was reported to decrease total cholesterol (38-48%) and increase HDL (high-density lipoprotein) in rats when fed on an atherogenic diet, hence providing Hypolipidemic activity⁷⁷. Alcoholic extract of *Boswellia serrata* was reported cause hepatoprotection in galactosamine/ endotoxin-induced liver damage in mice. The effect was reflected by the reduced titer of Serum glutamic oxaloacetic transaminase (SGOT), Serum glutamic pyruvic transaminase (SGPT), aminotransferase, and Serum enzymes⁷⁸.

Anti-ulcer Activity: *Boswellia serrata* was reported to possess anti-ulcer activity when used in burn wounds and cold fissures with swine fat. It is found useful in all types of septic ulcers⁸⁰. When the drug was used with honey, it showed a prominent effect on burn wounds⁸⁰.

Antimicrobial Activity: *Boswellia serrata* had been reported to show a significant antimicrobial activity when tested against the microbial pathogens of the oral cavity by using the filter paper disc diffusion method. The maximum inhibitory concentration reported was 2-4 µg/ml. it showed concentration-dependent bactericidal

activity and also prevented the emergence of *S. mutant*. The antimicrobial study suggested that the drug can be used as an antibacterial agent against oral pathogens. It has a great potential for use in mouthwash for the prevention and treatment of oral infections⁸¹. The essential oil obtained from the bark of *Boswellia serrata* plant was reported to possess antibacterial activity against Gram-positive and Gram-negative. The essential oil was reported to show inhibitory activity against *S. aureus*, *E. coli* and *Proteus mirabilis* strand⁸².

Anti-diabetic Activity: Oleo-gum-resin of *Boswellia serrata* was reported to possess significant anti-diabetic activity on non-insulin-dependent diabetes mellitus. The test was carried out using an herbal formulation containing *Boswellia serrata* oleo-gum-resin as one of the active ingredients in the streptozocin-induced diabetic rat model. A noticeable reduction in blood glucose level was comparable to that of phenformin used as control⁸³.

Anti-diarrhoeal Activity: *Boswellia serrata* extract was reported to possess promising anti-diarrhoeal activity and was found effective in treating diarrhoea in a patient with inflammatory bowel syndrome without constipation.

TABLE 1: PHARMACOLOGICAL ACTIVITIES OF BOSWELLIA SERRATA ROXB

S. no.	Pharmacological Activity	Plant Part	Test Model	References
1	Anti-inflammatory activity	Gum resin	Carrageenan induced paw edema in rats	Atal CK <i>et al</i> (1980), Atal CK <i>et al</i> (1981)
2	Analgesic activity	Gum resin	Rats	Menon MK <i>et al</i> (1970)
3	Anti-arthritis activity	Gum resin	<i>Mycobacterium</i> induced poly arthritis in rats	Vernon R (1969)
4	Anti-asthmatic activity	Gum resin	Double-blind, Placebo control study on 40 patients of 18-75 year old	Gupta I <i>et al.</i> (1998)
5	Immuno-modulatory activity	Gum resin	Passive paw anaphylaxis and 48/80 compound degranulation of mast cell in rats	Pungle P <i>et al</i> (2003), Upananlawar A (2009)
6	Anticancer activity	Gum resin	Ahrlic ascites carcinoma and S-180 tumor in mice	Tsukada T <i>et al.</i> (1986)
7	Hypolipidemic and Hepatoprotective activity	Gum resin	Galactosamin/endotoxin induced liver damage in mice	Zutsi U <i>et al.</i> (1986)
8	Anti-ulcer activity	Gum resin	Burn wound	Deshpande AP <i>et al</i>
9	Antimicrobial activity	Gum resin	Filter paper disc diffusion	Raja AF <i>et al.</i> (2011)
10	Anti-diabetic activity	Gum resin	Streptozocin induced diabetic rat	Al Awadi <i>et al.</i> (1991)
11	Anti-diarrhoeal activity	Gum resin	Acetylcholine, barium chloride, croton and castor oil induced diarrhoea in mice	Borrelli F <i>et al.</i> (2006)

It was found effective against acetylcholine and barium chloride-induced diarrhoea by inhibiting the

contraction of the intestinal smooth muscles. The plant extract also reported inhibiting

gastrointestinal transit in croton and castor oil-induced diarrhoea in mice⁸⁴. In view of the pharmacological activities of *Boswellia serrata*, a number of works has done. Some of the reported pharmacological activities of the *Boswellia serrata* are mentioned in **Table 1**.

CONCLUSION: *Boswellia serrata* is a deciduous plant found mainly in the dry hilly region of India. The gum resin of *Boswellia serrata* is mainly known for its medicinal uses and is used traditionally for the treatment of various diseases. In the Ayurveda and Unani System of medicine, *Boswellia serrata* is used for the treatment of asthma, cough, inflammation, arthritis, osteoarthritis, rheumatoid arthritis, hyperlipidemia, diarrhoea, fungal infection, obesity, convulsant and various types of cancers.

The curative property of the plant is due to the presence of the various secondary metabolites; amongst boswellic acid, derivatives are the most active. The boswellic acids, pentacyclic triterpenoids of *Boswellia serrata* are the potent candidate against inflammatory diseases. The known mechanism by which they show anti-inflammatory activity is inhibiting leukotriene biosynthesis non-competitive inhibition of 5-lipoxygenase. Boswellic acid is a drug of choice for patients with inflammatory and immunological problems. It is the better plant remedy as it has no toxicity and side effect compared to synthetic non-steroidal anti-inflammatory drugs.

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