



An Insight Review on the Prophylactic Effects of Ayurvedic Plants in the Global COVID-19 Pandemic

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STRINGENT adherence to WHO guidelines has been maintained to minimize the risk of COVID-19 infection and ensure safety. In addition, the AYUSH Ministry of India's recommendations, pertaining to the Ayurvedic approach to boosting immunity and lowering the risk of contracting SARS-CoV-2 infection, have shown to be highly effective prophylactic measures. Ayurvedic methods have played a significant role in managing COVID-19 infections and symptoms during the pandemic. Key recommendations include maintaining hydration by drinking water, using herbs and spices in food, and practicing daily yoga poses, pranayama, and meditation. Ayurvedic medications such as *Sudarsana Ghana Vati*, *Suvarna Vasanta Malati Rasa*, *Amrutadi Kasaya*, and so forth are commonly used. Additionally, Ayurveda offers therapeutic modalities such as *Panchakarma* (five purifying processes), *Rasanya Chikitsa* (immune-modulator therapy), and *Sadvritta* (good conduct) to support overall well-being and promote recovery from the disease. This review intends to deliver the Ayurvedic approaches, including the use of medicinal plants like *Withania somnifera* and *Tinospora cordifolia*, as well as the implementation of daily guidelines and measures in daily routines for combating COVID-19. It further highlights the present scenario, the emergence of the virus and genetic variations in its genome, and the potential therapeutic applications of Ayurvedic medicinal plants to discover the immunomodulatory effects and their impending ways of fighting and treating the infection.

Keywords: Ayurvedic, COVID-19, Medicinal plants, SARS-CoV-2, Therapeutic, *Rasayana*.

Introduction

In late 2019, the city of Wuhan in Hubei Province, mainland China, witnessed a surge of patients suffering from unique unidentified pneumonia characterized by unknown etiology featuring clinical symptoms such as fatigue, dry cough, fever, and gastrointestinal disorders. As the cases increased, creating an alarming situation,

the healthcare community in China diagnosed and analysed respiratory samples from several patients, successfully identifying the novel strain causing COVID-19 infection stemming from 2019-nCoV (Huang et al., 2020). On January 30, 2020, the COVID-19 outbreak was officially declared a Public Health Emergency of International Concern (PHEIC) due to the concerning and confirmed cases of the disease,

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as shown in Fig. 1 (Jin et al., 2020; Sun et al., 2020). With the increasing number of sporadic and contagious human infections escalating from 45,000+ worldwide cases on February 11, 2020, to 80,000+ cases in China on March 1, 2020, along with 7200+ cases outside China, the World Health Organization (WHO) declared COVID-19 a pandemic. On December 8, 2020, the first unidentified pneumonia was reported, which later turned out to be the origin of the COVID-19 pandemic. In a short span of time, the situation escalated rapidly, resulting in large outbreaks both in China and worldwide (Callaway et al., 2020). The global death toll due to COVID-19 has reached nearly 3.3 million, with India ranking among the top 4 countries in terms of global fatalities (Singh et al., 2023). Mild cases show the symptoms of non-pneumonia or mild pneumonia. In contrast, severe cases present symptoms of dyspnoea, characterized by a respiratory frequency of nearly 93%, an arterial oxygen partial pressure to the fraction of inspired oxygen ratio below 300, and lung infiltrates exceeding 50% within 24-48 hours. However, the management of severe instances remain a major concern in treatment as they depict the critical symptoms leading to respiratory failure, septic shock, or multiple organ dysfunctions (Wu & McGoogan, 2020). The primary symptoms of COVID-19 are illustrated in Fig. 2.

Displaying similarities to the 2002-2003 outbreak of severe acute respiratory syndrome (SARS) in the Guangdong Province, China, and the ongoing Middle East respiratory syndrome (MERS) since 2012 in Saudi Arabia, the COVID-19 pandemic is found to be different. While all three viral infections are linked to influenza-like symptoms such as cough, cold, pneumonia, headache, dyspnoea, etc., they differ in their modes of transmission. COVID-19 has demonstrated greater prevalence but lower fatality rates compared to SARS, with China reporting over 74,675 confirmed cases and 2,121 deaths, and globally 1,073 confirmed cases with eight deaths as of February 2020, whereas SARS took several months to emerge (Wu & McGoogan, 2019; Callaway et al., 2020). WHO guidelines have been adhered to minimize the risk of infection and ensure safety with appropriate medication and vaccination. Besides, the guidelines provided by the AYUSH Ministry in India, which promotes the Ayurvedic approach to strengthening immunity and reducing the chances

of contracting SARS-CoV-2, have proven to be highly effective preventive measures. This review aims to gain a comprehensive understanding of the virus responsible for causing COVID-19 infections. It explores the fundamental aspects of the Ayurvedic connection with CoV and the approaches employed to combat community-level CoV infections. COVID-19 has been defined as a pandemic in the available Hindu literature and scriptures based on the knowledge accessible in *Janapadodhwasa* by Acharya Charaka. According to Ayurveda, the treatment of any community or public infection is influenced by *Vayu* (air), *Jala* (water), *Desh* (area and soil), and *Kala* (time). This literature also explains the importance of *Panchakarma* (five purification practices), *Rasayna Chikitsa* (immune modulator therapy), and *Sadvritta* (good conduct) in the treatment of such infections. Additionally, the text contains numerous medicinal plants with prophylactic effects.

What we know about COVID-19 and the novel coronavirus

In order to develop effective strategies for combating the disease, it is crucial to identify the origin of the pandemic strain and understand its modes of transmission. Coronaviruses, which belong to the family Coronaviridae within the Nidovirales order, are prevalent among various mammalian species and can also infect humans (Richman et al., 2016; Sun et al., 2020). The events showing the progression of COVID-19 from its initial stages to treatment are depicted in the graphical flowchart in Fig. 3. The rapid transmission of the COVID-19 infection among the human population has created a state of fear and anxiety worldwide. This pandemic virus spread rapidly primarily through close contact between individuals. Another significant issue that has emerged is the escape of patients from quarantine zones, leading to havoc and an increased likelihood of the transmission of infection (Danchin et al., 2020).

The expression of angiotensin-converting enzyme 2 (ACE2) in the human body is of major concern in determining the potential routes of coronavirus infection (Xu et al., 2020). Various cells and organs, including kidney proximal tubule cells, absorptive enterocytes in the ileum and colon, type II alveolar cells in the lungs, myocardial cells, cholangiocytes, urothelial bladder cells, as well as upper and stratified

epithelial cells in the oesophagus, exhibit high levels of ACE2 expression. Consequently, these cells are particularly susceptible to COVID-19 infection (Zhang et al., 2020; Zhao et al., 2020). Once inside the body, COVID-19 enters lung cells by binding to the receptor and completes

its lifecycle. The spike glycoprotein of the coronavirus specifically binds to the ACE2 receptors, allowing the RNA genome of the virus to enter the host cells. Subsequently, the infected cells release new virions through a process called exocytosis, as explained in Fig. 4 (Chan et al.,

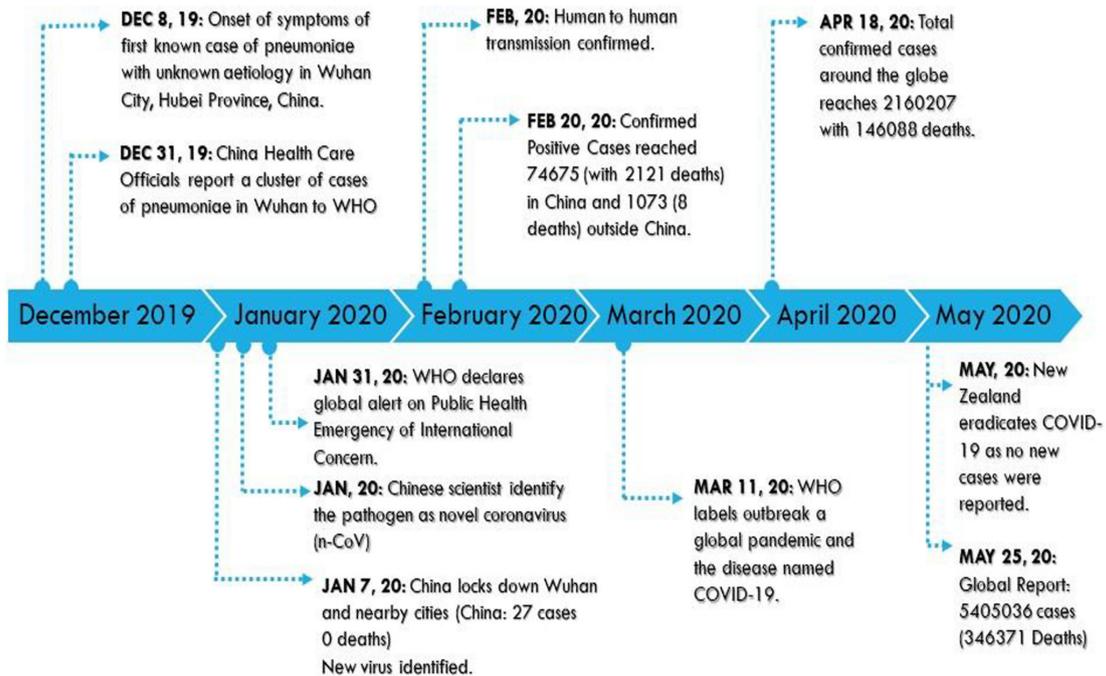


Fig. 1. Timeline of events since the first SARS-CoV-2 infection confirmed case

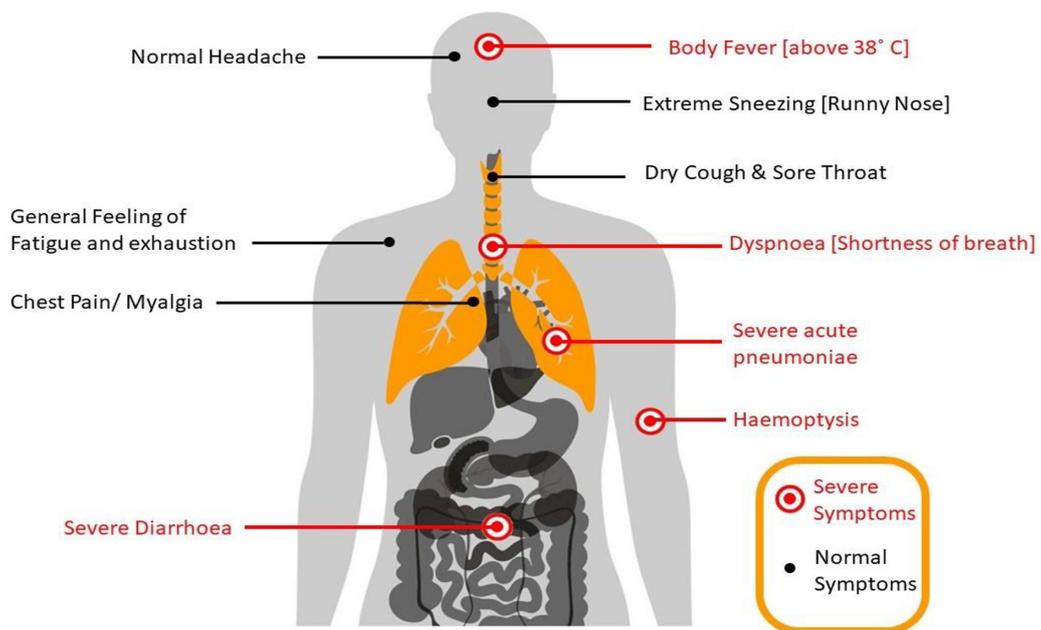


Fig. 2. Clinical Symptoms of COVID-19 according to WHO

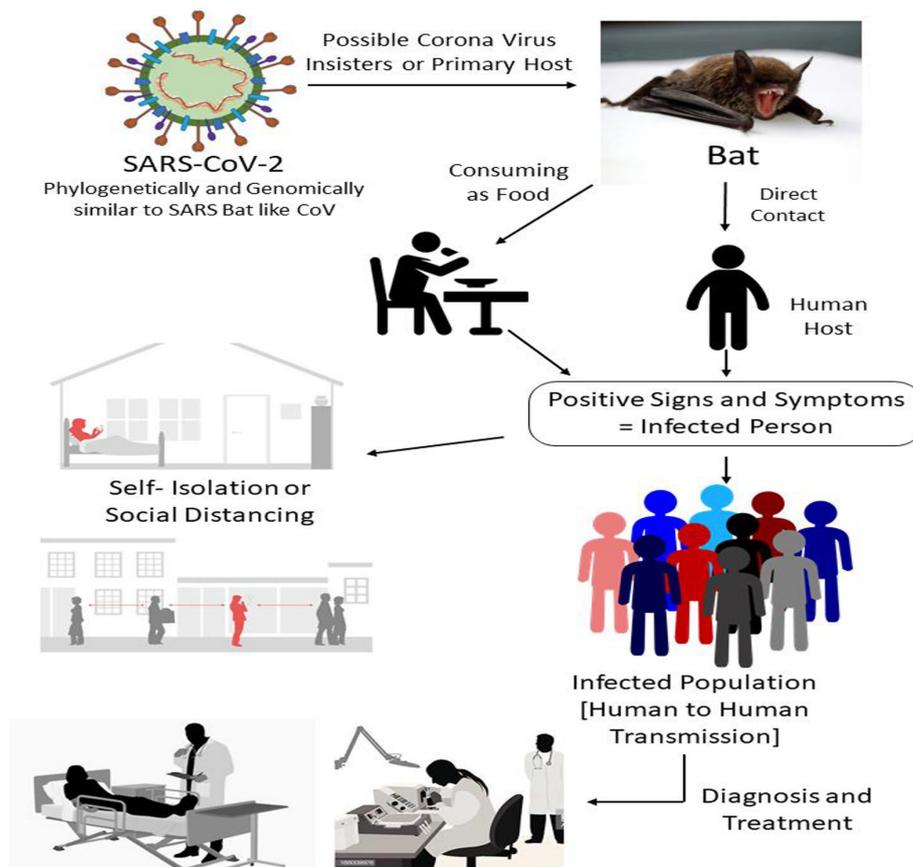


Fig. 3. Events depicting expedition of COVID-19: Initialization to Treatment

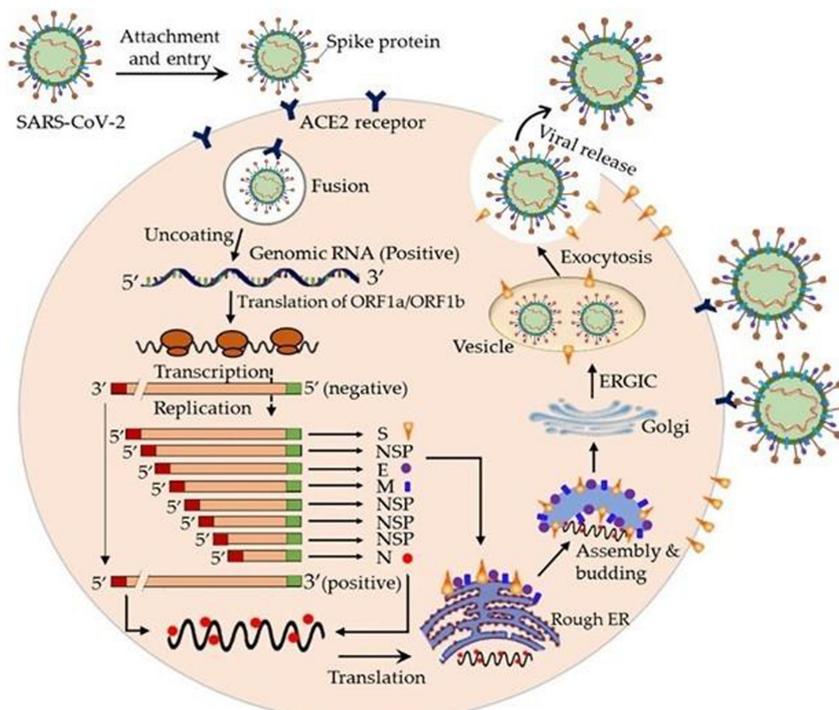


Fig. 4. Life Cycle of Coronavirus inside human lung cells (Shereen et al., 2020)

2020).

Meanwhile, the analysis of isolated SARS-CoV-2 from 10 patients' samples revealed a 99.9% similarity, with the genome sharing approximately 80% similarity to that of Human Coronavirus (hCoV/SARS-like Bat CoV) (Lu et al., 2020). Notably, the orf1ab gene is the most significant gene found on SARS-CoV-2, which is responsible for encoding pp1ab protein and 15 non-structural proteins, as shown in Fig. 5. Besides, Figs. 6A, 6B, and 6C provide a description of the SARS-S protein, which facilitates the entry of the virus into the host cell using ACE2 as a receptor (Li et al., 2003). The coronavirus S1 region contains two

major domains, namely the N-terminal domain (S1-NTD) and the C-terminal domain (S1-CTD), which has the potential to bind to the receptors to form a functional unit called the receptor-binding domain (RBD). With the exception of beta coronavirus MHV, which utilizes a protein receptor CEACAM1 through one or both of its S1 domains, it has been observed that all other coronaviruses use sugar receptors by means of these S1-NTDs domains (Peng et al., 2012; Liu et al., 2015). Additional domains known as S1-CTDs have been recognized to interact with protein receptors such as ACE2, APN, and DPP4, as illustrated in Figs. 6D and 6E (Mou et al., 2013). Based on their crystal structures, further studies have determined

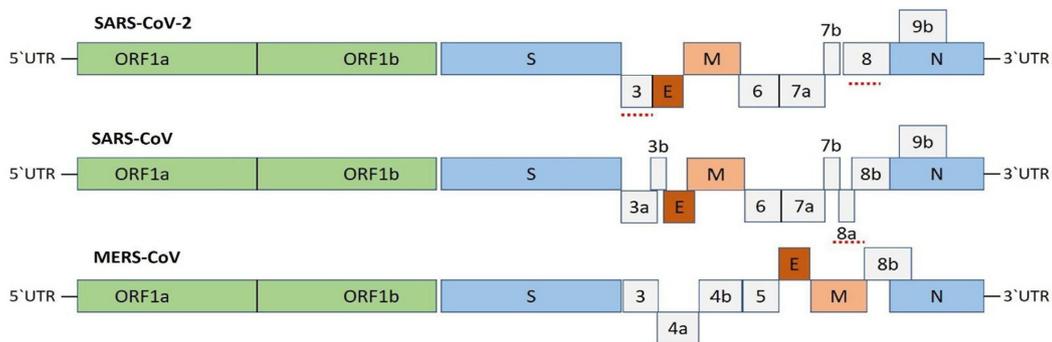


Fig. 5. Schematic Illustration of β -coronaviruses genome (SARS-CoV-2, SARS-CoV, MERS-CoV). ORF1a and ORF1b encode the non-structural proteins and the structural proteins are encoded by spike (S), envelope (E), membrane (M), and nucleocapsid (N) genes (Shereen et al., 2020)

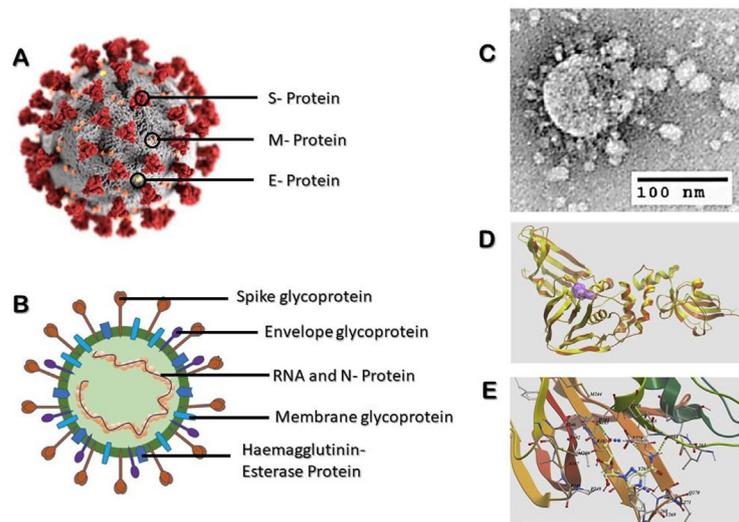


Fig. 6. Illustration of SARS-CoV-2 structure and its genome [A. Depiction of SARS-CoV-2 virion as created by Centers for Disease Control and Prevention (CDC); B. Diagrammatic representation of SARS-CoV-2 showing Spike glycoprotein, Envelope glycoprotein, RNA and N-protein Membrane glycoprotein, Haemagglutinin- Esterase protein; C. An electron microscopic image of a thin section of SARS-CoV-2 within the cytoplasm of an infected cell, showing the spherical particles and cross-sections through the viral nucleocapsid; D. Superimposing of 2019-nCoV PLpro (yellow) with the crystal structure of SARS PLpro (orange) (PDB code 3e9s); E. Detailed view of rivavirin binding in the active site of the enzyme (Jin et al., 2020; Yan et al., 2020)]

the recognition receptors for various S1 domains.

Clinical symptoms of COVID-19-infected patients

The early and rapid symptoms of coronavirus infection typically include fever, cough, runny nose, and shortness of breath (Buchholz et al., 2013). Conversely, common symptoms include fever, fatigue, dry cough, myalgia (muscle pain), and dyspnoea (difficulty breathing) (Harapan et al., 2020). In addition, some patients have reported experiencing dizziness, nausea, diarrhea, headache, abdominal pain, and vomiting, as exemplified in Fig. 7. Respiratory failure caused by alveolar damage can lead to severe and potentially fatal pneumonia, making death a later symptom of the disease (Zhou et al., 2020). Furthermore, clinical symptoms resembling SARS-CoV and MERS-CoV infections are dry cough, fever, dyspnoea, and opacities on chest CT scans (Assiri et al., 2013; Huang et al., 2020). Other symptoms affecting the upper respiratory tract may include rhinorrhoea, sneezing, or a sore throat. In certain rare cases, affected individuals may also experience diarrhoea due to the affected

intestine (Huang et al., 2020). Patients with severe conditions may develop acute respiratory distress syndrome (ARDS) and require intensive care in the ICU. The resulting breathlessness necessitates oxygen therapy. Infected patients exhibit increased levels of IL1B (Interleukin 1B), IFN γ (Interferon-gamma), IP10 (Interferon gamma-induced protein 10), and monocyte chemoattractant protein-1 (MCP1), which in turn activate T-helper-1 (Th1) cell responses. Additionally, increased T-helper-2 cell cytokines like IL-4 and IL-10 have also been supposed to be associated with COVID-19 infection. Moreover, the condition of severing ill patients has been attributed to a cytokine storm characterized by elevated concentrations of granulocyte colony-stimulating factor (GCSF), IP10, MCP1, MIP1A (macrophage inflammatory protein), and TNF α (Tumour Necrosis Factor-alpha). Certain cases revealed low levels of CD3+, CD4+, ALC, and CD3+ CD8+ cells prior to treatment. However, after viral clearance, these cell levels return to the average level. The detection of SARS CoV-2 RNA and chest CT examinations have greatly



Fig. 7. Guidelines by AYUSH ministry to combat COVID-19

facilitated the diagnosis and treatment of the disease (Corman et al., 2020).

Guidelines for impeding ways of COVID-19 transmission

COVID-19, which is primarily transmitted through respiratory droplets, is highly contagious amongst humans and can lead to severe and life-threatening illnesses compared to other CoV viruses. Like other CoVviruses, the SARS-CoV-2 virion can survive in the air for around 3 hours and can persist on various surfaces, such as plastics (up to 72h), stainless steel (up to 48 hours), and metal (up to 4h) (Van Doremalen et al., 2020). Therefore, it is of utmost importance for everyone to adhere to safety measures and guidelines of social distancing, maintaining hand hygiene, and actively contributing to prevent the spread of the disease. The WHO provides and recommends guidelines that emphasize overall hygiene practices and the use of personal protective equipment (PPE) for healthcare workers. Additionally, individuals suspected or confirmed to have the disease should be provided with a medical mask and be appropriately isolated or quarantined.

N95 respirators are regulated by organizations such as the Centers for Disease Control and Prevention (CDC), the National Institute for Occupational Safety and Health (NIOSH), and the Occupational Safety and Health Administration (OSHA). While N95 respirators offer higher filtration capabilities compared to other masks, it is important to note that they do not completely eradicate/eliminate the risk of infection, even when properly fitted. Meanwhile, the FDA regulates the masks depending upon their intended use (FDA, 2020). The surgical masks are loose-fitting and create a gap between the wearer's mouth and nose, which can potentially allow potent contaminants to enter, increasing the risk of infection. On the other hand, N95 respirators provide a higher level of protection.

Furthermore, the widespread use of facemasks globally, proportionate to the population, has led to shortages of both facemasks and PPE. Sanitization practices play an essential role in maintaining hygiene and preventing infections. It is recommended to wash hands for at least twenty seconds at regular intervals using water and soap or an alcohol-based hand sanitizer containing a minimum of 60-70% alcohol content. Social

distancing, self-isolation, and quarantine measures are also effective in reducing the probability of infection spread (Ong et al., 2020).

COVID-19 and immunity

SARS-CoV-2 infection induces an immune response that can be categorized into two phases: non-severe (immune protection) and severe stage (inflammation damaging). The non-severe stage marks the elimination of the virus and prevents the occurrence of severe stages by generating a specific adaptive immune response. Thus, it becomes very important to employ various strategies such as anti-sera or pegylated IFN- α during this stage to boost the immune response and mitigate the severity of the infection. During this stage, it is beneficial for the host to be in good health with an appropriate genetic background, particularly related to the human leukocyte antigen (HLA) system, making the host capable of generating specific antiviral immunity. When viral effects impair immunity, it can lead to an exaggerated immune response, leading to uncontrolled destruction of the infected tissues, especially in organs with higher ACE2 expression. This destructive process involves innate inflammation in the lungs controlled by pro-inflammatory macrophages and granulocytes, marking the occurrence of respiratory disorders toward fatality (Wu & McGoogan, 2020). Severe COVID-19 patients often exhibit lymphocytopenia and cytokine release syndrome triggered by the SARS-CoV-2 virus, which involves the activation of leukocytes. Consequently, blocking the activity of IL-6, IL-1, and TNF has shown beneficial effects against COVID-19. In addition, the usage of mesenchymal stromal/stem cells (MSCs) is being investigated for their potential importance in COVID-19 infection, although further research is needed to fully establish their efficacy conclusively. However, one limitation associated with MSCs is their activation by IFN- γ to exert anti-inflammatory effects, which may be absent in severe patients due to the lack of T-cell activation caused by SARS-CoV-2 infection. To address this limitation, an MSC licensing approach can be utilized, involving pre-treated MSCs with IFN γ with/without TNF α or IL-1 (Wang et al., 2014). Furthermore, the use of vitamin B3 has proved beneficial in repairing damaged lung tissues, making it a potential supplement for COVID-19 patients. Providing this fortified food supplement to COVID-19 patients appears to be a promising approach for addressing their nutritional needs.

COVID-19 and mental health

It is well-known that individuals with compromised and weak immune responses are more susceptible to the impact of COVID-19. Ayurveda, known for its immune-boosting properties, aims to prevent the eminent risk of respiratory tract infections related to the virus. The objective is to enhance both physiological and psychological well-being, creating a “meaning response,” as advocated by Moerman (Moerman, 2013). In other words, it is not solely the effectiveness of modern medicines and pharmacological drugs that determines the response of COVID-19 patients during treatment, but also the meaning they attribute to the treatment is equally significant. Uplifting psychological health during the COVID-19 pandemic has become a concern due to rising distress, especially among healthcare workers, and was achieved utilizing a psycho-neuroimmune mechanism (Rajkumar, 2020a, b).

Moreover, psychological symptoms like anxiety, depression, and stress have been linked with an increased risk of upper respiratory viral infections (Pedersen et al., 2010). A study conducted during the COVID-19 pandemic using an online survey with 1172 participants revealed the prevalence of mental disorders, including depression (18.8%), anxiety (13.3%), mental health problems (7.6%), clinical insomnia (7.2%), clinical post-traumatic stress disorder symptoms (7.0%), and suicidal and behavioural risk (2.8%). Additionally, 67.9% of the subjects showed symptoms of apparent stress ranging from moderate to high levels (Wang et al., 2020). There is substantial evidence supporting the close link between the functioning of the nervous, endocrine, and immune systems. Another study conducted among the populations in the United Kingdom, Spain, and Italy found that 42%, 46%, and 41% of individuals, respectively, reported experiencing psychological stress, including anxiety, stress, and depression.

Ayurvedic approach for preventing the SARS-CoV-2 infection

Consistently following an unhealthy lifestyle lead to increased mental stress and illness as physical exercise is reduced. These factors weaken the immune system, making the body more prone to several disorders and infectious diseases. In addition to the mentioned factors, numerous other elements such as industrialization, population

growth, poverty, malnutrition, unauthorized use of antibiotics, prolonged use of immune-suppressing drugs, and growing prevalence of drug-resistance microbes have increased the likelihood of new viral infection and their re-emergence. Ayurveda has traditionally emphasized the importance of adopting specific patterns and maintaining a healthy lifestyle routine rather than solely relying on a mere set of prescriptions. The classic Ayurveda text, *Charaka Samhita*, highlights the significance of immunity in averting diseases and obstructs their progression to maintain homeostasis, making it a main objective of Ayurveda to strengthen both the mind and body to effectively cope with infections and stress (Tillu et al., 2020). This knowledge is derived from the principles of “Dinacharya” (daily routine) and “Ritucharya” (seasonal regimes) to maintain a healthy life. The Ministry of AYUSH has approved the clinical trials of Ayurvedic Rasayanas as an essential measure for combating COVID-19, with the primary purpose of restoring holistic health and fighting against infections. The Ministry of AYUSH, in collaboration with the Council for Scientific and Industrial Research (CSIR) with technical support from the Indian Council of Medical Research (ICMR), takes the initiative to promote preventive measures and enhance immunity, recommending individuals to combat infectious diseases by boosting their immune system.

Furthermore, the consumption of golden milk (made with half a teaspoon of turmeric powder in 150 mL hot milk) and herbal tea/decoction made with basil leaves, cinnamon sticks, black pepper, dry ginger, and raisins are potent immunity boosters. In addition, mint leaves, caraway seeds, and clove powder with natural sugar are recommended for relieving dry cough or sore throat, as explained in Fig. 7. Apart from this, many other medicinal plants such as *Withania somnifera* (*Ashwagandha*), *Tinospora cordifolia* (*Guduchi*), *Asparagus racemosus* (*Shatavari*), *Phyllanthus emblica* (*Amalaki*), and *Glycyrrhiza glabra* (*Yashtimadhu*) are potential immunomodulators and possess antiviral properties (Balasubramani et al., 2011). In particular, *Withania somnifera* can potentially restore homeostasis through its multi-target effects on inflammatory conditions. In a clinical trial, a formulation containing *Withania somnifera* was indicated to have efficacy equivalent to hydroxychloroquine but with better safety in treating rheumatoid arthritis.

However, it is worth mentioning that the viral clearance might be delayed by impairing the induction of antiviral immunity for the treatment of COVID-19 as the broad immunosuppression result in anti-inflammatory effects (Rautela et al., 2018). A plethora of studies and reports suggest that Ashwagandha could be an effective agent in managing COVID-19 via the modulation of host Th-1/Th-2 immunity. Figure 8 provides detailed information about the use of *Withania somnifera* for enhancing antiviral immunity, leading to increased IFN γ responses. It also highlights the optimal anti-inflammatory activities through the downregulation of IL-1, IL-6, TNF α , and other inflammatory mediators, which serve as the key targets appropriate to COVID-19 (Tillu et al., 2020).

Why rely on Yoga and other Ayurveda approaches?

During the pandemic and quarantine, a significant adverse health effect is the increase in physical inactivity and reduced mobility. This issue is particularly pronounced among older adults, as inactivity leads to the depletion of muscle reserves and promotes sarcopenia

by accelerating bone turnover. Inactivity has also been linked with detrimental effects on respiratory function, impaired regulation of blood pressure, and metabolic alterations. Also, it indirectly affects the brain health and overall well-being of an individual (Jimenez-Pavonet et al., 2020). Furthermore, the modulation of emotional states by adaptive behaviour can influence the development of pathological conditions resulting from unhealthy lifestyle choices. In such cases, an inflammatory response may be triggered, exacerbating psychological problems (Gialluisi et al., 2020). Meanwhile, unprecedented suffering from hypertension, joint and musculoskeletal diseases, ophthalmic diseases, diabetes, neurological diseases, dermatological diseases, etc., have been seen due to the shortage of healthcare services during the COVID-19 pandemic (Nair et al., 2020). This posed considerable challenges in providing necessary medical assistance to individuals in need suffering from other diseases due to the disruptions in hospitals and ambulance facilities (Rastogi et al., 2020). In such circumstances, Ayurvedic medications have emerged as a viable

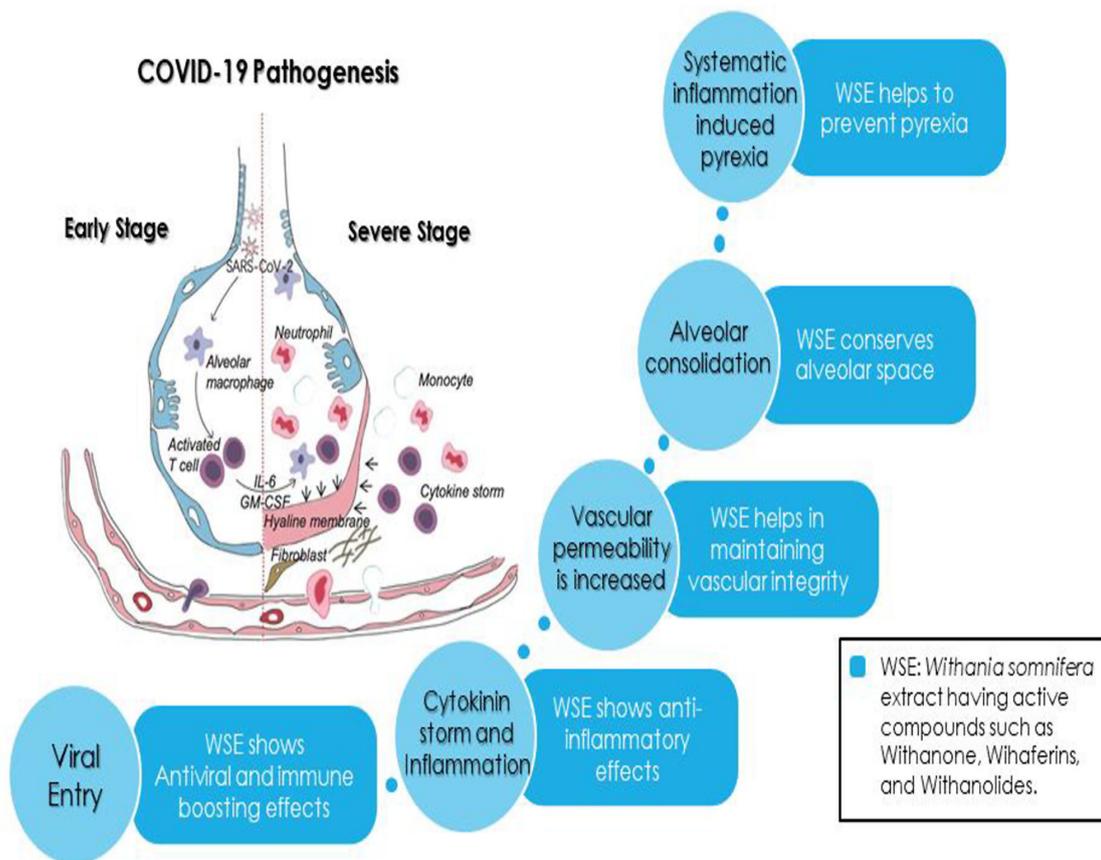


Fig. 8. Role of *Withania somnifera* in COVID-19 Management (Tillu et al., 2020).

TABLE 1. Ayurvedic medicaments against COVID-19 infection (Panda et al., 2020; Poonam & Akondi, 2020)

Ayurvedic approaches	Functions
Medicaments taken by healthy individuals with no sign and symptoms of COVID-19 infection	
Sunthi, Lavang, Maricha, Tej patta, Cinnamon bark, Piplali Decocotion	Antioxidant, anti-influenza activity, anti-allergic, immune-modulatory, smooth muscle relaxant activity
Haridra milk or Cow ghee	Enlivening, anti-aging, laxative, improves strength, immunity, intelligence, lactation
Chyawanprash Avaleha	Detoxify the body, cleansing of organs, immune booster, helps in blood cell production, promotes digestion
Aswagandha	Antiviral, vascular integrity, immune boosting
Amalaki Churna	Drives body toxins out via unblocking body's channels
Fumigation of Neem leaves, hingu, coconut shell and resin of saal (Sarjja rasa)	Anti-microbial activities
Pranayama	Improve lung functioning
Medicaments taken by individuals with pre-symtometric phase of COVID-19 (people in quarantine/isolation and immigrants)	
Sudarsana Ghana vati	Antipyretic, antimalarial, antidiabetic and antiviral properties
Gudduchi Ghana vati	Reduce duration of viral shedding and prevent in worsening the clinical conditions and symptoms
Samsamana Vati	Antipyretic, antibacterial, anti-arthritis, anti-inflammatory, antioxidant, anti-gout, etc. activities
Fumigation of Neem leaves, hingu, coconut shell and resin of saal (Sarjja rasa)	Anti-microbial activities
Chyawanprash Avaleha	Detoxify the body, cleansing of organs, immune booster, helps in blood cell production, promotes digestion
Nitya Rasayana Haridra milk/Cow milk	Enlivening, anti-aging, laxative, improves strength, immunity, intelligence, lactation
Pranayama	Improve lung functioning
Medicaments taken by individuals with asymptomatic positive Covid-19 infection	
Sudarsana Ghana vati	Antipyretic, antimalarial, antidiabetic and antiviral properties
Gudduchi Ghana vati	Reduce duration of viral shedding and prevent in worsening the clinical conditions and symptoms
Samsamana Vati	Antipyretic, antibacterial, anti-arthritis, anti-inflammatory, antioxidant, anti-gout, etc. activities
Nitya Rasayana Haridra milk/Cow milk	Enlivening, anti-aging, laxative, improves strength, immunity, intelligence, lactation
Agathi Haritaki	Antioxidant and anti-inflammatory properties
Siddha Makardwaja	Treat asthma, sexual ailments, fatty liver disorders, chronic respiratory disease

TABLE. 1. Cont.

Ayurvedic approaches	Functions
Kusmandu Avaleha	Helps in heatburns, peptic ulcer, acid reflux (GRE), hyperacidity, gastritis, improves appetites and increase strength
Vyagri haritaki	Helps in cold, cough, breathlessness, coryza etc
Bilvadi gulika	anti-inflammatory properties, helps in gastroenteritis, fecer, dyspepsia and psychological problems
Kapha ketu rasa	Use in cough, cold, rhinitis, bronchitis, asthma, teeth, throat and eye diseases
Arogya vardhini Rasa	Helps in liver diseases and cholesterol related problems
Saubhagya vati	Improves digestion and relieves impediment following delivery
Talisadi churna	
Medicaments taken by individuals with uncomplicated Covid-19 infection without showing signs of dyspnea and hypoxemia	
Sudarsana Ghana vati	Antipyretic, antimalarial, antidiabetic and antiviral properties
Sanjeevani vati	Prevents fever, polydypsia, anorexia and painful cramps
Amrutadi kasayam	Improves abdominal distension, constipation, gas, bloating, cold, jaundice, edema, gout problems, help in loss of appetite, fevers, etc.
Shadanga Paneeya	Antibacterial activity
Agathi haritaki	Antioxidant and anti-inflammatory properties
Bilvadi gulika	anti-inflammatory properties, helps in gastroenteritis, fecer, dyspepsia and psychological problems
Savrna Vasanta	Helps in cough, fever and asthma
Purna Chandra Rasa	Treat sexual disorders, asthma, anemia, urinary, digestive and eye disorders
Vyagri haritaki	Helps in cold, cough, breathlessness, coryza etc
Saubhagya vati	Improves digestion and relieves impediment following delivery
Arogya vardhini rasa	Helps in liver diseases and cholesterol related problems
Talisadi churna	Helps in coughing, gas, bloating, shortness of breath, increasing appetite,
Kapha ketu rasa	Use in cough, cold, rhinitis, bronchitis, asthma, teeth, throat and eye diseases

alternative for the general public to consider as both a prevention and a remedy, as described in Table 1.

Despite strict adherence to social distancing and precautionary measures outlined in the guidelines, the risk of COVID-19 infection remains a persistent threat among people. While extensive research is being conducted to develop vaccines and effective drugs against COVID-19, the use of Ayurvedic medicine provides a sense of mental peace to many individuals due to its perceived safety, affordability, and reliability (Girija & Sivan, 2020). Moreover, Doctors do not discourage using Ayurvedic medicines alongside conventional medications, as they have minimal or no side effects, thereby contributing to the core betterment of the human body. Some

commonly used Ayurvedic medicines, such as *Sudarsana Ghana Vati*, *Suvarna Vasanta Malati Rasa*, and *Amrutadi Kasaya*, are often prescribed for asymptomatic patients without dyspnoea and hypoxemia (Panda et al., 2020). Besides, various methods described in Ayurvedic scriptures and granthas state the benefits of these approaches, promoting safety, immunity, and prosperity to human health. Detailed information about these approaches is discussed in Table 2.

Pathogenesis of COVID-19 infection

According to Ayurveda, COVID-19 is considered *Janapadodhwamsa* or *Maraka*. Additionally, the term *Aupasargika Roga* is used to define COVID-19, with *Upa* denoting nearness and *Sarga* indicating its origin or production due to proximity. This term implies

contagious diseases that can easily transmit within a community. A similar model on smallpox (*Masurika*) is employed to define COVID-19 as an *Agantuja* (exogenous) disease. The models of *Janapadodhwamsa* explained by Acharya Charaka, *Maraka* by Acharya, and the *Masurika* by Acharya Madhava, as explained in Fig. 9, contribute to the understanding and diagnosis of COVID-19 as *Nija Jwara* (endogeneous) and *Oupasargika Roga* (exogeneous) (Adluri & Tripathi, 2020).

Treatment

As per Ayurveda, COVID-19 falls under the category of *Agantuja Vyadhi*, which belongs to exogenous diseases like viral infections. This concept of *Agantuja Vyadhi* can be implied to all kinds of infections caused by external agents such as parasites, bacteria, fungi, viruses, and so on (Agnivesha, 2011). Certain conventional formulations like *Sudarshan Ghana Vati* and *Sanshamani* are utilized in symptomatic patients having symptoms like fever, coryza, etc. Table 3

TABLE 2. Ayurvedic methods against COVID-19 Prophylaxis

Ayurvedic methods	Their beneficial role	References
Local prophylaxis- improve innate immunological response and function as “physiological masks”		
Medicated water	Improve digestion, helps in preventing fever, inflammation, allergy and metabolism	Tillu et al. (2020)
Steam inhalation	Reduce congestion and inflammation	Tillu et al. (2020)
Mouth rinse and gargle	Cleansing of oral cavity, pharynx, tonsil area and induces antioxidant, immunomodulatory and anti-microbial benefits	Tillu et al. (2020)
Nasal oil application	Prevent pathogen entry inside the respiratory tract	Tillu et al. (2020)
Systemic prophylaxis- non-pharmacological medications		
Yoga	Improve lung and mental health	Tillu et al. (2020)
Ginger (<i>Zingiber officinale</i>)	Antioxidant, anti-inflammatory and anti-diabetic activity	El-Saber Batiha et al. (2020)
Garlic (<i>Allium sativum</i>)	Anticholesterol, antioxidant, anti-inflammatory, anti-diabetic, renoprotective, anti-atherosclerotic, antihypertensive and antibacterial activities	El-Saber Batiha et al., (2020)
Cumin seeds (<i>Cuminum cyminum</i>)	Protection against type 2 diabetes, improve insulin sensitivity and protection against heart diseases	Szóllósi (2020)
Mustard seeds (<i>Brassica nigra</i>)	Anti-tumor, anti-diabetes, anti-hyperglycemia, anti-hyperlipidemia, anti-hypercholesterolemia	Szóllósi (2020)
Rasayana therapy		
Ashwagandha (<i>Withania somnifera</i>)	Immunomodulatory and antioxidant effects	Tillu et al. (2020)
Guduchi (<i>Tinospora cordifolia</i>)	Reduce duration of viral shedding and prevent in worsening the clinical conditions and symptoms	Rajkumar (2020a, b)
Shatavari (<i>Asparagus racemosus</i>)	Immunomodulatory and antioxidative properties	Veena et al. (2014)
Amalaki (<i>Phyllanthus embelica</i>)	Drives body toxins out via unblocking body's channels	Anagha et al. (2104)
Yashtimadhu (<i>Glycyrrhiza glabra</i>)	Antimicrobial properties	Anagha et al. (2104)

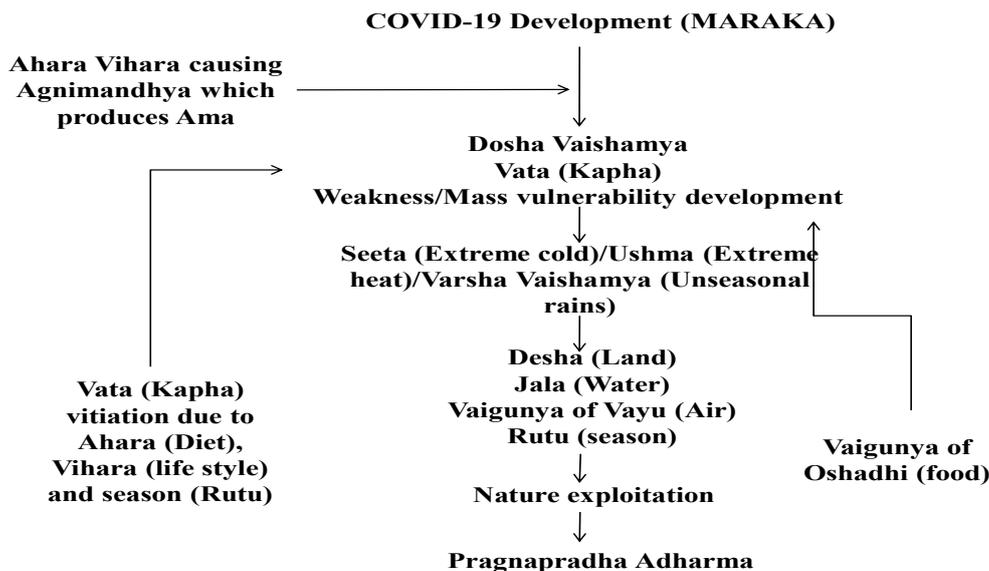


Fig. 9. The masurika model by Acharya Madhav to explain the pathophysiology of COVID-19 (Sharma, 2011; Murty, 2016; Patil & Rajeshwari, 2018)

TABLE 3. Ayurvedic formulations being used in COVID-19 treatment

Drugs	Drug Composition	References
Agastya Haritaki churna	<i>Terminalia chebula</i> Retz. (Haritaki) <i>Piper longum</i> (Pippali) <i>Dashmoola</i>	CCRAS (2014)
Anuthaila	Sesame oil <i>Embelia ribes</i> Burm.f (Vidanga) Goat milk (Ajadugdha)	Pandey (2006)
Tab. AYUSH-64	<i>Alstonia scholaris</i> (Saptaparna) <i>Caesalpinia crista</i> L. (Kuberaksha) <i>Picrorhiza kurroa</i> Royle ex Benth. (Katuki) <i>Swertia chirata</i> Buch.-Ham. ex Wall. (Kiratatika)	Gundeti et al. (2020)
Dashamoolakadutradyadi Kashya Gulika	<i>Adhatoda casica</i> (Vasa) <i>Aeles marmelos</i> (Bilva) <i>Desmodium gangeticum</i> (Shalaparni) <i>Gmelina arborea</i> (Gambhari) <i>Oroxylum indicum</i> (Shyonaka) <i>Piper longum</i> (Pippali) <i>Piper nigrum</i> (Marich) <i>Premna integrifolia</i> (Agnimantha) <i>Solanum indicum</i> (Brihati) <i>Solanum xanthocarpum</i> (Kantakari) <i>Stereospermum suaveolens</i> (Patala) <i>Tribulus terrestris</i> (Gokshura) <i>Uraria picta</i> (Prishniparni) <i>Zinigiber officinale</i> (Sunthi)	Wanjarkhedkar et al. (2020)
Guluchyadi Kwatham	<i>Azadirachta indica</i> (Arishta) <i>Corriander sativum</i> (Dhanyaka) <i>Prunus celesoides</i> (Padmaka) <i>Pterocarpus santalinus</i> (Raktachandan) <i>Tinospora cordifolia</i> (Guduchi)	Wanjarkhedkar et al. (2020)

summarizes some of such formations and their uses in managing COVID-19.

Prevention and management

In Ayurveda, specifically in the *Janapadodhwansa* Chapter 3 of the *Vimana Sthana*, Acharya Charaka elucidated that the root cause of any pandemic can be attributed to four main factors called *Vāyu* (air), *Jala* (water), *Desh* (soil and area) and *Kala* (time) (Pandey, 2006a, b). Ayurveda also encompasses specific treatment approaches for such cases, including *Panchakarma* (five procedures of purification), *Rasanya Chikitsa* (immune-modulator therapy), and *Sadvritta* (good conduct). *Rasanya Chikitsa*, which utilizes Rasa as an implication to *Dhatu*, results in cleansing and enhancing the quality of the body, mind, and soul, thereby contributing the most to the treatment by using various herbs and compounds. Moreover, ancient scriptures mention the utilization of numerous *Rasayana dravyas* as potent remedies to improve the body's defense mechanism and enhance longevity (Satyapal et al., 2015). Table 4 comprises the *Rasanya dravyas*, recognized as immune modulators that have demonstrated high efficacy in fighting COVID-19 infection. These *Rasanya dravyas* play a role in modulating cytokine secretion, histamine release, lymphocyte secretions, phagocytosis, and immunoglobulin secretion (Kumar et al., 1999). *Rasanya* drugs possess notable immune-modulatory and antiviral properties that make them valuable in treating COVID-19 (Tripathi & Singh, 1999). Majorly, immune-modulator drugs are classified into three main categories: immune-adjuvants, immune-stimulants, and immune-suppressants. Immune-adjuvant drugs are substances that increase the efficacy of vaccines, while immune-stimulants are drugs that target both innate and adaptive immune responses, thereby enhancing the body's overall immunity. On the other hand, immune-suppressants are chemical compounds specifically designed to suppress the immune system in response to autoimmune diseases or cases of organ transplants (Upadhyay et al., 2012).

Swarna prashana

Furthermore, in the literature of *Kashyapa Samhita*, *Sutra Sthana*, and *Lehadhyaya*, Acharya Kashyap mentioned the benefits of *Swarna prashana* (Jyothy et al., 2014). This method, used during the infantile period, involves rubbing gold on a white stone with water to obtain *Swarna Bhasma*, which is then mixed with honey, ghee, and other medicines or drugs and is administered to newborns

for improving digestion, memory, and immunity. Meanwhile, other drugs commonly used in Ayurveda for their beneficial effects include *Brahmi* (*Bacopa monnjeri* (L.) Wettst), *Shankhapushpi* (*Convolvulus pluricaulis Choisy*) and *Vacha* (*Acrorus calamus* L.), etc. (Raj et al., 2017).

Addressing COVID-19 with Ayurvedic solutions

The integration of Ayurvedic methods, along with medicines and vaccination in the management of COVID-19, has shown remarkable results in stopping the progression of the disease and revitalizing immunity. The concept of Ayurveda, with its focus on rejuvenating immunity and combating infections and diseases, has been practiced for centuries and continues to be traditionally followed as standard practices within certain communities (Goothy et al., 2020; Janiaud et al., 2021; Al-Kuraishy et al., 2022). The practices and traditions of *Siddha*, *Unani*, *Ayurveda*, *Yoga*, *Naturopathy*, and *Homeopathy* have long been embraced by some communities in their efforts to prevent and defend against many diseases and infections (Guo et al., 2020). These practices are rooted in scientific principles and rarely cause any side effects, even when used with modern medicines and drugs. Ayurvedic medicines and herbs have also been found to support humoral and cell-mediated immunological reactions. They also prevent airway hypersensitivity by inhibiting cytokine storms, which contribute to the progression of COVID-19 infection (Zeng et al., 2020).

Kadha

It is a decoction made from various parts of plants, herbs, and spices, and has been consumed orally in India for centuries. It is believed to work against viral infections and many other ailments (Maurya & Sharma, 2022). Further, it has been found to possess pharmacological properties and exhibits antiviral activity by inhibiting viral replication. The Ministry of Ayush has recommended the consumption of Kadha to boost immunity against COVID-19 infection (Hirsch et al., 2020).

Guduchighanvadi

Guduchi (Giloe) is a large climbing tree belonging to the *Menispermaceae* family. It is prepared as an aqueous extract of *Tinospora cordifolia* and *Piper longum* (Patgiri et al., 2014). Both Indian and Chinese traditional medicine systems have used *Guduchi* for its medicinal, antioxidant, and immunomodulatory therapeutic properties (Alam et al., 2021). Bala et al. (2020) have reported its potential to work against COVID-19 infection. In

TABLE 4. The most important *Rasayana dravyas* used as immune-modulators against COVID-19 infection (Rajkumar, 2020)

Common name	Biological name	Biological activity	Biological role
<i>Ashwagandha</i>	<i>Withania Somnifera</i> (L.) Dunal	<ul style="list-style-type: none"> Enhance nitric oxide synthetase activity of macrophages Increase INF-γ responses Decrease IL-1, IL-6 and TNF Increase IL-2, INF-γ, NK cells 	<ul style="list-style-type: none"> Improve immune cells Restore immune homeostasis Anti-viral immunity Anti-inflammatory activities
<i>Amalaki</i>	<i>Phyllanthus emblica</i> L.	<ul style="list-style-type: none"> Both enzymatic and non-enzymatic (via Vitamin C, Vitamin E and Flavonoids) Increase in CD4⁺ lymphocyte 	<ul style="list-style-type: none"> Enhance cell-mediated and humoral immunity Anti-oxidant defense activity
<i>Kalmegha</i>	<i>Andrographis paniculata</i> (Burm.f.) Nees	<ul style="list-style-type: none"> Andrograppolides increases WBC production, INF Tinosporin (Diterpenoid) leads in increase cytokine production 	<ul style="list-style-type: none"> Respiratory infections treatment Improve immune response Immunostimulatory functions
<i>Guduchi</i>	<i>Tinospora cordifolia</i> (Willd.) Miers	<ul style="list-style-type: none"> Activate immune effectors' cells Increase number of macrophages Glycyrrhizin inhibits SARS-associated virus replication 	<ul style="list-style-type: none"> Rejuvenate dead cells Immune-modulatory activities Enhance innate activity Phagocytic activity
<i>Mulethi</i>	<i>Glycyrrhiza glabra</i> L.	<ul style="list-style-type: none"> Increase Type I and Type II INF and secretion of Th2 cytokine Activates macrophages Piperine increases WBC, Bone marrow cellularity and α-esterase positive cells 	<ul style="list-style-type: none"> Immunomodulatory activity Antioxidant activity
<i>Pippali</i>	<i>Piper longum</i> L.	<ul style="list-style-type: none"> Increase Macrophage migration index (MMI), Haemagglutination titre (HA) and Phagocytic index (PI) Decrease in TNF-α, IL-1β and IL-6 	<ul style="list-style-type: none"> Immunomodulatory activity Phagocytic activity
<i>Punarnava</i>	<i>Boerhaavia diffusa</i> L.	<ul style="list-style-type: none"> Inhibits NK cells Increase production of nitric oxide 	<ul style="list-style-type: none"> Immunomodulatory activity Immunosuppressive activity Immunostimulatory activity Anti-inflammatory and anti-viral activity
<i>Shatavari</i>	<i>Asparagus racemosus</i> Willd.	<ul style="list-style-type: none"> Alter macrophage function Up-regulation of Th1, Th2 and cytokines Increase CD4⁺ and CD8⁺ Flavonoids helps in increase level of IL-4, NK cells and Helper cells 	<ul style="list-style-type: none"> Immunomodulatory activity Immunoadjuvant activity T cell activation
<i>Tulsi</i>	<i>Ocimum sanctum</i> L.	<ul style="list-style-type: none"> Eugenol inhibits viral replication 	<ul style="list-style-type: none"> Immunomodulatory activity Anti-viral activity

addition, *Piper Longum*, also called Indian Long Pepper or *Pippali*, is recognized for its antiviral properties.

Sudarshan Ghana Vati

It is an Ayurvedic formulation, which is known to have a balancing effect on the three doshas (*Tridosha*). It contains various ingredients, such as *Amalaki*, *Guduchi*, *Haridra*, *Haritaki*, *Karya*, *Trikatu*, and *Yashtimadhu* (Tiwari, 1995).

Chywanprasha Avaleha

It is used as *Balya*, *Medhya*, and *Rasayana*. It is believed to have balancing effects on *Vata*, *Pitta*, and *Kapha doshas*. It contains *Amalaki*, *Brahmi*, *Dalchini*, *Gokshura*, *Guduchi*, *Haritaki*, *Karya*, *Pippali*, and *Yashtimadhu* (Kulkarni, 2012).

Vyaghriharitaki

It helps in soothing sore throat, cough, hoarseness of voice, and *Swasa*. When mixed with water, it helps balance the *Vata* and *Pitta doshas*. The key ingredients of *Vyaghriharitaki* include *Elaichi*, *Guda*, *Haritaki*, *Madhu*, *Marich*, *Nagkeshar*, *Patra*, *Pippali*, and *Shunthi* (Gupta et al., 2022).

Talisadi Churna

It is renowned for treating asthma, cough, common cold, chronic bronchitis, and whooping cough. It possesses antiviral, antibacterial, antimicrobial, carminative, and bronchodilator properties. It comprises *Black pepper*, *Dalchini*, *Elaichi*, *Misri*, and *Talis Patra* (Kulkarni, 2012).

Arogya wardhinivati

It exhibits antiviral properties and helps in reducing viral load virulence. It is made up of *Adhrad*, *Bhasma*, *Gandhak*, *Katuki Bhavana Dravya*, *Loha*, *Neem Patraswarasa*, *Parad*, *Shriddha Shilajit*, and *Shruddha Guggul* (Gupta et al., 2022).

Segregation of population based on Ayurveda interventions

Based on exposure, symptoms, and Ayurvedic interventions, the infected population can be grouped into four categories described below (Randeepraj et al., 2020; Rastogi et al., 2022):

Group I: The first category comprises individuals who are asymptomatic and have not been exposed to COVID-19 infection. They are least expected to suffer from COVID-19 infection

and are assumed to follow a healthy diet plan, engage in regular physical activity, and prioritize adequate sleep. Engaging in regular healthy activities and adopting habits can help them avoid the development of symptoms if they are careful enough to avoid contact with an infected person or refrain from visiting the affected area (Srikantha Murthy, 2014; Pandey, 2019). Following good conduct not only promotes the development of strong immunity but also enhances overall self-resilience against any kind of infection or disease in general (Hotchkiss & Opal, 2020). Additionally, individuals may consume *Brahma Rasayana*, *Amrit Bhallataka*, *Chyavanprasha*, *Sanjeevani Vati*, and *Swarna prashan*, which are believed to have positive effects on the respiratory tract, as suggested in Ayurvedic interventions (et al., 1999; Patil et al., 2017; Rastogi et al., 2019; Sharma et al., 2019). The disinfection practices can be performed by *Allium sativum*, *Curcuma longa*, *Styrax benzoin resin* and *Boswellia* species (Loban), and *Trachyspermum ammi* (Bhatwalkar et al., 2019).

Group II: The second group of individuals are at higher risk in terms of health and require additional upkeep. They are under quarantine despite not exhibiting any symptoms of COVID-19 infection. Ayurveda suggests several herbs and decoctions for this group, including *Brahma Rasayana*, *Chitrakatdivati*, *Chyavanprasha*, and *Sanjeevani Vati*, which helps in rejuvenating the immune system and preventing the progression of COVID-19 infection (Tripathi & Singh, 1999; Rastogi et al., 2007; Srikantha Murthy, 2012). A decoction can be prepared by mixing various herbs acting against viral infection and working as protease inhibitors like *Adhatodavastica*, *Andrographis paniculate*, *Curcuma longa*, *Glycyrrhiza glabra*, *Moringa oleifera*, *Ocimum sanctum*, *Swertia chirata*, *Tinospora cordifolia*, *Trikatu*, *Triphala*, and *Zingiber officinale* (Rege & Chowdhary, 2013, 2014; Panche et al., 2019).

Group III: This group consists of individuals with mild symptoms of COVID-19 infection who are under quarantine and monitored for any disease progression. This group is advised to use herbs and ayurvedic drugs such as *Chitrakadivati*, *Dashamool kwath*, *GoJihvadhu Quath*, *Kantakari Avaleha*, *Lakshmi Vilas rasa*, *Pippalirasayan*, *Sanjeevani Vati*, *Sitopaladi*, *Talishadi*, *Vyaghriharitaki*, and *Yashtimadhu* (Rastogi et al., 2007; Bisht et al., 2009; Makhija et al., 2013;

Srikanth et al., 2019).

Group IV: The fourth group comprises individuals who are at the highest risk in terms of health, as they have moderate to severe symptoms of COVID-19 infection. Ayurvedic interventions recommended for this symptomatic population include *Brihata Vata Chintamani Rasa*, *Mrityunjaya rasa*, *Laghu Vasant Malati*, *Pippalirasayan*, *Sanjeevani Vati*, *Siddha Makardhvaja*, and *Tribhuvan Keerti rasa* (Panigrahi, 2006; Bisht et al., 2009). The oral and sublingual routes of administration are suitable for the intake of these formulations due to their nanoparticle size, enhancing their absorbability and absorption in the body. This further can be increased when they are mixed with ingredients like ghee and black pepper, similar to the practice followed with *Swarna bhasma* (Sharma & Prajapati, 2016; Patil-Bhole et al., 2018).

Conclusion

Ayurveda has indeed played a role in managing symptoms and infection from COVID-19 during the pandemic. The global outbreak has sparked interest in research and studies in the upcoming decades. Tragically, approximately 3.3 million people worldwide have lost their lives to COVID-19, highlighting the urgency for everyone to strengthen their immunity through various measures. This includes the improvisation of diet by consuming foods rich in beta-carotene, ascorbic acid, and other essential vitamins. Additionally, supplements such as Vitamin C, Vitamin D, Zinc, Elderberry, Turmeric, and Garlic have been found to offer a mild protective effect against such respiratory illnesses, further aiding in immune system support. We also suggest the effective use of medicinal plants known for their antiviral effects and immunomodulatory properties. These plants include such as *Withania somnifera* (*Ashwagandha*), *Tinospora cordifolia* (*Guduchi*), *Asparagus racemosus* (*Shatavari*), *Phyllanthus emblica* (*Amalaki*), and *Glycyrrhiza glabra* (*Yashtimadhu*). Besides, practicing yoga asanas and pranayama techniques and following an Ayurvedic plan based on guidelines can be beneficial to bolster immunity, thereby helping to combat COVID-19. Undoubtedly, the COVID-19 pandemic has been proven to be stressful for the existing healthcare systems. However, by diligently following the guidelines provided by the WHO and Ayush Ministry, preventive

measures have become more accessible, and our community has largely managed to navigate through this difficult situation. Moreover, Ayurvedic interventions have immensely helped in numerous ways, offering prevention and immunity rejuvenation through the use of homemade and readily available ingredients. These traditional medicines and therapies, with their centuries-old wisdom, have provided in-depth knowledge of the science behind their effectiveness. By comprehending the knowledge found in ancient literature and the practices rooted in Indian culture, our community has witnessed a strengthened sense of health and immunity. Traditional plants, herbs, and spices have been recognized for their potent immunological effects, antiviral activities, and rejuvenating capacities. There are numerous pharmacological and therapeutic properties associated with these ingredients; however, there is still much to explore in terms of the potential benefits offered by these phytochemicals and plant species.

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