Antiviral Potential of Indian Medicinal Plants Against Influenza and SARS-CoV: A Systematic Review

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Abstract
The COVID-19 pandemic has posed a significant threat to human health due to the lack of drugs that can potentially act against SARS-CoV-2. Also, even after the emergency approval of WHO, the vaccines’ efficacy is still a question, and people are getting reinfections. Previous studies have demonstrated the efficacy of traditional medicinal plants against influenza and SARS coronavirus. The present article aims to review potential phytochemicals from Indian medicinal plants that may be used against SARS-CoV-2. Articles published in the English language between 1992 and 2021 were retrieved from Embase, PubMed, and Google scholar using relevant keywords, and the scientific literature on efficacies of Indian medicinal plants against SARS-CoV and influenza virus were analyzed. The initial search revealed 1304 studies, but, on subsequent screening, 115 eligible studies were reported. Twenty research articles investigating traditional medicinal plant extracts and metabolites against SARS-CoV and influenza A virus in in vitro and in vivo systems satisfied the search criteria. The studies reported that plant extracts and active compounds such as glycyrrhizin, 14-α-lipoyl andrographolide, and curcumin from medicinal plants such as Yashtimadhu (Glycyrrhiza glabra), Bhunimba (Andrographis paniculata), and Haridra (Curcuma longa) are effective against the various phases of the virus life cycle, viz., virus-host cell attachment, viral replication, 3CL protease activity, neuraminidase activity, adsorption and penetration of the virus. As per ancient Indian literature, plants in Ayurveda possess Rasayana (revitalizing) and Jwara hara (antipyretic, anti-inflammatory) properties. This evidence may be used to conduct experimental and clinical trials to study the underlying mechanisms and efficacy of antiviral properties of Indian medicinal plants against SARS-CoV-2.

Keywords
terpenoids, medicinal plants, anti-viral, influenza, SARS coronavirus, COVID-19

Received: December 9th, 2021; Accepted: February 21st, 2022.

Introduction
The Coronavirus Disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) originated from Wuhan city in China. The rapid global dissemination has posed a significant threat to human health, life, and the economy.1 The number of cases has been exponentially increasing since then. As of January 29th, 2022, more than 370 million patients have suffered from the disease, with over 5.5 million deaths worldwide.2-2

The vaccination drive against SARS-CoV-2 started with great enthusiasm worldwide and is accepted as the most efficacious tool for COVID-19 prevention. However, chances of reinfection, even to vaccinated individuals, are prevalent worldwide.5,6 For instance, in the UK, 0.5% of the population has been tested

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positive for SARS-CoV-2 after the first dose of vaccine, while 0.2% of people reported SARS-CoV-2 positive after the second dose of vaccine. Although we have completed 100 core vaccine doses, the vaccination drive may be of long duration to cover the entire population. The few individuals who are either susceptible or contraindicated for the vaccine need safer evidence-based antiviral drugs against SARS-CoV-2. Therefore, effective antiviral therapies are required for ensuring comprehensive prevention and therapeutics against the COVID-19 pandemic. This provides a scope for safer antiviral drugs, preferably of herbal origin, for prevention and therapeutic objectives to cover the entire population.

Many conventional antiviral drugs and other medicines are being repurposed against SARS-CoV-2, such as Lopinavir, Ribavirin, Favipiravir, Remdesivir, Oseltamivir, Chloroquine, and Hydroxychloroquine, with no proven efficacy to date. Moreover, these drugs are associated with various side effects such as insomnia, gastrointestinal adverse effects, immune suppression, and cardiac rhythm disorders (Table 1).8-19 Thus, there is an urgent need for identifying efficacious molecules/phytocompounds against SARS-CoV-2.

Past experiences have shown that Chinese traditional medicine has effective prevention and management strategies during epidemics, like 2003 SARS and 2009 H1N1 influenza.20

| S. No. | Conventional drugs | Mechanism of action | Side effects of conventional drugs | Similar mechanism of action by medicinal plants | References |
|--------|--------------------|---------------------|-----------------------------------|-----------------------------------------------|------------|
| 1.     | Chloroquine phosphate | Blocks viral entry by inhibiting glycosylation of host ACE2 receptors, proteolytic processing, and endosomal acidification | Major: Cardiovascular effects, hypoglycemia, retinal toxicity, neuropsychiatric and central nervous system effects, idiosyncratic adverse drug reactions, hypersensitivity Minor: Abdominal cramps, anorexia, diarrhea, nausea, vomiting | Glycyrrhizaglabra (inhibits viral replication, penetration and adsorption); Andrographis paniculata – (blocks virus binding to cellular receptors); Punica granatum (inhibits viral replication); Ephedra sinica (inhibits acidification of endosomes & lysosomes and viral growth) | 8-9,18 |
| 2.     | Hydroxychloroquine-sulfate | Blocks viral entry as by Chloroquine | Adverse drug reactions similar to chloroquine, but less common | Glycyrrhizaglabra (inhibits viral replication, penetration and adsorption); Andrographis paniculata – (blocks virus binding to cellular receptors); Punica granatum (inhibits viral replication); Ephedra sinica (inhibits acidification of endosomes & lysosomes and viral growth) | 8-9,18 |
| 3.     | Lopinavir/Ritonavir | Blocks 3-Chymo-trypsin like (3-CL) protease | Major: Pancreatitis, hepatotoxicity, cardiac conduction abnormalities Minor: Gastrointestinal intolerance, nausea, vomiting, diarrhea | Curcuma longa | 12 |
| 4.     | Remdesivir | Interferes in RNA replication by inhibiting RNA-dependent RNA polymerase | Elevated transaminases (reversible), kidney injury | Glycyrrhizaglabra, Punica granatum, Santalum album - inhibits viral replication | 8,11,18 |
| 5.     | Favipiravir | RNA polymerase inhibitor | Hyperuricemia, diarrhea, elevated transaminases, reduction in neutrophil count | Glycyrrhizaglabra, Punica granatum, Santalum album - inhibit viral replication | 8,11,18 |
| 6.     | Dexamethasone | Curcumin as a potential treatment Macrophage-mediated inhibitory effect | Reduces cytokines storm, anti-inflammatory and anti-fibrotic drug | Anxiety, sleep disorders | Zingiber officinale (stimulation of TNF-α release via macrophage activation); Curcuma longa (anti-inflammatory action) | 10 |
Genomic and in silico structural characterization of SARS-CoV-2 has revealed its close resemblance to SARS-CoV.\textsuperscript{21,22} Studies have reported that SARS-CoV-2 resembles almost 80% of the genome of SARS-CoV.\textsuperscript{23-26} There are a few structural and functional differences, such as longer spike protein,\textsuperscript{23,26} and prolonged incubation time, respectively. However, due to the high similarity between proteins of SARS-CoV-2 and SARS-CoV, conventional drugs are being used as a reference for COVID-19 treatment.\textsuperscript{25} Phytochemicals from traditional medicinal plants have been shown to inhibit the SARS-CoV and host proteins.\textsuperscript{27-29}

India is rich in diverse environmental and cultural ethnicity, and the knowledge of plant-based medicinal systems has grown, and this journey is continuing to the time of modern science as well. Traditional Indian medicinal plants have excellent medicinal properties that potentially can work against the deadliest of diseases, like influenza. The ancient Indian medicinal system, Ayurveda, has a rich source of plant-based formulations exhibiting antiviral, antibacterial, and anti-protozoal activity.\textsuperscript{30} Additionally, these unique synergistic herbal combinations have a long tradition of clinical efficacy with safety profiles enabling their usefulness as therapeutic agents against SARS-CoV infections. Therefore, it was planned to systematically search and review the evidence concerning the antiviral activity of Indian medicinal plants mentioned in Ayurveda texts, their extracts, and isolated molecules against SARS and influenza-like respiratory infections, highlighting their mechanism of action.

**Methods**

The present review adopted the framework of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The articles were screened for in vitro and in vivo studies against influenza and SARS-CoV. The PRISMA checklist has been given as Supplementary file 1.

**Search Strategy**

The search for suitable studies was performed in Embase and PubMed using the following keywords: ('ayurveda' OR 'ayurvedic herbal medicine' OR 'ayurvedic medicine' OR 'ayurveda' OR 'ayurvedic medicine' OR 'medicine, ayurvedic' OR 'herbal medicine' OR 'botanical medicine' OR 'herbal medicine' OR 'medicinal plant' OR 'phyto-medicine' OR 'phytomedicine' OR 'plant medicine' OR 'plant-based medicine') AND ('antiviral activity' OR 'antiviral action' OR 'antiviral activity' OR 'antiviral effect' OR 'antiviral property' OR 'anti-virus action' OR 'anti-virus activity' OR 'anti-virus effect' OR 'anti-virus property' OR 'antiviral action' OR 'antiviral effect' OR 'antiviral property' OR 'antiviral action' OR 'antiviral activity' OR 'antiviral effect' OR 'antiviral property' OR 'antiviral action' OR 'antiviral activity' OR 'antiviral effect' OR 'antiviral property'). No language restrictions were applied. The search fields were modified based on the search parameters imposed on each electronic database. The databases were explored for articles published between 1992 and 2021. Boolean operators were used to manage the search strategy. The electronic reference databases were searched in September 2021. Articles investigating the antiviral potential of Indian medicinal plants and their active compounds against influenza and SARS-CoV using in vitro and/or in vivo experimental approaches were extracted.

**Study Selection**

The search was conducted by two reviewers, independently. After carefully assessing the inclusion and exclusion criteria, the relevant studies were screened and shortlisted (20 studies) after carefully assessing the inclusion and exclusion criteria (Table 2). The results of both the reviewers were matched, and no discrepancies were found. The third author also performed an additional independent review to confirm the inclusion of all relevant studies. Antiviral studies that reported a favourable outcome were included in this review.

**Data Extraction**

The data were collected and examined by the authors using standard procedures. The information from the chosen articles regarding study substances, animal models, strains, doses or concentrations, route of administrations, cell lines, biochemical assays, histological assessments, and molecular mechanisms studied were extracted and assessed. In the current study, pooling statistics and meta-analysis were not performed due to methodological variations between the selected studies.

**Results**

A total of 1304 studies were identified using the adopted search strategy. After initial screening, 115 studies related to influenza and SARS-CoV were included, while 1189 studies on other

| Criteria | Inclusion                                                                 | Exclusion                                                                                                                   |
|----------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| Plants   | Indian medicinal plants                                                   | Traditional Chinese medicines and medicinal plants of non-Indian origin                                                    |
| Biological activity | Antiviral activity against SARS Corona virus and Influenza virus | Studies related to other viral diseases eg Hepatitis, HIV, Herpes virus, Pox viruses etc                                  |
| Study design | in vitro and in vivo experimental studies                                        | Narrative or other systematic reviews, in silico studies                                                                       |
| Language | Articles in English                                                        | Articles in other than English language                                                                                     |
| S.no. | Ayurvedic plant name | Botanical name | Plant extract/ active compound used | Assay employed | Cell line/animal model used | Mechanism of action | Effective against |
|------|----------------------|----------------|------------------------------------|----------------|-----------------------------|---------------------|------------------|
| 1    | Yashtimadhu          | Glycyrrhiza glabra | Glycyrrhizin                      | Cytotoxicity assay, Cell viability assay, cytopathic reduction assay, ELISA, virucidal and virusstatic test | in vitro: Vero cells, MDCK cells and in A549 Cells; and in vivo: mice | Inhibition of viral replication, adsorption and penetration | Influenza virus and SARS-CoV |
| 2    | Bhunimba             | Andrographis paniculata | Andro-grapholide & derivatives | Plaque reduction assay, MTT assay, Hemagglutination inhibition assay | MDCK cells | Blocking virus binding to cellular receptors | Influenza virus |
| 3    | Haridra              | Curcuma longa    | Curcumin                           | Cytotoxicity assay, Plaque-reduction assay, Hemagglutination inhibition assay, ELISA, Protease inhibition assay | MDCK cells; Vero E6 cells | Inhibition of virus-cell attachment, replication and inhibition of 3CL protease | Influenza virus and SARS-CoV |
| 4    | Shunthi              | Zingiber officinale | Lyophilized aqueous extract       | Virus growth assay, ELISA | MDCK cells | Stimulation of TNF-α release via macrophage activation | Influenza virus |
| 5    | Ghretakamari         | Aloe vera       | Aloe                             | Neuraminidase (NA) assay, Plaque reduction assay | in vitro: MDCK cells; in vivo: Mouse | Inhibition of viral neuraminidase activity | Influenza virus |
| 6    | Chondana             | Santalum album  | β-Samacosol                       | Antiviral assay, Cytotoxicity assay | MDCK cells | Inhibition of viral replication and mRNA synthesis | Influenza virus |
| 7    | Dadhima              | Punicagranatum  | Polyphenol extract (Punicalagin)  | Cell viability assay, Extracellular virus yield reduction assay, Cell-associated virus yield assay, Plaque reduction assay, Hemagglutination inhibition assay | MDCK cells | Inhibition of viral replication | Influenza virus |
| 8    | Kudinana             | Alpinia officinarum | Diallylheptanoids | MTT assay | MDCK cells | Reduction of virus-induced cell destruction | Influenza virus |
| 9    | Pushanabhadra        | Bergenia gigulata | Methanolic-aqueous extract        | Cytotoxicity assay, MTT assay, Protease inhibition assay | MDCK cells and Vero cells | Inhibition of posttranslational degradation of the viral glycoprotein haem-agglinitin | Influenza virus |
| 10   | Patrangga            | Canadipina asappan | Active compounds 3-deoxysappan - chalcone and sappan-chalcone | Neuraminidase activity assay, Cytopathic effect reduction assay | MDCK cells | Inhibition of viral neuraminidase (NA) activity involved in viral replication | Influenza virus |
| 11   | Soma                 | Ephedra sinica  | (-)-catechin                      | MTT assay, Plaque reduction assay | MDCK cells | Inhibition of both acidification of endosomes and lysosomes and virus growth | Influenza virus |
| 12   | Kakazuma             | Neemamindicus   | Methanolic extract                | Cytotoxic assays, Protease inhibition assays | MDCK Cells | Cytotoxic activity against virus | Influenza virus |

MCDK, Madin-Darby Canine Kidney; MTT, 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide; ELISA, Enzyme-linked immunosorbent assay; 3CL protease, 3Chymotrypin like protease; TNF-α, Tumor necrosis factor alpha.
viruses like hepatitis and HIV were excluded. Subsequently, full-text articles were assessed, and only studies investigating Indian medicinal plant extracts and active compounds were included. In contrast, 95 studies investigating non-Ayurveda medicinal plants, such as Traditional Chinese Medicines (TCM) and other plants not mentioned in Ayurveda were excluded. Finally, 20 articles fulfilled the inclusion criteria were selected. Thus, 12 Indian medicinal plants mentioned in Ayurveda (extracts, active compounds/metabolites, and essential oils) having antiviral properties against SARS-CoV and influenza virus were reviewed (Table 3).

**Study Characteristics**

Most of the studies reported are in vitro and in vivo studies that investigated the intervention of plant extracts, essential oils, and metabolites against SARS-CoV and influenza A virus in MDCK (Madin-Darby Canine Kidney) and Vero cells (Table 3). In most studies, cytotoxic, plaque reduction, MTT, protease inhibition, and neuraminidase activity (NA) assays were employed.

Glycyrrhizin, diarylheptanoids, 14-α-lipoyl andrographolide (AL-1), oligonol, curcumin, aloin, β-santalol, 3-deoxysappanchalcone, sappanchalcone, and (+)-catechin, extracted from 12 different plants, were found to possess antiviral properties, mainly inhibiting virus-host cell interaction, and viral replication.

**Risk of Bias Within Studies**

The selected in vitro studies showed methodological variations, such as using different extracts, assays, and cell lines to observe the antiviral activity of the medicinal plants. In vivo studies included in this review have not mentioned sample size calculation and randomization details.

**Discussion**

Here we discuss the antiviral potential of the selected medicinal plants and their active constituents/metabolites against SARS-CoV and influenza virus. Among the selected articles, most of the in vitro studies have used MDCK and Vero cell lines because of their high susceptibility to influenza virus and SARS-CoV and have investigated the antigenic properties of the virus during isolation and propagation stages. The mouse model was used in all the in vivo studies. The assays employed in the studies to evaluate influenza and SARS-CoV infectivity included cytotoxicity, cell viability, neuraminidase (NA), and plaque reduction assays, inhibitions of virus replication and absorption, virus growth assay, and hemagglutination inhibition assay.

Regarding the mechanism of antiviral activity revealed in the selected studies, most of the plant extracts and active compounds showed activity via inhibition of virus cell attachment (A.paniculata, C. longa) and inhibition of viral replication (G. glabra, C. longa, S. alba, P. granatum). On the other hand, a few of the plant’s active compounds stimulated TNF-α release (Z. officinale) and induced cytotoxic activity against the virus (N. indica). In Figure 1, we have provided a detailed view of the drug action against influenza, as well as SARS-CoV-2.

Curcumin from C. longa has been reported to interrupt the virus-host cell attachment and affect influenza virus (H1N1) propagation. Other studies have also reported that curcumin possesses antiviral properties against SARS-CoV. In addition, it has been experimentally investigated that curcumin inhibited SARS-CoV replication and 3CL protease activity in infected Vero cells. Bisabolene-type sesquiterpenoids from C. longa have been shown to inhibit H1N1 influenza virus replication. These compounds also inhibited the expression of inflammatory cytokines induced by the virus and regulated the activity of NF-κB/MAPK and RIG-1/STAT-1/2 signalling pathways in vitro.

Glycyrrhizin (GR) from G. glabra has been reported to act against the influenza virus by inhibiting viral adsorption onto the host cell (ie, virus uptake) with reduced endocytotic activity, which augments viral replication inhibition. It has also been found effective against SARS-CoV. It has been reported that GR inhibited SARS-CoV replication and checked the adsorption and penetration of the virus, which are early steps in the virus’s replication cycle. They visually scored cytopathogenicity induced by the virus for 72–96 h after infection in Vero cells and found that GR was less effective when added during the adsorption period than after virus adsorption. However, GR was observed to be most efficacious when added both during and after the adsorption period. Another group investigated the effect of GR in mice infected with influenza virus A2 (H2N2). It has been reported that GR increased the mice’s survival by significantly reducing the lung consolidations and virus titer. It was concluded that the antiviral effect of GR was due to activation of IFN-gamma, produced by T cells as part of a protective mechanism.

Andrographolide from A.paniculata has been found to inhibit human influenza A H1N1 virus activity by hindering hemagglutinin glycoprotein. Active compounds, such as 3-deoxysappanchalcone, rhamnetin, and sappanchalcone have been isolated from Caesalpiniasappan. These compounds have been shown to significantly inhibit influenza virus neuraminidase (NA) activity, which plays a crucial role in viral replication, release, and pathogenesis of influenza A virus.

Shunthi (Z. officinale) has been shown to exert its antiviral effect through macrophage activation, which further leads to the production of TNF-α, which was measured using a capture ELISA kit (R&D Systems, USA). TNF-α has been described as an anti-influenza cytokine that acts as the main line of defence against influenza virus infection. Furthermore, the antiviral activity on influenza A virus (IAV) has been reported of gingerenone A (Gin A), a compound derived from ginger roots. It suppressed H1N1 influenza virus replication by inhibiting JAK2 activity.

Aloin from Ghritakumari (Aloe vera) has shown in vivo antiviral activity using the H1N1 influenza virus-infected mice model. It inhibited viral neuraminidase and also hampered
neuraminidase-mediated TGF-β activation. Antiviral properties of aloin have also been observed in MDCK cells infected with influenza virus and oseltamivir-resistant A (H1N1) pdm09 influenza viruses. In addition, cytotoxicity (IC50value), plaque reduction assay, neuraminidase activity, T-cell response, and cytokine expression were reported. Also reported was a reduction of viral load in influenza-infected mice. Thus, both in vitro and in vivo studies provided compelling evidence that aloin inhibits the viral machinery and boosts a T-cell response, and thus could be considered as a potential drug for clinical applications.

β-Santalol isolated from Santalum album has also been reported to show antiviral effect against influenza A/HK(H3N2) virus by inhibiting viral RNA replication.49 The aforementioned medicinal plants are commonly used in Ayurveda to heal infections and related complications with a proven safety profile. Moreover, these plants, such as G. glabra and C. longa, have revitalizing properties, termed Rasayana in Ayurveda, and anti-inflammatory and antipyretic properties (A.paniculata, Z.officinalis) termed Jwarahara.50 This enhances their potential use, not only as antiviral agents, but also as anti-inflammatory and immuno modulatory drugs.

Relevance in the Context of COVID-19

SARS-CoV-2 is highly contagious and spreads through close contacts by tiny droplets produced during coughing, sneezing, and talking. The pathophysiology and virulence mechanism of SARS-CoV-2 viral infection depends on the non-structural protein (nsp) and structural proteins for virus entry, replication, assembly, release, and host cell innate immune system activation and production of a cytokine storm.51-52 Therefore, studies have identified important drug targets in SARS-CoV-2 viz., spike protein, envelope protein, membrane protein, protease, nucleocapsid protein, hemagglutinin esterase, and helicase,53-57 which are being investigated with prior approved drugs and traditional medicinal plants. In this context, medicinal plants such as G. glabra, C. longa, and A.paniculata and their active compounds have been found to inhibit virus pathogenesis at various stages of the virus life cycle (Figure 1). Moreover, these traditional medicinals exhibit multiple mechanisms of action, such as antiviral and immuno modulatory effects, as supported by in silico studies and other mechanistic studies.58-62 Some of these Indian medicinal plants have already been evaluated in clinical studies around the world against SARS-CoV-2. For instance, Z. officinale and Echinacea intervention reduced symptoms such as coughing, shortness of breath, and muscular pain in suspected COVID-19 outpatients compared to hydroxychloroquine alone. In addition, the rate of hospitalization in the intervention group (2.0%) was found to be lower compared to the control group (6.0%).63 Ministry of AYUSH, Govt. of India has recommended Nilavembukudineer (NVK), a multi-herbal formulation consisting of A. paniculata, Z. officinale, S. album, and S. album, along with other herbs as a prophylactic add-on for COVID-19. Recent double-blind, randomized placebo-controlled trials have reported that combined administration of NVK with Kaba Sura Kudineer (KSK) (another herbal medicine...
formulation) in mild to moderate symptomatic COVID-19 patients shortened hospital stay, decreased SARS-CoV-2 viral load, and reduced the time taken for patients to become asymptomatic from symptomatic, in comparison to the placebo arm. Experimental evidence corroborated by the Ayurveda classical textual references and recent literature suggests that Yashtimadhu (*G. glabra*), Bhunimba (*A. paniculata*), Haridra (*C. longa*), and Shunthi (*Z. officinale*) may constitute a synergistic combination which could be potentially helpful in the near future for effective management of COVID-19 infection and the associated cytokine storm like inflammatory conditions.

**Limitations**

Studies investigating the efficacy of medicinal plants mentioned in Ayurvedic classical texts against influenza and SARS-CoV were chosen based on their similarity in pathogenesis, structure, and mechanism of action to SARS-CoV-2. First, due to this reason, studies related to other viruses such as respiratory syncytial virus (RSV), hepatitis B, New Castle, human immunodeficiency virus (HIV), and Ebola were not included in the search strategy. Second, meta-analysis could not be carried out due to the heterogeneity of studies, and only qualitative analysis was done.

**Conclusions**

This systematic review presents the evidence from the studies on the antiviral activity of Indian medicinal plants and secondary metabolites against SARS-CoV and influenza virus. This review summarizes the potential of plant extracts and active compounds from Indian herbal plants as antiviral drug candidates/formulations exhibiting inhibitory effects on viral replication, virus-host cell attachment, 3CL protease activity, neuraminidase activity, adsorption, and penetration of the virus. The active principles of herbs identified against SARS-CoV, such as *G. glabra*, *C. longa*, *A. paniculata*, and *Z. officinale*, have shown promising potential against SARS-CoV-2 in various in silico, invitro and in vivo studies, while *G. glabra*, *A. paniculata*, and *C. longa* (primarily curcumin) are also reported against influenza. This thorough review gives enough evidence of previous studies that can boost confidence to treat these plants as multi objective, multi-purpose plants. However, some of the plants, such as *A. vera*, *P. granatum*, *C. sappan*, *N. indicum*, *E. sinica*, and *B. ligulata*, are underexplored. This evidence may facilitate further experimental or human trials with selected medicinal plant extracts or secondary metabolites to reveal their underlying mechanisms for effective prevention and management of COVID-19.

**Abbreviations**

| Abbreviation | Full Form |
|--------------|-----------|
| ANP | andrographolide |
| ALO | aloin |
| BER | *Bergenia ligulata* |
| COVID-19 | coronavirus disease 2019 |
| CUR | curcumin |
| EPH | *Ephedra sinica* |
| GLY | glycyrrhizin |
| H1N1 | influenza A virus subtype |
| PUN | punicalagin |
| SAN | β-santalol |
| SAP | 3-deoxysappanchalconeand sappanchalcone |
| SARS-CoV | severe acute respiratory syndrome coronavirus |

**Author Contributions**

Bharat Krushna Khuntia, Vandna Sharma, Mohit Wadhawan and Varun Chhabra: Original draft preparation; Data curation, analysis, and interpretation; Shubhangi Rathore, Amritha Ram, Sahar Qazi, Shaban Ahmad; Original draft preparation: Aman Agrawal: Analysis and interpretation of data; Khalid Raza and Gautam Sharma: Conceptualization, Critical review, and editing, Supervision & final approval.

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Data Availability**

The following information was supplied regarding data availability: This is a literature review article.

**Ethical Approval**

Not applicable, because this article does not contain any studies with human or animal subjects.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

**Informed Consent**

Not applicable, because this article does not contain any studies with human or animal subjects.

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**Trial Registration**

Not applicable, because this article does not contain any clinical trials.

**Supplemental Material**

Supplemental material for this article is available online.
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