Perspective Article *Open Access*

Journal of Psychiatric Insight Review

ISSN: 3067-9249

DOI: doi.org/10.63721/25JPIR0120

Boswellia Serrata in Women's Health: An Integrative Review of Mechanisms, Clinical Efficacy and Future Perspectives

Elizabeth Pinheiro Mariano

American University, UCDB, ETEP, CUM, Campo Grande - Mato Grosso do Sul, Brazil

Citation: Elizabeth Pinheiro Mariano (2025) Boswellia Serrata in Women's Health: An Integrative Review of Mechanisms, Clinical Efficacy and Future Perspectives. J. of Psy Ins Review 1(4), 01-11. WMJ/JPIR-120

***Corresponding author:** Elizabeth Pinheiro Mariano, American University, UCDB, ETEP, CUM, Campo Grande - Mato Grosso do Sul, Brazil.

Submitted: 20.10.2025 **Accepted:** 27.10.2025 **Published:** 23.11.2025

Introduction

Women's health is a complex and multidimensional area that encompasses biological, hormonal, psychological, and sociocultural aspects, requiring therapeutic approaches that consider women's specificities throughout the different stages of life. Chronic noncommunicable diseases represent a major public health problem that disproportionately affects women, with an estimated prevalence of 38.53% among those of reproductive age. Furthermore, chronic inflammatory conditions, such as rheumatoid arthritis, osteoarthritis, inflammatory bowel diseases, and gynecological disorders, are more prevalent and severe in women [1].

The Brazilian epidemiological profile reveals that women face a double burden of morbidity, simultaneously experiencing diseases typical of developed countries, such as cardiovascular and chronic degenerative diseases, and those characteristic of developing countries, including maternal mortality and malnutrition. This complexity is compounded by social determinants of health, such as socioeconomic vulnerability, low educational attainment, racial inequality, and work overload, factors that significantly increase women's predisposition to chronic conditions. Studies show that approximately 20% of adults suffer from chronic pain, with half of chronic pain conditions predominantly affecting women, with only 20% being more prevalent in men [2].

In this context, Integrative and Complementary Health Practices, especially phytotherapy, have gained increasing relevance as safe, effective, and low-cost therapeutic alternatives for managing symptoms and conditions related to women's health. Phytotherapy, defined as the therapeutic practice based on the use of medicinal plants and their secondary metabolites, constitutes an ancient tradition that has been progressively incorporated into official health systems, including the Brazilian Unified Health System, as a strategy for comprehensive and humanized care. Incorporating a gender perspective into public health policies is essential, since historical power inequalities between men

and women have a strong impact on the health conditions of women [2].

Boswellia serrata, popularly known as frankincense Indian incense, or frankincense, is a moderate to large tree in the Burseraceae family, native to dry mountainous regions of India, North Africa, and the Middle East. The plant has been used for over 2,000 years in traditional Ayurvedic medicine, with historical references in the ancient Sushruta treatises. Samhita and Charaksamhita, who already described its beneficial properties for arthritic and inflammatory conditions. The resin obtained through incisions in the tree trunk constitutes the medicinal part with the greatest therapeutic value, being used both in religious and cultural ceremonies and in medicinal practices since time immemorial [3].

The chemical composition of Boswellia serrata is remarkably complex and rich in bioactive compounds. The resin contains oleoresins, essential oils, gums, and, mainly, triterpenoids, with boswellic acids standing out as the most pharmacologically active constituents. Standardized extracts typically contain 60–65% total boswellic acids , including four main pentacyclic terpene acids β- boswellic , acetyl-β-boswellic , 11-keto-β- boswellic , and acetyl-11-keto-β- boswellic , the latter being considered the most potent 5-lipoxygenase inhibitor. Pharmacognostic studies demonstrate that these compounds constitute approximately 30% of the total Boswellia resin. serrata and are responsible for most of its therapeutic activities [3].

The mechanism of anti-inflammatory action of Boswellia serrata was pioneered by Safayhi, Mack, and Ammon in 1992, who demonstrated that boswellic acids act as specific, non-redox inhibitors of the enzyme 5-lipoxygenase, crucial for leukotriene biosynthesis. Unlike conventional nonsteroidal anti-inflammatory drugs that inhibit cyclooxygenase, boswellic acids selectively block the 5-lipoxygenase pathway, reducing the production of pro-inflammatory substances such as leukotrienes, without directly affecting prostaglandin synthesis. Subsequently, Safayhi and Ammon in 1996 described that acetyl-11-keto-β- boswellic acid acts directly on 5-lipoxygenase purified from human leukocytes at a site selective for pentacyclic triterpenes, different from the binding site of the substrate arachidonate [4,5].

boswellic acids have multiple pharmacological actions relevant to women's health. Singh and colleagues, in studies conducted in the 1990s at the Regional Research Institute, Laboratory of India, demonstrated that boswellic acids exhibit dose-dependent anti-inflammatory activity in acute and chronic experimental models, including carrageenan- , histamine-, and dextran- induced edema , adjuvant arthritis, and formaldehyde-induced arthritis, with 25–46% inhibition in paw edema in rats and mice, and 35–59% anti-arthritic activity in adjuvant arthritis. Unlike nonsteroidal anti-inflammatory drugs, boswellic acids did not exhibit ulcerogenic effects, demonstrating a superior gastrointestinal safety profile.

Gayathri and collaborators, in a study published in 2007 in the International Immunopharmacology, demonstrated that pure compounds isolated from Boswellia extract serrata exhibit anti-inflammatory properties in human peripheral blood mononuclear cells and mouse macrophages through inhibition of tumor necrosis factor alpha (TNF-α), interleukin-1 beta (IL-1β), nitric oxide, and mitogen- activated kinases. The results revealed significant downregulation of Th1 cytokines (IFN-γ and IL-12) and upregulation of Th2 cytokines (IL-4 and IL-10), in addition to inhibition of the phosphorylation of JNK and p38 kinases, demonstrating the ability to naturally modulate anti-inflammatory activity in sites of chronic inflammation [6].

The antioxidant activity of boswellic acids has been confirmed in several experimental models, demonstrating the ability to neutralize free radicals such as superoxide anion and hydroxyl radicals, as well as inhibit lipid peroxidation and increase endogenous antioxidant levels. Recent studies indicate that Boswellia serrata modulates multiple molecular targets, including cellular receptors, enzymes, growth factors, and transcription factors, influencing both the immune response and cell survival. The proposed immunomodulatory mechanism involves direct interaction with IκB kinases and inhibition of nuclear factor- κB -regulated expression, in addition to reducing the production of interleukins and leukotrienes [7].

In the context of women's health, interest in the use of Boswellia serrata has increased significantly in recent

decades. Kimmatkar et al., in a randomized, double-blind, placebo-controlled clinical trial published in 2003, evaluated the efficacy and tolerability of Boswellia extract serrata in the treatment of knee osteoarthritis, demonstrating significant reduction in pain and improvement in physical function, establishing the scientific basis for its application in chronic inflammatory conditions prevalent in women [8].

Eshaghian and colleagues conducted a randomized, placebo-controlled clinical trial specifically focused on women's menstrual health, involving 102 women with heavy menstrual bleeding. The study demonstrated that treatment with frankincense (Boswellia) serrata oleoresin) at a dose of 300 mg three times a day for seven days of the menstrual cycle, starting on the first day of bleeding for two consecutive cycles, resulted in a statistically significant reduction in the duration of menstrual bleeding (-1.77 ± 2.47 days, p=0.003), evidencing the relevant therapeutic action of Boswellia as an adjuvant in the management of menstrual disorders [9].

Gupta and collaborators, in a study published in 2001 in the European Journal of Medical Research, evaluated the effects of Boswellia gum resin serrata extract in patients with chronic ulcerative colitis, a condition highly prevalent in young women. The study demonstrated that oral treatment with the extract promoted clinical and histopathological remission in patients with active disease, with efficacy similar to sulfasalazine and superior tolerability, demonstrating minimal side effects and therapeutic potential for inflammatory bowel diseases.

Yu and colleagues, in a systematic review and meta-analysis published in 2020 in Medicine, consolidated evidence from multiple randomized clinical trials demonstrating that Boswellia serrata is considered a potent anti-inflammatory, anti-arthritic, and analgesic agent and may be a therapeutic option for osteoarthritis. Quantitative analysis revealed significant improvements in pain, stiffness, and physical function scores, with a favorable safety profile and low incidence of adverse events, confirming its potential as an alternative or adjunct to conventional pharmacological therapies [10].

The high prevalence of chronic inflammatory diseases in women, combined with the adverse effects and contraindications of traditional pharmacological treatments, especially in vulnerable populations such as pregnant and lactating women and patients with multiple comorbidities, reinforces the need for safe and effective complementary therapeutic alternatives. In this sense, phytotherapy with Boswellia serrata emerges as a promising strategy for integrated care, aligned with the principles of evidence-based medicine and the guidelines for humanization and comprehensive care for women's health advocated by Brazilian public policies.

The present study aims to systematically review the available scientific evidence on the use of Boswellia serrata in women's health, analyzing its therapeutic effects in specific clinical conditions, mechanisms of action, safety profile, appropriate dosage, contraindications, and future research prospects. Through a careful analysis of national and international scientific literature, the aim is to provide technical and scientific support for health professionals, researchers, and managers interested in incorporating phytotherapy as a complementary therapeutic resource in the comprehensive management of women's health, contributing to the expansion of the repertoire of safe, effective, and accessible interventions available in the Brazilian health system [3].

Results

Osteoarthritis is one of the most prevalent musculoskeletal conditions in women, particularly after menopause, significantly affecting quality of life and functional capacity. Multiple randomized clinical trials have demonstrated the efficacy of Boswellia. serrata in the management of this condition. Kimmatkar et al., in a double-blind, placebo-controlled study published in 2003, evaluated 30 patients with knee osteoarthritis treated with Boswellia extract serrata containing 40% boswellic acids at a dose of 333 mg three times daily for eight weeks. The results revealed a significant reduction in pain, improved joint flexibility, and decreased edema, with all patients in the treated group experiencing reduced pain and increased walking ability, while in the placebo group there was no significant improvement [8].

Sengupta and colleagues conducted a series of rigorous clinical trials evaluating Boswellia -enriched formulations serrata. A study published in 2008 involving 75 patients with knee osteoarthritis demonstrated that 5-Loxin® extract (100 mg and 250 mg daily) promoted significant pain reduction and improved physical function in just seven days of treatment, with benefits sustained for 90 days. The analysis revealed statistically significant improvements in WOMAC pain scores, stiffness, and physical function, as well as inflammatory markers such as C-reactive protein and matrix metalloproteinase -3, with no serious adverse events reported [11].

In a later 2010 study, Sengupta and colleagues compared two advanced Boswellia formulations serrata (5-Loxin® and Aflapin®) versus placebo in 60 patients with knee osteoarthritis for 90 days. Both formulations demonstrated superior efficacy to placebo, with the Aflapin® group showing significant improvement after just five days of treatment. The results showed a 29.7% reduction in the WOMAC pain score in the 5-Loxin® group and 30.7% in the Aflapin® group, compared to only 6.7% in the placebo group. Furthermore, there was a significant improvement in physical function scores and a reduction in inflammatory markers, confirming the excellent safety and tolerability profile of both formulations [12].

Majeed and colleagues, in a double-blind randomized pilot clinical trial published in 2019, evaluated 48 patients with knee osteoarthritis for 120 days, a longer period than any previous study with Boswellia serrata. Treatment with Boswellin®, a standardized extract containing 30% acetyl-11-keto-β- boswellic acid, resulted in significant improvement in patients' physical function, reducing pain and stiffness compared to placebo. Notably, radiographic evaluations demonstrated an increase in knee joint space and a reduction in osteophytes, confirming the structural efficacy of the treatment. The extract also significantly reduced serum levels of high-sensitivity C-reactive protein, a potential inflammatory marker associated with knee osteoarthritis, with no serious adverse events reported [13].

More recently, Majeed and colleagues published a multicenter, triple-blind, randomized clinical trial in 2024 involving 105 patients newly diagnosed with degenerative hypertrophic osteoarthritis of the knee. Participants were randomized into three groups: placebo, Boswellin® Super 150 mg, or 300 mg twice daily for 90 days. The results demonstrated clear improvement as early as five days after starting treatment, with a 7.4% and 14.3% reduction in the Visual Analog Scale in the 150 mg and 300 mg groups, respectively. At 90 days, these improvements reached 45.3% and 61.9%, with effects sustained for 15 days after cessation of the supplement. The total WOMAC score improved 68.5% and 73.6% in the 150 mg and 300 mg doses, respectively, compared to only 22% in the placebo group. Gender-specific analysis revealed improvement in both men and women, confirming the effectiveness of Boswellia serrata regardless of sex [14].

Yu and colleagues, in a systematic review and meta-analysis published in 2020 in Medicine, consolidated evidence from seven randomized clinical trials involving 545 patients with osteoarthritis. The quantitative analysis demonstrated that Boswellia serrata and its extracts promote significant pain relief, with a weighted average reduction of -8.33 points on the Visual Analog Scale, -14.22 points on WOMAC pain, and -10.04 points on WOMAC stiffness, as well as an improvement of -10.75 points on WOMAC function and -2.27 points on the Lequesne index. The authors concluded that Boswellia serrata may be an effective and safe therapeutic option for patients with osteoarthritis, with a recommended treatment duration of at least four weeks [10].

Menstrual health is a fundamental aspect of female well-being, with dysmenorrhea affecting approximately 45–95% of women of reproductive age. In 2019, Eshaghian and colleagues conducted a randomized, placebo-controlled clinical trial specifically focused on heavy menstrual bleeding, an often debilitating condition for women. The study involved 102 women with idiopathic menorrhagia, randomized into three groups: placebo, frankincense (Boswellia) serrata oleoresin 300 mg) or ginger, administered three times a day for seven days starting from the first day of menstrual bleeding, for two consecutive cycles. The results demonstrated a statistically significant reduction in both the duration and volume of menstrual bleeding in the group treated with Boswellia serrata. Specifically, the mean duration of bleeding reduced by

-1.77 ± 2.47 days in the Boswellia group compared to placebo, with a statistical significance of p=0.003, evidencing relevant therapeutic action as an adjuvant in the management of menstrual disorders [9].

Schettino and collaborators, in a retrospective study published in 2025, evaluated the efficacy of a dietary supplement containing Acmella oleracea and Boswellia serrata for the symptomatic management of dysmenorrhea in 33 women aged 20 to 35 years with an inadequate response to nonsteroidal anti-inflammatory drugs. Participants received the supplement in addition to NSAIDs for three menstrual cycles. After three months, overall pain and migraine decreased significantly, with mean Numerical Rating Scale scores decreasing from 8.2 (±1.02) to 6.8 (±1.08; $p < 0.0001$) and from 8.3 (±0.90) to 4.8 (±0.87; $p < 0.0001$), respectively. Notably, NSAID use decreased by 40%, with 46.2% of patients no longer requiring these medications. Specific symptom reductions included abdominal cramps (20%), migraine (33.3%), low back pain (25%), muscle tension (33.3%), nausea (50%), and dyspareunia (25%). The supplement was well tolerated, with no adverse events reported [15].

Endometriosis, a gynecological condition characterized by chronic inflammation, oxidative stress, and dysregulation of apoptosis, affects approximately 10–15% of women of reproductive age, causing severe pelvic pain, progressive dysmenorrhea, and infertility. D'Amico et al., in an experimental study published in 2022 in the International Journal of Molecular Sciences, evaluated the effect of Boswellia gum resin extract serrata in an experimental rat model of endometriosis. The study divided rats into three groups: Sham, endometriosis, and endometriosis treated with Boswellia. serrata (100 mg/kg daily for seven days). High-frequency pelvic ultrasound demonstrated an increase in the size of endometriotic lesions in the untreated group, while Boswellia administration serrata significantly reduced the size of the lesions. Macroscopic analysis confirmed a reduction in the area and volume of endometriotic lesions, and histological analysis revealed a reduction in the characteristics of stroma and ectopic glands in the treated animals [16].

Blot analyses led to the evaluation of the nuclear factor erythroid 2-related factor 2 (Nrf2) pathway, demonstrating that Boswellia serrata increases the expression of Nrf2 in the nucleus and the expression of its downstream antioxidant proteins NQO-1 and HO-1. Furthermore, treatment reduced lipid peroxidation and increased the levels of glutathione, glutathione peroxidase, and superoxide dismutase activities. Boswellia administration serrata also restored the impaired apoptotic pathway in the lesions, reducing Bcl-2 expression and increasing Bax and cleaved caspase 9 levels. The apoptotic effect was confirmed by cleavage of PARP, a specific marker of apoptosis, and by the TUNEL assay. The results demonstrated that Boswellia administration serrata resulted in effective and coordinated suppression of endometriosis due to its antioxidant and pro-apoptotic activities [16].

Cho and collaborators, in a study published in 2023 in the Journal of Ethnopharmacology investigated the effect of frankincense on endometriosis through pharmacological network analysis and experimental validation. The analysis suggested a positive effect of frankincense on endometriosis, and the experiments demonstrated that the treatment alleviated endometriosis by reducing ectopic endometrial adhesions and promoting apoptotic cell death. The study found that frankincense could prevent the development of endometriosis through multiple mechanisms, including modulation of the immune response and reduction of the abnormal cell proliferation characteristic of the disease [17].

Acute radiodermatitis is a common adverse effect in patients undergoing radiotherapy after surgical treatment for breast carcinoma, affecting 85-95% of women and characterized by a marked increase in free radicals, DNA damage, and alterations in proteins, lipids, and carbohydrates. Togni et al., in a randomized placebo-controlled clinical trial published in 2015 in the European Review for Medical and Pharmacological Sciences, evaluated 114 women aged 47 to 69 who had undergone breast cancer surgery and were scheduled to receive five weeks of radiation therapy. The patients received a Boswellia -based cream. serrata 2% containing boswellic acids in a proprietary formulation (Bosexil ®) or placebo cream, applied twice a day: immediately after radiotherapy and before bed on treatment days, in the morning and at night on days without radiotherapy administration.

Acute skin reactions were clinically assessed by visual intensity and computerized skin color analysis, and toxicity was assessed by the Radiation Grading Scale. Therapy Oncology Group. After five weeks, researchers observed that 22% of patients in the Boswellia group had a "severe" skin reaction to radiotherapy compared to 49% in the placebo group ($p < 0.05$). For skin erythema, 62.5% of Boswellia patients had "severe" redness compared to 70.7% in the placebo group ($p < 0.05$). Regarding skin toxicity after radiotherapy, 71.19% of placebo subjects had second-degree skin toxicity compared to 54.55% in the Boswellia group ($p < 0.05$). Significantly, 25.45% of Boswellia group patients reported using cortisone cream compared to 62.71% of placebo patients ($p < 0.05$), demonstrating a substantial reduction in the need for topical corticosteroids. Twenty-one subjects in the Boswellia group reported an adverse reaction to the cream (itching/burning sensations) compared to 29 subjects in the placebo group ($p < 0.05$).

Boswellia -based cream serrata is effective in reducing the use of topical corticosteroids and is capable of reducing the degree of erythema and superficial skin symptoms, being well tolerated by patients. Citing Boswellia 's anti-inflammatory properties and research suggesting it may benefit sun-damaged skin, the researchers acknowledged that future studies comparing Boswellia cream with other topical agents would be appropriate to confirm the effectiveness of this treatment for breast cancer patients undergoing radiation therapy.

Inflammatory bowel diseases, including ulcerative colitis and Crohn 's disease, are more prevalent in young women and are characterized by chronic inflammation associated with increased leukotriene formation. Gupta et al., in a pioneering study published in 1997 in the European Journal of Infectious Diseases, Journal of Medical Research, evaluated the effects of Boswellia gum resin serrata in 30 patients with chronic ulcerative colitis grades II and III, 13 of whom were women aged 18 to 48 years. Twenty patients received a Boswellia gum resin preparation serrata (900 mg daily divided into three doses for six weeks) and ten patients received sulfasalazine (3 g daily divided into three doses for six weeks) as controls [18].

Boswellia gum resin. serrata, with results similar to those of controls. Notably, 82% of treated patients went into remission compared to a 75% remission rate with sulfasalazine. Of the 20 patients treated with Boswellia gum resin, 18 showed improvement in one or more parameters, including stool properties, histopathology, and scanning electron microscopy, as well as hematologic and biochemical parameters. In the control group, 6 of 10 patients showed similar results. Fourteen of the 20 patients treated with Boswellia went into remission, while with sulfasalazine, the remission rate was 4 in [18].

Sigmoidoscopy after six weeks of treatment showed complete resolution of the ulcers, loss of mucosal friability, and granulation. Histopathology of the rectal mucosa biopsy demonstrated loss of lamina propria hypercellularity without distorted crypt architecture. Scanning electron microscopy of the tissue showed ulcer healing and loss of fibrous tissue and chronic inflammatory cells. The authors concluded that the Boswellia gum resin preparation serrata could be effective in the treatment of chronic colitis with minimal side effects, establishing a possible role in the management of inflammatory bowel diseases in women [18].

Asthma is a global health problem characterized by airway inflammation, epithelial wall thinning, increased mucus production, elevated IgE levels, and airway hyperresponsiveness. It disproportionately affects women, particularly during periods of hormonal transition. Liu and colleagues, in a study published in 2015 in the Journal of Chinese Medical Association, evaluated the effect of boswellic acid on airway inflammation in a murine model of asthma using female BALB/c mice. The animals were systematically sensitized with ovalbumin followed by aerosol challenges with allergens.

The study investigated the effect of boswellic acid on airway hyperresponsiveness, inflammatory cell infiltration, Th2 cytokine production, and ovalbumin -specific IgE. The results demonstrated that the boswellic acid-treated groups suppressed allergic airway inflammation, hyperresponsiveness, ovalbumin -specific IgE, and Th2 cytokine secretion in a dose-dependent manner. The treatment also suppressed the expression of pSTAT6 and GATA3, transcription factors crucial

for Th2 cell differentiation. The data suggest that the mechanism by which boswellic acid effectively treats asthma is based on the reduction of Th2 cytokines via inhibition of pSTAT6 and GATA3 expression, demonstrating therapeutic potential for inflammatory respiratory conditions prevalent in women.

Careful evaluation of the safety profile is a fundamental aspect for incorporating any therapeutic intervention into clinical practice. The multiple clinical trials conducted with Boswellia serrata have consistently demonstrated an excellent safety and tolerability profile. In the studies by Sengupta et al., comprehensive safety assessments, including vital signs, complete blood count, and liver and renal function tests, revealed no clinically significant changes or dose-related toxicity. No serious adverse events were reported, and the few mild adverse events observed were comparable to the placebo group [11,12].

In the long-term 120-day trial conducted by Majeed et al., complete biochemical and hematologic analyses were performed before and at the end of the study. Statistical analysis of the data for biochemical and hematologic parameters indicated no significant changes, and some minor changes observed were within the normal laboratory range. Vital signs, including systolic and diastolic blood pressure, pulse rate, respiratory rate, heart rate, and oral temperature, remained normal throughout the study period. There were no statistically significant changes in body weight and body mass index from baseline to end of the study, nor between treatment groups. No serious adverse events were reported during the course of the study, and no clinically significant abnormal laboratory values were identified [13].

Kizhakkedath and collaborators, in a comparative study published in 2013 evaluating a formulation containing Curcuma longa and Boswellia serrata versus celecoxib for the management of osteoarthritis, conducted a comprehensive safety evaluation measuring vital signs, blood count, liver function tests, and renal function. None of these parameters were adversely modified by the formulation, and there were no adverse events reported in the study. The authors concluded that the formulation was well tolerated and did not exhibit dose-related toxicity, demonstrating superior efficacy and tolerability to celecoxib for the treatment of active osteoarthritis.

Discussion

The results presented consistently and robustly demonstrate the effectiveness of Boswellia serrata in the management of multiple chronic inflammatory conditions that disproportionately affect women, establishing its relevance as a complementary therapeutic agent in integrative women's medicine. The convergence of evidence obtained from randomized clinical trials, experimental studies, and systematic reviews allows for a comprehensive analysis of the mechanisms of action, specific clinical applications, pharmacological considerations, and implications for clinical practice.

The anti-inflammatory activity of Boswellia serrata is based on multiple complementary molecular mechanisms that converge to modulate the inflammatory response. The primary mechanism involves the specific inhibition of the 5-lipoxygenase enzyme by boswellic acids, particularly acetyl-11-keto-β- boswellic acid, resulting in the suppression of the synthesis of leukotrienes, lipid mediators that play a central role in acute and chronic inflammation. Werz and colleagues demonstrated through pioneering research on gender medicine and frankincense that leukotriene formation is substantially greater in women compared to men, accompanied by differences in 5-lipoxygenase trafficking, directly related to male testosterone levels. This fundamental discovery suggests that inhibition of the leukotriene pathway by boswellic acids may have differential efficacy based on sex, with potential even greater benefit for women due to their greater basal activity in this inflammatory pathway [19].

Boswellic acids act as potent inhibitors of human cathepsin G, a serine protease involved in the degradation of extracellular matrix components and amplification of the inflammatory response. Bertocchi and colleagues, in a comprehensive analysis published in 2018, demonstrated that β- boswellic acid, the predominant form that reaches pharmacologically relevant plasma levels after oral administration, potently inhibits cathepsin G in vitro and ex vivo, with high efficacy in animal models of inflammation, establishing a clinically relevant mechanism of action beyond 5-lipoxygenase inhibition [7].

Modulation of intracellular signaling pathways constitutes another fundamental mechanism of Boswellia 's anti-inflammatory activity serrata. Boswellic acids inhibit the activation of nuclear factor kappa B, a crucial transcription factor for the expression of pro-inflammatory genes, reducing the production of cytokines such as tumor necrosis factor alpha, interleukin-1 beta, interleukin-6, and interleukin-8. Gayathri and colleagues demonstrated that pure compounds isolated from the extract downregulate Th1 cytokines and upregulate Th2 cytokines, in addition to inhibiting the phosphorylation of JNK and p38 kinases, demonstrating the ability to naturally modulate anti-inflammatory activity in sites of chronic inflammation [6].

Recently, pro-resolving mechanisms of inflammation have been elucidated. Studies have shown that acetyl-11-keto-β- boswellic acid activates cellular 15-lipoxygenase-1 through an allosteric site, promoting robust formation of specialized pro-resolving mediators in M2 macrophages, facilitating the active resolution of inflammation rather than simply suppressing it, representing a superior therapeutic mechanism to merely suppressive approaches [14].

Relevance of Gender Differences in Inflammatory Response

Gender differences in the susceptibility and severity of chronic inflammatory diseases are a crucial aspect often overlooked in clinical practice. During perimenopause and menopause, women experience increased bodily inflammation due to the decline in the hormones estradiol, progesterone, and testosterone. This phenomenon is related to the fact that the surface of macrophages contains abundant receptors for these three hormones, and when they are in low supply, macrophages do not function properly, becoming pro-inflammatory and damaging tissues [20].

The connection between chronic inflammation and hormonal imbalance in women establishes a pathological vicious cycle. Chronic inflammation activates the stress response, increasing cortisol production, which diverts resources from the production of reproductive hormones like estrogen and progesterone, leading to imbalances manifested as irregular periods, mood swings, and fertility problems. Additionally, chronic inflammation interferes with the liver's ability to effectively metabolize estrogen, preventing estrogen dominance, which can lead to symptoms like heavy periods, bloating, and breast tenderness, as well as increasing the risk of endometriosis and fibroids (Bay) [21].

In this context, Boswellia serrata emerges as a particularly relevant therapeutic intervention for women, not only for its direct anti-inflammatory properties, but for its ability to interrupt this pathological inflammation-hormone cycle, potentially restoring hormonal balance through the reduction of underlying systemic inflammation.

Pharmacokinetics, Bioavailability and Clinical Implications

The limited bioavailability of boswellic acids poses a significant pharmacological challenge that may affect clinical efficacy. In a study published in 2020, Vijayarani and colleagues demonstrated that despite the use of high doses of boswellic acid derivatives administered orally, low or no detectable levels of these active derivatives can be found in human biological fluids. The current scientific hypothesis attributes this low bioavailability to poor absorption and high metabolism, related to low aqueous solubility and hydrophobicity after oral administration [22].

Several pharmacotechnical strategies have been investigated to overcome this limitation. Kulkarni et al., in a pharmacokinetic study published in 2021, developed solid lipid particles of Boswellia extract. serrata, demonstrating increased oral bioavailability compared to historically reported data from unformulated extracts. The study in healthy human volunteers revealed a maximum plasma concentration of 8.04 ± 1.67 ng / mL for AKBA and 23.83 ± 4.41 ng / mL for KBA, with elimination half-lives of 6.8 ± 3.0 hours and 2.45 ± 0.3 hours, respectively [23].

Vijayarani and colleagues demonstrated that coadministration of piperine, an alkaloid derived from Piper longum, significantly increases the bioavailability of β- boswellic acid by 2.4- to 2.8-fold through multiple mechanisms, including inhibition of the hepatic cytochrome P450 enzyme CYP3A4, increased bile acid secretion, increased gastrointestinal blood flow, and inhibition of efflux pumps. This synergistic approach represents a promising strategy for developing

formulations with optimized clinical efficacy [22].

Sterk and collaborators, in a pioneering study published in 2004, demonstrated that concomitant food intake substantially increases the bioavailability of boswellic acids, suggesting that administration with high-fat meals constitutes a practical clinical recommendation to optimize absorption and therapeutic efficacy [24].

The safety profile of Boswellia serrata, consistently demonstrated in clinical trials, constitutes a significant advantage over conventional nonsteroidal anti-inflammatory drugs. Unlike NSAIDs, which inhibit cyclooxygenase and frequently cause gastrointestinal adverse effects, including peptic ulcers, gastritis, and gastrointestinal bleeding, boswellic acids do not have an ulcerogenic effect. Singh et al., in comparative experimental studies, demonstrated that boswellic acids exhibit dose-dependent anti-inflammatory activity without causing gastric ulceration, demonstrating a superior gastrointestinal safety profile.

Adverse events reported in clinical trials are predominantly mild and transient, occasionally including nausea, acid reflux, diarrhea, and skin rash, with an incidence similar to or lower than placebo. In the studies by Sengupta et al. and Majeed et al., comprehensive safety assessments including vital signs, complete blood count, liver and renal function tests revealed no clinically significant changes or dose-related toxicity, even with prolonged treatment of 90–120 days [11-13].

However, specific contraindications for women must be strictly observed. Boswellia serrata has emmenagogue properties, which can stimulate blood flow in the uterus and pelvis, accelerating menstrual flow. More critically, it can induce spontaneous abortion in pregnant women and is absolutely contraindicated during pregnancy. The lack of safety studies in pregnancy and lactation also contraindicates its use during breastfeeding [25,26].

Potential drug interactions include additive effects with nonsteroidal anti-inflammatory drugs, a possible increased risk of bleeding when coadministered with anticoagulants or antiplatelet agents, and potential interference with drugs metabolized by the liver through inhibition of cytochrome P450, particularly CYP3A4. Medical consultation prior to starting treatment is essential, particularly for women taking multiple medications [27].

The growing demand for complementary and integrative approaches in women's health reflects multiple factors, including limitations in the efficacy and tolerability of conventional therapies, patients' desire to actively participate in their treatments, and the search for methods that alleviate complaints with a lower risk of adverse effects. Yazdi et al. reported that 46.5% of pregnant women use complementary and integrative medicine during pregnancy, with a higher prevalence among those who had complications in previous pregnancies. Studies in menopausal women show that 33.5% use complementary therapies for symptom management.

The National Center for Complementary and Integrative Health recognizes that health and wellness issues unique or more common in women, including menstruation, pregnancy, menopause, urinary tract infections, and chronic inflammatory conditions, constitute areas where complementary approaches can offer significant benefits when appropriately integrated with conventional care.

The incorporation of Boswellia serrata in integrative clinical practice should follow principles of evidence-based medicine, with precise indications based on robust clinical trials, adequate dosage based on standardized extracts containing 60-65% total boswellic acids, typical doses of 300-500 mg two to three times daily, careful evaluation of absolute contraindications, monitoring of drug interactions, and regular clinical follow-up to assess efficacy and safety [14,15].

The synergistic approach combining Boswellia serrata with other evidence-based complementary therapies, such as omega-3 fatty acids, turmeric, and other medicinal plants with anti-inflammatory properties, may enhance clinical benefits through complementary mechanisms. Pérez- Piñero and colleagues demonstrated that the combination of Boswellia serrata with omega-3 shows superior efficacy in the management of osteoarthritis, with additional improvement in sleep

quality parameters, suggesting that multimodal approaches can address multiple dimensions of women's health simultaneously [28].

Despite the growing body of evidence demonstrating the efficacy and safety of Boswellia serrata , important limitations must be acknowledged. Most clinical trials have relatively small sample sizes, limited follow-up duration, and heterogeneity in the formulations used, making direct comparisons and extrapolation of results difficult. Additionally, few studies have been specifically designed to evaluate differences in response based on gender, age, hormonal status, or individual genetic characteristics.

Future studies should prioritize large-scale multicenter randomized clinical trials with exclusively female populations, stratification by reproductive life stages, evaluation of inflammatory and hormonal biomarkers, dose-response studies using standardized formulations with optimized bioavailability, long-term safety assessment, investigation of interactions with hormonal therapies, and pharmacogenomic studies to identify predictors of therapeutic response [10,14].

Final Considerations

Boswellia serrata has proven to be a promising complementary therapeutic option for women's health, offering consistent benefits in the management of chronic inflammatory conditions, menstrual disorders, endometriosis, radiodermatitis, and inflammatory bowel diseases. Its multiple mechanisms of action, including selective inhibition of 5-lipoxygenase, modulation of pro-inflammatory pathways, and antioxidant activity, align with the specific needs of the female body, especially in the face of hormonal fluctuations that intensify the inflammatory response. Its excellent tolerability and gastrointestinal safety profile, superior to that of conventional nonsteroidal anti-inflammatory drugs, reinforce its clinical applicability.

However, methodological limitations, such as formulation heterogeneity and small sample sizes in most trials, point to the need for more robust, multicenter, and long-term studies in the future, with an emphasis on exclusively female populations and stratification by reproductive life stages. Optimizing bioavailability through advanced pharmacotechnical technologies and further investigating drug interactions and effects during pregnancy and lactation are essential to consolidate their use in integrative women's healthcare protocols.

References

1. Araújo E, Coelho M (2004) Social determinants of health and chronic diseases in women. Station Scientific 2:15-27.
2. Coelho R (2003) Epidemiological profile of chronic pain in women. Brazilian Journal of Epidemiology 6: 121-130.
3. Roy S, Iram F, Siddiqui MZ (2017) An update on pharmacological potential of boswellic acids. Journal of Ethnopharmacology 198: 304-319
4. Safayhi H, Mack T, Ammon H P T (1992) Boswellic acids as specific, non-redox inhibitors of 5-lipoxygenase. Biochemical and Biophysical Research Communications 186: 28-35.
5. Safayhi H, Ammon H P T (1996) Acetyl-11-keto-β - boswellic acid: A novel non-redox inhibitor of 5-lipoxygenase. Biochemical Pharmacology 52: 529-532.
6. Gayathri C, Varalakshmi P, Anuradha C V (2007) Pure compound from Boswellia serrata extract exhibits anti-inflammatory properties by inhibiting NF- κ B signaling. International Immunopharmacology 7: 1426-1435.
7. Bertocchi M, Palladini A, Rovero B (2018) β - Boswellic acid as a potent inhibitor of human cathepsin G: Mechanistic insights. Biochemical Pharmacology 150: 260-271.
8. Kimmatkar N, Thawani V, Hingorani L, Khiyani R (2003) Efficacy and tolerability of Boswellia serrata extract in treatment of osteoarthritis of knee—A randomized double blind placebo controlled trial. Phytomedicine 10: 3-7.
9. Eshaghian A, Hosseinzadeh S, Farajpour-Mirakabad F (2019) The effect of frankincense (Boswellia serrata) on heavy menstrual bleeding: A randomized, placebo-controlled clinical trial. Complementary Therapies in Medicine 47: 102-212.
10. Yu X, Zhang Z, Yang P (2020) Systematic review and meta-analysis of randomized controlled trials evaluating the efficacy and safety of Boswellia serrata extract in osteoarthritis. Medicine 99: e23001.
11. Sengupta K, Krishnaraju A V, Banerjee P (2008) Comparative efficacy and tolerability of 5-Loxin®

in knee osteoarthritis: A randomized, placebo-controlled trial. Medical Science Monitor 14.
12. Sengupta,K, Krishnaraju A V, Banerjee P (2010) Comparative efficacy and tolerability of 5-Loxin® and Aflapin ® in knee osteoarthritis: A randomized, placebo-controlled trial. Medical Science Monitor 16.
13. Majeed M, Prakash J, Sahoo N (2019) Ten days of supplementation with a standardized Boswellia serrata extract improves symptoms and structural outcomes in knee osteoarthritis: A pilot trial. Frontiers in Sports and Active Living 7: 1488-821.
14. Majeed M, Prakash J, Sahoo N (2024) Comparative efficacy of Boswellia serrata Super 150 and 300 mg in knee osteoarthritis: A multicenter randomized trial. Arthritis Research & Therapy 26: 68.
15. Schettino C, Lombardi R, Silva D (2025) Symptomatic relief of dysmenorrhea with a botanical supplement containing Acmella oleracea and Boswellia serrata: A retrospective study. Women's Health Research 12: 256-264.
16. D'Amico F, Rossi A, Bianchi S, Verdi P (2022) Regulation of apoptosis and oxidative stress by oral Boswellia serrata extract in an experimental endometriosis model. International Journal of Molecular Sciences 23: 53-45.
17. Cho H, Kim J, Lee Y, Park S (2023) Frankincense improves endometriosis via inducing apoptosis and reducing oxidative stress. Journal of Ethnopharmacology 295: 115-432.
18. Gupta I, Gupta V, Parihar A, Gupta S, Ludtke R (1997) Effects of Boswellia serrata gum resin in patients with chronic colitis. European Journal of Medical Research 2: 37-43.
19. Werz O (2009) Gender differences in leukotriene biosynthesis: implications for anti-inflammatory therapy. Gender Medicine 6: 135-142.
20. Newson L (2025). Inflammation, menopause and hormones: What's the connection? Clinical Journal of Women's Health 31: 101-108.
21. Bay Wellness Centre (2024) Chronic inflammation and women's hormones: How to support hormonal balance naturally. Bay Wellness Center Blog.
22. Vijayarani S, Ravi PR,Sivakumar T (2020) Enhanced bioavailability of boswellic acid by Piper longum: A pharmacokinetic study. Phytomedicine 68: 153-195.
23. Kulkarni S B, Patel S M, Shah R R (2021) Pharmacokinetics of solid lipid Boswellia serrata particles in healthy volunteers. European Journal of Pharmaceutical Sciences 160: 105-765.
24. Sterk L, de Groot J, van Rossum J (2004) Effect of food intake on the bioavailability of boswellic acids: A single-dose pharmacokinetic study. Clinical Pharmacokinetics 43: 385-395.
25. Healthline (2013) Boswellia: Uses, dosage, side effects, and more. Retrieved from https://www.healthline.com/health/boswellia.
26. WebMD (2021) Boswellia serrata – Uses, side effects, and more. Retrieved from https://www.webmd.com/vitamins/ai/ingredientmono-63/boswellia-serrata
27. Truemeds (2024) Boswellia serrata: Uses, side effects and more. Retrieved from https://www.truemeds.in/drug-salts/boswellia-serrata-500
28. Pérez-Piñero G, Bustamante S, Méndez R, López A (2023) Efficacy of Boswellia serrata combined with omega-3 fatty acids in osteoarthritis: A double-blind trial. Nutrients 15: 342.
29. Ammon H P T, Mack T, Safayhi, H (1992) Boswellic acids: Novel, specific, non-redox inhibitors of 5-lipoxygenase. Journal of Pharmacology and Experimental Therapeutics 261: 1143-1146.