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Systematic Review of Ayurvedic Plants in Respiratory Diseases

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Abstract:

Respiratory conditions, including asthma, chronic obstructive pulmonary complaint(COPD), bronchitis, and acute respiratory infections, remain among the leading causes of global morbidity and mortality, assessing significant healthcare and socioeconomic burdens(12). Ayurveda, India's traditional system of drug, has a long history of employing factory- grounded rectifiers for Kasa(cough), Shwasa(asthma and dyspnea), and Pratishyaya(rhinitis), with numerous remedies still used in pastoral and civic homes(19). Prominent plants include Adhatoda vasica(Vasaka), Andrographis paniculata(Kalmegh), Ocimum sanctum(Tulsi), Glycyrrhiza glabra(Licorice), Tinospora cordifolia(Guduchi), Zingiber officinale(gusto), Piper longum(Pippali), and Curcuma longa(Turmeric), each of which exhibits pharmacological parcels applicable to respiratory pathophysiology, similar as bronchodilation, mucolysis, immunomodulation, and antiviral effects (4). The ideal of this review was to totally collate and critically dissect available substantiation on these plants, fastening on preclinical data, randomized controlled trials(RCTs), and methodical reviews(2). A targeted literature hunt linked 25 representative references, including beast studies, mechanistic studies, and clinical data, to give a balanced evaluation(15). The strongest substantiation supports Andrographis paniculata for the characteristic relief of uncomplicated upper respiratory tract infections, as shown in multiple RCTs and meta- analyses(26). Adhatoda vasica and Tinospora cordifolia demonstrate promising results in small clinical studies, particularly during the COVID- 19 epidemic(5). Other plants similar as Glycyrrhiza glabra and Zingiber officinale give preclinical support but bear robust RCT confirmation(3).

Keywords: Respiratory disorders,AyurvedaMedicinal plants,Asthma and COPD,Herbal therapeutics,Andrographis paniculata,Adhatoda vasicaImmunomodulation.

1. Introduction

Respiratory diseases remain a significant challenge for global health systems. According to the World Health Organization, hundreds of millions of people suffer from asthma and COPD, while acute respiratory infections continue to be leading causes of hospitalization and death worldwide, particularly in children under five times(20). Chronic respiratory illnesses are characterized by patient inflammation, mucus hypersecretion, and bloodied tailwind, while acute infections frequently

complicate these conditions or beget independent morbidity(9). Ayurveda conceptualizes respiratory diseases under orders like Kasa(cough runs), Shwasa(breathlessness and asthma), and Pratishyaya(rhinitis), recommending a range of botanicals to restore balance and palliate symptoms(1). Over centuries, several plants similar as Tulsi, Vasaka, Guduchi, Pippali, and Haridra(turmeric) have been deeply integrated into both formal Ayurvedic phrasings and informal home remedies(23). Their conduct are described in terms of reducing Kapha(numbness, mucus) and restoring normal Prana Vayu(breathing force). Ultramodern pharmacological studies have corroborated numerous of these traditional claims. For illustration, Adhatoda vasica contains alkaloids like vasicine, which parade bronchodilatory and mucolytic effects(4). Andrographis paniculata is rich in andrographolide, a diterpenoid lactone with immunomodulatory and antiviral conditioning(25). Licorice root has glycyrrhizin, which shows bothanti-inflammatory and antiviral activity (3). Curcumin, deduced from turmeric, demonstrates antioxidant andanti-inflammatory mechanisms applicable to airway redoing(8). These bioactive composites give a presumptive pharmacological foundation for traditional use.Despite this, restatement into ultramodern rectifiers remains deficient. Some plants, similar as Andrographis paniculata, have experienced multiple RCTs with methodical reviews supporting characteristic benefits in upper respiratory tract infections(26).

2. **Evidence by Plant**

Adhatoda vasica(Vasaka)

Adhatoda vasica has been considerably proved in Ayurvedic textbooks as an expectorant and antitussive(4). Its main alkaloid, vasicine, exhibits bronchodilatory parcels by relaxing airway smooth muscle, alongside mucolytic exertion by enhancing bronchial concealment(16). Preclinical models demonstrate that Vasaka reduces airway inflammation and hypoxia- convinced lung injury(5). In experimental asthma models, it decreases eosinophil infiltration andpro-inflammatory cytokines(22). Clinically, phrasings containing Vasaka have shown benefit in reducing cough frequence and perfecting symptom scores in acute respiratory infections(15). During the COVID- 19 epidemic, Vasaka combined with Tinospora cordifolia was trialed in mild cases, yielding advancements in clinical and molecular labels of inflammation(5). Still, these trials are frequently small and open-marker, limiting generalizability. No major safety enterprises have been constantly reported, though standardization of extracts remains an issue(24).

Andrographis paniculata(Kalmegh)

Among Ayurvedic plants, Andrographis paniculata enjoys the most robust clinical substantiation. Multiple randomized controlled trials and methodical reviews confirm its effectiveness in reducing symptom inflexibility and duration in uncomplicated upper respiratory tract infections(26). Cases entering Andrographis reported briskly resolution of cough, sore throat, and fever compared to placebo(2). Andrographolide, the crucial element, exerts broad- diapason antiviral and immunomodulatory effects, including repression of NF- κB and modulation of cytokines(14). Beast studies demonstrate defensive effects in viral pneumonia and influenza- suchlike illness(18). Adverse effects are rare but include gastrointestinal worried and, sometimes, antipathetic responses(10). These findings punctuate Andrographis as a implicit substantiation- grounded herbal intervention for acute respiratory infections, though large multicenter trials are demanded for chronic conditions like asthma or COPD(9).

Ocimum sanctum(Tulsi/ Holy Basil)

Tulsi holds sacred and medicinal significance in Ayurveda, frequently appertained to as the " catholicon of life. " Preclinical studies confirm bronchodilatory exertion intermediated through modulation of calcium channels in airway smooth muscle(7). Anti-inflammatory effects are attributed to eugenol and rosmarinic acid, which reduce cytokine product and oxidative stress in experimental asthma(24). Clinically, small studies suggest Tulsi extracts reduces symptoms of asthma, cough, and cold, with advancements in pulmonary function tests(1). In traditional use, Tulsi tea or decoctions are extensively consumed for snap and flu. Its immunomodulatory part, enhancing both humoral and cell- intermediated responses, adds farther explanation for use in respiratory infections(17).

Glycyrrhiza glabra(Licorice)

Licorice root is extensively used as a soothing agent in cough and sore throat phrasings. Glycyrrhizin exhibitsanti-inflammatory and antiviral effects by inhibiting prostaglandin metabolism and snooping with viral replication(3). Beast studies confirm attenuation of bronchial inflammation and enhancement in lung function when administered as part of polyherbal phrasings(12). Clinical reports suggest that licorice- grounded tablets or bathos reduce chronic cough frequence and

inflexibility(22). Chronic or high- cure consumption can induce pseudoaldosteronism, leading to hypertension, hypokalemia, and metabolic alkalosis(21). A rare case of licorice- convinced respiratory failure has been proved, emphasizing the significance of safety monitoring(27). Therefore, while licorice offers strong characteristic relief, careful dosing and mindfulness of side effects are essential(14).

Tinospora cordifolia(Guduchi)

Tinospora cordifolia is famed for its immunomodulatory parcels. Preclinical studies reveal improvement of macrophage exertion, stimulation of lymphocyte proliferation, and modulation ofpro-andanti-inflammatory cytokines(11). These effects give a explanation for its traditional use in chronic respiratory conditions associated with vulnerable dysfunction. Clinically, Guduchi has been tested as peripheral remedy in mild COVID- 19 and upper respiratory tract infections, showing advancements in seditious labels and briskly clinical recovery(5). Before studies also suggest a part in modulating vulnerable responses in antipathetic asthma(22). Safety data indicate that Tinospora is generally well permitted, though rare hepatotoxicity reports leave caution in dragged use(19). Further large- scale clinical trials are demanded to clarify efficacity in asthma and COPD(8).

Zingiber officinale(gusto)

Gusto, generally used in Ayurvedic remedies, exhibitsanti-inflammatory, antioxidant, and bronchodilatory parcels. Preclinical studies confirm relaxation of airway smooth muscle and inhibition ofpro-inflammatory cytokines(6). Active factors similar as 6- gingerol and 6- shogaol contribute to these effects. Clinical studies, including randomized trials of gusto combined with honey or echinacea, demonstrate characteristic relief in cough, sore throat, and viral respiratory infections(17). In COVID- 19 cases, gusto supplementation bettered recovery times and reduced seditious labels in small RCTs(16). Gusto is generally safe, though gastrointestinal discomfort may do in sensitive individualities(13). Its wide artistic acceptance enhances its eventuality as an adjunct in respiratory complaint operation(9).

Piper longum(Pippali)

Pippali is traditionally described as a rejuvenator for respiratory health in Ayurveda. Bioactive alkaloids similar as piperine ply bronchodilatory andanti-inflammatory effects in beast models(23). Piperine enhances bioavailability of other phytochemicals, making it precious in polyherbal phrasings(28). Clinical substantiation remains limited, though traditional use explosively supports its part in bronchitis, cough, and asthma(19). Recent reviews call for well- designed RCTs to validate these claims(12). Pippali is generally safe in traditional boluses, though inordinate use may beget gastrointestinal vexation(20).

Curcuma longa(Turmeric/ Haridra)

Curcumin, the top bioactive in turmeric, has strong antioxidant andanti-inflammatory parcels. Preclinical studies show reduction of airway hyperresponsiveness, inhibition of NF- κB, and downregulation of seditious cytokines in asthma models(8). In addition, curcumin modulates oxidative stress pathways applicable to COPD and airway redoing(20). Early- phase airman trials have examined curcumin as an peripheral remedy in asthma, with some advancements in forced expiratory volume and symptom scores(9). Poor bioavailability remains a major challenge,

challenging new delivery systems similar as nanoparticles and liposomal curcumin(7). Turmeric is generally safe and extensively used in food, however high- cure supplementation may beget gastrointestinal worried or interact with anticoagulants(18).

Mechanisms of Action of Ayurvedic plants in Respiratory diseases

Ayurvedic plants ply remedial effects in respiratory conditions through multiple natural mechanisms that target inflammation, vulnerable imbalance, airway condensation, oxidative stress, and microbial infections. This multitarget mode of action aligns well with the complex pathophysiology of respiratory diseases similar as asthma, bronchitis, upper respiratory tract infections, and chronic obstructive pulmonary complaint.

Anti-inflammatory Mechanisms

Inflammation is a central point of both acute and chronic respiratory conditions. Several Ayurvedic plants reduce airway inflammation by modulatingpro-inflammatory intercessors. Andrographolide, the top bioactive emulsion of Andrographis paniculata, inhibits seditious signaling pathways and suppresses cytokine product, thereby reducing airway inflammation and towel damage(14).

Curcumin from Curcuma longa exhibits stronganti-inflammatory exertion by downregulating enzymes similar as cyclooxygenase- 2 and inhibiting seditious cytokines involved in antipathetic and chronic respiratory conditions(7).

Immunomodulatory Activity

Immune dysregulation plays a crucial part in respiratory infections and antipathetic airway conditions. Ayurvedic plants modulate vulnerable responses rather than causing broad immunosuppression. Ocimum sanctum has been shown to enhance vulnerable defense by regulating humoral and cell-intermediated impunity, which helps in precluding intermittent respiratory infections(17).

also, Tinospora cordifolia stimulates macrophage exertion and lymphocyte proliferation, contributing to bettered vulnerable surveillance and resistance against respiratory pathogens(11).

Bronchodilatory and Airway Smooth Muscle Relaxation

Airway condensation is a major cause of breathlessness and gasping in asthma and COPD. Certain Ayurvedic plants directly relax airway smooth muscles. Zingiber officinale induces bronchodilation by regulating calcium signaling in airway smooth muscle cells, leading to bettered tailwind and reduced bronchospasm(6).

Adhatoda vasica produces bronchodilatory effects due to alkaloids similar as vasicine, which ameliorate airway patency and support respiratory function in obstructive airway conditions(16).

Antitussive and Expectorant effects

Cough repression and mucus concurrence are essential factors of respiratory complaint operation. Experimental studies have demonstrated that Adhatoda vasica significantly suppresses cough convinced by mechanical and chemical stimulants, attesting its traditional use as an antitussive agent(4).

Glycyrrhiza glabra acts as a soothing demulcent and expectorant, reducing vexation of the respiratory mucosa and easing mucus expatriation(12).

Antiviral and Antimicrobial conduct

Respiratory infections are frequently caused by viral and bacterial pathogens. Several Ayurvedic plants retain antiviral parcels. Glycyrrhiza species inhibit viral replication and intrude with viral entry into host cells, making them precious in viral respiratory infections(3).

Clinical substantiation also supports the use of Andrographis paniculata in reducing symptom inflexibility and duration in acute respiratory tract infections due to its antiviral and immunomodulatory conduct(2).

Antioxidant Mechanisms

Oxidative stress contributes to airway inflammation and complaint progression in chronic respiratory diseases. Ayurvedic plants rich in polyphenols and flavonoids neutralize free revolutionaries and enhance endogenous antioxidant defenses. Ocimum sanctum exhibits strong antioxidant exertion, guarding respiratory apkins from oxidative damage(23).

Synergistic effects in Polyherbal phrasings

Ayurvedic remedy frequently employs polyherbal phrasings to enhance remedial efficacity. Traditional combinations similar as Trikatu ameliorate medicine bioavailability, stimulate digestion, and grease respiratory tract concurrence, demonstrating synergistic action among constituent sauces(28).

3. Safety and limitations

Ayurvedic medicinal plants are extensively perceived as safe due to their long history of traditional use. still, adding global application and integration with conventional drug bear a critical evaluation of their safety profile and associated limitations. Although numerous Ayurvedic sauces demonstrate

promising remedial effects in respiratory conditions, several challenges related to toxin, standardization, condiment – medicine relations, and clinical confirmation remain.

Safety Profile of Ayurvedic Medicinal plants utmost Ayurvedic plants used in respiratory diseases, similar as Ocimum sanctum, Andrographis paniculata, Adhatoda vasica, Glycyrrhiza glabra, and Tinospora cordifolia, have demonstrated respectable safety perimeters when used in recommended boluses(15,19). Clinical and experimental studies suggest that these plants ply their pharmacological effects through immunomodulation,anti-inflammatory action, and smooth muscle relaxation without causing severe organ toxin(). still, safety enterprises arise when these herbal drugs are consumed in high boluses, for dragged ages, or without proper medical supervision. For case, inordinate input of Glycyrrhiza glabra has been associated with pseudoaldosteronism, hypertension, hypokalemia, and fluid retention due to glycyrrhizin- convinced mineralocorticoid effects (21). Rare but serious cases of licorice- convinced respiratory failure and cardiovascular complications have been reported, emphasizing the significance of cure regulation and case monitoring(27). also, Andrographis paniculata, though generally well permitted, may beget mild adverse effects similar as gastrointestinal discomfort, headache, fatigue, and antipathetic responses in susceptible individualities(2,18). Long-term use or high- cure administration has raised enterprises regarding reproductive toxin and immunosuppression in experimental models, warranting conservative use, especially in pregnant and immunocompromised cases(15).

Herb – Drug relations

One of the major safety enterprises associated with Ayurvedic plants is their implicit commerce with conventional respiratory specifics. numerous herbal ingredients impact cytochrome P450 enzymes, medicine transporters, and vulnerable pathways, which may alter the pharmacokinetics and pharmacodynamics ofco-administered medicines(19).

For illustration, immunomodulatory sauces similar as Tinospora cordifolia and Ocimum sanctum may theoretically intrude with corticosteroids, immunosuppressants, or biologics generally specified in asthma and COPD(11,17). also, bronchodilatory sauces like Zingiber officinale may potentiate the effects of β_2- agonists, adding the threat of tachycardia or temblors(6,13). Despite these possibilities, methodical clinical data on condiment – medicine relations remain limited, pressing a critical gap in current exploration.

Lack of Standardization and Quality Control

A major limitation in the clinical operation of Ayurvedic plants is the lack of standardization. Variations in plantspecies, geographical origin, harvesting time, birth styles, and storehouse conditions lead to significant differences in phytochemical composition and remedial efficacity(15,22).

For case, the attention of andrographolide in Andrographis paniculata excerpts or vasicine content in Adhatoda vasica medications may vary extensively between marketable products, performing in inconsistent clinical issues(16,18). The absence of widely accepted quality control parameters and nonsupervisory fabrics further complicates their safe integration into mainstream respiratory care.

Insufficient Large- Scale Clinical Trials

Although multitudinous experimental studies and small- scale clinical trials support the efficacity of Ayurvedic plants in respiratory conditions, large multicenter randomized controlled trials are scarce(10,26). numerous studies suffer from methodological limitations similar as small sample size, short duration, lack of bedazzling, and shy reporting of adverse events. also, utmost available substantiation focuses on acute respiratory tract infections, while robust clinical data for chronic conditions similar as COPD, bronchial asthma, and interstitial lung conditions remain limited(20). This restricts the capability to formulate standardized treatment guidelines and substantiation- grounded dosing rules.

Regulatory and Pharmacovigilance Challenges

Unlike conventional medicinals, numerous Ayurvedic products are retailed as salutary supplements or traditional remedies, frequently bypassing strict nonsupervisory evaluation. This may affect in impurity with heavy essence, fungicides, or pollutants, posing significant safety pitfalls(19).

Pharmacovigilance systems for traditional drugs are still evolving, and adverse medicine responses related to herbal drugs are likely underreported. The lack of mindfulness among healthcare professionals and cases further exacerbates this issue.

Ethical and Artistic Limitations

While Ayurveda emphasizes personalized treatment grounded on Prakriti(body constitution), ultramodern clinical research relies on standardized protocols. This philosophical difference creates challenges in rephrasing traditional knowledge into substantiation- grounded clinical practice(5). likewise, indecorous tone- drug driven by the misconception that " natural means safe " can lead to abuse and adverse issues.

4. **Future Prospects**

Large- Scale Randomized Controlled Trials(RCTs) The most critical need is to design and conduct multicenter RCTs with acceptable sample sizes, fastening on both acute respiratory infections and chronic conditions similar as asthma and COPD(25). similar trials should employ standardized extracts of Andrographis paniculata, Adhatoda vasica, and Tinospora cordifolia, thereby reducing diversity and enabling clearer comparisons with conventional curatives(10).

Ultramodern expression and medicine Delivery Systems A major hedge to clinical restatement is poor bioavailability of certain composites similar as curcumin and vasicine(7). unborn research should prioritize nano- phrasings, liposomal carriers, and inhalable delivery systems acclimatized to respiratory medicine delivery(8). For case, aerosolized phrasings of Vasaka alkaloids or liposomal curcumin could offer targeted pulmonary action with reduced systemic side effects.

Systems Biology and Mechanistic perceptivity Omics- grounded approaches — transcriptomics, proteomics, and metabolomics — can help unravel themulti-target conduct of Ayurvedic botanicals. This would allow experimenters to move beyond single- emulsion studies and explore the full pharmacological community essential in whole plantexcerpts(18). Systems biology tools can also prognosticate condiment – medicine relations, perfecting clinical safety biographies(19).

Polyherbal Synergy and Formalized Combinations Traditional Ayurveda emphasizes phrasings like Trikatu and Dashamoola, where multiple sauces act together. unborn research should scientifically

validate similar phrasings through controlled trials, exploring both pharmacodynamic community and pharmacokinetic improvement(28).

Pharmacovigilance and Long- Term Safety Monitoring For wider global relinquishment, robust pharmacovigilance systems must be established to cover adverse events, condiment – medicine relations, and accretive long- term effects (21). This is especially important for plants like licorice and Tinospora, which can sometimes produce clinically significant side effects if misused.

Integration into Global Health programs The World Health Organization formerly recognizes the value of traditional drug(9). Ayurvedic botanicals could be integrated into global respiratory health strategies, particularly in low- and middle- income countries where availability and affordability of synthetic medicines remain walls(20).

5. Conclusion

The present methodical review highlights that Ayurvedic botanicals give a precious and underutilized force of remedial options for respiratory conditions, ranging from acute infections to chronic conditions similar as asthma and COPD(20). Among the reviewed plants, Andrographis paniculata stands out as the most substantiation- supported seeker, with several randomized controlled trials and methodical reviews demonstrating clinically meaningful benefits in upper respiratory tract infections(26). The strength of Ayurvedic drug lies not only in its long- standing empirical use but also in its holistic frame, where multiple plants are frequently combined to achieve synergistic benefits. This is apparent in phrasings similar as Trikatu(Pippali, black pepper, and gusto), which enhances bioavailability of other phytochemicals and supports respiratory adaptability(28). Quality control, batch standardization, and adherence to transnational pharmacopoeia norms remain significant challenges. While Tinospora has been intertwined in hepatotoxicity under certain conditions(19).

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