

## Therapeutic Role of Phytonutrients in Chronic Respiratory Diseases in the Indian Population

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**ABSTRACT:** The respiratory tract's chronic inflammation is an extremely worrisome public health concern in India because it may develop into CRDs, some of which pose a greater threat than others. COPD, & asthma are examples of chronic respiratory conditions. The dilemma of representative chemotherapy to treat respiratory distress necessitates discovering the medications that successfully combat the modern complexities of the target sickness. Chronic pulmonary illnesses are characterized by several intricate regulatory mechanisms, necessitating chemotherapeutics with composite inhibitory action. Cost-effective & natural product-based molecules are more likely to meet the challenges that respiratory-distress treatment poses by avoiding the laborious archetypes of drug designing & development, showing a strong case for a probable substitute of poly-pharmacology, & guaranteeing disease-relapse prevention. The cell signalling pathways & components of natural product moieties are summarised in this study to show how successful they are as a therapy for respiratory ailments affecting the Indian population. The study of the therapeutic role of phytonutrients in chronic respiratory diseases in the Indian population faces significant challenges because of the heterogeneity of patient profiles and disease severity. Moreover, the diverse dietary habits and lifestyle factors across different regions of India may influence the response to phytonutrient-based interventions, necessitating careful consideration in study design and interpretation. Despite these challenges, research on the medicinal applications of phytonutrients, including their anti-inflammatory, antioxidant, and immunomodulatory capabilities, has made notable advances in our knowledge of their mechanisms of action. Clinical research has produced encouraging results, including increased lung function, decreased airway inflammation, and improved quality of life for those with chronic obstructive pulmonary disease (COPD) and asthma. The creation of tailored and individualized therapies for various chronic respiratory illnesses is made possible by the identification of phytonutrients with positive therapeutic profiles. Additionally, including phytonutrients as adjunctive therapy in standard medical procedures has the potential to improve patient outcomes and reduce the need for traditional drugs, which could result in more cost-effective healthcare administration. Realizing the full potential of phytonutrients as beneficial complements to managing chronic respiratory disorders requires collaboration between academics and healthcare providers.

**Keywords:** Chronic respiratory diseases, Phytonutrients, Indian population, different age groups, cell signalling.

### INTRODUCTION

Infectious diseases & non-communicable diseases are simultaneously on India's shoulders. The Global Burden of Disease (GBD) survey statistics indicate that India has a high prevalence of acute & chronic respiratory disorders (Leng *et al.*, 2018). Chronic respiratory illnesses, specifically asthma & COPD, are of special concern because morbidity & death rates in different Indian states vary widely. In India, chronic respiratory disorders, like COPD, pulmonary fibrosis & asthma place a significant demand on health care & the economy (Joshi *et al.*, 2015). Chronic lung parenchyma inflammation mediated by macrophages; neutrophils, & cytotoxic (CD8+) T cells characterise the pathophysiology of COPD (Szeet *et al.*, 2014). Several cell signalling pathways constitute the inflammatory & oxidative responses, extracellular matrix remodelling,

& pulmonary fibrosis that contribute towards asthma, COPD, & pulmonary fibrosis.

Chronic respiratory diseases, such as asthma, COPD and bronchitis, pose a significant health burden in the Indian population. Despite advancements in conventional therapies, the management of these conditions remains challenging. There is a need for alternative and complementary approaches to improve patient outcomes and alleviate the burden of chronic respiratory diseases. One promising avenue is exploring the therapeutic role of phytonutrients derived from plants, which have demonstrated potential health benefits. However, a comprehensive investigation into the effectiveness of phytonutrients in the context of chronic respiratory diseases in the Indian population is lacking. Previous research in this area has been limited and often focused on other populations, neglecting the unique genetic, dietary, and lifestyle factors of the

Indian population. Furthermore, the studies conducted may have lacked appropriate sample sizes or have not employed robust methodologies to measure the outcomes accurately (Islam, 2023). Additionally, some studies might not have considered the regional variations in the prevalence and severity of chronic respiratory diseases in India, which could impact the efficacy of phytonutrients in different regions. The lack of well-designed, population-specific studies hinders our understanding of the potential benefits of phytonutrients for managing chronic respiratory diseases in India. Hence proposed study aims to address the gaps in existing research and provide valuable insights into the therapeutic role of phytonutrients in chronic respiratory diseases among the Indian population (Daniel *et al.*, 2021). The key advantages of this study include:

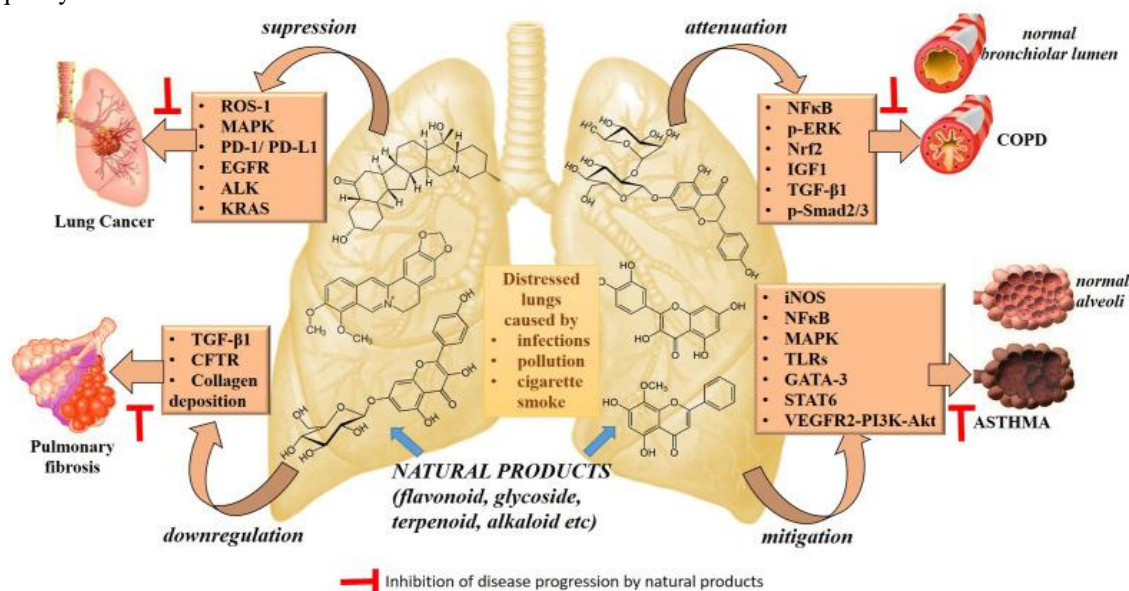
- **Population-Specific Investigation:** This research will focus specifically on the Indian population, taking into account genetic, cultural, and dietary factors that may influence the response to phytonutrients. By considering the unique characteristics of the Indian population, the study findings are more relevant and applicable to healthcare practices in India.
- **Regional Variations:** Recognizing the diversity in disease prevalence and risk factors across different regions of India, the study incorporates a multi-centre approach, including participants from various geographic locations. This approach provides insights into the regional efficacy of phytonutrients in managing chronic respiratory diseases (Burgel *et al.*, 2012).
- **Comprehensive Outcome Measures:** The study assesses a wide range of clinical, functional, and quality-of-life outcomes to evaluate the holistic

impact of phytonutrient interventions. This comprehensive approach sheds light on the potential benefits beyond symptom relief.

- **Potential Cost-Effectiveness:** Given the economic disparities in India, exploring the therapeutic role of phytonutrients may offer cost-effective and accessible alternatives for managing chronic respiratory diseases, particularly for underserved communities.

In short, the proposed study seeks to investigate the therapeutic potential of phytonutrients in chronic respiratory diseases in the Indian population. By addressing the limitations of previous research and leveraging the unique advantages of the proposed study, thus the review aims to contribute valuable knowledge to the field of respiratory medicine and potentially offer new, effective, and affordable therapeutic options for individuals living with chronic respiratory conditions in India (Grieger *et al.*, 2013).

However, proliferation pathways & cell migration are the leading causes of the advancement of lung cancer. Airway inflammation in asthma & COPD is induced by oxidative stress through the nuclear factor (NF)-kappaB (NF-kappaB) passage. Many natural compounds are capable of targeting the cell-signalling pathway that has anti-respiratory illness action (Fig. 1). They also encourage the creation of innovative medication systems by supplying adequate pharmacophores for optimal action on the target passages linked with respiratory illness manifestation (Liu *et al.*, 2020). This review elaborates on a concise discussion of the potential of medications derived from natural products, like alkaloids, flavones, & terpenes, to treat conventional & developing respiratory illnesses in different age groups in India.



**Fig. 1.** Natural compounds that target distinct cell signalling pathways (Prasher *et al.*, 2020).

## INFLAMMATION IN THE LUNGS- MOLECULAR ASPECTS

Inflammation is a crucial homeostatic cellular response & host defence mechanism that protects the lungs from dangerous foreign chemicals. Typically,

inflammation is characterised as either acute or chronic (Indrajeet *et al.*, 2023). An inflammation that is acute is characterised by the activation of resident cells & the proinflammatory cytokine & chemokine production, building up to the influx of polymorphonuclear particles, primarily neutrophils, originating in the innate immune system and moving to the site of the injury (Leng *et al.*, 2018). Persistent inflammation produces airway constriction & diminished lung recoil, along with other serious disorders, & extreme respiratory failure causes death (Figure 2). Many pathogenic variables, like an imbalance between oxidation & antioxidation, inflammatory response, cell death, & glucocorticoid resistance, contribute to the complex mechanisms underlying COPD onset & development (Singh *et al.*, 2018)

[ROS—Reactive Oxygen Species; EGFR—Epidermal Growth Factor Receptor].

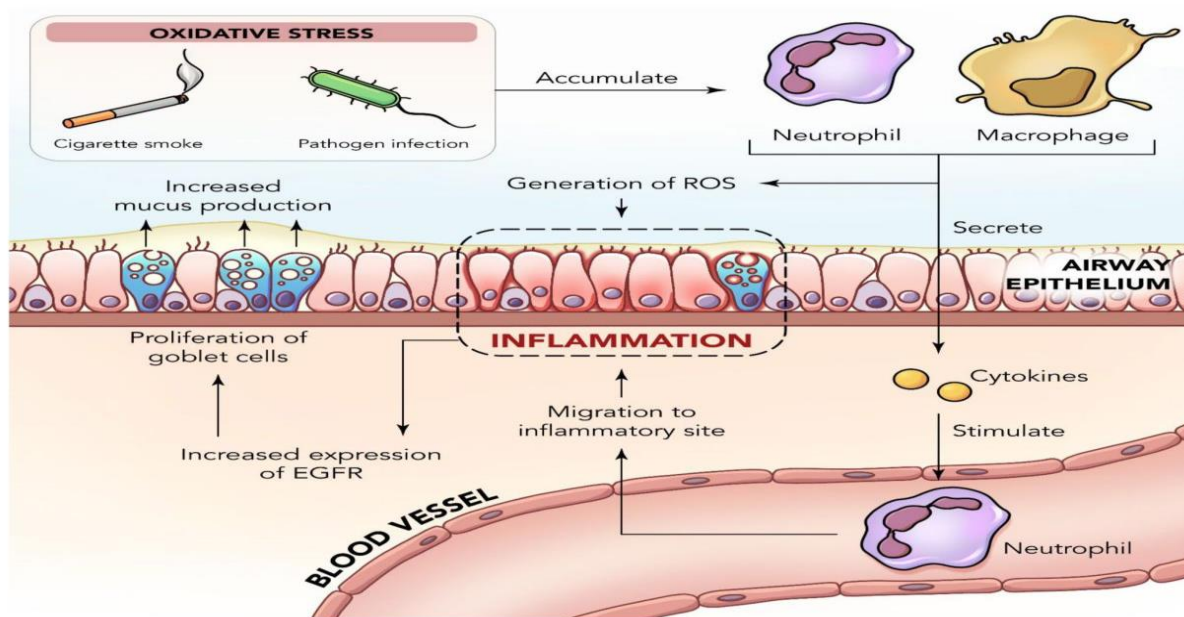
The course of inflammatory lung illnesses originates from the innate immune system of the body, wherein the harmful substances from cigarette smoke & the external environment cause the receptors for recognising patterns to activate along with the purinergic receptors. With damaged alveolar epithelial cells, the body produces TGF through connective

TGF, causing local fibrosis, deposition of collagen, & remodelling of the airway (Bivona *et al.*, 2018).

#### A. Antioxidants and Oxidative Stress

Antioxidants constitute crucial dietary elements to shield one from the detrimental effects of airways being put under oxidative stress, which is a feature of respiratory disorders in India. Oxidative stress occurring due to ROS is brought about in the lungs because of different exposures, including air pollution, airborne irritants, & usual airway inflammatory cell responses. In physiological or pathological circumstances, mitochondria mostly create ROS. LOX & COX in the metabolism of arachidonic acid, as well as endothelial and inflammatory cells, can produce  $O_2^{\bullet}$  (Joshi *et al.*, 2015). Dietary antioxidants can positively affect respiratory health, ranging from the impact of maternal nutrition on the foetus to the consumption of antioxidants by children, adults, pregnant women having asthma, & people with COPD (Hsieh *et al.*, 2016).

Antioxidants may be essential in asthma while pregnant, whereas oxidative stress generally rises throughout regular pregnancies, and oxidative stress is elevated in asthmatic women (Lu *et al.*, 2018). Antioxidants, especially lycopene, appear to have a good effect on respiratory disorders (Pestaño *et al.*, 2022).



**Fig. 2.** The mechanistic pathways that lead to the pathogenesis of inflammatory lung diseases (Clarence *et al.*, 2022).

#### EFFECT OF PHYTONUTRIENTS (CELL SIGNALLING PATHWAYS) IN THE MANAGEMENT OF RESPIRATORY DISORDERS

In India, functional foods that have a therapeutic effect on the lung epithelium have been highlighted as having made significant contributions. These naturally occurring foods are shown to provide protection & healing, mostly due to their strong nutrients. For a number of these natural biomolecules, molecular-level

processes have been established (Fulton *et al.*, 2013). By manipulating the inflammatory pathway, activator protein 1, & the NF- $\kappa$ B pathway, these drugs possess anti-inflammatory properties. Researchers have looked at how these nutrients function on a molecular level and how their presence disrupts networks of cell communication & how they interact with numerous receptors located throughout the respiratory tract, thus eliciting their biological effects (Melo *et al.*, 2017). It is also known that these substances neutralise damaging



poisons & free radicals produced by the body, therefore creating a synergistic effect (Whyand *et al.*, 2018).

#### A. Alkaloids

Tetrahydroquinoline alkaloid 'Antidesmone's medicinal properties for treating ALI & ARDS, i.e., prolonged inflammatory disorders triggered through membrane LPS present on gram-negative bacteria, & are characterised by interstitial oedema & lung parenchymal injury (Hsieh *et al.*, 2016). Antidesmone exposure dramatically downregulated the MAPK & TNF-signalling pathways & reduced NF- expression by counteracting the nuclear translocation of REL-associated protein p65, which activates it. Antidesmone exhibited considerable suppression of MPO, the biomarker for the concentration of neutrophils in the diseased lungs, adding support for the alkaloid's therapeutic advantage. Apparently, CS exacerbates redox imbalance by stimulating lung epithelial cells & macrophages, leading to chronic respiratory conditions (Reyfman *et al.*, 2018). Alkaloids isolated from *Pericarpium Citri Reticulata* are said to possess highly anti-asthmatic properties. The treatment of alkaloids in animal models having histamine-induced asthma reduced the production of eosinophils in bronchoalveolar lavage fluid & blood, along with IgE, IL-4, & IL-5. The therapeutic impacts & pharmacokinetics of alkaloids extracted from *A. scholaris* on an ovalbumin-induced model of allergic inflammation of the airways were notably proved (Kaluza *et al.*, 2018).

#### B. Flavonoids

Flavonoids are powerful antioxidants with anti-inflammatory & anti-allergic properties, owing in part to their capacity to neutralise ROS. An adult case-control investigation revealed that flavonoid-rich apple & red wine intake was related to decreased asthma prevalence & severity in humans (Kaluza *et al.*, 2018). Nevertheless, follow-up research examining the consumption of three subclasses of flavonoids found no relationships with the occurrence or severity of asthma. The injection of flavonoid reduced the deposition of collagen in the subepithelium & inhibited goblet cell hyperplasia. Therefore, the flavonoid that was tested acted as a bradykinin antagonist & reduced the primary pathophysiological hallmarks of allergic asthma. The flavonoids obtained from *Mosla chinensis Maxim* inhibited the H1N1 influenza virus primarily by causing downregulation in the host's TLR signalling pathways (Vasankar *et al.*, 2019). Also, the overexpression of key factors (IL-6, TNF-, IFN-, & NO) & repression of IL-2, SOD, & cytokine GSH led to a considerable decrease in the inflammatory damage induced by the virus to lung tissues (Pestaño *et al.*, 2022).

#### C. Terpenes

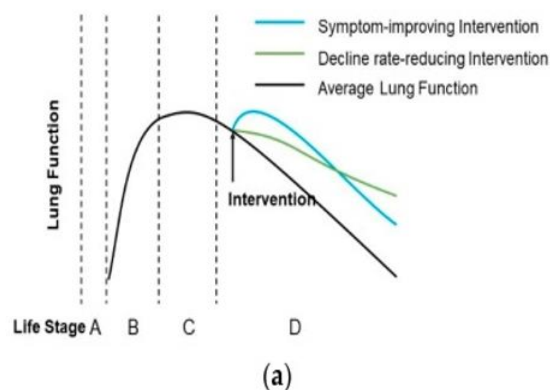
In animal models treated with *Dermatophagoides farina*, limonene suppresses allergic airway inflammation primarily by reducing reactive oxygen species. Bronchoalveolar lavages were dramatically depleted of interleukins-3/5, eotaxin, MCP-1, & TGF- after exposure to limonene (Lu *et al.*, 2018).

#### D. Carotenoids

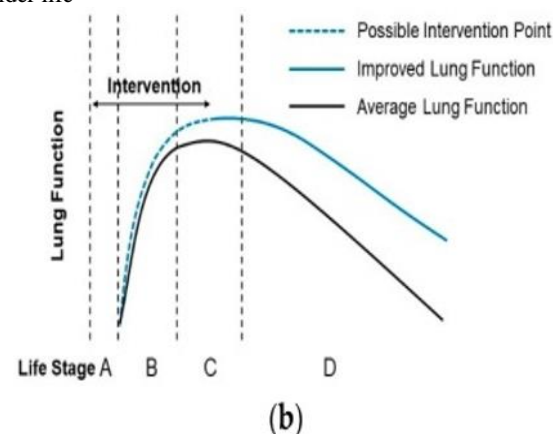
By reviewing a number of cross-sectional researches, it was proved that provitamin A carotenoids available in food or the bloodstream positively affect lung function. The community-dwelling & impaired populations tended to have higher blood carotene levels than the general population. Serum  $\beta$ -carotene & retinyl palmitate revealed a favourable correlation between FEV1 & FVC in a supplementation experiment, although having no advantage in terms of LC risk (Durham *et al.*, 2015). Serum levels of nitric oxide believed to be responsible for plasma extravasation & pulmonary oedema that is generated by endothelial nitric oxide synthase & were significantly reduced by treating models of animals with carvacrol. CS induces pulmonary emphysema, COPD, & pulmonary fibrosis. Preventive farnesol therapy demonstrated lung-protective effects by decreasing the levels of LDH & the GR, GPx, & catalase enzyme activity (Salari *et al.*, 2019).

#### E. Influence of Dietary Interventions on Lung Function

Along with non-provitamin A carotenoids, a number of dietary phytochemicals have been investigated for their promising bioactive potential in India (Lu *et al.*, 2018).



(a) Intervention patterns of symptom-improving & decline rate-reducing through dietary nutrients or phytochemicals in older life



(b) A conceptual model concerning nutritional intervention per life stage before lung function peak for maintenance of lung function across the lifetime. A is the maternal & prenatal period, B is childhood, C is young adulthood, & D is old age (Zhai *et al.*, 2018).

**Fig. 3.** Hypothetical model of dietary interventions' influence on lung function throughout the course of a person's lifetime.

Secondary metabolites from polyphenolic plants called flavonoids have strong antioxidant properties. In a long-term study of older men, anthocyanin consumption had a significant protective impact against age-related pulmonary function deterioration (Zhai *et al.*, 2018). They compiled the aforementioned longitudinal data & added carotenoids to the pattern that improved symptoms, whereas the pattern that decreased rates included lycopene, flavonoids, & vitamins C & E. (Fig. 3a& 1b).

## **IMPACT OF RESPIRATORY DISEASES ON THE INDIAN POPULATION**

### *A. Research Evidence*

India has a high prevalence of chronic respiratory illnesses according to global disease burden (GBD) statistics. It is necessary to understand the real practice patterns & socioeconomic effects of these prevalent respiratory illnesses. Furthermore, unknown is the effect of seasonal patterns on the onset or aggravation of certain disorders. In India, the SWORD study was established by the Indian Chest Association in collaboration with Asthma Bhawan, a national coordinating centre, in an attempt to answer some of these problems.

As a result of antioxidant, vitamin, mineral, fibre & phytochemical-rich nutritional profile, fruit & vegetable consumption has been explored for its possible advantages in relation to respiratory disorders. Epidemiological proof exhibited that young people aged 8-12 who ate more fruits and cooked green vegetables had a lower risk of wheezing and asthma. (Whyand *et al.*, 2018). In addition, decreased vegetable consumption in children was associated with present asthma. In adults, the data showing fruit & vegetable intake & lung function is heterogeneous, with a study showing no effect of higher fruit & vegetable intake over 10 years on lung function, while another study (Hsieh *et al.*, 2016) showed that greater fruit intake across 2 years was associated with greater FEV1(Forced Expiratory Volume), & in yet another study, a large reduction in fruit intake over 7 years may have led to reduced FEV1(Forced Expiratory Volume). Research studies revealed that a high intake of fruits & vegetables decreases the risk of wheezing during childhood & is inversely associated with the risk of asthma in both adults & children (Kaluza *et al.*, 2018). While some maternal nutrition studies revealed zero association between fruit & vegetable consumption & asthma risk in children, others found asthma risk is lowered in children with higher fruit & vegetable consumption (Lu *et al.*, 2018). Fruit & vegetable eating may shield an individual from developing COPD, with a "prudent" diet that includes increased fruit & vegetable consumption guarding against lung function decline.

### *B. Proportional Clinical Burden of Respiratory Illnesses in Different Age Groups*

32 of India's 36 states & union territories happened to be in the SWORD research. 86 (28.5) sites from the northern area, 66 (21.8) sites from the southern region, 56 (18.5) sites from the eastern region, 40 (13.2) sites from the western region, & 54 (17.5) sites from the

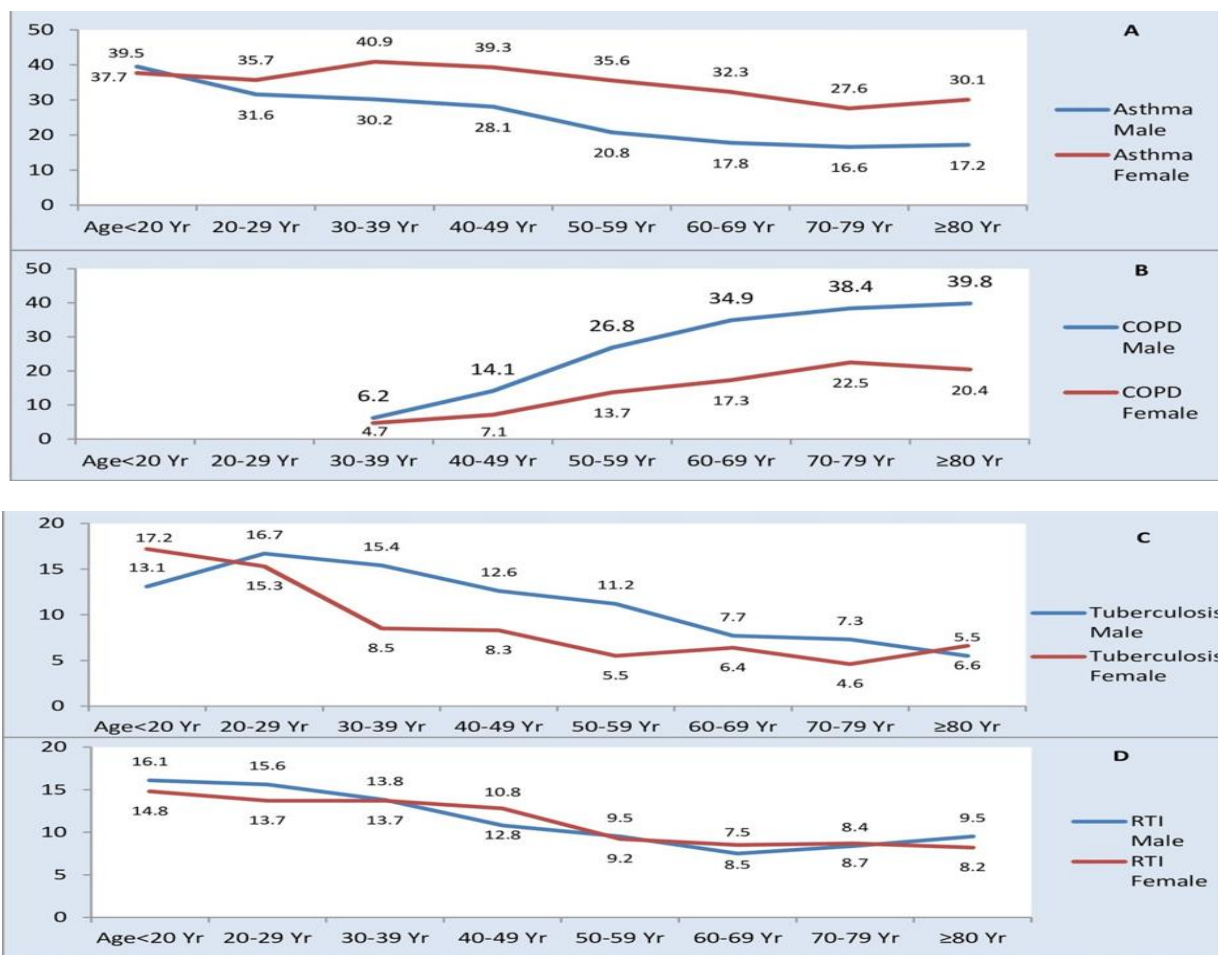
centre region participated. 14102 (56%) of the 25177 patients from 302 sites in India were male, while 11075 (44%) were female. The average age of the people under investigation was 46,118.1 years (Sharma *et al.*, 2022). In men, asthma's prevalence reduced with ageing, whereas a little increase was observed between 30 & 49 years of age & in those older than 80 years (Fig.4A). COPD prevalence grew with ageing in both sexes, but beyond the age of 40, males were about twice as likely to have the disease as females (Fig.4 B). Males were more susceptible to tuberculosis (TB), especially between the ages of 30 & 49, except at extreme ages (Fig. 4C). Respiratory Tract Infection (RTI) did not demonstrate a statistically significant difference in frequency according to age or gender (Fig.4D).

## **THERAPEUTIC POTENTIAL OF PHYTONUTRIENTS IN MANAGING CHRONIC RESPIRATORY DISEASES AMONG THE INDIAN POPULATION**

The literature review reveals a growing interest in exploring the therapeutic role of phytonutrients in chronic respiratory diseases among the Indian population. Preclinical studies demonstrate the potential anti-inflammatory and antioxidant effects of various phytonutrients, and traditional Indian medicine provides a rich repository of medicinal plants with potential respiratory benefits. However, more clinical research is essential to validate these findings and identify specific phytonutrients that could complement conventional therapies effectively. A comprehensive understanding of the therapeutic potential of phytonutrients in chronic respiratory diseases will pave the way for safer, accessible, and cost-effective treatment options, benefiting patients in India and beyond.

Chronic respiratory diseases, including asthma, COPD, and bronchitis, are a significant public health concern in India. Conventional therapies have limitations, leading researchers to explore alternative treatment options, such as phytonutrients derived from plants. Phytonutrients have gained attention for their potential health benefits, including anti-inflammatory and antioxidant properties, which may be advantageous in managing chronic respiratory diseases. This literature review aims to explore the current state of research on the therapeutic role of phytonutrients in chronic respiratory diseases within the Indian population.

According to Adeloje *et al.*, (2019), bioactive substances called phytonutrients are present in many plant-based meals. They display a variety of pharmacological traits, including immunomodulatory, anti-inflammatory, and antioxidant activities. These characteristics are especially pertinent in the context of chronic respiratory disorders, where oxidative stress and inflammation are key contributors to the development of the illness. Numerous phytonutrients have been found in studies, including flavonoids (quercetin, epigallocatechin gallate), carotenoids (beta-carotene, lycopene), and polyphenols (curcumin, resveratrol), which have shown promise in reducing respiratory inflammation, enhancing antioxidant defences, and improving lung function.



**Fig. 4.** The figure depicts the proportion of males & females with respiratory disorders by age in the population under investigation. Distribution by age & gender of the most prevalent respiratory disorders; Differences in distribution by age & gender group exist in the Indian population. The Y-axis represents the proportion of cases belonging to a certain gender among the defined age ranges (Sharma *et al.*, 2022).

According to Vesto *et al.*, (2018), bioactive substances called phytonutrients are present in our food every day and are known to improve human health. They function as antioxidants and support the regulation of physiological processes, avoiding illnesses and metabolic problems. However, due to low bioavailability, their effectiveness is constrained. It's interesting to note that the gut microbiota, which has been linked to a number of disorders, has the ability to convert phytonutrients into easily absorbed tiny molecules, increasing their bioavailability. Additionally, phytonutrients can affect the gut microbiota's makeup, further enhancing the host's health. This review examines the connections between gut microbiota and phytonutrients as well as the mechanisms behind their respective contributions to human health. The studies on the effectiveness of phytonutrients in human health are also summarized, along with future research prospects.

According to Vestbo *et al.*, (2017), different nutrients included in food are essential for supporting healthy bodily functions. Carbohydrates, proteins, fats, vitamins, and minerals are important nutrients. There are also bioactive substances known as "phytonutrients," which have considerable health

advantages and could be used to cure or prevent illnesses and physiological abnormalities. Due to their absence of adverse effects in comparison to chemotherapy or radiation therapy, phytonutrients can be used in clinical therapy and have a good impact on immune function. They save money by lowering healthcare costs. Probiotics, polyphenols, terpenoids, and flavonoids are only a few phytonutrients that have been shown to have unique biological effects that benefit human health, such as antibacterial, antioxidant, anti-inflammatory, and anticancer properties. An overview of significant phytonutrients, their contribution to promoting human health, and their potential as marketable medicinal agents are given in this mini-review.

According to Agusti *et al.*, (2017), chronic respiratory diseases are characterized by persistent airway inflammation. Several studies have reported the anti-inflammatory properties of various phytonutrients in pre-clinical and clinical models. For instance, curcumin, a polyphenol found in turmeric, has been shown to suppress pro-inflammatory cytokines and inhibit the activation of inflammatory signalling pathways in asthmatic and COPD patients.



According to Burgel *et al.* (2018), inflammation is the immune system's initial response to infection, along with injury, or even irritation. Evidence suggests that phytochemicals found in fruits, vegetables, and food legumes may have anti-inflammatory effects by regulating various inflammatory cytokines and mediators. However, the exact mechanisms of their actions remain incompletely understood. This paper aims to summarize recent research on the anti-inflammatory effects of these phytochemicals through *in vitro* and also animal model studies. Understanding the specific cytokines targeted by each phytochemical source could provide insights into their selective use to counter inflammatory responses. Incorporating these natural modulators into novel bioactive formulations may offer promising strategies for nutraceuticals and pharmaceuticals. Additionally, phenolics and triterpenoids in fruits and vegetables appear to exhibit higher anti-inflammatory activity, while lectins and peptides in food legumes also show potential. However, human studies on the anti-inflammatory activity of these phytochemicals are lacking, warranting further investigation to explore their potential benefits for human health.

According to Burgel *et al.* (2018), COPD is a major global health concern, causing significant morbidity and mortality. As the scientific community seeks modifiable factors for COPD prevention and treatment, diet has emerged as a crucial aspect of COPD management. To better understand the processes through which certain nutrients and dietary patterns may affect lung function, COPD onset, progression, and outcomes, this review synthesises information from observational and also clinical trials.

According to Burgel *et al.* (2016), various dietary options hold promise for COPD prevention and management. While definitive data are still lacking, scientific proof suggests that certain foods and also nutrients, particularly those with antioxidant and also anti-inflammatory properties, may contribute to improved pulmonary function, reduced lung function decline, and a decreased risk of COPD. The consumption of balanced dietary patterns that include such nutraceuticals further enhances these benefits. Understanding the dietary influences on COPD empowers health professionals to offer proof-based lifestyle approaches for better pulmonary health. Identifying and promoting the role of diet in COPD management is crucial for tackling this growing healthcare challenge and improving the well-being of individuals affected by the disease.

According to Miravites *et al.* (2012), immunomodulation is another crucial aspect of managing chronic respiratory diseases. Abnormal immune responses can exacerbate inflammation and contribute to disease progression. Certain phytonutrients, such as quercetin and epigallocatechin gallate, have been shown to modulate immune responses, potentially alleviating symptoms and preventing exacerbations in respiratory conditions. Various phytonutrients have been found to influence the function of immune cells, including T cells, B cells,

and macrophages, which are key players in the immune response. For instance, flavonoids, found in a range of plant-based foods, have been shown to regulate T cell activation and cytokine production, potentially contributing to immunomodulation in chronic respiratory diseases.

According to Postma *et al.* (2020), the anti-inflammatory and antioxidant properties of phytonutrients play a crucial role in managing chronic respiratory diseases. By scavenging free radicals and reducing oxidative stress, phytonutrients can help mitigate lung inflammation and protect respiratory tissues from damage. This has significant implications for improving lung function and reducing disease severity.

According to Rabe *et al.* (2017), studies have demonstrated the potential benefits of phytonutrients in chronic respiratory diseases, but there are still challenges to address. Much existing research is limited by small sample sizes, lack of control groups, and varying phytonutrient dosages. Additionally, the influence of regional dietary habits and genetic factors on the efficacy of phytonutrients requires further exploration to ensure the relevance of findings for the diverse Indian population

According to Schulze *et al.* (2020), studies have investigated the therapeutic potential of phytonutrients in chronic respiratory diseases. Evidence suggests that phytonutrients, such as curcumin, quercetin, and resveratrol, possess anti-inflammatory, antioxidant, and immunomodulatory properties that can improve lung function, reduce airway inflammation, and enhance the quality of life for individuals with asthma and COPD. These studies have shown promising outcomes in terms of symptom relief, reduced exacerbations, and improved respiratory health.

According to Berthon *et al.* (2020), the clinical proof supports the mechanisms by which phytonutrients exert their beneficial effects. By targeting inflammatory pathways, neutralizing oxidative stress, and modulating immune responses, phytonutrients can potentially alleviate the symptoms and progression of chronic respiratory diseases. These mechanisms provide a scientific basis for considering phytonutrients as complementary therapeutic agents. Despite the encouraging clinical proof, challenges remain in fully establishing the therapeutic role of phytonutrients in chronic respiratory diseases. Some of the challenges include variations in phytonutrient bioavailability, differences in individual responses, and limited clinical trials specific to the Indian population. Additionally, standardization of dosages and formulations for different phytonutrients poses a challenge in designing effective treatments.

## CONCLUSION

Chronic respiratory illnesses are primarily brought about by bronchial & pulmonary inflammation resulting from a heightened innate response, which causes an increase in pro-inflammatory metabolites. Inflammatory cells' recruitment into the bronchial & alveolar mucosa is proofd through the inhalation of

toxicants. Even after a lengthy stimuli cascade, the persistence of non-specific macrophages & adaptive T-lymphocytes inadvertently stimulates the memory cells of adaptive immunity, a phenomenon that is sustained by dendritic cells that promote the remodelling of lung tissue. Additionally, oxidative stress & disruption of the balance of protease/antiprotease reduce corticosteroids' efficacy to decrease airway inflammation.

## FUTURE PROSPECTS

Functional foods have several positive qualities & medicinal applications that can play a key part in the health of the populace in India. For meeting future demand for such functional foods, however, industries involving food & pharmaceuticals should recognise & face a number of important challenges, including low bioavailability, establishing optimal intake levels, solubility-lack, creating sufficient food-delivery matrices, formulation for products, & problems regarding regulations.

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