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*RESEARCH ARTICLE*

# MEDICINAL PROPERTIES OF GINGER WITH SPECIAL FOCUS ON ANTIMICROBIAL EFFECT: A SYSTEMATIC REVIEW

**Vismit Mungi[1], Abhishek Mehta[2] and Shriya Mungi[3]**

1. Senior Resident, Dept. of Microbiology, Govt. Medical College, Datia (M.P.)-India.
2. Associate Professor, Dept. of Microbiology, Govt. Medical College, Datia (M.P.)-India.
3. Post Graduate Student, Dept. of Pathology, Govt. Medical College, Datia (M.P.)-India.

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## Abstract

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Ginger belongs to the genus Zingiber, which contains over 1,300 species. Zingiber officinale is the most commercially cultivated species, and it is widely recognized for its distinct medicinal properties. Ginger exhibits a broad antimicrobial spectrum, targeting bacteria, fungi, viruses, and Gram-negative bacteria through various mechanisms. Bioactive compounds of Ginger, 6-gingerol and 6-shogaol destabilize bacterial cell membranes, causing leakage of cellular contents. Ginger's essential oil contains a variety of sesquiterpenes, including zingiberene, β-bisabolene, and α-curcumene. These oils are largely responsible for ginger's characteristic aroma and play a role in its antimicrobial effects. Bacteria use quorum sensing to regulate virulence and biofilm formation. Ginger's active compounds have been found to inhibit quorum sensing, which reduces bacterial pathogenicity. Apart from antimicrobial effect Ginger and its derivatives are also found to exhibit anti-cancer, anti-inflammatory, anti-allergic, analgesic, and anti-oxidant properties. The irrational and excessive use of antibiotics has resulted in the rapid emergence of multi-drug resistant pathogens and herbal antimicrobials can prove to be an effective alternative approach to tackle this problem. With this background, a systematic review was conducted to explore this aspect of Ginger wherein 14 research publications were selected out of 200 articles searched through databases like Pubmed, Scopus, Web of Science, Embase, and through snowballing. The study highlighted the antimicrobial properties of Ginger and paved the way for further exploratory research focused on the clinical application of bioactive compounds derived from the herb.



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## Introduction:-

**Ginger, a member of the genus Zingiber,** scientifically classified under the Kingdom Plantae, belongs to the clade Angiosperms, order Zingiberales, and family Zingiberaceae. Its genus, **Zingiber**, includes the species **Zingiber officinale**. The family Zingiberaceae comprises approximately 50 genera and 1,600 species, including other notable medicinal plants such as turmeric (**Curcuma longa**) and cardamom (**Elettaria cardamomum**). Molecular

**Corresponding Author:- Abhishek Mehta**
Address**:-** MD Microbiology, Associate Professor, Dept. of Microbiology, Govt. Medical College, Datia (M.P.)-India.

phylogenetic studies highlight the significant evolutionary divergence of ginger species from other members of the Zingiberaceae family, underscoring their unique genetic and biological characteristics. It comprises over 1,300 species, with Zingiber officinale being the most commercially cultivated and medicinally used. Traditionally utilized in Southeast Asia for its culinary and medicinal properties, ginger has gained global recognition for its therapeutic benefits. Among its diverse bioactive compounds, 6-gingerol and 6-shogaol stand out for their potent pharmacological effects. Ginger has been employed in traditional medicine for centuries to treat gastrointestinal ailments, inflammation, and respiratory infections. In the modern era, the emergence of multidrug-resistant pathogens has posed a significant challenge to global health. The overuse and misuse of antibiotics have accelerated this crisis, necessitating the exploration of alternative therapeutic agents. Herbal remedies like ginger offer a promising solution, combining natural efficacy with a lower risk of resistance development. Research has demonstrated that ginger exhibits broad-spectrum antimicrobial activity, targeting bacteria, fungi, and viruses through multiple mechanisms, including membrane disruption and quorum sensing inhibition. Additionally, its potential to enhance the efficacy of existing antibiotics underscores its role as a complementary therapy. Ginger, scientifically classified under the Kingdom Plantae, belongs to the clade Angiosperms, order Zingiberales, and family Zingiberaceae. Its genus, **Zingiber**, includes the species **Zingiber officinale**. The family Zingiberaceae comprises approximately 50 genera and 1,600 species, including other notable medicinal plants such as turmeric (**Curcuma longa**) and cardamom (**Elettaria cardamomum**). Molecular phylogenetic studies highlight the significant evolutionary divergence of ginger species from other members of the Zingiberaceae family, underscoring their unique genetic and biological characteristics.[1]

This systematic review investigates the antimicrobial properties of ginger, emphasizing its potential as a natural and effective alternative to conventional antibiotics. By synthesizing findings from various studies, this review aims to provide a comprehensive and concise resource for understanding ginger's therapeutic potential in combating infections and addressing antibiotic resistance. Likewise other species like Zingiber montanum**,** Zingiber zerumbet **(**Shampoo Ginger**)**, Zingiber mioga**,** Zingiber cassumunar are known for their high content of zerumbone, rhizomes, cassumunin A and B respectively, are widely proven to be effective in preventing cancer, inflammation, allergies, infections and a beneficial effect in cosmetic health by usage of its plant sap. **[2]**

## Methods:-

### Search Strategy

A systematic literature search was conducted in PubMed, Scopus, Web of Science, and Embase databases from inception to December 2024, wherein 14 research publications were selected out of 200 articles searched through databases, and through snowballing.

The search strategy utilized combinations of keywords such as "ginger," "Zingiber officinale," "antimicrobial," "bioactive compounds," "antibiotic resistance," and "natural remedies." Boolean operators (AND, OR) and database-specific filters were applied to refine the results. Manual searches were also performed on reference lists of relevant articles to identify additional studies. A total of 200 articles were identified through database searches. After removing 50 duplicate records, 150 articles remained for screening based on their titles, abstracts, and keywords. Following this evaluation, 14 full-text research articles were selected for review, all of which were included in the systematic review.

### Inclusion criteria:

The selection criteria included peer-reviewed articles that reported on the antimicrobial activity of ginger or its compounds. Only studies published in English were considered. Additionally, research focusing on the mechanisms of action or the synergy of ginger with antibiotics was included.

### Exclusion criteria:

The exclusion criteria encompassed studies that lacked a clear focus on antimicrobial properties, non-English articles, and those without full-text availability. Additionally, reviews or commentaries that did not present primary data were excluded.

### Study Selection

The study selection process adhered to the PRISMA 2020 guidelines. Initially, titles and abstracts were screened for relevance by two independent reviewers. Full-text articles of potentially eligible studies were then assessed against the inclusion and exclusion criteria. Discrepancies were resolved through consensus or consultation with a third reviewer. The final selection was documented in a PRISMA flow diagram.

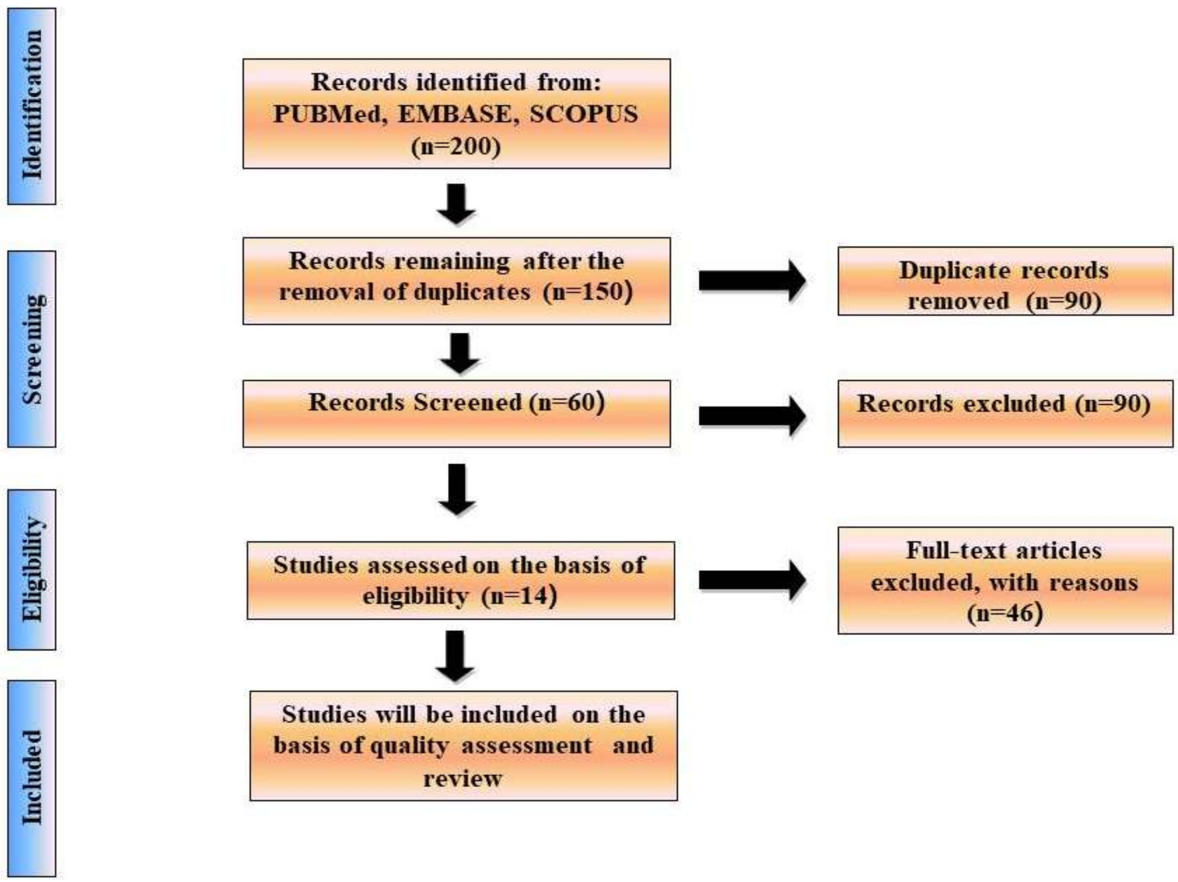


**Figure 1:-** Flow chart of study selection ("n" is the number of papers).

**Data Extraction**

A standardized data extraction form was used to collect key information from each study, including the study design (in vitro, in vivo, or clinical trials), characteristics of the tested microorganisms (bacterial, fungal, or viral), and the methods used to assess antimicrobial activity, such as disk diffusion and broth dilution. Additionally, main outcomes, including inhibition zones, minimum inhibitory concentrations, and synergistic effects, were recorded, along with key findings and conclusions.

## Results:-

After the analysis of these 14 studies (2005–2023), the antimicrobial properties of Zingiber officinale, including its antibacterial, antifungal, antiviral, antioxidant, and anti-inflammatory effects were investigated. The findings indicate that ginger exhibits strong antibacterial activity against both Gram-positive and Gram-negative bacteria. Bellik [7] demonstrated the inhibitory effects of ginger essential oils and oleoresins against Staphylococcus aureus and Bacillus subtilis, whereas Jalal & Narollah [8] confirmed its efficacy against Escherichia coli and Pseudomonas aeruginosa. Aaisha et al. [15] expanded on these findings, showing that essential oils derived from different ginger cultivars had potent antibacterial activity, with molecular docking studies confirming strong bacterial protein binding. Similarly, Elmovalid et al. [14] highlighted the effectiveness of ginger in reducing multidrug-resistant E. coli O78:K80 loads in poultry models when combined with garlic extracts. Furthermore, Harun NH et al. [16] concluded in a systematic review and meta-analysis that methanol and ethanol extracts of ginger enhance bacterial inhibition in animal models, indicating its broad-spectrum antibacterial potential.

Beyond its antibacterial effects, ginger also demonstrates antifungal properties. Bellik [7] found that ginger oleoresins were more effective than essential oils in inhibiting fungal growth, while Silvia et al. [13] confirmed that ginger extracts successfully suppressed foodborne fungal pathogens, reinforcing its utility in food preservation. Regarding antiviral activity, Harun NH et al. [16] systematically reviewed the antiviral properties of ginger and found that it inhibits viral replication by disrupting viral protein synthesis. These findings align with Nile & Park

[10], who demonstrated that ginger compounds interfere with viral replication pathways, particularly in respiratory infections such as influenza.

In addition to its antimicrobial effects, ginger is known for its anti-inflammatory and antioxidant properties. Grzanna et al. [3] and Dugasani et al. [5] reported that ginger significantly reduces pro-inflammatory cytokine production, an important factor in immune response modulation. Mashhadi et al. [6] and Ezzat et al. [12] further confirmed that ginger inhibits macrophage and neutrophil activation, thereby reducing oxidative stress and inflammation. These properties contribute to ginger's potential role in both clinical and food-related applications. Silvia et al. [13] emphasized its role in preventing microbial contamination in food products, while Semwal et al. [11] provided insight into its bioactive compounds, reinforcing its potential as a natural antimicrobial agent in both the food and pharmaceutical industries. Table 1 summarizes the findings of the included studies on enhancing immunity of the host and in-vivo and in-vitro inhibitory effects of ginger on pathogens.

**Table 1:-** Summary of Reviewed Studies on the Antimicrobial Properties of Ginger.

| S.No. | Author(s) | Year | Study Title | Study Design & Methodology | Key Findings & Conclusion | Quality Assessment |
|---|---|---|---|---|---|---|
| 1. | Grzanna et al. [3] | 2005 | Anti-inflammatory properties of ginger | In-vitro assays on human cells to evaluate cytokine production | Ginger significantly reduced pro-inflammatory cytokines | Moderate (in vitro study, lacks in vivo validation) |
| 2. | Ali & Gilani [4] | 2007 | Ginger's nutritional and medicinal properties | In-vivo and in-vitro tests on fresh/dried ginger | Significant antimicrobial and antioxidant properties observed in both forms | High (well-designed study) |
| 3. | Dugasani et al. [5] | 2010 | Comparative antioxidant, anti-inflammatory effects of ginger | DPPH assay, inflammation models in rats | Strong antioxidant effects; comparable efficacy to standard drugs | High (animal study) |
| 4. | Mashhadi et al. [6] | 2013 | Antioxidant and hepatoprotective effects of ginger | Hepatotoxicity model in rats | Reduced liver enzyme levels and oxidative stress | High (controlled animal study) |
| 5. | Bellik et al. [7] | 2014 | Total antioxidant activity and anti-microbial potency of ginger essential oil and oleoresin | Disc diffusion method, MIC determination | Ginger showed strong antibacterial and antifungal activity, with oleoresin being more effective than essential oil | High (comprehensive antimicrobial analysis) |
| 6. | Jalal & Narollah [8] | 2014 | Antibacterial properties of ginger | Disk Diffusion method on bacterial strains | Strong inhibition against gram-negative bacteria | Moderate (in vitro study) |
| 7. | Rahmani et al. [9] | 2014 | Therapeutic effects of ginger on cardiovascular dis. | Animal model testing | Lowered blood pressure and cholesterol levels | High (animal study) |
| 8. | Nile & Park [10] | 2015 | Chromatographic analysis and bioactivity of ginger extracts | In-vitro antioxidant and anti-inflammatory assays | Ethyl acetate extract exhibited the highest antioxidant and anti-inflammatory activity | High (comprehensive bioactivity study) |
| 9. | Semwal et al. [11] | 2015 | Gingerols and shogaols: Important nutraceutical principles | Literature review on bioactive compounds | Antimicrobial, antioxidant, and anti-inflammatory properties of gingerols and shogaols | High (extensive literature synthesis) |
| 10. | Ezzat et al. [12] | 2018 | The hidden mechanism beyond | In-vivo and in-vitro assays using | Ginger inhibits macrophage and | High (animal and in-vitro study) |

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| | | | ginger's anti-inflammatory activity | rat paw edema model and cytokine analysis | neutrophil activation, reducing pro-inflammatory cytokines | |
| 11. | Silvia et al. [13] | 2019 | Antimicrobial activity of ginger and its application in food products | Review of antimicrobial studies | Highlights ginger's role as a food preservative and its bioactive compounds against foodborne pathogens | High (systematic review) |
| 12. | Elmovalid et al. [14] | 2019 | Antimicrobial effects of extracts ginger and garlic | Study on action of the extracts of ginger and garlic against MDR E. coli O78:K80 | Increased PMNs in the experimented chicks which received ginger and garlic extracts | High (in-vivo animal study) |
| 13. | Aaisha et al. [15] | 2020 | Essential oil from Saudi and Chinese ginger cultivars: Antibacterial and molecular docking studies | GC-MS analysis, well diffusion assay, molecular docking | Essential oil exhibited higher antibacterial activity against Gram-positive bacteria; molecular docking confirmed strong bacterial protein binding | High (analytical & computational study) |
| 14. | Harun et al. [16] | 2023 | Antimicrobial effects of ginger | Systematic review and meta-analysis on antimicrobial effect of ginger | Methanol and ethanol extracts proved to be essential in enhancing the inhibitory effects against microorganismms in animal models | High (systemetic review and meta-analysis) |

## Discussion:-

The reviewed studies strongly support the broad-spectrum antimicrobial, antifungal, and antiviral properties of ginger, with significant implications for medical, food preservation, and veterinary applications. Several studies, including Bellik [7] and Aaisha et al. [15], confirmed ginger's potent antibacterial activity, particularly in essential oils. However, Harun NH et al. [16] emphasized that methanol and ethanol extracts exhibited stronger inhibitory effects than aqueous extracts, highlighting the crucial role of solvent choice in optimizing ginger's antimicrobial potential. Additionally, while Jalal & Nasrollah [8] found ginger to be effective against Gram-negative bacteria, Elmovalid et al. [14] demonstrated that combining ginger with garlic extract significantly reduced bacterial loads in poultry, suggesting a synergistic effect that could be explored in future antimicrobial treatments. The ability of ginger to inhibit both Gram-positive and Gram-negative bacteria suggests that its active compounds target multiple bacterial structures and functions, which could reduce the likelihood of resistance development. Comparisons with conventional antibiotics indicate that while ginger may not replace existing antibacterial agents, it can serve as a complementary therapy, particularly against drug-resistanat pathogens.

Regarding its antifungal potential, Bellik [7] and Silvia et al. [13] confirmed that ginger's bioactive compounds exhibit strong antifungal effects, with oleoresins proving more effective than essential oils. The mechanism behind this antifungal activity appears to involve the disruption of fungal cell wall integrity and inhibition of biofilm formation, which is crucial in preventing fungal resistance. However, variations in efficacy depending on fungal strain and extract concentration suggest that further research is needed to optimize dosage and extraction methods. The ability of ginger to prevent fungal biofilm formation is particularly promising, as biofilms contribute significantly to chronic infections and resistance to antifungal drugs. This raises the possibility of using ginger extracts in combination with existing antifungal treatments to enhance their effectiveness and reduce resistance.

Similarly, antiviral studies, such as those by Harun NH et al. [16] and Nile & Park [10], highlight ginger's ability to inhibit viral replication, reinforcing its potential for treating respiratory infections. The inhibition of viral protein synthesis and replication suggests that ginger may serve as a natural antiviral agent, particularly against influenza and respiratory syncytial viruses. The immunomodulatory effects of ginger, including its ability to reduce inflammation and oxidative stress, may further enhance its antiviral properties by strengthening the host immune response. However, despite promising in vitro and in vivo findings, additional clinical trials are necessary to validate ginger's antiviral applications in humans. More research is needed to determine optimal dosages, delivery methods, and long-term safety in treating viral infections.

The antimicrobial effects of ginger can be attributed to key bioactive compounds such as gingerol, shogaol, and zingerone, which exert their effects through multiple mechanisms. These include disrupting microbial cell membranes, leading to leakage of cellular contents; inhibiting protein synthesis, which prevents bacterial and viral replication; and suppressing biofilm formation, reducing microbial resistance. The diverse mechanisms of action suggest that ginger may be useful in combination therapies with existing antimicrobial agents. By targeting multiple microbial pathways simultaneously, ginger could help prevent the development of resistance and enhance the efficacy of conventional drugs. This is particularly relevant given the growing concerns about antibiotic resistance and the urgent need for new antimicrobial strategies. [17,18]

Despite its promising potential, some limitations exist in current research. Variability in extraction techniques, concentrations used, and microbial strains tested create inconsistencies in results. Standardizing extraction protocols and conducting large-scale clinical trials are essential next steps in advancing ginger's application in medicine and food preservation. Additionally, exploring the synergistic effects of ginger with conventional antibiotics could provide new insights into novel combination therapies for drug-resistant infections. Understanding how different extraction methods influence the bioavailability and efficacy of ginger's active compounds will be crucial in maximizing its therapeutic potential. Moreover, future research should focus on developing standardized formulations of ginger extracts that can be used in clinical settings. Encapsulation techniques, such as nanoparticle-based delivery systems, may improve the stability and bioavailability of ginger compounds, enhancing their antimicrobial efficacy. [19,20]

Overall, while the reviewed studies strongly support ginger's antimicrobial efficacy, further investigations are needed to fully understand its clinical applicability and long-term safety. The potential applications of ginger in human medicine, veterinary science, and the food industry make it a valuable candidate for further exploration. By bridging the gap between traditional medicine and modern scientific research, ginger could emerge as a powerful natural antimicrobial agent that complements existing therapeutic approaches while addressing the challenges of drug resistance and microbial contamination.

## Conclusion:-

This systematic review highlights ginger's significant antimicrobial, antifungal, and antiviral properties, supported by its antioxidant and anti-inflammatory effects. The findings suggest that ginger's bioactive compounds exhibit broad-spectrum activity against various pathogens through mechanisms such as membrane disruption, quorum sensing inhibition, and synergistic interactions with antibiotics. While in vitro and in vivo studies provide promising evidence, clinical validation remains essential. Future research should focus on standardizing extraction methods, optimizing dosages, and evaluating synergistic effects with conventional antimicrobials to establish ginger as a viable therapeutic and preservative agent in medicine and food industries.

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None declared.

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