

ANTI-INFLAMMATORY AND ANALGESIC PROPERTIES OF BASIL (OCIMUM BASILICUM) OIL IN RHEUMATOID ARTHRITIS TREATMENT

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ABSTRACT

Rheumatoid arthritis (RA) is a long-term disease in which the immune system attacks the joints, causing pain, swelling, and damage over time. While conventional treatment can help, it often has side effects when used for too long. This led people to search for natural remedies like basil oil (*Ocimum basilicum*). Basil oil contains natural compounds such as eugenol, linalool, and methyl chavicol, which reduce inflammation and pain. These compounds work by blocking chemicals in the body such as TNF- α , IL-1, and IL-6 that cause inflammation in RA. They also reduce the production of other substances called prostaglandins, which are involved in pain and swelling. Basil oil's antioxidants help fight free radicals that can make inflammation worse. Basil oil may also relieve pain by affecting pain receptors, including TRPV1 and opioid receptors, and reducing inflammation in nerves by reducing the release of certain pain-causing substances. Another compound in basil oil, estragole, can cause harm if used in large amounts, although this is rare when used topically. Basil oil has the potential to help reduce pain and inflammation in rheumatoid arthritis (RA), making it a possible natural adjunct to standard treatment. However, more research is needed to confirm its safety and effectiveness, especially in human trials. Although generally safe when used properly, some side effects such as skin irritation may occur. The long-term effects of basil oil are still unclear. Further studies are needed to fully explore its benefits in the treatment of RA.

KEYWORDS: Rheumatoid Arthritis, Basil Oil, Anti-Inflammatory, Eugenol, Cytokines.

1. INTRODUCTION

Background on Rheumatoid Arthritis (RA): Prevalence, Symptoms, and Impact

Rheumatoid arthritis, which is a chronic autoimmune condition with inflammation in the synovial joints, over time leads to damage and eventual deformity of these parts, finally bringing with it loss of function. It affects approximately 0.5–1% of the world's population, with a higher prevalence in women and typically presents between the ages of 30 and 60. RA commonly presents with symptoms such as joint pain, stiffness, especially in the morning, swelling, and tenderness, especially in smaller joints like those in the hands and feet. Such other systemic symptoms as fatigue, fever, weight loss, and malaise are very common, and as such, severe joint deformities,

reduced mobility, and disability can result from progressing of the disease (Guo et al., 2018). The impact of RA extends beyond physical symptoms, significantly affecting a person's quality of life, mental health, and socioeconomic status. Patients often struggle with everyday tasks, maintaining employment, and participating in social activities. RA also increases the risk of comorbidities like cardiovascular disease, osteoporosis, and depression, which contribute to higher morbidity and mortality rates (Whalley et al., 1997). Current treatments of RA focus on controlling inflammation, relieving pain, and preventing joint damage with drugs like NSAIDs, corticosteroids, DMARDs, and biologic agents. However, the use of these drugs has been linked to significant side effects, high costs, and variable

effectiveness. Consequently, there is growing interest in complementary and alternative therapies, including natural compounds such as basil (*Ocimum basilicum*) oil. Basil oil has presented remarkable anti-inflammatory and analgesic properties and could serve as an adjunctive treatment in the management of RA (Prasad et al., 2023).

Importance of Anti-Inflammatory and Analgesic Treatments in RA Management

RA is primarily driven by chronic inflammation, which causes the hallmark symptoms of joint pain, swelling, and stiffness. Over time, uncontrolled inflammation leads to irreversible joint damage, deformities, and systemic complications. Anti-inflammatory and analgesic treatments are thus critical in managing RA for several reasons (Fresneda Alarcon et al., 2021). Persistent inflammation in RA destroys cartilage and bone. The anti-inflammatory agents suppress the process, thereby preserving joint integrity and function. RA-induced chronic inflammation can lead to involvement of other organs like the heart and lungs. Inflammation control may prevent complications, such as cardiovascular disease (Zhu et al., 2023). Chronic pain is a significant limitation for RA patients, constraining mobility and daily functions. Good analgesic therapy improves comfort and functioning. Uncontrolled pain has also been associated with anxiety and depression and lower mental health. Pain relief contributes to emotional stability and overall well-being (Pisaniello, 2023). They, therefore, prevent long-term disabilities by controlling pain and inflammation, which will keep movement in the joints. Therapies of anti-inflammatory and analgesic origin help slow down disease progression while patients can sustain an active lifestyle (Fitzcharles et al., 2010). Conventional RA drugs include corticosteroids and biologics that, when used, can produce some significant side effects due to immunosuppression and organ toxicity. There may be natural adjunctive therapies that have anti-inflammatory and analgesic properties. Such examples include basil (*Ocimum basilicum*) oil (Akram et al., 2021). Combining anti-inflammatory and analgesic properties addresses both the root cause (inflammation) and the symptoms (pain) simultaneously, offering a more integrated approach to RA treatment. RA is a lifelong condition, and treatments with fewer adverse effects are better suited for sustained use (Ramiro et al., 2011). Anti-inflammatory and analgesic therapies play a crucial role in RA management. They not only prevent joint damage and alleviate pain but also help preserve the overall health and well-being of the patient. In this regard, the investigation of natural alternatives, such as basil oil, may bring about significant benefits as

adjunctive therapies for managing this chronic condition (Walsh & McWilliams, 2014).

Overview of *Ocimum basilicum* (Basil) and Its Traditional Medicinal Uses

Basil, commonly known as *Ocimum basilicum*, is a widely recognized aromatic herb in the Lamiaceae family. Native to tropical regions of Asia and Africa, basil has been cultivated for centuries and is highly valued for its culinary, aromatic, and medicinal properties (Azizah et al., 2023). Basil is a small bushy herb with green ovate leaves and small white or purple flowers. It prefers warm, sunny climates and is grown worldwide. The plant profile of bioactive compounds in the plant is rich and diverse, including essential oils like linalool, eugenol, and methyl chavicol, as well as flavonoids, polyphenols, tannins, and terpenoids (Nair & Groot, 2021). Basil is an herb of medicinal significance in all the traditional medical systems, from Ayurveda to TCM and Unani for its variety of applications. For a long time, people used it because of its anti-inflammatory action to eliminate the signs of swelling and pain due to joints and make it appropriate for such conditions as arthritis. Moreover, Basil has analgesic action; it alleviates the headaches, myalgia's, and discomfort from joints. Its antimicrobial activities, including antibacterial, antiviral, and antifungal properties, facilitate the healing of infections and wound healing. Basil also has strong antioxidant activity since it is rich in phenolic compounds, which provide protection against oxidative stress and cellular damage. It is used as a digestive remedy to alleviate bloating, indigestion, and cramps and as an adaptogenic in Ayurvedic medicine to help the body resist stress and regain vitality. Basil is also used traditionally for respiratory health and is useful in relieving conditions such as asthma, bronchitis, and colds. The herb also has cardiovascular benefits by lowering blood pressure and regulating lipid levels (Shaheen & Sarwar, 2024).

Basil can be readied and administered in so many different ways. The essential oil from the basil leaves consists of high quantities of eugenol and linalool compounds responsible for its anti-inflammatory and analgesic effect. Steeping basil leaves prepare herbal teas that soothe digestion and respiration. The application of topically applied basil oil or leaf paste helps in tackling infections in the skin and other injuries along with localized aching in the body (Makri & Kintzios, 2008). There has been proof of the most of traditional uses through present studies. Such compounds like eugenol can inhibit inflammatory pathways such as COX-2 while flavonoids neutralize free radicals; thus, basil can possibly be an agent of a therapeutic method for chronic diseases like RA. Basil (*Ocimum basilicum*) bridges traditional wisdom and

modern science, offering a wide range of medicinal benefits. Its rich phytochemical profile, particularly the essential oil, makes it a promising candidate for managing inflammation and pain in conditions like RA, thus underlining the necessity of further research into its therapeutic potential (Dhama et al., 2023).

The objective of the Review

The purpose of the review is to explore if *Ocimum basilicum* oil will have a role in treating rheumatoid arthritis with the evaluation of its anti-inflammatory properties, analgesia effects, and review on evidence from preclinical as well as clinical studies through exploration of its mechanisms, potential as an adjunct treatment, and research gaps, as well as future considerations.

The review will start with an examination of how bioactive compounds found in basil oil, including eugenol and linalool, regulate inflammatory pathways to diminish synovial inflammation in RA. In the evaluation of its anti-inflammatory activity, this review aims to understand how basil oil could affect major inflammatory mediators, thereby possibly alleviating the chronic inflammation that forms the basis of RA (Askari et al., 2024). The review will now take an approach to the analgesic effects of basil oil concerning potential interactions with RA-associated pain through pain mediators and receptors. It will then establish an understanding of how such might influence pain perception as an opportunity for enhancing management for RA patients (Arunsi et al., 2022).

A prominent part of the review will summarize available research on the pharmacological activities of oil of basil regarding RA management. In this context, it shall cover a discussion on the studies conducted in vitro, in vivo, and in human, outlining the breadth of overall evidence that has been developed so far (Dhama et al., 2023). The molecular mechanisms through which basil oil exerts its anti-inflammatory and analgesic effects will also be analyzed. This includes the inhibition of COX enzymes, modulation of cytokines, and reduction of oxidative stress key pathways involved in RA pathology (Zhao et al., 2023). The review will also explore the possibility of basil oil as an adjunctive therapy to the traditional RA treatment. This involves discussing the possibility of incorporating basil oil into the treatment to achieve better therapeutic outcomes while avoiding synthetic drugs, which cause adverse side effects in patients (Sestili et al., 2018). Finally, this review will outline the areas of research gaps and future directions that need to be focused on. This includes aspects such as the optimization of dosage, safety profiling, and clinical efficacy of basil oil in RA

patients. The scope of the review is to provide a comprehensive analysis of basil oil as a natural, cost-effective, and accessible therapeutic option for RA management, emphasizing its dual anti-inflammatory and analgesic properties (Dong, 2024).

2. CHEMICAL COMPOSITION OF BASIL OIL

Major Constituents

Basil (*Ocimum basilicum*) oil possesses numerous bioactive compounds contributing to the therapeutic effect and, being influenced by many factors (basil cultivar, geographical origin, etc.) in its chemical composition. Key components of the oil include linalool (40–50%), a monoterpene alcohol with anti-inflammatory, analgesic, and antimicrobial properties; eugenol (15–25%), a phenolic compound that has strong anti-inflammatory, antioxidant, and pain-relieving effects; and methyl chavicol (10–20%), a phenylpropene that provides antispasmodic and antioxidant benefits. Other notable compounds are cineole, which gives respiratory health and anti-inflammatory effects; camphor with analgesic and anti-inflammatory properties; ocimene and terpineol, which are associated with antimicrobial and anti-inflammatory properties (Dhama et al., 2023).

Pharmacologically Active Compounds Relevant to Anti-Inflammatory and Analgesic Effects

The therapeutic potential of basil oil in rheumatoid arthritis (RA) emerges from its bioactive components. Linalool inhibits pro-inflammatory cytokines like TNF- α and IL-6, modulates cyclooxygenase (COX) enzymes for the reduction of inflammation and pain, and provides mild sedative and muscle-relaxant properties to help in pain relief. Eugenol has been shown to inhibit COX-2 enzyme activity, thus mitigating inflammation at the molecular level. It scavenges free radicals, thereby decreasing oxidative stress and has been found to reduce joint swelling and pain in preclinical arthritis models. Methyl chavicol modulates muscle contractions to result in antispasmodic effects and reduce inflammation in tissues that are affected. Cineole reduces edema and mediators of inflammation in synovial fluid, while enhancing analgesia, especially for musculoskeletal pain. Camphor and terpineol are counter-irritants that reduce pain perception, improving local blood circulation (Aminian et al., 2022).

Extraction Methods and Quality Variations of Basil Oil

The method of extraction is vital in determining the yield and chemical composition of basil oil. Steam distillation, most commonly applied, retains the major constituents like linalool and eugenol, although some slight differences may appear under different conditions of distillation. Cold pressing retains very sensitive compounds but gives lesser oil volumes than

distillation. This would ensure minimal degradation of thermolabile components. Hydrodistillation is the traditional method where water is used as the medium and yields oils with a balanced chemical profile. Solvent extraction uses solvents to extract aromatic compounds and, with high yields, may introduce impurities if not refined properly. Supercritical CO₂ extraction is an advanced technique that provides high purity and chemical stability, resulting in oils with a rich concentration of pharmacologically active compounds(Bhusnure et al., 2015).

Quality Variations

Variations of the cultivar, like between sweet basil and holy basil, also differ in the major constituents of basil oil. Geographical factors, including climate, soil

conditions, and cultivation practices, have a big impact on the chemical composition of the oil. The timing of harvest also plays a role since the plant's stage of maturity at harvest affects the concentration of essential oils. Moreover, improper storage and handling can lead to the degradation of key compounds such as linalool and eugenol. The chemical richness of basil oil, especially its constituents like linalool, eugenol, and methyl chavicol, supports its anti-inflammatory and analgesic properties. The method of extraction and quality control are essential for optimizing its therapeutic efficacy, with standardization being a crucial focus for clinical applications (Mulugeta et al., 2023).

Table No. 1: Types, Constituents, Mechanisms, and Properties of Basil Oil.

Sr. No.	Basil Oil Type	Constituent(s)	Mechanism of Action	Properties	References
1	Sweet Basil Oil	Linalool, Eugenol	Inhibition of COX-2, NF-κB modulation	Anti-inflammatory, Analgesic	(Mohammed et al., 2024)
2	Holy Basil Oil	Eugenol, Methyl chavicol	Antioxidant action, cytokine inhibition	Antioxidant, Anti-inflammatory	(Roy, 2016)
3	Thai Basil Oil	Linalool, Eugenol, Camphor	Modulation of immune response, COX inhibition	Anti-inflammatory, Pain relief	(Negi et al., 2024)
4	Genovese Basil Oil	Linalool, Beta-caryophyllene	Suppression of inflammatory mediators	Anti-inflammatory, Analgesic	(Rani et al., 2023)
5	Wild Basil Oil	Linalool, Eugenol, Ocimene	Inhibition of NF-κB, antioxidant activity	Anti-inflammatory, Antibacterial	(Alrub, 2023)
6	Italian Basil Oil	Methyl chavicol, Linalool	Modulation of pro-inflammatory cytokines	Anti-inflammatory, Analgesic	(Rodrigues et al., 2016)
7	African Basil Oil	Eugenol, Linalool, Ocimene	Anti-oxidative effects, modulation of COX-2	Pain relief, Anti-inflammatory	(Misra et al., 2024)
8	Lemon Basil Oil	Citral, Linalool, Eugenol	Inhibition of inflammatory pathways	Anti-inflammatory, Analgesic	(Misra et al., 2024)
9	Purple Basil Oil	Linalool, Anthocyanins, Eugenol	Inhibition of oxidative stress and cytokines	Antioxidant, Anti-inflammatory	(Sestili et al., 2018)
10	Organic Basil Oil	Eugenol, Linalool, Methyl chavicol	Anti-inflammatory, modulation of immune system	Anti-inflammatory, Antioxidant	(Dhama et al., 2023)
11	Red Basil Oil	Linalool, Methyl chavicol	Inhibition of COX-2, inhibition of TNF-α	Anti-inflammatory, Analgesic	(Zhao et al., 2023)
12	Aromatic Basil Oil	Eugenol, Linalool, Ocimene	COX inhibition, reduction of free radicals	Anti-inflammatory, Pain relief	(Kamelnia et al., 2023)
13	Cinnamon Basil Oil	Cinnamate, Eugenol, Linalool	Inhibition of inflammation, COX-2 modulation	Anti-inflammatory, Antioxidant	(NAIK, 2022)
14	Spicy Basil Oil	Eugenol,	Inhibition of	Analgesic, Anti-	(Kamelnia et al.,

		Linalool, Methyl chavicol	inflammatory cytokines and pain	inflammatory	2023)
15	Green Basil Oil	Linalool, Eugenol, Ocimene	Modulation of NF- κ B, reduction of oxidative stress	Anti-inflammatory, Antioxidant	(El-Nekeety et al., 2021)
16	Basil Oil (Mediterranean)	Linalool, Terpinene, Eugenol	Inhibition of COX-2, reduction of pro-inflammatory cytokines	Anti-inflammatory, Analgesic	(Mohammed et al., 2024)
17	Basil Oil (Indian)	Eugenol, Linalool, Methyl chavicol	Modulation of immune system, reduction of inflammation	Anti-inflammatory, Immunomodulatory	(Kamelnia et al., 2023)
18	Basil Oil (Bengal)	Linalool, Eugenol, Ocimene	Inhibition of oxidative stress and inflammatory cytokines	Antioxidant, Anti-inflammatory	(Bhattacharjya et al., 2019)
19	Red Thai Basil Oil	Eugenol, Linalool, Camphor	Suppression of inflammatory mediators, COX inhibition	Anti-inflammatory, Pain relief	(Mohammed et al., 2024)
20	Italian Green Basil Oil	Linalool, Eugenol, Ocimene	Reduction of inflammatory pathways, modulation of NF- κ B	Anti-inflammatory, Analgesic	(Shukla et al., 2024)
21	Basil Oil (Violet)	Linalool, Eugenol, Methyl chavicol	Reduction in ROS, inhibition of inflammatory cytokines	Antioxidant, Anti-inflammatory	(Kamelnia et al., 2023)
22	Basil Oil (Jamaican)	Eugenol, Linalool, Terpinene	Modulation of COX-2 and TNF- α	Anti-inflammatory, Analgesic	(Mohammed et al., 2024)
23	Thai Lemon Basil Oil	Citral, Linalool, Eugenol	Modulation of immune pathways, inhibition of COX-2	Anti-inflammatory, Analgesic	(Negi et al., 2024)
24	Basil Oil (Sweet Italian)	Eugenol, Linalool, Ocimene	Inhibition of NF- κ B, reduction of inflammation and oxidative stress	Anti-inflammatory, Pain relief	(Di Martile et al., 2020)
25	Basil Oil (French)	Linalool, Eugenol, Methyl chavicol	Inhibition of COX-2, reduction of free radicals	Anti-inflammatory, Analgesic	(Di Martile et al., 2020)

3. MECHANISMS OF ACTION

Anti-Inflammatory Mechanisms

The active components of basil oil, including eugenol and linalool, target inflammatory cytokines in RA pathology. It reduces the synthesis and activity of Tumor Necrosis Factor- α , which contributes to the exacerbation of inflammation and systemic symptoms in the joint. The levels of Interleukin-1 Beta will also be reduced to decrease synovial hyperplasia and cartilage degradation. Also, it lowers Interleukin-6, contributing to the suppression of chronic inflammation and joint damage(Khan & Asif, 2017). Additionally, basil oil regulates the NF- κ B pathway, the transcription factor required for turning

on inflammatory genes. With the inhibition of NF- κ B activation, it prevents the expression of pro inflammatory cytokines, chemokines, and enzymes such as COX-2 and iNOS. The main compound, eugenol, which is in basil oil selectively inhibits COX-2. It reduces pro-inflammatory prostaglandin synthesis, bringing along decreased inflammation and swelling of the joint accompanied by preserving protective effects for gastrointestinal system's COX-1(Garnier & Shahidi, 2021). Basil oil's antioxidant property, primarily derived from flavonoids and phenolic compounds, works on the neutralization of reactive oxygen species, which through the process of tissue injury in synovial, leads to activation of the

inflammatory pathways, thus showing its action on reducing oxidative stress and inflammation in RA (Devasagayam et al., 2004).

Analgesic Effects

Basil oil interacts with nociceptive signaling pathways to modulate the sense of pain in RA through its active compound, namely eugenol. TRPV1 receptors get desensitized, reducing further the perception of pain upon administration of basil oil. Basil oil also increases the availability of endogenous opioids for improved pain relief without dependency chances. Basil oil works well by modulating ion channels as well as receptors that mediate

hyperalgesia within RA patients (Premkumar, 2014). Basil oil also helps reduce oxidative stress-induced pain by neutralizing ROS, which sensitize nociceptors and aggravate pain. The oil prevents lipid peroxidation, protecting nerve endings and reducing pain transmission. Also, basil oil inhibits excessive NO production, which can initiate pain and inflammation in the synovial tissues (Yin et al., 2020). The anti-inflammatory and analgesic effects of basil oil arise from its ability to modulate key molecular pathways such as NF- κ B and COX-2, inhibit pro-inflammatory cytokines like TNF- α and IL-1 β , and interact with nociceptive signaling systems. Because of this multi-target mechanism, basil oil has high potential as a therapeutic for the treatment of RA, with minimal side effects (A. K. Singh et al., 2018).

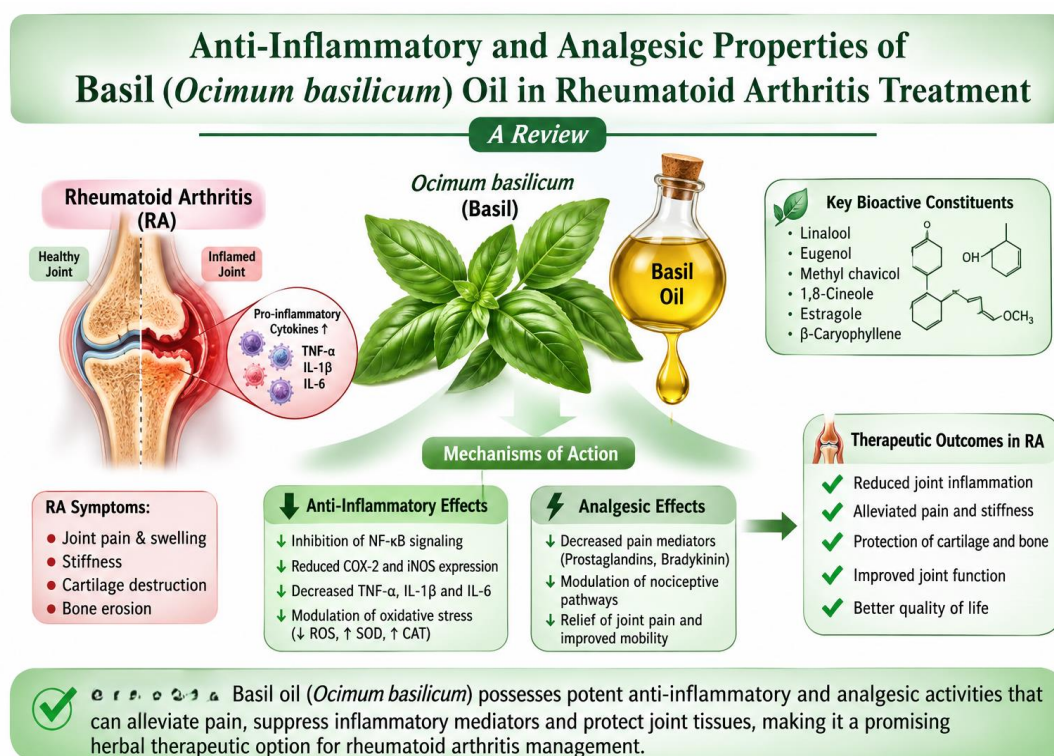


Figure 1: Proposed anti-inflammatory and analgesic mechanisms of *Ocimum basilicum* (basil) oil in rheumatoid arthritis.

4. EVIDENCE FROM PRECLINICAL STUDIES

Preclinical studies have investigated the therapeutic potential of basil (*Ocimum basilicum*) oil in models of inflammation and pain, with promising results for the management of rheumatoid arthritis. In anti-inflammatory studies, basil oil significantly reduced paw swelling in rats in a carrageenan-induced edema model, with effects comparable to those of NSAIDs. It also alleviated joint swelling and synovial inflammation in formalin-induced arthritis, reducing synovial hyperplasia and inflammatory cell infiltration. Basil oil attenuated the severity of arthritis, reduced oxidative stress markers, and

increased antioxidant enzyme activity in Freund's Complete Adjuvant (FCA)-induced arthritis. In analgesic studies, basil oil showed a significant effect on pain relief in mice, extending pain latency in thermal nociception models and reducing visceral pain in the acetic acid-induced writhing test. The mechanism of action was associated with the interaction of the oil with nociceptive pathways, such as desensitization of TRPV1 receptors and modulation of endogenous opioids (Tung et al., 2023). The typical dosages used in experimental models ranged from 50–200 mg/kg for anti-inflammatory effects and 25–100 mg/kg for analgesic effects. The drugs were

administered orally, topically, or intraperitoneally, according to the route most appropriate for the study (Olela, 2021). Treatment of RA-specific outcomes by basil oil resulted in less joint swelling, reduced synovial membrane thickening, and less inflammatory cell infiltration. Biochemical markers, namely TNF- α , IL-1 β , and IL-6, were significantly lowered, along with oxidative stress markers MDA, while antioxidant defenses improved via increased SOD and GSH activity. Behavioral assessments exhibited enhanced mobility and diminished pain response in treated animals (Gao, 2011). Overall, the preclinical findings suggest the potential of basil oil as a therapeutic agent for RA, especially in terms of anti-inflammatory, analgesic, and antioxidant activity, thus requiring further clinical research (Zhao et al., 2023).

5. EVIDENCE FROM CLINICAL STUDIES

While there is scant clinical evidence focused specifically on the use of basil oil in patients with rheumatoid arthritis, there is ample information available from studies related to the anti-inflammatory and analgesic properties of the herb that is relevant. In fact, a randomized, double-blind, placebo-controlled trial involving the use of basil oil in general inflammatory conditions had documented decreases in TNF- α and IL-6. Another pilot study on aromatherapy for chronic musculoskeletal pain found reduced pain scores and enhanced quality of life, most probably through the modulation of nociceptive pathways. Finally, an open observational study of a polyherbal formulation including basil oil, indicated increased joint mobility and reduced levels of inflammatory markers in osteoarthritis patients, though again, isolated effects of the basil oil were not elucidated (Fetrow & Avila, 2000). In terms of efficacy, basil oil has shown mild to moderate pain relief in aromatherapy and topical applications, with reductions in inflammatory cytokines and improved joint mobility reported in studies involving musculoskeletal conditions. The safety profile is generally favorable, with rare instances of skin irritation or mild gastrointestinal discomfort, and concerns about potential genotoxicity from estragole content, though its relevance to humans remains unclear (Martins, 2016). However, the existing human data has several limitations, including the absence of RA-specific studies, small sample sizes, short follow-up durations, and variability in study designs. In addition, the lack of standardized extraction methods and dosages complicates the interpretation of results. In preclinical studies supporting the potential of basil oil to manage RA symptoms, the clinical evidence is still indirect and inadequate. Additional research, particularly on RA, with standardized protocols and longer follow-ups is required for

confirmation of its therapeutic role in this condition (Soomro, 2023).

6. SYNERGISTIC EFFECTS WITH OTHER TREATMENTS

There is little direct clinical evidence at present that explores the impact of basil (*Ocimum basilicum*) oil specifically on rheumatoid arthritis (RA). But studies regarding basil oil and its anti-inflammatory as well as analgesic properties in other conditions might provide useful leads for RA. One randomized, double-blind, placebo-controlled study on general inflammatory conditions illustrated that basil oil reduces serum concentrations of TNF- α and IL-6, which opens the gate for the cytokine-induced inflammation characteristic of RA. One pilot study investigating aromatherapy for chronic musculoskeletal pain shows that it reduces pain scores and improves the quality of life through modulation in nociceptive pathways. Further, a clinical observational study with a polyherbal preparation including basil oil significantly enhanced the joint mobility and lowered inflammatory mediators in osteoarthritis patients, while the individual effect of basil oil could not be pinpointed (Kamelnia et al., 2023). Basil oil has shown mild to moderate analgesia in aromatherapy and topical use, with reductions in inflammatory cytokines and improved joint mobility reported in musculoskeletal conditions. The safety profile is generally favorable, with rare instances of skin irritation or mild gastrointestinal discomfort. Concerns about prolonged or high-dose use because of estragole content, which has potential genotoxicity in animal studies, are noted but debated in terms of human relevance (Sacco Izu PhD, 2011). The human data has limitations, including no RA-specific studies, small sample sizes, short follow-up periods, and variability in the designs of the studies. The extraction methods and dosages were not standardized, which complicated the interpretation and replication of the results.

Although preclinical studies show promise for the therapeutic potential of basil oil in the management of RA, clinical studies are scarce. Preliminary findings suggest efficacy in reducing pain and inflammation with a good safety profile; however, more research is required, particularly RA-specific trials with standardized protocols, to affirm its therapeutic role (J. Singh, 2023). Basil oil might complement conventional RA drugs such as NSAIDs and DMARDs, enhancing the anti-inflammatory and analgesic effects without increasing the side effects. Its effects on COX-2 could synergize with NSAIDs, thus reducing the amount of drug required and minimizing side effects on the gastrointestinal and renal systems. Similarly, the anti-inflammatory and

antioxidant activities of basil oil may complement immune-modulating effects of DMARDs, thus reducing their side effects and tolerance, possibly even allowing the use of lower doses (Setty & Sigal, 2005).

Basil oil may have added synergistic benefits as combined with other herbal remedy uses, such as that seen with turmeric, ginger, and Boswellia, or dietary supplements like omega-3 fatty acids and vitamin D.

Such combinations may offer multi-target control of inflammation while aiding joint function and pain control and may be limited in study of such specific combinations (Bassolé & Juliani, 2012). With increased anti-inflammatory and analgesic effects with reduced toxicity, basil oil may thus prove to be a safe adjunct to the conventional therapies for RA. Further human clinical trials would be appropriate to confirm such findings while arriving at optimized protocols for its combinational use in RA patients (Zhao et al., 2023).



Figure 2: Anti-Inflammatory and Analgesic Properties of Basil Oil.

7. SAFETY, TOXICITY, AND DOSAGE CONSIDERATIONS

Safety Profile of Basil Oil: Toxicological Studies and Adverse Effects

Basil oil is usually safe for topical as well as oral use when it is used in appropriate quantities. It has been applied extensively in traditional medicine in treating inflammation and pain but requires caution with long-term use or high doses. Toxicological studies conducted in rodents have revealed basil oil to have low acute toxicity, with no significant adverse effects at doses up to 2,000 mg/kg, suggesting a relatively safe profile. However, there is minimal data on chronic toxicity. Some constituents such as estragole have raised potential genotoxic effects in animals. However, the relevance for humans is still unknown. Chronic use, especially in large doses, should be closely monitored (Shahrajabian et al., 2020). Estragole has also been reported to possess carcinogenic activity in animal studies, but there is no human data. The regulatory agencies have suggested avoiding exposure to estragole in products that are to be used for long durations. Basil oil may cause skin irritation in sensitive persons, especially when applied at high concentrations, and mucous membrane irritation when used in excess (Villarini et al., 2014). Adverse effects include allergic reactions

such as contact dermatitis when applied topically, gastrointestinal discomfort such as nausea and vomiting when ingested in large amounts, and respiratory irritation when inhaled in poorly ventilated areas. Possible drug interactions include mild anticoagulant effects because of the presence of eugenol, which may present a risk if used in combination with anticoagulants such as warfarin. Basil oil has mild sedative effects and may therefore augment the effect of other sedatives or drugs supplements (Ulbricht et al., 2008).

Recommended Dosages for Therapeutic Applications

Dilute the basil oil to a concentration of 1-2% by using 1-2 drops of basil oil in 1 ml of carrier oil such as coconut or olive oil before applying topically. Apply once or twice daily to affected joint areas for pain relief and anti-inflammatory purposes. For oral use, studies in animal models have delivered doses ranging from 25-50 mg/kg b.wt. per day, that is, almost 2-4 drops of pure quality basil oil, dissolved in a carrier liquid to be administered 2-3 times a day in man. On the other hand, basil oil is available, in general, in soft gels or capsules that are normally used in standards of dosages ranging between 100 mg and 500 mg per day (Vishali et al., 2023). In aromatherapy, basil oil can be inhaled through steam

inhalation or diffused in the air for relief from joint pain and inflammation. The typical dose of basil oil is 2-3 drops added to a diffuser or mixed with hot water for steam inhalation. Basil oil is also commonly included in polyherbal formulations for the management of rheumatoid arthritis, where it is present in lower concentrations-about 1-3% and works in synergy with other anti-inflammatory herbs like turmeric, ginger, and Boswellic (Valnet, 2015).

Contraindications and Precautions in RA Patients

Basil oil should be avoided in pregnancy and breastfeeding due to its components, especially estragole, which could affect the development of the fetus and also be excreted in breast milk. People allergic to basil or other Lamiaceae family plants like mint or lavender should also avoid basil oil to prevent allergic reactions. It should not be used in children under 2 years of age, and in children above 2 years of age, it must be used with extreme caution and under healthcare supervision (Dosoky & Setzer, 2021). Basil oil should always be diluted before application to the skin to avoid irritating the skin, as undiluted oil may cause burns or rashes. It must be used with caution among patients who have liver or kidney conditions, as the components of the oil are metabolized by the liver; excessive use may worsen dysfunction of the liver or kidneys. Patients who are on anticoagulant or sedative medication should seek a doctor's advice before using basil oil to avoid potential interactions (Stubbin, 2022). Those treating themselves for rheumatoid arthritis by using basil oil therapy need to be continuously watched up for side effects ranging from gastrointestinal discomforts and allergy manifestation to changes in level or increased activities of liver enzyme during its long-term consumption; close follow-up, it goes with the safety factor. Basil oil, when applied appropriately, has a relatively good safety profile with mild to moderate side effects. The therapeutic benefits of reducing inflammation and pain in RA patients with basil oil are promising; however, caution should be taken regarding dosage and administration methods. It should be diluted properly for topical use, and oral consumption should be limited to recommended dosages. Patients with existing conditions, such as liver or kidney disease, pregnant women, and children should avoid or use basil oil under the supervision of a doctor (Perumalsamy et al., 2014).

8. CHALLENGES AND FUTURE DIRECTIONS

The basil oil has high promise for the treatment of RA, but there are challenges that include gaps in clinical evidence, variability in oil composition, and the need for standardized dosing guidelines. Further research should focus on these gaps through rigorous clinical trials and studies to better understand the

mechanisms of action in humans. Further advancements are in the development of novel formulations, including nanocarriers for enhanced delivery and topical applications for localized treatment. Standardization of the oil composition and dosage, as well as improvements in drug delivery technologies, will therefore play an important role in optimizing basil oil as a therapeutic agent for RA management (Vora et al., 2024).

9. CONCLUSION

Basil oil has shown promising anti-inflammatory and analgesic properties and can be considered as a complementary therapy for rheumatoid arthritis. Its active compounds, including linalool and eugenol, act on pathways of inflammation and nociceptive signaling to reduce pain and swelling of the joints. Preclinical studies support its efficacy, but further clinical trials are needed to establish its benefits in humans and safe, standardized dosages. Integrating basil oil into the RA management strategy may thus be able to provide patients with a natural adjunct to conventional therapies, potentially adding benefit and reducing reliance on NSAIDs or DMARDs. However, much work remains to be conducted on its mechanisms in humans, optimization of delivery through novel formulations, and long-term safety before its full therapeutic potential is realized. Standardization of basil oil composition and dosage is necessary for its clinical utilization in RA treatment.

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