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EVALUATING THE EFFICACY OF AYURVEDIC RASAYANA BOTANICALS ON CELLULAR INTEGRITY DURING VIRAL THREATS: A REVIEW

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ABSTRACT

Viral infections can disrupt cellular integrity through oxidative stress, mitochondrial dysfunction, inflammatory signaling, immune dysregulation, membrane injury, and altered cell-death pathways. Ayurvedic Rasayana botanicals are traditionally used to promote vitality, tissue nourishment, and disease resistance and are increasingly being investigated for their cytoprotective and immunomodulatory properties. This narrative review evaluates the potential of major Ayurvedic Rasayana botanicals to preserve cellular integrity during viral threats and examines the mechanisms that may contribute to their antiviral and host-protective effects. Botanicals such as Withania somnifera, Tinospora cordifolia, Phyllanthus emblica, Ocimum tenuiflorum, Glycyrrhiza glabra, Curcuma longa, and Asparagus racemosus contain diverse phytochemicals with antioxidant, anti-inflammatory, immunomodulatory, and cytoprotective activities. Their proposed mechanisms include modulation of Nrf2/ARE, NF-κB, MAPK, PI3K/Akt, JAK/STAT, cytokine signaling, endogenous antioxidant systems, mitochondrial function, apoptosis, and autophagy. Some phytochemicals may also interfere with viral entry, replication, or viral proteins. However, much of the available evidence remains preclinical, computational, or derived from small clinical studies. Rasayana botanicals show promising potential as host-supportive approaches for maintaining cellular homeostasis during viral infections. Nevertheless, standardized formulations, mechanistic validation, and well-designed clinical trials are required before definitive therapeutic conclusions can be established.

KEYWORDS: Rasayana; Ayurvedic botanicals; viral infections; cellular integrity; immunomodulation

1. INTRODUCTION

Viral infections still continue to be a serious health threat throughout the world due to their speed of transmission, disruption of cellular functions, and resulting diseases, which can range from mild illness to severe systemic effects. Once inside susceptible host cells, viruses take over cellular functions for their replication and can disrupt mitochondrial function, redox systems, membrane integrity, protein biosynthesis, and protein signaling. Such modifications could lead to an increase in reactive oxygen species, inflammatory mediators, immune dysfunction, and programmed cell death. Therefore, the integrity of cells is important for the resilience of the host, since the preservation of normal cell structure and function might affect immune effectiveness and the degree of tissue injury. This has heightened the interest in natural products that have the ability to modulate oxidative stress, inflammation, immune activity, and virus–host interactions.

The Ayurvedic medicinal plants have been gaining increasing attention as many of them contain bioactive compounds with antioxidant, immunoregulatory, and anti-inflammatory properties as well as antiviral activity. In the context of the COVID-19 pandemic, various Ayurveda-based interventions were considered to be potential supportive or preventative measures, which has led to an increased interest in the mechanisms of these interventions. The mechanistic reviews indicate that the Ayurvedic herbs might have multiple biological targets, such as inflammatory pathways, regulation of oxidative stress, immune responses, and mechanisms related to viral replication (Sarkar & Mukhopadhyay, 2022). A few Ayurvedic medicinal plants have also been assessed for their possible preventive and therapeutic relevance during viral pandemics, especially in providing support to host defense and in controlling harmful inflammatory responses (Kumar et al., 2021).

In Ayurveda, the Rasayana is a therapeutic term that refers to vitality, nourishment of tissues, physiological strength, and resistance to disease. Traditionally, Rasayana is not only about the treatment once a person falls ill; it is also about the

protection of health and strengthening the resistance of the body against harmful influences. In the biomedical context, some of these effects are understood in terms of immune modulation, antioxidant defense, cellular repair, metabolic regulation, and maintaining homeostasis. Rasayana botanicals have thus sparked interest on their side as a possible source of compounds that can be beneficial to antiviral defense and cellular resistance. Their immunomodulatory and antiviral effects are also apparent, as revealed during reviews during COVID-19, which include regulation of innate and adaptive immune responses and inhibition of viral pathogenesis processes (Singh et al., 2021).

The complexity of phytochemicals and the biological relevance of the botanicals also support their use in Ayurvedic medicine. Other secondary metabolites such as Phenolic compounds, flavonoids, alkaloids, terpenoids, and glycosides may be responsible for antioxidant and immune-regulatory functions. Some of the phytochemical-rich Ayurvedic herbs have been reported to control oxidative stress and immune responses, thereby playing a role in cellular defense (Mahammed, n.d.). Computational studies have also suggested some phytochemicals derived from Ayurveda can interact with host and viral molecular targets, which may lead to multi-target activity (Borse et al., 2021). Computational results, however, are not sufficient to prove therapeutic efficacy and must be supported by experimental and clinical studies.

Indian medicinal plants and traditional formulations have also been studied for possible applications in viral infections both pre-clinically and clinically. Studies from the past few years on the botanicals that are being investigated for COVID-19 have reviewed the action of the natural products which contain antiviral, anti-inflammatory, antioxidant, and immunomodulatory properties and therefore are worth further investigation (Ahmad et al., 2021). Similar assessments suggest that the existing evidence consists of traditional knowledge, laboratory studies, studies with animals, and a lower number of studies in humans, implying interesting and critical gaps in evidence. Prophylactic reviews have also suggested that Ayurvedic plants could be used as supportive medicines to boost the immune system and manage pathways involved in the progression of viral diseases and increase the need for better-controlled studies (Thapliyal et al., 2023).

The protective effects of Rasayana botanicals on cellular organelles and endogenous antioxidants against viral stress are another emerging field of interest. In HIV-1-associated cellular stress, experimental studies revealed effects on mitochondrial resilience and antioxidant defense, which indicates a potential cytoprotective ability under challenge of HIV-1 (Jadaun et al., 2024). These results go beyond viral inhibition to cell protection.

There has also been an increased interest in the preventive aspect of Ayurveda, as indicated by the community -based evidence. Although it is a non-randomized study, it was observed that an Ayurvedic immunity-supporting intervention among frontline staff during COVID-19 had possible prophylactic benefit (Nesari et al., 2022). To conclude, available evidence indicates that Rasayana botanicals could modulate the oxidation-reduction state, mitochondrial activity, inflammatory responses, immune function, and anti-viral activity. But clinical evidence is not consistent and scarce. Hence, this narrative review assesses the efficacy and mechanism of action of the important Rasayana botanicals of Ayurveda in maintaining the integrity of the cells during viral attacks, focusing on antioxidant, immunomodulatory, anti-inflammatory, cytoprotective, and antiviral properties.

2. Concept of Rasayana in Ayurveda

Rasayana is a multidimensional Ayurvedic treatment that connects with several aspects related to vitality and function of tissues, resistance to physiological stress and disease. The above-mentioned principles are now more commonly viewed as pertaining to cellular homeostasis, immune competence, antioxidant defence, stress adaptation and maintenance of functional reserve (Chaudhry, 2021; Maru et al., 2026). These connections do not imply direct correspondence between the concepts of Ayurveda and the biomedical field; rather, they serve as a framework for understanding how Rasayana could help to increase host resistance and protect cells. The main conceptual interplay that is important for threats from viruses is summarized in Table 1.

Table 1. Integration of Rasayana Concepts with Cellular Protection and Host Defense

Rasayana Domain	Modern Biological Correlate	Relevance to Viral Threats	References
Ojas–Bala	Physiological resilience and stress tolerance	Supports host stability during infection	Shriwas et al. (2021)
Vyadhikshamatva	Immune competence and host defense	Supports antiviral resistance and immune balance	Shriwas et al. (2021)
Tissue preservation	Cellular homeostasis and repair	Protects against oxidative and inflammatory injury	Chaudhry (2021); Maru et al. (2026)
Adaptogenic action	Stress regulation and functional reserve	May improve tolerance to systemic stress	Dubey & Jain (2026); Voss (2026)
Immunomodulation	Cytokine and immune-cell regulation	Helps maintain balanced antiviral responses	Wu et al. (2024); Midha et al. (n.d.)
Cytoprotection	Antioxidant defense and organelle stability	Limits virus-associated cellular damage	Sharma et al. (2025); Wu et al. (2024)

2.1 Rasayana as a Rejuvenative and Preventive Approach

The branch of Ayurveda that deals with the preservation of health, promotion of longevity, increase in vitality and physiological strength is called Rasayana. It is comprised of medicinal plants, dietary practices, behavioral and

rejuvenative practices which are meant to help nourish tissue and maintain balance on a systemic level. Classical Rasayana botanicals continue to be a topic of interest in contemporary healthcare due to their restorative, strengthening and adaptogenic qualities (Chaudhry, 2021). In modern understandings, Rasayana is associated with healthy ageing, resilience, metabolic stability and the maintenance of cellular function. It is therefore seen as a multidimensional strategy that includes the use of phytotherapy, nutrition, regulation of lifestyle and preventive care (Maru et al., 2026). In geriatrics, these concepts have been employed to maintain functional capacity and to minimize age-related deterioration (Dubey & Jain, 2026). There have also been clinical investigations into its role in vitality and healthy aging (Voss, 2026).

2.2 Rasayana and Ayurvedic Foundations of Host Defense

The three concepts of Ojas, Bala, and Vyadhikshamatva are all related to Rasayana. Vitality (ojas), strength (bala) and resistance to disease (vyadhikshamatva). Physiological balance and nourishment of tissues are traditionally believed to be also supported by Rasayana. Achar Rasayana is not just about medicines; it also involves correct behavior, managing emotions, disciplined actions, and healthy living habits. These measures are deemed to be supportive of mental, social, and physiological health (Shriwas et al., 2021). These ideas can be loosely equated to the modern concepts of biological resilience, immune competence, stress adaptation, and homeostasis. In this way, Rasayana can be considered as a wider concept to boost the body's resistance and to establish physiological equilibrium in times of greater stress or vulnerability.

2.3 Traditional Role of Rasayana in Disease Resistance

Rasayana therapy is traditionally used to help build up tissues, improve physiological resilience, and help to recover from stress. The other significance of its preventive role is that it is intended to keep people healthy before they become severely dysfunctional. As a result, it is believed that Rasayana botanicals are more than just anti-disease agents; they can actually boost host resistance. This position has recently been resurfaced in oncology and chronic care. Rasayana-based adjuvants are being studied for their potential in immune support, minimizing the burden of treatment, and maintaining physiological reserve (Sharma et al., 2025). A scoping review also revealed potential applications for Rasayana adaptogens in stress management, immune regulation, and quality of life, with mixed clinical results (Wu et al., 2024). Rasayana has also been suggested as an immunomodulatory and supportive treatment for cancer (Midha et al., n.d.).

2.4 Modern Interpretation as a Cytoprotective and Immunomodulatory Approach

The modern understanding of Rasayana with a biomedical perspective involves antioxidant, anti-inflammatory, immunomodulatory, and cytoprotective properties. The phytochemicals might affect pathways that regulate oxidative balance, cellular repair, inflammatory signaling, and immune regulation. All such effects indicate that Rasayana can be considered as an approach of cytoprotection, which may help in maintaining the integrity of the cell membranes, the function of the organelles, the redox balance, and the function of the intracellular signalling pathways during stress. The antioxidant, anti-inflammatory, immunoregulatory, and stress-modulating effects of Rasayana botanicals have also been highlighted in reviews, but further clinical evidence is needed to substantiate these properties (Wu et al., 2024; Sharma et al., 2025). This immunomodulatory function is important when viral threats occur, as both hyper- and hypo-response can lead to cell damage. Thus, besides any antiviral effects, Rasayana can contribute to host resistance, integrity of the cells, and immune homeostasis.

3. Cellular Integrity During Viral Threats

There are several ways by which viral infections affect the integrity of cells, but these interrelate. These include disruption of entry and replication processes of the host cell, increased oxidative stress, impaired mitochondrial function, membrane and barrier damage, DNA and protein damage, inflammatory activation, changes in cell death pathways, and immune dysfunction. These disturbances, when combined, may disrupt cellular homeostasis and help lead to tissue damage and disease. Figure 1 shows the main mechanism of virus-induced cellular injury.

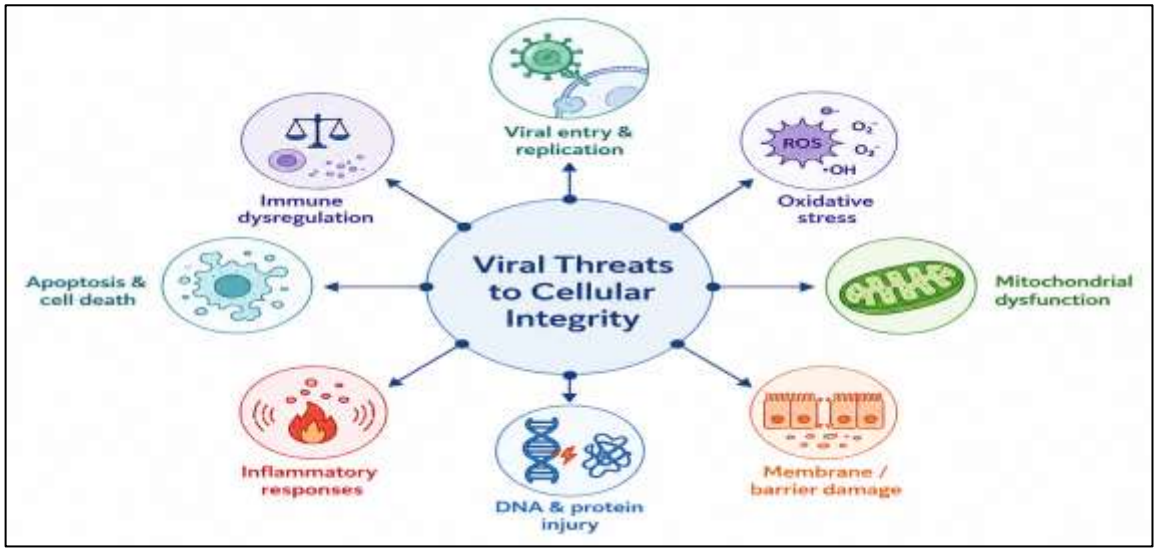

Figure 1. Major mechanisms of virus-induced cellular injury

3.1 Viral Entry and Replication

The viral infection process involves receptor attachment, entry into the cell, uncoating, genome release, and viral macromolecules' replication with host machinery. The damage to epithelial and endothelial functions may lead to the destruction of tissue barriers via these processes. Damage to mucociliary epithelium in the respiratory tract may lead to dysfunction of virus clearance and penetration (Adivitiya et al., 2021). Viral disruption of vascular and tissue barriers can also facilitate systemic spread (Apoorva & Singh, 2026), and endothelial dysfunction can affect inflammation, permeability, and perfusion (Fosse et al., 2021). RNA viruses also hijack host RNA processing and degradation pathways, ensuring the survival of the viral genome and promoting their replication (Markiewicz et al., 2021).

3.2 Oxidative Stress

Oxidative stress occurs when reactive oxygen and nitrogen species surpass antioxidants. Immune activation, mitochondrial disturbance, and metabolic changes can lead to increased oxidative burden and oxidative damage to lipids, proteins, and nucleic acids during viral infection. This stress can be exacerbated by environmental exposures, such as over-disinfecting during COVID-19, which led to concerns about the oxidative and toxic effects on tissues (Ghafoor et al., 2021). This has led to the significance of Rasayana botanicals as supportive agents. During COVID-19, Ayurveda approach to prophylactic measures highlighted herbs associated with resilience and host defence (Patwardhan et al., 2020). Ashwagandha has also been mentioned as having antioxidant and immune-supportive properties, but more clinical studies are needed to confirm this (Upendra & Ahmed, 2021).

3.3 Mitochondrial Dysfunction

Mitochondria control energy production, redox balance, apoptosis, and antiviral signaling. Infection with viruses can lead to decreased mitochondrial membrane potential, disruption of ATP production, increased production of reactive oxygen species, and interference with innate immune pathways. This ongoing mitochondrial dysfunction can then play a role in cell damage, inflammation, and inadequate antiviral defenses. There are some Rasayana botanicals containing phytochemicals, which could affect the redox and stress-response mechanisms. The phytoconstituents of Withania somnifera have been investigated as supportive botanicals during SARS-CoV-2 infection as they may have an impact on oxidative regulation, inflammatory signaling and host cellular defense (Saggam et al., 2021). But the majority of evidence is either mechanistic or preclinical and needs more translational confirmation.

3.4 Membrane and Barrier Damage

Compartmentalization, ion balance, pathogen resistance, and protection are provided by cellular membranes and tissue barriers. Viruses may directly disrupt membranes or alter repair processes to enhance their survival (Daussy & Wodrich, 2020). Disruption of tissue barriers (e.g., epithelial, endothelial, and blood-tissue barriers) can promote dissemination and inflammatory injury at the tissue level. Damage to the respiratory epithelium can impair mucociliary clearance (Adivitiya et al., 2021), and endothelial damage can result in vascular leakage and coagulation disturbances (Fosse et al., 2021). Neurotropic infections can lead to inflammation that results in increased permeability of the blood-brain barrier, and viral components or immune cells may enter neural tissues (Chen & Li, 2021).

3.5 DNA and Protein Injury

Damage to host DNA and proteins by a viral infection is caused by oxidative stress, inflammation, and impairment of repair mechanisms. SARS-CoV-2 has also been demonstrated to disrupt DNA-damage responses by CHK1 degradation and decreased recruitment of 53BP1, which may enhance genomic instability and cellular senescence (Gioia et al., 2023). Oxidative modification, abnormal folding, or degradation of proteins can also occur during infection. Viruses utilize host translational machinery and can redirect protein synthesis to viral components and disrupt normal protein synthesis. In addition, RNA viruses alter viral RNA stability, processing, and translation, which indirectly impacts protein homeostasis inside the cell (Markiewicz et al., 2021).

3.6 Inflammatory Responses

Viral defense relies on inflammation, but over-activation can result in tissue damage. The recognition of viruses triggers the release of cytokines, chemokines, interferons, and recruitment of immune cells, and may lead to damage of epithelial and endothelial surfaces and to increased oxidative stress if not terminated. Viral infection causes endothelial cells to be important in inflammatory signaling (Fosse et al., 2021), and neuroinvasive viruses could impair the blood-brain barrier via hyperinflammation (Chen & Li, 2021). Rasayana botanicals have therefore been of interest for their potential anti-inflammatory properties. Studies on Withania somnifera show that withanolides could have a role in regulating inflammatory mediators and host-response pathways that are associated with SARS-CoV-2; but this evidence is mostly from pre-clinical studies (Ramli et al., 2023; Singh et al., 2022).

3.7 Apoptosis and Other Forms of Cell Death

Elimination of infected cells by programmed cell death can be manipulated by viruses for replication. Some promote apoptosis early on in the infection, while some others promote cell death later on to aid in viral release. Autophagy, pyroptosis, necroptosis, and cellular senescence may also be affected by viral infection. Persistent effects of SARS-CoV-2 have been suggested beyond acute infection, as disruption of DNA-damage signaling has been related to cellular senescence (Gioia et al., 2023). Botanicals like Ashwagandha are studied for their potential protective effects against stress-related cellular damage due to their abilities to modulate oxidative stress and inflammation, which are known to affect cell death pathways (Saggam et al., 2021; Singh et al., 2022).

3.8 Immune Dysregulation and Loss of Cellular Homeostasis

Innate and adaptive immunity are the key to effective anti-viral defense. Over- or under-activation can be harmful, while strong responses may allow the virus to replicate. Viral infection could alter interferon signaling, cytokine balance, lymphocyte function, and barrier integrity (Apoorva & Singh, 2026). Rasayana approaches are relevant as they are suggested to be beneficial for immune resilience and not just for direct antiviral effects (Patwardhan et al., 2020). Ashwagandha is especially noteworthy due to its phytochemical components that could have an impact on immune signaling, inflammation, oxidative stress, and targets related to SARS-CoV-2 (Ramli et al., 2023). The potential immunomodulatory and host-directed effects are also reported, and the current demand is to have a strong clinical validation (Upendra & Ahmed, 2021; Singh et al., 2022).

4. Major Ayurvedic Rasayana Botanicals with Potential Relevance to Viral Threats

Major Rasayana botanicals differ in their phytochemical composition and proposed biological activities, but several share common antioxidant, immunomodulatory, anti-inflammatory, cytoprotective, and potential antiviral properties. Their principal constituents and relevance to viral threats are summarized in Table 2.

Table 2. Major Rasayana botanicals, principal constituents, and relevance to viral threats

Botanical	Major Phytoconstituents	Principal Biological Activities	Potential Relevance to Viral Threats	Key References
Withania somnifera	Withanolides, alkaloids, sitoindosides	Antioxidant, anti-inflammatory, immunomodulatory	Host immune support and possible interaction with viral targets	Shree et al. (2022); Gyawali et al. (2020); Singh et al. (2021)
Tinospora cordifolia	Alkaloids, diterpenoids, glycosides, polysaccharides	Immunomodulatory, antioxidant, anti-inflammatory	Immune regulation and possible antiviral target interaction	Jaiswal et al. (2025); Paliwal et al. (2025); Shree et al. (2022)
Phyllanthus emblica	Vitamin C, tannins, gallic acid, ellagic acid, flavonoids	Antioxidant, cytoprotective, immunomodulatory	Protection against oxidative injury and support of host defense	Reena et al. (2020); Yan et al. (2022); Khedkar (2025)
Ocimum tenuiflorum	Eugenol, ursolic acid, rosmarinic acid, linalool	Antioxidant, anti-inflammatory, antimicrobial	Modulation of viral entry-related and inflammatory pathways	Adithya et al. (2021); Bhattacharya et al. (2024); Paul et al. (2020)
Glycyrrhiza glabra	Glycyrrhizin, glycyrrhetinic acid, flavonoids	Antiviral, anti-inflammatory, immunoregulatory	Possible inhibition of viral replication and inflammatory injury	Khuntia et al. (2022); Gasmi et al. (2024); Gyawali et al. (2020)
Curcuma longa	Curcumin, curcuminoids, turmerone	Antioxidant, anti-inflammatory, cytoprotective	Regulation of oxidative and inflammatory pathways	Khuntia et al. (2022); Panda et al. (2020); Kothadia (2020)
Asparagus racemosus	Shatavarins, steroidal saponins, flavonoids	Antioxidant, immunomodulatory, mitochondrial protection	Mitochondrial resilience and possible antiviral activity	Chikhale et al. (2021); Jadaun et al. (2024); Mittal & Chand (2020)
Other Rasayana botanicals	Diverse polyphenols, alkaloids, terpenoids	Antioxidant, immune-supportive, antimicrobial	Broader host resilience and prophylactic support	Dorage et al. (2023); Sen (2020); Mohanty et al. (2024); Bendale et al. (2020)

As shown in Table 2, the major Rasayana botanicals share overlapping biological actions despite differences in their phytochemical profiles. Their relevance to viral threats appears to arise mainly from combined effects on oxidative stress, inflammation, immune regulation, cellular protection, and, in some cases, direct interactions with viral targets.

4.1 Withania somnifera (Ashwagandha)
Withania somnifera is a prominent Rasayana (restorative) herb that is traditionally used to strengthen the body, boost vitality, support stress adaptation, and the immune system. It contains a number of active compounds, such as withanolides, alkaloids, sitoindosides and steroidal lactones, which are known for their antioxidant, anti-inflammatory, immunoregulatory and cytoprotective properties. Ashwagandha may provide anti-oxidative effects, control inflammation and boost immunity during viral stress. It is suggested that its phytochemicals are able to interact with the SARS-CoV-2 protease targets based on computational evidence, but experimental confirmation may be needed (Shree et al., 2022). Ashwagandha has also been highlighted as a supportive botanical that has multiple targets and the traditional role of Rasayana during COVID-19 (Gyawali et al., 2020; Singh et al., 2021).

4.2 Tinospora cordifolia (Guduchi)
Guduchi (Tinospora cordifolia) is a herbaceous perennial that is traditionally used as a tonic for enhancing vitality, immunity and recovery. It contains a number of major components such as alkaloids, diterpenoid lactones, glycosides, steroids and polysaccharides. These compounds have antioxidant, anti-inflammatory and immunomodulatory properties. Guduchi could enhance host defense via modulation of immune response and reduction in oxidative damage (Jaiswal et al., 2025). This wide pharmacology has also led to its exploration as a potential therapeutic agent in infectious diseases (Paliwal et al., 2025). Guduchi is often talked about as an Ayurvedic herb for immunity during COVID times (Gyawali et al., 2020). Additionally, molecular docking studies have indicated potential interactions between its phytochemicals and SARS-CoV-2 protease targets, but the efficacy of this has yet to be confirmed in clinical trials. (Shree et al., 2022)

4.3 Phyllanthus emblica (Amalaki)
Amalaki or Phyllanthus emblica is a classical Rasayana which is known for rejuvenation, nourishment of tissues and disease resistance. It contains vitamin C, tannins, gallic acid, ellagic acid, flavonoids, and other polyphenols, which play a role in antioxidant activity. These constituents can prevent oxidative damage to cellular membranes, proteins, and nucleic acids. Amalaki also shows immunomodulatory and anti-inflammatory activities, which are important to host defense. It has been found to be a potential source of antiviral and immune supporting phytochemicals (Reena et al., 2020; Singh et al., 2021). Also, several pharmacological studies have been conducted on Phyllanthi Fructus and have shown antioxidant, anti-inflammatory, and cytoprotective effects (Yan et al., 2022). This type of biofloc technology has also been taken up for emerging viral diseases, with limited clinical data (Khedkar, 2025).

4.4 Ocimum tenuiflorum (Tulsi)
Tulsi (Ocimum tenuiflorum) is known for its various traditional applications in medicine, including respiratory health, immunity, and resistance. Key components are eugenol, ursolic acid, rosmarinic acid, linalool, flavonoids, and phenols. These phytochemicals are responsible for antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties. Tulsi could modulate innate and inflammatory immune responses and also has an antioxidant effect. During the SARS-CoV-2 pandemic, its potential as a supportive therapeutic agent due to its wide spectrum of pharmacological activities was brought to light (Adithya et al., 2021). The recent studies of Ocimum spp. have also indicated potential applications in COVID-19-related molecular pathways (Bhattacharya et al., 2024). Proposed antiviral mechanisms involve inhibiting viral entry and host proteases like furin, but these effects are still fairly experimental (Paul et al., 2020).

4.5 Glycyrrhiza glabra (Yashtimadhu)
Glycyrrhiza glabra, also known as Yashtimadhu, is a traditional herb used for rejuvenation and to support the respiratory system. It contains primarily glycyrrhizin, glycyrrhetinic acid, liquiritin, isoliquiritigenin, and flavonoids. These compounds have antioxidant, anti-inflammatory, immunoregulatory, and cytoprotective effects. Additionally, glycyrrhizin has been explored for its potential antiviral properties, including its role in viral replication, inflammatory responses, and cell signaling. Licorice has been found to be a potential antiviral medicinal plant in the context of influenza and coronavirus (Khuntia et al., 2022), but most of the evidence is still preclinical. Glycyrrhiza species have also been discussed for their activity against coronaviruses in Ayurvedic and Chinese herbal reviews with references to other studies (Gasmi et al., 2024). Its traditional respiratory and immune-supporting properties were also taken into consideration during COVID-19 (Gyawali et al., 2020).

4.6 Curcuma longa (Haridra)
Haridra (Curcuma longa) is a popular Ayurvedic herb that has a variety of uses to support tissues and alleviate inflammation. It contains the main compounds curcuminoids, specifically curcumin, and volatile oils, such as turmerone. Curcumin modulates the pathways of oxidation and inflammation, which gives it antioxidant, anti-inflammatory, and cytoprotective properties. Turmeric has been suggested as an antiviral medicinal plant for medicinal use against influenza and coronaviruses, with a few clinical studies available (Khuntia et al., 2022). COVID-19 reviews based on Ayurveda have also highlighted the ability of Haridra to regulate immune function and to reduce inflammation (Gyawali et al., 2020). During the pandemic, the use of turmeric has been extended to other preventive measures by Ayurvedic practitioners (Panda et al., 2020). Its potential applications in the context of COVID-19 have also been examined in light of its antioxidant, anti-inflammatory and antimicrobial properties (Kothadia, 2020).

4.7 Asparagus racemosus (Shatavari)

Asparagus racemosus (known as Shatavari) is a nourishing Rasayana herb that contains steroidal saponins, shatavarins, flavonoids and polyphenols. The constituents may have antioxidant, immune modulatory and mitochondrial protective properties. The computational studies indicate that Shatavari phytochemicals could interact with molecular targets that are related to SARS-CoV-2 (Chikhale et al., 2021). Experimental studies also suggest that the extracts from Shatavari and Shatavarin IV could enhance mitochondrial stability and antioxidant capacity under cellular stress induced by HIV-1 (Jadaun et al., 2024). There are reports on its traditional use for respiratory and immune system support in the common cold and asthma (Biswas et al., 2026). Shatavari has also been recommended among supportive Rasayana during the Pandemic care programme of Ayurvedic medicine (Mittal & Chand, 2020), and immune-enhancing respiratory medicine has also been proposed (Ghorai, 2026).

4.8 Other Relevant Rasayana Botanicals

The other Rasayana botanicals such as Piper longum, Terminalia chebula, Terminalia bellirica and Centella asiatica are rich in phytochemicals with antioxidant, immunomodulatory, anti-inflammatory and antimicrobial activities. The use of Rasayana has been suggested as a complementary public health intervention during communicable diseases due to its role in enhancing host resistance and balancing physiology (Dorage et al., 2023). In the context of COVID-19, reviews of Ayurvedic medicinal plants also highlight their preventive role by supporting immunity, reducing inflammatory stress, etc. (Sen, 2020). Herbal/phytotechnological interventions have also been discussed as potential phytoimmunoboosters against microbial pathogens (Mohanty et al., 2024). In the case of COVID-19, polyherbo-mineral Rasayana formulations have also been suggested for prophylaxis, but more clinical studies are needed to substantiate the use (Bendale et al, 2020).

5. Mechanisms of Cellular Protection by Rasayana Botanicals

Rasayana botanicals may preserve cellular integrity through several interconnected mechanisms involving antioxidant defense, inflammatory regulation, immune modulation, mitochondrial support, membrane stabilization, molecular protection, and control of cell-survival pathways. These complementary actions provide a mechanistic basis for their proposed cytoprotective role during viral stress, as summarized in Figure 2.

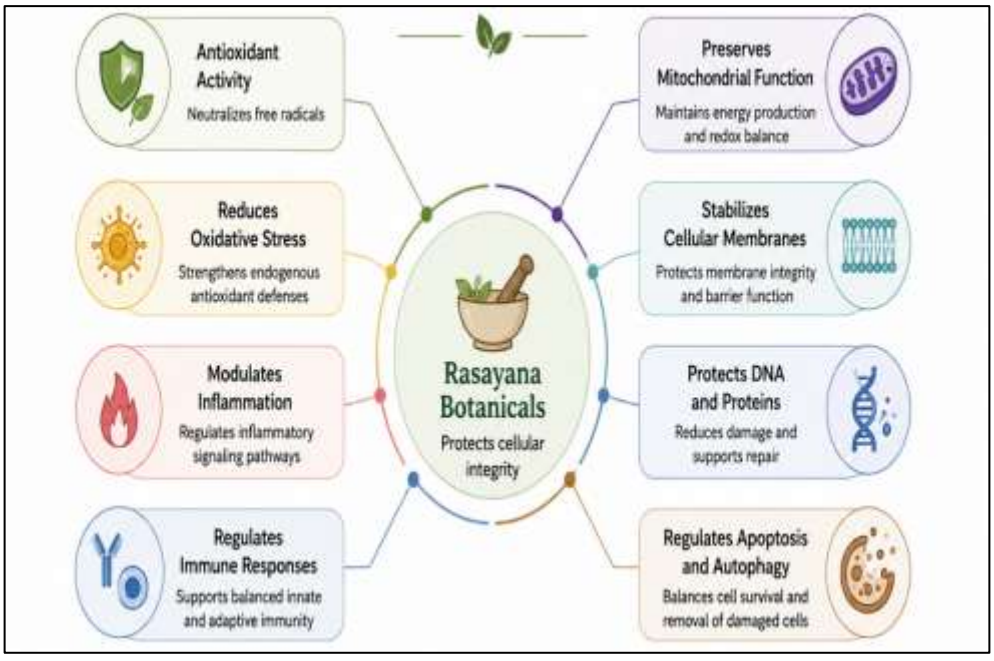

Figure 2. Major mechanisms of Rasayana-mediated cellular protection

5.1 Antioxidant and Free-Radical Scavenging Activity

Rasayana botanicals contain polyphenols, flavonoids, tannins, alkaloids, and other phytochemicals that can scavenge reactive oxygen and nitrogen species. This activity may help to prevent oxidative damage to lipids, proteins, DNA, and intracellular organelles. Antioxidant protection and maintenance of cellular homeostasis are correlated with classical Rasayana plants (Chaudhry, 2021). The wide-ranging nature of their chemical composition also makes them of interest for phytopharmaceutical protection against physiological stress (Mohandas & Ijunu, 2024). In viral infections, these effects can help reduce oxidative and inflammatory damage, which are essential for the proposed cytoprotective effect of Rasayana botanicals (Sarkar & Mukhopadhyay, 2022).

5.2 Reduction of Oxidative Stress

The rasayana botanicals can decrease oxidative stress by boosting endogenous antioxidant defenses, by restricting lipid peroxidation, and by protecting cellular components. They are involved in superoxide dismutase, catalase, glutathione, and other antioxidant systems. In oncology, the use of Rasayanas for normal tissue protection in the context of excessive

oxidative stress and physiological recovery has been explored (Sharma et al., 2025). Such mechanisms also play a role in viral infections, where the effects of oxidative stress can be mitigated by limiting it, leading to a more balanced immune response (Singh et al., 2021).

5.3 Modulation of Inflammatory Pathways

The goal of this study was to assess modulation of inflammatory pathways. Overproduction of cytokines, oxidative stress, and activation of inflammatory pathways can cause damage to cells during excessive inflammation. Rasayana botanicals can modulate pathways like NF-κB, MAPK, and cyclooxygenase-associated pathways, which help to tone down overactive inflammatory reactions. During COVID-19, drugs tested via the Ayurvedic approach have been discussed for their anti-inflammatory activity (Sarkar & Mukhopadhyay, 2022). Cancer treatments with Rasayana have been correlated with control of chronic inflammation and the maintenance of normal tissue function (Sharma et al., 2025). These effects could be significant during viral infections, when excessive inflammation can make a significant contribution to cellular damage.

5.4 Regulation of Immune Responses

Rasayana botanicals have the potential to affect macrophages, natural killer cells, lymphocytes, cytokines, and innate immune signaling. This immunomodulatory effect could have antiviral activity without causing excessive inflammation. The review articles on COVID-19 and Rasayana have pointed to its impact on the innate immune system and adaptive immune system (Singh et al., 2021). Rasayana has been suggested to have similar immunomodulatory effects in cancer supportive care, where it has been suggested to help maintain immune competence during cancer therapy-induced stress (Midha et al., n.d.). The discussions of Rasayana as an adjunct to chemotherapy have also focused on its role in supporting and restoring systemic resilience (Jain et al., 2026) and immune support.

5.5 Preservation of Mitochondrial Function

Mitochondria play a vital role in energy generation, redox balance, immune signaling, and cell survival. Oxidative and inflammatory stress may cause loss of mitochondrial membrane potential, reduction of ATP production, and elevated production of ROS. Rasayana botanicals can promote mitochondrial stability via antioxidant and metabolic regulation. They have been reported to have anti-aging properties, which have been associated with decreased oxidative and genomic damage and, consequently, maintenance of mitochondrial function (Sharma & Martins, 2020). Furthermore, phytopharmaceutical studies indicate that Rasayana herbs can act on multiple targets to offer protection from both oxidative stress and metabolic stress (Mohandas & Ijinu, 2024).

5.6 Stabilization of Cellular Membranes

Structural integrity, receptor activity, ion balance, and intracellular organization are events maintained by cellular membranes. Oxidative stress could cause damage to membrane lipids and their permeability. Phytochemicals found in Rasayana botanicals may have antioxidant and anti-inflammatory properties that can help to inhibit lipid damage and maintain membrane function. The tissue nourishment and functional stability concepts of traditional Rasayana could be correlated with the maintenance of cellular homeostasis (Chaudhry, 2021). Rasayana-centered supportive measures have also been shown to be protective of normal tissues from oxidative and inflammatory stress (Jain et al., 2026). These effects may contribute to maintaining the barrier properties of cells and tissues in viral infection.

5.7 Protection of DNA and Cellular Proteins

Oxidative stress and inflammation may lead to damage of DNA, shorten the length of telomeres, modify proteins, and impair cellular repair. Rasayana botanicals can help minimise such damage with the help of antioxidant and repair functions. They have been associated with their anti-aging properties, which involve the maintenance and protection of the telomeres and maintenance of genomic integrity (Sharma & Martins, 2020). Phytochemicals derived from Rasaayana can also target various cellular targets that are associated with the protection and repair from oxidation (Mohandas & Ijinu, 2024). These mechanisms could play a role in helping to prevent nucleic acids and proteins from being attacked by stressful conditions of infection and in keeping cells in normal condition.

5.8 Regulation of Apoptosis and Autophagy

The role of apoptosis and autophagy in the regulation of cell death and survival. Apoptosis and autophagy control the elimination of damaged cells and intracellular components; however, over-destruction can be a source of damage to the tissue. Rasayana botanicals can affect these processes via a number of pathways, including oxidative, mitochondrial, inflammatory, and survival-related pathways. The use of Rasayana in cancer treatment is being considered for its ability to modulate mechanisms that promote cell survival and spare healthy tissues (Sharma et al., 2025). Their potential role in regulating cellular stress and immune responses in chemotherapy is highlighted in similar reviews (Jain et al., 2026). Rasayana therapy has also been suggested to be an immunomodulatory and restorative therapy that helps in cellular survival and recovery (Midha et al., n.d.).

6. Molecular Pathways Involved in Rasayana-Mediated Cellular Protection

Rasayana-mediated cellular protection appears to involve coordinated regulation of antioxidant, inflammatory, immune, survival, and stress-response pathways. Rather than acting through a single molecular target, Rasayana botanicals may influence interconnected signaling networks that collectively support redox balance, immune regulation, cellular repair, and resilience. The principal pathways discussed in this section are summarized in Table 3.

Table 3. Major molecular pathways involved in Rasayana-mediated cellular protection

Molecular Pathway	Main Biological Role	Proposed Rasayana-Mediated Effect	Relevance to Cellular Protection	Key References
Nrf2/ARE	Antioxidant and detoxification defense	Enhances stress-responsive and antioxidant signaling	Supports redox balance and limits oxidative injury	Munde et al. (2026)
NF-κB	Inflammatory and immune regulation	Modulates excessive inflammatory signaling	Reduces cytokine-mediated cellular injury	Selvaraj et al. (2021)
MAPK	Stress, inflammation, proliferation, apoptosis	Regulates ERK, JNK, and p38-associated responses	Supports cellular adaptation and controlled stress responses	Manikyam & Joshi (2025)
PI3K/Akt	Cell survival, metabolism, repair	Influences survival and metabolic signaling	Promotes cellular resilience and recovery	Manikyam & Joshi (2025); Munde et al. (2026)
JAK/STAT	Cytokine and antiviral signaling	Modulates interferon- and cytokine-dependent responses	Supports immune balance and antiviral defense	Selvaraj et al. (2021); Munde et al. (2026)
Cytokine signaling	Immune-cell communication	Helps regulate inflammatory and immune mediators	Limits excessive immune-mediated damage	Selvaraj et al. (2021); Kumar et al. (2020)
Antioxidant enzyme systems	Control of reactive oxygen species	Supports SOD, catalase, glutathione-related defenses	Maintains redox homeostasis and cytoprotection	Kumar et al. (2020); Munde et al. (2026)

6.1 Nrf2/ARE Signaling

During oxidative stress, the Nrf2/ARE pathway is responsible for regulating antioxidant and detoxification responses. It stimulates genes that regulate glutathione metabolism and other cytoprotective processes. Rasayana botanicals may act to support this pathway by means of phytochemicals that help improve endogenous antioxidant systems. Based on genomic and epigenomic research, Rasayana therapy has been correlated with gene regulation related to antioxidant response, cellular repair, and stress response (Munde et al., 2026). These effects can be important when the virus is present; for example, during viral infection, its membranes, proteins, and nucleic acids can be damaged by oxidative stress.

6.2 NF-κB Pathway

Inflammation and immune activation involve the role of NF-κB. Overactivation during infection can result in elevated levels of cytokines, chemokines, and inflammatory enzymes, which can lead to tissue damage. Herbal phytochemicals could regulate these responses by targeting multiple immune and inflammatory targets (Selvaraj et al., 2021). Rasayana botanicals can consequently contribute to the regulation of NF-κB activity, which is crucial for a well-functioning immune system, but can also be harmful for excessive inflammation and maintenance of cellular integrity.

6.3 MAPK Signaling

Oxidative stress, inflammation, proliferation and apoptosis are regulated by MAPK pathways (ERK, JNK, p38). When the stress is persistent, there can be dys-regulation which can lead to inflammatory damage and abnormal cell death. These pathways are interconnected which can be regulated by the phytochemicals derived from Rasayana. Medicinal plants have been found to have multiple beneficial effects on various networks like inflammatory, metabolic, and survival networks in the context of network pharmacology studies (Manikyam & Joshi, 2025). Thus, modifying the signalling of the MAPK pathway may contribute to cellular adaptation and the prevention of injury caused by stress.

6.4 PI3K/Akt Pathway

The PI3K/Akt pathway plays a role in cell survival, cell metabolism, mitochondrial function and repair. Rasayana botanicals can affect this pathway in several ways, via various bioactive components in these plants that interact with cell survival and metabolic pathways. Based on network-based analysis, medicinal phytochemicals are proposed to interact and regulate PI3K/Akt along with inflammatory pathways (Manikyam & Joshi, 2025). Molecular mechanisms linked to repair, longevity and stress resistance have also been associated with Rasayana therapy (Munde et al., 2026). Regulation can help prevent cells from oxidative damage caused by infection.

6.5 JAK/STAT Pathway

Cytokines are transmitted via the JAK/STAT pathway in immunity and inflammation, cell survival and antiviral responses. This pathway is essential for the control of pathogens through interferons and interleukins, and can lead to inflammatory injury if overactive. Herbal compounds could have a multitargeted effect on cytokine-dependent signaling pathway (Selvaraj et al., 2021). Genomic and epigenomic effects of rasayana may also affect immune responsiveness and cellular

adaptation (Munde et al., 2026), which could be beneficial for antiviral defense and reduce unnecessary tissue damage caused by cytokines.

6.6 Cytokine-Mediated Signaling

The antiviral immunity is coordinated by cytokines like interferons, interleukins, tumor necrosis factor and chemokines. However, if cytokine production is excessive, it can lead to tissue damage in the body. Multi-target immunomodulatory activity of Rasayana botanicals may contribute to maintaining the balance of cytokines (Selvaraj et al., 2021). Long term administration of Amalaki Rasayana has also been linked to metabolic alterations at the level of immune pathways, showing its potential systemic effects on the immune regulation (Kumar et al., 2020).

6.7 Endogenous Antioxidant Enzyme Systems

Cells are protected from R.O.S. by the action of superoxide dismutase, catalase, glutathione peroxidase and associated systems. These defenses can be overcome by a viral infection, which aids in promoting oxidative damage. Botanicals used in Rasayana may boost antioxidant activity by activating protective enzymes and related metabolites. Amalaki Rasayana has been linked to the metabolic pathways related to immunity and lipid metabolism (Kumar et al., 2020). Epigenomic and genomic data also support the association of Rasayana with the regulation of response mechanisms of cellular stress (Munde et al., 2026). These effects can promote redox balance and long-term cytoprotection.

7. Antiviral Potential of Rasayana Botanicals

The antiviral potential of Rasayana botanicals can be broadly understood through two complementary mechanisms: direct effects on viral processes and host-directed protection. These botanicals may interfere with viral attachment, replication, and viral proteins while also supporting antiviral immunity, regulating inflammation, and strengthening cellular defenses. The principal mechanisms are summarized in Figure 3.

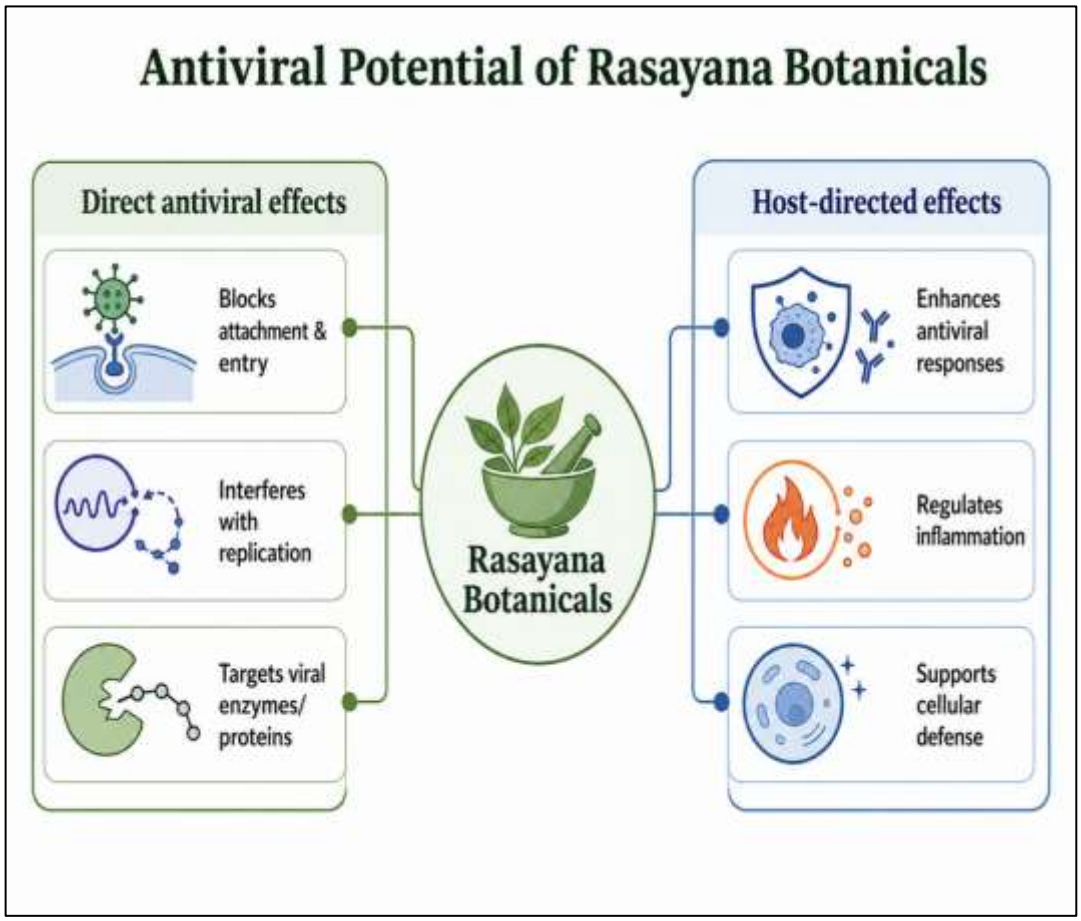

Figure 3. Direct and host-directed antiviral actions of Rasayana botanicals

As illustrated in Figure 3, Rasayana botanicals may exert antiviral effects through both virus-targeted and host-supportive pathways. Direct actions may involve inhibition of viral entry, replication, and viral enzymes or proteins, whereas host-directed effects include immune regulation, control of excessive inflammation, and reinforcement of cellular defense.

7.1 Inhibition of Viral Attachment and Entry

The viral infection process starts with its ability to attach to the receptor of the host cells and gain entry. Certain Rasayana phytochemicals could adversely affect the processes by interacting with the receptors or by altering the surface proteins of viruses. The compounds of Indian medicinal plants which disrupt virus–host interactions are reported as having potential activity against influenza viruses and coronaviruses in reviews (Khuntia et al., 2022). Its potential multi-target

activity against infectious diseases has also been investigated in Tinospora cordifolia (Paliwal et al., 2025). There are still only a few preliminary or theoretical studies showing that viruses are inhibited when they try to get inside, though.But there's not much proof yet to support that assertion, at least not much experimental evidence, and there's always the possibility that it's a theory.

7.2 Interference with Viral Replication

The viruses require the host-cell's machinery to copy the viral genome, synthesize proteins and produce new viruses. The phytochemicals in Rasayana can disrupt the enzymes of viruses or host pathways which are associated with these processes. Piper longum was examined for antiviral and immunomodulatory activity which could affect various phases of the infection (Subramaniam et al., 2021). Additionally, herbal compounds have been found to inhibit viral replication by various biochemical pathways (Bhagat & Mhaiskar, 2023). During the COVID-19 pandemic, preclinical investigations of Indian medicinal plants have led to a report of potential effects on targets involved in the process of replication, though there is doubt about their clinical efficacy (Sayeed et al., 2021).

7.3 Modulation of Host Antiviral Responses

Rasayana botanicals may not only modulate antiviral activity, but they do so as they regulate host immunity. Coordinated interferon, immune cell, cytokine, and adaptive responses are required for effective responses. Tinospora cordifolia is said to be an immunomodulatory plant with potential to modulate the activity of immune cells and inflammatory mediators (Paliwal et al., 2025). Further, Piper longum has demonstrated immune-supportive activity which could be used in conjunction with antiviral activity (Subramaniam et al., 2021). As such, Rasayana has been suggested as a supportive therapy when it comes to communicable diseases due to its focus on balancing immunity, prevention, and strengthening the host (Dorage et al., 2023).

7.4 Regulation of Virus-Induced Inflammation

During viral infection, excessive inflammatory responses may lead to oxidative stress, vascular dysfunction and tissue injury. Anti-inflammatory and immunomodulatory rasayana botanicals could help modulate these responses and maintain a healthy cellular integrity. During COVID-19, review of Indian medicinal plants revealed plants that possess anti-inflammatory, antioxidant and antiviral properties (Sayeed et al., 2021). A similar assessment of their activity against influenza and SARS-CoV suggests that their benefits may be either direct against the virus or by modulating host inflammatory pathways (Khuntia et al., 2022). A dual effect can be beneficial to limit the progression of the virus infection and also to decrease immune mediated tissue damage.

7.5 Possible Effects on Viral Enzymes and Proteins

Important targets include viral proteases, polymerases, and structural proteins that control entry, replication and assembly. These proteins have been screened with the help of molecular docking approaches for Rasayana phytochemicals. A study conducted in silico revealed several herbal compounds that bind with predicted affinity to viral proteins that are crucial for virus infection during Nipah virus infection (Debroy et al., 2023). The potential for interaction with the viral polymerases and proteases of the Indian medicinal plant constituents has also been examined (Khuntia et al., 2022). These findings can be used to identify potential candidates, but do not determine antiviral efficacy. It is necessary to validate it by experiments and clinical trials.

7.6 Host-Directed Antiviral Mechanisms

Host-directed strategies are designed to boost the host's resistance to the virus or to alter the host pathways that are needed for the survival of the virus. Rasayana botanicals are appropriate to this model as they focus on developing host resistance and systemic equilibrium. The potential mechanisms are antioxidant effects, modulation of cytokines, immune modulation, and maintenance of homesostasis. During communicable diseases, Rasayana has been suggested as a supportive public health measure, by enhancing host resistance (Dorage et al., 2023). Host immune and inflammatory pathways that participate in the progression of a virus might also be influenced by herbal therapeutics (Bhagat & Mhaiskar, 2023). Computational studies of Nipah virus also highlight the potential for integrating Rasayana principles with molecular methods to discover host and virus-targeting strategies (Debroy et al., 2023).

8. Evidence Supporting Rasayana Botanicals During Viral Threats

The evidence supporting Rasayana botanicals during viral threats spans laboratory, experimental, clinical, and broader infection-related studies. However, the strength of evidence differs considerably across these levels, with preclinical findings generally being more extensive than human clinical validation. The current evidence base is summarized in Table 4.

Table 4. Summary of evidence supporting Rasayana botanicals during viral threats

Evidence Level	Main Findings	Current Strength	Key References
In vitro	Possible effects on viral entry, replication, oxidative stress, and inflammatory signaling	Preliminary; mainly mechanistic and cell-based	Reena et al. (2020); Kumar et al. (2021)
Animal /	Antioxidant, immunomodulatory, cytokine-	Supportive but requires	Kumar et al.

experimental	regulating, and tissue-protective effects	standardized validation	(2021); Irole (2021)
Human / clinical	Possible prophylactic and supportive benefits during COVID-19	Limited; heterogeneous study designs and outcomes	Arya et al. (2024); Panda et al. (2020)
Respiratory viral infections	Supportive relevance for respiratory symptoms, inflammation, and immune function	Moderate conceptual and review-based support	Singh et al. (2020); Reena et al. (2020)
Emerging / re-emerging viral diseases	Potential preventive and host-supportive roles	Emerging and largely indirect evidence	Chowdhury et al. (2025)

8.1 In Vitro Evidence

Some of the lab studies indicate that certain Ayurvedic botanicals may affect viral entrance, multiplication, oxidative stress and inflammatory signaling. Selected Ayurveda botanicals have been shown to have antiviral and immunomodulatory activity in the reviews done during the COVID-19 time, but a majority of the evidence was obtained through cell-based or mechanistic studies (Reena et al., 2020). In a similar review, various plant extracts containing compounds that could serve as host defense compounds and have anti-viral activity were identified (Kumar et al., 2021). However, there is a limitation in direct clinical interpretation due to the differences in extracts, concentrations and experimental models.

8.2 Animal and Experimental Evidence

Experimental studies show that Rasayana botanicals may have antioxidant, immunomodulatory and tissue-protective properties. There is some pre-clinical evidence that certain Ayurvedic plants could provide antioxidant activity, control cytokines, and induce immunoregulatory activities during any state of stress during infection (Kumar et al., 2021). Other traditional formulations as Tribhuvan Keerti Ras also have been mentioned for their potential antiviral and immune-supportive properties (Irole, 2021). However, further standardized animal work is required to ensure efficacy and safety.

8.3 Human and Clinical Evidence

There is still limited clinical evidence, but there is more evidence in the preclinical field. During the COVID-19 period, all the approaches for prevention were based on Ayurveda; some were in the form of medicine from the medicinal plants and some were interventions to boost immunity; the study designs and outcomes were widely variable (Arya et al., 2024). The consensus of the practitioners was also in favor of the preventive and supportive Ayurvedic measures during the pandemic (Panda et al., 2020). Human evidence in general is suggestive of supportive effects, but larger and properly-controlled clinical trials are needed before firm antiviral conclusions can be drawn.

8.4 Evidence from Respiratory and Other Viral Infections

The use of Ayurvedic botanicals has been most commonly talked about in regard to respiratory viral infections, particularly COVID-19. A few medicinal plants have been suggested for supportive management of fever, respiratory symptoms, inflammation and immune function (Singh et al., 2020). In addition, a few broader reviews have included Ayurveda in new and re-emerging viral diseases via preventive and host-supportive mechanisms (Chowdhury et al. 2025). The immunomodulatory and antiviral properties indicated by the evidence from other viral diseases are also potential, but the clinical validation is limited (Reena et al., 2020).

9. Integrative Perspective: Ayurveda and Modern Cellular Biology

The purpose of Rasayana is to healthfully maintain vitality, physiological equilibrium and resistance to disease. These effects in modern biological parlance, may be linked to antioxidant defence, immune regulation, mitochondrial stability and inflammation control. The interpretation of Rasayana as a virus-targeting approach is supported by reviews of Ayurvedic plants during viral pandemics, where the focus is on strengthening the host (Kumar et al., 2021). Ojas is known as the force of vitality and resistance to disease. It could be understood generally as health and immune resistance. In the context of COVID-19, Ayurveda preventive approachs stressed on enhancing the systemic resistance and maintaining immunity (Arya et al., 2024). This may be achieved by certain botanicals, which can modulate immune responses and oxidative balance (Reena et al., 2020). Vyadhikshamatva is the resistance to disease and the ability to contain its spread. This idea is similar to the contemporary notion of host defense based on innate and adaptive immunity. During COVID-19, Ayurvedic suggestions focused on preventive measures aimed at enhancing the host resistance (Panda et al., 2020). Similar thoughts have been shared for emerging infectious diseases, where Ayurveda could play a part in supportive and preventive care (Chowdhury et al., 2025).

The term ‘dhatu protection' in Ayurveda signifies preserving and nourishing body tissues. This idea might be connected to repair, maintenance of membranes and protection from inflammatory and oxidative damage in modern interpretation. In Ayurvedic, systemic balance and function of tissues are the main principle for dealing with viral infections (Singh et al., 2020). The use of traditional formulations in viral diseases has also been discussed as a supportive medicine (Irole, 2021). These traditional principles – Rasayana, Ojas, Vyadhikshamatva, Dhatu – can be understood in the context of contemporary notions of cellular resilience, immune balance and tissue protection. Possible molecular mechanisms are antioxidant signalling, cytokine regulation, protection of mitochondria and control of inflammation (Kumar et al., 2021;

Arya et al., 2024). New viewpoints thus advocate for the careful incorporation of ayurvedic ideas into mainstream biomedical studies without assuming that they are interchangeable (Chowdhury et al., 2025).

10. Safety and Practical Considerations

Many Rasayana botanicals are traditional and have a long history of use but their safety has to be carefully evaluated as it depends on the type of herb, dosage, duration, formulation and individual health condition. High or repeated use can lead to increased risk of side effects, especially if high dose extracts are administered rather than standard preparations. Another point of interest is herb–drug interactions, as certain herbs could impact drug metabolism enzymes, immune responses, blood glucose, blood pressure or anticoagulant properties, which may affect the action of standard medications. There is also a significant variation in product quality because of variations in cultivation, harvesting, processing, extraction, storage and manufacturing techniques, which may impact the phytochemical composition and biological activity. When quality control is lacking, contamination with heavy metals, pesticides, microorganisms or adulterants may further compromise safety. Therefore, standardization of active constituents, authentication of the species and appropriate dosage guidelines are important. Use of Rasayana botanicals in clinical practice in the future should be based on well-characterized preparations that are established as being pure, safe, and have an established dose range and potential interaction profiles.

11. Limitations of Current Evidence

Existing findings on Rasayana botanicals during viral threats are largely limited to preclinical, in vitro and computational studies. The human clinical studies are limited and often small in numbers, have short observation periods, are not uniform in patient population, or have non-standard interventions. There is also significant variation in botanical species, parts, extraction methods, formulations, phytochemical content and dosages administered among various studies, making direct comparisons and reproducibility challenging. There is still no standardized dosage instructions or quality control parameters for some Rasayana preparations. Further, there is not enough direct evidence of specific viral diseases and results of one viral disease cannot be extrapolated to another. Others use molecular docking and in silico predictions, which are valuable in the identification of targets, but have limitations to confirming the biological and/or clinical efficacy. The evidence is further weakened by differences in outcome measures and by the fact that there are few long-term safety data. The restrictions underscore the importance of harmonized preparations, thorough experimental testing, well-designed clinical trials prior to definitive therapeutic suggestions.

12. Future Research Directions

Standardized preparations of Rasayana with well-defined phytochemical profile, purity and dose range should be investigated in future studies to enhance the reproducibility between the studies. Mechanistic studies should focus on the impact of these botanicals on oxidative stress, mitochondrial function, inflammatory signalling, immune regulation and cellular repair during a viral infection. Randomized clinical trials with proper sample size are required to verify the efficacy and safety. Objective evidence for therapeutic effects may be provided by assessing oxidative damage, cytokine response, cell activity and cellular integrity with biomarkers. Studies should also examine host–virus interactions to see if the effect of Rasayana botanicals is largely through direct anti-viral effects, or if they are mainly strengthening the host defenses. Omics technologies such as genomics, transcriptomics, proteomics and metabolomics can be useful in the discovery of molecular targets and pathways of response. The value of their use as an adjunct to standard antiviral treatment should be addressed for potential synergistic effects and interactions with other medications.

14. CONCLUSION

Given their wide-ranging antioxidant, anti-inflammatory, immunomodulatory, cytoprotective and possible antiviral properties, Ayurvedic Rasayana botanicals are a promising area of research for helping maintain cell integrity in response to viral attacks. The effect of the botanicals, Ashwagandha, Guduchi, Amalaki, Tulsi, Yashtimadhu, Haridra and Shatavari, on oxidative balance, mitochondrial function, immune signaling, inflammatory pathways and cell survival includes numerous bioactive components. These mechanisms offer a biomedicine interpretation of the traditional concepts of Rasayana for vitality diseases resistance and tissue preservation. The available data, however, are more robust at the mechanistic and preclinical levels than at the clinical level and are inconsistent for some infections. Conclusions are further hindered by the differences in formulations, dose levels and study designs. There is a need for standardized preparation, rigorous clinical trials, biomarker studies and integrated molecular studies to establish their therapeutic relevance. Eventually rasayana botanicals may prove more useful as supportive, complementary or adjunctive therapies rather than as alternatives to proven antiviral therapies.

REFERENCES

1. Adithya, J., Nair, B., Aishwarya, T. S., & Nath, L. R. (2021). The plausible role of indian traditional medicine in combating corona virus (SARS-CoV 2): a mini-review. Current Pharmaceutical Biotechnology, 22(7), 906-919.
2. Adivitiya, Kaushik, M. S., Chakraborty, S., Veleri, S., & Kateriya, S. (2021). Mucociliary respiratory epithelium integrity in molecular defense and susceptibility to pulmonary viral infections. Biology, 10(2), 95.
3. Ahmad, S., Zahiruddin, S., Parveen, B., Basist, P., Parveen, A., Gaurav, N., ... & Ahmad, M. (2021). Indian medicinal plants and formulations and their potential against COVID-19–preclinical and clinical research. Frontiers in pharmacology, 11, 578970.
4. Apoorva, & Singh, S. K. (2026). Pathogenic breaches: how viruses compromise blood-tissue barriers. Tissue Barriers, 14(1), 2549020.

5. Arya, P., Chauhan, J. S., Kumar, D., & Kumar, P. (2024). Potential of Ayurveda Therapeutic in Prophylaxis of COVID 19 Pandemic. Journal of Advances in Microbiology, 24(6), 1-11.
6. Bendale, Y. N., Bendale, V. Y., Kadam, A. P., Birari-Gawande, P. K., Jagtap, K. C., & Pandav, R. A. (2020). Potential of Rasayana (Ayurvedic) polyherbo-mineral formulation in prophylaxis of COVID-19 infection. Journal of Ayurvedic and Herbal Medicine, 6(3), 111-113.
7. Bhagat, R., & Mhaiskar, B. (2023). Potential Antiviral Herbal Therapeutics for Viral Infections. Med. Life Clin, 5, 1047.
8. Bhattacharya, R., Bose, D., Maqsood, Q., Gulia, K., & Khan, A. (2024). Recent advances on the therapeutic potential with Ocimum species against COVID-19: A review. South African Journal of Botany, 164, 188-199.
9. Biswas, P., Ansar, W., Biswas, S., Ghosh, S., & Jawed, J. J. (2026). Pulmonary Health Benefits of Asparagus racemosus against Common Cold and Asthma. In Health Benefits of Asparagus racemosus (Shatavari) (pp. 379-395). CRC Press.
10. Borse, S., Joshi, M., Saggam, A., Bhat, V., Walia, S., Marathe, A., ... & Tillu, G. (2021). Ayurveda botanicals in COVID-19 management: An in silico multi-target approach. Plos one, 16(6), e0248479.
11. Chaudhry, B. (2021). Key rasayana plants of Ayurveda. Environ We: Int J Sci Technol, 16, 53-73.
12. Chen, Z., & Li, G. (2021). Immune response and blood–brain barrier dysfunction during viral neuroinvasion. Innate immunity, 27(2), 109-117.
13. Chikhale, R. V., Sinha, S. K., Patil, R. B., Prasad, S. K., Shakya, A., Gurav, N., ... & Gurav, S. S. (2021). In-silico investigation of phytochemicals from Asparagus racemosus as plausible antiviral agent in COVID-19. Journal of Biomolecular Structure and Dynamics, 39(14), 5033-5047.
14. Chowdhury, B. R., Pal, D., Bhattacharjee, M., Sen, S., Chowdhury, P. R., Chattopadhyay, A., ... & Bhunia, S. (2025). Emerging and Re-Emerging Viral Diseases: Perspectives from Ayurvedic System of Medicine. In Emerging and Re-Emerging Viral Diseases (pp. 201-217). CRC Press.
15. Daussy, C. F., & Wodrich, H. (2020). “Repair me if you can”: membrane damage, response, and control from the viral perspective. Cells, 9(9), 2042.
16. Debroy, B., De, A., Bhattacharya, S., & Pal, K. (2023). In silico screening of herbal phytochemicals to develop a Rasayana for immunity against Nipah virus. Journal of Ayurveda and Integrative Medicine, 14(6), 100825.
17. Dorage, P., Thatere, A., & Singh, R. (2023). Rasayan as a Public Health Tool at the time of Communicable Disease. Journal of Ayurveda and Integrated Medical Sciences, 8(4), 141-146.
18. Dubey, N., & Jain, P. M. M. (2026). Ayurvedic Rasayana therapy in geriatric care: Current evidence and future perspectives. Journal of Swasthavritta and Yoga, 3(2), 25-38.
19. Fosse, J. H., Haraldsen, G., Falk, K., & Edelmann, R. (2021). Endothelial cells in emerging viral infections. Frontiers in Cardiovascular Medicine, 8, 619690.
20. Gasmi, A., Kanwal, S., Oliinyk, P., Lysiuk, R., Shanaida, M., Gasmi Benahmed, A., ... & Bjørklund, G. (2024). Ayurvedic and Chinese herbs against coronaviruses. Current Pharmaceutical Design, 30(21), 1681-1698.
21. Ghafoor, D., Khan, Z., Khan, A., Ualiyeva, D., & Zaman, N. (2021). Excessive use of disinfectants against COVID-19 posing a potential threat to living beings. Current Research in Toxicology, 2, 159-168.
22. Ghorai, S. (2026). Shatavari Root Extract Eradicates Whooping Cough by Enhancing Immune Competence. In Health Benefits of Asparagus racemosus (Shatavari) (pp. 273-284). CRC Press.
23. Gioia, U., Tavella, S., Martínez-Orellana, P., Cicio, G., Colliva, A., Ceccon, M., ... & d’Adda di Fagagna, F. (2023). SARS-CoV-2 infection induces DNA damage, through CHK1 degradation and impaired 53BP1 recruitment, and cellular senescence. Nature Cell Biology, 25(4), 550-564.
24. Gyawali, R., Paudel, P. N., Basyal, D., Setzer, W. N., Lamichhane, S., Paudel, M. K., ... & Khanal, P. (2020). A review on ayurvedic medicinal herbs as remedial perspective for COVID-19. Journal of Karnali Academy of Health Sciences, 3.
25. Irole, S. (2021). Scientific review of Tribhuvan Keerti Ras a potent Ayurvedic Herbomineral Combination against viral infection. National Journal of Research in Ayurved Science.
26. Jadaun, P., Harshithkumar, R., Seniya, C., Gaikwad, S. Y., Bhoite, S. P., Chandane-Tak, M., ... & Mukherjee, A. (2024). Mitochondrial resilience and antioxidant defence against HIV-1: unveiling the power of Asparagus racemosus extracts and Shatavarin IV. Frontiers in Microbiology, 15, 1475457.
27. Jain, V., Sandrepogu, J., Khandelwal, P., Kumari, K., Tiwari, S. K., Chauhan, S., ... & Naaz, S. (2026). Ayurvedic Rasayanas as adjuncts in chemotherapy: Reviving the holistic paradigm in cancer care. Ayush Journal of Integrative Oncology, 3(1), 7-18.
28. Jaiswal, A., Thakur, K., Chandra, A., Singh, T., Mir, B. A., Goel, S., ... & Rajpal, V. R. (2025). Exploring the medicinal and nutraceutical frontiers of Tinospora cordifolia in stress and cancer management. Current Topics in Medicinal Chemistry, 25(19), 2306-2324.
29. Khedkar, D. D. (2025). Plant products and essential oil therapy for treatment of new and emerging viruses. In Fighting multidrug resistance with herbal extracts, essential oils and their components (pp. 391-419). Academic Press.
30. Khuntia, B. K., Sharma, V., Wadhawan, M., Chhabra, V., Kidambi, B., Rathore, S., ... & Sharma, G. (2022). Antiviral potential of Indian medicinal plants against influenza and SARS-CoV: A systematic review. Natural Product Communications, 17(3), 1934578X221086988.
31. Kothadia, A. (2020). A Review to Summarize the Available Evidences on Turmeric's (Curcuma Longa) Medicinal Properties to Understand the Scope of Its Efficacy in the Treatment and Prevention of COVID19 Diseases. INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH.

32. Kumar, S., Namburi, U. R. S., Londhe, D. J., Chiluveri, A. C., Rai, A. K., Chiluveri, S. K., ... & Srikanth, N. (2021). A review on preventive and therapeutic potential of selected Ayurveda medicinal plants in viral pandemics. Journal of Research in Ayurvedic Sciences, 5(3), 102-116.
33. Kumar, V., Kumar, A. A., Joseph, V., Dan, V. M., Jaleel, A., Kumar, T. S., & Kartha, C. C. (2020). Untargeted metabolomics reveals alterations in metabolites of lipid metabolism and immune pathways in the serum of rats after long-term oral administration of Amalaki rasayana. Molecular and cellular biochemistry, 463(1), 147-160.
34. Mahammed, N. A Critical Review on the Role of Phenolic Compounds in Ayurvedic Herbs with Immunomodulatory Potential Uma Maheshwararao Vattikuttia, Amgad Gamal Abdulrahman Abbasb, Nawaz Mahammedc.
35. Manikyam, H. K., & Joshi, S. K. (2025). Intrinsic Network Pharmacology Guided Simulation of NAFLD Collapse and Recovery: A Systems Level Investigation of Picrorhiza Kurroa via Multi Layered Network Integration. Journal of Pharmaceutical Research International, 37(7), 46-58.
36. Markiewicz, L., Drazkowska, K., & Sikorski, P. J. (2021). Tricks and threats of RNA viruses–towards understanding the fate of viral RNA. RNA biology, 18(5), 669-687.
37. Maru, A. D., Sharma, L. C., Shah, D., Patel, H. H., & Chauhan, M. N. (2026). Ancient Principles, Modern Sustainability: A Critical Review of Rasayana and Vajikarana in the Charaka Samhita and Their Contemporary Biomedical Relevance: A Conceptual and Comparative Analysis with Contemporary Biomedical Perspectives. International Journal of Ayurveda360, 2(5), 1080-1086.
38. Midha, T., Kumar, D., Kumar, A., & Jha, S. K. Rasayana Therapy in Ayurveda: A Promising Approach for Cancer Support and Immunomodulation.
39. Mittal, B., & Chand, T. (2020). Global care through Ayurveda in pandemic of COVID-19. Int J Heal Sci Res, 10, 165-72.
40. MOHANDAS, N., & IJINU, T. P. (2024). Exploring The Potential Of Rasayana Herbs In Ayurvedic Medicine For Developing Phytopharmaceuticals. Traditional Medicines in Drug Discovery and Development, 395.
41. Mohanty, M., Mohanty, S., & Acharya, P. (2024). Phytotechnological interventions and herbal perspectives of medicinal plants in Ayurveda as phytoimmunoboosters-A novel preventive approach for microbial pathogens. Notulae Scientia Biologicae, 16(4), 12129-12129.
42. Munde, C. T., Pradnya, S., Kavatge, S. B., Dombe, J. V., Jamdade, Y. A., & Wagh, K. (2026). MOLECULAR MECHANISMS OF RASAYANA THERAPY FOR HEALTHY AGEING: A SYSTEMATIC REVIEW OF GENOMIC AND EPIGENOMIC EVIDENCE. Genetics and Molecular Research.
43. Nesari, T., Kadam, S., Vyas, M., Huddar, V. G., Prajapati, P. K., Rajagopala, M., ... & Tripathi, R. (2022). AYURAKSHA, a prophylactic Ayurvedic immunity boosting kit reducing positivity percentage of IgG COVID-19 among frontline Indian Delhi police personnel: A non-randomized controlled intervention trial. Frontiers in public health, 10, 920126.
44. Paliwal, P., Islam, M. U., Sharma, S., & Sharma, A. (2025). Tinospora Cordifolia, A Rasayana Herb, as a Potential Source of Infectious Disease Therapeutics. Current Traditional Medicine, 11(3), E090124225431.
45. Paliwal, P., Islam, M. U., Sharma, S., & Sharma, A. (2025). Tinospora Cordifolia, A Rasayana Herb, as a Potential Source of Infectious Disease Therapeutics. Current Traditional Medicine, 11(3), E090124225431.
46. Panda, A. K., Dixit, A. K., Rout, S., Mishra, B., Purad, U. V., & Kar, S. (2020). Ayurveda practitioners consensus to develop strategies for prevention and treatment of corona virus disease (COVID-19). Journal of Ayurveda and Integrated Medical Sciences, 5(01), 98-106.
47. Patwardhan, B., Chavan-Gautam, P., Gautam, M., Tillu, G., Chopra, A., Gairola, S., & Jadhav, S. (2020). Ayurveda rasayana in prophylaxis of COVID-19. Current Science, 118(8), 1158-1160.
48. Paul, D., Chowdhury, T., & Mandal, S. M. (2020). Ayurveda may play a preventive role against viral infections including SARS-CoV-2 by the inactivation of furin protease. Journal of the Indian Chemical Society, 97(8), 1305-1315.
49. Ramli, S., Wu, Y. S., Batumalaie, K., Guad, R. M., Choy, K. W., Kumar, A., ... & Ramachawolran, G. (2023). Phytochemicals of Withania somnifera as a future promising drug against SARS-CoV-2: pharmacological role, molecular mechanism, molecular docking evaluation, and efficient delivery. Microorganisms, 11(4), 1000.
50. Reena, K., Reshmi, P., Srilakshmi, C., Nayan, J., & Sarin, N. S. (2020). scoping antiviral and immuno-modulatory activity of specific ayurveda botanicals in the wake of covid-19 pandemic. Int. J. AYUSH Res, 9(4), 01-31.
51. Saggam, A., Limgaokar, K., Borse, S., Chavan-Gautam, P., Dixit, S., Tillu, G., & Patwardhan, B. (2021). Withania somnifera (L.) Dunal: opportunity for clinical repurposing in COVID-19 management. Frontiers in Pharmacology, 12, 623795.
52. Sarkar, P. K., & Mukhopadhyay, C. D. (2022). Mechanistic insights from the review and evaluation of ayurvedic herbal medicines for the prevention and management of COVID-19 patients. Journal of herbal medicine, 32, 100554.
53. Sayeed, A., Zahiruddin, S., Parveen, B., Basist, P., Parveen, A., Parveen, R., & Ahmad, M. (2021). Indian medicinal plants and formulations and their potential against COVID-19–Preclinical and clinical research. Frontiers in Pharmacology, 11, 578970.
54. Selvaraj, C., Yogeswari, C., & Singh, S. K. (2021). 11 Molecular Features. Traditional Herbal Therapy for the Human Immune System, 301.
55. Sen, B. (2020). Potentiality and possibility of Medicinal Plants on Ayurvedic Principle in prevention and treatment of COVID-19. J Ayurvedic Herb Med, 6(2), 100-107.
56. Sharma, H., Mahto, R. R., Jha, S. K., Chauhan, S., Khandelwal, P., & Tiwari, S. K. (2025). Rasayana-Based Adjuvant Strategies in Cancer Care: An Ayurvedic–Oncologic Perspective. Iranian Journal of Blood and Cancer, 17(4), 35-68.
57. Sharma, R., & Martins, N. (2020). Telomeres, DNA damage and ageing: potential leads from ayurvedic rasayana (anti-ageing) drugs. Journal of Clinical Medicine, 9(8), 2544.

58. Shree, P., Mishra, P., Selvaraj, C., Singh, S. K., Chaube, R., Garg, N., & Tripathi, Y. B. (2022). Targeting COVID-19 (SARS-CoV-2) main protease through active phytochemicals of ayurvedic medicinal plants–Withania somnifera (Ashwagandha), Tinospora cordifolia (Giloy) and Ocimum sanctum (Tulsi)–a molecular docking study. Journal of Biomolecular Structure and Dynamics, 40(1), 190-203.
59. Shriwas, H. K., Harzpal, L. C., & Chandrakar, R. (2021). Achar Rasayana and its clinical importance in the present scenario. DY Patil Journal of Health Sciences, 9(1), 27-32.
60. Singh, M., Jayant, K., Singh, D., Bhutani, S., Poddar, N. K., Chaudhary, A. A., ... & Khan, S. (2022). Withania somnifera (L.) Dunal (Ashwagandha) for the possible therapeutics and clinical management of SARS-CoV-2 infection: Plant-based drug discovery and targeted therapy. Frontiers in Cellular and Infection Microbiology, 12, 933824.
61. Singh, R., Goel, S., Bourgeade, P., Aleya, L., & Tewari, D. (2021). Ayurveda Rasayana as antivirals and immunomodulators: potential applications in COVID-19. Environmental Science and Pollution Research, 28(40), 55925-55951.
62. Singh, R., Kaushik, S., Badal, R., & Sahoo, S. (2020). Ayurveda and its medicinal plants: halting the surge of Covid-19. Journal of Ayurvedic and Herbal Medicine, 6(2), 90-99.
63. Subramaniam, K., Subramanian, S. K., Bhargav, S., Parameswari, R., Praveena, R., Ravikumar, R., ... & Manoj Kumar, V. (2021, April). Review on potential antiviral and immunomodulatory properties of Piper Longum. In IOP Conference Series: Materials Science and Engineering (Vol. 1145, No. 1, p. 012099). IOP Publishing.
64. Thapliyal, P., Dheer, P., Rautela, I., Kumar, S., Upadhyay, S., Tyagi, S., ... & Sharma, M. D. (2023). An insight review on the prophylactic effects of Ayurvedic plants in the global COVID-19 pandemic. Egyptian Journal of Botany, 63(3), 693-714.
65. Upendra, R. S., & Ahmed, M. R. (2021). Healthcare prominence and immune boosting activity of ashwagandha against various clinical conditions and covid 19 disease outbreak. Int J Pharm Res, 13(3), 489-497.
66. Voss, E. (2026). A Clinical Study on the Effects of Ayurvedic Rasayana Therapy on Healthy Aging. Revista Infoacceso, 13(2), 1096-1102.
67. Wu, C., Mulakaluri, A., Chaurasia, P., Suryanarayana, S., Singh, A., Krauss, N., ... & Dhruva, A. (2024). A scoping review of Ayurvedic rasayana adaptogens in oncology. Journal of Ayurveda and Integrative Medicine, 15(1), 100879.
68. Yan, X., Li, Q., Jing, L., Wu, S., Duan, W., Chen, Y., ... & Pan, X. (2022). Current advances on the phytochemical composition, pharmacologic effects, toxicology, and product development of Phyllanthi Fructus. Frontiers in Pharmacology, 13, 1017268.