THE NEW ARMENIAN MEDICAL JOURNAL
Volume18 (2024), Issue 3 p.82-92

DOI: https://doi.org/10.56936/18290825-3.v18.2024-82

GINGER REVITALIZED: EXPLORING THE MODERN APPLICATIONS OF ZINGIBER OFFICINALE IN MEDICINE AND BEYOND

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Received 12.05.2023 Accepted for printing 04.08.2024

Abstract

The rhizome of Zingiber officinale, stands as a time-honored component deeply rooted in the realms of traditional medicine, boasting a history spanning centuries. This expansive review endeavors to intricately dissect the multifaceted dimensions of Zingiber officinale, delving into its botanical intricacies, phytochemical constituents, and medicinal attributes.

Our overarching goal is to cast a comprehensive light on the manifold applications of Zingiber officinale within the domains of health and wellness.

Methodically integrate the wealth of existing knowledge surrounding the anti-inflammatory, antioxidant, and antimicrobial properties inherent in ginger. By doing so, we seek to unravel the potential therapeutic efficacy of ginger in the management of an array of health conditions. To achieve this objective, an exhaustive literature review was conducted, encompassing detailed examinations of botanical descriptors, comprehensive phytochemical analyses, and critical evaluations of clinical studies. Through this comprehensive exploration, we present a holistic and nuanced overview of Zingiber officinale.

Our findings resonate with the versatility of ginger, underscoring its efficacy in mitigating not only nausea and digestive issues but also in addressing the complexities of inflammatory diseases.

The culmination of our findings contributes significantly to a richer and more profound understanding of the versatile applications of ginger, positioning it as a compelling and promising subject for both further scientific inquiry and practical utilization.

Keywords: Zingiber officinale, Rhizome, Ginger, Anti-inflammation, Antioxidant, Antimicrobial properties, phytochemical

Introduction

Background of Zingiber officinale: Zingiber officinale, more commonly known as ginger, is a vigorous persistent herbaceous plant that has earned renowned for its subterranean rhizomes serving as a pivotal element in the tapestry of medicinal practices throughout the annals of time [*Ghlissi et al., 2013, Baliga et al., 2011*]. This botanical marvel traces its origins to the verdant landscapes of Southeast Asia, embarking on a journey that transcends geographical boundaries and firmly establishing itself not merely as a spice but as an indispensable ingredient in a mosaic of tradi-

Cite This Article as:

Mohammad I., Khan M.S., Ansari M.R. (2024). Ginger Revitalized: Exploring the Modern Applications of Zingiber officinale in Medicine and Beyond: A systematic review, The New Armenian Medical Journal, vol.18(2), 82-92; https://doi.org/ 10.56936/18290825-3.v18.2024-82

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tional medicinal systems [*Semwal R et al., 2015, Akinyemi A et al., 2016*].

The lush landscapes of Southeast Asia, with their tropical climates and rich soils, provided the nurturing cradle for the inception of Zingiber officinale. From these origins, ginger's cultural significance burgeoned as it journeyed across continents, weaving itself into the fabric of diverse societies [*Grzanna R et al., 2005, Apak R et al., 2016*].

The therapeutic potential of Zingiber officinale has been explored and exploited across diverse cultures and traditions [*Zaki M, 2022*]. The ancient civilizations of China and India recognized ginger not only as a spice but as a powerful medicinal herb. Its inclusion in traditional medicinal systems such as Ayurveda and traditional Chinese medicine underscore its role as a botanical reservoir of health benefits [*Kim S et al., 2005, Lee S et al.,2008, Alakali J et al., 2009*]. The historical journey of Zingiber officinale is, therefore, a rich tapestry interwoven with the threads of medicinal wisdom. As we delve into the depths of its history [*Shirin Adel P, Prakash J 2010, Drozdov V et al., 2012*], we unravel a captivating narrative that positions Zingiber officinale as more than a botanical specimen; it is a dynamic force that has shaped and continues to shape human experiences across time and space (Fig.1) [*Jittiwat J, Wattanathorn J, 2012; Atashak S et al., 2014*].

Objective of the review: This review endeavors to undertake a systematic examination and consolidation of the expansive reservoir of knowledge encompassing Zingiber officinale. Our purpose is to delve into the intricate realms of its botanical intricacies, elucidate its diverse phytochemical composition, and unravel the multifaceted medicinal properties that collectively contribute to the profound significance of this plant [*Mohd Sahardi N, Makpol S, 2019*]. Through a meticulous synthesis of existing information, our aim is to cast a comprehensive light on the various facets of Zingiber officinale, offering a nuanced understanding of its intricacies. The focal point of our exploration lies in the botanical intricacies of Zingiber officinale, dissecting not only its morphological features but also the ecological and geographical factors influencing its growth and development. Furthermore, our objective extends to unraveling the complex tapestry of phytochemical constituents inherent in ginger. We seek to provide a detailed examination of the compounds that contribute to its distinct flavor profile and, more importantly, its therapeutic properties [*Mozaffari-Khosravi H et al., 2016, Mashabela M, Otang-Mbeng W, 2023*].

As we navigate through the labyrinth of information, our overarching goal is to illuminate the medicinal properties of Zingiber officinale. This involves a comprehensive analysis of its potential benefits in managing various health conditions, drawing insights from scientific studies and traditional knowledge. By synthesizing this wealth of informa-

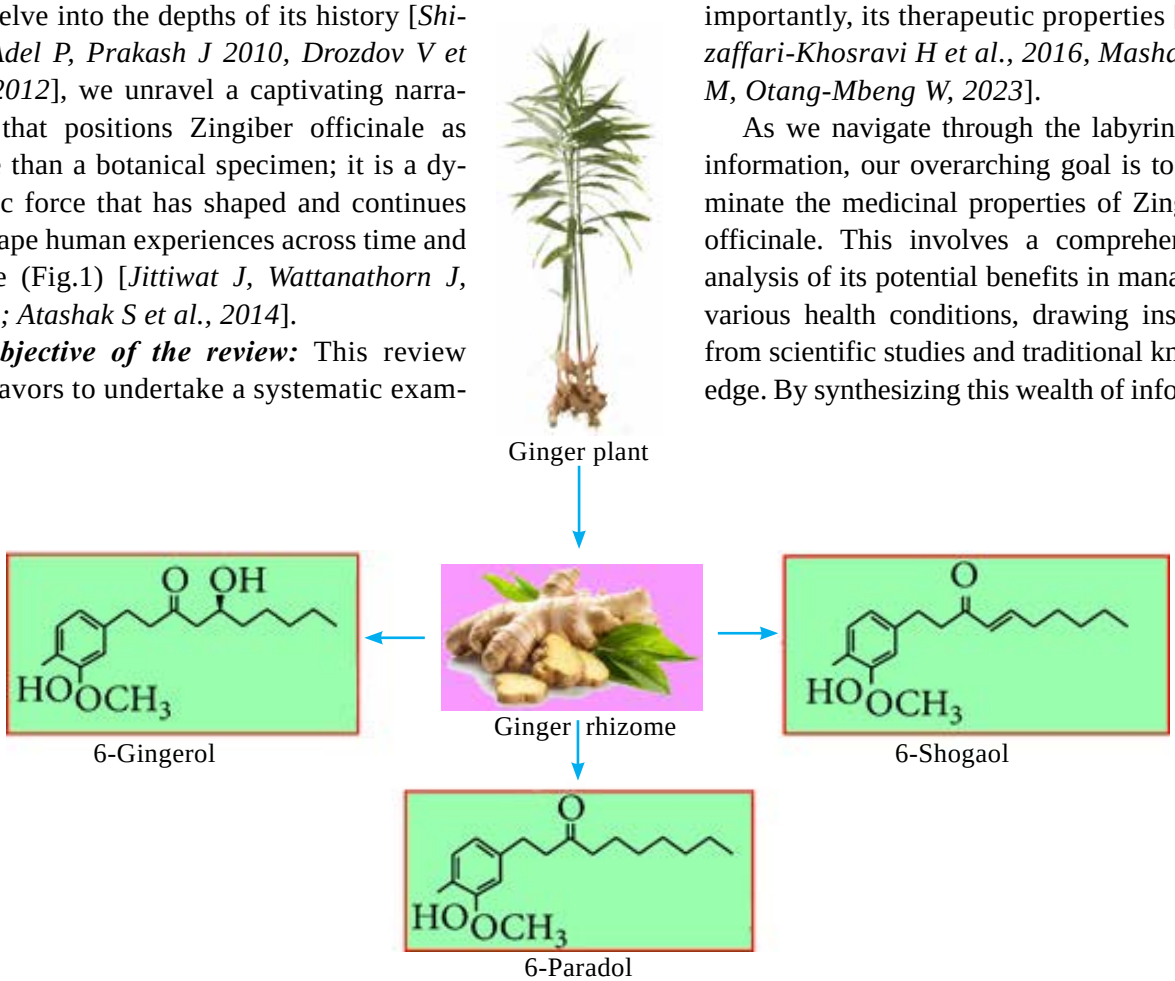

Figure 1. *Ginger, ginger rhizome, and its major active components: 6-gingerol, 6-shogaol, and 6-paradol [Prasad S, Tyagi A, 2015].*

tion, we aim to shed light on the therapeutic potential of ginger, positioning it as a versatile and valuable botanical resource [*Prasad S, Tyagi A, 2015*].

In essence, our review aspires to be a scholarly compass, guiding readers through the intricate terrain of Zingiber officinale. By synthesizing existing information, we endeavor to not only contribute to the academic discourse surrounding this botanical wonder but also to foster a deeper appreciation for its diverse applications, particularly in the realm of health and wellness [*Gholampour F et al., 2017; Adib Rad H et al., 2018*]. Through this comprehensive exploration, we aim to unravel the layers that make Zingiber officinale a subject of continual fascination and scientific inquiry.

Importance of Understanding Zingiber officinale: In the current landscape, delving into the various facets of Zingiber officinale assumes unparalleled significance. As global curiosity regarding natural remedies and functional foods surges, ginger ascends as a pivotal figure at the crossroads of traditional wisdom and contemporary scientific exploration [*Melati I et al., 2016*]. The intrinsic potential health benefits of Zingiber officinale, coupled with its remarkable culinary versatility, necessitate a thorough exploration and meticulous documentation of its diverse dimensions. This comprehensive review contributes significantly to fostering a nuanced comprehension of ginger, thereby empowering informed decision-making across diverse fields, ranging from healthcare to the culinary arts [*Aldhebiani A et al., 2017, Fadaki F et al., 2017*].

In the dynamic field of healthcare, where a shift towards holistic and natural approaches is increasingly evident, understanding Zingiber officinale becomes pivotal. Ginger's potential therapeutic properties, backed by scientific inquiry and historic wisdom, position it as a compelling subject for further exploration. By comprehensively documenting its various aspects [*Amri M, Touil-Boukoffa C, 2016*], this review seeks to equip healthcare professionals, researchers, and practitioners with the knowledge needed to integrate ginger into holistic healthcare practices effectively.

BOTANICAL DESCRIPTION AND PHYTOCHEMISTRY

Botanical Characteristics of Zingiber officinale: Zingiber officinale, known colloquially as ginger, presents an intriguing array of botanical traits that define its singular identity. As a perennial herbaceous species, ginger flourishes with a robust and verdant appearance, characterized notably by its substantial, intricately knotted rhizomes – subterranean stems that serve both as a storage unit and as the primary reservoir of its prized spice. Towering at heights ranging from two to four feet, ginger displays lance-shaped leaves of a deep, vibrant green hue, elegantly arrayed along its stems in an alternating fashion [*Melati I et al., 2016*]. Its flowering mechanism is represented by cone-like spikes, known as "bract spikes", enfolding delicate yellow-green flowers within. The growth behavior of Zingiber officinale aptly reflects its adaptability to tropical climates, where it thrives amidst the embrace of warmth, humidity, and well-drained soils, establishing itself as a resilient and flourishing presence in such environments [*Gaur M et al., 2016, Kala C et al., 2016*].

Chemical Composition and Phytochemicals in Ginger:Ginger's allure transcends its visual and aromatic appeal, delving into a rich tapestry of chemical compounds and phytochemicals that form the bedrock of its multifaceted properties. Within the rhizomes of Zingiber officinale lie a diverse array of bioactive constituents, each intricately woven into its flavor, fragrance, and therapeutic potential. From zingiberene to gingerol, shogaol, and paradol [*Dugasani S et al., 2010, Islam K et al., 2014*], these compounds not only impart ginger with its distinctive taste and scent but also bestow upon it a spectrum of medicinal virtues, ranging from anti-inflammatory and antioxidant to antimicrobial and gastro protective properties. This review aims to illuminate the intricate chemistry and pharmacology underpinning ginger's pharmacological efficacy, exploring its historical uses, modern applications, and emerging research avenues [*Ghayur M et al, 2005; Dehghani I et al., 2011*].

1. **Volatile Oils:** The characteristic pungency of ginger can be attributed to its volatile oils, predominantly composed of compounds such as zingiberene, gingerol, and shogaol. These oils are responsible for the distinct aroma and spiciness that define ginger.

2. **Gingerols:** Gingerols, a class of phenolic compounds, represent a major fraction of ginger's phytochemical profile. Among them, 6-gingerol stands out as a prominent bioactive compound, recognized for its antioxidant and anti-inflammatory properties. Through various studies, gingerols have been associated with potential health benefits, including antiemetic effects and gastrointestinal health promotion [*Imran M et al., 2023 a, b*].
3. **Shogaols:** Formed by the dehydration of gingerols during the drying or cooking process, shogaols contribute to the evolving flavor profile of ginger. Shogaols also exhibit antioxidant and anti-inflammatory properties, further enriching the therapeutic potential of Zingiber officinale.
4. **Zingerone:** Zingerone, another noteworthy compound, contributes to the warm and spicy flavor of ginger. It has demonstrated antioxidant and anti-inflammatory activities, enhancing the overall health-promoting characteristics of ginger.
5. **Gingerdiones and Paradols:** These lesser-known constituents also contribute to ginger's phytochemical complexity. While their specific roles are still under exploration, their presence suggests the intricate chemical diversity inherent in Zingiber officinale. The chemical composition of ginger, with its amalgamation of volatile oils and bioactive compounds, not only defines its sensory attributes but also underscores its potential health benefits. This intricate interplay of botanical characteristics and phytochemical richness positions Zingiber officinale as a captivating subject for further scientific inquiry, unraveling the complex web of compounds that contribute to its multifaceted nature.

Table 1

Phytochemical screening of Zingiber officinale [Imran et al., 2023]

S. No.	Solvent Name	Chemical Constituents	Results
1.	Hexane	Triterpenoids	-(Absent)
		Resins	-(Absent)
2.	Chloroform	Steroids	+(Present)
		Triterpenoids	+(Present)
		Alkaloids	-(Absent)
3.	Methanol	Flavonoids	+(Present)
		Alkaloids	+(Present)
		Reducing sugar	+(Present)
		Glycoside	-(Absent)
		Tannin	+(Present)
		Saponins	-(Absent)

MEDICINAL PROPERTIES OF ZINGIBER OFFICINALE:

Zingiber officinale, commonly known as ginger, occupies a pivotal position within the realm of botanical medicine, boasting a diverse array of medicinal properties. This revered spice has garnered extensive attention for its remarkable therapeutic potential, which encompasses a spectrum of health-promoting attributes. Delving into its rich pharmacological profile reveals a tapestry of benefits, including potent anti-inflammatory, antioxidant, and antimicrobial properties [*Ghayur M et al, 2005, Sandeep S, 2017*]. From ancient remedies to modern pharmacology, ginger has captivated researchers and practitioners alike, serving as a beacon of natural healing in an era marked by the quest for holistic wellness. Through systematic exploration and scientific inquiry, the intricate mechanisms underlying its physiological effects continue to be elucidated, unveiling new avenues for its application in preventive and therapeutic interventions. Thus, ginger emerges as a botanical treasure trove, offering a nuanced understanding of its role in promoting human health and vitality [*Mahmoud R, Elnour W, 2013, El Makawy A et al., 2019*].

1. Anti-Inflammatory Properties: Ginger's anti-inflammatory properties are well-documented and have been a subject of significant scientific interest. The bioactive compounds, particularly gingerols and their derivatives, are key contributors to these anti-inflammatory effects. They act by inhibiting inflammatory pathways, including the modulation of prostaglandins and cytokines. Numerous in vitro and in vivo studies have demonstrated ginger's efficacy in mitigating inflammatory responses, making it a promising natural remedy for conditions characterized by chronic inflammation, such as osteoarthritis and rheumatoid arthritis [*Rahmani A et al., 2014, Bartels E et al., 2015*].

2. Antioxidant Properties: Ginger possesses robust antioxidant properties attributed to its diverse phytochemical composition, including gingerols, shogaols, Zingerone, and other phenolic compounds.

These antioxidants play a pivotal role in neutralizing reactive oxygen species and free radicals, thereby protecting cells from oxidative damage. The cumulative antioxidant potential of Zingiber officinale positions it as a potential ally in combating oxidative stress-related diseases, including cardiovascular disorders, neurodegenerative conditions, and certain cancers [*Akinyemi A et al., 2015*].

3. Antimicrobial Properties: Ginger's antimicrobial properties contribute to its historical use as a preservative and remedy for various infections. Studies have highlighted its inhibitory effects against a spectrum of microorganisms, including bacteria, viruses, and fungi. The antimicrobial action is attributed to compounds like gingerol and Zingerone. Notably, ginger has shown promise in inhibiting the growth of pathogenic bacteria, including strains that are antibiotic-resistant, presenting possibilities for its application in addressing antibiotic resistance challenges (Fig. 2).

STUDIES SUPPORTING MEDICINAL PROPERTIES:

Numerous scientific investigations support the medicinal properties of Zingiber officinale:

- A study published in the Journal of nutrition in gerontology and geriatrics in 2016. 'Effect of ginger supplementation on pro inflammatory cytokines in older patients with osteoarthritis: outcomes of a randomized controlled clinical trial' demonstrated the anti-inflammatory effects of ginger in alleviating symptoms of osteoarthritis, suggesting its potential as a complementary therapy [*Mozaffari-Khosravi H et al., 2016*].
- Research in the 2016 "Antioxidant activity/capacity measurement. Reactive oxygen and nitrogen species (reactive oxygen species/reactive nitrogen species) scavenging assays, oxidative stress biomarkers, and chromatographic/chemo metric assays. in Journal of Agricultural and Food Chemistry", highlighted the antioxidant capacity of ginger, emphasizing its ability to scavenge free radicals and protect against oxidative stress [*Apak R et al., 2016*].
- Phytochemical screening and toxicity studies for ginger extracts with evaluation of some biochemical parameters and anticoagulant bioactivity. Egyptian Journal of Chemistry 2022 featured a study showcasing ginger's antimicrobial activity against common pathogens, reinforcing its traditional use in managing infectious conditions [*Zaki M, 2022*].
- Clinical trials, such as those documented in 2023. The therapeutic and phyto pharmacological potential of ginger (Zingiber officinale). In

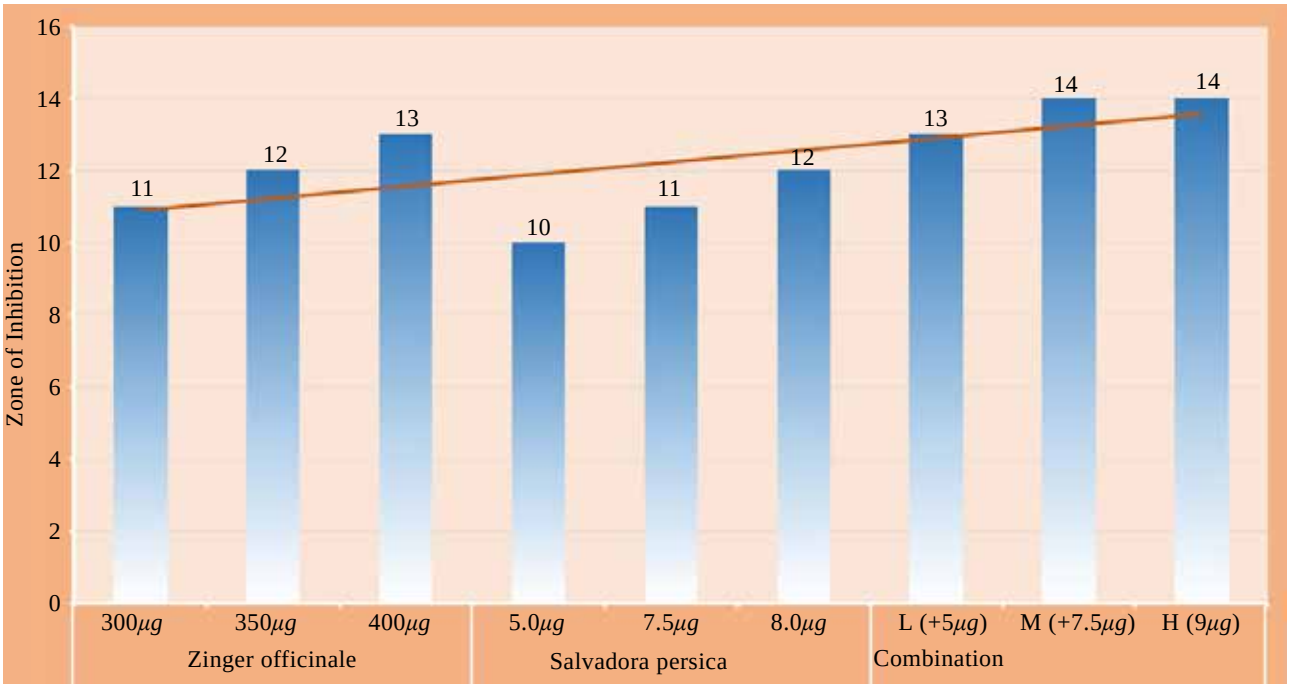

FIGURE 2. *Three methanolic extracts antibacterial activity against S. mutans [Imran M et al., 2023]. The mixture contains 350 μg of Zingiber officinale along with various concentrations of Salvadora persica.*

Ginger-Cultivation and Use. Intech Open., have explored ginger's efficacy in reducing inflammation markers in conditions like rheumatoid arthritis [*Mashabela M, Otang-Mbeng W, 2023*].

These studies collectively provide robust evidence supporting the medicinal properties of Zingiber officinale, substantiating its role as a versatile botanical with implications for various health conditions. The ongoing exploration of ginger's therapeutic potential continues to unveil new dimensions of its medicinal prowess, further establishing it as a valuable component in holistic health and wellness practices.

CLINICAL APPLICATIONS OF ZINGIBER OFFICINALE (GINGER):

Clinical studies have shed light on the diverse therapeutic applications of Zingiber officinale, commonly known as ginger, revealing its potential in managing a range of health conditions. The wealth of bioactive compounds presents in ginger, including gingerols and shogaols, contributes to its medicinal properties, making it a subject of interest in clinical research.

1. Management of Nausea: Ginger has demonstrated notable efficacy in mitigating nausea, making it particularly relevant in clinical applications for conditions such as motion sickness, chemotherapy-induced nausea, and morning sickness during pregnancy. A meta-analysis published in the "LWW Journal of Obstetrics and Gynecology" (2005) concluded that ginger is a safe and effective remedy for pregnancy-related nausea, showcasing its potential as an alternative or complementary therapy [*Pongrojpaw D et al., 2007*].

The initial trial involved 30 pregnant women hospitalized for hyperemesis gravidarum before the 20th week of gestation. They received either ginger or a placebo four times daily for four days, with a two-day washout period. Results showed ginger's superiority in reducing symptoms [*Borrelli F et al., 2005*].

2. Alleviation of Digestive Issues: Ginger's historical use as a digestive aid finds support in clinical studies. Research, including a study in the "Food science & nutrition Publisher, in Evidence-Based systematic review of clinical trials (2019), has explored ginger's effectiveness in reducing symptoms of indigestion, such as bloating and discomfort. The compounds in ginger are believed to stimulate digestive enzymes and promote motility in the gastrointestinal tract, contributing to its positive impact on digestive health. The initial double-blind crossover randomized controlled trial involved 30 pregnant women with hyperemesis gravidarum. They received either ginger or placebo four times daily for four days. Ginger showed superiority over placebo in reducing symptoms [*Nikkhah Bodagh M et al., 2019*].

Research Article the Effect of Ginger (Zingiber officinalis) and Artichoke (Cynara cardunculus) Extract Supplementation on Functional Dyspepsia: A Randomised, Double-Blind, and Placebo-Controlled Clinical Trial.

3. Management of Inflammatory Diseases: Investigations have delved into the anti-inflammatory properties of ginger and its potential in managing inflammatory diseases. Studies, including research in the "Doctoral dissertation, Evidence-Based Complementary and Alternative Medicine" in (2019), have explored its use in conditions like osteoarthritis and rheumatoid arthritis. The anti-inflammatory effects of ginger, attributed to compounds like gingerols, were found to alleviate symptoms and improve the quality of life for individuals with these inflammatory conditions (Fig.3).

4. Other Clinical Applications: Beyond its well-established efficacy in addressing nausea, digestive issues, and inflammatory diseases, ongoing clinical studies are delving into a plethora of additional applications of ginger. Emerging research is actively exploring its potential therapeutic benefits in managing diverse conditions such as migraine headaches, cardiovascular health, and metabolic disorders. This expanding body of research highlights the remarkable versatility of Zingiber officinale across various medical and pharmaceutical domains, underscoring its promising role in enhancing human health and well-being.

Safety and Side Effects of Zingiber officinale (Ginger): Zingiber officinale, commonly known as ginger, is generally considered safe for consumption, and its long history of medicinal use attests to its favorable safety profile. However, like any botanical or dietary supplement, there are considerations regarding its use, particularly in certain populations or under specific circumstances.

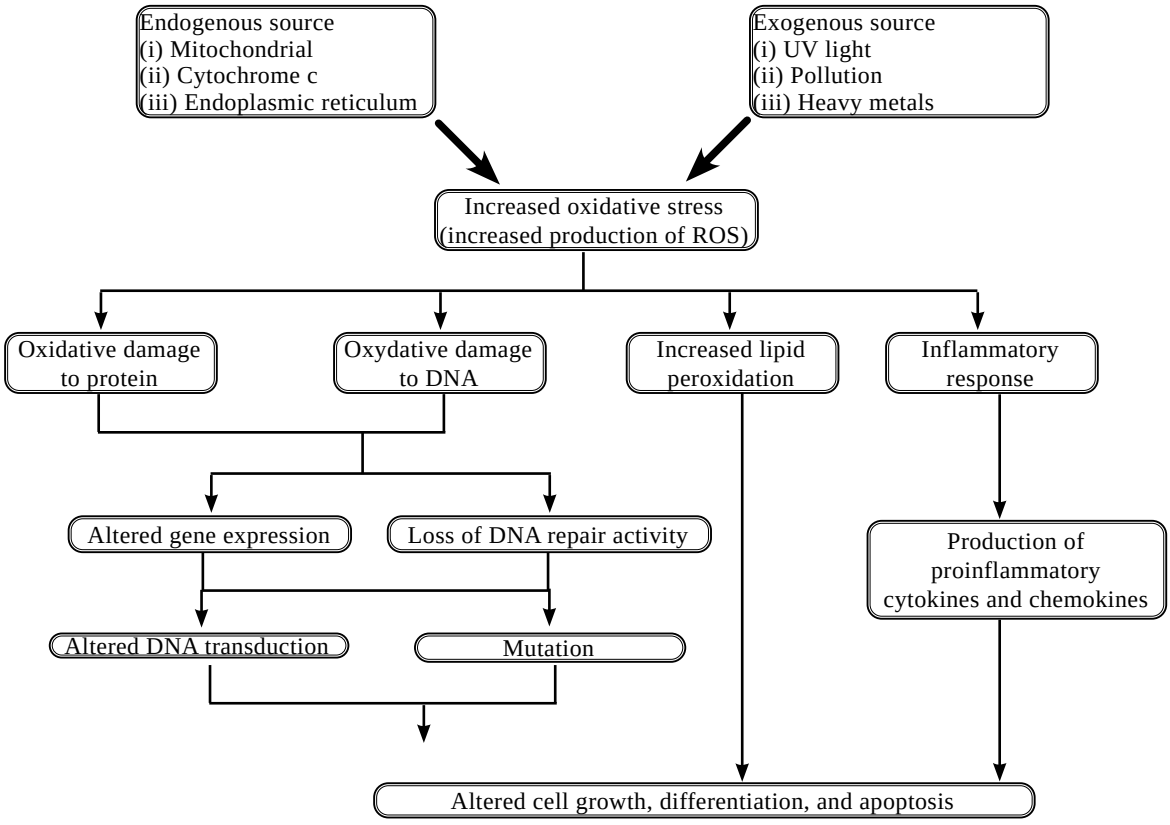

Figure 3. *Oxidative stress and inflammation in ageing and degenerative diseases [Mohd Sahardi N, Makpol S, 2019]*

1. General Safety:

Moderate Consumption: For individuals without specific health concerns, moderate consumption of ginger, either fresh or as a spice, is typically well-tolerated.

2. Side Effects:

- ***Gastrointestinal Distress:*** In some cases, excessive consumption of ginger, particularly in concentrated forms like supplements, may lead to mild gastrointestinal distress. This can include symptoms such as heartburn, gas, or abdominal discomfort. Adjusting the dosage or form of ginger consumed may alleviate these effects.
- **Interaction with Blood Thinners:** Ginger has natural blood-thinning properties, which may interact with anticoagulant medications. Individuals taking blood thinners should exercise caution and consult with their healthcare provider before incorporating ginger into their diet or taking ginger supplements to avoid potential interactions.

3. Special Considerations: Pregnancy and Lactation:

- While ginger has been traditionally used to alleviate nausea during pregnancy, pregnant individuals should consult their healthcare provider before using ginger supplements, especially in concentrated forms. Moderate culinary use is generally considered safe.
- **Surgery:** Due to its potential blood-thinning properties, individuals scheduled for surgery should inform their healthcare providers about ginger consumption, as it may affect blood clotting. Temporary cessation of ginger intake may be recommended before surgical procedures.

4. Allergic Reactions:

Allergies: Allergic reactions to ginger are rare but possible. Individuals with known allergies to ginger or related plants should exercise caution. Symptoms of an allergic reaction may include rash, itching, or difficulty breathing. Seeking medical attention is crucial if an allergic reaction is suspected.

5. Interactions with Medications:

Drug Interactions: Ginger may interact with certain medications, including anticoagulants, antiplatelet drugs, and medications for diabetes and hypertension. It is important for individuals on medications to consult with their healthcare provider before incorporating ginger supplements into their routine to avoid potential interactions.

Conclusion

The comprehensive exploration delving into the myriad facets of Zingiber officinale not only illuminates its deeply entrenched historical significance but also underscores its enduring relevance in contemporary contexts. Tracing its journey from the annals of traditional medicine, ginger emerges as an indispensable emblem of versatility, consistently captivating scholarly minds and provoking scientific curiosity. This expansive odyssey fosters a profound appreciation for the nuanced intricacies that characterize ginger's multifaceted essence, thereby deepening our understanding of its diverse dimensions and perpetuating its timeless allure.

While existing clinical evidence supports the therapeutic applications of ginger, ongoing research seeks to refine our understanding of optimal dosage, duration, and potential interactions with medications. The multifaceted nature of Zingiber officinale positions it as a subject of continual clinical exploration, offering promise for novel applications and integrative approaches in healthcare.

In conclusion, the clinical applications of Zingiber officinale extend beyond its traditional use as a spice, showcasing its potential as a natural remedy in managing a spectrum of health conditions. The findings from clinical studies not only validate traditional knowledge but also open avenues for further research, emphasizing the dynamic role of ginger in contemporary healthcare practices.

Acknowledgement: *The authors are grateful to the Deanship of Scientific Research, Prince Sattam bin Abdulaziz University, Al-Kharj, Saudi Arabia for its support and encouragement in conducting the research and publishing this report.*

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THE NEW ARMENIAN MEDICAL JOURNAL

Volume18 (2024). Issue 3

The Journal is founded by
Yerevan State Medical
University after M. Heratsi.

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Our journal is registered in the databases of Scopus, EBSCO and Thomson Reuters (in the registration process)

SCOPUS EBSCO
REUTERS

Copy editor: Tatevik R. Movsisyan

Printed in "LAS Print" LLC
Director: Suren A. Simonyan
Armenia, 0023,Yerevan,
Acharyan St. 44 Bulding,
Phone: (+374 10) 62 76 12,
E-mail: las.print@yahoo.com

THE NEW ARMENIAN MEDICAL JOURNAL
Volume18 (2024). Issue 3

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