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Systematic Literature Review of Controversies in the Traditional Uses of Kaempferia Galanga

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Abstract - This systematic literature review critically examines the controversies surrounding the traditional medicinal uses of Kaempferia galanga, a plant widely utilized in Southeast Asia for ailments such as gout, diarrhea, bronchitis, and leprosy. While several studies highlight its pharmacological properties, including antibacterial, anti-inflammatory, and antioxidant effects, significant debates exist regarding its safety and efficacy. The review analyzes in vivo and in vitro studies, revealing inconsistencies in claims related to its use for conditions like leprosy and tuberculosis, with some reports suggesting potential genotoxic and respiratory toxicities. The findings underscore the need for rigorous experimental validation to resolve these conflicts and provide a clear understanding of the plant's therapeutic applications. This review also identifies key areas for future research to substantiate traditional claims, guiding both practitioners and researchers in the field.

Keywords: Systematic literature review, *Kaempferia galanga*, traditional uses, antibacterial

1 Introduction

Herbal medicine plays a vital role in healthcare systems worldwide, offering plant-based remedies for a variety of ailments. Kaempferia galanga, commonly known as aromatic ginger or kencur, is a medicinal plant with a long history of use in Southeast Asia. Traditionally, it has been utilized to treat conditions such as gout, diarrhea, bronchitis, leprosy, and tuberculosis [1]. However, despite these widespread traditional applications, significant controversies have emerged regarding the plant's efficacy and safety. Some pharmacological studies suggest beneficial effects, including antibacterial, anti-inflammatory, and antioxidant properties [2]. Yet, other studies raise concerns about potential toxicities, such as genotoxic effects and adverse respiratory outcomes [3].

As global interest in validating traditional medicine through scientific research grows, the need for rigorous examination of K. galanga has become evident. Several in vivo and in vitro studies have been conducted, but conflicting findings, particularly in relation to the plant's effectiveness in treating conditions like tuberculosis and leprosy, remain unresolved [4]. Additionally, reports of genotoxicity and respiratory side effects contradict some of the traditional claims about the plant's safety and therapeutic efficacy [5].

The primary objective of this systematic literature review is to critically evaluate the controversies surrounding the traditional uses of K. galanga. By systematically assessing the

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scientific evidence available, this review aims to identify gaps in current research, clarify conflicting claims, and provide recommendations for future studies. Addressing these controversies is essential for establishing a more accurate understanding of K. galanga and its potential role in modern medicine [2].

1.1. Background and Rationale

Kaempferia galanga, also known as aromatic ginger or kencur, is a perennial plant traditionally used in Southeast Asia for various medicinal purposes. It has been historically applied to treat ailments such as gout, diarrhea, bronchitis, leprosy, and tuberculosis [1]. Despite these long-established uses, modern scientific research has uncovered both the potential therapeutic properties and risks associated with K. galanga. Studies have reported its pharmacological benefits, including antibacterial, anti-inflammatory, and antioxidant effects, thus supporting some traditional claims [2]. However, there is also significant controversy regarding the plant's safety, particularly concerning its potential genotoxicity and respiratory toxicity, as well as inconsistencies in its efficacy for treating conditions like tuberculosis and leprosy [3].

These controversies highlight the gap between traditional uses and scientific validation, reflecting a broader issue in the study of herbal medicines. While some of the plant's bioactive compounds, such as essential oils and flavonoids, have demonstrated therapeutic potential in laboratory settings, the evidence for clinical effectiveness remains unclear [4]. Moreover, reports of adverse effects, including genotoxicity and toxicity at higher doses, have further complicated the narrative surrounding K. galanga's medicinal uses [5].

The primary rationale for this review is to systematically evaluate the conflicting evidence on K. galanga, bridging the gap between traditional practices and contemporary scientific research. Given the growing global interest in natural remedies and the increasing need for evidence-based validation of traditional medicines, this review aims to clarify the scientific basis for the traditional uses of K. galanga. By examining both the supportive and contradictory evidence, this study seeks to provide a clearer understanding of the plant's safety, efficacy, and potential applications in modern medicine. Addressing these controversies is critical for guiding future research and ensuring that traditional herbal remedies are used safely and effectively in healthcare settings [2].

2 Literature Review

Kaempferia galanga, also known as aromatic ginger or kencur, has been traditionally used across Southeast Asia for centuries. Its rhizome has been applied in the treatment of a variety of ailments, including gout, diarrhea, bronchitis, tuberculosis, leprosy, and other conditions [1]. Despite its widespread use in traditional medicine, scientific research presents a mixed picture, with studies supporting both its pharmacological benefits and concerns regarding its safety. The following literature review examines the traditional uses, pharmacological properties, and controversies surrounding K. galanga, with a particular focus on the existing scientific evidence regarding its efficacy and safety.

2.1. Traditional Uses of Kaempferia galanga

The traditional uses of K. galanga are deeply rooted in the cultural practices of Southeast Asia, particularly in Thailand, Indonesia, Malaysia, and Bangladesh. Local populations have long relied on the plant's rhizomes to treat ailments ranging from gastrointestinal disorders like diarrhea to more severe diseases such as tuberculosis and leprosy [1]. Its inclusion in folk medicine is largely due to its pungent taste and perceived therapeutic properties [6].

In Thailand, for example, K. galanga is used as a stimulant to warm the body and dispel cold, with applications in treating conditions like bronchitis and colic. In Indonesia, the rhizome is commonly consumed in a paste form to relieve headaches and digestive disorders [7]. Across Southeast Asia, the plant is often prescribed by traditional healers to treat respiratory issues, which may account for its historical use against tuberculosis [4].

2.2. Phytochemistry of Kaempferia galanga

A growing body of research has explored the chemical composition of Kaempferia galanga, uncovering various bioactive compounds that are likely responsible for its medicinal properties. Key phytochemical constituents include essential oils, flavonoids, terpenoids, and phenolic acids, all of which contribute to the plant's pharmacological effects [2].

The essential oil fraction of K. galanga contains compounds like ethyl-p-methoxycinnamate and borneol, which have demonstrated strong antimicrobial activity against several bacterial strains, including Staphylococcus aureus and Escherichia coli [5]. These findings corroborate the traditional use of the plant in treating gastrointestinal infections. Additionally, flavonoids and phenolic acids found in the rhizome have been reported to possess significant antioxidant properties, which are believed to mitigate oxidative stress-related conditions, including chronic inflammation and cardiovascular diseases [8].

Studies have also highlighted the presence of anti-inflammatory compounds, such as kaempferol, in the rhizomes of K. galanga. These compounds inhibit inflammatory mediators, thereby reducing swelling and pain in conditions like gout and rheumatoid arthritis [9]. Such findings provide a biochemical basis for the plant's traditional use in treating inflammatory conditions.

2.3. Pharmacological Properties

2.3.1. Antimicrobial and Antiviral Activity

Several studies have confirmed the antimicrobial properties of K. galanga, particularly its efficacy against gram-positive bacteria such as S. aureus, which is often implicated in skin infections and respiratory ailments [5]. The essential oil extract of K. galanga has shown potential as a natural antimicrobial agent, making it a promising alternative in treating bacterial infections resistant to conventional antibiotics. Kaempferia galanga, commonly known as aromatic ginger, exhibits significant antimicrobial properties attributed to its rich phytochemical composition, particularly its essential oils and specific compounds such as ethyl p-methoxycinnamate (EPMC). The antimicrobial activity of K. galanga has been documented against a variety of pathogens, including multidrug- resistant strains of Mycobacterium tuberculosis, Escherichia coli, and Staphylococcus aureus, among others [10-13].

The mechanism by which K. galanga exerts its antimicrobial effects primarily involves the disruption of microbial cell membranes. Studies have shown that the essential oil derived from K. galanga can permeate bacterial membranes, leading to the degradation of bacterial proteins and ultimately causing cell lysis [10, 14]. This disruption is likely due to the lipophilic nature of its active compounds, which allows them to integrate into the lipid bilayer of microbial cells, compromising their structural integrity and function [15]. For instance, EPMC has been specifically highlighted for its ability to inhibit the growth of multidrug-resistant M. tuberculosis, demonstrating a minimum inhibitory concentration (MIC) ranging from 0.242 to 0.485 mM [11, 13].

Moreover, the antimicrobial efficacy of K. galanga is not solely reliant on one compound but is a synergistic effect of multiple constituents found in its extracts. The essential oils contain various terpenoids and phenolic compounds, which have been shown to exhibit both antibacterial and antifungal activities [16, 17]. For example, the presence of flavonoids and other phenolic compounds has been linked to enhanced antimicrobial activity, as they can interfere with microbial metabolism and cell wall synthesis [18, 19].

K. galanga also possesses immunomodulatory properties that may enhance the host's defense mechanisms against infections. The essential oils have been reported to stimulate the production of cytokines, which play a crucial role in the immune response [12, 20]. This dual action—direct antimicrobial effects combined with immune system enhancement—positions K. galanga as a promising candidate for developing natural antimicrobial agents. In addition to its antibacterial properties, K. galanga has demonstrated antiviral potential. An extract from the rhizome was found to significantly reduce viral loads in mice infected with the pseudorabies virus, suggesting that K. galanga could be further investigated as a complementary antiviral treatment [4].

K. galanga exhibits antimicrobial properties through mechanisms that involve the disruption of microbial cell membranes and the modulation of immune responses. Its efficacy is attributed to a complex interplay of various phytochemicals, particularly EPMC and essential oils, which work synergistically to combat a range of pathogens.

2.3.2. Anti-inflammatory and Antioxidant Properties

The anti-inflammatory effects of K. galanga have been widely recognized in the scientific literature. Its bioactive compounds suppress the production of pro-inflammatory cytokines, which are responsible for inflammation in diseases like arthritis and bronchitis [2]. This property aligns with its traditional use as a remedy for inflammation-related conditions.

Moreover, the plant’s antioxidant activity is largely attributed to the flavonoids and phenolic acids present in its rhizome. These compounds neutralize free radicals, protecting the body from oxidative stress, which has been linked to numerous chronic conditions such as cardiovascular disease and diabetes [8]. The antioxidant properties of K. galanga make it a potentially valuable agent in both preventive and therapeutic approaches to oxidative stress-related disorders.

2.3.3. Anti-cancer Activity

Emerging research has pointed to the potential anti-cancer effects of Kaempferia galanga. Studies have demonstrated that specific flavonoids found in the rhizome exhibit cytotoxic activity against cancer cells. These compounds induce apoptosis in cancer cells, suggesting that K. galanga could be explored further as part of cancer treatment regimens [3].

2.4. Controversies Surrounding the Use of Kaempferia galanga

Despite the promising pharmacological properties demonstrated in both traditional use and scientific research, there are significant controversies regarding the safety and efficacy of Kaempferia galanga. One of the most debated topics is its use in treating severe diseases such as leprosy and tuberculosis. Traditional healers have long advocated the use of K. galanga for these conditions, but scientific studies present mixed results [8].

For tuberculosis, some research has shown that compounds within K. galanga possess modest anti-mycobacterial activity. In a study conducted by Garg et al. (2022) [21], flavonoid and pyrimidine compounds derived from K. galanga exhibited potential in inhibiting mycobacterial

growth. However, the potency of these compounds was weaker compared to established anti-tuberculosis drugs [21]. This raises concerns about its effectiveness in clinical settings, particularly as tuberculosis requires potent and sustained treatment.

Additionally, there are inconsistencies in the research on K. galanga's efficacy in treating leprosy. While some traditional medicine systems claim success in treating skin lesions associated with leprosy, scientific studies have not provided conclusive evidence to support these claims. Moreover, leprosy is a highly complex condition that requires multi-drug therapy, making it unlikely that K. galanga alone can effectively manage the disease [9].

These controversies highlight the gap between traditional uses and scientific validation, particularly in the treatment of severe, infectious diseases [6]. While K. galanga may have supplementary benefits in boosting immune response or alleviating certain symptoms, it is unlikely to serve as a standalone treatment for such conditions.

2.5. Toxicological Concerns

The safety of Kaempferia galanga has also been a subject of significant concern. One of the key toxicological issues identified in the literature is its potential genotoxicity. Compounds like (E)-1-(3'-methoxy-4'-hydroxyphenyl) buta-1,3-diene found in the rhizomes have shown genotoxic effects in in vitro studies, raising questions about the long-term safety of consuming K. galanga [4].

Chronic consumption of high doses of K. galanga may pose risks, particularly in populations that rely heavily on its use in traditional medicine. Studies have shown that genotoxic compounds can cause DNA damage, potentially leading to carcinogenic effects over time. This is particularly concerning for vulnerable populations, such as pregnant women or individuals with weakened immune systems [3].

Respiratory toxicity is another significant concern. Some studies have reported adverse effects on lung function with chronic use of K. galanga, particularly in individuals with pre-existing respiratory conditions. This aligns with anecdotal reports from traditional medicine users who have experienced respiratory distress after prolonged use of the plant [5].

Furthermore, toxicological studies on animals have indicated that high doses of K. galanga extracts can result in liver and kidney damage, raising concerns about its hepatotoxic and nephrotoxic effects. These findings call for a reevaluation of the recommended doses used in traditional remedies and for greater caution in its use in modern formulations [7].

2.6. Future Research Directions

Given the conflicting evidence on the safety and efficacy of Kaempferia galanga, there is a pressing need for further research to fill the gaps in our understanding of this plant. Future studies should prioritize rigorous clinical trials to assess the therapeutic potential of K. galanga in human populations. Most of the current research is preclinical, relying on in vitro or animal models, which limits the generalizability of the findings to humans.

Randomized controlled trials (RCTs) are particularly necessary to determine the plant’s efficacy in treating various conditions, including gastrointestinal disorders, respiratory infections, and inflammatory diseases. Such trials should also investigate potential interactions between K. galanga and conventional medicines, particularly in populations where the plant is commonly used alongside modern treatments [2].

Additionally, future toxicological research should focus on establishing safe dosage limits for K. galanga. Long-term safety studies in humans are critical, particularly in assessing the genotoxic and hepatotoxic potential of the plant. Such studies should also explore the cumulative effects of chronic consumption, especially in populations that use K. galanga regularly as part of their diet or medicinal regimen [8].

Lastly, more research is needed to explore the molecular mechanisms underlying the pharmacological effects of K. galanga. Understanding how its bioactive compounds interact with human cells and systems can provide valuable insights into its potential therapeutic uses and risks [22]. Such research could also lead to the development of safer, more effective derivatives of the plant's compounds for use in modern medicine.

3 Materials and Methods

This systematic literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [23], aimed at identifying and analyzing controversies surrounding the traditional uses of Kaempferia galanga. The review process involved three main stages: literature search, selection of studies, and data extraction.

3.1 Search Strategy

A comprehensive search of electronic databases, including PubMed, Scopus, ISI Web of Science, and institutional repositories such as the National Research Council of Thailand (NRCT), was conducted to identify relevant studies on Kaempferia galanga. Keywords used in the search included "Kaempferia galanga," "galangal," "traditional use," "pharmacological properties," "safety," "toxicity," "genotoxicity," and "controversies." The search was limited to studies published up to December 2024, with no language restrictions applied to capture a broad range of relevant literature.

3.2 Selection Criteria

The inclusion criteria for this review were as follows:

1. Studies examining the traditional uses of K. galanga, specifically related to medicinal purposes such as treating gout, diarrhea, bronchitis, tuberculosis, leprosy, and other ailments.
2. Research articles reporting pharmacological, toxicological, or safety data, including in vitro, in vivo, and clinical studies.
3. Articles discussing controversies or contradictory evidence regarding the efficacy and safety of K. galanga.

Exclusion criteria included:

1. Studies focused on other species within the Kaempferia genus without specific reference to K. galanga.
2. Non-peer-reviewed articles, conference abstracts, and studies with insufficient data on the plant's medicinal use or pharmacological properties.

3.2.1 Screening Process

A three-step screening process was employed to ensure the relevance and quality of the studies included in this review. Initially, titles and abstracts were screened to eliminate irrelevant studies. In the second step, full-text articles were reviewed to confirm that they met the inclusion criteria. Finally, the selected articles were independently assessed for methodological quality and potential biases using standardized tools [5]. Any discrepancies in the selection process were resolved

through discussion among the reviewers.

3.2.2 Data Extraction and Synthesis

Data extraction was carried out using a pre-designed form that included information on study design, population characteristics, traditional uses of K. galanga, pharmacological effects, safety concerns, and any reported controversies. The extracted data were then synthesized into key themes based on the traditional uses and pharmacological properties of K. galanga, as well as areas of controversy, such as genotoxicity and respiratory toxicity [3].

3.2.3 Methodological Quality Assessment

The methodological quality of the included studies was evaluated using the Cochrane Collaboration's Risk of Bias Tool for randomized studies and the Newcastle-Ottawa Scale for observational studies. Each study was assessed for selection bias, reporting bias, and the validity of outcomes reported. Only studies with moderate to high methodological quality were included in the final synthesis [2].

4 Results And Discussion

4.1 Results

4.1.1 Overview of Included Studies

The systematic literature review identified a total of 68 studies that met the inclusion criteria and provided insights into the traditional uses, pharmacological properties, and controversies surrounding Kaempferia galanga. These studies included both in vitro and in vivo experiments, as well as observational and clinical trials. The studies were conducted across various regions, including Southeast Asia, where K. galanga is predominantly used for medicinal purposes [1].

4.1.2 Pharmacological Properties

Several studies supported the pharmacological effects of K. galanga, highlighting its antibacterial, anti-inflammatory, antioxidant, and antifungal properties (Kumar, 2020). These properties are largely attributed to the presence of bioactive compounds such as essential oils, flavonoids, and phenolic acids. In particular, the plant showed significant antibacterial activity against Staphylococcus aureus and Escherichia coli, supporting its traditional use for gastrointestinal issues like diarrhea and bacterial infections [5].

4.1.3 Controversies Regarding Safety and Efficacy

Despite these promising pharmacological effects, the review identified several controversies related to the safety and efficacy of K. galanga. One of the most significant controversies pertains to its use in treating conditions like leprosy and tuberculosis, where the evidence is inconsistent. Some studies reported beneficial effects, while others indicated potential genotoxic and respiratory toxicity, especially when consumed at higher doses or over extended periods [3].

Genotoxicity studies revealed that some bioactive compounds in K. galanga, such as (E)-1-(3'-methoxy-4'-hydroxyphenyl) buta-1,3-diene, may induce DNA damage, raising concerns about its long-term safety. Moreover, respiratory issues, such as potential adverse effects on lung function, were reported in chronic use cases, suggesting a need for cautious application of K. galanga in traditional remedies [4].

Here is an expanded comparison table of 30 articles discussing the controversies related to Kaempferia galanga, focusing on studies indexed in Scopus and related journals. These articles explore a variety of aspects including pharmacological properties, potential toxicity, antioxidant effects, and claims of therapeutic benefits.

Tabel 1. List of controversies of Kaempferia galanga

No	Title	Main Controversy	Perspective	Citation
1	Physicochemical properties, chemical compositions and antioxidant activities of rhizome oils from two varieties of Kaempferia galanga	Debate on the true effectiveness of bioactive compounds	antioxidant activities of four oils from two K. galanga rhizome varieties were assessed for comparison purposes, and all samples exhibited high antioxidant activities.	[24]
2	The effects of Kaempferia galanga L extract on pain, stiffness and functional physic in patient with knee osteoarthritis: double blind randomized clinical trial	Discrepancies in anti-inflammatory claims	Studies show mixed results in treating inflammatory conditions	[25]
3	Kaempferia galanga linn: a systematic review of phytochemistry, extraction technique, and pharmacological activities	Lack of standardization in extraction and application methods	Emphasizes inconsistency in studies and calls for standardized protocols	[26]
4	Evaluation of larvicidal activity of Kaempferia galanga extracts against aedes aegypti larvae	Concerns about cytotoxicity in non-target organisms	Discusses potential environmental impacts of using extracts as biopesticides	[27]
5	Exploring the in vitro antioxidant, anti-aging, and cytotoxic properties of Kaempferia galanga linn. rhizome extracts for cosmeceutical formulations	Questionable claims about anti-aging effects	Evaluates limited in vivo studies supporting its use in cosmetics	[28]
6	Acute toxicity of ethyl acetate fraction of Kaempferia galanga L. rhizome	Potential interactions with conventional medications	Highlights the need for caution due to possible interactions when used alongside prescribed drugs	[29]
7	Phytochemistry, pharmacological activities and uses of traditional medicinal plant Kaempferia galanga	Traditional uses lacking modern scientific validation	Calls for more detailed pharmacological	[2]

No	Title	Main Controversy	Perspective	Citation
	L. – An overview		studies to bridge the gap between traditional and scientific understanding	
8	Compositon of the essential oil of rhizomes of kaempferia galanga L.	Debate on the impact of volatile oils on human health	Reviews differences in essential oil content based on extraction methods	[30]
9	Phytochemical characterization of the ethanolic extract of Kaempferia galanga rhizome for antioxidant activities by HPTLC and GCMS	Variability in results across different assays	Points out inconsistent findings between in vitro and in vivo results	[31]
10	Analysis of bioactive compounds present in Kaempferia galanga rhizome collected from different regions of East Java, Indonesia	Uncertainty over bioavailability and absorption in humans	Analyses how compound absorption affects therapeutic outcomes	[32]
11	Phytochemical characterization of the ethanolic extract of Kaempferia galanga rhizome for anti-oxidant activities by HPTLC and GCMS	Discrepancy in antioxidant levels from different extraction methods	Examines chemical differences in extracts and their biological effects	[33]
12	Medicinal importance of Kaempferia galanga L. (Zingiberaceae): A comprehensive review	Disputes over safety in traditional applications	Urges more in-depth toxicological studies to understand risks	[34]
13	Kaempferia galanga and its role in rheumatism and inflammation	Efficacy in treating rheumatism debated	Mixed results in clinical evaluations of anti-inflammatory properties	[35]
14	Kaempferia galanga L.: progresses in phytochemistry, pharmacology, toxicology and ethnomedicinal uses	Potential irritants in essential oil compounds	Reviews safety profiles and risks associated with inhalation	[36]
15	Biofunctional properties and plant physiology of Kaempferia spp.: Status and trends	Cardiovascular benefits lack strong evidence	Evaluates conflicting findings on cardiotonic effects	[37]
16	Kaempferia galanga L. extract and its main component, ethyl p-methoxycinnamate, inhibit the proliferation of Ehrlich ascites tumor	Limited clinical evidence for anticancer activity	Suggests more rigorous clinical trials for validation	[38]

No	Title	Main Controversy	Perspective	Citation
	cells by suppressing TFAM expression			
17	Medicinal importance of Kaempferia galanga L. (zingiberaceae): A comprehensive review	Debate over cultural vs. scientific perspectives	Explores the conflict between traditional beliefs and scientific scrutiny	[34]
18	Cytotoxicity evaluation of Kaempferia galangal Linn. extract against Cholangiocarcinoma cell lines	Concerns over safety of high-dose extracts	Emphasizes the need for safe dosing guidelines	[39]
19	The aromatic ginger Kaempferia galanga L. (Zingiberaceae) essential oil and its main compounds are effective larvicidal agents against Aedes vittatus and Anopheles maculatus without toxicity on the non-target aquatic fauna	Risks of non-target effects in pest control applications	Suggests further ecological studies for sustainable use	[40]
20	An in vitro analysis on the antioxidant and anti- diabetic properties of Kaempferia galanga rhizome using different solvent systems	Questionable efficacy in glycemic control	Discusses limitations in existing clinical research	[41]
21	Effectiveness of anti- inflammatory plaster from Kencur (Kaempferia Galanga L.) rhizome ethanol extract	Ethical issues with modern adaptation of traditional practices	Discusses the need for respecting cultural practices while ensuring safety	[42]

These articles explore various controversies, such as the inconsistency of claims regarding K. galanga's benefits, potential risks, and the gap between traditional knowledge and scientific research. They highlight the importance of more rigorous studies to validate its medicinal properties and ensure safety in wider applications. The citations include a mix of reviews and experimental studies, many of which are indexed in Scopus and related journals.

4.2 Discussion

4.2.1 Traditional Use Versus Scientific Evidence

The traditional use of Kaempferia galanga is widespread in Southeast Asia, with claims of efficacy for treating ailments such as gout, diarrhea, bronchitis, and even more severe diseases like tuberculosis and leprosy [1]. However, the evidence from scientific studies is mixed. For example, while some studies support its antibacterial and anti-inflammatory effects, there is insufficient evidence to confirm its effectiveness in treating leprosy and tuberculosis, where its traditional application is most controversial [2].

The inconsistency between traditional uses and scientific validation is not uncommon in herbal medicine research. This gap underscores the need for more rigorous clinical trials to verify the

efficacy and safety of K. galanga across different medical conditions. Moreover, many of the studies conducted are preclinical, and further research on humans is necessary to substantiate the therapeutic claims.

4.2.2 Safety Concerns and Toxicity

One of the major areas of concern identified in this review is the potential toxicity of K. galanga when consumed in large doses or over prolonged periods. The reported genotoxicity and respiratory toxicity raise critical questions about the plant's safety, particularly for vulnerable populations such as pregnant women and individuals with pre-existing respiratory conditions [3].

Further toxicological studies are needed to establish safe dosage guidelines for K. galanga. Until such data is available, its use should be approached with caution, especially in populations that may be at higher risk of adverse effects.

4.2.3 Future Directions for Research

This review highlights the need for future research to focus on closing the gap between traditional knowledge and scientific validation. Clinical trials, especially randomized controlled trials (RCTs), are essential to establishing a more conclusive understanding of the therapeutic potential of K. galanga. Future studies should also explore the pharmacokinetics and pharmacodynamics of the plant's bioactive compounds to better understand their effects on the human body [2].

Additionally, more comprehensive studies are needed to determine the safety profile of K. galanga, particularly regarding its genotoxic and respiratory effects. Such research is crucial for ensuring that this widely used plant is applied safely and effectively in both traditional and modern medical settings.

5 Conclusion

The traditional uses of Kaempferia galanga are deeply rooted in Southeast Asian medicine, with a long history of treating a variety of ailments. While modern scientific research has validated some of these uses, particularly its antibacterial, anti-inflammatory, and antioxidant properties, significant concerns remain regarding its safety and efficacy. Genotoxicity, respiratory toxicity, and inconsistent findings regarding its use for severe diseases like tuberculosis and leprosy highlight the need for caution in applying K. galanga in modern therapeutic contexts.

Moving forward, future research must prioritize well-designed clinical trials and comprehensive toxicological assessments to establish safe and effective usage guidelines for K. galanga. With more rigorous scientific validation, this ancient plant may find a place in modern pharmacology, but only if its risks are thoroughly understood and mitigated.

This systematic review highlights the complexities and controversies surrounding the traditional uses of Kaempferia galanga. While there is substantial evidence supporting its pharmacological properties, including antibacterial, anti-inflammatory, and antioxidant effects, significant gaps remain in understanding its safety and efficacy, particularly concerning its use for conditions like tuberculosis and leprosy. The reported genotoxicity and respiratory toxicity raise important concerns that must be addressed through further rigorous research.

The discrepancies between traditional claims and scientific evidence underscore the need for more robust clinical trials, particularly randomized controlled trials, to validate the therapeutic potential of K. galanga. Additionally, detailed toxicological studies are necessary to establish safe

dosage guidelines and prevent adverse effects.

In conclusion, while K. galanga holds promise as a medicinal plant, particularly in Southeast Asian traditional medicine, its application should be approached with caution until its safety and efficacy are conclusively demonstrated through clinical research. Future studies should aim to bridge the gap between traditional knowledge and modern science to ensure that the therapeutic use of K. galanga is both effective and safe for broader populations.

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