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Review

Therapeutic Effects of Boswellia in Different Diseases: A Systematic Review on Human Studies

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Abstract

Boswellia, has been utilized for centuries in various cultures for its potential health benefits. It is known for its anti-inflammatory, antioxidant and immune-stimulating properties. Despite its historical use, scientific evidence regarding its efficacy and safety remains limited. This systematic review aims to evaluate the effectiveness of Boswellia in treating various diseases by analyzing randomized controlled trials (RCTs) from the MEDLINE database from 2001 to the first half of 2025. Data from RCTs involving human subjects were collected, focusing on the effects of Boswellia versus placebo. Key factors included age, type of disease, dosage, and duration of treatment. Outcomes assessed included efficacy and any adverse effects associated with Boswellia use. These studies included a total of 3274 individuals, comprising 1651 cases and 1623 controls, with ages ranging from 15 to 85 years. Of the 49 selected research studies: 12 studies focused on patients with osteoarthritis, 8 studies investigated gastrointestinal diseases, 8 studies examined neurological diseases, 5 studies addressed cutaneous reactions, 5 studies looked at cancer, 3 studies on diabetes mellitus, 2 studies on oral lesions and 2 on joint pain. Labor pain, asthma, ankle sprain, and obesity each had one study dedicated to them. The majority of studies (91.8%) reported better treatment outcomes of various diseases. However, four studies specifically focused on Crohn's disease, burn wounds, cancer-related fatigue and diabetes mellitus, showing no better outcomes. Ten studies did not consider any adverse effects, 19 studies observed no adverse reactions and the remaining studies noted minor gastrointestinal or skin manifestations with Boswellia. The review highlighted that Boswellia could serve as a complementary treatment for patients suffering from the various diseases studied. Current evidence suggests that Boswellia is generally well-tolerated. There is a need for additional investigations into its efficacy in various diseases through studies with a large number of participants.

Keywords: Boswellia; Clinical trial; Frankincense; Systematic review; Adverse effect; Therapeutic effect

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Introduction

Boswellia is an aromatic resin with a rich history of use in various cultural practices. It is commonly traded for religious ceremonies as incense and serves as a key ingredient in perfumes, natural medicines, and essential oils. The species of Boswellia that produce true frankincense include: *Boswellia sacra* Flück., *Boswellia serrata* Roxb., and *Boswellia papyrifera* (Caill.) Hochst. . The major active constituent is boswellic acid, which is believed to contribute to its therapeutic properties [1-2]. Boswellia is native to dry, hilly regions across North Africa, Yemen, Pakistan, and India. In recent years, the popularity of Boswellia has been increasing in Western and European countries, reflecting a growing interest in its potential health benefits [3,4].

Boswellia resin, a sticky substance derived from *Boswellia* spp., has been utilized in Asian and African folk medicine for centuries to treat various illnesses. Recent researches have highlighted its potential therapeutic properties. Boswellia is believed to exert its effects through several mechanisms: down regulation of the pro-inflammatory cytokines, it reduces leukotriene levels and inhibits the nuclear factor-κB (NF-κB) pathway; enzyme activity reduction, it decreases the activity of cathepsin G and prostaglandin E synthase [5, 6]. These anti-inflammatory properties make Boswellia beneficial for several conditions such as bronchial asthma, degenerative and inflammatory arthritis, and inflammatory bowel diseases [7,8]. Emerging studies suggest that Boswellia may also be useful in cancer treatment, particularly for breast cancer, by impacting apoptosis and reducing angiogenesis in cancerous cells [9, 10]. Additionally, research has explored Boswellia's potential in managing diabetes mellitus, likely due to its therapeutic effects on blood sugar regulation. It may also have benefits for neurodegenerative diseases like Alzheimer's diseases and multiple sclerosis, attributed to its antioxidative, anti-inflammatory, anti-amyloidogenic, and anti-apoptotic properties [11,12].

While Boswellia shows promise across various diseases, the extent of its efficacy can vary. Given the limited systematic reviews on the therapeutic effects of Boswellia, this study was undertaken to evaluate its efficacy across various disorders.

Materials and Methods

Search strategy

An electronic search was conducted to gather scientific literature regarding Boswellia published in the database PubMed/Medline (NLM), Scopus, Science Direct, Cochrane Library, ProQuest, Embase, Web of Science, and Google Scholar for articles published up to the first half of 2025. The study adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta- analyses (PRISMA) statement to ensure a rigorous and transparent review process. The search keywords in PubMed database was (Boswellia [MeSH Major Topic]) OR (Boswellia serrata [Title/Abstract])) OR (Boswellia carteri [Title/Abstract])) OR (Boswellia carterii [Title/Abstract])) OR (Boswellia sacra[Title/Abstract])) OR (Frankincense [MeSH Major Topic])) OR (Olibanum Resin [Title/Abstract])) OR (Resin, Olibanum [Title/Abstract])) OR (Frankincense Resin[Title/Abstract])) OR (Resin, Frankincense[Title/Abstract])) OR (Olibanum [Title/Abstract])) OR (salai guggal [Supplementary Concept])) OR (Sallaki [Title/Abstract])) OR (boswellic acid[Supplementary Concept]. The search field was "Title/Abstract/Keywords" in Scopus and Cochrane Library database, "Title/Abstract" in Embase, in Web of Science was "Topic" and in Science Direct all relevant research articles were obtained. The Boolean operation (i.e. OR) was used between these keywords to combine them. The search keywords were systematically explored across all databases, and the retrieved articles were imported into EndNote for classification. Additionally, the reference sections of all included studies were reviewed to identify any further relevant articles related to our title.

PICO template

According to the PICOs (Population, Intervention/Exposure, Comparator, Outcome, Study Design) template, the inclusion criteria for the study were as follows: Population (P): Human participants with various disorders, including conditions such as osteoarthritis; inflammatory bowel disease, neurological disorders, cutaneous diseases, breast conditions, diabetes, asthma, obesity, and persistent knee pain.

Intervention/Exposure (I/E): Mono herbal Boswellia preparations, primarily from *B. serrata*, but including also *B. sacra/ B. carterii* or unspecified variants, administrated by any route or formulation, at any dose and duration.

Comparator (C): Placebo, no treatment, usual care, or single -agent active comparators. Studies involving polyherbal interventions were excluded.

Outcomes (O): Condition-specific clinical efficacy measures, including pain, function, disease activity/remission, cognitive scores, wound healing, tumor metrics, glycemic/lipid outcomes, inhaler use, anthropometrics. Patient-reported outcomes and safety/adverse events were also considered.

Study Design (S): All types of clinical trials were included, encompassing randomized, non- randomized, and open- label trials that evaluated the therapeutic effect of Boswellia. Studies published in any languages were considered. Studies were excluded if they: 1) involved multi-herb treatments; 2) were an-

imal reports; 3) were in vitro and molecular studies; 4) were case reports; 5) involved healthy volunteers; 6) were letters to the editor, book selections, or article without available abstracts and full texts. Study participants primarily had diseases such as osteoarthritis, inflammatory bowed disease or asthma.

Data collection

All retrieved data were independently assessed by two authors (ZS, MM). Any disagreements were resolved with input from another author (AT) for the final decision.

We extracted the following information from each study: name of the first author, publication year, type of study, sample size of patients and type of disease. Additionally, we considered details about Boswellia, including: dosage, species, preparation method, administration interval, treatment duration, efficacy and adverse effects.

Outcome assessment for efficacy

Efficacy is evaluated by considering improvement in specific symptoms across various conditions such as improvement in joint pain and physical activity in osteoarthritis, reduction in abdominal pain and normalization of bowel movements in gastrointestinal diseases, decreased in breast density in affected individuals, improved in skin lesions among patients with cutaneous diseases, lower blood sugar levels in individuals with diabetes mellitus.

Safety

Any adverse event reported.

Data Analysis

The extracted data were entered into Excel tables.

Ethics Statements

Ethical approval: The study was approved by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.MED.REC.1401.299).

Results

Literature search

Initial databases searches identified 4263 articles. Additionally, 7 studies were found through hand searches and expert recommendations, leading to a total of 4151 articles screened. From these, 147 articles were selected for full-text review, and ultimately, 49 articles were included in this systematic review. Figure 1 illustrates the article selection process according to the PRISMA flowchart in the present study [15].

Risk of bias assessment

To assess the risk of bias, we applied the Cochrane Risk of Bias Tool 2.0 (ROB2) based on the study design (i.e., parallel, cross-over, or cluster RCT) as outlined by Higgins et al. studies [13, 14]. The results of the risk of bias for each primary study, as well as the total of studies, are reported in figures 2 and 3. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the certainty of evidence with detailed criteria presented in figure 2 and 3 (Higgins et al., 2019). All initial rating began at a high level of certainty, in accordance with guidelines for meta-analyses that includes only RCTs. The GRADE assessment was conducted by two authors (ZS, MM), while AT served as the adjudicator in cases of disagreement. As shown in figure 2, 26 studied were assessed to have a low risk of bias, 12 studies had some concern, and 11 studies were rated with a high risk of bias. Figure 3 illustrates that most studies either had a low risk of bias or raised some concerns.

Characteristics of the studies

The systematic review encompassed 49 clinical trials after evaluating inclusion and exclusion criteria. This review included a total of 3274 participants, compromising 1651 cases and 1623 controls [16-64]. The age of participants ranged from 15 to 85 years, and all studies were published from 2001 and the first half of 2025.

Of the 49 selected research studies, the distribution is as follows: 12 studies on patients with osteoarthritis [16-27], 8 studies on gastrointestinal diseases [28-35], 8 clinical studies on neurological disorders [36-43], 5 studies on cutaneous diseases [44-48] and 5 on cancer and its related fatigue [49-53], 3 on diabetes [55,56,62] and 2 on oral lesions [54,63], 2 on joint pain [58,64], 1 asthma [57], 1 obesity [59], 1 labor pain [61] and 1 ankle sprain [60] (Table 1-6).

The majority of studies, 41 (83.7 %) focused on *Boswellia serrata* Roxb. ex Colebr. extract, while 5 (10.2 %) examines Boswellia sacra Flück (also known as *Boswellia carterii* Birdw.), and 3 (6.1 %) involved unspecified species (see tables 1-6).

In terms of preparation, 38 studies utilize oral forms (capsules, tablets, sachets, resin); while 9 studies applied topical forms (oil, gel, cream). Additionally, one study each explored mouthwash and sitz bath formulation.

Adverse effects were not reported in 10 studies, with 19 studies observed no adverse reactions. The remaining studies noted minor gastrointestinal (GI) or skin manifestations (see tables 1-6).

Investigators demonstrated that herbal formulations of Boswellia impact various conditions, including: osteoarthritis, gastrointestinal complaints, skin diseases and neurological disorders, breast density, diabetes mellitus and asthma. However, four studies [31,48,52,62]

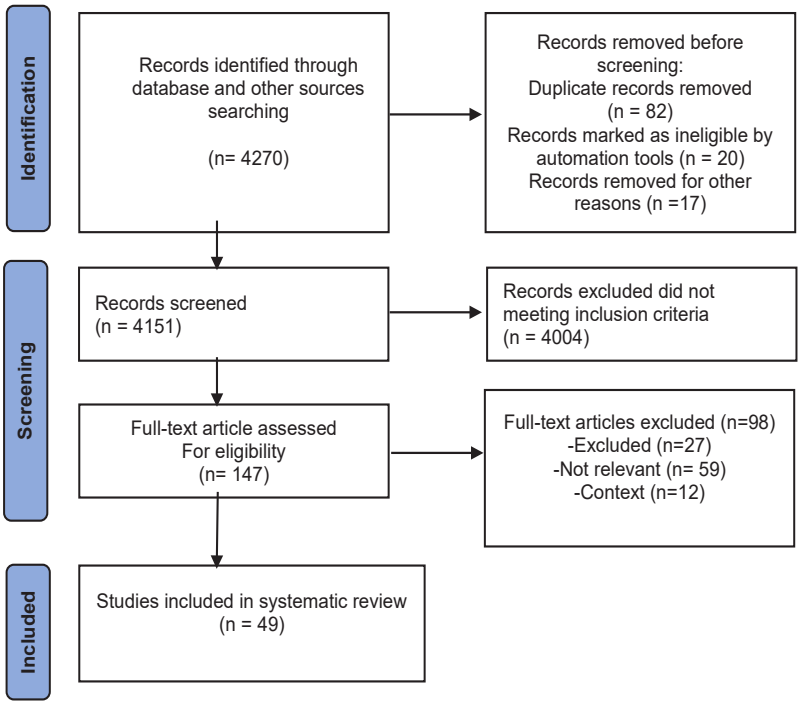

Figure 1. Flow diagram for study inclusion in the systematic review

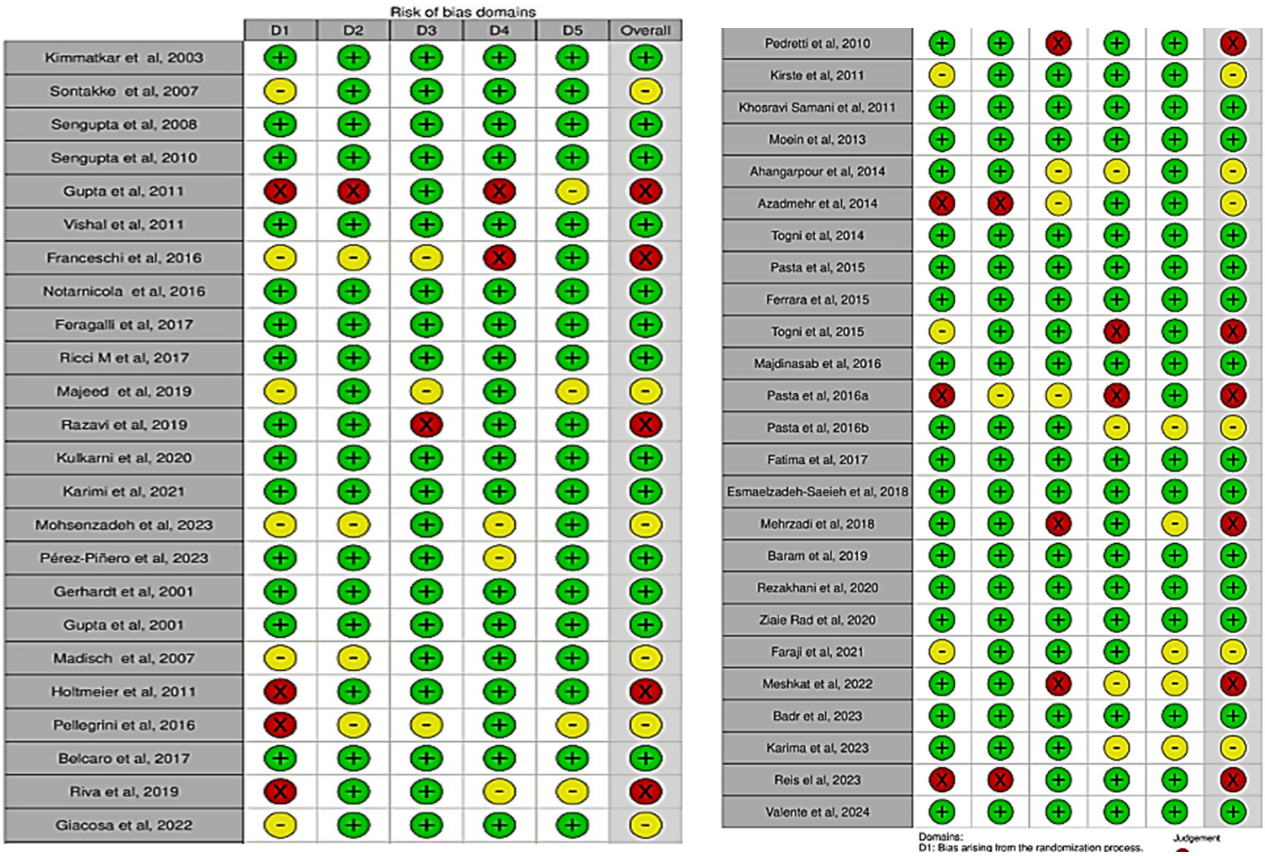

Figure 2. Assessment of risk bias in the included studies: 26 had a low risk of bias, 12 had some concern, and 11 were rated with a high risk of bias.

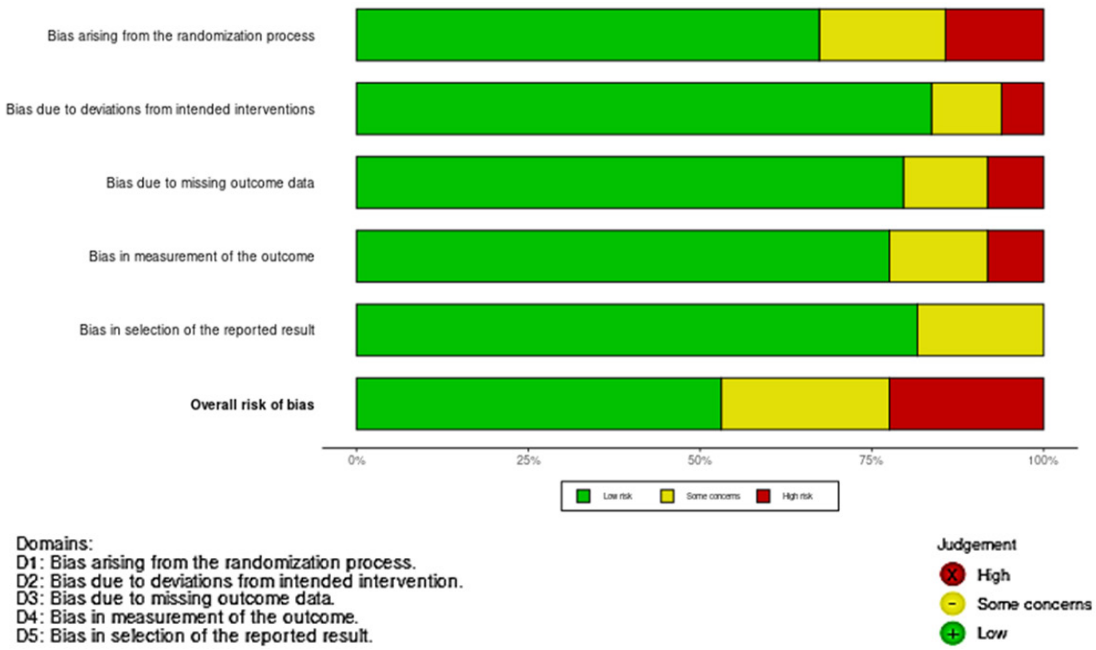

Figure 3. Risk of bias assessment for the included studies: most studies either had a low risk of bias or raised some concerns.

specifically focused on conditions including Crohn's disease, second-degree burn wounds, cancer-related fatigue and diabetes mellitus type 2, showing no better outcomes than placebo in clinical trials.

Discussion

There has been growing concern regarding the increasing clinical use of complementary medicine, particularly with plant- based natural products, among patients and health specialists in recent years. This systematic review aims to assess the efficacy of this class of complementary or alternative medicines in humans. In total, we included 49 clinical trial research studies: 12 studies on patients with osteoarthritis, 8 studies on gastrointestinal diseases, 8 clinical studies on neurological disorders, and 21 studies on additional disorders.

Osteoarthritis is a prevalent condition affecting over 500 million individuals globally, making it the most common form of arthritis [65]. The knee joint is most frequently impacted, with pain being the primary symptom that prompts patients to seek medical attention and diagnosis. The pathogenesis of osteoarthritis involves both the degradation of cartilage and the remodeling of bone, with inflammatory processes playing a crucial role. Currently, there are no approved disease-modifying drugs specifically for osteoarthritis. Conventional treatments primarily consist of non-steroidal anti-inflammatory drugs (NSAIDs) and physical therapy, which are used to manage symptoms until total joint replacement becomes necessary [66, 67]. Several clinical trials evaluated the effects of Boswellia on osteoarthritis. In total, 12 studies focused on its positive effects in this context, with two other studies specifically examining its impact on patients with osteo-muscular pain [58,64]. The majority of these studies (83.3%) utilized oral formulations; while a few employed topical oil. Notably, research by Mohsenzadeh et al. demonstrated significant pain relief and improved knee joint function in 33 patients with osteoarthritis after using topical oily solution containing Boswellia extract [27]. Similarly, Majeed et al. conducted a study on a standardized oral supplementation of Boswellia in 24 patients with knee osteoarthritis over a four- month period. The results showed significant improvements in physical function, pain reduction, and decreased stiffness compared to placebo [24]. Based on the findings from the included studies, it is suggested that Boswellia may serve as an effective complementary treatment for patients suffering from osteoarthritis.

Inflammatory bowel disease (IBD) is a chronic inflammatory condition of the gastrointestinal tract that includes both Crohn's disease and ulcerative colitis. A comprehensive understanding of the immunopathogenesis of IBD is crucial for developing new therapeutic approaches [68,69]. Research by Pellegrini et al. demonstrated the significant beneficial effects of Boswellia in patients with ulcerative colitis during the remission phase. Improvements were observed across multiple markers, including: diffuse intestinal pain, occult blood in stools, crampy abdominal pain, watery

Table 1. Characteristics of clinical trial studies on osteoarthritis treated with Boswellia

Authors, (publication year)	Total number (Boswellia cases)	Age years	Disease	Preparation, dose, species	Treatment duration	Boswellia's side effects	Boswellia's efficacy
Kimmatkar et al. (2003) [16]	30 (15)	> 40	Osteoarthritis of knee	Cap, 333 mg thrice, *B. serrata*	8 weeks	Mild GI manifestation	Significantly decrease in knee pain, increased knee flexion and increased walking distance.
Sontakke et al. (2007) [17]	66 (33)	40-70	Osteoarthritis of knee	Cap, 333 mg thrice, *B. serrata*	6 months	Mild GI manifestation	Slower onset of action than valdecoxib but the effect persists more.
Sengupta et al. (2008) [18]	75 (50)	40-80	Osteoarthritis of knee	Cap, 50 mg and 125 mg twice, *B. serrata*	3 months	Mild GI manifestation and mild other symptoms	Reduces pain and improves physical functioning
Sengupta et al. (2010) [19]	60 (40)	40-80	Osteoarthritis of knee	Cap, two 50 mg twice, *B. serrata*	3 months	Mild GI manifestation	Clinically and statistically significant improvements in pain scores and physical function scores
Gupta et al. (2011) [20]	56 (29)	40-70	Osteoarthritis	Cap, four 500 mg thrice, *B. serrata*	2 months	No report	Reduces pain and improves physical functioning
Vishal et al. (2011) [21]	60 (30)	40-80	Osteoarthritis of knee	Cap, 50 mg twice, *B. serrata*	1 month	Mild GI manifestation	Clinically and statistically significant improvements in pain scores and physical function
Notarnicola et al. (2016) [22]	120 (60)	59.2 ± 13	Knee arthritis	Sachet, 3.6 mg twice, *B. serrata*	2 months	No side effect	Reduces pain and improves physical functioning
Ricci M et al. (2017) [23]	60 (30)	40-70	Osteoarthritis of knee	Tab, 100 mg once, *B. serrata*	20 days	No report	Reduces pain and improves physical functioning on early osteoarthritis
Majeed et al. (2019) [24]	48 (24)	35-75	Osteoarthritis of knee	Tab, 169.33 mg twice, *B. serrata*	4 months	No serious adverse events	Significantly improved the physical function by reducing pain and stiffness
Razavi et al. (2019) [25]	154 (51)	18-80	Osteoarthritis of knee	Oil topical, 10 drops twice, *B. sacra (B. carterii)*	6 weeks	Skin pruritus	Symptomatic treatment of knee pain
Kulkarni et al. (2020) [26]	45 (45)	> 18	Osteoarthritis of knee	Tab & Cap thrice, *B. serrata* gum extract	2 months	No adverse events	Marked improvement in pain
Mohsenzadeh et al. (2023) [27]	70 (33)	40-80	Osteoarthritis of knee	Topical oily solution thrice, *B. serrata*	1 month	Mild itching and redness	Decreased pain severity and improve the function

Table 2. Characteristics of clinical trial studies on gastrointestinal diseases treated with Boswellia

Authors, (publication year)	Total number (Boswellia cases)	Age years	Disease	Preparation, dose, species	Treatment duration	Boswellia's side effects	Boswellia's efficacy
Gerhardt et al. (2001) [28]	102 (44)	18-70	Crohn's disease	Tab, three 400 mg thrice, *B. serrata*	8 weeks	Mild tiredness	Change of activity disease similar to mesalazine
Gupta et al. (2001) [29]	30 (20)	18-48	Chronic Colitis	Cap, 300 mg thrice, *B. serrata*	6 weeks	Mild heartburn	Clinical symptoms exhibited declining trends. Remission twice as high but not significant
Madisch et al. (2007) [30]	31 (16)	18-80	Collagenous colitis	Cap, 400 mg thrice, *B. serrata*	6 weeks	No serious adverse events	Proportion of patients in clinical remission was higher but no effect on histology and quality of life.
Holtmeier et al. (2011) [31]	82 (42)	18-75	Crohn's disease	Cap, two 400 mg thrice, *B. serrata*	52 weeks	Mild GI manifestation	No advantages in favor of active treatment. Lack of efficacy in maintaining remission
Pellegrini et al. (2016) [32]	43 (22)	48.4	Ulcerative colitis	Tab, 250 mg once, *B. serrata*	4 weeks	No report	A significant beneficial positive effect on diffuse intestinal pain, occult blood in stools, bowel movements and cramps, watery stools, malaise, anemia, rectal involvement, need for concomitant drugs and medical attention
Belcaro et al. (2017) [33]	71 (24)	36.0 ± 3.0	Irritable bowel symptom	Tab, 250 mg once, *B. serrata*	4 weeks	Mild stypsis	Clinical symptoms improved and the subjects who needed medical attention significantly decreased
Riva et al. (2019) [34]	69 (35)	45.1±1.2	Irritable bowel syndrome	Tab, 250 mg once, *B. serrata*	6 months	No serious adverse events	Common symptoms of recurrent abdominal pain, altered bowel movements, and spontaneous cramps of the abdomen appear to be better
Giacosa et al. (2022) [35]	49 (24)	18-70	Acute Diarrhea	Tab, 250 mg twice, *B. serrata*	5 days	No adverse effect	Reduces the time it takes to become healthy, the frequency of stools, the abdominal pain and nausea

stools, malaise, anemia and rectal involvement. Furthermore, a decrease in fecal calprotectin concentration- a key marker of bowel inflammation- was noted in these patients, indicating a reduction in inflammatory activity [32]. In contrast, a study conducted by Holtmeier et al. involving 42 patients with Crohn's disease over a 52- week period found no significant benefits from Boswellia supplementation [31]. This discrepancy may be attributed to differences in genetic backgrounds and environmental factors among patients with IBD, which can influence treatment outcomes.

Additionally, acute diarrhea remains a significant health challenge in developing countries. This review evaluated the efficacy of Boswellia in treating acute diarrhea through the analysis of one randomized controlled trial [35]. It is needed for further studies to better understand its potential benefits in this context. Numerous scientific studies have demonstrated the effects of Boswellia and its active constituents on the central nervous system [70,71]. Our review identified 7 selected studies that collectively demonstrate significant benefits associated with *B. serrata* and its components. These studies indicate that Boswellia has

Table 3. Characteristics of clinical trial studies on neurological disorders treated with Boswellia

Authors, (publication year)	Total number (Boswellia)	Age years	Disease	Preparation, dose, species	Treatment duration	Boswellia's side effects	Boswellia's efficacy
Kirste et al. (2011) [36]	40 (20)	32-83	Cerebral edema after radiation	Cap, Four 350 mg thrice, *B. serrata*	1 week	No adverse effect	Significantly reduced cerebral edema
Moein et al. (2013) [37]	38 (18)	15-65	Diffuse axonal injury	Cap, 360 mg thrice, *B. serrata*	6 weeks	Mild GI manifestation, skin rash	Not significantly effect on disability rating scale, significant improvement in cognitive ability to self-care
Majdinasab et al. (2016) [38]	60 (30)	16-53	Multiple sclerosis	Cap, 450 mg twice, *B. serrata*	2 months	No serious adverse events	Improvement of California verbal learning test and brief visuospatial memory test
Baram et al. (2019) [39]	80 (41)	40-80	Ischemic stroke	Cap, two 400 mg thrice, Not mentioned	4 weeks	No side effect	A significant recovery in neurological function during the 1-month follow-up
Rezakhani et al. (2020) [40]	120 (60)	55-85	Memory impairment in mild cognitive impairment	Cap, 300 mg/kg, twice, *B. serrata*	12 weeks	No report	A significant effect on the improvement of memory impairment
Karimi et al. (2021) [41]	36 (18)	18-65	Carpal tunnel syndrome	Oleogel, 1.5 fingertips twice (topical), *B. carterri*	6 weeks	No report	Improved pain and functional status but no significant changes were observed in electrodiagnostic parameters.
Meshkat et al. (2022) [42]	80 (46)	36.70 ± 15.2	Traumatic brain injury	Tab, 400 mg thrice, *B. serrata*	3 months	Minor adverse effect	Significant improvement in cognitive function
Karima et al. (2023) [43]	85 (43)	60-85	Mild to moderate Alzheimer's Disease	Cap, 400 mg thrice, *B. serrata*	6 months	Mild gastrointestinal side effects	Positive cognitive effects by neuropsychiatric assessment questionnaire

Table 4. Characteristics of clinical- trial studies on cutaneous diseases treated with Boswellia

Authors, (publication year)	Total number (Boswellia)	Age years	Disease	Preparation, dose, species	Treatment duration	Boswellia's side effects	Boswellia's efficacy
Pedretti et al. (2010) [44]	15 (15)	31-68	Photo and age-damaged skin	Cream, 0.5 % once, *B. serrata*	1 month	No adverse effect	Significant improvement of tactile roughness and fine lines in the half side of the face
Togni et al. (2014) [45]	59 (19)	27.3	Psoriasis and erythematous eczema	Cream, twice, *B. serrata*	30 days	Not observed any side effects	Improved both itch and erythema in 60% of cases
Togni et al. (2015) [46]	114 (55)	32-78	Radiotherapy skin damage in mammary carcinoma	Cream, 2% twice, *B. serrata*	Immediately after radiation	skin superficial symptoms including itching or burning sensation	Effective in reducing the use of topical corticosteroids and reduce the grade of erythema
Faraji et al. (2021) [47]	90 (30)	18-41	Episiotomy wound in primiparous women	Sitz bath, 20 mL extract 10 min twice, *B. carterii*	1 week	No adverse effect	Increased wound healing scores
Badr et al. (2023) [48]	54 (28)	***20-60***	Second-degree burn wounds	Cream 40 % *B. carterii*	Until complete healing	No report	Progressive healing effect (both groups showed a progressive result, no better than placebo)

Table 5. Characteristics of clinical trial studies on patients with cancer treated with Boswellia

Authors, (publication year)	Total number (Boswellia)	Age years	Disease	Preparation, dose, species	Treatment duration	Boswellia's side effects	Boswellia's efficacy
Pasta et al. (2015) [49]	62 (32)	22-51	Mammographic breast density	Cap, two 50 mg twice, Not mentioned	6 months	No significant adverse effects	Significant reduction on the breast density
Pasta et al. (2016) [50]	64 (36)	15-30	Breast fibroadenoma	Cap, two 50mg twice, *B. serrata*	6 months	No side effects	Reduces fibroadenoma dimension
Pasta et al. (2016) [51]	62 (32)	22-51	Mastalgia and benign breast lump	Cap, two 50 mg twice, Not mentioned	6 months	Without any side effects	Reduction of mastalgia and breast density
Reis et al. (2023) [52]	70 (35)	28 - 82	Cancer-related fatigue	Oil 5%, on sole and feet *B. carterii*	2 days before chemotherapy to 2 days after it for 2 cycles	Mild dermatitis	No statistically significant changes in fatigue
Valente et al. (2024) [53]	22 (20)	≥ 18	Invasive breast cancer	Cap, two 400 mg thrice, *B. serrata*	11 days	No serious adverse events	Reduction in proliferation with no change in apoptosis

Table 6. Characteristics of clinical trial studies on patients with other diseases treated with Boswellia

Authors, (publication year)	Total number (Boswellia)	Age years	Disease	Preparation, dose, species	Treatment duration	Boswellia's side effects	Boswellia's efficacy
Khosravi Samani et al. (2011) [54]	75(49)	15-18	Moderate	Extract, 0.1 g thrice, or powder, 0.2 g thrice, *B. serrata*	2 weeks	No report	Improve inflammation of gingiva
Ahangarpour et al. (2014) [55]	60 (30)	30-48	Diabetes mellitus type 2	Resin, 300 mg thrice, *B. serrata*	6 weeks	Not observed any side effects	Significant increase in blood HDL, reduction of serum triglyceride and LDL
Azadmehr et al. (2014) [56]	71 (37)	18-65	Diabetes mellitus type 2	Cap, 400 mg twice, *B. serrata*	12 weeks	Not observed any side effects	Blood sugar, HbA1c, Insulin consumption, cholesterol, LDL and triglyceride levels decreased
Ferrara et al. (2015) [57]	32 (18)	18-80	Asthma	Tab, 500 mg once, *B. serrata*	4 weeks	Mild to moderate adverse events	Reduce the need for inhalation therapy
Franceschi et al. (2016) [58]	52 (25)	18.3± 4.3	Osteo-muscular pain	Tab, two 250 mg daily, *B. serrata*	4 weeks	No report	Reduces pain and improves physical functioning, beneficial effect on minimal joint effusion and use of other drugs
Fatima et al. (2017) [59]	48 (16)	20-60	Obese adults	Powder, 3 gm once, B. *serrata*	8 weeks	Without any side effects	Significant reduction in anthropometric indices and improvement in obesity-associated symptoms
Feragalli et al. (2017) [60]	72 (35)	32.1	Ankle sprain	Tab, 250 mg once, *B. serrata*	7 days	No report	Effective in improving recovery after ankle sprain of mild severity with potentially beneficial role in relieving the trauma
Esmaelzadeh-Saeieh et al. (2018) [61]	126 (63)	20-40	Labor Pain among nulliparous women	Oil on gauze, 0.2 ml, (aromatherapy) *B. carterrii*	Every 30 min up to a cervical dilation of 10 cm	No side effect	Labor pain intensity decreased significantly at cervical dilations of 3–4 and 8-10 cm
Mehrzadi et al. (2018) [62]	56 (27)	18-65	Diabetes mellitus type 2	resin, 250 mg twice, *B. serrata*	12 weeks	Dyspepsia	No better glucose and lipid-lowering effect
Rad et al. (2020) [63]	90 (45)	> 18	Dental Plaque Formation under Mechanical Ventilation	0.8% mouth wash, twice, *B. serrata*	4 days	No report	Effective in the prevention of dental plaque
Pérez-Piñero et al. (2023) [64]	120 (59)	40-75	Healthy with persistent knee pain	Tab, two 12.5 % twice, *B. serrata*	8 weeks	Mild GI manifestation	Reducing pain and sleep efficiency improved

the potential to reduce cerebral edema, enhance cognitive outcomes in patients, and ameliorate learning and memory dysfunction. These beneficial effects are primarily attributed to the antioxidant and anti-inflammatory properties inherent in Boswellia. The ability of this plant to combat oxidative stress and inflammation suggests its potential therapeutic applications in promoting neurological health and addressing various cognitive disorders. Carpal tunnel syndrome is a prevalent neurological condition resulting from the compression of the median nerve. In a study conducted by Karimi et al., 36 patients diagnosed with carpal tunnel syndrome were treated with topical Boswellia [41]. The results showed that improvement in clinical symptoms among patients receiving Boswellia was significantly superior to that of the placebo group. This suggests that topical application of Boswellia may be an effective therapeutic option for alleviating symptoms associated with carpal tunnel syndrome.

Boswellia has long been recognized for its soothing effects on damaged skin, attributed to its five-ring triterpene (pseudo-steroid) structure [72]. Our review found that 4 out of 5 included studies on cutaneous diseases treated with Boswellia reported a positive effect, particularly in healing of patients with hand wounds, episiotomy wounds, photo and age-damaged skin. Additionally, Boswellia has been shown to reduce the grade of erythema in patients experiencing skin damage from radiotherapy [46]. Supporting these findings, Badr et al. demonstrated that a cream containing 40 % *B. carterii* exhibited healing activity in treating second-degree burn wounds [48]. This review suggests a promising basis for the future application of Boswellia in the treatment of dermatitis and damaged skin, warranting further research in this area.

Cancer is a major cause of death worldwide and researchers are making significant efforts to treat it [73]. Several studies have demonstrated anti-proliferative and pro-apoptotic effects of Boswellia acids on various cancer cells [9,10]. In this review, a total of five reports focused on the management of breast cancer: three studies reported effective outcomes, including reduced pain and decreased size of the breast mass, as noted by Pasta et al. studies [49-51]. The study by Reis et al. indicates that the use of topical Boswellia did not lead to significant change in fatigue symptoms among patients experiencing cancer- related fatigue [52]. The study indicates a noteworthy reduction in cell proliferation without a change in apoptosis among women with invasive breast cancer [53]. These findings suggest a potential opportunity for using Boswellia as a complementary and alternative therapy in breast cancer. Further research is warranted to explore its efficacy and mechanisms in this context.

The therapeutic and protective effects of Boswellia species on type 2 diabetes mellitus have been investigated in two included studies, indicating their potential in reducing hyperglycemia and hyperlipidemia [55,56]. Kavitha et al. demonstrated that oral administration of *Boswellia glabra* leaf and root extract significantly lowered blood glucose levels and improved lipid profiles in alloxan-induced diabetic rats [74]. This effect was attributed to an increase in the synthesis of secretory granules in the beta cells. Conversely, Mehrzadi et al. investigated the use of *B. serrata* gum resin over an 8- week period, administrating 250 mg twice daily [62]. Their findings suggested that this treatment did not produce better results in glucose and lipid reduction compared to a placebo in diabetic patients. These mixed results highlight the need for further research to fully understand the positive impacts of Boswellia species on diabetes mellitus. Continued investigations could clarify their efficacy and mechanisms of action in managing diabetes- related complications.

Oral health is a crucial indicator of overall health, well-being and quality of life. Two studies have highlighted the positive effects of mouthwash containing Boswellia [54,63]. One study focused on its role in preventing dental plaque formation in patients undergoing mechanical ventilation; while the other emphasized its effectiveness in managing plaque-induced gingivitis. Given the anti-inflammatory and antibacterial properties of Boswellia [75], along with its safety as an herbal material, it appears that incorporating Boswellia – based mouthwash into routine oral care could benefit patients.

In a study examining the effects of Boswellia on asthma, 32 participants who received Boswellia alongside standard inhalational steroid and long- acting β2 agonist demonstrated a reduced need for inhalations compared to those who did not receive the herb [57]. Liu et al. proposed that the efficacy of Boswellic acid in treating asthma may stem from its ability to lower Th2 cytokines by inhibiting the expression of pSTAT6 and GATA-3 in murine models [76]. This mechanism highlights the potential of Boswellia in modulating inflammatory pathways associated with asthma.

Obesity is a significant medical condition that highlights the risk of various diseases and health issues. One study found the efficacy and safety of *B. serrata* in obese adults with Body Mass Index (BMI) ranging from 30 to 39.9 kg/m^2 [59]. However, more research is required to fully assess its effectiveness in managing obesity.

In the present systematic review, two studies demonstrated significant analgesic activity for Boswellia compared to placebo: one study focused on healthy individuals with persistent knee pain; while the other involved women experiencing labor pain [61,64]. Additionally, Prabhavathi et al. found that Boswellia significantly increased both the pain threshold and

pain tolerance (force and time) compared to placebo in healthy volunteers using a mechanical pain model [77].

Conclusion

This review could emphasize the application of Boswellia as an effective complementary treatment in patients suffering from osteoarthritis. Additionally, there is potential for Boswellia to serve as a complementary and alternative therapy for gastrointestinal diseases and other health conditions. Further investigations are recommended to explore these opportunities and confirm its therapeutic benefits across various medical contexts.

Conflict of Interests

Nothing to declare.

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