STM JOURNALS

International Journal of
Antibiotics

Volume 2, Issue 1, 2025
January -June
DOI (Journal): 10.37591/IJAB

https://journals.stmjournals.com/ijab

Review IJAB

A Factualistic Study of Phytomedicinal Activity of *Curcuma longa* (Haldi): Plant That Infuses Life

Mohd. Wasiullah[1], Piyush Yadav[2,*], Ankit Rai[3]

Abstract

Curcuma longa, commonly known as turmeric, is a plant of remarkable medicinal significance that has been utilized for centuries in traditional medicine and has garnered considerable attention in modern scientific research. This review explores its extensive phytomedicinal potential, focusing on the plant's bioactive compounds, particularly curcumin, which is recognized as the primary agent responsible for its therapeutic properties. Turmeric contains an array of chemical constituents, including curcuminoids, volatile oils, and polysaccharides, contributing to its diverse pharmacological effects. These effects include anti-inflammatory, antioxidant, antimicrobial, anticancer, neuroprotective, and cardioprotective properties. Despite its therapeutic promise, the clinical application of curcumin faces significant challenges, primarily related to its poor bioavailability, rapid metabolism, and limited absorption. These issues necessitate innovative strategies, such as the use of curcumin analogs, nanoparticles, and combination therapies, to enhance its efficacy and stability. This review consolidates the current scientific evidence supporting turmeric's medicinal potential and underscores its clinical relevance. Furthermore, it highlights ongoing research aimed at overcoming the hurdles associated with curcumin's use in therapeutic contexts. By delving into its pharmacological activities and clinical implications, this article serves as a comprehensive resource for understanding Curcuma longa's potential as a versatile and effective natural therapeutic agent.

Keywords: *Curcuma longa*, curcumin, phytomedicine, therapeutic properties, Turmeric

INTRODUCTION

The perennial herb *Curcuma longa*, also known as Haldi or turmeric, is a plant in the family. Zingiberaceae Turmeric is native to South Asia especially India. It has been grown and used for cooking and medicine for over 4,000 years. The plant is renowned for its vibrant yellow rhizomes, which are dried and powdered to produce the spice known as turmeric. This spice is a staple in South Asian cuisine and holds significant cultural and religious importance in many communities.

***Author for Correspondence**
Piyush Yadav
E-mail: piyush6118@gmail.com

[1]Principal, Department of Pharmacy, Prasad Institute of Technology, Jaunpur, Uttar Pradesh, India.
[2]Academic Head, Department of Pharmacy, Prasad Institute of Technology, Jaunpur, Uttar Pradesh, India.
[3]Scholar, Department of Pharmacy, Prasad Institute of Technology, Jaunpur, Uttar Pradesh, India.

Received Date: December 14, 2024
Accepted Date: January 03, 2025
Published Date: January 07, 2025

Citation: Mohd. Wasiullah, Piyush Yadav, Ankit Rai. A Factualistic Study of Phytomedicinal Activity of *Curcuma longa* (Haldi): Plant That Infuses Life. International Journal of Antibiotics. 2025; 2(1): 14–24p.

Turmeric has a long history of use in traditional medicine systems, such as Ayurveda, Unani, and Traditional Chinese Medicine (TCM). Turmeric is a warming species used in Ayurveda to treat liver problems. Digestive and respiratory problems. It is said to help balance the body's boiler, phlegm, and vata and vices. It is often applied topically for wound healing and as a cosmetic for skin care. In Turmeric, which is often referred to as "jiang huang" in traditional Chinese medicine. Used to stimulate the flow of qi. make the blood strong and relieve pain [1].

Asia isn't the only region where turmeric is used. Because it is a golden color. Therefore, it is called

"Indian Saffron" in Medieval Europe and it is often used in place of the more expensive spice saffron. Its medicinal properties were also recognized in ancient Greek and Roman texts.

The resurgence of interest in turmeric's medicinal properties can be largely attributed to the discovery of curcumin, the principal curcuminoid of turmeric, which constitutes approximately 2–8% of turmeric's composition. Vogel and Pelletier first isolated curcumin in 1815, and in 1910 the structure of curcumin was established. Since then, curcumin has been the focus of extensive scientific research, with thousands of studies investigating its pharmacological effects and therapeutic potential.

Many traditional uses of turmeric are confirmed by contemporary research. This also shows the possibility of new treatments. Curcumin, the main active compound in turmeric, has demonstrated a wide array of pharmacological activities, including anti-inflammatory, antioxidant, antimicrobial, and anticancer effects. These properties have been investigated in numerous preclinical studies and clinical trials, highlighting curcumin's potential as a multi-targeted therapy.

There are many ways in which curcumin works to produce its effects. It modulates several cells signaling pathways, including nuclear factor-kappa B (NF-κB), cyclooxygenase-2 (COX-2), and various cytokines and enzymes involved in inflammation and oxidative stress. Curcumin is a potent antioxidant and anti-inflammatory due to its ability to alter these pathways.

In addition to curcumin, other curcuminoids (desmethoxycurcumin and bisdemethoxycurcumin) and volatile oils (such as turmerone) in turmeric contribute to its therapeutic effects. These ingredients complement each other. And it has been shown to increase the overall effectiveness of turmeric extracts [2].

Turmeric and its constituents, particularly curcumin, have significant implications for global health. Chronic diseases around the world include cancer, cardiovascular disease, diabetes, and neurological diseases. It is the main cause of illness and death. The development of curcumin-based therapeutics could potentially offer a natural, cost-effective alternative for managing these conditions. Furthermore, turmeric's role in promoting general health and wellness is supported by its use as a dietary supplement and its inclusion in functional foods.

The safety profile of turmeric is another factor contributing to its popularity. Turmeric and curcumin are generally regarded as safe (GRAS) by the U.S. Food and Drug Administration (FDA). Adverse effects are rare and usually associated with high doses or long-term use. This safety profile, combined with its therapeutic potential, makes turmeric an attractive candidate for integrative and complementary medicine [3].

Turmeric's versatility extends beyond medicine. It is used as a natural dye in textiles and cosmetics, and its antimicrobial properties make it a useful preservative in food and other products. Its significance in cultural and religious practices also underscores its value across different societies.

Cultivation

Curcuma longa is primarily cultivated in tropical and subtropical regions, with India being the largest producer and exporter of turmeric globally. The plant thrives in warm, humid climates and requires specific soil and environmental conditions to maximize its yield and quality (Figure 1).

Climate and Soil Requirements

Turmeric grows best in regions with temperatures ranging from 20°C to 30°C and annual rainfall between 1500 to 2000 mm. The plant needs soil that is rich in organic matter and well-drained. Turmeric grows best in sandy, loamy and clay soils with a pH between 4.5 and 7.5. Proper drainage is important to avoid waterlogging. This can result in rhizome rot and other fungal diseases.

Figure 1. Turmeric Cultivation: A vibrant *Curcuma longa* field, showcasing the golden spice derived from its rhizomes, thriving in warm, tropical conditions.

Propagation

Turmeric is propagated vegetatively through its rhizomes. The rhizomes are cut into small pieces, each containing a bud, and planted in prepared beds. The ideal time for planting turmeric is at the onset of the monsoon, ensuring sufficient moisture for germination and early growth. Before planting, the rhizomes are often treated with fungicides to prevent soil-borne diseases.

Planting and Crop Management

Turmeric is typically planted in rows, with a spacing of 25–30 cm between plants and 45–60 cm between rows. This spacing allows sufficient room for the rhizomes to grow and facilitates field management practices, such as weeding and earthing up. Organic manures like farmyard manure or compost are applied at planting to enhance soil fertility (Figure 2).

Crop management involves regular weddings, earthing up, and irrigation. In the early stages of growth Weed control is important to reduce competition for water and nutrients. Earthing up, the process of piling soil around the base of the plants support the plants and promotes the development of rhizomes. Turmeric requires regular irrigation, especially during dry spells, to maintain soil moisture levels [4].

Figure 2. Lifecycle and growth stages of turmeric (*Curcuma longa*), highlighting the development from rhizome to sprout, leaf, flower, and rhizome regeneration.

Harvesting and Post-Harvest Processing

Turmeric is harvested when the leaves are dry and yellow. This usually takes 7 to 10 months after planting. The rhizomes are carefully dug up to avoid damage, cleaned of soil, and separated into mother rhizomes (primary) and finger rhizomes (secondary). The harvested rhizomes are then boiled or steamed to reduce raw odor, gelatinize the starch, and improve color. This process, known as curing, also enhances the storage life of the rhizomes.

Rhizomes are boiled and then dried in the sun for 10 to 15 days until they reach a moisture content of 8–10%. Proper drying is important for long-term storage and prevention of mold development. The dried rhizomes are then polished to remove rough surfaces, often using mechanical polishers, resulting in the familiar smooth, bright yellow turmeric [5].

Quality Control and Standards

Maintaining the quality of turmeric is essential for both medicinal and culinary uses. Inspection of pollutants, such as pesticides, heavy metals, and microbial pathogens. It is considered one aspect of the quality control process. Important quality factors include color, odor, and curcumin concentration and overall characteristics guidelines for safety and quality of turmeric products are provided by several national and international standards. Including standards set by the International Organization for Standardization (ISO) and the Indian Standards Institute (ISI).

Economic and Social Impact

Turmeric cultivation provides significant economic benefits to farmers, especially in rural areas of India, China, and Southeast Asia. It offers a source of income and employment opportunities in farming, processing, and trade sectors. The global demand for turmeric and its products has been steadily increasing due to rising awareness of its health benefits, leading to enhanced market opportunities for producers.

In addition to the economic impact Turmeric also has cultural and social value in many ways. Represents health prosperity and purity and are used in religious ceremonies, festivals, and traditional celebrations.

Importance of Study Understanding the medicinal properties of *Curcuma longa* is critical for developing new therapeutic strategies and improving existing treatments for various diseases. The bioactive compounds found in turmeric, particularly curcumin, have shown promise in preclinical and clinical studies, making it essential to consolidate this information for future research and application.

Chemical Constituents

The rich phytochemical composition of *Curcuma longa* is responsible for its medicinal potential. The rhizomes of turmeric contain curcuminoids (curcumin, desmethoxycurcumin, and bisdemethoxycurcumin), essential oils (turmerone, atlantone, and zingiberene), proteins, resins, and sugars.

Curcuminoids

Curcumin is the most studied curcuminoid, renowned for its vibrant yellow pigment and therapeutic properties. It constitutes approximately 2–8% of most turmeric preparations and has been extensively studied for its role in various biological activities.

Structure and Properties

Curcumin ($C_{21}H_{20}O_6$) is a polyphenol compound with a diketone structure. Its chemical structure allows it to participate in redox reactions, acting as a hydrogen donor and neutralizing free radicals (Figure 3**)**.

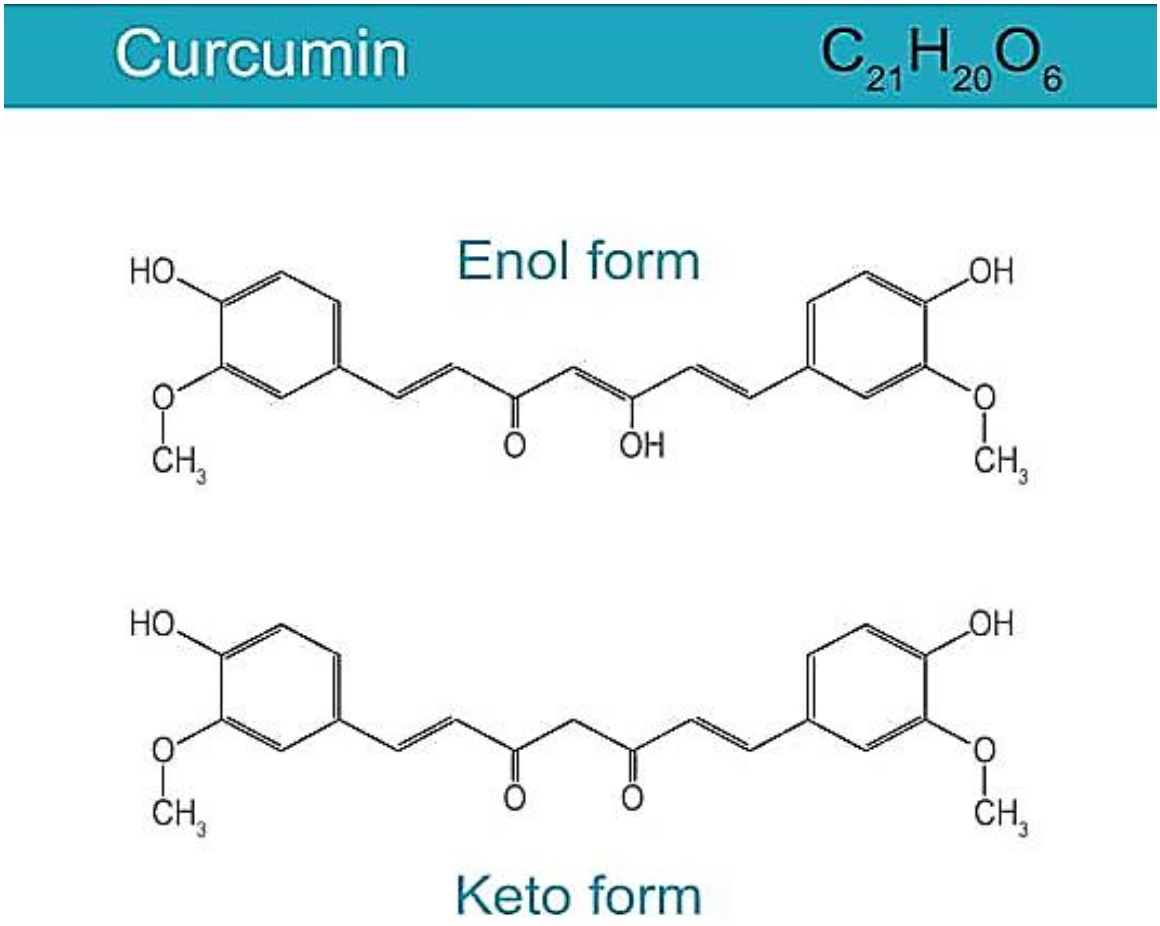

Figure 3. Chemical Structure of Curcumin ($C_{21}H_{20}O_6$).

- *Biological Activities:* Several biological properties Including anti-inflammatory effects Antioxidants antibacterial and anti-cancer. It has been shown for curcumin. These activities are attributed to its ability to modulate various molecular targets, including transcription factors, enzymes, cell cycle proteins, and inflammatory cytokines.
- *Essential Oils:* The essential oils of turmeric, particularly ar-Turmerone, have shown significant anti-inflammatory and antimicrobial activities. These oils contribute to the overall therapeutic efficacy of turmeric.
- *Composition and Benefits:* Essential oils from *Curcuma longa* consist of sesquiterpenes, monoterpenes, and other volatile compounds. These oils have demonstrated efficacy in treating inflammation and infections due to their ability to inhibit pro-inflammatory mediators and microbial growth.

Minor Constituents

In addition to curcuminoids and essential oils, turmeric contains various other constituents, such as resins, proteins, and sugars, which contribute to its therapeutic properties. These minor components may enhance the bioavailability and efficacy of curcumin through synergistic effects [6].

PHARMACOLOGICAL EFFECTS

Anti-Inflammatory Activities

By altering several molecular pathways, such as inhibiting cyclooxygenase-2 (COX-2) and nuclear factor-kappa B (NF-κB), curcumin exerts anti-inflammatory effects.

- *Mechanisms of Action:* Curcumin inhibits the activation of NF-κB, a key regulator of inflammation, which reduces the expression of inflammatory cytokines and enzymes. Additionally, curcumin suppresses the activity of COX-2, an enzyme involved in the synthesis of pro-inflammatory prostaglandins.
- *Preclinical Studies:* The anti-inflammatory properties of curcumin have been demonstrated in several preclinical studies using various animal models of inflammation. From this research Curcumin reduces inflammation in diseases, such as colitis, arthritis, and neurological disorders (Jurenka, 2009).
- *Clinical Evidence:* Clinical trials have provided evidence supporting the anti-inflammatory effects of curcumin in humans. For example, a study by Chandran and Goel (2012) found that curcumin supplementation significantly reduced markers of inflammation in patients with rheumatoid arthritis.
- *Clinical Implications:* Due to its anti-inflammatory properties Curcumin can therefore be used as a treatment for certain inflammatory diseases, such as psoriasis, arthritis, and inflammatory cancers. Future research should focus on improving the dosing schedule and delivery system to optimize the anti-inflammatory benefits of curcumin in the clinical setting.

Antioxidant Activities

Curcumin's ability to destroy reactive oxygen species (ROS) and increase the production of antioxidant enzymes is responsible for its antioxidant effect [7].

- *Mechanisms of Action:* By giving electrons to free radicals. Curcumin neutralizes them and reduces oxidative stress. It also protects cells from oxidative damage by increasing the activity of antioxidant enzymes, such as glutathione peroxidase (GPX) and superoxide dismutase (SOD).
- *Preclinical Studies:* The antioxidant properties of curcumin have been demonstrated in several preclinical studies using various animal models of oxidative stress. These studies have shown that curcumin can reduce oxidative damage in conditions, such as diabetes, cardiovascular diseases, and neurodegenerative diseases.
- *Clinical Evidence:* Clinical trials have provided evidence supporting the antioxidant effects of curcumin in humans. For example, a study found that curcumin supplementation significantly reduced markers of oxidative stress in patients with cardiovascular disease.
- *Clinical Implications:* Due to its antioxidant properties Curcumin can therefore be used as a treatment for diseases related to oxidative stress, such as diabetes, heart disease, and neurodegenerative diseases. Future research should focus on improving the dosing schedule and delivery system to optimize the antioxidant benefits of curcumin in the clinical setting.

Antimicrobial Activity

When it comes to bacteria, fungi, and viruses, *Curcuma longa* has broad-spectrum antibacterial activity. Curcumin disrupts microbial cell membranes, inhibits enzyme activity, and interferes with microbial signaling pathways.

- *Antibacterial Effects:* Curcumin has been shown to inhibit the growth of various pathogenic bacteria, including Staphylococcus aureus, Escherichia coli, and Helicobacter pylori. The ability to disrupt bacterial cell membranes and inhibit bacterial enzymes is believed to be the reason for its bactericidal effect.
- *Antifungal Effects:* Curcumin exhibits antifungal activity against a range of fungal species, including Candida albicans and Aspergillus niger. It disrupts fungal cell membranes and inhibits the synthesis of fungal cell wall components.
- *Antiviral Effects:* Curcumin has demonstrated antiviral activity against several viruses, including influenza virus, hepatitis C virus, and human immunodeficiency virus (HIV). To improve virus protection, it blocks viral replication and alters the host's immune response.
- *Mechanisms of Action:* Many processes, such as the breakdown of microbial cell membranes Inhibition of microbial enzymes and interfering with microbial signaling pathways. It is responsible for the antimicrobial effects of curcumin.

Anticancer Properties

By stimulating cell death Stopping the progression of the cell cycle and inhibiting the creation of new blood vessels Curcumin has been shown to limit the spread of many types of cancer cells. It modulates multiple signaling pathways, including those involving p53, NF-κB, and Wnt/β-catenin.

- *Mechanisms of Action:* By stimulating pro-apoptotic proteins and inhibiting anti-apoptotic proteins. Curcumin causes cancer cell death. It stops cell cycle progression by altering the expression of cell cycle regulatory proteins. By inhibiting angiogenic factors Curcumin also prevents the formation of new blood vessels. This is the growth of new blood vessels that create tumors.
- *Preclinical Studies:* The anticancer benefits of curcumin have been demonstrated in several preclinical investigations using a variety of animal cancer models. These studies have shown that curcumin can inhibit the growth of tumors and enhance the efficacy of conventional cancer therapies [8].
- *Clinical Evidence:* Clinical trials have provided evidence supporting the anticancer effects of curcumin in humans. For example, a study by Gupta et al. (2013) found that curcumin supplementation significantly reduced the growth of tumors in patients with colorectal cancer.

CLINICAL APPLICATIONS

Arthritis

Clinical trials have demonstrated the efficacy of curcumin in managing symptoms of rheumatoid arthritis and osteoarthritis. Curcumin supplementation has shown to reduce inflammation and pain, improving joint function (Figure 4) [9].

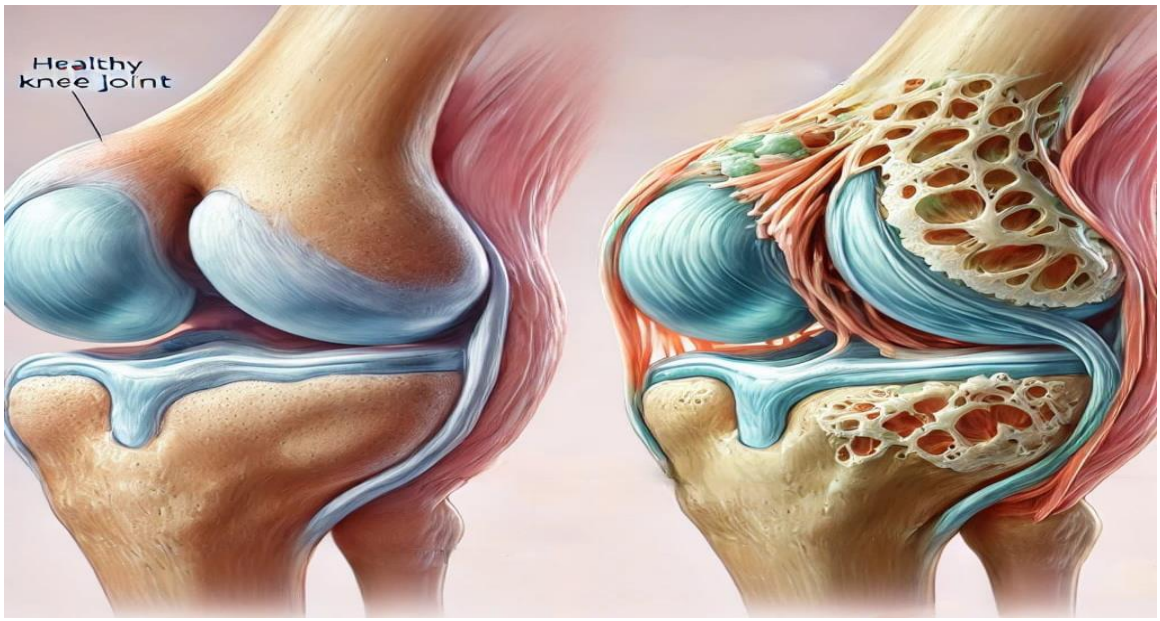

Figure 4. Healthy knee vs. osteoarthritic knee: Curcumin aids in reducing inflammation and pain in arthritis.

- *Mechanisms of Action:* The anti-inflammatory properties of curcumin are primarily responsible for its therapeutic effects in arthritis. By inhibiting inflammatory mediators, such as NF-κB and COX-2, curcumin reduces joint inflammation and pain.
- *Preclinical Studies:* Curcumin's anticancer benefits have been shown in numerous preclinical investigations using a variety of animal cancer models. These studies provide a basis for clinical trials investigating the efficacy of curcumin in human arthritis.
- *Clinical Evidence:* Clinical research shows the effectiveness of curcumin in treating arthritis. For example, a randomized controlled trial by Chandran and Goel (2012) found that curcumin

supplementation significantly reduced symptoms of rheumatoid arthritis, including pain and inflammation.

- *Dosage and Safety:* The optimal dosage of curcumin for treating arthritis is still under investigation, but studies have used doses ranging from 500 to 2000 mg per day. Curcumin is generally well-tolerated, with few reported side effects.

Cardiovascular Health

Curcumin's ability to lower cholesterol Oxidative stress and inflammation mediates heart protection. It has been shown to reduce the risk of atherosclerosis and improve endothelial function (Figure 5**)**.

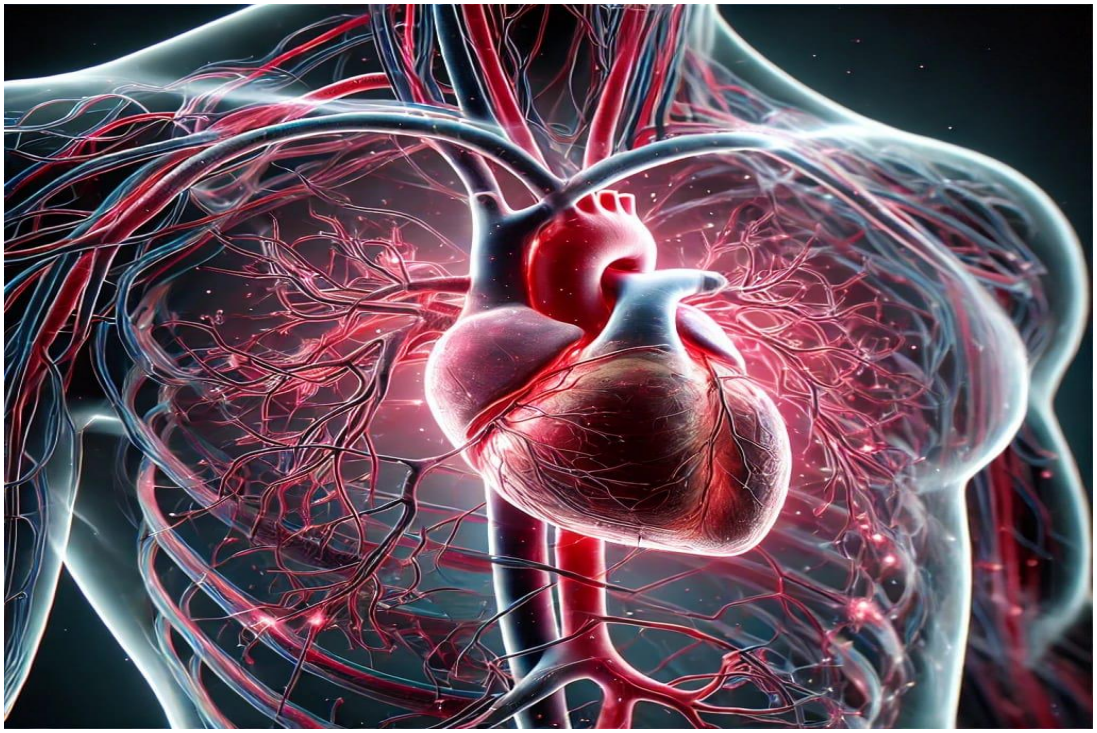

Figure 5. Curcumin and Cardiovascular Health: Highlighting its role in reducing oxidative stress, lowering cholesterol, and improving endothelial function to prevent atherosclerosis.

- *Mechanisms of Action:* Curcumin reduces oxidative stress and inflammation. These are the two leading causes of heart disease. It also lowers cholesterol levels and improves endothelial function, reducing the risk of atherosclerosis.
- *Preclinical Studies:* Preclinical studies have shown that curcumin can reduce the risk of cardiovascular disease in animal models. These studies have demonstrated that curcumin reduces inflammation, oxidative stress, and cholesterol levels, improving overall cardiovascular health.
- *Clinical Evidence*: Clinical trials have provided evidence supporting the cardioprotective effects of curcumin in humans. For example, a study found that curcumin supplementation significantly improved endothelial function and reduced markers of inflammation and oxidative stress in patients with cardiovascular disease.
- *Dosage and Safety:* The optimal dosage of curcumin for improving cardiovascular health is still under investigation, but studies have used doses ranging from 500 to 2000 mg per day. Curcumin is generally well-tolerated, with few reported side effects.

NEUROPROTECTIVE EFFECTS

Curcumin crosses the blood-brain barrier and exhibits neuroprotective properties. It may be useful in treating neurological diseases, such as multiple sclerosis. Parkinson's disease and Alzheimer's disease (Figure 6).

Figure 6. Mechanisms of Action: How Curcumin Safeguards Neurons from Degeneration.

- *Mechanisms of Action:* Curcumin exerts its neuroprotective effects by reducing inflammation, oxidative stress, and amyloid plaque formation in the brain. It also enhances the clearance of amyloid plaques and promotes the survival of neurons.
- *Preclinical Studies:* According to preclinical research, it may reduce the risk of neurological disorders in laboratory animals. These studies have demonstrated that curcumin reduces inflammation, oxidative stress, and amyloid plaque formation, improving overall brain health.
- *Clinical Evidence:* Clinical trials have provided evidence supporting the neuroprotective effects of curcumin in humans. For example, a study by Mishra and Palanivelu (2008) found that curcumin supplementation significantly improved cognitive function and reduced markers of inflammation and oxidative stress in patients with Alzheimer's disease.
- *Dosage and Safety:* The optimal dosage of curcumin for neuroprotection is still under investigation, but studies have used doses ranging from 500 to 2000 mg per day. Curcumin is generally well-tolerated, with few reported side effects [10].

CHALLENGES AND STRATEGIES FOR CLINICAL APPLICATION

Bioavailability Issues

Despite the promising therapeutic potential of curcumin, its clinical application is hindered by poor bioavailability, rapid metabolism, and systemic elimination. Various strategies have been explored to enhance its bioavailability, including the use of adjuvants like piperine, formulation in nanoparticles, liposomes, phytotomies, and chemical modifications.

- *Challenges:* Curcumin's low water solubility limits its ability to be absorbed into the digestive system. Additionally, it undergoes rapid metabolism and systemic elimination, reducing its bioavailability and therapeutic efficacy.
- *Strategies:* Several strategies have been investigated to increase the bioavailability of curcumin. These include:
  - *Use of Excipients:* Piperine, a bioactive compound in black pepper. It has been shown to increase the bioavailability of curcumin by preventing its metabolism. Co-administration of curcumin with piperine can increase its absorption and bioavailability.
  - *Nanoparticle Formulation:* Formulating curcumin in nanoparticles can enhance its solubility and stability, improving its absorption and bioavailability. Nanoparticles can also facilitate targeted delivery of curcumin to specific tissues.

- *Liposomes and Phytosomes:* Liposomes and phytosomes are lipid-based delivery systems that can enhance the bioavailability of curcumin by improving its solubility and stability. Additionally, these methods of administration can prevent curcumin from breaking down in the gastrointestinal tract.
- *Chemical Modifications:* Chemical modifications of curcumin, such as the development of curcumin analogs and conjugates, can improve its bioavailability and therapeutic efficacy. These modifications can enhance the solubility, stability, and metabolic profile of curcumin [11].

Clinical Application

- *Challenges:* The clinical application of curcumin is hindered by variability in its absorption, distribution, metabolism, and excretion among individuals. Additionally, the optimal dosage and duration of curcumin supplementation for various therapeutic applications are still under investigation [12].
- *Strategies:* To overcome these challenges, future research should focus on:
- *Standardizing Dosing Regimens:* Establishing standardized dosing regimens for curcumin supplementation based on clinical evidence. This includes determining the optimal dosage and duration of supplementation for various therapeutic applications.
- *Conducting Comprehensive Clinical Trials:* Conducting comprehensive clinical trials to evaluate the long-term safety and efficacy of curcumin supplementation in different populations. These trials should consider factors, such as age, gender, and genetic variability in curcumin metabolism.
- *Developing Personalized Therapies:* Developing personalized therapies based on individual variability in curcumin metabolism and response. This includes the use of pharmacogenomics and personalized medicine approaches to tailor curcumin supplementation to individual needs [13].

CONCLUSIONS

Curcuma longa, with its wide range of pharmacological activities, holds a significant promise as a therapeutic agent. Future studies should focus on addressing the bioavailability of curcumin and explore its potential in new treatment contexts. Comprehensive clinical trials are essential to establish standardized dosing regimens and confirm the long-term safety and efficacy of curcumin.

REFERENCES

1. Aggarwal BB, Harikumar KB. Potential therapeutic effects of curcumin, the anti-inflammatory agent, against neurodegenerative, cardiovascular, pulmonary, metabolic, autoimmune, and neoplastic diseases. Int J Biochem Cell Biol. 2009;41(1):40–59.
2. Aggarwal BB, Sung B. Pharmacological basis for the role of curcumin in chronic diseases: An age-old spice with modern targets. Trends Pharmacol Sci. 2009;30(2):85–94.
3. Anand P, Kunnumakkara AB, Newman RA, Aggarwal BB. Bioavailability of curcumin: Problems and promises. Mol Pharm. 2007;4(6):807–18.
4. Anand P, Sundaram C, Jhurani S, Kunnumakkara AB, Aggarwal BB. Curcumin and cancer: An "old age" disease with an "age-old" solution. Cancer Lett. 2008;267(1):133–64.
5. 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):1719–25.
6. Gupta SC, Patchva S, Aggarwal BB. Therapeutic roles of curcumin: Lessons learned from clinical trials. AAPS J. 2013;15(1):195–218.
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):141–53.
8. Mishra S, Palanivelu K. The effect of curcumin (turmeric) on Alzheimer's disease: An overview. Ann Indian Acad Neurol. 2008;11(1):13–9.
9. Negi PS, Jayaprakasha GK, Jagan Mohan Rao L, Sakariah KK. Antibacterial activity of turmeric oil: A byproduct from curcumin manufacture. J Agric Food Chem. 1999;47(10):4297–300.

10. Punia S, Kaur M, Kumar K. Health benefits of curcumin: An updated review. J Food Sci Technol. 2019;56(10):4491–502.
11. Ravindran PN, Nirmal Babu K, Sivaraman K. Turmeric: The genus Curcuma. CRC Press; 2007.
12. Shoba G, Joy D, Joseph T, Majeed M, Rajendran R, Srinivas PS. Influence of piperine on the pharmacokinetics of curcumin in animals and human volunteers. Planta Med. 1998;64(4):353–6.
13. Singh G, Maurya S, De Lampasona MP, Catalan CAN. A comparison of chemical, antioxidant and antimicrobial studies of cinnamon leaf and bark volatile oils, oleoresins and their constituents. Food Chem Toxicol. 2010;48(2):327–33.

