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Review Article

Anti-inflammatory study of *Zingiber officinale* (Ginger): A Systematic Review

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ABSTRACT

Zingiber officinale Roscoe's ginger is a widely used and ubiquitous spice. Among its many chemical components are phenolic chemicals, terpenes, polysaccharides, lipids, organic acids, and unprocessed fibers. The health benefits of ginger are mainly attributed to phenolic components like gingerols and shogaols. It has been utilized for several biological purposes in Ayurvedic medicine from ancient times. The objective of this systematic review is to evaluate and compile the available data regarding *Zingiber officinale's* anti-inflammatory properties. The specific objectives are to identify the methods used to evaluate anti-inflammatory activity, to analyze the bioactive compound responsible for the observed effects, and to evaluate the overall anti-inflammatory potency demonstrated by *Zingiber officinale* across different studies. A thorough search of the literature was carried out using electronic databases, such as PubMed, Scopus, and Web of Science, using predefined search terms related to *Zingiber officinale* and anti-inflammatory activity. Studies meeting the inclusion criteria were selected based on predetermined eligibility criteria. Data extraction was performed to compile information on anti-inflammatory assays employed, bioactive compounds identified, and outcomes related to anti-inflammatory efficacy. A quality assessment was carried out on the included studies in order to examine the validity and dependability of the stated results. Preliminary findings from the selected studies indicate that *Zingiber officinale* exhibits significant anti-inflammatory activity. The comprehensive synthesis of evidence from this systematic review will enhance understanding of *Zingiber officinale* therapeutic potential, particularly in the context of anti-inflammatory mediated health benefits, and may guide future research and applications in health promotion and disease prevention.

Keywords: Anti-inflammatory study, Ginger, Gingerol, Phenolic components, Shogaols, *Zingiber officinale*.

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INTRODUCTION

Ginger is one of the most researched medicinal plants due to its long-known health benefits and high bioactive agent content. In the last few years, a number of studies have proven the pharmacological potential of ginger-derived phytochemicals. Among these, gingerols and shogaols have received the greatest scientific attention, as they account for most of the reported pharmacological effects. However, the cellular and molecular mechanisms behind their activities are not fully revealed yet. Experimental evidence suggests that shogaols exhibit stronger biological activity than gingerols, which may be attributed to their increased lipophilicity and superior bioavailability. It was shown that ginger phytochemicals might exert their anti-inflammatory effects by modulating the function of various immune cells such as macrophages, neutrophils, T cells and dendritic cells

Ginger is extensively used in South East Asia, China, and India as a spice and food preservative; it most likely originated in India.[1] The subterranean stems of *Zingiber officinale Rosc.*, a tropical herbaceous perennial of the *Zingiberaceae* family, are used to make ginger. It has been utilized for several biological purposes in Ayurvedic medicine from ancient times. Different ginger components have been utilized historically to treat a wide range of ailments in different parts of the world.[2] There has been a surge in interest in using natural items to treat a variety of illnesses in recent years. With a broad range of biological activities, ginger (*Zingiber officinale*) is a non-toxic, extremely promising natural antioxidant molecule (antimicrobial, anti-inflammatory, antioxidant, immunomodulatory, anticarcinogenic). Studies on safety evaluation show that *Zingiber officinale* is safe and well tolerated, even at very high doses. The primary goal of this review is to demonstrate how ginger and its bioactive components may be used to quickly and affordably treat diseases that are linked to inflammation, such as cancer, autoimmune diseases, heart disease,

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diabetes type 2, pulmonary diseases, arthritis, Alzheimer's, and neurological disorders.

Recently, researchers have also looked into how ginger can help cells die and stop them from growing. Ginger has been known for a long time to reduce inflammation and protect cells from damage. Now, scientists are starting to recognize that it can also help stop different types of cancer from growing. Through modulation of key molecular pathways, ginger shows promising pro-apoptotic and anti-proliferative effects.

Present studies have demonstrated that ginger-derived phytochemicals exert significant anti-inflammatory effects in both *in vitro* and *in vivo* models. These effects are mediated through the modulation of key immune cells, including macrophages, neutrophils, T lymphocytes, and dendritic cells, as well as through the regulation of inflammatory mediators and signaling pathways at the cellular and molecular levels.[3] Although several reviews have discussed the general biological, anticancer, neuroprotective, and anti-inflammatory properties of ginger, a comprehensive and up-to-date systematic evaluation of the immunomodulatory mechanisms underlying its anti-inflammatory actions remains limited.

Therefore, the present systematic review aims to critically synthesize current evidence on the anti-inflammatory effects of major ginger phytochemicals, with a particular focus on their cellular targets and molecular mechanisms.

Chemical composition and phytoconstituents

Many countries throughout the world, especially those in Asia, employ ginger (*Zingiber officinale*) and other members of the *Zingiberaceae* family as spices (as shown in Figure 1).[4] Ginger contains a lot of active components, including as phenolic and terpene chemicals. The main phenolic chemicals (as shown in Figure 2) included in ginger are gingerols, shogaols, and paradols. Gingerols, which comprise 6-gingerol, 8-gingerol, and 10-gingerol, are the primary polyphenols found in fresh ginger. If gingerols are heat-treated or kept for an extended length of time, they can be transformed into matching shogaols. Hydrogenation can convert shogaols into paradols.

Numerous other phenolic compounds, such as 6-dehydro-gingerdione, zingerone, quercetin, and gingerenone-A, are also present in ginger. Furthermore, some terpene components found in ginger are thought to constitute the primary ingredients of ginger essential oils, including as β-bisabolene, αcurcumene, zingiberene, α-farnesene, and βsesquiphellandrene. Apart from these, other components of ginger include lipids, polysaccharides, organic acids, and raw fibers. Chemical study has revealed that ginger contains approximately 400 distinct chemicals.

Ginger rhizomes are mostly composed of lipids (3-8%), phenolic chemicals, terpenes, and carbohydrates (50-70%).[5] The phenolic constituents of ginger include paradols, shogaol, and gingerol, while the terpene components include zingiberene, β-bisabolene, α-farnesene, β- sesquiphellandrene, and αcurcumene. These gingerols (23-25%) and shogaols (18-25%) are more common than other kinds. Apart from these, other components include protein, ash, amino acids, minerals, phytosterols, and vitamins (such as A and Nicotinic Acid).[6,7]

Examples of aromatic ingredients are bisabolene and zingiberene, whereas examples of pungent compounds are gingerols and shogaols. The ginger rhizome contains other (1-10%) chemicals linked to gingerol or shogaol, including diarylheptanoids 6-paradol,[8] 1- dehydrogingerdione, 6-gingerdiol, and 10-gingerdione, 4-gingerdiol, 6-gingerdiol, 8- gingerdiol, and 10-gingerdiol and so on. Ginger's unique flavor and smell are caused by a mixture of volatile oils, such as shogaols and gingerols.[9]

METHODOLOGY

Study Design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature Search

A comprehensive literature search was performed in electronic databases including PubMed, Scopus, Web of Science, Google Scholar and other resources. Studies published up to [month, year] were retrieved using combinations of keywords such as ginger, *Zingiber officinale*, gingerols, shogaols, anti-inflammatory and inflammation. A systematic review was conducted; research publications on *Zingiber officinale* were found there. The phrase "Anti- inflammatory activity of *Zingiber officinale*" will be used from 2000 until 2025. There were 373 items found by the engine. Research on several actions of *Zingiber officinale* including antibacterial, antioxidant, anti-inflammatory, antidiabetic, antifungal, anticancer, and wound healing, was included in these.

Selection of Studies

This review included original research studies that examined the anti-inflammatory effects of *Zingiber officinale* (ginger). Only studies in which the full text was available were considered. Both laboratory-based (*in vitro*) and animal-based (*in vivo*) experiments were included. Theses and original experimental studies were excluded if the complete text could not be accessed. To identify additional relevant studies, the reference lists of the selected articles were also manually searched. All published pharmacological studies on the anti-inflammatory activity of ginger that matched the search criteria were included in the final analysis.

Inclusion Criteria

Studies were included if they:

- Investigated ginger extracts or specific ginger compounds.
- Evaluated anti-inflammatory or immune-modulating effects.
- Used *in vitro*, *in vivo* or *ex vivo* experimental models.
- Were published in English.
- Were initially screened by reviewers based on the title and abstract, and,
- Were confirmed as eligible after full-text review.

Exclusion Criteria

Studies were excluded if they were review articles, editorials, conference abstracts, paid-access articles, or required special permission to obtain. Research articles that did not clearly state their objectives or had incomplete or insufficient data were also excluded.

Data Extraction and Analysis

Important information from each included study was collected using a standard data collection format. This included details about the study design, experimental model, ginger components studied, inflammatory markers measured, and key findings. Because the studies differed widely in their methods and outcome measures, the results were summarized qualitatively rather than combined using statistical analysis.

Study Identification

A total of 373 articles were identified through database searching. After removing 12 duplicate records, 361 unique articles remained for screening. During the initial screening of titles and abstracts, 348 articles were excluded for various reasons. These included:

- 100 review articles.
- 6 paid-access articles.
- 61 articles available only on request.
- 30 articles published in languages other than English.
- 87 articles related to Zingiber-like drugs other than *Zingiber officinale*.
- No articles published before the year 2000, and,
- 64 articles excluded for other reasons, such as unclear objectives or incomplete data.

After this screening process, 13 articles met all the eligibility criteria and were included in the study. All 13 eligible articles were included in the qualitative synthesis, focusing on the anti-inflammatory activity of *Zingiber officinale*.

This selection process followed the standard steps of identification, screening, eligibility, and inclusion, in accordance with PRISMA guidelines (Figure 3).

RESULTS

Table 1: The overview of articles selected in a systematic review.[10-21]

Sl. No.	Author name, Journal, and year of publication	Topic	Aim of the study	Conclusion
1.	Habib *et al.*, Journal of clinics 2008.[10]	Anti- cancer and anti inflammatory effects	Examine how ginger extract affects the expression of TNF- and NFB- in the liver of rats given liver cancer.	Ginger extract significantly reduced the elevated expression of TNF and NFKB in rats with liver cancer.
2	Dugasani SB *et al.*, Journal of Ethno pharmacology Year 2010.[11]	Anti-oxidant and anti-inflammatory effect	To examine and compare the anti-oxidant and anti-inflammatory activities of gingerols and their natural analogs to determine their structure-activity relationship and molecular mechanism.	6-shogaol has exhibited the most potent antioxidant and anti-inflammatory properties which can be attributed to the presence of alpha, beta unsaturated ketone moiety. The carbon chain length has also played a significant role in making 10-gingerol as the most potent among all the gingerols.
3.	Nefiseh Shori *et al.*, Int J Prev Med. 2013.[12]	Anti-oxidative and Anti- inflammatory effect	Examining the information currently available on ginger's antioxidant and anti-inflammatory qualities was the aim of the study.	Because of its anti- inflammatory properties, ginger helps reduce muscle discomfort.

Sl. No.	Author name, Journal, and year of publication	Topic	Aim of the study	Conclusion
4.	Subodh Kumar *et al*., IJHM 2013.[13]	Anti- inflammatory action	Zinger bioactive ingredients, characteristics, chemical makeup, mode of action, purpose, adverse reactions, present studies, and possible uses in contemporary Medicine.	Finds that the bioactive Ingredients in ginger have the potential to advance current medicine by treating anemia and other conditions in the near future.
5.	Shahira M Ezzat *et al*., Journal of Ethnopharmacology. 2018.[14]	Anti-inflammatory active	To investigate its mode of action and establish a relationship with its phytochemicals.	Ginger's anti- inflammatory properties are mediated through blocking the activation of neutrophils and macrophages, as well as by adversely influencing the migration of leukocytes and monocytes. The replenishment of the total antioxidant capacity and the dose- dependent reduction in pro-inflammatory cytokines and chemokines provided support for this.
6.	Iryna Kravchenko *et al*., JHP. 2019.[15]	Anti-inflammatory and analgesic activity	Analyze the Analgesic and anti-inflammatory effects of *Z. officinale* dense extract.	We can suggest that the phytoconstituents' binding to the ion channels TRPA1 and TRPV1 is one possible mechanism of action, as ginger extract has been examined in an AITC- induced model.
7.	Mehtap Ozkur *et al*., Oxidative Medicine and Cellular Longevity, 2022.[16]	Antioxidant, Anti-inflammatory, and Anti- cancer properties	To have exceptional antiviral action because of a high concentration of antiviral chemicals, as well as antioxidant, anti- inflammatory, anticancer, and antibacterial qualities.	The available research on ginger's possible anti-aging properties is reviewed in this study along with its active components.
8.	K. Pazmandi *et al*., Front. Immunol. 2024.[17]	Anti-inflammatory activity	Concentrated on the potential chemical mechanism that could be responsible for their anti-inflammatory properties.	Ginger may offer an alternate, or most likely a complementary, therapeutic strategy to the management of a range of autoimmune and inflammatory conditions.
9.	Jitendra Gupta *et al*., Pharmacological Research- Modern Chinese Medicine. 2025.[18]	Anti- inflammatory properties	A thorough examination of existing literature to gather information on the anti-inflammatory properties and clinical applications of ginger and also focused on studies reporting on the phytochemical composition of ginger, including its antioxidant compounds and active ingredients.	Ginger emerges as a valuable botanical remedy in TCM due to its diverse phytochemical profile and therapeutic properties. The antioxidant components and active ingredients present in ginger contribute to its anti-inflammatory effects and clinical applications in managing various health conditions.
10.	Edo, G.I., Igbuku, U.A., Makia, R.S. *et al*., Discover Food 2025.[19]	anti- inflammatory, anti-oxidation, antimicrobial, anti-cancer, gastroprotective effects associated with ginger.	Article also explores the applications of ginger in pharmaceuticals, nutraceuticals, and functional foods, highlighting its value in various industries.	Ginger is a versatile plant with a wide range of bioactive compounds and biological activities; it possesses antioxidant, antimicrobial, anti- inflammatory, and anticancer properties.

Sl. No.	Author name, Journal, and year of publication	Topic	Aim of the study	Conclusion
11.	Jacob Broeckel. *et al*., Nutrients 2025.[20]	To display anti-inflammatory properties and inhibit pain receptors.	The primary outcomes were subjective ratings of muscle pain, functional capacity questionnaires, and markers of inflammation.	Ginger supplementation appears to have some favorable effects on perceptions of pain, functional capacity, and inflammatory markers in men and women experiencing mild to moderate muscle and joint pain.
12.	Tiwari VK, *et al*., International Journal of Pharmaceutical Science and Medicine. 2025.[21]	Anti- inflammatory properties and various clinical applications.	To explore the phytochemical properties of ginger, focusing on its antioxidant components and active ingredients such as shogaols, gingerols, and zingerone.	Ginger supplements and extracts show the versatility of ginger in TCM. Overall, the comprehensive review of ginger's anti- inflammatory properties and clinical applications in TCM underscores its importance as a botanical remedy with promising therapeutic benefits.
13.	Anil Kumar, *et al*., DeepScience 2025.[22]	Anti- Inflammatory and Pro- Apoptotic Interventions	To explores the molecular mechanisms, pharmacokinetics, and therapeutic implications of ginger in cancer prevention and treatment.	Through anti- inflammatory, pro-apoptotic, and anti- proliferative mechanisms, modulate key oncogenic pathways, including NF-kB, COX-2, PI3K/AKT, MAPK. These mechanisms contribute to tumor suppression, immune modulation, and the inhibition of angiogenesis and metastasis.

Figure 1: Image of Ginger (*Zingiber officinale* Rosc.)

DISCUSSION

The objective of the systematic review was to assess *Zingiber officinale's* anti-inflammatory properties, consolidating evidence from various studies that investigated its bioactive compounds and their mechanisms. Using the PRISMA guidelines, we identified 373 articles, ultimately including 13 studies that met the stringent inclusion criteria (Table 1).

In most diseases, including cancer, pulmonary, cardiovascular, diabetes type 2, autoimmune, arthritis, Alzheimer's, neurological, and autoimmune diseases, NF-κB activation is a significant mediator of inflammation. Inhibiting NF-κB activation can reduce inflammation. NF-κB, COX2, 5-LOX, and iNOS overexpression causes inflammation and diseases linked to inflammation. Ginger lowers the production of COX2, 5-LOX, and iNOS due to its strong NF- κB inhibitory activity, most likely by downregulating NF-κB activation. By inhibiting the activation of NF-κB through the inhibition of pro-inflammatory cytokine TNF-α, ginger may have anti-inflammatory properties. The bioactive compounds-such as gingerols, shogaols, and zingerone-not only protect cells from oxidative damage but also actively interfere with cancer progression. By modulating critical molecular pathways like NF-κB, COX-2, PI3K/AKT, and MAPK,

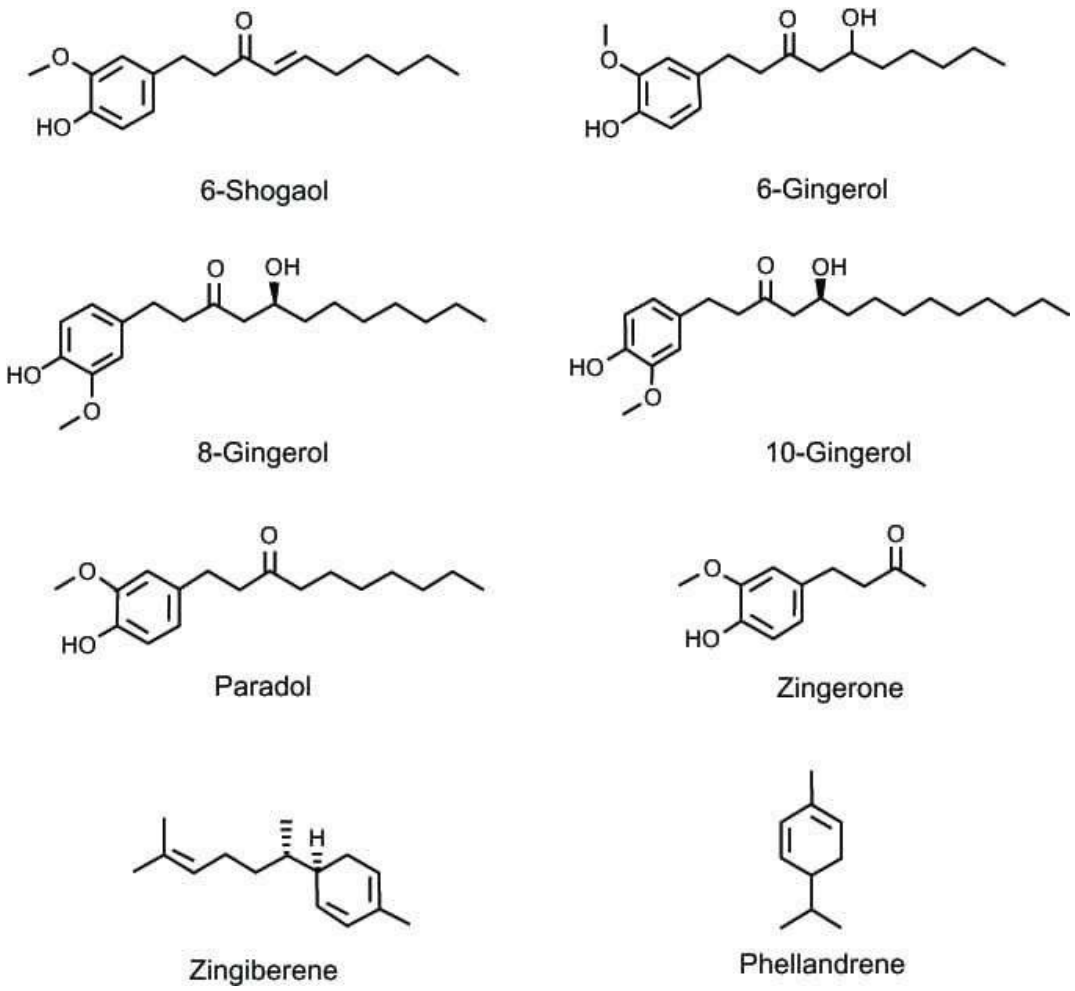

Figure 2: Chemical structures of bioactive constituents of Ginger.

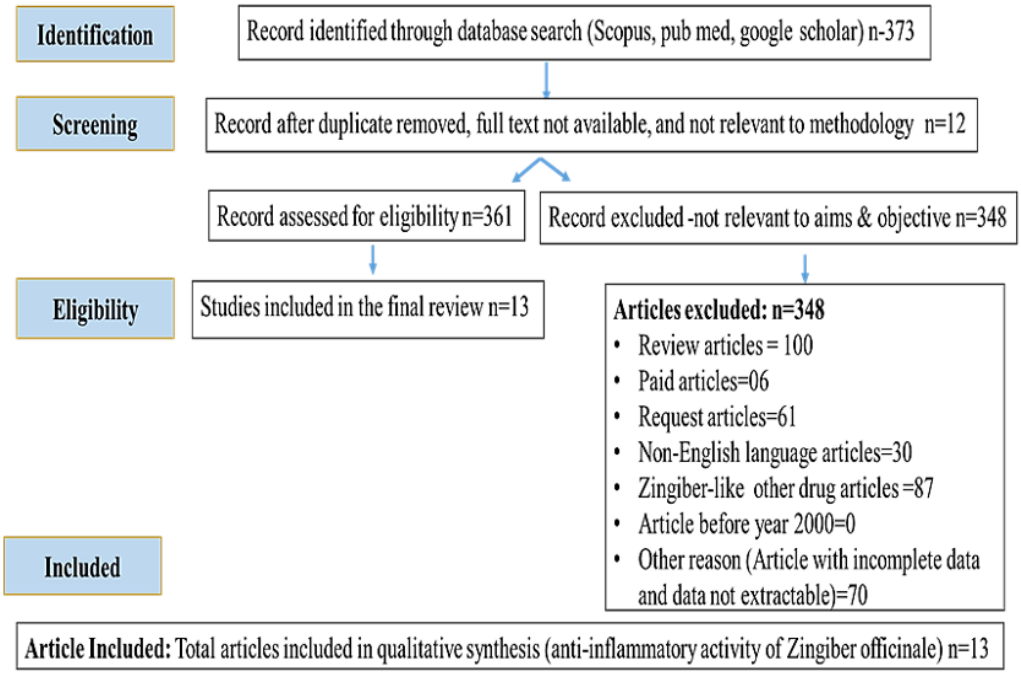

Figure 3: The PRISMA flow diagram of the study.

ginger promotes apoptosis (programmed cell death) and inhibits uncontrolled cell proliferation.

In addition to direct anti-inflammatory actions, ginger exhibits strong antioxidant and immunomodulatory properties**,** which collectively support immune homeostasis rather than broad immunosuppression. These mechanisms are highly relevant to the pathophysiology of chronic inflammatory diseases, including cancer, cardiovascular disorders, diabetes mellitus, arthritis, autoimmune conditions, and neurodegenerative diseases.

RESEARCH GAPS

Despite the comprehensive analysis, several research gaps were identified:

- **Limited Accessibility:** Many studies were excluded due to being paid articles or request- based, indicating a need for more open-access research to broaden the availability of data.
- **Geographical and Methodological Variability:** The variability in antioxidant content based on geography and extraction methods suggests a need for standardized protocols to ensure consistent and reproducible results.
- **Temporal Limitations:** Articles before 2000 and other languages were excluded, potentially overlooking.

Future Directions

Research on nano-based delivery systems for ginger phenolic compounds is still at an early stage. However, ongoing advances in nanotechnology suggest that these systems may improve the targeted delivery and controlled release of ginger's active constituents. In the future, ginger-based supplements could potentially be used as an alternative, or more likely as a complementary treatment, for inflammatory and autoimmune disorders. Further well-designed experimental and clinical studies will be necessary to confirm their effectiveness and practical clinical use.

CONCLUSION

Ginger regulates the molecular mechanism of inflammation, this systemic review paper indicates that ginger and its bioactive components have the potential to be used in the treatment of many inflammatory illnesses in the near future.

ABBREVIATIONS

5-LOX: 5-Lipoxygenase; **AITC:** Allyl Isothiocyanate; **AKT:** Protein Kinase B; **COX-2:** Cyclooxygenase-2; **iNOS:** Inducible Nitric Oxide Synthase; **MAPK:** Mitogen-Activated Protein Kinase; **NF-κB:** Nuclear Factor kappa-light-chain-enhancer of activated B cells; **PI3K:** Phosphoinositide 3-kinase; **PRISMA:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses; **TCM:** Traditional Chinese Medicine; **TNF-α:** Tumor Necrosis Factor alpha; **TRPA1:** Transient Receptor Potential Ankyrin 1; **TRPV1:** Transient Receptor Potential Vanilloid 1.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

SUMMARY

This systematic review shows that the included studies provide meaningful mechanistic evidence supporting the anti-inflammatory effects of *Zingiber officinale*. Most of the available evidence is derived from preclinical models, while high-quality clinical studies remain limited. Differences in study design, experimental models, ginger preparations, and dosage regimens create methodological variability, which restricts direct translation of these findings into clinical practice.

Despite these limitations, the results across studies are largely consistent and indicate that ginger possesses significant anti-inflammatory potential. Its favorable safety profile, wide availability, and cost-effectiveness further strengthen its value as a therapeutic agent.

In conclusion, this review identifies *Zingiber officinale* as a promising natural modulator of inflammation. However, well-designed, standardized clinical trials are necessary to confirm its efficacy, establish optimal dosing strategies, and support its clinical use in the management of inflammatory and immune-mediated disorders.

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