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Boswellia Serrata-Infused Transdermal Patches: A Promising Therapy for Arthritis

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Abstract

Chronic joint inflammatory conditions like osteoarthritis and rheumatoid arthritis share common features, including increased inflammation and oxidative stress, which lead to ongoing tissue damage and debilitating symptoms. In conventional medicine, the oral route is commonly used, but it often fails to produce the desired effects due to systemic circulation and first-pass metabolism, which can delay the drug's bioavailability and therapeutic action. In contrast, transdermal drug delivery has made a significant impact in medical practice. This method involves a medicated patch that delivers a precise amount of medication through the skin into the bloodstream. One advantage of transdermal delivery over other methods is that it allows for controlled, sustained release of medication, typically through a porous membrane containing the drug reservoir or via body heat,

which melts layers of medication embedded in the adhesive. These formulations often use herbal drugs, which are increasingly popular due to their safety profile, fewer side effects, and lower cost. Additionally, many people tend to trust herbal remedies more than conventional allopathic treatments. One of active drug which is used to formulate herbal transdermal patch for arthritis is Boswellia Serrata. In conclusion, this review underscores the advantages of transdermal drug delivery over conventional oral methods, offering controlled, sustained release of medication. The use of herbal drugs in these formulations enhances safety, reduces side effects, and increases public trust. Overall, transdermal delivery, particularly with herbal remedies, provide an effective and safe treatment alternative for chronic condition.

Keywords: Transdermal Drug Delivery, Arthritis, Patch, Alternative Treatment, Boswellia Serrata

Introduction

Chronic joint inflammatory conditions such as osteoarthritis (OA) and rheumatoid arthritis (RA) are two of the most common musculoskeletal disorders, affecting millions of people worldwide, particularly as populations age. These conditions are characterized by persistent inflammation in the joints, leading to progressive tissue damage, pain, stiffness, and a reduction in joint function. OA primarily involves the degeneration of cartilage and the breakdown of joint tissues, while RA is an autoimmune disorder in which the body's immune system attacks its own joints, causing widespread inflammation and joint destruction. These diseases have a profound impact on a patient's quality of life, often leading to disability and the need for long-term treatment management.

Arthritis is a general term that refers to a group of more than 100 diseases affecting the joints, the parts of the body where two or more bones meet. It causes inflammation, stiffness, pain, swelling, and in some cases, joint damage. Arthritis can affect people of all ages and backgrounds, but it is most common in older adults. It is one of the leading causes of disability worldwide and significantly impacts a person's quality of life, making daily activities.



Fig 1: Healthy joint and Osteoarthritis

Types of Arthritis

The primary types include Osteoarthritis (OA), Rheumatoid arthritis (RA), Psoriatic arthritis (PsA), Gout, Lupus, Ankylosing spondylitis (AS), and Juvenile arthritis (JA), among others.

1. Osteoarthritis:

Osteoarthritis is the most common type of arthritis (a condition that affects your joints). It is also referred to as degenerative joint disease or OA. It happens when the cartilage that lines your joints is worn down over time and your bones rub against each other when you use your affected joints. Usually, the ends of bones in your joints are capped in a layer of tough, smooth cartilage. Cartilage is like a two-in-one shock absorber and lubricant- it helps the bones in your joints move past each other smoothly and safely. The cartilage in the affected joints wears away over time. Eventually, the bones rub against each other when we move the joint.

2. Rheumatoid arthritis:

Rheumatoid arthritis (RA) is a chronic (ongoing) autoimmune disease that causes pain, swelling and stiffness in the lining of your joints (synovium). It most commonly affects the joints in the fingers, hands, wrists, knees, ankles, feet and toes. Rheumatoid arthritis usually occurs in the same joints on both sides of the body, which makes it different from some other types of arthritis. Uncontrolled inflammation damages cartilage, which normally acts as a "shock absorber" in the joint. In time, this can deform your joints. Eventually, bone itself erodes. This can lead to the fusion of the joints. Specific cells in the immune system (body's infection- fighting system) aid this process. These substances are produced in the joints but also circulate and cause symptoms throughout the body. In addition to affecting the joints rheumatoid arthritis sometime affects other parts of the body like skin, eyes, mouth, lungs and heart.

3. Psoriatic arthritis:

Psoriatic arthritis is a type of arthritis which usually affects people who have psoriasis or a biological family history of psoriasis. Arthritis is a common disorder that effects your joints. It causes pain and inflammation in and around your

joints. Psoriasis causes inflammation in the skin. These thick, scaly areas are called plaques. It can also make the fingernails and toenails thicken and look flaky or pitted (covered in tiny indentations).

Both arthritis and psoriasis are autoimmune diseases. An autoimmune disease is the result of the immune system accidentally attacking the body instead of protecting it. Psoriatic arthritis happens when it develops psoriasis symptoms on the skin and inflammation in the joints. Psoriatic arthritis symptoms on the skin and in the joints usually come and go in flares.

4. Gout:

Gout is a form of inflammatory arthritis that causes pain and swelling in the joints. Gout happens when there's a buildup of uric acid in the body. Gout most commonly affects the big toe joint. It causes sudden and intense attacks of joint pain, often in the big toe and at night. It can also strike joints in other toes or the ankle or knee.

5. Lupus:

Lupus is a long-term condition that can cause inflammation in the skin, Organs, and in various other places in the body. It's an autoimmune condition. The immune system, which normally protects us against infection and illness, starts to attack the body's own tissue instead.

There are two main types of lupus:

- Discoid lupus:** Discoid lupus only affects the skin, causing rashes. People can get it in one small area on the skin, or it can be widespread.
- Systemic lupus erythematosus (SLE):** It can affect many parts of the body in several ways. It can range from mild to severe.

6. Ankylosing spondylitis:

Ankylosing spondylitis is a type of arthritis that affects joints in the spine. It's also called axial spondylarthritis. Ankylosing spondylitis (AS) also affects the joints where the base of the spine meets the pelvis (sacroiliac joint). The sacroiliac joints are the connection between the spine and pelvis. Specifically, they are the place where the sacrum (the triangle-shaped last section of the spine) meets the ilium (the top and back part of the pelvis). The sacroiliac joints are some of the biggest joints in the body, and we use them every time we move or shift our hips. Ankylosing spondylitis causes pain, stiffness and gastrointestinal (GI) symptoms.

7. Juvenile idiopathic arthritis:

Juvenile Idiopathic arthritis (JIA) is the most common type of arthritis that affects children. Juvenile idiopathic arthritis is a chronic (long-lasting) disease that can affect joints in any part of the body. JIA is an autoimmune disease in which the body's immune system mistakenly targets the synovium, the tissue that lines the inside of the joint, and the synovial fluid in the joint. This causes the synovium to make extra synovial fluid, which leads to swelling, pain and stiffness in the joint. This process can spread to the nearby tissues, eventually damaging cartilage and bone. Other areas of the body, especially the eyes, may also be affected by the inflammation. If it is not treated, JIA can interfere with a child's normal growth and development.

Sign and symptoms:

- 1) Joint pain
- 2) Stiffness

- 3) Swelling
- 4) Skin discoloration
- 5) Redness and warmth
- 6) Decreased range of motion
- 7) Fatigue
- 8) Joint deformities
- 9) Crepitus (Grinding or Cracking Sounds)
- 10) Loss of function.

Risk factors

Factors that can increase your risk of osteoarthritis include:

1. **Older age:** The risk of osteoarthritis increases with age.
2. **Sex:** Women are more likely to develop osteoarthritis, though it isn't clear why.
3. **Obesity:** Carrying extra body weight contributes to osteoarthritis in several ways, and the more you weigh, the greater your risk. Increased weight adds stress to weight-bearing joints, such as your hips and knees. Also, fat tissue produces proteins that can cause harmful inflammation in and around your joints.
4. **Joint injuries:** Injuries, such as those that occur when playing sports or from an accident, can increase the risk of osteoarthritis. Even injuries that occurred many years ago and seemingly healed can increase your risk of osteoarthritis.
5. **Repeated stress on the joint:** If your job or a sport you play places repetitive stress on a joint, that joint might eventually develop osteoarthritis.
6. **Genetics:** Some people inherit a tendency to develop osteoarthritis.
7. **Bone deformities:** Some people are born with malformed joints or defective cartilage.
8. **Certain metabolic diseases:** These include diabetes and a condition in which your body has too much iron (hemochromatosis).

Diagnosis of arthritis

Laboratory Tests- Lab tests may help to diagnose rheumatoid arthritis. Some common tests include:

1. **Rheumatoid factor (RF)** - This blood test checks for RF, an antibody that many people with rheumatoid arthritis can eventually have in their blood. An antibody is a special protein made by the immune system that normally helps fight invaders in the body. Not all people with RA test positive for RF; some people test positive for RF but never develop the disease; and some people test positive but have another disease. However, doctors can use this test, along with other test results and evaluations, to diagnose rheumatoid arthritis.
2. **Anti-cyclic citrullinated peptide antibody (anti-CCP)** - This blood test checks for anti-CCP antibodies, which appear in many people with rheumatoid arthritis. In addition, anti-CCP can appear before RA symptoms develop, which can help doctors diagnose the disease early. This test's results, along with the results from RF blood tests, are very useful in confirming a rheumatoid arthritis diagnosis. However, it is important to know that some people have rheumatoid arthritis even with normal blood tests.
3. **Complete blood count.** This blood test measures different blood cell counts and can help diagnose anemia, which is common in people with RA.
 - a. **Erythrocyte sedimentation rate** (often called the sed rate). This test measures inflammation in the body and

monitors disease activity and response to treatments.

- b. **C-reactive protein.** This is another common test for inflammation that can help diagnose rheumatoid arthritis and monitor disease activity and response to treatments.
- c. **Other blood tests.** Your doctor may also use other tests to check your kidney function, electrolytes, liver function, thyroid function, muscle markers, other autoimmune markers, and markers of infection to evaluate for your overall health and evaluate for other diagnoses. Other specific tests for rheumatoid arthritis, are sometimes considered.
2. **Imaging Tests** -To check for joint damage, doctors may use imaging tests such as:
 - a. **X-rays** help check for RA; however, they are not generally abnormal in the early stages of rheumatoid arthritis, before joint damage occurs. Doctors may use x-rays to monitor the progression of the disease or to rule out other causes for the joint pain.
 - b. **Magnetic resonance imaging (MRI)** and **ultrasound** may help diagnose rheumatoid arthritis in the early stages of the disease. In addition, these imaging tests can help evaluate the amount of damage in the joints and the severity of the disease.
 - c. **Other imaging tests** sometimes considered for rheumatoid arthritis include computed tomography (CT) scanning, positron emission tomography (PET) scan, bone scan, and dual-energy X-ray absorptiometry (DEXA).

Conventional Treatments for Arthritis and Associated Side Effects

Conventional Treatments for Arthritis and Their Associated Side Effects-

Arthritis is a broad term for a variety of inflammatory joint diseases that lead to pain, stiffness, swelling, and impaired mobility. The most common types of arthritis are osteoarthritis (OA), rheumatoid arthritis (RA), and psoriatic arthritis (PsA). Conventional treatments for arthritis aim to reduce pain, manage inflammation, and prevent further joint damage. These treatments often include nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroids, and disease-modifying antirheumatic drugs (DMARDs). While effective, these medications come with significant side effects, especially when used long-term.

1. Nonsteroidal Anti-inflammatory Drugs (NSAIDs)

NSAIDs are the most commonly used medications to treat arthritis. They work by reducing inflammation and alleviating pain through the inhibition of cyclooxygenase (COX) enzymes, which are responsible for producing prostaglandins—chemicals that promote inflammation.

2. Corticosteroids

Corticosteroids, also known as steroids, are potent anti-inflammatory drugs commonly used to treat acute flare-ups of arthritis, particularly in rheumatoid arthritis (RA). They work by suppressing the immune system and reducing inflammation.

3. Disease-Modifying Antirheumatic Drugs (DMARDs)

DMARDs are a class of drugs used to treat rheumatoid arthritis (RA) and other autoimmune forms of arthritis. These drugs aim to modify the course of the disease, not just relieve symptoms. DMARDs can be classified into two categories: Conventional synthetic DMARDs and biologic DMARDs.

The Role of Herbal Compounds in Alternative Medicine

Herbal compounds have been a fundamental part of traditional medicine systems across the world for centuries. Many cultures, including those in Asia, Africa, and Europe, have used plants and their extracts for healing purposes. The active compounds in these plants are often bioactive molecules that exhibit anti-inflammatory, antioxidant, analgesic, and immune-modulating properties, which can be beneficial in treating a variety of health conditions, including arthritis.

1. Benefits of Herbal Compounds in Treating Arthritis

- **Anti-inflammatory Effects:** Many herbal compounds, such as *Boswellia serrata*, turmeric (curcumin), ginger, and willow bark, have potent anti-inflammatory properties that help reduce the swelling and pain associated with arthritis. These compounds work by inhibiting inflammatory pathways, including the prostaglandin and leukotriene pathways, thereby reducing inflammation in the joints.
- **Pain Relief:** Herbal compounds can also act as analgesics, helping to alleviate the chronic pain that often accompanies arthritis. For instance, cannabis (CBD) and capsaicin are well-known for their pain-relieving properties. These compounds can block pain signals and reduce sensitivity to pain.
- **Antioxidant Properties:** Many herbs contain antioxidants, which help neutralize free radicals that can cause oxidative stress and contribute to joint damage in conditions like osteoarthritis and rheumatoid arthritis. For example, green tea extract and turmeric have strong antioxidant effects that protect joint tissues.
- **Disease Modulation:** Some herbal compounds, like *Boswellia serrata*, have been shown to modulate the immune response, which can be particularly beneficial in autoimmune forms of arthritis, such as rheumatoid arthritis (RA). By reducing the activity of the immune system that attacks the joints, these herbs help manage the underlying disease process.
- **Fewer Side Effects:** Herbal treatments are often seen as a natural alternative to synthetic pharmaceuticals, with a perception of fewer adverse effects. For people with sensitivity or contraindications to conventional drugs (such as NSAIDs or corticosteroids), herbal compounds can offer a gentler option for managing symptoms.

2. Popular Herbal Compounds in Arthritis Management

- **Boswellia Serrata:** Known for its potent anti-inflammatory and analgesic properties, *Boswellia serrata* has been widely used in treating osteoarthritis and rheumatoid arthritis. Boswellic acids, the active components of this herb, inhibit the 5-lipoxygenase enzyme involved in the inflammatory cascade.
- **Curcumin (from Turmeric):** Curcumin is well-known for its anti-inflammatory effects, and studies have shown it can help reduce joint pain and swelling. It inhibits key inflammatory pathways, including NF- κ B and COX-2.

Transdermal Patches

Transdermal patch is a medicated adhesive patch that is placed on the skin to deliver a specific dose of medication through the skin and into the bloodstream. An advantage of a transdermal drug delivery route over other types of medication delivery (such as oral, topical, intravenous, or

intramuscular) is that the patch provides a controlled release of the medication into the patient, usually through either a porous membrane covering a reservoir of medication or through body heat melting thin layers of medication embedded in the adhesive. The main disadvantage to transdermal delivery systems stems from the fact that the skin is a very effective barrier; as a result, only medications whose molecules are small enough to penetrate the skin can be delivered by this method. Transdermal patch is a patch that attaches to your skin and contains medication. The drug from the patch is absorbed into your body over a period of time. If you'd rather not have a pill or an injection, a transdermal patch may be a more comfortable option for taking some medications. Apply the patch to a dry, flat skin area on your upper arm, chest, or back. Choose a place where the skin is not very oily and is free of scars, cuts, burns, or irritation.



Fig 2: Transdermal Patch

Mechanism of transdermal patches:

A transdermal patch is a medicated adhesive patch that is applied to the skin to deliver a specific dose of medication over a period of time. The patch works by using the skin as a route of absorption, allowing the drug to enter the bloodstream directly, bypassing the digestive system and liver metabolism. Here's how the mechanism of a transdermal patch works:

1. Application to the Skin

- The patch is typically applied to clean, dry, and intact skin, often on areas where there is minimal hair and good blood flow (e.g., upper arm, back, chest).
- The adhesive layer of the patch keeps it in place on the skin.

2. Drug Diffusion

- The patch contains a drug reservoir or matrix that holds the medication. The drug is usually in a dissolved or suspended form.
- Upon application, the drug gradually diffuses from the patch through the layers of the skin. The patch is

designed to control the rate at which the drug is released.

3. Penetration through the Skin

- The skin is made up of several layers, with the stratum corneum (the outermost layer of dead skin cells) being the most significant barrier to drug absorption.
- The medication must penetrate through the epidermis (outer layer), dermis (inner layer), and eventually reach the blood vessels in the dermis to enter the bloodstream.

There are several ways drugs can penetrate the skin:

- **Passive Diffusion:** The drug moves from an area of high concentration (in the patch) to an area of lower concentration (inside the body).
- **Enhancers:** Some patches include chemicals that enhance the permeability of the skin, allowing for better absorption of the drug.
- **Microneedles:** Some advanced patches use microneedles to create microscopic channels in the skin, helping the drug pass through more effectively.

4. Systemic Absorption

- Once the drug reaches the dermis, it enters the capillaries and blood vessels.
- The drug then circulates through the bloodstream, reaching the target tissues or organs to produce the desired therapeutic effect.
- The advantage is that the drug bypasses the digestive system and liver (which can metabolize some drugs before they are fully absorbed), allowing for more direct and consistent delivery.

5. Controlled Release

- Transdermal patches are designed to release drugs at a steady, controlled rate over an extended period (from hours to days, depending on the type of patch).
- The rate of release is typically determined by the design of the patch—it can be controlled by the membrane or reservoir system in the patch, which limits how much drug is released at a time.

6. Duration of Action

- The medication is slowly absorbed into the bloodstream over time, ensuring a continuous effect. This sustained release helps maintain steady drug levels and reduces the likelihood of peak-and-valley fluctuations (compared to oral medications, where drug levels can vary significantly).

Advantages of Transdermal Patches:

- **Bypass First-Pass Metabolism:** They avoid the liver's first-pass effect, ensuring more of the drug reaches the bloodstream.
- **Convenience:** Easy to apply and discreet.
- **Continuous Delivery:** Provides a steady release of medication, which can be more effective than intermittent dosing.
- **Reduced Side Effects:** Because of the controlled release, there may be fewer side effects compared to oral medications.

Boswellia serrata

Boswellia serrata, commonly known as Indian frankincense,

is a tree native to the Indian subcontinent, Africa, and parts of the Middle East. This plant has a long history of use in traditional medicine and spiritual practices, particularly in Ayurveda, where it has been valued for its anti-inflammatory, analgesic, and therapeutic properties for thousands of years.

The plant produces a resin that has been highly prized since ancient times. This resin contains bioactive compounds, particularly Boswellic acids, which are credited with many of its medicinal properties. The resin has been used in incense, perfumes, and ritualistic offerings since ancient civilizations like those in Egypt and Greece.

In Ayurvedic medicine, Boswellia serrata is considered a potent herb for the management of conditions like arthritis, digestive disorders, and respiratory issues. In recent decades, scientific studies have increasingly supported many of these traditional uses, especially in the context of joint health, inflammatory conditions, and autoimmune disorders. The plant's anti-inflammatory and pain-relieving properties have led to the development of various pharmaceutical and nutraceutical formulations, ranging from topical creams and ointments to capsules and tablets, with applications in the treatment of osteoarthritis, rheumatoid arthritis, inflammatory bowel diseases, and bronchial asthma.



Fig 3: Boswellia serrata and resin

Table 1: Drug profile

Drug Profile	Boswellia Serrata Extract
Common Name	Indian frankincense, Salai guggul
Active Constituents	Boswellic acids
Classification	Anti-inflammatory, Analgesic
Pharmacological Category	Natural Herbal Remedy

Pharmacological Properties and Mechanism of Action: -

Boswellia serrata extract, derived from the resin of the Boswellia serrata tree, contains boswellic acids, which are the primary active constituents responsible for its medicinal properties. Boswellia serrata extract is widely recognized for its anti-inflammatory and analgesic effects.

1. **Anti-inflammatory:** Boswellia acids, particularly acetyl-11-keto- β -Boswellia acid (AKBA), inhibit the enzyme 5-lipoxygenase (5-LOX), which is involved in the production of pro-inflammatory molecules called leukotrienes. By blocking this enzyme, Boswellia reduces inflammation and helps manage conditions such as arthritis and inflammatory bowel disease.

2. **Analgesic:** The anti-inflammatory effects of *Boswellia serrata* extend to its ability to reduce pain. The extract helps reduce pain in individuals suffering from inflammatory conditions, especially joint pain related to osteoarthritis and rheumatoid arthritis.
3. **Immunomodulatory and Antioxidant:** *Boswellia serrata* also exhibits immunomodulatory properties by regulating immune responses, making it beneficial for treating autoimmune diseases and managing chronic inflammation. Additionally, it possesses antioxidant properties that help reduce oxidative stress, which is associated with many chronic conditions, including arthritis, cardiovascular diseases, and neurodegenerative disorders.

Clinical Applications:

- **Osteoarthritis (OA):** Numerous studies have shown that *Boswellia serrata* extract can help reduce pain and improve joint function in individuals with osteoarthritis. The extract reduces inflammation in the joints, alleviates pain, and enhances mobility. This makes it a valuable option for non-pharmacological treatment of OA, especially for individuals who cannot tolerate traditional non-steroidal anti-inflammatory drugs (NSAIDs) due to side effects.
- **Rheumatoid Arthritis (RA):** *Boswellia serrata* extract may also be useful for individuals with rheumatoid arthritis by reducing the pain and swelling associated with the disease, and improving joint function.
- **Inflammatory Bowel Disease (IBD):** The anti-inflammatory effects of *Boswellia* have shown benefits in the management of ulcerative colitis and Crohn's disease, conditions characterized by chronic inflammation in the gastrointestinal tract.

TAXONOMY –

Table 2: Taxonomical Characteristics

Kingdom	Plantae
Division	Angiosperms
Class	Eudicots
Order	Sapindales
Family	Burseraceae
Genus	<i>Boswellia</i>
Species	<i>Boswellia serrata</i>

The active boswellic acids found in *Boswellia serrata* are a group of pentacyclic triterpenoids, which are the primary bioactive compounds responsible for the anti-inflammatory, analgesic, and other therapeutic properties of the plant. Among these acids, several have been identified as having strong pharmacological effects, particularly in terms of reducing inflammation, improving joint health, and potentially offering neuroprotective benefits.

Active Boswellic Acid

1. Acetyl-11-Keto- β -Boswellic Acid (AKBA)

- AKBA is considered the most potent boswellic acid with the most significant anti-inflammatory and analgesic properties.
- It works by inhibiting 5-lipoxygenase (5-LOX), an enzyme involved in the production of leukotrienes, which are molecules that promote inflammation.

- AKBA is widely researched for its ability to reduce inflammation in conditions such as osteoarthritis, rheumatoid arthritis, and inflammatory bowel disease (IBD).
- Anti-cancer potential: Some studies suggest that AKBA might have anti-cancer effects by inhibiting the growth of cancer cells and preventing their spread.
- β -Boswellic Acid (BA)
- β -Boswellic acid is another important component of *Boswellia serrata*, known for its anti-inflammatory effects.
- It also inhibits 5-LOX, though its potency is less than that of AKBA.
- BA contributes to the pain-relieving effects of *Boswellia* and may be useful in the treatment of joint pain and swelling associated with conditions like arthritis.
- Acetyl- β -Boswellic Acid (ABA)
- Acetyl- β -boswellic acid is a derivative of β -boswellic acid that has similar, though slightly weaker, anti-inflammatory and anti-arthritic effects compared to AKBA.
- It may enhance the bioavailability of other boswellic acids when consumed together in the form of *Boswellia* extract.
- 11-Keto- β -Boswellic Acid (KBA)
- 11-Keto- β -boswellic acid is a precursor to acetyl-11-keto- β -boswellic acid (AKBA) and also possesses significant anti-inflammatory effects.
- Though less active than AKBA, KBA still contributes to the joint health benefits and inflammatory response modulation associated with *Boswellia serrata* extract.

Mechanism of Action

Boswellic acids primarily act by inhibiting 5-lipoxygenase (5-LOX), an enzyme that catalyzes the production of leukotrienes from arachidonic acid. Leukotrienes are involved in the inflammatory response and can contribute to conditions like asthma, arthritis, and ulcerative colitis. By inhibiting 5-LOX, boswellic acids reduce the production of these inflammatory molecules, leading to a decrease in pain, swelling, and inflammation.

Therapeutic Applications of Boswellic Acids

- **Joint Health:** Boswellic acids, particularly AKBA, are known to reduce inflammation and pain associated with osteoarthritis and rheumatoid arthritis. They improve mobility and function in affected joints.
- **Respiratory Health:** Boswellic acids have shown benefits in reducing inflammation in the airways, making them useful for asthma and bronchitis.
- **Digestive Health:** In conditions like inflammatory bowel disease (IBD), AKBA and BA can help reduce inflammation in the gastrointestinal tract, alleviating symptoms of Crohn's disease and ulcerative colitis.
- **Neuroprotection:** Some studies suggest that boswellic acids may help protect against neurodegenerative conditions like Alzheimer's disease by reducing inflammation in the brain and protecting neurons.
- **Anti-cancer Potential:** Certain boswellic acids, especially AKBA, have been shown to inhibit cancer cell growth and induce apoptosis (programmed cell death) in certain types of cancer, including colon cancer and breast cancer.

Conclusion

The formulation and evaluation of topical patches using *Boswellia serrata* for arthritis management presented promising results throughout the research process. *Boswellia serrata*, a renowned natural anti-inflammatory agent, demonstrated its potential in alleviating symptoms of arthritis when incorporated into transdermal patches. The patches were designed to deliver the active compounds of *Boswellia serrata*, specifically boswellic acids, directly to the site of inflammation, enhancing local therapeutic effects. The formulation studies revealed that the patches exhibited satisfactory characteristics, including appropriate drug release, skin compatibility, and mechanical strength. The *in-vitro* drug release studies showed a controlled and sustained release profile, suggesting that the patches could provide long-lasting relief with minimal side effects. Furthermore, the stability studies indicated that the formulated patches maintained their efficacy and quality over time under various storage conditions.

Evaluation through pre-clinical trials or *in vivo* studies would be essential to confirm the effectiveness of these patches in a clinical setting, but the preliminary results support the potential of *Boswellia serrata*-loaded patches as a viable alternative or adjunct to traditional oral medications for arthritis management. The localized delivery system is beneficial in reducing systemic side effects commonly associated with oral drugs.

Overall, the study highlights the potential of using *Boswellia serrata* in topical patch formulations as a novel approach to managing arthritis symptoms. Future research focusing on optimizing formulation parameters, evaluating the clinical efficacy, and assessing patient compliance could further solidify the role of *Boswellia serrata*-based patches in modern therapeutic strategies for arthritis.

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Conflict of Interest

The authors declare that no conflict of interest of any financial or other issues.

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