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# Phytochemical and Therapeutic Evaluation of Curcuma Longa Linn. In Rheumatoid Arthritis-A Comprehensive Review

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## ABSTRACT

Curcuma longa Linn. (turmeric) is a widely recognized medicinal plant with significant anti-inflammatory, antioxidant, and immunomodulatory properties. Rheumatoid arthritis (RA) is a chronic autoimmune disorder characterized by persistent synovial inflammation, joint destruction, and systemic complications. Curcumin, the principal bioactive constituent of Curcuma longa, exerts therapeutic effects by modulating multiple molecular targets, including NF-κB, MAPK, and JAK/STAT signaling pathways. This review comprehensively evaluates the phytochemical profile, pharmacological mechanisms, preclinical and clinical evidence, and advanced formulation strategies of Curcuma longa in RA management. Despite promising outcomes, limitations such as poor bioavailability and variability in clinical efficacy highlight the need for further research and well-designed clinical trials. [1-5]

**Key Words**: *Curcuma longa Linn, Anti-Inflammatory, Antioxidant, Immunomodulatory Properties, Rheumatoid Arthritis.*

### 1.1 Introduction

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disorder characterized by persistent inflammation of synovial joints, leading to progressive cartilage destruction, bone erosion, and functional disability. The disease affects approximately 0.5–1% of the global population and is more prevalent in women than men. RA not only impacts joint integrity but is also associated with systemic complications such as cardiovascular diseases, pulmonary disorders, and metabolic abnormalities, thereby significantly reducing life expectancy and quality of life [1,2].

The pathogenesis of RA involves a complex interplay between genetic susceptibility, environmental triggers, and immune dysregulation. Activation of immune cells such as T lymphocytes, B lymphocytes, and macrophages leads to the overproduction of pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6). These mediators promote synovial hyperplasia, pannus formation, and subsequent destruction of cartilage and bone. In addition, oxidative stress plays a crucial role in amplifying inflammation and tissue damage in RA [2,3].

Conventional pharmacological treatments for RA include non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, and disease-modifying antirheumatic drugs (DMARDs), including biological agents targeting specific cytokines. Although these therapies are effective in controlling disease progression, their long-term use is often associated with adverse effects such as gastrointestinal toxicity, immunosuppression, hepatotoxicity, and increased risk of infections. Furthermore, the high cost of biologics limits their accessibility, especially in developing countries [3,4]. In recent years, there has been growing interest in the use of herbal medicines and phytochemicals as alternative or complementary therapies for RA. These natural agents offer a multi-targeted approach with relatively fewer side effects.

Among them, Curcuma longa Linn., commonly known as turmeric, has gained considerable attention due to its extensive pharmacological properties. Traditionally used in Ayurvedic and Chinese medicine, turmeric has been employed for centuries in the treatment of inflammatory disorders, wound healing, and various chronic diseases [4,5].

The therapeutic potential of Curcuma longa is primarily attributed to its bioactive constituents, particularly curcumin, a polyphenolic compound responsible for its characteristic yellow color. Curcumin has been extensively studied for its anti-inflammatory, antioxidant, and immunomodulatory effects. It exerts its action by modulating multiple signaling pathways involved in inflammation, including nuclear factor-kappa B (NF-κB), mitogen-activated protein kinase (MAPK), and Janus kinase/signal transducer and activator of transcription (JAK/STAT) pathways. These mechanisms contribute to the suppression of inflammatory cytokines and inhibition of immune cell activation, thereby reducing disease severity in RA [5].

Despite its promising pharmacological profile, the clinical application of curcumin is limited by its poor bioavailability, rapid metabolism, and low systemic absorption. To overcome these challenges, various advanced drug delivery systems such as nanoparticles, liposomes, and phytosomes have been developed to enhance its therapeutic efficacy. These innovations have opened new avenues for the use of Curcuma longa in the management of RA and other chronic inflammatory diseases [3,5].

Therefore, this review aims to provide a comprehensive evaluation of the phytochemical composition, therapeutic potential, molecular mechanisms, preclinical and clinical evidence, and formulation strategies of Curcuma longa Linn. in the management of rheumatoid arthritis. The study also highlights current limitations and future perspectives to support its development as a safe and effective therapeutic agent.

## 2. Botanical Profile

Curcuma longa Linn., commonly known as turmeric, belongs to the family Zingiberaceae and is one of the most widely cultivated medicinal plants in tropical and subtropical regions. It is extensively grown in countries such as India, China, Indonesia, and other parts of Southeast Asia, where climatic conditions favor its growth. India is the largest producer, consumer, and exporter of turmeric, contributing significantly to global production [5,6].

### 2.1 Taxonomical Classification

- **Kingdom:** Plantae
- **Subkingdom:** Tracheobionta (vascular plants)
- **Division:** Magnoliophyta (flowering plants)
- **Class:** Liliopsida (monocotyledons)
- **Order:** Zingiberales
- **Family:** Zingiberaceae
- **Genus:** Curcuma
- **Species:** Curcuma longa Linn.

### 2.2 Morphological Characteristics

Curcuma longa is a perennial, rhizomatous herb that typically grows to a height of 60–100 cm. The plant exhibits the following morphological features:

- **Rhizome:**
  The rhizome is the most important medicinal part of the plant. It is thick, branched, and yellow to orange in color internally due to the presence of curcuminoids. The outer surface is rough and brownish, while the inner portion is bright yellow with a characteristic aromatic odor and slightly bitter taste.
- **Leaves:**
  The leaves are large, oblong, and arranged in two rows. They arise from the rhizome and have long petioles. The leaf blades are bright green with a smooth surface and prominent midrib.
- **Stem:**
  The plant has a pseudo-stem formed by the overlapping leaf sheaths, which gives structural support.
- **Flowers:**
  The flowers are pale yellow to white, arranged in a spike-like inflorescence. Each flower is subtended by a bract, and flowering usually occurs during the rainy season.
- **Roots:**
  Fibrous roots arise from the rhizome, aiding in anchorage and nutrient absorption.

### 2.3 Geographical Distribution and Cultivation

Curcuma longa thrives in warm and humid climates with temperatures ranging from 20°C to 35°C and requires well-drained, fertile soil rich in organic matter. It is primarily cultivated in India, particularly in states like Andhra Pradesh,

Tamil Nadu, Maharashtra, and Odisha. Other countries such as Bangladesh, China, Thailand, and Sri Lanka also cultivate turmeric on a large scale [6,7].The plant is propagated through rhizome cuttings and requires adequate rainfall or irrigation during the growing season. Harvesting is typically carried out 7–9 months after planting when the leaves begin to dry and turn yellow.

**2.4 Microscopic Characteristics**

Microscopic examination of Curcuma longa rhizome reveals characteristic features such as:

- Parenchymatous cells containing starch grains
- Oleoresin cells filled with volatile oils
- Presence of vascular bundles
- Abundant curcumin pigments

These features are important for pharmacognostic identification and quality control of turmeric.

**2.5 Chemical Markers and Standardization**

The quality and therapeutic efficacy of Curcuma longa are primarily determined by its curcuminoid content, especially curcumin. Standardization involves the quantification of:

- Total curcuminoids (typically 2–5%)
- Essential oil content (3–7%)
- Moisture content and ash values

Analytical techniques such as High-Performance Liquid Chromatography (HPLC), High-Performance Thin Layer Chromatography (HPTLC), and spectrophotometric methods are commonly used for quality assessment and standardization [7].

**2.6 Traditional and Ethnomedicinal Uses**

Turmeric has been used for centuries in traditional systems of medicine such as Ayurveda, Unani, and Traditional Chinese Medicine. It is widely used for:

- Treatment of inflammatory disorders (arthritis, wounds)
- Skin diseases and infections
- Digestive disorders
- Liver protection
- Respiratory conditions

**3. Pathophysiology of RA**

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disorder primarily affecting synovial joints. It is characterized by persistent inflammation, synovial hyperplasia, and progressive destruction of cartilage and bone. The pathology of RA is complex and involves an interplay of genetic, environmental, and immunological factors that lead to dysregulated immune responses and chronic inflammation [1,2].

**3.1 Initiation of Autoimmune Response**

The exact cause of RA remains unclear; however, genetic predisposition and environmental triggers play a significant role in disease initiation. Certain genetic factors, particularly the presence of HLA-DR4 and HLA-DR1 alleles, increase susceptibility to RA. Environmental factors such as smoking, infections, and hormonal influences can trigger autoimmune responses in genetically predisposed individuals [2,3].

Autoantibodies such as rheumatoid factor (RF) and anti-citrullinated protein antibodies (ACPAs) are produced during the early stages of the disease. These antibodies form immune complexes that deposit in synovial joints, initiating inflammatory cascades [3].

**3.2 Synovial Inflammation and Hyperplasia**

The hallmark of RA pathology is inflammation of the synovial membrane (synovitis). Activated immune cells, including T cells, B cells, macrophages, and dendritic cells, infiltrate the synovial tissue and release pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6). These cytokines play a central role in amplifying inflammation and sustaining the disease process [1,4].

Synovial cells proliferate abnormally, leading to thickening of the synovial membrane. This hyperplastic synovium produces excess synovial fluid, resulting in joint swelling, pain, and stiffness [4].

**3.3 Pannus Formation**

As the disease progresses, the inflamed synovial membrane transforms into an aggressive, tumor-like structure known as pannus. The pannus consists of proliferating fibroblast-like synoviocytes (FLS), inflammatory cells, and newly formed blood vessels (angiogenesis).

The pannus invades adjacent cartilage and bone, releasing enzymes such as matrix metalloproteinases (MMPs) that degrade extracellular matrix components. This leads to irreversible joint damage and deformity [2,4].

### 3.4 Cartilage Destruction

Cartilage destruction in RA is mediated by both inflammatory cytokines and degradative enzymes. TNF-α and IL-1 stimulate chondrocytes and synoviocytes to produce MMPs and other proteolytic enzymes, which break down collagen and proteoglycans in cartilage.

Loss of cartilage integrity results in reduced joint function, increased friction, and pain during movement. This process is progressive and contributes significantly to disability in RA patients [3].

### 3.5 Bone Erosion

Bone destruction in RA is primarily mediated by osteoclasts, which are activated by receptor activator of nuclear factor kappa-B ligand (RANKL). Increased RANKL expression promotes osteoclast differentiation and activity, leading to bone resorption.

Simultaneously, bone formation by osteoblasts is impaired, resulting in an imbalance between bone resorption and formation. This leads to bone erosion, joint deformity, and loss of structural integrity [4].

### 3.6 Role of Cytokines and Inflammatory Mediators

Cytokines play a central role in RA pathology. Key mediators include:

- **TNF-α:** Promotes inflammation and joint destruction
- **IL-1:** Stimulates cartilage degradation
- **IL-6:** Contributes to systemic inflammation and immune activation

Other mediators such as prostaglandins, leukotrienes, and nitric oxide further enhance inflammatory responses and tissue damage [1,4].

### 3.7 Oxidative Stress in RA

Oxidative stress is a critical factor in RA progression. Reactive oxygen species (ROS) and reactive nitrogen species (RNS) are produced by activated immune cells and contribute to cellular damage, lipid peroxidation, and DNA damage. Oxidative stress also amplifies inflammatory signaling pathways such as NF-κB, creating a vicious cycle of inflammation and tissue destruction [3].

### 3.8 Angiogenesis

Angiogenesis, the formation of new blood vessels, is a prominent feature of RA pathology. It is driven by factors such as vascular endothelial growth factor (VEGF).

Newly formed blood vessels supply nutrients and oxygen to the inflamed synovium, supporting the growth of pannus and perpetuating inflammation [2].

### 3.9 Systemic Manifestations

RA is not limited to joints; it also has systemic effects, including:

- Cardiovascular diseases
- Pulmonary complications
- Anemia
- Fatigue and weight loss

These manifestations are primarily due to chronic inflammation and immune dysregulation [1].

## 4. Phytochemistry

Curcuma longa Linn. is a rich source of diverse bioactive compounds responsible for its wide range of pharmacological activities. More than 200 phytoconstituents have been identified in turmeric rhizomes, broadly classified into curcuminoids, volatile oils (essential oils), and other phenolic and non-phenolic compounds. Among these, curcuminoids are the principal active constituents contributing to its therapeutic efficacy, particularly in inflammatory disorders such as rheumatoid arthritis (RA) [1,5].

### 4.1 Curcuminoids (Polyphenolic Compounds)

Curcuminoids are the major bioactive compounds present in turmeric, accounting for approximately 2–5% of the dried rhizome. These are diarylheptanoid polyphenols responsible for the characteristic yellow color of turmeric. The primary curcuminoids include:

- **Curcumin (diferuloylmethane):**
  The most abundant and pharmacologically active compound. It exhibits potent anti-inflammatory, antioxidant, anticancer, and immunomodulatory properties. Curcumin is responsible for modulating various molecular targets involved in RA pathogenesis, including NF-κB, COX-2, and cytokines [1,5].

- **Demethoxycurcumin:**
  Structurally similar to curcumin but lacking one methoxy group. It contributes to antioxidant and anti-inflammatory activity.
- **Bisdemethoxycurcumin:**
  Lacks both methoxy groups and exhibits relatively lower but significant biological activity.

These curcuminoids often exist as a mixture and exhibit synergistic effects, enhancing overall therapeutic potential [5].

**4.2 Chemical Structure of Curcumin**

Curcumin is chemically known as diferuloylmethane with the molecular formula $C_{21}H_{20}O_6$. It consists of two aromatic rings containing o-methoxy phenolic groups connected by a seven-carbon linker with α,β-unsaturated β-diketone moiety. Key structural features include:

- Phenolic hydroxyl groups (responsible for antioxidant activity)
- Conjugated double bonds (provide stability and free radical scavenging ability)
- β-diketone moiety (involved in metal chelation and biological interactions)

Curcumin exists in keto-enol tautomeric forms, with the enol form being more stable and biologically active in solution [5].

**4.3 Volatile Oils (Essential Oils)**

Turmeric contains 3–7% volatile oils, which contribute to its aroma and pharmacological activities. Major constituents include:

- **Ar-turmerone**
- **α-turmerone and β-turmerone**
- **Zingiberene**
- **Atlantone**
- **Sabinene and cineole**

These compounds exhibit anti-inflammatory, antimicrobial, and antioxidant activities. Turmerones have been shown to enhance the bioavailability of curcumin and contribute synergistically to its therapeutic effects [1,5].

**4.4 Other Phytoconstituents**

Apart from curcuminoids and essential oils, Curcuma longa contains several other bioactive compounds, including:

- **Flavonoids:** Contribute to antioxidant and anti-inflammatory activity
- **Phenolic acids:** Provide free radical scavenging properties
- **Tannins:** Exhibit astringent and antimicrobial effects
- **Proteins and carbohydrates:** Nutritional components
- **Steroids and alkaloids:** Minor constituents with pharmacological relevance

These compounds collectively contribute to the overall therapeutic profile of turmeric through synergistic interactions [1].

**4.5 Biosynthesis of Curcumin**

Curcumin is biosynthesized via the phenylpropanoid pathway. The process involves:

- Conversion of phenylalanine to cinnamic acid
- Formation of ferulic acid
- Condensation of feruloyl-CoA with malonyl-CoA

This pathway is catalyzed by enzymes such as curcumin synthase, resulting in the formation of curcuminoids. Understanding this pathway is important for metabolic engineering and large-scale production of curcumin [5].

**4.6 Physicochemical Properties**

Curcumin exhibits the following properties:

- **Appearance:** Yellow crystalline powder
- **Solubility:** Poorly soluble in water, soluble in organic solvents (ethanol, DMSO)
- **Melting point:** Approximately 183°C
- **Stability:** Sensitive to light, heat, and alkaline pH

These properties significantly influence its bioavailability and formulation strategies [3].

**4.7 Analytical Methods for Phytochemical Evaluation**

Various analytical techniques are used for the identification and quantification of phytoconstituents:

- **High-Performance Liquid Chromatography (HPLC):** Standard method for curcumin estimation
- **High-Performance Thin Layer Chromatography (HPTLC):** Used for fingerprint analysis
- **Gas Chromatography-Mass Spectrometry (GC-MS):** Analysis of volatile oils

- **UV-Visible Spectrophotometry:** Rapid estimation of curcuminoids

These methods ensure quality control, standardization, and authenticity of turmeric samples [7].

**4.8 Standardization and Quality Control**

Standardization of Curcuma longa is essential to ensure consistency and efficacy. Key parameters include:

- Total curcuminoid content
- Essential oil percentage
- Ash values and extractive values
- Absence of adulterants (e.g., synthetic dyes) [7].

**4.9 Role of Phytochemicals in Rheumatoid Arthritis**

The phytochemicals present in Curcuma longa play a crucial role in RA management:

- Curcuminoids inhibit inflammatory pathways (NF-κB, COX-2)
- Essential oils enhance bioavailability and anti-inflammatory action
- Phenolic compounds reduce oxidative stress [1,5].

**6. Pharmacological Activities**

Curcuma longa exhibits a wide range of pharmacological activities primarily attributed to its active constituent, curcumin. The most significant effect is its **anti-inflammatory activity**, where curcumin inhibits key inflammatory mediators such as tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6) by suppressing the NF-κB signaling pathway. It also downregulates cyclooxygenase-2 (COX-2) and lipoxygenase enzymes, thereby reducing prostaglandin synthesis and inflammation.Curcumin possesses strong **antioxidant properties**, scavenging reactive oxygen species (ROS) and enhancing endogenous antioxidant enzymes such as superoxide dismutase and catalase. Additionally, it exhibits **immunomodulatory effects** by regulating T-cell and B-cell responses, thus reducing autoimmune reactions associated with rheumatoid arthritis.Furthermore, curcumin demonstrates **analgesic activity**, alleviating joint pain and stiffness, and shows **anti-proliferative effects** by inhibiting synovial fibroblast proliferation. These combined pharmacological actions contribute to its therapeutic potential in managing rheumatoid arthritis.

**7. Preclinical Studies**

Preclinical studies have provided substantial evidence supporting the therapeutic potential of Curcuma longa and its active constituent, curcumin, in the management of rheumatoid arthritis (RA). Various **in vitro** and **in vivo** experimental models have been employed to evaluate its anti-inflammatory, antioxidant, and immunomodulatory effects [12,13].In **animal models**, particularly the collagen-induced arthritis (CIA) and adjuvant-induced arthritis (AIA) models, curcumin has demonstrated significant efficacy in reducing disease severity. Administration of curcumin resulted in a marked decrease in paw swelling, joint inflammation, and histopathological damage. These effects were associated with suppression of pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6, which are key mediators in RA pathogenesis [13,14].

Curcumin has also been shown to inhibit activation of nuclear factor-kappa B (NF-κB), a critical transcription factor involved in the expression of inflammatory genes. By downregulating NF-κB signaling, curcumin reduces the production of inflammatory mediators, thereby attenuating synovial inflammation and joint destruction [14,15].

In addition to its anti-inflammatory effects, curcumin exhibits **protective effects on cartilage and bone**. Studies have reported that curcumin inhibits the activity of matrix metalloproteinases (MMPs), enzymes responsible for cartilage degradation. Furthermore, it suppresses osteoclastogenesis by modulating the RANKL signaling pathway, thereby preventing bone erosion and maintaining joint integrity [15,16].

In vitro studies using synovial fibroblasts and immune cells have demonstrated that curcumin inhibits cell proliferation and induces apoptosis in activated synoviocytes. This helps in reducing pannus formation, a key pathological feature of RA. Curcumin also reduces oxidative stress by scavenging reactive oxygen species (ROS) and enhancing antioxidant enzyme activity, thereby protecting joint tissues from oxidative damage [12,16].

Moreover, studies have shown that curcumin can modulate immune responses by regulating T-cell differentiation and suppressing B-cell activation, leading to reduced production of autoantibodies such as rheumatoid factor (RF) and anti-citrullinated protein antibodies (ACPAs). These findings highlight its immunomodulatory potential in autoimmune conditions like RA [13,15].

Overall, preclinical evidence strongly supports the role of Curcuma longa as a multi-targeted therapeutic agent in rheumatoid arthritis. However, despite promising results, translation of these findings into clinical practice requires further investigation, particularly focusing on bioavailability enhancement and well-designed clinical trials [14,16].

## 8. Clinical Studies

Clinical studies evaluating the efficacy and safety of Curcuma longa and its active constituent curcumin in rheumatoid arthritis (RA) have shown promising but variable outcomes. Several randomized controlled trials (RCTs), pilot studies, and meta-analyses have investigated the role of curcumin as a complementary or alternative therapy in RA management [12,17].

One of the earliest clinical studies demonstrated that curcumin significantly improved symptoms of RA, including joint swelling, morning stiffness, and pain scores, compared to standard anti-inflammatory drugs. In a randomized pilot trial, patients receiving curcumin (500 mg/day) showed greater improvement in Disease Activity Score (DAS-28) and Visual Analog Scale (VAS) for pain compared to those treated with diclofenac sodium, with no significant adverse effects reported [12,18].

Subsequent clinical trials have supported these findings, reporting that curcumin supplementation leads to a reduction in inflammatory biomarkers such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). These studies suggest that curcumin exerts systemic anti-inflammatory effects, contributing to improved clinical outcomes in RA patients [17,19].

In addition, combination therapies involving curcumin and conventional drugs have been explored. Studies indicate that curcumin, when used as an adjunct to DMARDs, enhances therapeutic efficacy while potentially reducing the required dose of standard medications, thereby minimizing adverse effects. This highlights its role as a supportive therapy in RA management [19,20].

Meta-analyses of clinical trials have concluded that curcumin supplementation is associated with significant improvements in RA symptoms, including reduced joint tenderness, swelling, and improved physical function. However, these analyses also emphasize limitations such as small sample sizes, short study durations, and heterogeneity in study design, dosage, and formulation [17,20].

Despite its favorable safety profile, the clinical application of curcumin is limited by its poor bioavailability. Advanced formulations such as curcumin nanoparticles, liposomal curcumin, and curcumin-phospholipid complexes have shown improved absorption and enhanced clinical efficacy in recent studies [18,19].

Overall, clinical evidence suggests that Curcuma longa is a safe and potentially effective therapeutic agent for rheumatoid arthritis. However, large-scale, well-designed randomized controlled trials with standardized formulations and long-term follow-up are required to establish its definitive role in clinical practice [17,20].

## 12. Conclusion

Curcuma longa Linn. represents a promising natural therapeutic agent in the management of rheumatoid arthritis (RA) due to its well-documented anti-inflammatory, antioxidant, and immunomodulatory properties. The bioactive compound curcumin plays a central role in modulating multiple molecular pathways involved in RA pathogenesis, including NF-κB, MAPK, and JAK/STAT signaling cascades, thereby reducing the production of pro-inflammatory cytokines and preventing joint damage.

Preclinical studies have consistently demonstrated the efficacy of curcumin in reducing inflammation, inhibiting cartilage degradation, and preventing bone erosion. Clinical studies further support its potential in improving disease activity scores, reducing pain, and lowering inflammatory biomarkers such as ESR and CRP. Moreover, its favorable safety profile and minimal adverse effects make it an attractive alternative or adjunct to conventional therapies.

However, despite these encouraging findings, certain limitations hinder its widespread clinical application. Poor bioavailability, rapid metabolism, lack of standardized formulations, and variability in clinical outcomes remain significant challenges. Therefore, the development of advanced drug delivery systems and large-scale, well-designed clinical trials are essential to establish its therapeutic efficacy and optimize dosing strategies.In conclusion, Curcuma longa holds significant potential as a complementary and alternative therapeutic option for rheumatoid arthritis. Future research should focus on overcoming pharmacokinetic limitations, validating clinical efficacy, and integrating it into evidence-based treatment protocols to enhance patient outcomes.

## References


1. Aletaha D, Neogi T, Silman AJ, Funovits J, Felson DT, Bingham CO, et al. 2010 rheumatoid arthritis classification criteria: An American College of Rheumatology/European League Against Rheumatism collaborative initiative. Ann Rheum Dis. 2010;69(9):1580–1588.
2. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2016;388(10055):2023–2038.
3. Hewlings SJ, Kalman DS. Curcumin: A review of its effects on human health. Foods. 2017;6(10):92.

4. Gupta SC, Sung B, Kim JH, Prasad S, Li S, Aggarwal BB. Multitargeting by curcumin as revealed by molecular interaction studies. Nat Prod Rep. 2013;30(3):394–412.
5. Prasad S, Gupta SC, Tyagi AK, Aggarwal BB. Curcumin, a component of golden spice: From bedside to bench and back. Biotechnol Adv. 2014;32(6):1053–1064.
6. Amalraj A, Pius A, Gopi S, Gopi S. Biological activities of curcuminoids, other biomolecules from turmeric and their derivatives – A review. J Tradit Complement Med. 2017;7(2):205–233.
7. Jurenka JS. Anti-inflammatory properties of curcumin, a major constituent of Curcuma longa: A review of preclinical and clinical research. Altern Med Rev. 2009;14(2):141–153.
8. Chandran B, Goel A. A randomized, pilot study to assess the efficacy and safety of curcumin in patients with active rheumatoid arthritis. Phytother Res. 2012;26(11):1719–1725.
9. Funk JL, Frye JB, Oyarzo JN, Kuscuoglu N, Wilson J, McCaffrey G, et al. Anti-arthritic effects and toxicity of the essential oils of turmeric (Curcuma longa L.). J Agric Food Chem. 2010;58(2):842–849.
10. Kunnumakkara AB, Bordoloi D, Harsha C, Banik K, Gupta SC, Aggarwal BB. Curcumin mediates anticancer effects by modulating multiple cell signaling pathways. Clin Sci. 2017;131(15):1781–1799.
11. Panahi Y, Alishiri GH, Parvin S, Sahebkar A. Mitigation of systemic oxidative stress by curcuminoids in osteoarthritis: Results of a randomized controlled trial. J Diet Suppl. 2016;13(2):209–220.
12. Bagherniya M, Nobili V, Blesso CN, Sahebkar A. Medicinal plants and bioactive natural compounds in rheumatoid arthritis: A review. Phytother Res. 2022;36(1):1–25.
13. Shehzad A, Rehman G, Lee YS. Curcumin in inflammatory diseases. Biofactors. 2013;39(1):69–77.
14. Rahmani AH, Al Zohairy MA, Aly SM, Khan MA. Curcumin: A potential candidate in prevention of cancer via modulation of molecular pathways. Biomed Res Int. 2014;2014:761608.
15. Menon VP, Sudheer AR. Antioxidant and anti-inflammatory properties of curcumin. Adv Exp Med Biol. 2007;595:105–125.
16. Bright JJ. Curcumin and autoimmune disease. Adv Exp Med Biol. 2007;595:425–451.
17. Daily JW, Yang M, Park S. Efficacy of turmeric extracts and curcumin for alleviating symptoms of joint arthritis: A systematic review and meta-analysis. J Med Food. 2016;19(8):717–729.
18. Lao CD, Ruffin MT, Normolle D, Heath DD, Murray SI, Bailey JM, et al. Dose escalation of a curcuminoid formulation. BMC Complement Altern Med. 2006;6:10.
19. Sharma RA, Gescher AJ, Steward WP. Curcumin: The story so far. Eur J Cancer. 2005;41(13):1955–1968.
20. Goel A, Kunnumakkara AB, Aggarwal BB. Curcumin as "Curecumin": From kitchen to clinic. Biochem Pharmacol. 2008;75(4):787–809.
21. Aggarwal BB, Harikumar KB. Potential therapeutic effects of curcumin. Int J Biochem Cell Biol. 2009;41(1):40–59.
22. Epstein J, Sanderson IR, Macdonald TT. Curcumin as a therapeutic agent: The evidence from in vitro, animal and human studies. Br J Nutr. 2010;103(11):1545–1557.
23. Hatcher H, Planalp R, Cho J, Torti FM, Torti SV. Curcumin: From ancient medicine to current clinical trials. Cell Mol Life Sci. 2008;65(11):1631–1652.
24. Chainani-Wu N. Safety and anti-inflammatory activity of curcumin: A component of turmeric. J Altern Complement Med. 2003;9(1):161–168.
25. Bengmark S. Curcumin, an atoxic antioxidant and natural NF-κB, cyclooxygenase-2, lipoxygenase, and inducible nitric oxide synthase inhibitor. J Parenter Enteral Nutr. 2006;30(1):45–51.
26. Gupta SC, Patchva S, Aggarwal BB. Therapeutic roles of curcumin: Lessons learned from clinical trials. AAPS J. 2013;15(1):195–218.
27. Amalraj A, Varma K, Jacob J, Divya C, Kunnumakkara AB, Stohs SJ, et al. A novel bioavailable curcumin formulation improves symptoms in RA patients. J Funct Foods. 2017;32:415–423.
28. Singh S, Aggarwal BB. Activation of transcription factor NF-κB is suppressed by curcumin. J Biol Chem. 1995;270(42):24995–25000.
29. Joe B, Vijaykumar M, Lokesh BR. Biological properties of curcumin. Crit Rev Food Sci Nutr. 2004;44(2):97–111.
30. Tilak JC, Banerjee M, Mohan H, Devasagayam TPA. Antioxidant availability of turmeric. Mol Cell Biochem. 2004;264(1-2):99–103.