

# Applications of Curcumin in Various Microbial Infections

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## Abstract

Curcumin is a chemical produced from turmeric; a plant known for its medicinal use. It is an effective agent for the treatment of several skin conditions. It has been exposed to a variety of antimicrobial investigations due to no side effects and extensive traditional uses. It exhibits many pharmacological activities such as anti-bacterial, anti-inflammatory, anti-cancer, anti-Alzheimer, anti-fungal, anti-viral, antioxidant, and anti-ulcer activity. The likely-looking results for antimicrobial activity of curcumin made it a promising candidate to increase the inhibitory effect of existing antimicrobial agents through synergism. This review goal is to summarize previous studies of curcumin towards its application in future studies as a natural antimicrobial agent.

**Keywords:** curcumin; antibacterial activity; antifungal activity; antiviral activity

## Introduction

Curcumin is one of the potent, non-irritating, non-allergenic, and major bioactive component present in turmeric. It is a member of the ginger family, Zingiberaceae. It is also called diferuloylmethane, a bright yellow chemical which is a main natural polyphenol found in the rhizome of *Curcuma longa* (turmeric). The major issues of curcumin are: it has low absorption and poor bioavailability. [1] *Curcuma longa* rhizome has been used as an insect repellent and antimicrobial agent. The antimicrobial agent is suitable for textile materials. To develop antimicrobial skin gels and emulsions with improved skin protection and wound dressing properties, a mixture of curcumin with other microbial agents is used. [2]

IUPAC name: (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione)

Formula: C<sub>21</sub>H<sub>20</sub>O<sub>6</sub>

Molar mass: 368.38 g/mol

Appearance: Bright yellow-orange powder

Melting point: 183 °C

Boiling point: 591.4 °C

Solubility: Insoluble in water and ether, but soluble in ethanol, dimethyl sulfoxide, and acetone.

## 2) Antibacterial Activity

It has been proved that curcumin owns the activity against *Helicobacter pylori*. The two inflammatory molecules, that are present in *H. pylori* are metalloproteinase 9 (MMP9) and Matrix metalloproteinase 3 (MMP3).

Curcumin controls the expression of both the MMP3 and MMP9, making it effective against *H. pylori*. [3]

Curcumin is also studied to be a potential chemopreventive candidate against *H. pylori*-related gastric carcinogenesis. Curcumin also suppresses *V. vulnificus* infection. It defends host cells from *V. vulnificus* cytotoxicity and infection. Curcumin will suppress both cell death and induction of the pro-inflammatory response caused by bacterial infection. Curcumin exhibit various activities on both eukaryotic cells and *V. vulnificus*. Curcumin partially suppresses *V. vulnificus* growth, which probably results in defects seen in adhesion, cytotoxicity, motility, and other virulence-related factors of the pathogen. [4]

Nanoparticles and microemulsion which are prepared with curcumin are known for their antimicrobial activity. Curcumin-loaded myristic acid microemulsion which is a formulated curcumin microemulsion is used to suppress *Staphylococcus epidermidis*, that is mainly responsible for health-care associated infections. [6] It was also demonstrated that curcumin nanoparticles inhibit the growth of *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis* due to its antibacterial activity and it also inhibits *Penicillium notatum* and *Aspergillus niger* due to its antifungal activity. [5]

Curcumin microcapsule with more solubility is suitable as a preservative and colorant in the food industry and it shows potent antimicrobial effect against food-borne pathogens including *E. coli*, *Staph. aureus*, *B. subtilis*, *B. cereus*, *Penicillium notatum*, *Yersinia enterocolitica*, and

*Saccharomyces cerevisiae* with MIC values ranging from 15.7 to 250  $\mu\text{g/mL}$ . [9]

Tabular form of Some studies on antibacterial activity of curcumin on different strains of bacteria

Bacteria	Study aim	Antiviral substances	Anti-bacterial activity
<i>Streptococcus mutants</i>	Evaluation of the preventive effect of curcumin on adherence of <i>S. mutants</i> to extracellular matrices and tooth surfaces	Curcumin	Suppressed <i>S. mutants</i> adherence to surfaces of the human tooth such as proteins of ECM
MRSA	Study of a synergistic effect of the curcumin and antibiotics and the anti-bacterial action of curcumin against specific MRSA strains	Curcumin	Curcumin decreased the MICs of several antibiotics tested, notably ciprofloxacin, ampicillin, oxacillin, and norfloxacin against MRSA.
<i>Acinetobacter baumannii</i>	Evaluation of synergistic effects with EGCG against multidrug-resistant strains of <i>A. baumannii</i> .	Curcumin	Curcumin activity is significantly improved in the attendance of EGCG resulting in anti-bacterial action against multidrug-resistant <i>A. baumannii</i> .
<i>Escherichia coli</i>	Study the novel anti-bacterial mechanism of curcumin that displays an apoptosis response in <i>E. coli</i>	Curcumin	Curcumin stimulates apoptosis response in <i>E. coli</i> that includes RecA.
<i>Escherichia coli</i> , <i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> , <i>Enterococcus faecalis</i>	Membrane permeabilization of curcumin against the ordinary opportunistic pathogens	Curcumin	The bacterial cell membrane was damaged when exposed to curcumin. It had a high level of antibacterial potential against all examined bacteria from Gram-positive to Gram-negative groups.

### 3) Antiviral Activity

Curcumin treats against *Hepatitis C virus* (HCV) due to its antiviral activity. Researchers illustrated that curcumin is used for the treatment of hepatitis virus, herpes simplex virus type-1 (HSV-1). [8]

Previous researches concluded that curcumin interacts directly with almost 30 proteins, such as DNA polymerase, protein kinase (PK), lipoxygenase (LOX), thioredoxin reductase, focal adhesion kinase

(FAK), and tubulin. Moreover, in addition to modulating cellular events, curcumin limits viral infection by interfering with critical steps in their replication cycle, including but not limited to, viral attachment, and genome replication.

In nanotechnology, Nanoemulsion which is prepared by curcumin will improve the bioavailability and physiochemical properties of curcumin, and it is used as an anti-dengue drug for commercial purposes. [9]

Tabular form of Some studies on antiviral activity of curcumin

Virus	Antiviral substances	Antiviral activity
HIV	Curcumin	Inhibits Tat-mediated transactivation of HIV-1 LTR, Inhibits HIV-1 and HIV-2 proteases, Inhibition of HIV-1 Integrase
HSV-1	Curcumin	Reduction of HSV-1 replication
HSV-2	Curcumin	Significant protection in a mouse model
Influenza	Curcumin	Inhibition of haemagglutination
Coxsackievirus	Curcumin	Replication inhibition through UPS dysregulation
HPV	Curcumin	Inhibition expression of viral oncoproteins E6 & E7
HCV	Curcumin	Decrease of HCV replication by suppressing the Akt-SREBP-1 pathway

### 4. Antifungal Activity

Curcumin shows its antifungal activity against all tested *Candida* strains, with minimum inhibitory concentrations (MICs) varying from 250 to 2000  $\text{mg}\cdot\text{mL}^{-1}$ . Curcumin is well known to inhibit several eukaryotic P-type ATPases. PM-ATPase of *Candida*, which belongs to the family of P-type ATPases, is shown to be affected by curcumin. [10]

The methanol extract of turmeric demonstrated antifungal activity against *Cryptococcus neoformans* and *Candida albicans* with MIC values of 128 and 256  $\mu\text{g/mL}$ , respectively.

Curcumin at 500  $\text{mg/L}$  shows antifungal activity against *Rhizoctonia solani*, *Puccinia recondita*, and *Phytophthora infestans* [11].

Tabular form of Some studies on antifungal activity of curcumin

Fungi	Antifungal substances	Antifungal activity
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<i>Cryptococcus spp.</i>	Curcumin	Inhibits the growth
<i>Candida spp.</i>	Curcumin	Growth inhibition, Gene expression inhibition, Adhesion inhibition
<i>Aspergillus spp.</i>	Curcumin	Inhibits growth, Aflatoxin production inhibition.

## 5. Curcumin Applications in Skin Related Issues

- By quenching free radicals and slowly reducing inflammation through nuclear factor-kB inhibition, curcumin protects the skin.
- Curcumin treatment also reduces wound healing time, improved collagen deposition, and increased fibroblast and vascular density in wounds thereby improving both normal and impaired wounds.
- Turmeric is an anti-inflammatory agent. Its anti-inflammatory properties help to reduce redness from blemishes and calm rosacea and the antibacterial properties disinfect the skin and combat acne.
- It helps to prevent and improve wrinkles and dry skin because curcumin contains anti-aging properties.
- It also prevents the skin diseases like psoriasis, Atopic dermatitis, skin cancer, skin infections, skin disorders, etc. [12]

### Conclusion

Curcumin is popular due to its less toxic effect and has no side effects. It plays an important role in preventing microbial diseases. so, it is used as an antibacterial agent, antiviral agent, and antifungal agent. It also reduces wound healing time for skin-related issues.

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