IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

Turmeric (Curcuma longa) Anti-inflammatory & Antioxidant Activity

Dr. Bhagwan M Kale[1], Dr. Bhagwan M Kale[2], Ritesh Rohidas Aade[3], Ganesh R Adhane[4], Akshay B Badak[5]

Principal & Assistant Professor, Shri Goraksha College of Pharmacy and Research Centre, Khamgaon, Maharashtra[1,2]
Students, Shri Goraksha College of Pharmacy and Research Centre, Khamgaon, Maharashtra, India[3-5]

Abstract : *Chronic inflammation and oxidative stress underlie a wide range of disorders, including arthritis, metabolic syndrome, cardiovascular disease and neurodegeneration. Conventional anti-inflammatory drugs such as nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroids give effective symptomatic relief, but long-term use is limited by gastrointestinal, renal, cardiovascular and metabolic adverse effects. Turmeric, the dried rhizome of Curcuma longa L. (family Zingiberaceae), is a spice and traditional medicine whose principal bioactive constituents are the curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) together with volatile oils rich in turmerones. Preclinical studies show that curcumin suppresses nuclear factor kappa B (NF-κB) signalling, down-regulates cyclooxygenase-2 (COX-2), lipoxygenase and inducible nitric oxide synthase, lowers the production of tumour necrosis factor-alpha (TNF-α), interleukin-1β (IL-1β) and interleukin-6 (IL-6), scavenges reactive oxygen species and activates the Nrf2-dependent antioxidant response. Several small clinical trials in rheumatoid arthritis and osteoarthritis have reported improvement in pain and function with good tolerability. However, curcumin has poor aqueous solubility, rapid metabolism and low systemic bioavailability, and some medicinal chemistry analyses have questioned its suitability as a drug lead. This review summarises the history, phytochemistry, experimental protocols, mechanisms, health benefits, applications, advantages and limitations of turmeric, with emphasis on its anti-inflammatory and antioxidant activity and on formulation strategies that may overcome its bioavailability barrier*

Keywords: CLAIA :- Curcuma longa, Curcumin, Anti-inflammatory, Antioxidant, Phytochemicals

I. INTRODUCTION

Inflammation is a protective response of the body to infection and tissue injury, but when it fails to resolve it becomes a driver of chronic disease [1]. In rheumatoid arthritis, for example, persistent synovial inflammation leads to cartilage and bone destruction and permanent disability [2]. NSAIDs act mainly through inhibition of cyclooxygenase enzymes, and their long-term use is associated with gastric ulceration and cardiovascular and renal risk [3]. This has encouraged interest in plant-derived anti-inflammatory agents as complementary or alternative therapies [4].

Turmeric (Curcuma longa L.) is a perennial herb of the ginger family that is cultivated widely in India and other tropical countries. The rhizome is used as a colouring and flavouring spice, as a cosmetic and as a traditional medicine for wounds, digestive complaints, skin disease and joint pain [5]. The yellow pigments of turmeric are known as curcuminoids; curcumin (diferuloylmethane) is the most abundant and the most studied [6]. Early pharmacological work demonstrated that curcumin has anti-inflammatory activity in acute and chronic rodent models [7], and later studies showed that it blocks activation of NF-κB, a master regulator of inflammatory gene expression [8].

Curcumin is now known to interact with numerous molecular targets, including transcription factors, cytokines, enzymes and growth-factor receptors [9,10]. Its phenolic structure also makes it an effective free-radical scavenger [11]. Despite this broad activity, its clinical use is constrained by poor absorption and rapid metabolism [12], and a critical medicinal chemistry assessment has highlighted its chemical instability and its tendency to interfere with

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

biochemical assays [13]. A balanced review of the evidence is therefore necessary, and this article presents the current understanding of turmeric as an anti-inflammatory and antioxidant agent in the format of a structured review.

Literature survey :

1. Srimal, R. C. & Dhawan, B. N. (1973)

In one of the earliest pharmacological studies, curcumin (diferuloyl methane) was shown to reduce carrageenan-induced paw oedema and cotton pellet granuloma in rats, and its activity in the chronic model was reported to be comparable to that of phenylbutazone. [7]

2. Ammon, H. P. T. & Wahl, M. A. (1991)

This early review of the pharmacology of Curcuma longa summarised choleretic, anti-inflammatory, antioxidant and antimicrobial activities of turmeric and curcuminoids and established the basis for later mechanistic work. [14]

3. Singh, S. & Aggarwal, B. B. (1995)

Curcumin was found to inhibit the activation of the transcription factor NF-κB in cells treated with TNF-α, an effect linked to suppression of IκBα degradation, providing a molecular explanation for its anti-inflammatory action. [8]

4. Shoba, G. et al. (1998)

Co-administration of piperine with curcumin markedly increased the serum concentration and bioavailability of curcumin in rats and in human volunteers, establishing the principle of using absorption enhancers. [15]

5. Chainani-Wu, N. (2003)

This review examined the safety and anti-inflammatory activity of curcumin and concluded that it was well tolerated in the studies available at that time, with potential in several inflammatory conditions. [16]

6. Lao, C. D. et al. (2006)

A dose-escalation study in healthy volunteers showed that single oral doses of a curcuminoid formulation over a wide range were tolerated, although serum levels of curcumin remained very low. [17]

7. Anand, P. et al. (2007)

The authors analysed the poor bioavailability of curcumin, attributed to low absorption, rapid metabolism and rapid elimination, and discussed adjuvants, nanoparticles, liposomes and phospholipid complexes as solutions. [12]

8. Aggarwal, B. B. & Harikumar, K. B. (2009)

This review described the modulation of transcription factors, inflammatory cytokines, enzymes and kinases by curcumin and its potential in neurodegenerative, cardiovascular, pulmonary, metabolic, autoimmune and neoplastic disease. [9]

9. Chandran, B. & Goel, A. (2012)

In a randomised pilot study of patients with active rheumatoid arthritis, curcumin alone, diclofenac sodium alone and their combination were compared; the curcumin group showed the greatest improvement in disease activity score and was well tolerated. [18]

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 6, November 2026 Impact Factor: 8.2

10. Nelson, K. M. et al. (2017)
This critical analysis concluded that curcumin is chemically unstable, poorly bioavailable and frequently active in screening assays through non-specific mechanisms, and cautioned that these properties limit its development as a conventional drug. [13]

Historical Background of Turmeric (Curcuma longa):
Turmeric has been cultivated and used in South Asia for several thousand years. In the Ayurvedic tradition it is known as Haridra and is recommended for wounds, skin disorders, digestive complaints, respiratory problems and joint pain, and it also holds a ritual place in Hindu ceremonies as a symbol of auspiciousness [5]. From India the spice travelled along trade routes to Southeast Asia, China, the Middle East and East Africa, and it was later described by European travellers who compared its colour and use with those of saffron [5]. In Traditional Chinese Medicine and Unani medicine turmeric has long been used for pain, abdominal complaints and "blood stagnation", while in Southeast Asian practice it is applied as a paste to the skin and consumed as a decoction [19].
The scientific study of turmeric began in the early nineteenth century with the isolation of the yellow pigment, and the chemical structure of curcumin was established in the early twentieth century [6]. The first systematic pharmacological investigations of its anti-inflammatory activity were carried out in the 1970s [7], and from the 1990s onward the discovery of its effect on NF-κB opened a large field of molecular research [8]. Today turmeric and curcumin supplements are among the most widely sold herbal products worldwide, and curcumin has been evaluated in many clinical trials [20].

PROTOCOL :
Materials
1. Plant Material
Fresh rhizomes of Curcuma longa used in experimental studies are normally collected from cultivated fields or authenticated herbal gardens and identified by a qualified botanist or pharmacognosist [21]. The rhizomes are washed with water to remove soil, sliced, and dried either in shade or in a hot-air oven at a controlled temperature, because excessive heat and light degrade curcuminoids [6]. The dried slices are powdered with a mechanical grinder, passed through a sieve of defined mesh size and stored in airtight amber containers away from moisture. A voucher specimen is deposited in the institutional herbarium for future reference.

2. Chemicals and Reagents
Analytical-grade solvents such as ethanol, methanol, acetone, hexane and distilled water are used for extraction [22]. Carrageenan is used to induce acute inflammation [23], and Complete Freund's Adjuvant (CFA) is used to induce experimental arthritis [24]. Reference drugs such as diclofenac sodium or indomethacin serve as positive controls. Bovine serum albumin, phosphate-buffered saline, Folin–Ciocalteu reagent, aluminium chloride and 2,2-diphenyl-1-picrylhydrazyl (DPPH) are used in in vitro assays [25,26]. Curcumin of high purity is used as a reference standard in chromatographic analysis.

3. Experimental Animals
Healthy adult Wistar or Sprague–Dawley rats (150–200 g) of either sex, or Swiss albino mice, are obtained from a registered breeding facility and acclimatised for at least one week. Animals are housed under standard laboratory conditions (22 ± 2 °C, 50–60% relative humidity, 12-hour light/dark cycle) with free access to pellet diet and water. All procedures require prior approval of the Institutional Animal Ethics Committee (IAEC) and should conform to national regulations and the ARRIVE reporting guidelines [27].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

4. Extraction Equipment and Methods

Curcuminoids are extracted from powdered rhizome by Soxhlet extraction, maceration, ultrasound-assisted extraction or microwave-assisted extraction, and the extract is concentrated under reduced pressure in a rotary evaporator [6]. Volatile oil is obtained separately by hydrodistillation in a Clevenger-type apparatus. Extracts are stored at 4 °C in amber bottles to prevent photodegradation of curcumin.

5. Analytical Instruments

High-performance liquid chromatography (HPLC) with a photodiode-array detector is used to quantify curcumin, demethoxycurcumin and bisdemethoxycurcumin, while gas chromatography–mass spectrometry (GC-MS) is used to profile turmerones and other volatile constituents [6]. A UV–visible spectrophotometer is used for total phenolic content, total flavonoid content, DPPH scavenging and protein-denaturation assays. A digital plethysmometer measures paw volume and vernier callipers measure paw thickness in animal models [28].

6. Phytochemical Screening

Qualitative tests are performed to detect alkaloids, flavonoids, phenolic compounds, tannins, saponins, terpenoids and glycosides using standard procedures [21,22]. Thin-layer chromatography on silica gel can be used for a preliminary fingerprint of curcuminoids. Total phenolic content is estimated by the Folin–Ciocalteu method [25] and total flavonoid content by the aluminium chloride colorimetric method [29].

Methods

1. Preparation of Turmeric Extracts

Typically 50 g of powdered rhizome is extracted successively with solvents of increasing polarity (for example hexane, acetone or ethanol, and water) in a Soxhlet apparatus for 6–8 hours per solvent. The extracts are filtered, concentrated by rotary evaporation and dried; the percentage yield is calculated against the dry weight of the starting material.

2. Phytochemical Analysis

Qualitative phytochemical tests are carried out on each extract, and total phenolic and flavonoid contents are quantified [25,29]. Curcuminoid content is determined by HPLC against authentic standards.

3. In Vitro Anti-inflammatory Assays

Protein Denaturation Assay: Extract at graded concentrations is incubated with bovine serum albumin or egg albumin, heated to induce denaturation, and the turbidity is measured to calculate percentage inhibition [30]. Membrane Stabilisation Assay: Human or rat erythrocytes are exposed to hypotonic or heat stress in the presence of extract, and the inhibition of haemolysis is measured spectrophotometrically. Enzyme Assays: Inhibition of COX-1, COX-2 and 5-lipoxygenase is determined with commercial enzyme kits. Cell-based Assays: RAW 264.7 macrophages stimulated with lipopolysaccharide are used to measure nitric oxide (Griess reaction) and cytokine release (ELISA), with cell viability confirmed by the MTT assay [31].

4. In Vivo Anti-inflammatory Studies

Acute Inflammation (Carrageenan-induced Paw Oedema): Rats are divided into control, standard (e.g., diclofenac) and extract-treated groups. One hour after oral treatment, 0.1 mL of 1% carrageenan is injected into the sub-plantar region of the hind paw, and paw volume is measured with a plethysmometer at hourly intervals [23,32]. Chronic Inflammation (Cotton Pellet-Induced Granuloma): Sterile cotton pellets are implanted subcutaneously, animals are treated daily for 7 days, and the dry weight of the granulomatous tissue is measured [33].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

5. Anti-Rheumatoid Arthritis Activity

Complete Freund's Adjuvant (CFA) Model: Arthritis is induced by sub-plantar injection of CFA into the hind paw, and treatment with the test substance is given orally for about 21 days. Paw thickness, arthritic score, body weight and joint mobility are recorded periodically, and at the end of the study blood is collected for inflammatory markers and joints are processed for histopathology [24].

6. Toxicity Studies

Acute oral toxicity of turmeric preparations is evaluated in rodents following OECD Guideline 423 (acute toxic class method), in which a single oral dose, commonly up to 2000 mg/kg, is administered and the animals are observed for 14 days for mortality, behavioural changes and body-weight alterations [34]. Sub-acute toxicity is evaluated by repeated daily dosing for 28 days according to OECD Guideline 407, followed by estimation of haematological and serum biochemical parameters and histopathology of vital organs [35].

7. Histopathological Analysis

At the end of an experiment the joint tissue is excised, fixed in 10% neutral buffered formalin, dehydrated through graded alcohols, cleared, embedded in paraffin and sectioned at about 5 µm. Sections are stained with haematoxylin and eosin (H&E) and examined under a light microscope for inflammatory cell infiltration, tissue architecture and degenerative changes by a pathologist who is blinded to the treatment groups [28].

8. Statistical Analysis

In the experimental studies summarised in this review, data are generally expressed as mean ± SEM. Group comparisons are performed by one-way analysis of variance (ANOVA) followed by a post hoc test such as Tukey's or Dunnett's test, and $p < 0.05$ is usually taken as the threshold of statistical significance. Reporting of animal experiments is expected to follow the ARRIVE guidelines [27].

Mechanism of Action

The anti-inflammatory and antioxidant effects of turmeric arise mainly from curcuminoids, which interact with several cellular signalling pathways, enzymes and cytokines. Because curcumin binds to many targets, its activity is best described as multi-target modulation rather than inhibition of a single receptor or enzyme [10].

1. Inhibition of NF-κB and Pro-inflammatory Cytokines:

NF-κB regulates the transcription of TNF-α, IL-1β, IL-6, COX-2 and adhesion molecules [36]. Curcumin was shown to suppress NF-κB activation by preventing IκBα degradation, thereby blocking nuclear translocation of the transcription factor [8]. The resulting fall in cytokine production reduces recruitment of leukocytes to inflamed tissue, which is of particular relevance in the rheumatoid synovium [9].

2. Inhibition of COX-2 and Lipoxygenase:

Prostaglandins and leukotrienes are important mediators of pain, vasodilatation and oedema, and they are produced by cyclooxygenase and lipoxygenase enzymes [3]. Curcumin down-regulates COX-2 expression and inhibits the activity of 5-lipoxygenase, thereby reducing the generation of inflammatory eicosanoids [19,37].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

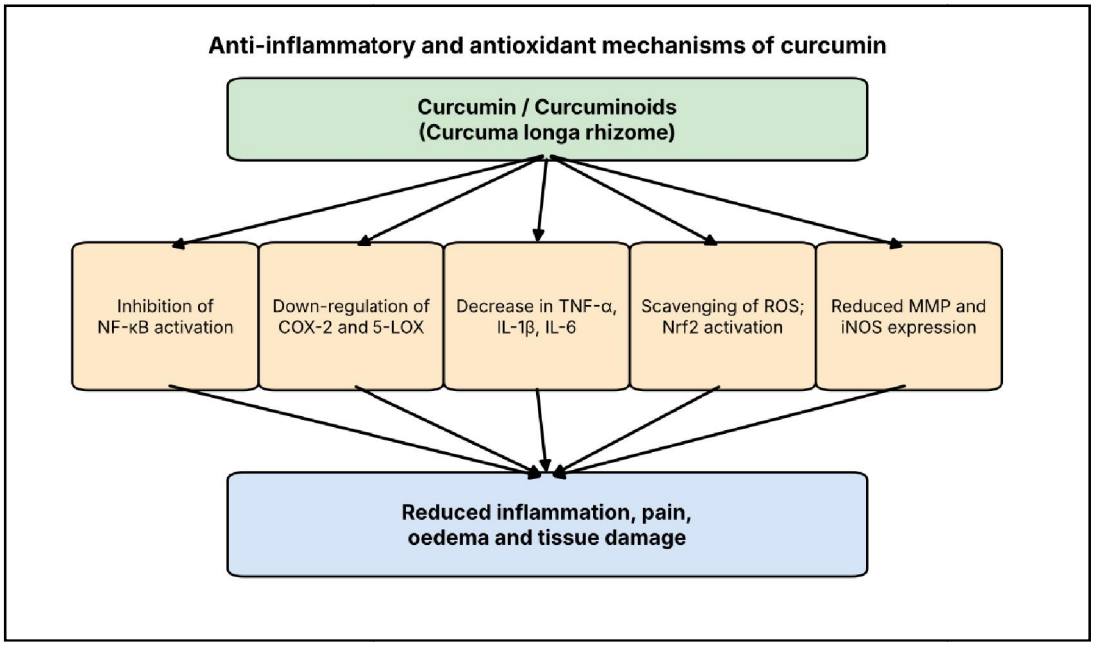


Fig.No.1. Mechanism of Action of Turmeric (Curcumin)

3. Antioxidant Activity:

Reactive oxygen species damage synovial membranes, cartilage and many other tissues, and they also activate redox-sensitive transcription factors that amplify inflammation [11]. Curcumin scavenges superoxide, hydroxyl and peroxyl radicals through its phenolic hydroxyl groups and its β-diketone moiety, inhibits lipid peroxidation, and activates the Nrf2 pathway, which increases the expression of antioxidant enzymes such as haem oxygenase-1 and glutathione-related enzymes [6,10].

4. Modulation of Matrix Metalloproteinases:

Matrix metalloproteinases (MMPs) degrade cartilage collagen and proteoglycans in arthritic joints. Curcumin has been reported to reduce the expression of MMP-3 and MMP-9 in cell and animal studies, which may help preserve joint structure [9,19].

5. Modulation of Nitric Oxide Production:

Excessive nitric oxide generated by inducible nitric oxide synthase (iNOS) contributes to tissue damage in chronic inflammation. Curcumin decreases iNOS expression in activated macrophages, largely through its effect on NF-κB, and this lowers nitric oxide output [37].

6. Effect on Immune Cells and Signalling Kinases:

Curcumin influences T-cell differentiation, macrophage polarisation and the activity of kinases such as MAPKs and JAK/STAT proteins, which together shape the intensity of the immune response [10,20].

Overall Mechanism Summary:

The anti-inflammatory activity of turmeric is the combined result of NF-κB suppression, reduced COX-2 and lipoxygenase activity, free-radical scavenging with Nrf2 activation, reduced MMP expression and lower nitric oxide production. These actions explain the reduction of oedema, pain and tissue damage in experimental models.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

Health Benefits of Turmeric (Curcuma longa)

Turmeric is valued both as a spice and as a medicinal plant. The curcuminoids, volatile oils and polysaccharides contribute to several health benefits that have been investigated in preclinical and clinical studies [38].

1. Anti-inflammatory Activity

Curcumin reduces inflammation in acute and chronic animal models and lowers inflammatory markers in several human studies [20,37].

2. Anti-arthritic Activity

Small randomised trials have reported that curcumin or turmeric extract improves pain and function in rheumatoid arthritis and osteoarthritis, and a meta-analysis of randomised trials found symptomatic improvement with tolerability that was generally good [18,39]. The overall quality of the trials is limited, so the results need confirmation.

3. Antioxidant Properties

Curcuminoids neutralise free radicals, reduce lipid peroxidation and enhance antioxidant enzyme activity in several models [6,11].

4. Antimicrobial Activity

Extracts and essential oil of turmeric have shown activity against a range of bacteria and fungi in vitro, although concentrations needed are often high [19].

5. Digestive Health

Turmeric is used traditionally for dyspepsia and flatulence, and animal studies indicate that curcumin stimulates bile secretion and protects the gastric mucosa [14].

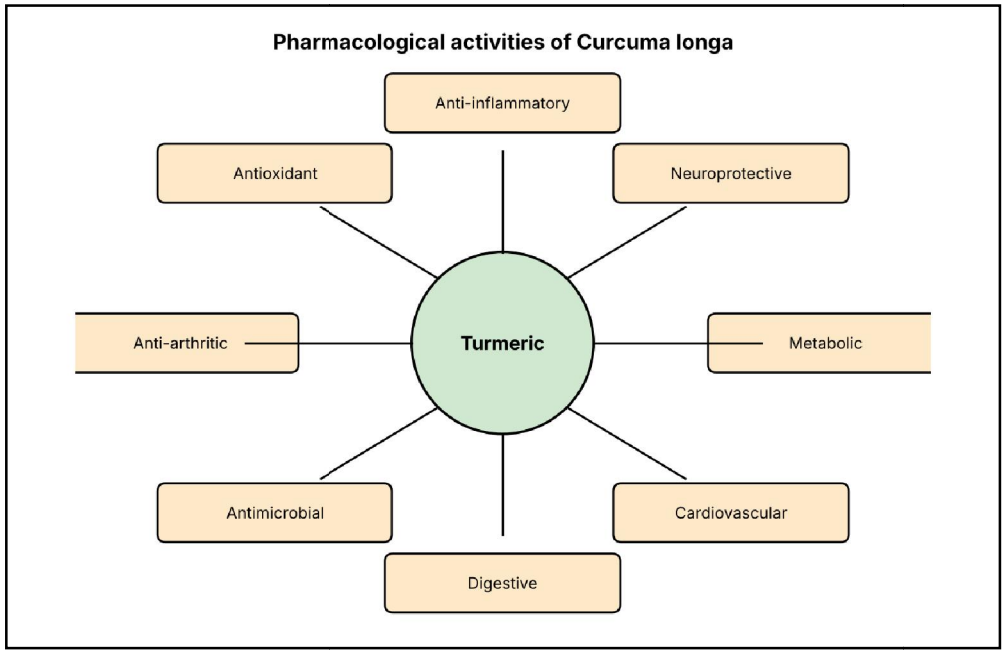


Fig.No.2. Pharmacological Activities of Turmeric

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

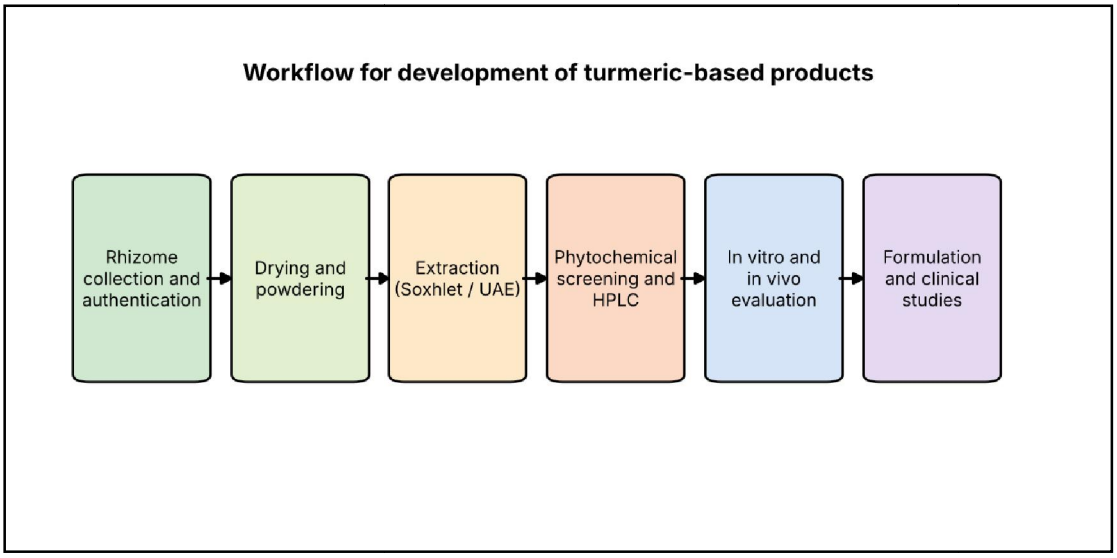


Fig.No.3. From Turmeric Rhizome to Formulation and Evaluation

6. Cardiovascular Benefits

Experimental and early clinical studies suggest that curcumin improves endothelial function, reduces oxidative stress and lowers lipid levels, although larger trials are required [9,38].

7. Metabolic Health and Diabetes

Curcumin has been studied for effects on insulin sensitivity and for reducing inflammation associated with obesity and type 2 diabetes [9,10].

8. Neuroprotective Effects

Because curcumin reduces neuroinflammation and oxidative damage in animal models, it is being investigated in neurodegenerative disorders, but its poor brain bioavailability remains a challenge [9,12].

Reported Findings from Experimental Studies

1. Phytochemical Analysis

Phytochemical analysis of turmeric rhizome consistently reveals curcuminoids, phenolic compounds, terpenoids, essential oil, and carbohydrates, with curcumin typically the main curcuminoid [6,14]. The content of curcuminoids varies with variety, geographic origin, harvest time and drying method.

2. In Vitro Anti-inflammatory Activity

Turmeric extracts and curcumin inhibit protein denaturation, stabilise erythrocyte membranes and reduce nitric oxide and cytokine release from activated macrophages in a concentration-dependent manner [10,37]. Inhibition of COX-2 and lipoxygenase activity has also been reported [19].

3. In Vivo Anti-inflammatory Studies

In rodents, oral curcumin reduced carrageenan-induced paw oedema and cotton pellet granuloma formation, and its activity was reported to be comparable to that of standard drugs in some studies [7,37].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 6, November 2026 Impact Factor: 8.2

4. Anti-Rheumatoid Arthritis Activity

In adjuvant and collagen-induced arthritis models, curcumin reduced paw swelling, inflammatory cytokine levels and joint damage [9,10]. In a human pilot trial in active rheumatoid arthritis, the curcumin group showed the greatest improvement in disease activity score [18].

5. Toxicity Studies

Turmeric and curcumin have low acute toxicity in animals, and in healthy volunteers wide dose ranges were well tolerated, with mild gastrointestinal complaints being the most common adverse effect [16,17]. Case reports of liver injury with high-bioavailability supplements have appeared, and long-term safety is not fully established.

6. Antioxidant Activity

Curcumin increases the activity of endogenous antioxidant enzymes such as superoxide dismutase and catalase and reduces lipid peroxidation in treated animals [6,40].

Applications of Turmeric (Curcuma longa)

Turmeric has applications in medicine, food, cosmetics and industry because of its colour, flavour and bioactive constituents.

1. Medicinal Applications

Anti-inflammatory and Anti-arthritic: Turmeric extracts and curcumin formulations are used as supplements for joint pain and inflammatory conditions [20,39].
Antioxidant Support: Curcuminoids protect tissues from oxidative damage [6].
Digestive Aid: Turmeric is used traditionally for dyspepsia and bloating [14].
Wound and Skin Care: Turmeric paste is traditionally applied to wounds and skin disorders [5].

2. Culinary Applications

Turmeric is a key ingredient of curry powders and is used for colour and flavour in rice, vegetable and meat dishes, mustard and beverages [5].

3. Industrial Applications

Curcumin is used as a natural yellow food colour, in cosmetics and in the textile industry as a dye [6]. It also serves as an indicator in analytical chemistry and as a model compound in nanomedicine.

4. Traditional and Folk Medicine

In Ayurveda, Unani and folk medicine, turmeric is used with milk, honey or ghee for cough, cold, injuries and joint pain [5,19].

Advantage and limitations of Turmeric :

Advantages of Turmeric

1. Natural anti-inflammatory agent with multi-target action [10].
2. Rich source of antioxidant phenolic compounds [6].
3. Clinical studies suggest symptomatic benefit in arthritis [18,39].
4. Generally good tolerability over a wide dose range [16,17].
5. Inexpensive, widely available and culturally accepted [5].
6. Potential benefit in several chronic diseases [9].
7. Digestive and hepatoprotective traditional uses [14].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

8. Multiple formulation strategies are available to improve absorption [12,15].
9. Versatile uses as a spice, dye, cosmetic and supplement [19].
10. Long history of safe use as a food [5].

Limitations of Turmeric

1. Very low aqueous solubility and poor oral bioavailability of curcumin [12].
2. Rapid metabolism and elimination, with very low plasma levels [12,17].
3. Chemical instability and assay interference raise questions about drug-likeness [13].
4. Many clinical trials are small and of variable quality [39].
5. Content of curcuminoids varies with source and processing [6].
6. Standard dose and treatment duration are not established [20].
7. Possible interaction with anticoagulants and some drugs metabolised by cytochrome P450 [20].
8. Gastrointestinal discomfort at high doses [17].
9. Piperine-containing formulations may alter the pharmacokinetics of other drugs [15].
10. Adulteration of commercial turmeric with synthetic dyes is a quality concern [41].

Future Prospects of Turmeric:

1. Pharmaceutical Development

- Development of standardised curcuminoid extracts for inflammatory disease.
- Design of analogues with improved stability and potency [13].

2. Clinical Trials

- Large, well-designed randomised trials to confirm efficacy and safety.
- Determination of optimal dose, duration and biomarkers of response [20].

3. Nutraceutical Applications

- Integration of curcumin into functional foods and beverages.
- Standardised supplements for joint and metabolic health [38].

4. Drug Delivery Systems

- Nanoparticles, liposomes, micelles and phospholipid complexes to improve bioavailability [12].
- Controlled-release and targeted formulations for chronic inflammation.

5. Absorption Enhancers

- Combination with piperine and other adjuvants [15].
- Study of safety of enhanced-absorption formulations.

6. Combination Therapies

- Combining curcumin with conventional drugs for additive effect [18].
- Research on lowering NSAID dose and side effects.

7. Molecular and Mechanistic Studies

- Identification of direct protein targets and metabolites responsible for activity.
- Systems-biology and omics-based studies of curcumin action.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

8. Cosmetic Industry
- Anti-ageing and skin-care formulations using antioxidant properties.
- Natural pigments with antimicrobial action.

9. Food Industry
- Natural colour and preservative in processed foods.
- Packaging films containing curcumin.

10. Agricultural Applications
- Use of turmeric extracts as eco-friendly crop-protection agents.
- Improved cultivars with higher curcuminoid content.

11. Anti-cancer Research
- Investigation of effects on apoptosis and cell proliferation [19].
- Evaluation in combination with chemotherapy.

12. Neuroprotective Research
- Studies in neurodegenerative diseases.
- Brain-targeted delivery systems.

13. Metabolic Disorder Management
- Trials in obesity, diabetes and fatty liver disease.
- Functional supplements for metabolic health.

14. Quality Control and Certification
- Standard HPLC fingerprints and limits for adulterants.
- Global quality standards for turmeric products.

15. Integration with Modern Medicine
- Combination of traditional knowledge with modern pharmacology.
- Potential place in integrative treatment guidelines.

Summary

Turmeric (Curcuma longa) is a spice and medicinal plant with a long history of use in inflammatory conditions, digestive disorders and wound care. Its main constituents, the curcuminoids and volatile oils, have antioxidant and anti-inflammatory properties. In vitro studies show reduced protein denaturation, membrane stabilisation and decreased production of nitric oxide and cytokines, while in vivo studies in carrageenan, cotton pellet and arthritis models show reduced oedema, granuloma formation and joint damage. The mechanisms involve suppression of NF-κB, COX-2 and lipoxygenase, free-radical scavenging with Nrf2 activation, reduced MMP expression and lower nitric oxide production. Clinical trials in arthritis suggest symptomatic benefit with generally good tolerability, though many are small. Applications span medicine, food, cosmetics and industry. The main limitations are poor bioavailability, chemical instability, variable composition and limited high-quality clinical data. Future work should focus on better formulations, rigorous clinical trials and standardised quality control [10,13].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 6, November 2026
Impact Factor: 8.2

II. CONCLUSION

Turmeric and its principal constituent curcumin show consistent anti-inflammatory and antioxidant activity in experimental models and encouraging, though preliminary, clinical results in arthritis. Their multi-target action and safety profile make them attractive complementary agents, but poor bioavailability and the need for stronger clinical evidence must be addressed before turmeric-based products can be recommended as established therapy. Advances in formulation, standardisation and clinical research are expected to define the true therapeutic role of turmeric.

REFERENCES

1. Medzhitov R., Origin and physiological roles of inflammation, Nature, 2008, 454, 428–435.
2. Firestein G. S., Evolving concepts of rheumatoid arthritis, Nature, 2003, 423, 356–361.
3. Vane J. R., Botting R. M., Mechanism of action of anti-inflammatory drugs, The American Journal of Medicine, 1998, 104, 2S–8S.
4. Newman D. J., Cragg G. M., Natural products as sources of new drugs over the nearly four decades from 01/1981 to 09/2019, Journal of Natural Products, 2020, 83, 770–803.
5. Aggarwal B. B., Sundaram C., Malani N., Ichikawa H., Curcumin: the Indian solid gold, Advances in Experimental Medicine and Biology, 2007, 595, 1–75.
6. Priyadarsini K. I., The chemistry of curcumin: from extraction to therapeutic agent, Molecules, 2014, 19, 20091–20112.
7. Srimal R. C., Dhawan B. N., Pharmacology of diferuloyl methane (curcumin), a non-steroidal anti-inflammatory agent, Journal of Pharmacy and Pharmacology, 1973, 25, 447–452.
8. Singh S., Aggarwal B. B., Activation of transcription factor NF-kappa B is suppressed by curcumin (diferuloylmethane), Journal of Biological Chemistry, 1995, 270, 24995–25000.
9. Aggarwal B. B., Harikumar K. B., Potential therapeutic effects of curcumin, the anti-inflammatory agent, against neurodegenerative, cardiovascular, pulmonary, metabolic, autoimmune and neoplastic diseases, The International Journal of Biochemistry & Cell Biology, 2009, 41, 40–59.
10. Kunnumakkara A. B., Bordoloi D., Padmavathi G., et al., Curcumin, the golden nutraceutical: multitargeting for multiple chronic diseases, British Journal of Pharmacology, 2017, 174, 1325–1348.
11. Pandey K. B., Rizvi S. I., Plant polyphenols as dietary antioxidants in human health and disease, Oxidative Medicine and Cellular Longevity, 2009, 2, 270–278.
12. Anand P., Kunnumakkara A. B., Newman R. A., Aggarwal B. B., Bioavailability of curcumin: problems and promises, Molecular Pharmaceutics, 2007, 4, 807–818.
13. Nelson K. M., Dahlin J. L., Bisson J., Graham J., Pauli G. F., Walters M. A., The essential medicinal chemistry of curcumin, Journal of Medicinal Chemistry, 2017, 60, 1620–1637.
14. Ammon H. P. T., Wahl M. A., Pharmacology of Curcuma longa, Planta Medica, 1991, 57, 1–7.
15. Shoba G., Joy D., Joseph T., Majeed M., Rajendran R., Srinivas P. S. S. R., Influence of piperine on the pharmacokinetics of curcumin in animals and human volunteers, Planta Medica, 1998, 64, 353–356.
16. Chainani-Wu N., Safety and anti-inflammatory activity of curcumin: a component of tumeric (Curcuma longa), Journal of Alternative and Complementary Medicine, 2003, 9, 161–168.
17. Lao C. D., Ruffin M. T., Normolle D., et al., Dose escalation of a curcuminoid formulation, BMC Complementary and Alternative Medicine, 2006, 6, 10.
18. Chandran B., Goel A., A randomized, pilot study to assess the efficacy and safety of curcumin in patients with active rheumatoid arthritis, Phytotherapy Research, 2012, 26, 1719–1725.
19. Prasad S., Gupta S. C., Tyagi A. K., Aggarwal B. B., Curcumin, a component of golden spice: from bedside to bench and back, Biotechnology Advances, 2014, 32, 1053–1064.
20. Gupta S. C., Patchva S., Aggarwal B. B., Therapeutic roles of curcumin: lessons learned from clinical trials, The AAPS Journal, 2013, 15, 195–218.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 6, November 2026 Impact Factor: 8.2

21. Kokate C. K., Practical Pharmacognosy, 4th Edition, Vallabh Prakashan, New Delhi, 1994.
22. Harborne J. B., Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis, 3rd Edition, Chapman and Hall, London, 1998.
23. Winter C. A., Risley E. A., Nuss G. W., Carrageenin-induced edema in hind paw of the rat as an assay for anti-inflammatory drugs, Proceedings of the Society for Experimental Biology and Medicine, 1962, 111, 544–547.
24. Newbould B. B., Chemotherapy of arthritis induced in rats by mycobacterial adjuvant, British Journal of Pharmacology and Chemotherapy, 1963, 21, 127–136.
25. Singleton V. L., Rossi J. A., Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents, American Journal of Enology and Viticulture, 1965, 16, 144–158.
26. Blois M. S., Antioxidant determinations by the use of a stable free radical, Nature, 1958, 181, 1199–1200.
27. Kilkenny C., Browne W. J., Cuthill I. C., Emerson M., Altman D. G., Improving bioscience research reporting: the ARRIVE guidelines for reporting animal research, PLoS Biology, 2010, 8, e1000412.
28. Vogel H. G. (Ed.), Drug Discovery and Evaluation: Pharmacological Assays, 3rd Edition, Springer, Berlin, 2008.
29. Chang C., Yang M., Wen H., Chern J., Estimation of total flavonoid content in propolis by two complementary colorimetric methods, Journal of Food and Drug Analysis, 2002, 10, 178–182.
30. Mizushima Y., Kobayashi M., Interaction of anti-inflammatory drugs with serum proteins, especially with some biologically active proteins, Journal of Pharmacy and Pharmacology, 1968, 20, 169–173.
31. Mosmann T., Rapid colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays, Journal of Immunological Methods, 1983, 65, 55–63.
32. Di Rosa M., Giroud J. P., Willoughby D. A., Studies of the mediators of the acute inflammatory response induced in rats in different sites by carrageenan and turpentine, Journal of Pathology, 1971, 104, 15–29.
33. Winter C. A., Porter C. C., Effect of alterations in side chains upon anti-inflammatory and liver glycogen activities of hydrocortisone esters, Journal of the American Pharmaceutical Association, 1957, 46, 515–519.
34. OECD, Test No. 423: Acute Oral Toxicity – Acute Toxic Class Method, OECD Guidelines for the Testing of Chemicals, Section 4, OECD Publishing, Paris, 2002.
35. OECD, Test No. 407: Repeated Dose 28-day Oral Toxicity Study in Rodents, OECD Guidelines for the Testing of Chemicals, Section 4, OECD Publishing, Paris, 2008.
36. Lawrence T., The nuclear factor NF-kappaB pathway in inflammation, Cold Spring Harbor Perspectives in Biology, 2009, 1, a001651.
37. Jurenka J. S., Anti-inflammatory properties of curcumin, a major constituent of Curcuma longa: a review of preclinical and clinical research, Alternative Medicine Review, 2009, 14, 141–153.
38. Hewlings S. J., Kalman D. S., Curcumin: a review of its effects on human health, Foods, 2017, 6, 92.
39. Daily J. W., Yang M., Park S., Efficacy of turmeric extracts and curcumin for alleviating the symptoms of joint arthritis: a systematic review and meta-analysis of randomized clinical trials, Journal of Medicinal Food, 2016, 19, 717–729.
40. Kakkar P., Das B., Viswanathan P. N., A modified spectrophotometric assay of superoxide dismutase, Indian Journal of Biochemistry and Biophysics, 1984, 21, 130–132.
41. Ekor M., The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety, Frontiers in Pharmacology, 2014, 4, 177.