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Review Article

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Pharmacological Evidence and Therapeutic Insights of *Curcuma longa* (Turmeric): Review

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ABSTRACT

Curcuma longa (turmeric) is a rhizomatous perennial plant belonging to the family Zingiberaceae and is widely cultivated across several Asian regions. The rhizome, which constitutes the medicinally valuable part of the plant, is processed into a yellow powder commonly used both as a spice and as a traditional therapeutic agent. Turmeric has long been employed in the management of various ailments, particularly inflammatory conditions, gastrointestinal disturbances such as flatulence and colic, hepatic disorders including jaundice, menstrual irregularities, hematuria, and hemorrhagic conditions. In addition, topical formulations of turmeric have been traditionally used for the treatment of several dermatological disorders. The pharmacological activity of turmeric is primarily attributed to curcumin (diferuloylmethane), a polyphenolic flavonoid, along with a range of volatile oils such as turmerone, atlantone, and zingiberene. Both aqueous and lipid-soluble extracts of turmeric, as well as isolated curcumin, exhibit potent antioxidant properties comparable to those of vitamins C and E. The hepatoprotective effects of turmeric are largely mediated through its antioxidant capacity, which enhances cellular defense against oxidative stress and suppresses the production of pro-inflammatory cytokines. Furthermore, turmeric extracts have been shown to markedly reduce fungal aflatoxin synthesis and to reverse pathological hepatic changes such as biliary hyperplasia, fatty degeneration, and necrosis. Oral supplementation of curcumin has been investigated in experimental and clinical contexts for its potential benefits in metabolic disorders, malignancies, gastrointestinal diseases, and neurological conditions. Additionally, topical application of curcumin has been reported to alleviate inflammation and irritation associated with allergic and inflammatory skin disorders. Notably, curcumin exhibits anticancer potential by interfering with multiple stages of carcinogenesis, including tumor initiation, angiogenesis, and progression. This

review highlights the medicinal and pharmacological significance of turmeric in the prevention and management of diverse disease conditions.

Keywords: *Curcuma longa*, anti-inflammatory, pharmacology, turmeric

INTRODUCTION

Medicinal plants continue to serve as an important source of therapeutic agents, particularly in regions where traditional medicine plays a major role in primary healthcare. *Curcuma longa* is a perennial herb and member of the Zingiberaceae (ginger) family and is cultivated extensively in Asia mostly in India and China. India is the largest producer and consumer of turmeric, where it is traditionally employed for the management of inflammatory disorders, metabolic diseases, infections, and hepatic ailments (Sivakumar *et al.*, 2022). Turmeric powder and calcium hydroxide are well-known home remedies for treating sprains and swelling brought on by wounds, or they might be applied directly to the injury site. Dried curcumin powder has long been used to treat ailments in traditional medicine (Labban, 2014, Gupta *et al.*, 2013). According to reports, *Curcuma longa* has antioxidant, antitoxin, anticancer, antibacterial, and anti-inflammatory properties. *Curcuma longa* can be cultivated in a variety of environmental conditions with temperatures between 20 and 35 °C and 1500 mm of annual rainfall. It thrives magnificently in well-drained sandy or clay loam soils with a pH of 4.5 to 7.5 and good organic status (Anand *et al.*, 2007). Oral administration is the main route of administration for *Curcuma longa*, it can also be used topically and via inhalation or can be applied topically on skin for the treatment of acne, wounds, boils, bruises, blistering, ulcers, eczema, insect bites, parasitic infections, haemorrhages and skin diseases like herpes zoster and pemphigus (WHO, 1999).

Phytochemistry of *Curcuma longa*

The rhizome of *Curcuma longa* is rich in bioactive compounds, primarily curcuminoids and volatile oils. Curcuminoids include curcumin, demethoxycurcumin, and bisdemethoxycurcumin, which are responsible for the characteristic yellow pigmentation and major biological activities (Labban, 2014). The essential oil fraction contains ar-turmerone, α-turmerone, β-turmerone, zingiberene, and atlantone. Additional constituents such as sugars, proteins, resins, and minerals also contribute to the pharmacological profile.

Nutritional value of *Curcuma longa*

Turmeric possesses rhizomes and underground root-like stems that had been originally used as a food additive in curries to improve the storage condition, appearance, flavour, palatability, and preservation of food used medicinally as human remedies and non-medicinally as spice or feed additives (Sharma *et al.*, 2005). Turmeric contains 6.3% protein, 5.1% fat, 3.5% minerals, 69.4% carbohydrates and 13.1% moisture. The active ingredients of turmeric rhizomes consist of volatiles and non-volatiles constituents. The major active substances in non-volatile are the colouring agent and are a rich source of phenolic compounds (Sivakumar *et al.*, 2022).

Pharmacological Activities

Anti-inflammatory and Immunomodulatory Activity

Curcumin exhibits potent anti-inflammatory activity by modulating multiple molecular targets involved in inflammation. It suppresses the activation of nuclear factor-kappa B (NF-κB), activator protein-1, and signal transducer and activator of transcription pathways (Tilak *et al.*, 2004). Curcumin downregulates cyclooxygenase-2, lipoxygenase, inducible nitric oxide synthase, and pro-inflammatory cytokines such as tumor necrosis factor-α, interleukin-1β, and interleukin-6 (Labban, 2014). These mechanisms have been demonstrated in experimental models of arthritis, colitis, and inflammatory pain. Clinical studies also suggest symptomatic improvement in inflammatory conditions, although results vary due to formulation differences (Iweala *et al.*, 2013).

Antimicrobial Activity

Extracts and isolated compounds of *Curcuma longa* demonstrate broad-spectrum antimicrobial activity. Curcumin has shown inhibitory effects against Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella species* (Labban, 2014). Antifungal activity against Candida and Aspergillus species has also been reported. The antimicrobial action is attributed to disruption of microbial cell membranes, inhibition of quorum sensing, and interference with essential enzymatic pathways. These properties suggest potential application of turmeric as a natural antimicrobial or adjunct to conventional antibiotics (Iweala *et al.*, 2013).

Antidiabetic and Metabolic Effects

Curcumin exerts antidiabetic effects through multiple mechanisms, including improvement of insulin sensitivity, enhancement of pancreatic β-cell function, and modulation of carbohydrate-metabolizing enzymes. Experimental studies demonstrate activation of AMP-activated protein kinase and reduction of oxidative stress in diabetic models (Sivakumar *et al.*, 2022; Joe *et al.,* 2004). Curcumin has also been shown to inhibit α-amylase and α-glucosidase enzymes, contributing to postprandial glucose regulation. Limited clinical evidence suggests beneficial effects on glycemic control and lipid profiles (Labban, 2014).

Anticancer and Antiproliferative Activity

Extensive research indicates that curcumin possesses anticancer properties against a wide range of cancer types. It modulates multiple signaling pathways involved in cell proliferation, apoptosis, angiogenesis, and metastasis (Labban, 2014). Curcumin induces apoptosis through mitochondrial pathways, suppresses tumor growth by inhibiting NF-κB and COX-2 signaling, and reduces matrix metalloproteinase activity. Synergistic effects with conventional chemotherapeutic agents have been observed in preclinical studies. However, clinical translation is limited by poor systemic bioavailability (Aggarwal & Harikumar, 2009).

Safety and Toxicity

Curcuma longa and curcumin are generally recognized as safe. Animal studies and human trials report high tolerability even at relatively high doses. Adverse effects are usually mild and include gastrointestinal disturbances (Labban, 2014).

CONCLUSION

Curcuma longa L. represents a medicinal plant with substantial pharmacological potential supported by traditional knowledge and modern scientific research. While experimental evidence strongly supports its anti-inflammatory, antimicrobial, antidiabetic, and anticancer activities, further well-designed clinical studies are essential to establish standardized therapeutic applications. Advances in formulation strategies may enhance its clinical utility in the future.

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