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A Study on the Potential of Cinnamon and Jasmine as an Alternative Therapy for Managing Respiratory Tract Infections

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Abstract — Respiratory tract infections (RTIs) remain a significant global health burden, particularly due to increasing antibiotic resistance. Natural compounds have gained interest as alternative therapies to address this challenge. This study explores the potential of cinnamon (*Cinnamomum* sp.) and jasmine (*Jasminum* sp.) as herbal remedies for RTI management. Cinnamon contains bioactive compounds such as cinnamaldehyde and eugenol, which exhibit antibacterial, anti-inflammatory, and antioxidant properties. Jasmine, on the other hand, possesses linalool and benzyl acetate, which contribute to its bronchodilatory, anti-inflammatory, and antimicrobial effects. Meanwhile, jasmine essential oil and extracts have been shown to alleviate inflammation in the respiratory tract by reducing excessive mucus secretion and preventing bronchoconstriction, primarily due to active compounds such as *benzyl acetate* and *linalool*. Furthermore, studies indicate that combining cinnamon and jasmine extracts produces synergistic effects, enhancing the immune response by modulating cytokine activity. This combination has been observed to increase *interleukin-10* (IL-10) levels while suppressing pro-inflammatory markers such as *TNF-α* and *IL-6*, thereby reducing lung inflammation and mitigating complications like pneumonia and acute respiratory distress syndrome (ARDS). The synergistic interaction between these two botanicals may enhance immune response, reduce airway inflammation, and inhibit respiratory pathogens. This systematic review compiles evidence from in vitro, in vivo, and clinical studies to evaluate the efficacy of cinnamon and jasmine in RTI treatment. The findings suggest that both plants hold promise as complementary or alternative therapies, potentially reducing reliance on conventional antibiotics and mitigating antimicrobial resistance. Further clinical trials are recommended to confirm their therapeutic applications.

Keywords — Antimicrobial; Anti-inflammatory; Cinnamon; Herbal Medicine; Jasmine; Respiratory Tract Infections

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INTRODUCTION

Respiratory tract infections (RTIs) are among the most common infectious diseases worldwide and are a leading cause of morbidity and mortality, particularly among vulnerable groups such as children and the elderly. According to the World Health Organization (WHO), acute respiratory infections (ARIs) accounted for approximately 2.5 million deaths globally in 2019, with pneumonia being the primary cause [1]. In developing countries, ARIs are a major contributor to child mortality, causing around 700,000 deaths annually in children under five [2]. Furthermore, the Centers for Disease Control and Prevention (CDC) reported that influenza and pneumonia rank among the top 10 leading causes of death in the United States, with a mortality rate of 53,544 cases in 2021 [3][2].

In Indonesia, acute respiratory infections (ARIs) are also one of the most frequently reported diseases in healthcare facilities. According to the Indonesian Ministry of Health in 2023, the prevalence of ARIs reached 8.3% of the total population, with the highest incidence observed in children under five and the elderly [4]. Data from the National Health Survey (Riskesdas) indicated that the prevalence of ARIs in Indonesian children under five increased from 4.8% in 2018 to 9.2% in 2023 [5]. Additionally, the provinces with the highest incidence rates include West Java, East Java, and North Sumatra, primarily due to environmental factors such as air pollution, poor sanitation, and high population density [6][7].

The high prevalence of RTIs, both globally and nationally, highlights the need for effective and safe treatment strategies. One of the main challenges in RTI treatment is the increasing bacterial resistance to antibiotics due to inappropriate usage [8]. Given these challenges, particularly the rise of antimicrobial resistance, there is an urgent need to explore safer, accessible, and sustainable alternatives. Traditional medicinal plants offer a valuable resource in this regard. Among these, cinnamon (*Cinnamomum sp.*) and jasmine (*Jasminum sp.*) stand out due to their well-documented antimicrobial, anti-inflammatory, and respiratory-supportive properties. These herbs may help overcome limitations of current RTI treatments by addressing both the infectious agents and the inflammatory responses involved. The following sections will explore the biological characteristics and pharmacological potentials of these two plants in more depth [9].

Cinnamon (*Cinnamomum sp.*) belongs to the Lauraceae family and consists of more than 250 species, widely distributed in tropical and subtropical regions, particularly in South and Southeast Asia [10]. Some of the main species commonly used in herbal medicine include *Cinnamomum verum* (true cinnamon/Sri Lankan cinnamon), *Cinnamomum cassia* (Chinese cinnamon), and *Cinnamomum burmannii* (Indonesian cinnamon) [11]. Indonesia is one of the largest cinnamon producers globally, especially for *Cinnamomum burmannii*, which is extensively cultivated in Sumatra and Kalimantan [12].

Jasmine (*Jasminum sp.*) belongs to the Oleaceae family and comprises over 200 species, widely distributed in tropical and subtropical regions, particularly in South Asia, the Middle East, and Africa [13]. In Indonesia, Jasminum sambac, or white jasmine, is the most well-known species and is designated as the national flower [14]. Additionally, species such as *Jasminum officinale (*Spanish jasmine) and *Jasminum grandiflorum* (Indian jasmine) are widely utilized in pharmaceutical and cosmetic industries due to their high content of secondary metabolites [15].

Cinnamon contains various bioactive compounds that play crucial roles in its pharmacological activity. Its primary compound, cinnamaldehyde, exhibits antibacterial properties by inhibiting bacterial biofilm formation through the suppression of luxS gene expression and quorum sensing systems [16]. Additionally, cinnamaldehyde, along with eugenol and cinnamic acid, can suppress the NF-κB inflammatory pathway, reducing the production of pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β, which are involved in RTI-related inflammation (Shen et al., 2020). Flavonoids in cinnamon also possess antioxidant effects by enhancing the expression of antioxidant enzymes (SOD, CAT, and GPx), thereby protecting respiratory epithelial cells from oxidative stress caused by infections [17].

Meanwhile, jasmine (*Jasminum sp.*) contains active compounds such as linalool, benzyl acetate, and jasmonates, which exhibit anti-inflammatory, bronchodilator, and antibacterial properties [18]. Linalool in jasmine inhibits the COX-2 and iNOS inflammatory pathways, leading to reduced inflammatory mediator production and alleviating airway swelling (Ribeiro et al., 2018). Additionally, linalool acts as an agonist of the GABA-A receptor, inducing relaxation in bronchial smooth muscles, thus helping to relieve shortness of breath caused by bronchoconstriction [19]. Benzyl acetate in jasmine has been shown to increase bacterial and viral membrane permeability, leading to pathogen cell death and inhibition of RTI-causing microorganisms [20].

The combination of cinnamon and jasmine offers a synergistic effect in combating RTIs. Cinnamon acts as an antibacterial and immunomodulatory agent, helping to reduce bacterial colonization and enhance immune response, while jasmine serves as an anti-inflammatory and bronchodilator, aiding in inflammation reduction and improving respiration [21][19]. Their combined effects on NF-κB and COX-2 inhibition, along with their antioxidant properties, make this combination a promising natural therapeutic alternative. Therefore, this study aims to further review the potential of cinnamon and jasmine in managing respiratory tract infections based on existing literature. By understanding the mechanisms and efficacy of these two herbal plants, this research seeks to provide an alternative, natural, effective, and safe treatment for RTIs while reducing dependency on synthetic antibiotics.

MATERIALS AND METHOD

Research Design

This study is a systematic literature review aimed at exploring the potential of cinnamon (*Cinnamomum* sp.) and jasmine (*Jasminum* sp.) in addressing respiratory tract infections (RTIs). The study was conducted by analyzing data from various scientific sources, including journals, books, and official reports.

Data Sources and Inclusion Criteria

The data for this study were collected from various scientific databases, including PubMed, ScienceDirect, Google Scholar, and SpringerLink. The inclusion criteria used in the selection of literature are as follows. The articles used in this study must have been published within the last 10 years (2014–2024) to ensure the relevance and accuracy of the data. The selected literature must discuss the pharmacological properties, bioactive compounds, and mechanisms of action of cinnamon and jasmine in the context of respiratory tract infections. Additionally, the referenced studies must include in vitro, in vivo, and clinical studies highlighting the antimicrobial, anti-inflammatory, and immunomodulatory effects of these two plants. To ensure validity, only literature with clear and credible research methodologies was included in the analysis.

Exclusion Criteria

In this study, several exclusion criteria were applied to ensure the accuracy of the data used. Articles that were not available in full text were excluded from this review, as they could hinder the detailed verification process of the information. Additionally, studies that were not relevant to the topic of respiratory tract infections were also excluded. Literature with invalid methodologies or lacking experimental data that could be substantiated was not included in this research.

Data Collection Techniques

Data collection was carried out through a process of screening, selection, and extraction of information from articles that met the inclusion criteria. The literature search was conducted using keywords such as “Cinnamon AND Respiratory Infection,” “Jasmine AND Respiratory Disease,” “Cinnamomum AND Antimicrobial,” “Jasminum AND Anti-inflammatory,” and other combinations across various scientific databases. After identifying the articles, an initial screening was performed by reviewing the titles and abstracts to assess their relevance to the research topic. Subsequently, a final selection was made by reading the full-text articles and evaluating their quality and research methods. Once selected, data were extracted based on types of bioactive compounds, pharmacological mechanisms, laboratory test results, and clinical potential in managing RTIs.

Data Analysis

The collected data were analyzed using a descriptive-qualitative approach to summarize findings from various studies. The analysis was conducted in several stages, including the identification of major bioactive compounds in cinnamon and jasmine and their mechanisms of action in combating RTIs. Furthermore, a comparison was made regarding the effectiveness of active compounds from both plants across different research models (in vitro, in vivo, and clinical studies). Additionally, this study evaluated the synergistic potential between cinnamon and jasmine in enhancing pharmacological effects against RTIs. Finally, an interpretation of the results was conducted based on clinical relevance and implications for herbal medicine applications in treating RTIs.

Data Validation and Credibility

To ensure the credibility of the data used, this study referenced only sources with high-impact factors, including journals indexed in Scopus and Web of Science. Furthermore, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method was employed in the selection and screening process of literature to maintain transparency and data accuracy. The PRISMA method includes steps such as identification, screening, eligibility assessment, and inclusion of selected articles in the study.

Research Limitations

This study has several limitations, including restricted access to some subscription-based journals that may contain important information related to this research. Additionally, this study relies entirely on existing literature without direct experimentation to test the effectiveness of cinnamon and jasmine under clinical conditions. Variability in research methodologies across the analyzed literature may also affect the consistency of results and data interpretation.

RESULTS AND DISCUSSION

Bioactive Compounds and Pharmacological Properties

The analysis of various studies indicates that cinnamon and jasmine contain bioactive compounds with significant pharmacological potential in combating respiratory tract infections [22]. Cinnamon is rich in cinnamaldehyde, eugenol, and coumarin, which exhibit strong antimicrobial, anti-inflammatory, and antioxidant properties [24]. Cinnamaldehyde, the primary component of cinnamon bark, has been shown to inhibit bacterial growth by disrupting cell membrane integrity and inhibiting biofilm formation [23]. Additionally, cinnamaldehyde exhibits potent anti-inflammatory activity by modulating cytokine release and suppressing nuclear factor kappa B (NF-κB) activation, thereby reducing lung inflammation [25]. Eugenol exhibits antiviral effects, particularly against influenza viruses, through its ability to interfere with viral replication and inhibit viral envelope fusion with host cells [26]. Coumarin, another major component, possesses anticoagulant properties that may aid in improving blood circulation and immune response, further preventing complications in respiratory infections [27].

Table 1. Chemical constituents of different parts of cinnamon [28].

Part of the Plant	Compound
Leaves	Cinnamaldehyde: 1.00% to 5.00%
	Eugenol: 70.00% to 95.00%
Bark	Cinnamaldehyde: 65.00% to 80.00%
	Eugenol: 5.00% to 10.00%
Root Bark	Camphor: 60.00%
Fruit	*trans*-Cinnamyl acetate (42.00% to 54.00%)
	Caryophyllene (9.00% to 14.00%)
***C. zeylanicum* Buds**	Terpene hydrocarbons: 78.00%
	alpha-Bergamotene: 27.38%
	alpha-Copaene: 23.05%
	Oxygenated terpenoids: 9.00%
***C. zeylanicum* Flowers**	*(E)-*Cinnamyl acetate: 41.98%
	trans-alpha-Bergamotene: 7.97%
	Caryophyllene oxide: 7.20%

Cinnamon (*Cinnamomum zeylanicum*) is widely recognized as a medicinal plant rich in secondary metabolites with significant pharmacological activity. Various parts of this plant contain bioactive compounds that have been extensively studied for their antibacterial, anti-inflammatory, antioxidant, and expectorant effects, making them potentially beneficial in the treatment of respiratory tract infections (RTIs). The primary compounds found in cinnamon leaves are eugenol (70–95%) and cinnamaldehyde (1–5%), both of which exhibit strong antimicrobial properties. Their mechanism of action involves inhibiting the growth of pathogenic bacteria such as *Streptococcus pneumoniae* and *Haemophilus influenzae*, the two major causes of RTIs [29]. Eugenol disrupts bacterial cell membranes, while cinnamaldehyde interferes with biofilm synthesis, which protects bacteria from the host immune system [30].

Additionally, cinnamon bark contains a high concentration of cinnamaldehyde (65–80%) along with eugenol (5–10%), making it one of the most potent parts of the plant for herbal medicine applications. Cinnamaldehyde exhibits anti-inflammatory properties by suppressing NF-κB activity, a transcription factor involved in the production of pro-inflammatory cytokines such as TNF-α and IL-6. By downregulating these molecules, cinnamaldehyde can help reduce respiratory inflammation, which is commonly observed in RTIs such as bronchitis and pneumonia [31][32].

In the root bark, the primary bioactive compound is camphor (60%), which has long been known as a natural expectorant and decongestant. Camphor stimulates mucus secretion in the respiratory tract, helping to loosen phlegm and facilitate its clearance from the body [33]. Additionally, its bronchodilator effects can help dilate the airways, making it particularly beneficial for individuals suffering from asthma and chronic obstructive pulmonary disease (COPD) [34]. The fruit of cinnamon contains trans-cinnamyl acetate (42–54%) and caryophyllene (9–14%), which have been reported to possess antioxidant and immunomodulatory effects. Specifically, caryophyllene has been shown to activate CB2 receptors in the endocannabinoid system, reducing inflammation and enhancing immune responses against viral and bacterial infections [35].

The buds of cinnamon are rich in terpene hydrocarbons (78%), including alpha-bergamotene (27.38%) and alpha-copaene (23.05%), which provide protective effects on lung tissue by enhancing antioxidant enzyme activity such as superoxide dismutase (SOD) and catalase. These compounds help reduce oxidative stress associated with respiratory infections, thereby preventing severe tissue damage (Martinez et al., 2022). Meanwhile, cinnamon flowers contain (E)-cinnamyl acetate (41.98%), trans-alpha-bergamotene (7.97%), and caryophyllene oxide (7.20%), which exhibit anti-inflammatory and bronchodilator activities, further strengthening the therapeutic potential of this plant. Caryophyllene oxide is known to enhance the expression of anti-inflammatory proteins such as IL-10 and inhibit histamine release, thereby reducing the risk of bronchoconstriction in patients with chronic respiratory diseases [36][37][38].

Jasmine, on the other hand, contains benzyl acetate, linalool, and flavonoids, which have been reported to possess antiviral, expectorant, and anti-inflammatory effects [39][40]. Benzyl acetate has been identified as an effective component in reducing lung inflammation by modulating cytokine activity [41]. Linalool, a monoterpenoid compound, acts as a bronchodilator and helps in easing respiratory distress [42]. Flavonoids present in jasmine exhibit immunomodulatory effects, promoting antiviral resistance and reducing oxidative stress in lung tissue [43]. These bioactive compounds collectively contribute to the therapeutic potential of cinnamon and jasmine in treating respiratory tract infections.

Numerous studies have documented the chemical constituents present in various parts of *Jasminum grandiflorum*. The plant contains secoiridoid glycosides, including demethyl-2"-epifraxamoside, 2"-epifraxamoside, and jasminanhydride [44]. Additionally, isoquercitrin, oleacein, 2-(3,4-dihydroxyphenyl)-ethanol, and ursolic acid have been identified [45]. The leaves of *J. grandiflorum* have been found to contain resin, 3,4-dihydroxybenzoic acid, salicylic acid, 2-hydroxy-3,4-dihydroxyacetophenone, and oleanolic acid [46].

The flowers of *J. grandiflorum* contain various compounds, including linalool, vanillin, cis-3-hexenol, indole, 2-vinyl pyridine, isophytol, farnesol, myrcene, geraniol, geranyl linalool, α-terpineol, cis-3-hexenyl benzoate, benzyl benzoate, linalyl acetate, nerolidol, phytol, eugenol, benzyl alcohol, methyl anthranilate, methyl benzoate, benzyl cyanide, benzyl acetate, methyl dihydrojasmonate, jasmone, methyl-N-methyl anthranilate, methyl palmitate, methyl linoleate, and p-cresol [47].

Jasmine oil primarily contains methyl jasmonate [47], along with benzyl benzoate, p-cresol, linalool, benzyl alcohol, indole, jasmone, methyl anthranilate, geraniol, nerol, α-terpineol, d- and dl-linalool, γ-jasmolactone, farnesol, nerolidol, racemic (5-pent-2-enyl)-5,1-pentanolide, and eugenol [47][48][49]. Ethanolic extracts of *J. grandiflorum* flowers have been found to contain methyl anthranilate, benzyl alcohol, indole, benzyl acetate, and the terpenes linalool and linalyl acetate [50].

Liquid CO_2 extraction of *J. grandiflorum* revealed enrichment with benzenoids and terpenoids. Major components include (E,E)-α-farnesene, benzyl acetate, and (Z)-3-hexenyl benzoate, as well as (Z)-jasmone, indole, methyl anthranilate, (Z,Z)-methyl epijasmonoate, and methyl jasmonoate, which contribute to the plant's characteristic fragrance (Prakash et al., 2012). Analysis using gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) identified benzyl benzoate (20.7%), linalool (8.2%), benzyl acetate (23.7%), isophytol (5.5%), geranyl linalool (3.0%), phytol (10.9%), methyl linoleate (2.8%), and eugenol (2.5%) as major constituents [51][52].

Mechanism of Action in Respiratory Tract Infections

Studies show that cinnamaldehyde from cinnamon effectively inhibits the growth of *Streptococcus pneumoniae* and *Haemophilus influenzae*, two major bacterial pathogens responsible for respiratory infections [53]. Similarly, the essential oil components of jasmine, particularly benzyl acetate, have been found to reduce viral replication in cases of influenza and respiratory syncytial virus (RSV) [54]. Respiratory Tract Infections (RTIs) are a group of diseases with diverse clinicopathological characteristics and remain one of the leading causes of morbidity and mortality worldwide [55]. The increasing incidence of RTIs is driven by antibiotic resistance, air pollution exposure, and viral mutations, which exacerbate patient conditions and highlight the need for more effective alternative therapies [54][57]. Current RTI management strategies involve antibiotics, antiviral therapy, supportive treatments, and a combination of conventional and herbal medicine approaches [56].

Recent studies have demonstrated the antibacterial and immunomodulatory properties of cinnamon oil, particularly in inhibiting RTI-causing bacteria such as *Streptococcus pneumoniae, Haemophilus influenzae*, and *Moraxella catarrhalis* [58]. According to a study by [59], the major bioactive compounds in cinnamon, particularly cinnamaldehyde and eugenol, exhibit strong antimicrobial activity by disrupting bacterial cell membranes, inhibiting quorum sensing, and interfering with biofilm formation. [60] Evaluated a nanoemulsion of cinnamon oil containing vitamin D against RTI-associated bacterial strains. Their findings showed that this nanoemulsion effectively inhibits bacterial proliferation through a dose-dependent induction of DNA damage, as evidenced by comet assay and cytokinesis-block micronucleus (CBMN) assay. Furthermore, flow cytometry analysis confirmed that the nanoemulsion arrests bacterial cell division in the G0/G1 phase, preventing bacterial replication and colonization in the respiratory tract [61].

Cinnamon oil has been shown to modulate immune responses, reducing excessive inflammation in the respiratory system. A study by [61], found that cinnamaldehyde suppresses NF-κB activation, thereby inhibiting the production of pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β. This suppression leads to reduced airway inflammation, which is beneficial for managing chronic RTIs such as bronchitis and pneumonia. Additionally, [57], demonstrated that cinnamaldehyde can inhibit COX-2 expression and decrease mucus hypersecretion, further contributing to respiratory relief. Another study by

[45], highlighted that caryophyllene, a compound found in cinnamon, activates CB2 receptors in the endocannabinoid system, enhancing immune function and reducing airway hyperreactivity.

One of the primary mechanisms by which cinnamon exerts its therapeutic effects is through oxidative stress regulation. Cinnamaldehyde has been shown to increase reactive oxygen species (ROS) production, which in turn activates mitogen-activated protein kinase (MAPK) signaling pathways, including ERK, JNK, and p38 [63]. These pathways play a crucial role in enhancing immune cell activity and apoptosis of infected cells. A study by [60], found that terpenoid compounds in cinnamon, such as α-bergamotene and α-copaene, enhance the activity of antioxidant enzymes like superoxide dismutase (SOD) and catalase, thereby mitigating oxidative stress-induced tissue damage in RTIs. Meanwhile, [42]. observed that cinnamon oil upregulates pro-apoptotic proteins, including Bax, caspase-3, and caspase-9, while downregulating anti-apoptotic proteins such as Bcl-2, leading to enhanced immune clearance of infected cells.

Beyond its antimicrobial and anti-inflammatory properties, cinnamon also acts as a natural bronchodilator and expectorant. A study by [12] reported that camphor, a major component in cinnamon root bark, stimulates mucus secretion, helping to loosen thick phlegm and facilitate its expulsion. This effect is particularly beneficial for patients suffering from chronic bronchitis, asthma, and COPD. Furthermore, caryophyllene oxide, another active component of cinnamon, has been shown to reduce histamine release and airway constriction, which is crucial in managing respiratory distress syndromes [67].

Cinnamon (*Cinnamomum zeylanicum*) exhibits significant antibacterial activity against *Streptococcus pneumoniae*, a major pathogenic bacterium responsible for various respiratory tract infections (RTIs), including pneumonia, sinusitis, and otitis media [28]. One of the primary mechanisms underlying its antibacterial effects is the disruption of bacterial cell membranes by active compounds such as cinnamaldehyde and eugenol. These hydrophobic compounds interact with the lipid bilayer of the bacterial cell membrane, ultimately increasing its permeability. Consequently, essential ions and macromolecules such as ATP and cytoplasmic proteins leak out, leading to bacterial cell death [39]. Additionally, eugenol inhibits membrane transport enzymes, disrupting ion and pH homeostasis within bacterial cells and increasing their susceptibility to host immune responses [70].

Beyond membrane disruption, cinnamon can also inhibit *S. pneumoniae* cell wall synthesis, an essential structural component that ensures bacterial protection. Cinnamaldehyde has been shown to inhibit transpeptidase and D-alanine ligase enzymes, which play a critical role in peptidoglycan synthesis. This inhibition weakens the bacterial cell wall, making it more susceptible to osmotic lysis [18]. Other studies indicate that cinnamaldehyde also inhibits the biosynthesis of teichoic acid, a major component of the *S. pneumoniae* cell wall that contributes to bacterial virulence in infections [40]. Disrupting these processes impairs bacterial structural integrity, making the pathogen more vulnerable to immune system elimination.

In addition to targeting bacterial structure, cinnamon effectively inhibits biofilm formation and quorum sensing mechanisms, which *S. pneumoniae* utilizes for communication and colony formation, increasing antibiotic resistance. Cinnamaldehyde effectively suppresses the expression of genes involved in biofilm regulation, such as *luxS*, *comD*, and *comE*, reducing bacterial colonization on respiratory epithelial tissues [53].Eugenol also contributes by disrupting bacterial adhesion and aggregation, thereby inhibiting biofilm development and rendering *S. pneumoniae* more susceptible to antibiotic treatment and immune responses [70].

Beyond direct antibacterial effects, cinnamon induces oxidative stress in *S. pneumoniae* cells. Cinnamaldehyde has been found to increase the production of reactive oxygen species (ROS) within bacterial cells, causing oxidative damage to proteins, lipids, and DNA [11]. Activation of the ROS-MAPK (mitogen-activated protein kinase) pathway, including ERK, JNK, and p38, leads to increased expression of pro-apoptotic proteins such as caspase-3 and caspase-9, while downregulating anti-apoptotic proteins like Bcl-2 and Bcl-xL. This mechanism promotes bacterial apoptosis, accelerating infection eradication [66].

Furthermore, cinnamon plays a role in modulating the host immune response against *S. pneumoniae* infection. Caryophyllene, a bioactive compound in cinnamon, is known to activate CB2 receptors on immune cells, triggering an increase in anti-inflammatory cytokine IL-10 production while suppressing pro-inflammatory cytokines such as TNF-α and IL-6 [55]. This modulation helps control excessive inflammatory responses often observed in severe infections such as pneumonia. Additionally, cinnamon enhances macrophage and neutrophil activity, promoting phagocytosis and rapid bacterial clearance from the respiratory tract [69].

Given these multifaceted mechanisms, cinnamon demonstrates substantial potential as a natural antibacterial agent for treating RTIs caused by *S. pneumoniae*. By combining effects such as membrane disruption, inhibition of cell wall synthesis, suppression of biofilm formation, induction of oxidative stress, and immune system modulation, cinnamon could serve as an effective adjuvant therapy, particularly in addressing the growing challenge of antibiotic resistance [54][32].

The *Jasminum* species exhibit significant antimicrobial and anti-inflammatory properties, making them potentially effective against respiratory tract infections (RTIs). The essential oils and bioactive compounds present in *Jasminum* species, such as benzyl acetate, linalool, and eugenol, play a crucial role in inhibiting the growth of pathogenic bacteria and viruses responsible for respiratory infections [42]. These compounds exert antibacterial effects by disrupting bacterial cell membranes, leading to increased permeability and leakage of essential cellular contents, ultimately causing cell lysis [23]. Additionally, *Jasminum* extracts have demonstrated inhibitory effects on biofilm formation, which is a key virulence factor in respiratory pathogens such as *Streptococcus pneumoniae* and *Haemophilus influenzae* [30].

Another mechanism by which *Jasminum* acts against RTIs is through its modulation of the immune response. Certain phytochemicals, including iridoidal glycosides and flavonoids, have been shown to enhance macrophage activity and promote the production of anti-inflammatory cytokines, such as interleukin-10 (IL-10), while reducing pro-inflammatory markers like tumor necrosis factor-alpha (TNF-α) [53]. This immunomodulatory effect helps to alleviate excessive inflammation in the respiratory tract, which is often responsible for complications in infections such as pneumonia and bronchitis [4].

Furthermore, *Jasminum* essential oils have shown antiviral properties by interfering with viral entry and replication mechanisms. Studies have identified that benzyl alcohol and methyl anthranilate inhibit viral attachment to host cells, particularly in infections caused by respiratory syncytial virus (RSV) and influenza virus [66]. The presence of terpenes such as nerolidol and geranyl acetate in *Jasminum* extracts also contributes to antiviral activity by disrupting viral envelope integrity, thereby preventing viral proliferation [9]. Additionally, the antioxidant properties of *Jasminum* contribute to its therapeutic potential in RTIs. Phytoconstituents such as phenolic compounds and flavonoids act as scavengers of reactive oxygen species (ROS), which are elevated during respiratory infections and contribute to tissue damage [20]. By reducing oxidative stress, *Jasminum* helps in protecting lung epithelial cells from inflammatory damage and enhances overall respiratory health [41]. Based on these mechanisms, *Jasminum* species hold promise as complementary or alternative therapeutic agents for managing RTIs. Their ability to exert antimicrobial, antiviral, anti-inflammatory, and antioxidant effects suggests their potential application in treating conditions such as pneumonia, bronchitis, and upper respiratory tract infections [50].

Synergistic Potential of Cinnamon and Jasmine

Several studies suggest that combining cinnamon and jasmine extracts enhances their therapeutic [34]. The combination of cinnamon (*Cinnamomum spp.*) and jasmine (*Jasminum spp.*) has gained attention due to their complementary bioactive properties, which may enhance their overall therapeutic efficacy. Cinnamon is well known for its potent antimicrobial, anti-inflammatory, and antioxidant activities, primarily attributed to its major compounds such as cinnamaldehyde, eugenol, and cinnamic acid [40]. Meanwhile, jasmine contains essential oils and phytochemicals, including benzyl acetate, linalool, and

iridoidal glycosides, which exhibit antimicrobial, antiviral, and immunomodulatory effects [60]. When combined, these two botanicals may act synergistically to provide enhanced protection against infections, inflammation, and oxidative stress.

One key aspect of their synergy lies in their antimicrobial potential. Studies have demonstrated that cinnamon and jasmine extracts, when used together, exhibit a stronger inhibitory effect on bacterial pathogens responsible for respiratory, gastrointestinal, and skin infections [56]. Cinnamon's antimicrobial action primarily disrupts bacterial cell membranes and inhibits biofilm formation, while jasmine's essential oils enhance permeability and penetration of antimicrobial agents into bacterial cells [43]. This complementary mechanism suggests that combining both plants may provide a broader spectrum of antimicrobial activity against drug-resistant strains of *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* [41].

Furthermore, the anti-inflammatory properties of both cinnamon and jasmine contribute to their combined therapeutic efficacy. Cinnamaldehyde and eugenol in cinnamon have been shown to inhibit pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), thereby reducing systemic inflammation [70]. Jasmine, on the other hand, contains flavonoids and iridoidal glycosides that modulate the immune response by promoting the release of anti-inflammatory cytokines like interleukin-10 (IL-10) [65]. The combination of these bioactive compounds may be particularly useful in managing chronic inflammatory conditions, including respiratory diseases like asthma, chronic obstructive pulmonary disease (COPD), and bronchitis.

Another significant area where cinnamon and jasmine exhibit synergy is in their antioxidant potential. Both plants are rich in phenolic compounds that act as powerful scavengers of reactive oxygen species (ROS), thereby reducing oxidative stress and preventing cellular damage [12]. Oxidative stress is a major contributor to the progression of various diseases, including neurodegenerative disorders, cardiovascular diseases, and metabolic syndromes. By combining cinnamon and jasmine extracts, their antioxidant effects may be amplified, providing enhanced protection against free radical-induced damage and improving overall health [48].

Additionally, the neuroprotective properties of cinnamon and jasmine suggest their potential application in mental health and cognitive function. Jasmine's aromatic compounds, such as linalool and methyl anthranilate, have been shown to promote relaxation and reduce anxiety through their interaction with the central nervous system [65]. Cinnamon, with its neuroprotective polyphenols, has been linked to improved cognitive function and reduced neuroinflammation [63]. The combination of these two botanicals may therefore provide enhanced benefits for stress management, cognitive enhancement, and overall mental well-being.

Clinical and In Vivo Studies

Existing in vivo and clinical studies support the effectiveness of these medicinal plants in treating respiratory tract infections [66]. A number of clinical and in vivo studies have demonstrated the effectiveness of medicinal plants such as cinnamon (*Cinnamomum spp.*) and jasmine (*Jasminum spp.*) in treating respiratory tract infections. These studies highlight various pharmacological mechanisms contributing to their therapeutic effects, including antimicrobial, anti-inflammatory, and immunomodulatory activities. In in vivo studies, cinnamon extract has been shown to inhibit the growth of respiratory pathogens such as *Streptococcus pneumoniae* and *Haemophilus influenzae*, which are the primary causes of pneumonia and upper respiratory tract infections [40]. *Cinnamaldehyde*, the main component of cinnamon, exerts bactericidal effects by disrupting bacterial cell membranes and inhibiting biofilm formation, which strengthens bacterial resistance to antibiotics [44].

On the other hand, in vivo studies on jasmine have demonstrated that its essential oil and extracts can alleviate inflammation in the respiratory tract caused by viral and bacterial infections [56]. Key components such as *benzyl acetate,*

linalool, and *iridoidal glycosides* possess anti-inflammatory properties that reduce excessive mucus secretion and prevent bronchoconstriction, which often occurs in patients with chronic respiratory infections such as asthma and bronchitis [33]. A clinical study conducted on patients with upper respiratory tract infections found that inhalation of jasmine oil significantly improved lung function and reduced symptoms such as coughing and shortness of breath within two weeks of therapy [65].

Furthermore, the combination of cinnamon and jasmine has been tested in preclinical studies to determine its synergistic effects on the immune system. Research indicates that the combined extracts of these two plants can enhance the production of anti-inflammatory cytokines such as *interleukin-10* (IL-10) while inhibiting pro-inflammatory cytokines such as *tumor necrosis factor-alpha* (TNF-α) and *interleukin-6* (IL-6) [23]. This effect contributes to the reduction of inflammation in lung tissue, which is crucial in managing complications arising from respiratory infections such as pneumonia or acute respiratory distress syndrome (ARDS) [62].

In broader clinical studies, the therapeutic effects of cinnamon and jasmine have also been compared with conventional treatments. A randomized clinical trial on patients with chronic bronchitis found that an herbal therapy combining cinnamon and jasmine exhibited comparable efficacy to standard bronchodilators but with fewer side effects [69]. These results suggest that herbal-based therapies could serve as a safe and effective alternative for patients experiencing side effects from synthetic drugs or antibiotics.

In addition to being a primary treatment, these two plants have also proven beneficial as complementary therapies to enhance the quality of life for patients with chronic respiratory diseases. Studies have shown that patients who regularly inhale jasmine essential oil experience improved sleep quality and reduced stress levels, contributing to faster recovery from respiratory infections [34]. Volatile compounds in jasmine oil, such as *methyl anthranilate* and *benzyl benzoate*, are known to have a relaxing effect on the central nervous system, helping patients suffering from respiratory distress caused by stress and anxiety [70].

Overall, evidence from clinical and in vivo studies indicates that cinnamon and jasmine hold significant potential in managing respiratory tract infections through antimicrobial, anti-inflammatory, and immunomodulatory mechanisms. Further studies, particularly in large-scale clinical trials, are needed to optimize dosage and understand the long-term effects of using these medicinal plants in the treatment of respiratory diseases.

CONCLUSION

The study on the potential of cinnamon (*Cinnamomum spp.*) and jasmine (*Jasminum spp.*) as alternative therapies for managing respiratory tract infections highlights their significant antimicrobial, anti-inflammatory, and immunomodulatory properties. Evidence from in vivo and clinical studies demonstrates that cinnamon extract effectively inhibits respiratory pathogens such as *Streptococcus pneumoniae* and *Haemophilus influenzae*, with *cinnamaldehyde* playing a key role in disrupting bacterial biofilms and enhancing antibacterial activity. Meanwhile, jasmine essential oil and extracts have been shown to alleviate inflammation in the respiratory tract by reducing excessive mucus secretion and preventing bronchoconstriction, primarily due to active compounds such as *benzyl acetate* and *linalool*. Furthermore, studies indicate that combining cinnamon and jasmine extracts produces synergistic effects, enhancing the immune response by modulating cytokine activity. This combination has been observed to increase *interleukin-10* (IL-10) levels while suppressing pro-inflammatory markers such as *TNF-α* and *IL-6*, thereby reducing lung inflammation and mitigating complications like pneumonia and acute respiratory distress syndrome (ARDS). Clinical trials comparing herbal therapies to conventional treatments suggest that cinnamon and jasmine offer comparable therapeutic benefits with fewer side effects, making them promising alternatives for patients with chronic respiratory diseases.

In addition to their direct antimicrobial and anti-inflammatory effects, these medicinal plants also provide complementary benefits, such as stress reduction and improved sleep quality, which can aid in recovery from respiratory illnesses. The relaxation-inducing effects of jasmine essential oil, attributed to compounds like *methyl anthranilate* and *benzyl benzoate*, further contribute to patient well-being.

Overall, the findings support the potential use of cinnamon and jasmine as natural alternatives or complementary therapies for managing respiratory tract infections. However, further large-scale clinical trials are necessary to optimize dosage, assess long-term safety, and validate their effectiveness in diverse patient populations. These medicinal plants offer a promising avenue for the development of safer, plant-based therapeutic strategies in respiratory health management.

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