



International Journal of Homoeopathic Sciences

E-ISSN: 2616-4493

P-ISSN: 2616-4485

www.homoeopathicjournal.com

IJHS 2024; 8(2): 244-250

Received: 12-02-2024

Accepted: 16-03-2024

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***Boswellia serrata*: Its phytochemistry, pharmacological activity and its potential health benefits**

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DOI: <https://doi.org/10.33545/26164485.2024.v8.i2d.1141>

Abstract

The plant *Boswellia serrata* (BS) which belong to the Burseraceae family yields boswellic acid (BA), one of the active components. Indian olibanum, Indian frankincense, and Salai guggul are other names for the plant's oleoresin gum. *Boswellia* species include a range of phytochemicals, essential oils, and beta-, acetyl, and keto-basins (BA). Several extraction techniques, including hydrodistillation, solvent extraction, percolation, and ultraviolet-assisted extraction, were used to isolate this range of compounds from the plant. The biological actions of the active ingredient include antitumor, antidiuretic, anticancer, and anti-inflammatory properties. This review on the plant BS upgraded the information regarding its medicinal property, its isolation in the traditional or Indian system of medicine, and finally it proved to be efficacious in homoeopathic system of medicine.

Keywords: *Boswellia*, anti-inflammatory, literatures, health benefits, homoeopathy

Introduction

Plants and phytochemicals obtained from plants are being utilized to cure a variety of illnesses since ancient times. Natural products are superior to synthetic ones in many ways, including less adverse effects and guaranteed biological activity. Countries in Africa, the Middle East, and India are home to *Boswellia serrata*. Currently, *Boswellia* can be found in over 21 different species worldwide. Johan Boswell, who made the discovery of certain *Boswellia* species, is honored by the name *Boswellia* ^[1]. The first people to describe Frankincense as a natural remedy were the Egyptians, who employed it to treat tumors, inflammatory conditions, and asthma. In the first and second centuries AD, the Indian Ayurvedic medical system used *Boswellia* to cure a variety of diseases, according to Ayurvedic texts including the Charaka Samhita.

Furthermore, frankincense has been used by Middle Eastern scholars to cure a wide range of illness, including gastrointestinal inflammation, osteoarthritis, and wounds. Research on the anti-inflammatory properties of *Boswellia* species has dominated most investigations. *Boswellia* also helps with skin problems, cancer, age-related illnesses, neurorecovery, asthma, antidepressants, and more. The so-called boswellic acids and essential oil terpenes are the phytochemical elements that are in charge of the pharmacological effects. Multiple anti-inflammatory actions have been assessed in a number of preclinical and clinical investigations.

Historical/traditional applications

Given that *Boswellia serrata* is a highly valued herb in Ayurveda. A Sanskrit term for boswellia that is occasionally used is "Gajabhakshya", which implies that elephants consume this herb. Gugguls, or the gum-resins of trees, have antirheumatic (antiarthritis) properties that are described in the first two pillars of Ayurveda, Charaka's Charaka Samhita (C.B.C. 700) and Susruta's Susruta Samhita (C.B.C. 600). This gummy resin is used to treat arthritis, but it is also mentioned in traditional Ayurvedic and Unani texts as a useful treatment for diarrhoea, dysentery, ringworm, boils, fevers (antipyretic), skin and blood diseases, cardiovascular diseases, mouth sores, bad throat, bronchitis, asthma, cough, vaginal discharges, hair loss, jaundice, hemorrhoids, syphilitic diseases, irregular menses, and liver stimulation ^[2]. Additionally, it functions as an external and internal stimulant and is diuretic, astringent, and diaphoretic. Its usage as an antiarthritic, anti-inflammatory, antihyperlipidemic, antiatherosclerotic, analgesic, and hepatoprotective is strongly supported by modern medicine and pharmacology.

It is advised for use as a face toner and wrinkle smoother in cosmetic applications. The "Olibanum" was a component of mummification embalming solutions. In the past, boswellia was used in religious ceremonies and to enhance mental health. Burning it is supposed to release a psychoactive compound called trans-hydrocannabinole, which has been observed to improve spirituality, mental perception, meditation, prayer, and consciousness. Boswellia has drawn attention lately as a potential treatment for inflammatory conditions like asthma, inflammatory bowel disease, arthritis, and other inflammatory illnesses.

Literature review

- According to recent studies, 3-O-Acetyl-11-keto-beta-boswellic acid (AKBA) is the only boswellic acid with potent pharmacological activity. For instance, AKBA has a potent inhibitory impact on 5-lipoxygenase (5-LOX) [3]. *In vitro* tests also demonstrate that *Boswellia serrata* extract can inhibit the expression of inflammatory factors like adhesion molecules. Clinical studies have demonstrated that *Boswellia serrata* extract not only has anti-inflammatory and anti-arthritis properties, but also improves pain and physical function. Research on the safety of *Boswellia serrata* has revealed that at larger doses, extracts from the plant, such as 5-Loxin and Aflapin, do not exhibit any harmful side effects. Based on available data, these suggest that the active component of boswellia extract (AKBA) is safe [4].
- Boswellic acids were thus demonstrated to be particular, non-redox inhibitors of leukotriene production, either directly interacting with 5-LO or preventing its translocation [5], as demonstrated by *in vitro* investigations conducted by Ammon *et al.* in 1993. Additionally, it has been noted that boswellic acids block human leukocyte elastase (HLE), a protein that may play a role in the etiology of emphysema. Acute respiratory distress syndrome, chronic bronchitis, and cystic fibrosis may all be influenced by HLE because it also increases mucus output. A serine protease known as HLE causes tissue damage, which sets off the inflammatory process. Only boswellic acids exhibit this dual inhibitory impact on the inflammatory process. Three-acetyl-11-keto- β -boswellic acid (AKBA), the most powerful of all four boswellic acids, inhibits the enzyme 5-LO, which is in charge of inflammation.
- In their investigation into the anti-inflammatory properties of a combination of boswellic acids, Singh *et al.* found that rats and mice's paw oedema was inhibited by 25-46%. Additionally, they have shown that in a comparable dose range, it demonstrated 45-67% anti-arthritis effect in a chronic test of formaldehyde arthritis⁶. The fraction shown efficacy in treating both adjuvant arthritis (35-59%) and established arthritis (54-84%). Additionally, it had an antipyretic effect without having an ulcer-causing impact.
- In patients with osteoarthritis and rheumatoid arthritis, the gum-resin of *Boswellia* alone has been demonstrated to alleviate symptoms in clinical trials⁷. In a test conducted on a novel model, the Papaya Latex Model, boswellic acid from *Boswellia serrata* demonstrated a noteworthy means 35% reduction of inflammation. The new model's usefulness on boswellic

acid sheds some insight on its mechanism of action, which appears to be different from that of aspirin and steroidal medications, given that it is reportedly sensitive to slowly acting remission-inducing drugs.

- In 2007, Gayathri and colleagues discovered that a pure extract from *Boswellia serrata* shows anti-inflammatory properties in human peripheral blood mononuclear cells (PBMCs) and mouse macrophages by inhibiting TNF-alpha, IL-1beta, NO, and mitogen-activated protein (MAP) kinases [8]. By reducing vascular endothelial growth factor receptor 2-mediated angiogenesis, acetyl-11-keto- β -boswellic acid suppresses the formation of prostate tumors.
- According to a clinical trial carried out in India by Raychaudhuri and colleagues, *Boswellia serrata* [9] plant extract can significantly improve knee-joint functioning and reduce pain, with some instances exhibiting pain alleviation within seven days. As the first to assess the effectiveness of an extract enhanced with a kind of boswellic acid on osteoarthritis, Raychaudhuri and her associates characterized their research.
- Although numerous meta-analyses [10] have extensively examined and summarized the available data from RCTs regarding the efficacy of *Boswellia serrata* and its extract in OA, boswellia and its extract offer potential benefits for experimental animals as well as cultivated cells *in vitro*.

Composition of *Boswellia serrata* resin

Boswellia serrata's resinous portion contains [11] the following compounds: monoterpenes (α -thujene); diterpenes (macrocyclic diterpenoids such as incensole, incensole oxide, iso-incensole oxide, a diterpene alcohol [serratol]); pentacyclic triterpenic acids (boswellic acids); tetracyclic triterpenic acids (tirucall-8,24-dien-21-oic acids).

Phytochemistry

An essential blend of oleo-gum resin contains several phytochemicals. These consist of pure resin, mucous, and essential oils. The quality, age, and geographic conditions of the resin can affect the content and composition of oleo-gum resin, which can differ between species. The primary terpenoids found in *Boswellia* species resins—pentacyclic and tetracyclic triterpenes are what give them their medicinal properties [12]

The six primary BAs are 3-o-AKBA (0.1-3%), acetylated α - and β -BAs (0.05-6%), KBA (2.5-7.5%), and α - and β -BAs (10-21%). Commercially available standardized extracts with varying levels of BA concentration range from 37.5 to 65%. The most bioactive AKBA fraction, comprising 1-3 percent, is present in the dry extract of *B. serrata*, which has roughly 50-60% of different α - and β -BAs. AKBA and KBA are the two most powerful, active, and anti-inflammatory of all the *Boswellia* BAs.

Dosage

Generally, boswellia is consumed orally as a pill, capsule, or bark decoction. Based on past performance or accessible trials, the suggested dosage has been determined. The ideal dosage to strike a balance between safety and efficacy [13] is yet unknown. It's vital to remember that because different products from different manufacturers were utilized in the majority of the trials, clinical results could not be similar.

Precautions/contradictions

No allergic or hypersensitivity reactions to boswellia have been reported in the available literature, although this area lacks systematic study.

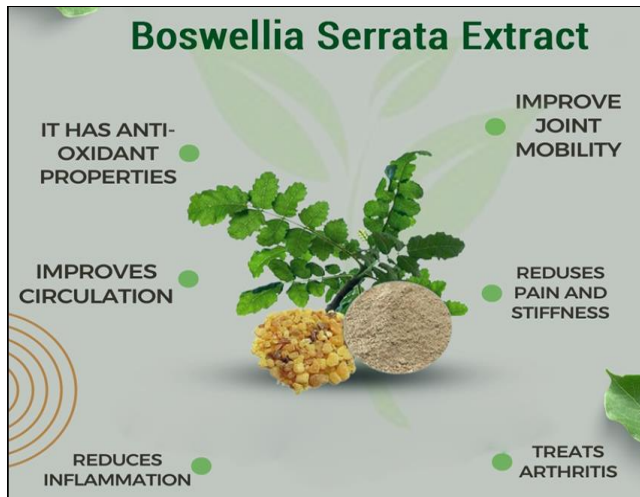


Fig 1: Show *Boswellia serrata* Extract

Clinical benefits /effectiveness

Natural health practices have used boswellia for centuries to treat various chronic inflammatory disorders. The scientific research on boswellia is less developed, but it is beginning to unveil potential uses for the resin and its extracts.

Boswellia and its active ingredients, such as boswellic acid, appear to have a good anti-inflammatory effect on the body, according to a various review of literature.

Four acids in boswellia resin contribute to the herb's anti-inflammatory properties. These acids inhibit 5-lipoxygenase (5-LO), an enzyme that produces leukotriene. Acetyl-11-keto- β -boswellic acid (AKBA) is thought to be the most powerful of the four boswellic acids.

The following sections showed the evidence behind its potential benefits for inflammatory health conditions.

▪ In osteoarthritis

Boswellia has been shown in numerous studies to be beneficial in the treatment of osteoarthritis (OA) pain and inflammation. According to a 2003 study that was written up in the journal *Phytomedicine*, all 30 patients with OA knee pain who took boswellia reported having less knee pain¹⁴. They also mentioned being able to walk farther and with greater knee flexion. Recent research bolsters the use of boswellia treating OA indefinitely.

An another study that was supported by a company that produces boswellia discovered that increasing the dosage of enriched boswellia extract improved physical abilities. Compared to a lower dosage and placebo, the boswellia product reduced OA knee discomfort after 90 days. A cartilage-degrading enzyme's levels were also lowered with its assistance.

▪ In rheumatoid arthritis

Research on boswellia's efficacy in treating RA has produced contradictory findings. According to a previous study that was published in the *Journal of Rheumatology*, boswellia can lessen the swelling of RA joints. Boswellia may disrupt the autoimmune process, according to some study, which would make it a useful treatment for RA¹⁵.

The beneficial anti-inflammatory and immune-balancing effects are supported by additional research.

The primary cause of rheumatoid arthritis (RA) symptoms is inflammation surrounding the joints. Reducing inflammation is a major goal of many RA treatments, which include steroids and non-steroidal anti-inflammatory medications (NSAIDs).

Boswellia has been shown to be useful in decreasing inflammation, which suggests that it may potentially alleviate RA symptoms. The Arthritis Foundation suggests using boswellic acid capsules as a possible treatment for osteoarthritis and RA.

▪ In cancer

Antitumor chemicals are abundant in plants. Triterpenoids with anticancer effects are present in oleogum resins derived from different species of *Boswellia*. In a survey, it was discovered that the four triterpenic acids (BA, ABA, KBA, and AKBA) that were separated from the gum resin of *B. serrata* had anticancer properties that effectively and dose-dependently suppressed the synthesis of DNA, RNA, and protein in human leukemia HL-60 cells¹⁶. AKBA was found to have the strongest inhibitory effect on the synthesis of DNA, RNA, and proteins, with the effect on DNA synthesis being irreversible. While it had no effect on the viability of the cells, this substance dramatically reduced the HL-60 cells' ability to proliferate.

According to research, boswellic acids are effective cancer cell apoptotic agents. In six human myeloid leukemia cell lines, boswellic acid acetate appears to cause apoptosis via a caspase-mediated pathway that is triggered by the activation of death receptors 4 and 5 (DR4, DR5)¹⁷. Because AKBA inhibits lipoxygenases, tumor cells undergo apoptosis and cell growth is inhibited, which contributes to its anticancer efficacy.

▪ As a cancer therapy

According to a different study, boswellic acids effectively prevent pancreatic cancer cells from invasively spreading. Research is ongoing, and it appears that boswellia has improving anti-cancer properties with each trial¹⁸.

Boswellic acids may be harmful to malignant cells and have anticancer characteristics, according to a 2016 review research published in *Trusted Source*. It was determined that this would make them useful in upcoming cancer treatments; however, further clinical trials are required to verify this.

According to a recent study published in the journal *Oncotarget Trusted Source*¹⁹, boswellia essential oil reduced aggressive skin cancer cells without endangering good skin cells. Although these first results are encouraging, further human study is necessary to confirm these findings and learn more about the potential benefits of boswellia in cancer therapy.

▪ Prostate cancer

Numerous studies have demonstrated the inhibitory effect of pentacyclic triterpenoids present in *B. serrata* on the development of prostate cancer cells²⁰. One of the boswellic acids, AKBA, prevents prostate cancer by squelching angiogenesis mediated by vascular endothelial growth factor receptor 2.

Akt also known as (Protein kinase B) is a serine/threonine protein which has an important role in multiple cellular

processes such as cell proliferation, apoptosis, transcription, and cell migration. Akt1 has been associated as a major factor in many types of cancer since it can block apoptosis and promote the survival of the cell.

▪ **In brain tumor**

A disorder known as brain cancer occurs when cancerous tumors grow inside the brain. Because of the tumor's size, kind, and location, surgical excision of brain tumors is a challenging and meticulous process that is frequently not successful in completely removing the tumor. Because of these factors, even after receiving surgery and radiation therapy for their brain tumors, the average survival time for these individuals is just roughly nine months. Furthermore, only approximately 10% of individuals can have their survival prolonged by chemotherapy. Highly active leukotrienes and other inflammatory mediators are produced in the brain and surrounding tumors in patients with malignant brain tumors, leading to localized fluid accumulation and injury to healthy nerve cells.

Patients with brain tumors have been evaluated for *B. serrata*'s anti-inflammatory effects. Boswellic acids are present in an ethanolic extract of *B. serrata* gum resin. According to a study, there was a 22-48% decrease in peritumoral cerebral edema following the use of this product, known as phytopharmakon H15, over seven days [21]. Within two weeks, there was no tendency for the cells in the treated tumor tissue to multiply, in contrast to the cells in the untreated patients.

A study on malignant glioma patients [22] revealed that giving 3600 mg/day of *Boswellia* extract (which contains 60% boswellic acids) to patients seven days before surgery resulted in an average 30% decrease in the fluid surrounding the tumor in eight out of the twelve patients, as well as a reduction in the patients' indications of brain damage. In a recent comprehensive study, patients with malignant brain tumors receiving radiation therapy in addition to a specific dose of *Boswellia* extract demonstrated a 75% reduction in cerebral edema following radiation therapy in 60% of the patients receiving the extract. In addition to the antiedema action, the study also revealed that the ratio of tumor to volume dropped in these patients, indicating an anticancer effect.

▪ **In inflammatory bowel disease**

Owing to its anti-inflammatory qualities, *boswellia* may be useful in the treatment of inflammatory bowel diseases, including Crohn's disease and ulcerative colitis (UC). A recent study [23] that contrasted H15, a unique *boswellia* extract, with the anti-inflammatory prescription medication mesalamine (Apriso, Asacol HD) revealed that the *boswellia* extract may be useful in the treatment of Crohn's disease. Our understanding of how *boswellia*'s immune-balancing and anti-inflammatory properties can benefit an inflamed bowel is still developing.

A study in the World Journal of Gastroenterology had looked into the action of these compounds. In animal models, boswellic acids improved markers of IBD without causing adverse effects on the surrounding organs. So, they proved to be a useful supportive treatment for these chronic conditions.

▪ **In asthma**

The reduction of leukotrienes, which results in the

contraction of bronchial muscles, is one function of *boswellia*. In 1998, a study examining the herb's effects on bronchial asthma revealed that *boswellia* supplementation resulted in a reduction in asthma symptoms and signs. This suggests that bronchial asthma may benefit greatly from the use of BS herbs [24]. Asthma patients' response to environmental allergens can be lessened by *boswellia*'s immune-balancing benefits, according to ongoing research. Numerous studies have demonstrated that boswellic acid reduces airway inflammation and prevents the release of cytokines, which are indicators of inflammation. Boswellic acid therefore seems to inhibit the allergic reaction that first triggers an asthma attack. This could eventually turn *boswellia* into a beneficial adjunctive asthma treatment. For the time being, more studies involving humans must be the focus of researchers.

▪ **In Parkinson's disease**

According to a 2019 study [25], *boswellia* may be used to treat Parkinson's disease in the medical field. In rat models of Parkinson's disease, *boswellia* showed anti-inflammatory and antioxidant properties that seemed to shield brain neurons and enhance motor function. But further human study trials are needed because this is preliminary research.

▪ **In heart diseases**

The accumulation of plaque inside blood vessels that results in atherosclerosis is what hardens the arteries. It has been discovered to be connected to inflammation and is the primary cause of coronary heart disease [26]. Twenty Results from the survey unequivocally show that AKBA inhibits nuclear transcription factor-kappa B (NF-κB), a critical player in the onset and progression of chronic inflammatory disorders, thereby mitigating chronic inflammation. Thus, it is necessary to develop treatment strategies that specifically target this transcription factor in order to treat chronic inflammation associated with atherosclerosis.

▪ **In diabetes**

Additionally, *boswellia* has shown to be highly beneficial for diabetes mellitus [30]. According to a study, giving diabetic patients an oral aqueous extract of *Boswellia glabra*'s leaves and roots lowered their blood sugar levels. Following a 28-day course of leaf and root extract administration, notable hypoglycemic effects were observed along with reductions in serum glucose, cholesterol, triglyceride, urea, and creatinine levels and enzyme activity [27]. Insulin insufficiency and beta-cell death are the ultimate results of a protracted inflammatory process in type I diabetes, an autoimmune illness. It has been demonstrated that extracts from *B. serrata* gum resin have anti-inflammatory qualities, particularly when it comes to addressing autoimmune disease-related variables or mediators [28]. According to the study, *boswellia* extract contains anti-diabetic properties and may shield the kidneys and liver from the negative consequences of diabetes.

▪ **Antimicrobial effects**

According to a study, boswellic acids have antibacterial properties against a variety of microorganisms, including gram-positive and gram-negative bacterial strains as well as fungi. AKBA was the most effective boswellic acid at inhibiting bacterial pathogens. Nevertheless, only gram-positive bacteria were susceptible to AKBA's action. The

presence of a lipophilic outer membrane, which is mainly made up of lipopolysaccharide molecules and forms a hydrophilic permeability barrier that protects against the effects of highly hydrophobic compounds, may be the cause of gram-negative bacteria's resistance to lipophilic AKBA [29]. In a study, AKBA was found to be effective in inhibiting the staphylococcal biofilm forming property. This report showed that AKBA can prevent as well as reduce the biofilm generation by *Staphylococcus aureus* and *Staphylococcus epidermidis* [30].

The antimicrobial activity of boswellic acid molecules was studied against the oral cavity pathogens. AKBA can be used in the development of an antibacterial agent against oral pathogens and can be used in mouthwash for preventing and treating oral infections.

▪ In improving memory

According to conventional medicine, frankincense, also known as *olibanum*, enhances learning and memory when consumed. It has been used to aid memory in the elderly and to boost the intelligence and memory of fetuses. Results of a study indicate that rats whose mothers were given an oral aqueous extract of *B. serrata* during gestation had much higher learning capacities in the post-learning stage, as well as better short- and long-term memory [31].

The hippocampal region is a sensitive area of the brain that plays a role in learning and memory functions. The dendritic systems represent the majority of the receptive surface of neurons, and their organization is crucial for the integration and transfer of information at the synaptic level [32]. An increase in the somal volume of hippocampal neurons in the offspring of pregnant mothers who consumed frankincense during their pregnancy. These results imply that frankincense and its compounds need to be thoroughly studied in neurophysiology and potentially for the treatment of neurodegenerative disorders in the future.

Learning and memory significantly declined in a study when adult males were given methimazole to induce hypothyroidism [33]. It was discovered that using frankincense could effectively prevent this deficit. This finding bolsters the conventional wisdom that *olibanum* improves memory and learning abilities.

▪ In enhancing fertility

Numerous plant species have been investigated for their impact on fertility, with backing from both domestic and foreign organizations. The people of Jordan utilize frankincense as a fertility enhancer and aphrodisiac. Boswellic acids and other pentacyclic triterpenes, which share a chemical structure with steroids, are found in frankincense gum resin [34].

Frankincense was shown to be highly effective in raising male fertility rates and examining its effects on the reproductive system in a study that was carried out. Furthermore, there was a rise in both the number of implantations and viable pregnancies, which could perhaps be attributed to the improved sperm motility and density. The medication may affect the pituitary gland and raise the primary spermatogenesis hormones. A notable rise in cauda epididymis sperm motility was noted in the treatment group; this could be attributed to frankincense's impact on oxidative phosphorylation enzymes. Finally, frankincense resin is a substance that aids in conception due to its effects

on pituitary gland cells. Further research is needed to pinpoint the precise mechanism of action of frankincense.

Side effects

It has the potential to hasten menstrual flow and cause miscarriage in expectant mothers.

Other possible side effects of boswellia include

- Nausea
- Acid Reflux
- Diarrhea
- Skin rashes

Boswellia extract may also interact with certain medications, including ibuprofen, aspirin, and other non-steroidal anti-inflammatory drugs (NSAIDs).

Discussion

All of these studies seem to point to the efficacy of *B. serrata* extracts in the treatment of a variety of diseases that are aggravated or sustained by inflammatory processes. *B. S* has long been used to treat inflammatory illnesses. Boswellic acid α and β as well as other pentacyclic triterpenic acids are its primary pharmacologically active components. By affecting 5-lipoxygenase, cyclooxygenase, and the complement system, these substances have been demonstrated to decrease pro-inflammatory activities [35].

Though it is not convincing, the evidence reviewed here may be encouraging. For any illness, there are not enough published big randomised clinical studies. It is not possible to directly compare the substance and potency of the drugs utilized in these studies. Generally, oral administration of 600-3000 mg of gum resin per day or similar is advised due to the lack of knowledge regarding the pharmacokinetics and ideal dosage of *B. serrata* extracts.

There are dozens of *B. serrata* oral medicines on the market. Most of them are offered as food supplements rather than under medical regulations. Thankfully, *B. serrata* has a good safety record. Certain data can suggest that there is a chance of moderate side effects such as nausea, acid reflux, and gastrointestinal distress. There is no proof of any significant medication interactions.

Conclusion

Boswellia has a long history of medicinal use in natural practices. Early research shows that it appears to be a potent anti-inflammatory and that it has promise as a supportive treatment for various inflammatory disorders in the body. While the existing research on boswellia is promising, its anti-inflammatory activities in various disorders. Frankincense has a significant effect on the hippocampus, increasing the amount of dendritic segments and branching in the neuron cells there. This leads to more synaptic connections in the area and improves learning and memory. Researching the effects of frankincense on neurophysiology [36] in great detail may be the first step in developing a supplementary or alternative natural medication that can be used to treat, prevent, or manage many neurodegenerative illnesses, including Parkinson's and Alzheimer's. Additional human clinical trials and investigations are required to validate the health advantages of boswellia use. This article provided a review of the pharmacokinetics, clinical and preclinical trial results, and phytochemical ingredients of

BS.

Conflict of Interest:

Not available

Financial Support:

Not available

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How to Cite This Article

Singh B, Sonkar DK, Gupta K. *Boswellia serrata*: Its phytochemistry, pharmacological activity and its potential health benefits. International Journal of Homoeopathic Sciences. 2024;8(2):244-250.

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