Classification of Medicinal Plants Showing Anti-Viral Activity, Classified by Family and Viral Infection Types

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Abstract

Surprisingly little overlap has been found in the studies of the several hundred plant and herb species with promise as new anti-viral medicines. Given the rise in migration, international travel, and urbanization today, viral infections are one of the leading causes of disease around the world. Researchers are looking to the plant world as a source of potential novel anti-viral treatments due to the numerous adverse effects of synthetic medicines and the growing problem of resistance. For their various therapeutic purposes, a large number of biologically active compounds have been discovered. Over the past few decades, thorough research into phytochemicals' anti-viral properties has gained relevance. This chapter demonstrates the abundance of potentially beneficial medicinal plants and herbs that are only waiting to be assessed and used for therapeutic applications against genetically and functionally varied plant and viral families.

Keywords

Anti-viral · Hepatitis C virus · Herpes virus · HIV · Influenza virus · Plant extracts · Polio virus

Abbreviation

ACVR-HHV-1	Acyclovir-resistant herpes simplex virus type 1
ADV	Adenoviruses
AIDS	Acquired immuno deficiency syndrome
AI	Avian influenza viruses
ASFV	African swine fever virus
ASV	Avian sarcoma virus
BoHV-1	Bovine alpha herpes virus 1
BPV	Bovine papillomavirus
BVDV	Bovine viral diarrhea virus
EAV	Equine arteritis virus
BVDV	Bovine viral diarrhea virus
CAV	Canine adeno virus
CCoV	Canine cororavirus
CDV	Canine distemper virus
CMV	Cytomegalovirus
CoxB2	Coxsackie B virus 2
CPV	Canine parvovirus
DENV	Dengue virus
DPV	Duck plague virus
EHV-1	Equine herpesvirus
EIV	Equine influenza virus
FCV	Feline calicivirus
H1N1	Influenza type A virus H1N1
HAV	Hepatitis type A virus
HBV	Hepatitis type B virus

HCoV	Human coronavirus
HCV	Hepatitis type C virus
HPeV	Human parechoviruses
HPIV-3	Human parainfluenza virus type 3
HRSV	Human respiratory syncytial virus
HRV1B	Human rhinovirus 1B
HRV2	Rhinovirus type 2
HSV	Herpes simplex virus
IAV	Influenza type A virus
IBD	Infectious bursal disease
IV	Influenzas virus
MAYV	Mayaro virus
MCV	Molluscum contagiosum virus
MoMLV	Moloney murine leukemia virus
PEDV	Porcine epidemic diarrhea virus
PIV3	Parainfluenza virus type 3
PrV	Pseudorabies virus
PRRS	Porcine reproductive and respiratory syndrome
PV	Poliovirus
RRV	Ross river virus
RSV	Respiratory syncytial virus
SAF7	Semliki forest virus A7
SF	Semliki forest
SLEV	St. Louis encephalitis
SuHV	Swine herpesviruses
VSV	Vesicular stomatitis virus
VZV	Varicella-zoster virus
WEEV	Western equine encephalitis virus
WNV	West Nile virus

1 Introduction

Viruses are a class of microorganism that produce exceedingly common infections known as viral diseases. Viral illnesses can be caused by a range of different virus types. The most prevalent viral illness is the common cold, which is brought on by an upper respiratory tract viral infection (nose and throat). Other widespread viral illnesses include:

- Chickenpox/Varicella
- Influenza virus
- Herpes
- HIV/AIDS
- Human papillomavirus infection (HPV infection)
- Infectious mononucleosis (mono)
- Mumps, measles, and rubella

- Shingles/Zoster
- Viral gastroenteritis (stomach flu)
- Viral hepatitis
- Viral pneumonia
- Viral meningitis

Viruses are obligate intracellular parasites of eukaryotic cells that are enveloped by a lipid-containing sheath and essentially consist of bundles of gene strands of either RNA or DNA [1]. In addition to the metabolic activities that the virus itself has coded for, viruses use a variety of host metabolic processes. But viruses are anything but easy. Viruses use the environment of the host cell to spread new viruses, in contrast to bacterial cells, which are free-living organisms. They employ the reproductive system of the cells they enter to spread diseases that can be as harmless as a common wart, as annoying as a cold, or as fatal as the so-called "bloody African fever." Researchers refer to viruses that spread readily, sometimes kill quickly, and for which there is no treatment or vaccination as "hot agents" [2]. Examples include the viruses that cause Lassa fever, Ebola fever, and the retrovirus that causes acquired immunodeficiency syndrome (AIDS). Viruses employ a variety of invasion techniques. The surface molecules of each viral strain differ from one another. By perfectly matching the chemicals on their surfaces to those on the membranes of target cells, these surface molecules function like keys in a lock, allowing viruses to enter their hosts. Genetic diversity, a range of transmission methods, effective replication within host cells, and the capacity to remain in the host are four characteristics that have contributed to the success of viruses throughout evolution [1]. Because of this, viruses have evolved to fit into many different "ecological niches" and cause widespread diseases in people, animals, and plants.

1.1 Virus Transmission

There are numerous ways that viruses can spread. Some viruses are contagious by contact, saliva, and even air. Other viruses can be spread by shared needles or through sexual contact. Ticks and mosquitoes are examples of insects that can serve as "vectors," passing a virus from one host to another. Other potential causes of viral infection include contaminated food and water.

1.1.1 Respiratory Viral Infections

The lungs, nose, and throat are all affected by respiratory virus infections. Inhaling droplets containing virus particles is the most frequent method of transmission for these viruses. Examples comprise:

Rhinovirus

Although there are more than 200 distinct viruses that can cause colds, the rhinovirus is the one that does so most frequently. Up to two weeks are usual for the duration of cold symptoms such coughing, sneezing, minor headaches, and sore throats.

Seasonal Influenza
Every year, between 5 and 20% of the US population suffer from seasonal influenza. In the USA, complications from the flu result in more than 200,000 hospital admissions each year. Body aches and extreme exhaustion are frequent flu symptoms that are more severe than cold symptoms. A cold usually takes longer to start than the flu.

Respiratory Syncytial Virus (RSV)
Upper respiratory infections (like colds) and lower respiratory infections can both be brought on by the respiratory syncytial virus (RSV) (like pneumonia and bronchiolitis). Infants, young children, and old individuals may experience it in a very severe way.

SARS-COV-2
A respiratory coronavirus called SARS-COV-2 is the source of COVID-19 infection. In 2020, COVID-19 sparked a global epidemic that closed down schools, companies, and public life in many different countries. It also infected millions of people, killed over 1 million people worldwide, and caused 210,000 deaths in the USA as of the beginning of the fall. In December 2019, Wuhan, China, provided the first reports of this virus. Cough, fever, breathlessness, and pneumonia are among the symptoms.

1.1.2 Viral Skin Infections

Mild to severe viral skin infections frequently result in a rash. Viral skin infections include, for example:

Molluscum contagiosum: Causes small, flesh-colored bumps most often in children ages 1–10 years old; however, people of any age can acquire the virus. The bumps usually disappear without treatment, usually in 6–12 months.

Herpes simplex virus-1 (HSV-1): Although persons of any age can contract the virus, children between the ages of 1 and 10 are most frequently affected by molluscum contagiosum, which results in small, flesh-colored pimples. Usually within 6–12 months, the bumps go away on their own.

Varicella-zoster virus (VZV): Cold sores are a typical complication of the herpes simplex virus-1 (HSV-1) infection. By kissing or sharing food or beverages with an infected person, it is spread by saliva. HSV-1 can occasionally cause genital herpes. By the time they reach their 60s, an estimated 85% of Americans have HSV-1.

1.1.3 Viral Food Poisoning

One of the most frequent causes of food poisoning is viruses. Depending on the virus involved, these infections exhibit a variety of symptoms.

Hepatitis A is a virus that has a short-term to long-term effect on the liver. Yellow skin, nausea, diarrhea, and vomiting are possible symptoms. Within six months of infection, up to 15% of infected people develop recurrent disease.

Norovirus has been implicated in outbreaks of severe gastrointestinal sickness that occur on cruise ships, although it can spread disease in a variety of settings. Each year, these extremely contagious viruses infect over 20 million people in the USA.

Rotavirus dehydration can result from severe, watery diarrhea. Although rotavirus can infect anyone, it most frequently affects infants and young children.

1.1.4 Viral Infections and STIs

Through contact with bodily fluids, sexually transmitted virus diseases are transferred. Blood can also be used as a means of transmission for some sexually transmitted diseases (blood-borne transmission).

Human papillomavirus (HPV) in the USA is the most typical sexually transmitted infection. There are numerous varieties of HPV. While some raise the risk of cervical cancer, some result in genital warts. Cancer-causing HPV strains can be prevented with vaccination.

Hepatitis B is a virus that damages the liver by inflaming it. It is spread through contaminated body fluids including blood. While some virus-infected individuals show no symptoms, others get flu-like symptoms. More than 90% of people can prevent infection with the hepatitis B vaccine.

Genital herpes is a typical sexually transmitted infection brought on by HSV-2 (HSV-2). Genital herpes can occasionally be brought on by herpes simplex virus-1 (HSV-1), the virus that causes cold sores. Genital herpes has no known treatment. During outbreaks, itchy sores frequently come again. Anti-viral drugs can shorten outbreaks' duration and frequency.

Human immunodeficiency virus (HIV) is a virus that affects specific immune system T cell subtypes. Acquired immune deficiency syndrome results from the infection's progression, which reduces the body's capacity to combat illness and infection (AIDS). Contact with the blood or body fluids of a person who has HIV causes transmission of the disease.

1.1.5 Other Viral Infections

The world is full of viruses, which can cause a variety of illnesses ranging from minor to fatal.

Epstein-Barr virus (EBV) is a particular strain of the herpes virus that causes fever, exhaustion, swollen lymph nodes, and an enlarged spleen. The virus that causes mononucleosis, EBV, is fairly prevalent ("mono"). This "kissing sickness," which is mainly transmitted through saliva, has affected more than 90% of adults.

West Nile virus (WNV) is a virus that is primarily spread by contaminated mosquitoes. The majority of WNV patients (70–80%) show no symptoms, although some also experience fever, headaches, and other side effects. Inflammation of the brain (encephalitis) or the tissue surrounding the brain and spinal cord occurs in less than 1% of WNV patients (meningitis).

Viral meningitis is a condition that produces symptoms such as a headache, fever, stiff neck, and inflammation of the brain and spinal cord's lining. Viral

meningitis can be brought on by a variety of viruses, but enteroviruses are most frequently to fault.

1.2 Viral Infection Control

Similar to other types of infection management, viral infection control can be applied therapeutically to treat viral infections that have already taken hold in the host or prophylactically (as a protective strategy). Because viruses are not self-sufficient organisms like bacteria, fungi, and parasites, they need living cells to reproduce. Therefore, it is challenging to develop a treatment that directly target the virion or its reproduction without causing side effects on the infected cells. Most of the steps in their replication include typical cellular metabolic pathways as a result. Fortunately, we are aware of the distinctive characteristics that many viruses have in their structures or replication cycles, and these characteristics represent prospective targets. With the invention of acycloguanosine, sometimes known as "acyclovir," successful anti-viral chemotherapy against the herpes virus has been made possible [1]. This drug interferes with some important viral enzymes that have differential affinities for various nucleotide analogs. The condition is primarily caused by viral enzymes. Viral replication would not occur if viral enzymes could be neutralized. The maturity of the virus depends on the viral proteinase's proteolytic processing of viral polyprotein precursors. Therefore, it would be ideal to develop unique inhibitors for each viral protease.

2 Overview of Medicinal Plants Worldwide

A sizable and constantly growing portion of the world's population like using natural remedies to treat and prevent medical issues. The development of new antimicrobial formulations derived from plants or herbs has been influenced by this, leading several pharmaceutical companies. As far as the hunt for valuable phytochemicals is concerned, plant and herb resources are currently limitless, but they are quickly running out due to the advance of civilization. In our efforts to utilize the plant world for antimicrobials, we have just scratched the surface (namely, anti-viral, antibacterial, and antifungal compounds). Few screening programs have been started on raw plant materials, despite the fact that many researches have used well-known purified plant compounds.

Almost all societies throughout the world have historically relied on medicinal plants for basic health care and still do now. The use of herbal remedies and the active components extracted from medicinal plants in health care is currently increasing on a global scale. Up to 40% of modern medications are obtained from natural sources, either using the original chemical or a synthetic version. Plant-based natural products have historically been one of the pharmaceutical industry's most significant sources of "lead" compounds.

3 Plant as a Source of Virucides

Plants are a significant, underutilized source of anti-viral medicines (Tables 1-59). Despite the fact that there have only been a few research looking for anti-viral compounds in plants, those investigations have found an unexpectedly widespread occurrence of anti-viral activity in plants. According to their records, the ancient Egyptians and the Chinese employed plants to make hundreds of medical remedies as well as to treat a variety of serious health problems and diseases [3]. Eighty percent of people on the planet use medicinal plant items to combat various infections. The high level of efficiency of medicinal plants as anti-viral medicines has been extensively documented in literature. A few of them have been given the go-ahead to treat viral infections in both people and animals [4, 5]. When Duggar and Armstrong identified the first plant inhibitors in 1925, they also learned that various plant extracts were home to TMV proliferation [6]. The discovery of viral inhibitors made significant strides throughout the course of the next 25 years. Although luck played a role, basic science understanding was fairly restricted when researchers first began looking for an anti-viral drug in the 1950s. The demand for anti-viral medications in Europe following the Second World War in 1952 stimulated research in this area [7]. Less than 300 different plants were evaluated by the Boots drug business in Nottingham, England, in pursuit of an influenza anti-viral. These initiatives served as the first real test in the search for anti-viral medicines. A significant development in this area happened in 1964. Anti-viral compounds were successfully identified by a plant survey as having antibacterial, antifungal, and anti-viral properties. It was made possible to uncover and identify new anti-viral medications with excellent efficiency against viral infections, thanks to the wealth of knowledge about virus reproduction that had gathered over the previous 30 years [8]. Anti-viral drugs must also be safe for use in the field and in the environment, so scientists in charge of plant protection are always searching for anti-virals with these qualities [9].

4 Major Plant Families Having Anti-Viral Activity

Acanthaceae Plants from the Acanthaceae family, for example, play a significant role in the treatment of a range of severe diseases (Table 1). It contained alkaloids, saponins, phenols, tannins, terpenoids, quinones, cardiac glycosides, carbohydrates, flavonoids, and proteins, among other therapeutically beneficial secondary metabolites. Acanthaceae members *Andrographis paniculata, Hygrophila spinosa*, *Barleria prionitis,* and *Adhatoda vasica* have traditionally been used as antipyretics, anti-asthmatics, anti-virals, and in the treatment of respiratory illnesses. Many plant species in this family have anti-viral activity, such as anti-HIV, anti-flu, and other anti-viral properties. Leaves extract of *Justitia schimperiana* exhibit viral activity against HIV-1 and HIV-2, similarly leaves extract of *Justicia reptans and Andrographis paniculate* also show anti-HIV activity. Leaves extract of

Table 1 List of plants of the family Acanthaceae with anti-viral activity

Family	*Plant*	Part of plant	Type of virus	Reference
Acanthaceae	*Justitia schimperiana*	Leaves	HIV-1 and HIV-2	[10]
Acanthaceae	*Andrographis paniculata Nees*	Leaves	HSV-l	[11]
Acanthaceae	*Justicia adhatoda l.*	Leaves	Influenza	[12]
Acanthaceae	*Clinacanthus siamensis Bremek.*	Leaves	Influenza	[13]
Acanthaceae	*Justicia reptans*	Leaves	HIV	[14]
Acanthaceae	*Rostellularia procumbens (L.) Nees*	Whole plant	HSV-1 RSV	[15]
Acanthaceae	*Andrographis paniculata (Burm. F.) Nees*	Aerial parts	RSV	[16]
Acanthaceae	*Trichocalyx obovatus Balf. f.*	Leaves and fruit	HSV-1 and influenz-A	[17]
Acanthaceae	*Clinacanthus nutans (Burm.f.) Lindau*	Leaves	Chikungunya	[18]
Acanthaceae	*Strobilanthes crispus (L.) Blume*	Leaves	Chikungunya	[18]
Acanthaceae	*Monechma subsessile*	Leaves	Cox	[19, 20]
Acanthaceae	*Hemigraphis reptans*	Leaves	DENV2	[21]
Acanthaceae	*Rhinacanthus nasutus*	Whole plant	CMV	[22]
Acanthaceae	*Justicia adhatoda (L.) Nees*	Leaves	H1N1	[23]
Acanthaceae	*Barleria eranthemoides (C.B.Cl.),*	Root	VSV	[24]
Acanthaceae	*Justicia Adhatoda*	Leaves	HSV-1	[25]
Acanthaceae	*Andrographis paniculata*	Aerial parts	DENV-1	[26]
Acanthaceae	*Andrographis paniculata*	herb	HIV	[27]

Andrographis paniculata Nees from genus *Andrographis*, extract of *Trichocalyx obovatus Balf. f. Justicia adhatoda* and extract of *Rostellularia procumbens (L.) Nees*, shows anti-herpes activity. Leaves extract of *Justicia adhatoda* L. and *Clinacanthus siamensis* Bremek. exhibit anti-influenza virus (H1N1) activity. Plant species in this family have also been found to have anti-respiratory syncytial virus (RSV) action. *Clinacanthus nutans (Burm.f.) Lindau* extract and *Strobilanthes crispus (L.) Blume* extract have anti-chikungunya virus action. Extracts of *Hemigraphis reptans* and *Andrographis paniculata* have also been found to have anti-viral effects against the dengue virus [10–27].

Acoraceae, Adoxaceae, Agavaceae, Aizoaceae, Alliaceae, and Aloaceae *Acorus calamus* extract from the Acoraceae family has anti-coxsackievirus action. The extracts of *Sambucus sieboldiana var. pendula, Dracaena cinnabari Balf. f. Mesembryanthemum cristallinum L., Allium oreoprasum Schrenk, Allium prattii C.H. Wright,* and *Lomatophyllum macrum* have anti-viral action against HSV-1,

Table 2 List of plants of the family Amaranthaceae with anti-viral activity

Amaranthaceae	*Chenopodium ambrosoides L.*	Leaves	SRV	[35]
Amaranthaceae	*Beta vulgaris L.*	Root	Chikungunya	[18]
Amaranthaceae	*Chenopodium ambrosioides*	Aerial parts	HSV-1	[36]
Amaranthaceae	*Alternanthera sessilis (L.) DC.*	Leaves	HSV-1	[37]
Amaranthaceae	*Quercus dentata*	Stem	HSV-1 and HSV-2	[30]
Amaranthaceae	*Beta vulgaris*	Fruit	HSV-2	[38]
Amaranthaceae	*Chenopodium ambrosioides*	Leaves	HSV-2	[38]
Amaranthaceae	*Alternanthera philoxeroides*	Herb	HIV	[27]

influenza A virus. A few plants in this family have also been shown to exhibit anti-*polio virus* activity [28–34].

Amaranthaceae The Amaranthaceae family's *chenopodium ambrosoides l.* (Mexican-tea) leaf extract has anti-viral action against the respiratsory syncytial virus (SRV) (Table 2). Beta vulgaris L. root extract also has anti-chikungunya virus properties. Alternanthera philoxeroides extract was found to have anti-HIV action. Various extracts of *Chenopodium ambrosioides, Alternanthera sessilis* (L.) DC., Quercus dentata, *Beta vulgaris*, and *Chenopodium ambrosioides* were also examined for anti-herpes action [30, 36–38].

Amaryllidaceae Chen and colleagues investigated the anti-viral activity of *Allium sativum L., Allium ascalonicum L., Allium fistulosum L.,* and *Allium cepa L.* bulb extracts against adenovirus [39] (Table 3). Hippeastrum rhodophiala K. Pres, Narcissus poeticus L., and *Narcissus pseudonarcissus L.* are studied for their anti-herpes efficacy by Abou-Karam and Shier [43]. Anti-herpes action has also been shown in extracts of *Allium victorialis var. platyphyllum*, *Allium victorialis var. platyphyllum.* was found to have anti-hepatitis A virus (HAV) action. The activity of a plant extract from the Amaryllidaceae family against influenza, porcine epidemic diarrhoea, and echovirus has also been investigated. [30, 40, 41, 46, 47].

Anacardiaceae The cashew family, Anacardiaceae, contains over 700 species and 80 genera, and different parts of the plant are used in traditional medicine. *Spondias lutea L.* and *Anacardium occidentale L.* are tested for anti-rotavirus activity by Gonçalves et al. Various researchers have reported anti-herpes activity of extracts from Rhus aromatica L. (root, stem bark), Schinus mole (Aerial parts), *Pistacia atlantica Desf., Mangifera indica (peels), Pistacia vera, Schinus terebinthifolia Lithraea molleoides, Anacardium occidentale L.,* and *Lannea humilis Oliv. (bark)* (Table 4). There have also been reports of anti-viral activity against influenza virus, rotavirus, dengue virus, and poliovirus [24, 36, 48–61].

Anisophylleaceae and Annonaceae Rajasekaran et al. reported anti-viral activity of stem and root extracts of *Anisophyllea disticha* (Anisophylleaceae) and *Trivalvaria macrophylla* (Annonaceae) against influenza A virus subtype H1N1 and H3N1 [62]

Table 3 List of plants of the family Amaryllidaceae with anti-viral activity

Amaryllidaceae	*Allium victorialis var. platyphyllum*	Whole plant	HSV-1 and HSV-2	[30]
Amaryllidaceae	*Allium ascalonicum L*	Bulb	Adenoviruses	[39]
Amaryllidaceae	*Allium sativum L.*	Bulb	Adenoviruses	[39]
Amaryllidaceae	*Allium fistulosum L*	Bulb	Adenoviruses	[39]
Amaryllidaceae	*Allium cepa L.*	Bulb	Adenoviruses	[39]
Amaryllidaceae	*Allium sativum*	Bulb	H1N1	[40]
Amaryllidaceae	*Haemanthus albzjlos*	Bulb	PV-1	[41]
Amaryllidaceae	*Clivia miniata Regel*	Leaves	Semliki forest Herpes, and PV	[42]
Amaryllidaceae	*Hippeastrum rhodophiala K. Pres*	Bulb	HSV-1 and VSV	[43]
Amaryllidaceae	*Narcissus poeticus L.*	Bulb	HSV-1 and VSV	[43]
Amaryllidaceae	*Narcissus pseudonarcissus L.*	Bulb	HSV-1 and VSV	[43]
Amaryllidaceae	*Crinum jagus (J. Thomps.) Dandy*	Bulb	echovirus	[44]
Amaryllidaceae	*Haemanthus albiflos*	Aerial part	MoMLV	[45]
Amaryllidaceae	*Allium fistulosum*	Whole plant	HAV	[46]
Amaryllidaceae	*Allium thunbergii*	Whole plant	HAV	[46]
Amaryllidaceae	*Allium sativum*	Whole plant	HAV	[46]
Amaryllidaceae	*Crinum asiaticum L.*	Leaves	PEDV	[47]

(Table 5). The anti-herpes activity of various extracts of *Goniothalamus umbrosus* (leaves), *Annona muricata* (leaves), *Rollinia menbranacea* (root), *Uvaria chamae P. Beauv* (root), and *Annona cherimolia* (leaves) was studied by several researchers. Padilla et al. investigate the anti-viral activity of *Xylopia aromatica* leave extract against EHV-1 and SuHV-1 viruses. Leaves extract of *Annona muricata* exhibit anti-viral activity against the dengue virus [38, 63–66].

Apecynaceae and Apiaceae Beuscher et al. study the anti-viral property of tuber extract of *Adenium obesum* (Apecynaceae) against poliovirus and rhinovirus type 2 [67]. Miladi and coworker investigate the anti-hepatitis and anti-viral activity of seed extract of *Daucus maritimus* against West Nile virus [68]. Anti-viral activity of root extract of Saposhnikovia divaricata (Turez.) was also reported against the respiratory syncytial virus [16]. *Petroselinum crispum (Mill.) Fuss*. leaves and stem extract exhibit anti-viral activity against the chikungunya virus [18] (Table 6). The anti-herpes activity of several extracts of *Dystaenia takeshimana* (aerial part and root), *Bupleurum sulphureum* (whole plant), *Prangos aspurela L* (leaves and seeds), *Trachyspermum ammi L* (fruit), and *Heracleum moellendorffii* (aerial part) was also investigated by several researchers [30, 55, 69, 70].

Table 4 List of plants of the family Anacardiaceae with anti-viral activity

Anacardiaceae	*Spondias lutea L.*	Leaves	Human (HCR3) rotaviruses	[48]
Anacardiaceae	*Anacardium occidentale L.*	Leaves	Human (HCR3) rotaviruses	[48]
Anacardiaceae	*Rhus aromatica L.*	Root, stem, and bark	HSV-2	[49]
Anacardiaceae	*Schinus molle*	Aerial parts	HSV-1	[36]
Anacardiaceae	*Mangifera indica L.*	Dried pulp	Influenza virus H9N2	[50]
Anacardiaceae	*Schinus molle L.*	Stem and leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Anacardiaceae	*Rhus coriaria*	Fruit	HSV-l and HSV-2	[52]
Anacardiaceae	*Rhus parviflora Roxb*	Leaves	HIV	[53]
Anacardiaceae	*Spondias mombin*	Leaves	DENV-2	[54]
Anacardiaceae	*Spondias tuberosa*	Leaves	DENV-2	[54]
Anacardiaceae	*Pistacia atlantica Desf.*	Leaves	HSV-1	[55]
Anacardiaceae	*Mangifera indica*	Peels	HSV-1	[56]
Anacardiaceae	*Myracrodruon urundeuva (Allemão) Engl.*	Leaves	Rotavirus	[57]
Anacardiaceae	*Pistacia vera*	Leaves, branches, and stem	HSV and PIV	[58]
Anacardiaceae	*Schinus terebinthifolia*	Bark	HSV-1	[59]
Anacardiaceae	*Lithraea molleoides*	Leaves	HSV and RSV	[60]
Anacardiaceae	*Spondias mombin L.*	Bark	Echovirus	[44]
Anacardiaceae	*Lannea schweinfurthii (Engl.) Engl*	Stem bark	SFA7	[24]
Anacardiaceae	*Ozoroa reticulata (Bak.f.) R.A.,*	Leaves	VSV	[24]
Anacardiaceae	*Anacardium occidentale L.*	Bark	PV, ASV, HSV 1, equine HSV, BPV, and CPV	[61]
Anacardiaceae	*Lannea humilis (Oliv.)*	Bark	PV, ASV, HSV 1, and equine HSV	[61]

Apocynaceae Several extracts of the plant belonging to the family Apocynaceae exhibit significant anti-viral activity against herpes, rabies, polio, coxsackie B, vesicular stomatitis, echoviruses, and influenza viruses (Table 7). Müller et al. studied anti-herpes and anti-rabies activity of root and leaves extract of *Alamanda blanchetti and Alamanda schottii*, respectively [71] (Table 7). The root extract of *Hemidesmus indicus (L.) R. Br.*, leave extract of *Acokanthera schimperi, Alstonia scholaris, Tabernaemontana catharinensis, Cerbera odollam Lam., Willughbeia edulis Roxb.*, *Pachypodium geayi,* and *Vinca rosea*, and stem extract of *Holarrhena antidysentrica, Wall.* exhibit significant anti-herpes activity [25, 34, 71 73-74,76, 78]. Plante and coworker investigate the anti-viral activity of *Nerium oleander* extract against SARS-CoV-2 [80].

Table 5 List of plants of the family Anisophylleaceae and Annonaceae with anti-viral activity

Anisophylleaceae	*Anisophyllea disticha*	Stem	H3N1 and H1N1	[62]
Annonaceae	*Annona muricata*	Leaves	DENV- 2	[63]
Annonaceae	*Goniothalamus umbrosus*	Leaves	HSV-l	[64]
Annonaceae	*Annona muricata*	Leaves	HSV-2	[38]
Annonaceae	*Rollinia menbranacea*	Root	HSV-2	[38]
Annonaceae	*Xylopia aromatica*	Leaves	HSV-1, EHV-1, and SuHV-1	[65]
Annonaceae	*Uvaria chamae P. Beauv.*	Root	HSV-1 and ASFV	[66]
Annonaceae	*Trivalvaria macrophylla*	Root	H3N1 and H1N1	[62]
Annonaceae	*Annona cherimolia*	Leaves	HSV-2	[38]

Table 6 List of plants of the family Apecynaceae and Apiaceae with anti-viral activity

Apecynaceae	*Adenium obesum*	Tuber	PV and HRV-2	[67]
Apiaceae	*Dystaenia takeshimana*	Aerial part and root	HSV-1 and HSV-2	[30]
Apiaceae	*Bupleurum sulphureum*	Whole plant	HSV-l and HSV-2	[55]
Apiaceae	*Daucus maritimus*	Seed	WNV and HCV	[68]
Apiaceae	*Prangos aspurela L*	Leaves and seeds	HSV-1	[69]
Apiaceae	*Saposhnikovia divaricata (Turez.)*	Root	RSV	[16]
Apiaceae	*Petroselinum crispum (Mill.) Fuss*	Leaves and stem	Chikungunya	[18]
Apiaceae	*Trachyspermum ammi L*	Fruit	HSV	[70]
Apiaceae	*Heracleum moellendorffii*	Aerial part	HSV-1 and HSV-2	[30]

Aquifoliaceae Traditional Chinese medicine and food have been using genus Ilex for thousands of years as a botanical source of several health-promoting and pharmaceutically active ingredients. The growing interest in Ilex pharmaceutical and food resources has led to additional discoveries of terpenoids, saponins, polyphenols (especially flavonoids), glycosides, and many other compounds in different Ilex species, as well as investigations into their chemotaxonomy, molecular phylogeny, and pharmacology.

Müller et al. investigated the anti-herpes and anti-rabies properties of Ilex paraguariensis leaf extract from South America [71]. *Ilex brevicuspis Reiss* (Aquifoliaceae) and *Ilex theezans Mart*. extracts were found to have anti-herpes efficacy by Montanha and colleagues [83]. The anti-viral activity of *Ilex asprella (Hook. et Arn.) Champ. ex Benth*., a plant from Southern Mainland China, is being investigated by Li and colleagues [15].

Table 7 List of plants of the family Apocynaceae with anti-viral activity

Apocynaceae	*Alamanda blanchetti*	Roots	HSV-1 and rabies virus	[71]
Apocynaceae	*Alamanda schottii*	Leaves and flower	HSV-1 and rabies virus	[71]
Apocynaceae	*Hemidesmus indicus (L.) R. Br.*	Root	HSV-1 and HSV-2	[72]
Apocynaceae	*Holarrhena pubescens*	Stem bark	PV and HRV-2	[67]
Apocynaceae	*Acokanthera schimperi*	Leaves	CVB3 and HSV-1	[73]
Apocynaceae	*Alstonia scholaris*	Leaves	Coxsackie B and HSV-1	[74]
Apocynaceae	*Cerbera manghas L.*	Fruit and leaves	VSV	[37]
Apocynaceae	*Tabernaemontana catharinensis*	Bark and leaves	HSV-1	[75]
Apocynaceae	*Cerbera odollam Lam.*	Leaves	HSV-1	[76]
Apocynaceae	*Willughbeia edulis Roxb.*	Leaves	HSV-1	[76]
Apocynaceae	*Tabernaemontana ventricosa Hochst. ex. A.DC.*	Leaves	H1N1	[77]
Apocynaceae	*Holarrhena antidysentrica, Wall.*	Stem bark	HSV-1 and HSV-2	[78]
Apocynaceae	*Tabernaemontana cymosa*	Seed	DENV	[79]
Apocynaceae	*Pachypodium geayi*	Leaves	HSV-1 and PV	[34]
Apocynaceae	*Allamanda blanchetii A.DC*	Leaves	Echoviruses	[44]
Apocynaceae	*Allamanda cathartica L*	Leaves	Echoviruses	[44]
Apocynaceae	*Vinca rosea*	Leaves	HSV-1	[25]
Apocynaceae	*Nerium oleander*	Aerial parts	SARS-CoV-2	[80]
Apocynaceae	*Calotropis gigentea*	Whole herb	Coxsackievirus B3	[28]
Apocynaceae	*Catharanthrrs roseas*	Whole plant	Vaccinia and PV-III	[81]
Apocynaceae	*Holarrhena antidysenterica*	Leaves and stem bark	EHV-1	[82]

Araceae and Araliaceae Rittà et al. investigated and evaluated the anti-viral activity of *Arisaema tortuosum* leaf extract against the HSV-2 virus [84]. The anti-herpes activity of several extracts from Araliaceae plants was investigated (Table 8). *Acorus gramineus Soland* aerial parts extract has anti-herpes and anti-viral action against the vesicular stomatitis virus. *Schefflera arboricola* leaf extract also has anti-herpes efficacy against the HSV-1 virus. Anti-viral activity of *Eleutherococcus senticosus* root extract against HRV, RSV, and influenza A virus was reported by Glatthaar-Saalmüller et al. Anti-viral activity of *Schefflera heptaphylla* extract against respiratory syncytial virus was investigated by Li and colleagues [15, 18, 43, 46, 85–87].

Table 8 List of plants of the family Araceae and Araliaceae with anti-viral activity

Araceae	*Arisaema tortuosum*	Leaves	HSV-2	[84]
Araceae	*Acorus gramineus Soland*	Aerial parts	HSV-1 and VSV	[43]
Araliaceae	*Schefflera octophylla (Lour.) Harms*	Leaves stalk	HSV-1 RSV	[15]
Araliaceae	*Cussonia spicata Thunb.*	Leaves	H1N1	[77]
Araliaceae	*Hydrocotyle sibthorpioides Lam.*	Whole plant	Chikungunya	[18]
Araliaceae	*Schefflera arboricola*	Leaves	HSV-1	[25]
Araliaceae	*Hedera helix*	Whole plant	EV71	[85]
Araliaceae	*Eleutherococcus senticosus*	Root	HRV, RSV, and influenza A	[86]
Araliaceae	*Eleutherococcus senticosus*	Leaves and stem	HAV	[46]
Araliaceae	*Schefflera heptaphylla*	Aerial part	RSV	[87]

Araucariaceae, Arecaceae, and Aristolochiaceae The genus *Araucaria* includes evergreen coniferous trees (*Araucariaceae*). There are 19 species in the genus *Araucaria*, with several of them being used for aesthetic and wood reasons. *Araucaria angustifolia, Araucaria bidwilli, Araucaria araucana, Araucaria cunninghamii,* and *Araucaria heterophylla* are some of the species utilized for medicinal purposes. Andrighetti-Fröhner and coworkers evaluated the anti-viral activity of leave extracts of Brazilian Atlantic tropical forest plants *Araucaria angustifolia (Bert.)* and *Araucaria angustifolia (Bert.) O. Kuntze* against HSV-1 virus [88]. Root extract of *Elaeis guineensis Jacq.* was also evaluated for anti-viral activity against the herpes virus. Chan et al. demonstrated the anti-viral activity of fruit extract of *Salacca zalacca (Gaertn.) Voss* against the mosquito-borne chikungunya virus [18, 66, 88–90].

Aristolochiaceae and Asclepiadaceae In Africa, several Aristolochia species are employed as medicinal plants (Table 9). *Aristolochia ringens* (Vahl.) is one of them (used in Nigeria and several African countries for the management of snakebite venom, rheumatoid arthritis, gastrointestinal disturbances, and insomnia, among others). Betancur-Galvis et al. evaluated the anti-viral activity of stem and leaves extract of *Aristolochia cordiflora* against the herpes virus [38]. *Aristolochia acuminata Lam* and *Aristolochia xuanlienensis* extracts in ethanol and aqueous form were examined for their anti-viral properties by Trinh and his colleague and used in traditional Vietnamese medicines for the prevention of porcine epidemic diarrhea virus (PEDV) [47].

Asclepiadaceae family contains many medicinally important species. Locher and coworker studied the anti-viral activity of Hawaiian medicinal plant *Calotropis Gigantea R. Br* against human immunodeficiency virus type-1 (HIV-1) [91]. Different extracts of plants from Asclepiadaceae family-like *Calotropis gigantea R. Br*

Table 9 List of plants of the family Aristolochiaceae and Asclepiadaceae with anti-viral activity

Aristolochiaceae	*Aristolochia cordiflora*	Stem and leaves	HSV-2	[38]
Aristolochiaceae	*Aristolochia xuanlienensis*	Stem and leaves	PEDV	[47]
Aristolochiaceae	*Aristolochia acuminata Lam.*	Stem and leaves	PEDV	[47]
Asclepiadaceae	*Calotropis gigantea R. Br.*	Leaves	HSV-1 and VSV	[37]
Asclepiadaceae	*Calotropis Gigantea R. Br.*	Flower	HIV-1	[91]
Asclepiadaceae	*Gymnema sylvestre R. Br.*	Herb	HSV and MCV	[92]
Asclepiadaceae	*Pergularia daemia (Forsskal) Chiov.*	Herb	HSV and MCV	[92]
Asclepiadaceae	*Cryptolepis sanguinolenta Schltr.*	Root	HSV-1 and ASFV	[66]
Asclepiadaceae	*Hoya carnosa*	Leaves	HSV-1	[25]
Asclepiadaceae	*Cryptostegia grandiflora*	Whole plant	HSV-1	[93]

(leave)., *Calotropis Gigantea R. Br* (flower)., *Gymnema sylvestre R. Br* (aerial part)., *Pergularia daemia (Forsskal) Chiov* (aerial part)., *Cryptolepis sanguinolenta Schltr (leave)., Hoya carnosa (leave),* and *Cryptostegia grandiflora* have also been evaluated for anti-viral activity against herpes, molluscum contagiosum virus, vesicular stomatitis virus, and African swine fever virus [25, 37, 38, 66, 91–93].

Asparagaceae and Asphodelaceae *Asparagus racemosus* is a plant that has been utilized in Indian medicine for centuries (Ayurveda). Medicine is made from the root. Song and coworker studied the anti-viral activities of Nepalese and Korean plant *Asparagus racemosus* extracts against coxsackievirus B3 [28]. Woo et al. investigate the anti-herpes activity of *Majanthemum dilatatum* extract. *Asphodelus* L [30]. (Asphodelaceae) is a genus containing 18 species and a total of 27 species, subspecies, and variants found across the Mediterranean basin. It has been used for a very long time to treat a wide range of illnesses, including viral and inflammatory skin disorders. Shoeib et al. and Kambizi et al. studied the anti-viral activities of leave extracts of *Aloe ferox* and *Aloe vera* against the HSV-1 virus [25, 94].

Asteraceae In Asia and Europe, many plants in the Asteraceae family have been utilized in traditional medicine (Table 10). Several researchers studied the anti-viral activity of different extracts of plants from Asteraceae family, *viz Eupatorium articulatum, Tagetes pusilla*, *Baccharis teindalensis, Eupatorium glutinosum, Baccharis spicataAchyrocline alata (H. B. K.), Baccharis gaudichaudiana, DC., Aster aquamatus (Spreng.) Hieron, Achyrocline satureioides (Lam.) DC., Baccharis trimera (Less.) DC., Baccharis ochracea (Spreng.), Bidens pilosa L., Elephantopus scaber L., Eupatorium inulaefolium L., Galinsoga parviflora Cav., Gochnatia polymorpha (Less.) Cabr., Mikania periplocifolia Hook. et Am., Trixis praestans (VeiL) Cabr., Pluchea sagittalis (Lam.) Cabr., and Solidago chilensis Meyen.* against

Table 10 List of plants of the family Asteraceae with anti-viral activity

Asteraceae	*Eupatorium articulatum*	Whole plant	VSV	[95, 96]
Asteraceae	*Tagetes pusilla*	Whole plant	VSV	[95, 96]
Asteraceae	*Sambucus gaudichaudiana*	Aerial parts	HSV-1	[97]
Asteraceae	*Baccharis teindalensis*	Whole plant	VSV	[95, 96]
Asteraceae	*Eupatorium glutinosum*	Whole plant	VSV	[95, 96]
Asteraceae	*Centaureasolstitialis L. ssp. Solstitialis*	Aerial parts	HSV-1	[98]
Asteraceae	*Aspilia pluriseta*	Leaves	HIV-1	[19, 20]
Asteraceae	*Blumea balsamifera*	Leaves	Zika virus	[99]
Asteraceae	*Baccharis gaudichaudiana*	Aerial parts	PV-2, VSV	[100]
Asteraceae	*Baccharis spicata*	Aerial parts	PV-2, VSV	[100]
Asteraceae	*Bidens subalternans*	Aerial parts	HSV-1	[100]
Asteraceae	*Pluchea sagittalis*	Aerial parts	HSV-1	[100]
Asteraceae	*Tessaria absinthioides*	Aerial parts	PV-2	[100]
Asteraceae	*Tagetes minuta*	Aerial parts	HSV-1	[100]
Asteraceae	*Inula confertiflora*	Leaves	Coxsackievirus B3 (CVB3) HSV-1	[73]
Asteraceae	*Achyrocline satureioides*	Aerial parts	HSV-1	[36]
Asteraceae	*Saussurea auriculata (DC.) Sch. Bip.*	Whole plant	HSV-1 and influenza	[33]
Asteraceae	*Atractylis macrophylla Desf*	Leaves,stems, and roots	HSV-1 and HSV-2	[101]
Asteraceae	*Gnaphalium chilense Spreng*	Leaves, stems, and roots	HSV-1	[101]
Asteraceae	*Hymenoclea salsola Torr. & A. Gray*	Leaves, stems, and roots	HSV-1 and HSV-2	[101]
Asteraceae	*Psilostrophe cooperi Greene.*	Leaves, stems, and roots	HSV-1 and HSV-2	[101]
Asteraceae	*Ambrosia artemisiifolia var. elation*	Whole plant	HSV-1 and HSV-2	[30]
Asteraceae	*Cirsium pendulum*	Aerial part	HSV-1 and HSV-2	[30]
Asteraceae	*Eupatorium lindleyanum*	Whole plant	HSV-1 and HSV-2	[30]
Asteraceae	*Taraxacum coreanum*	Whole plant	HSV-1 and HSV-2	[30]
Asteraceae	*Calendula officinalis*	Flowers	HIV-1	[102]
Asteraceae	*Tagetes minuta L.*	Leaves	HIV-1	[103]
Asteraceae	*Inula viscosa (L.) Ait*	Aerial part	HSV-1	[32]
Asteraceae	*Artimisia dubia*	Whole herb	Coxsackievirus B3	[28]
Asteraceae	*Artimisia sp essential oil*	Whole herb	Coxsackievirus B3	[28]
Asteraceae	*Achyrocline alata (H. B. K.) DC.*	Inflorescences	HSV-l , HSV-2, PV VSV, and AD	[51]

(continued)

Table 10 (continued)

Asteraceae	*Achyrocline satureioides (Lam.) DC.*	Inflorescences	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Aster aquamatus (Spreng.) Hieron.*	Whole plant	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Baccharis trimera (Less.) DC.*	Aerial part	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Baccharis ochracea (Spreng.)*	Aerial part	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Bidens pilosa L.*	Leaves	HSV-l , HSV-2, PV VSV, AD	[51]
Asteraceae	*Elephantopus scaber L.*	Whole plant	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Eupatorium inulaefolium L.*	Arial part	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Galinsoga parviflora Cav.*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Gochnatia polymorpha (Less.) Cabr.*	Leaves	HSV-l , HSV-2, PV VSV, AD	[51]
Asteraceae	*Mikania periplocifolia Hook. et Am.*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Pluchea sagittalis (Lam.) Cabr.*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Solidago chilensis Meyen*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Trixis praestans (VeiL) Cabr.*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Asteraceae	*Baccharis erioclada DC.*	Whole plant	HSV-l	[83]
Asteraceae	*Baccharis megapotamica Hook. & Arn.*	Whole plant	HSV-l	[83]
Asteraceae	*Baccharis uncinella DC*	Whole plant	HSV-l	[83]
Asteraceae	*Echinacea pallida var. sanguinea*	Achenes	HSV-l	[104]
Asteraceae	*Achillea biebersteinii*	Aerial part	HSV-l and HSV-2	[55]
Asteraceae	*Achillea teretifolia*	Aerial part	HSV-l and HSV-2	[55]
Asteraceae	*Centaurea tchihatcheffii*	Aerial parts	HSV-l and PI-3	[105]
Asteraceae	*Echinacea purpurea*	Root	HSV-l and PI-3	[105]
Asteraceae	*Echinaceapallida var. angustifolia*	Root	HSV-l and PI-3	[105]
Asteraceae	*Echinacea pallida var. pallida,*	Root	HSV-l and PI-3	[105]
Asteraceae	*Eupatorium perfoliatum L.*	Aerial parts	IAV	[106]
Asteraceae	*Baccharis burchellii Baker*	Leaves	EqHV-1 and SuHV-1	[107]
Asteraceae	*Baccharis oblongifolia*	Leaves	EqHV-1 and SuHV-1	[107]
Asteraceae	*Baccharis dracunculifolia DC.*	Leaves	EqHV-1 and SuHV-1	[107]

(continued)

Table 10 (continued)

Asteraceae	*Baccharis uncinella DC.*	Leaves	EqHV-1 and SuHV-1	[107]
Asteraceae	*Echinacea purpurea*	Whole plant	HSV and FV	[108]
Asteraceae	*Pulicaria crispa*	Aerial parts	HBV	[109]
Asteraceae	*Achyrocline satureioides*	Aerial vegetal parts	WEEV	[110]
Asteraceae	*Conyza aegyptiaca (L.)*	Leaves	Herpes simplex Sindbis Polio	[111]
Asteraceae	*Neurolaena lobata*	Leaves	HIV	[14]
Asteraceae	*Chamaemelum nobile*	Herb	IBV	[112]
Asteraceae	*Perilla frutescens*	Herb	IBV	[112]
Asteraceae	*Agastache foeniculum*	Herb	IBV	[112]
Asteraceae	*Origanum vulgare*	Herb	IBV	[112]
Asteraceae	*Mentha piperita*	Herb	IBV	[112]
Asteraceae	*Melissa officinalis*	Herb	IBV	[112]
Asteraceae	*Echinacea purpurea*	Herb	IBV	[112]
Asteraceae	*Artemisia annua*	Leaves	HAV	[46]
Asteraceae	*Centaurea glomerata*	Aerial parts	HSV-1	[56]
Asteraceae	*Centaurea calcitrapa*	Aerial parts	HSV-1	[56]
Asteraceae	*Centaurea aegyptiaca*	Aerial parts	HSV-1	[56]
Asteraceae	*Centaurea pallescens*	Aerial parts	HSV-1	[56]
Asteraceae	*Centaurea alexanderina*	Aerial parts	HSV-1	[56]
Asteraceae	*Achillea fragrantissima,*	Aerial parts	PV	[113]
Asteraceae	*Jasonia montana*	Aerial parts	VP	[113]
Asteraceae	*Tanacetum sinaicum (Fresen.) Delile ex Bremer & Humphries*	Aerial parts	PV	[113]
Asteraceae	*Ageratum conyzoides L.*	Aerial part	HSV-1 RSV	[15]
Asteraceae	*Bidens bipinnata L.*	Aerial part	HSV-1 RSV	[15]
Asteraceae	*Blumea laciniata (Roxb.) DC.*	Whole plant	HSV-1 RSV	[15]
Asteraceae	*Elephantopus scaber L.*	Whole plant	HSV-1 RSV	[15]
Asteraceae	*Emilia sonchifolia (L.) DC.*	Whole plant	HSV-1 RSV	[15]
Asteraceae	*Laggera pterodonta (DC.) Benth.*	Whole plant	HSV-1 RSV	[15]
Asteraceae	*Wedelia prostrata (Hook. et Arn.) Hemsl.*	Whole plant	HSV-1 RSV	[15]
Asteraceae	*Arctium lappa L.*	Fruit	RSV	[16]
Asteraceae	*Artemisia capillaries Thunb.*	Aerial parts	RSV	[16]
Asteraceae	*Dendranthema indicum (L.) Des Moul.*	Flower	RSV	[16]
Asteraceae	*Dendranthema. morifolium (Ramat.) Tzvel.*	Flower	RSV	[16]
Asteraceae	*Baccharis genistelloides*	Whole plant	HSV-1, VSV	[95, 96]

(continued)

Table 10 (continued)

Asteraceae	*Cichorium intybus L.*	Root	VSV	[114]
Asteraceae	*Lactuca sativa L*	Leaves	VSV	[114]
Asteraceae	*Sphaeranthus indicus L.*	Aerial parts	HSV, MCV	[92]
Asteraceae	*Helichrysum aureonitens*	Aerial parts	HSV-1, CoxB1	[115]
Asteraceae	*Youngia japonica (L.)*	Whole plants	Flu A and HSV-1	[116]
Asteraceae	*Youngia japonica (L.)*	Whole plants	RSV	[117]
Asteraceae	*Tanacetum vulgare*	Aerial parts	HSV-1, HSV-2	[118]
Asteraceae	*Achyrocline flaccida*	Aerial part	HSV-1, HSV-2	[119]
Asteraceae	*Acanthospermum hispidum*	Leaves	HSV-1, HSV-2, VZV, BHV-1, and PRV	[120]
Asteraceae	*Psiadia dentata*	Leaves	HSV-1, PV	[34]
Asteraceae	*Psiadia retusa*	Leaves, stem	HSV-1, PV	[34]
Asteraceae	*Senecio ambailla*	Leaves, stem	HSV-1, PV	[34]
Asteraceae	*Pterocaulon sphacelatum*	Aerial parts	CMV, RRV	[121]
Asteraceae	*Berkheya spekeana*	Leaves, stem	Cox V	[19, 20]
Asteraceae	*Guizotia scabra*	Leaves	HSV, Cox V, and polio	[19, 20]
Asteraceae	*Guthenbergia cordifolia*	Leaves	HSV	[19, 20]
Asteraceae	*Microglossa pyrifolia*	Stem	HSV	[19, 20]
Asteraceae	*Spilanthes mauritiana*	Leaves	HSV and Cox V	[19, 20]
Asteraceae	*Ageratum conyzoides L.*	Leaves	Echovirus	[44]
Asteraceae	*Lactuca indica L.*	Stem, leaf	PEDV	[47]
Asteraceae	*Vernonia cinerea*	Leaves	DENV2	[21]
Asteraceae	*Tridax procumbers*	Stems	DENV2	[21]
Asteraceae	*Arctium lappa L*	Herb	HIV	[27]
Asteraceae	*Senecio scandens*	Herb	HIV	[27]
Asteraceae	*Artemisia arborescens L.*	Aerial parts	HSV-1, HSV-2	[122]
Asteraceae	*Baccharis audichaudiana*	Aerial parts	HSV-1, PV-2, and VSV	[100]
Asteraceae	*Baccharis spicata*	Aerial parts	HSV-1, PV-2, and VSV	[100]
Asteraceae	*Pluchea sagittalis*	Aerial parts	HSV-1, PV-2, and VSV	[100]
Asteraceae	*Tagetes minuta*	Aerial parts	HSV-1, PV-2, and VSV	[100]
Asteraceae	*Tessaria absinthioides*	Aerial parts	HSV-1, PV-2, and VSV	[100]
Asteraceae	*Pluchea Indica Less.*	Leaves	HIV-1	[91]
Asteraceae	*Conyza aegyptiaca (L.) Aiton*	Leaves	HSV, Sindbis, and PV	[123]
Asteraceae	*Achyrociine satureioides*	Leaves, branch	Herpes suis virus	[124]
Asteraceae	*Ambrosia tenurolia*	Leaves, branch	Herpes suis virus	[124]

(continued)

Table 10 (continued)

Asteraceae	*Baccharis articulata*	Leaves, branch	Herpes suis virus	[124]
Asteraceae	*Eupatorium bungifidium*	Leaves, branch	Herpes suis virus	[124]
Asteraceae	*Anthemis tinctoria var. tinctoria*	Whole plant	HSV-1, PI-3	[125]
Asteraceae	*Anthemis austriaca*	Whole plant	HSV-1, PI-3	[125]
Asteraceae	*Carduus nutans*	Whole plant	HSV-1, PI-3	[125]
Asteraceae	*Carduus acanthoides*	Whole plant	HSV-1, PI-3	[125]
Asteraceae	*Cirsium hypoleucum*	Whole plant	HSV-1, PI-3	[125]
Asteraceae	*Cynara scolymus*	Whole plant	HSV-1, PI-3	[125]
Asteraceae	*Baccharis trinervis*	Whole plant	HSV-1	[95, 96]
Asteraceae	*Cacalia auriculata var. matsumurana*	Aerial part and root	HSV-1 and HSV-2	[30]
Asteraceae	*Aster spathulifolius*	Whole plant	H1N1	[126]
Asteraceae.	*Lactuca sativa var longifolia*	Leaves	HCMV and CoxB-3	[127]

vesicular stomatitis virus [51, 95, 96, 100]. Several researchers studied the anti-viral activity of different extracts of plants viz *Sambucus gaudichaudiana*, *Centaureasolstitialis L. ssp. Solstitialis*, *Bidens subalternans Pluchea sagittalis*, *Tagetes minuta, Inula confertiflora, Achyrocline satureioides, Saussurea auriculata (DC.) Sch. Bip. Atractylis macrophylla Desf, Gnaphalium chilense Spreng, Hymenoclea salsola Torr. & A. Gray, Psilostrophe cooperi Greene. Ambrosia artemisiifolia var. elation, Cirsium pendulum, Eupatorium lindleyanum, Taraxacum coreanum, and Inula viscosa (L.) Ait* against herpes virus HSV-1 and HSV-2 [32, 36, 51, 97, 98, 100, 101]. Vista and coworker evaluate the anti-viral activity of leaf extracts of the Philippine medicinal plant *Blumea balsamifera* against Zika virus [99]. Gebre-Mariam investigates the anti-viral activity of *Inula confertiflora* leaves extract against coxsackievirus B3 (CVB3) virus [73].

Avicenniaceae, Balanitaceae, Barringtoniaceae, Basellaceae, Berberidaceae, and Betulaceae The anti-HIV property of different plant extracts from these families has been evaluated by several researchers. Different extracts of *Avicennia marina, Barringtonia Asiatica Kurz., and Epimedium grandiflorum* exhibit significant anti-HIV activity [27, 91, 128]. Leaves extracts of *Basella alba L.* (Basellaceae) were assessed for their ability to combat the chikungunya virus [18]. Extracts of *Mahonia bealei (Fortune) Carriere* and *Epimedium koreanum* (Berberidaceae) were evaluated for anti-viral action against porcine epidemic diarrhea virus (PEDV) [47, 131]. Chang et al. investigate the anti-HIV activity of *Epimedium grandiflorum* (Berberidaceae) extract [27]. Anti-hepatitis activity of *Berberis lyceum* (Berberidaceae) *Alnus japonica* (Betulaceae) extract was also evaluated by several researchers [46, 129, 130].

Bignoniaceae Plants from the Bignoniaceae family are widely utilized in traditional medicine in a variety of countries. Bignoniaceae plants have been identified as one of the most promising sources of antimalarial chemicals. Different extracts of *Tecoma stansb, Fridericia formosa (Bureau) Jacaranda mimosifolia D. Don, Tabebuia ave Uanedae (*leaves*) Lorentz ex Gris., and Crescentia cujete* (fruit) were tested for their ability to combat the HSV-1 and HSV-2 viruses that cause herpes. [38, 51, 132, 133]. Anti-viral activity against vesicular stomatitis virus was also investigated [24, 132]. Simões et al. study the anti-viral activity of different extracts of *Tabebuia ave Uanedae Lorentz ex Gris* and *Jacaranda mimosifolia D. Don* (Bignoniaceae) against poliovirus and adenovirus [51].

Bischofiaceae, Blechnaceae, and Bombacaceae Lipipun and coworkers study the anti-viral activity of leave extracts of *Bischofia javanica Blume* (Bischofiaceae), a Thai medicinal plant against herpes simplex virus type1 infection in vitro and in vivo [76]. Chang et al. reported anti-HIV activity of *Woodwardia unigemmata* (Blechnaceae) extract [27]. Anti-viral activities of *Adansonia digitata L* (Bombacaceae) extracts against herpes simplex, Sindbis polio, porcine epidemic diarrhea, and African swine fever virus were studied by different researchers [66, 111, 123, 134].

Boraginaceae Boraginaceae are found all over the world. Medicinal/herbal supplements are of economic value. Plants of the Boraginaceae family have essential medicinal and aesthetic benefits. The existence of naphthaquinones, flavonoids, phenols, terpenoids, or the purine derivative allantoin is linked to their pharmacological impact (Table 11). The anti-herpes activity of different plants from this family has been evaluated in different extracts [33, 101, 125, 136, 137]. Civra et al. instigated anti-viral activity of *Rindera lanata var. lanata extracts against Rotavirus* [135].

Brassicaceae Brassicaceae is known as the mustard family. Cruciferous vegetables are those that belong to the Brassicaceae family and are popularly known as crucifera. Brassica crops have biological properties such as antibacterial, anticancer,

Table 11 List of plants of the family Boraginaceae with anti-viral activity

Boraginaceae	*Maharanga emodi DC.*	Roots	HSV-1 and influenza	[33]
Boraginaceae	*Lithospermum officinale L.*	Leaves, stems, and roots	HSV-1 and HSV-2	[101]
Boraginaceae	*Rindera lanata var. lanata*	Aerial parts	Rotavirus	[135]
Boraginaceae	*Cordia salicfolia*	Leaves and twigs	HSV-1	[136]
Boraginaceae	*Lithospermum erythrohizon Sieb. et Zucc.*	Aerial parts	RSV	[16]
Boraginaceae	*Lithospermum erythrorhizon*	Herb	HIV	[27]
Boraginaceae	*Lappula barbata*	Whole plant	HSV-1 and PI-3	[125]
Boraginaceae	*Echium Amoenum-L*	Flower	HSV-1	[137]

Table 12 List of plants of the family Brassicaceae with anti-viral activity

Brassicaceae	*Radix Isatidis*	Aerial parts	Influenza virus (FM1)	[138]
Brassicaceae	*Folium Isatidis*	Leaves	IAV, RSV, Ad-7	[139]
Brassicaceae	*Brassica nigra*	Seed	SARS-CoV-2	[140]
Brassicaceae	*Brassica juncea*	Seed	H1N1	[141]
Brassicaceae	*Isatis indigotica Fort.*	Root	RSV	[16]
Brassicaceae	*Lepidium meyenii*	Root	IV	[142]
Brassicaceae	*Diplotaxis erucoides subsp. erucoides*	Wall rocket	SARS-CoV-2	[140]

Table 13 List of plants of the family Brassicaceae with anti-viral activity

Burseraceae	*Protium serratum Engl.*	Leaves	HSV-1	[76]
Burseraceae	*Boswellia ameero Balf. F.*	Bark	HSV-1, influenz-A	[17]
Burseraceae	*Boswellia longate Balf. F.*	Bark	HSV-1, influenz-A	[17]
Burseraceae	*Boswellia carterii Birdw..*	Bark	HCV	[70]
Burseraceae	*Santiria apiculata*	Whole plant	H3N1 and H1N1	[62]
Burseraceae	*Tetragastis panamensis*	Leaves	HSV-1, HSV-2, and VSV	[143]
Buxaceae	*Pachysandra terminalis Sieb. & Zucc.*	Whole plant	HSV-1 and VSV	[43]
Buxaceae	*Buxus hildebrandtii Baill.*	Leaves	HSV-1 and influenz-A	[17]

and anti-viral activity (Table 12), and they also operate as a significant modulator of the innate immune response system. The crude extracts of medicinal plants are commonly employed at a home level in rural areas in traditional systems of medicine such as Chinese and Unani.

Bromeliaceae The Tillandsia species belong to the Bromeliaceae family are utilized in the Mexican traditional medicines. For anti-viral effectiveness against types 1 and 2 of the herpes simplex virus, various plant extracts were tested. The anti-herpes activity of *Tillandsia usneoides* and *Bromelia antiacantha Bert.* extracts against herpes simplex virus type 1 were investigated by Andrighetti-Fröhner and coworkers. [88]. Similarly, the anti-herpes activity of *Tillandsia usneioides L, Tillandsia aeranthos Loisel, Tillandsia usneoides L. Tillandsia aeranthos, and Tillandsia usneoides* were also evaluated by the different researchers [36, 51, 83, 88].

Burseraceae and Buxaceae Burseraceae phytoconstituents are utilized in Chinese herbal medicine and Indian Ayurvedic medicine to treat a variety of diseases. *Bursera* is a genus in the Burseraceae family that has been utilized in traditional Mexican medicine to cure a variety of pathophysiological conditions. Terpenoids and lignans are the most common phytochemicals isolated from this species. Lignans are phenolic metabolites with anti-viral (Table 13) and various other

pharmacological activities. Plants in the Buxaceae family are commonly utilized in traditional medicine and are rich in terpenoid alkaloids. Because of their fascinating biological characteristics, such as cholinesterase inhibition, antibacterial, and anti-leishmanial activity, compounds in this family have been the focus of numerous chemical and pharmacological investigations in recent decades.

Cactaceae, Caesalpiniaceae, Campanulaceae, Canellaceae, and Capparaceae The plant species *Caesalpinia crista* is generally utilized across the African mainland and Asia for the treatment of different illnesses and problems (Table 14**)**. Ahmad and coworker evaluated the anti-viral activity of leave extract of *Opuntia streptacantha* (Cactaceae) against cytomegalo, varicella-zoster, HIV, herpes, and equine herpesvirus [144]. Extract of *Detarium microcarpum* (Caesalpiniaceae*)* shows anti-hepatitis activity [145]. The anti-herpes activity of several leaf extracts from *Cassia alata L.* (Caesalpiniaceae), *Cassia socotrana Serratoa*, and *Cassia didymobotrya* against herpes type 1 and type 2 viruses was assessed [17, 19, 20, 92].

Caprifoliaceae The Caprifoliaceae family of plants is a prominent herbal medication used to treat viral infections (Table 15) and inflammatory illnesses, and is a well-known dietary supplement that has been utilized in Asian countries for ages. Different extracts of *Lonicera japonica* and *Sambucus nigra L.* were tested for the ability to combat the AIDS virus [27, 150]. Several researchers investigated the anti-herpes activity of extracts of *Sambucus nigra L, Lonicera insularis, Lonicera*

Table 14 List of plants of the family Cactaceae, Caesalpiniaceae, Campanulaceae, Canellaceae, and Capparaceae with anti-viral activity

Cactaceae	*Opuntia streptacantha*	Leaves	HSV-2, CMV, VZV, EHV,-IV, and HIV-1	[144]
Caesalpiniaceae	*Detarium microcarpum*	Stem, bark, and root	HCV	[145]
Caesalpiniaceae	*Cassia alata L.*	Leaves	HSV and MCV	[92]
Caesalpiniaceae	*Cassia socotrana Serratoa*	Leaves and fruit	HSV-1 and influenz-A	[17]
Caesalpiniaceae	*Cassia didymobotrya*	Leaves	HSV, VSV	[19, 20]
Campanulaceae	*Condonopsis lanceloata*	Root	HSV-1 and HSV-2	[30]
Campanulaceae	*Platycodon grandiflorum (Jacq.) A. DC.*	Root	RSV	[16]
Campanulaceae	*Laurentia longiflora*	Leaves	DENV2	[21]
Canellaceae	*Warburgia ugandensis*	Arial part	Measles virus	[146]
Capparaceae	*Capparis decidua*	Stem	HBV	[109]
Capparaceae	*Capparis sinaica Veill. in Duh.*	Aerial parts	HSV-1	[113]
Capparaceae	*Stixis scandens Lour.*	Leaves	PEDV	[47]

Table 15 List of plants of the family Caprifoliaceae with anti-viral activity

Caprifoliaceae	*Sambucus racemosa*	Whole plant	RSV	[147]
Caprifoliaceae	*Patrinia villosa Juss.*	Whole plant	RSV	[16]
Caprifoliaceae	*Sambucus nigra*	Fruit	AIV	[148]
Caprifoliaceae	*Vibumum opulus*	Fruit	AIV	[148]
Caprifoliaceae	*Sambucus nigra L*	Flower	IV, HSV	[149]
Caprifoliaceae	*Sambucus nigra L.*	Bark	AIDS	[150]
Caprifoliaceae	*Lonicera insularis*	Aerial part	HSV-1, HSV-2	[30]
Caprifoliaceae	*Lonicera maackii stem*	Stem	HSV-1, HSV-2	[30]
Caprifoliaceae	*Patrinia villosa*	Whole plant	HSV-1, HSV-2	[30]
Caprifoliaceae	*Weigela florida*	Aerial part	HSV-1, HSV-2	[30]
Caprifoliaceae	*Lonicera japonica Thunb.*	Flower bud	RSV	[16]
Caprifoliaceae	*Lonicera japonica*	Herb	HIV	[27]

maackii stem, Patrinia villosa, and *Weigela florida* [30, 149]. Ma et al. found that Patrinia villosa Juss. and *Lonicera japonica Thunb*. have anti-viral actions against the respiratory syncytial virus [16, 147]. Fruit extracts of *Sambucus nigra* and *Vibumum opulus* were also evaluated for anti-viral activity against avian influenza viruses [148].

Cariaceae, Caryophyllaceae, Celastraceae, Chenopodiaceae, and Cistaceae There are about 35 species of flowering plants in the Caricaceae family, which is divided into six genera. The most famous member of the family, the Carica papaya, is widely cultivated across the tropics (Table 16). It is prized not just for its tasty and nutritious fruits, but also for containing the enzyme papain, which is widely utilized in medicine. Raw and ripe fruit extracts of *Carica papaya, Linn.* (Caricaceae) were examined for anti-viral action against the herpes viruses [78].

Several plants of the Caryophyllaceae family are widely utilized as traditional medicine by numerous ethnic groups around the world. The family contains the most plants utilized in Chinese traditional medicine (Table 16). Plants in this family have anti-viral, anticancer, antibacterial, antifungal, antioxidant, and anti-inflammatory effects, according to ethnopharmacological studies. Several researchers looked into the anti-viral effectiveness of different *Dianthus caryophyllus L. Saponaria oficinalis Lo* and *Silene vulgaris* extracts against the herpes virus [125, 149, 151].

For centuries throughout South America and China, plant extracts from the Celastraceae family have been employed as pesticides and insect repellents in traditional agriculture as well as to cure a number of medicinal ailments (Table 16) ranging from cancer, stomach complaints, and fever to rheumatoid arthritis. Stem and whole plant extracts of *Celastrus orbiculatus*, *Euonymus oxyphyllus*, and *Maytenus ilicifolia Mart. ex Reiss* were studied for anti-viral activity against herpes virus [30, 83]. Anti-viral property of *Euonymus europaeus* aqueous fruit extract against avian influenza viruses was discovered by Sauter and Wolfensberger [148].

Table 16 List of plants of the family Cariaceae, Caryophyllaceae, Celastraceae, and Chenopodiaceae with anti-viral activity

Cariaceae	*Carica papaya, Linn.*	Raw and ripe fruits	HSV-1 and HSV-2	[78]
Caryophyllaceae	*Dianthus caryophyllus L.*	Whole herb	HSV-1 HAV-27	[151]
Caryophyllaceae	*Saponaria oficinalis Lo*	Root	IV, HSV	[149]
Caryophyllaceae	*Silene vulgaris*	Whole herb	HSV-1 and PI-3	[125]
Celastraceae	*Celastrus orbiculatus*	Stem	HSV-1 and HSV-2	[30]
Celastraceae	*Euonymus oxyphyllus*	Stem	HSV-1 and HSV-2	[30]
Celastraceae	*Maytenus ilicifolia Mart. ex Reiss*	Whole herb	HSV-l	[83]
Celastraceae	*Euonymus europaeus*	Fruit	AIV	[148]
Chenopodiaceae	*Atriplex parvifolia Lowe var. ifiniensis (Caball) Maire*	Whole herb	HSV-1	[32]
Chenopodiaceae	*Salicornia fruticosa L.*	Whole herb	HSV-1	[32]
Chenopodiaceae	*Arthrocnemum indicum (Willd.) Moq.*	Whole herb	HSV-1	[32]
Chenopodiaceae	*Atriplex inflata Muell.*	Leaves and fruits	HSV-1	[32]
Chenopodiaceae	*Beta vulgaris*	Leaves	HSV-1	[25]
Chenopodiaceae	*Chenopodium ambrsioides*	Leaves	HSV-1	[25]

Many Chenopodiaceae species are valuable for human consumption (Table 16). These include some therapeutic plants that are utilized in both conventional and contemporary medicines. Different extract of plant species of Chenopodiaceae family, *viz A. parvifolia Lowe var. ifiniensis (Caball) Maire, Moq. A. inflata Muell, S. fruticosa L. A. indicum (Willd.). Beta vulgaris,* and *Chenopodium ambrsioides* were investigated for their ability to combat the type 1 herpes virus [25, 32].

Chloranthaceae, Cistaceae, Cleomaceae, Clusiaceae, and Cochlospermaceae The Chloranthaceae is a minor family with only a few genera (*Ascarina, Chloranthus, Hedyosmum, and Sarcandra*) and roughly 70 species found in the tropics and subtropics of South America, East Asia, and the Pacific. Many Chloranthaceae species have been utilized as herbal remedies with a variety of therapeutic properties (Table 17) [16]. Several medicinal plants from the Cistaceae family have been used in traditional medicine to treat a variety of pathological conditions, including hyperglycemia (Table 17). This family of plants is renowned for its antifungal, anti-viral, anti-inflammatory, gastroprotective, antitumor, and cardiovascular disease prevention characteristics [5, 32, 132]. The Clusiaceae (Guttiferae) family produces anti-viral compounds, and varieties of *Hypericum* have long been used in traditional medicine (Table 17). Viral infections are routinely treated using plant extracts and isolated compounds from the *Hypericum* species [62, 154].

Table 17 List of plants of the family Chloranthaceae, Cistaceae, Cleomaceae, Clusiaceae, and Cochlospermaceae with anti-viral activity

Chloranthaceae	*Sarcandra glabra (Thunb.) Nakai*	Whole plant	RSV	[16]
Cistaceae	*Tuberaria lignosa*	Aerial parts	HSV-1 and VSV	[132]
Cistaceae	*Cistus populifolius*	Leaves	HSV-1 and VSV	[132]
Cistaceae	*Helianthemum ledifolium var. ledifolium*	Callus	HSV-l and HSV-2	[55]
Cistaceae	*Tuberaria lignosa*	Aerial parts	HIV-1	[151]
Cistaceae	*Cistus monspeliensis L.*	Flowers and leaves	HSV-1	[32]
Cistaceae	*Cistus incanus*	Whole plant	HIV and filoviruses	[152]
Cleomaceae	*Cleome rosea*	Leaves, stems, and roots	ACVr-HSV-1 ACVr-HSV-2	[153]
Clusiaceae	*Calophyllum lanigerum*	Whole plant	H3N1 and H1N1	[62]
Clusiaceae	*Calophyllum lanigerum*	Stem	H3N1 and H1N1	[62]
Clusiaceae	*Vismia macrophylla*	Resin	HSV	[154]
Clusiaceae	*Symphonia globulifera*	Bark	HSV	[154]
Cochlospermaceae	*Cochlospermum angolense Welw.*	Root	HSV-1 and ASFV	[66]
Cochlospermaceae	*Cochlospermum tinctorium A. Rich.*	Rhizome	HSV-1 and ASFV	[66]

The herb *Cochlospermum tinctorium* A. Rich (Cochlospermaceae) has a long history of usage in traditional medicine in numerous African nations to treat a wide range of illnesses, including viral infections (Table 17) [66].

Combretaceae More than 20 genera and 600 species make up the large plant, shrub, and tree family Combretaceae, which has a tropical distribution with diversity hotspots in Africa and Asia. The treatment of viral skin diseases, inflammation, infections, diabetes, malaria, hemorrhage, diarrhea, and digestive problems using some species of *Combretum* is common in traditional medicine (Table 18).

The Commelinaceae family of plants now mostly grows in tropical and subtropical regions and has succulent stems and sheathing leaves. The Commelinaceae family of plants' leaves are frequently used to treat herpes virus infections (Table 19). Anti-viral activity against the poliovirus has also been demonstrated [25, 38, 111, 123, 156].

Compositae A wide variety of species in the Compositae plant family have been and are currently utilized as therapeutic plants, notably in folk medicine. With over 1100 genera and 20 000 species, the Asteraceae is the biggest flowering plant family. Many species of the Compositae family have been discovered to have pharmacological activity, containing key phytochemical substances such as polyphenols,

Table 18 List of plants of the family Combretaceae with anti-viral activity

Combretaceae	*Combretum paniculatum Vent.*	Leaves	HIV-1 and HIV-2	[10]
Combretaceae	*Guiera senegalensis*	Leaves	HBV	[109]
Combretaceae	*erminalia bellirica (Gaertn.) Roxb.*	Fruit rind	HIV-1	[155]
Combretaceae	*Terminalia mulleri*	Leaves	HSV-1	[56]
Combretaceae	*Guiera senegalensis J. F. Gmel.*	Aerial parts and root	HSV-1 and ASFV	[66]
Combretaceae	*Terminalia macroptera Guill. & Perr.*	Root	HSV-1 and ASFV	[66]
Combretaceae	*Terminalia ivorensis A. Chev.*	Bark	Echovirus	[44]
Combretaceae	*Combretum adenogonium Steud ex A.Rich,*	Leaves and root	HSV-1, Cox B2, and HIV	[24]
Combretaceae	*Anogeissus schimperi*	Leaves	PV, ASV, HSV 1, and equine HSV	[61]
Combretaceae	*Guiera senegalensis*	Leaves	PV, ASV, HSV 1, and equine HSV	[61]
Combretaceae	*Terminalia mollis Laws*	Root bark	HSV-1 and SFA7	[24]

Table 19 List of plants of the family Combretaceae with anti-viral activity

Commelinaceae	*Callisia gracilis*	Stem and leaves	HSV-2	[38]
Commelinaceae	*Palisota hirsuta (Thunb.) K. Schum.*	Leaves	HSV Sindbis and polio	[111]
Commelinaceae	*Palisota hirsuta (Thunb.) K. Schum.*	Leaves	HSV, Sindbis, and PV	[123]
Commelinaceae	*Tradescantia pallida*	Leaves	HSV-1	[25]
Commelinaceae	*Callissia fragrans*	Leaves	HSV-1 and HSV-2	[156]

flavonoids, and diterpenoids. Compositae is the most populous and diversified plant family, and it has great promise in terms of pharmacology (Table 20).

Convolvulaceae Convolvulaceae is a family of roughly 55 genera and 1650 species found in both tropical and temperate climates. Various maladies, such as rheumatic arthralgia, primary glaucoma, hepatopathies, and infectious and malignant disorders, have traditionally been treated using the family's species in folk medicine (Table 21). Stem and seed extract of *Cuscuta Sandwichiana Choisy* and *Ipomoea Congesta R. Br.* were studied for anti-HIV activity [91]. Different extracts of *Ipomoea aquatica Forsk. Evolvulus alsinoides L. and Convolvulus arvensis were tested for their effectiveness against the herpes virus as an anti-viral* [25, 76, 92].

Cornaceae, Crassulaceae, and Cruciferae *Cornus officinalis Sieb. et Zucc.* belongs to the Cornaceae family's *Cornus* genus. Traditional Chinese medicine

Table 20 List of plants of the family Compositae with anti-viral activity

Compositae	*Blumea chinensis DC.*	Leaves	HSV-1	[37]
Compositae	*Siegesbeckia glabrescens*	Whole plant	HSV-1 and HSV-2	[30]
Compositae	*Tanacetum microphyllum*	Flower	HSV-1 and VSV	[132]
Compositae	*Santolina oblongifolia*	Flower	HSV-1 and VSV	[132]
Compositae	*Dittrichia viscosa*	Aerial parts	HSV-1, VSV, and poliovirus type 1	[157]
Compositae	*Artemisia abyssinica Schtz.-Bip ex Richard*	Arial part	HIV-1 and HIV-2	[10]
Compositae	*Artemisia afra Jacq. ex Willd.*	Arial part	HIV-1 and HIV-2	[10]
Compositae	*Solanecio gigas (Vatke) C. Jeff.*	Root	HIV-1 and HIV-2	[10]
Compositae	*Vernonia galamensis*	Leaves	HIV-1 and HIV-2	[10]
Compositae	*Conyza canadensis (L.)*	Aerial parts	HCMV and Cox-B3	[158]
Compositae	*Blumea lacera (Burn. f.) DC.*	Whole plant	HSV-1 and HSV-2	[159]
Compositae	*Eclipta prostrata Linn.*	Whole plant	HSV-1, HSV-2, and HIV	[159]
Compositae	*Senecio scandens Buch.-Ham. ex D. Don*	Whole herb	HSV-1 and HSV-2	[159]
Compositae	*Tithonia diversifolia (Hewsl.) A. Gray*	Whole plant	HSV-1 and HSV-2	[159]
Compositae	*Ixeris chinensis (Thunb.) Nakai*	Whole plant	HSV-1 and HSV-2	[159]
Compositae	*Gamochaeta simplicicaulis*	Aerial parts	Herpes virus	[160]
Compositae	*Artemisia annua*	Whole plant	SARS-CoV.	[161]
Compositae	*Calendula arvensis*	Aerial parts	VSV and HRV1B	[162]
Compositae	*Euryops arabicus Steud.ex Jaub.& Spach*	Leaves and fruit	HSV-1 and influenz-A	[17]
Compositae	*Pulicaria stephanocarpa Balf. f.*	Leaves and fruit	HSV-1 and influenz-A	[17]
Compositae	*Gynura bicolor (Roxb. ex Willd.) DC.*	Leaves	Chikungunya	[18]
Compositae	*Helianthus annus*	Leaves	HSV-1	[25]
Compositae	*Helianthus annus*	Leaves	HSV-1	[25]

(TCM) recognizes ripening and dry fruits (Corni Fructus) as an essential herb medication that has been widely utilized for over 2000 years. Seo and coworker studied the anti-viral property of fruit extract of *Cornus officinalis* against the hepatitis A virus [46]. Lavoie and coworker evaluate the anti-viral property of leaf extract of *Cornus canadensis L.* against herpes virus [163].

Table 21 List of plants of the family Convolvulaceae with anti-viral activity

Convolvulaceae	*Ipomoea aquatica Forsk.*	Leaves	HSV-1	[76]
Convolvulaceae	*Cuscuta Sandwichiana Choisy*	Stem	HIV-1	[91]
Convolvulaceae	*Ipomoea Congesta R. Br.*	Seed	HIV-1	[91]
Convolvulaceae	*Ipomoea cairica (L.) Sweet*	Root	RSV	[16]
Convolvulaceae	*Evolvulus alsinoides L.*	Aerial parts	HSV and MCV	[92]
Convolvulaceae	*Ipomoea asarifolia (Desr.) Roem. & Schult.*	Leaves	Echovirus	[44]
Convolvulaceae	*Convolvulus arvensis*	Leaves	HSV-1	[25]

Table 22 List of plants of the family Cornaceae, Crassulaceae, and Cruciferae with anti-viral activity

Cornaceae	*Cornus canadensis L.*	Leaves	HSV-1	[163]
Cornaceae	*Cornus officinalis*	Fruit	HAV	[46]
Crassulaceae	*Crassula swaziensis*	Aerial parts	PV and HRV-2	[67]
Crassulaceae	*Kalanchoe pinnata Pers.*	Leaves, stems, and roots	HSV-1 and HSV-2	[101]
Crassulaceae	*Sedum sarmentoy*	Whole plant	HSV-1 and HSV-2	[30]
Crassulaceae	*Kalanchoe farinacea Balf. f.*	Leaves and fruit	HSV-1 and influenz-A	[17]
Crassulaceae	*Bryophyllum pinnatum (Lam.) Oken*	Leaves	Echovirus	[44]
Crassulaceae	*Sedum hispanicum*	Whole plant	HSV-1 and PI-3	[125]
Crassulaceae	*Umbilicus erectus*	Leaves	HSV-1	[25]
Cruciferae	*Isatis indigotica*	Root	Coxsackievirus B3, and H3N2	[164]
Cruciferae	*Isatis indigotica*	Root	H1N1, H3N2, H6N2, H7N3, and H9N2	[165]
Cruciferae	*Isatis indigotica*	Root and leaves	PrV	[16]

The Crassulaceae family contains roughly 1410 species that are often utilized as ornamentals. And it currently has various therapeutic properties. Several members of the family have recently been identified to have biological and pharmacological actions such as anti-viral (Table 22) and antimicrobial.

During the SARS outbreaks in China, Hong Kong, and Taiwan, *Isatis indigotica* (Cruciferae) root and phenolic Chinese herbs were frequently utilized for SARS prophylaxis. The root of *Isatis indigotica* (Radix isatidis), a member of the Cruciferae family, is endemic to China. *Isatis indigotica* root has anti-viral properties against, coxsackie, influenza, pseudorabies virus (PrV) hepatitis A, and Japanese encephalitis [16, 164, 165].

Cucurbitaceae *Momordica charantia* leaf extract has been found in numerous studies to increase resistance to viral infections and provide immunostimulant effects

Table 23 List of plants of the family Cucurbitaceae with anti-viral activity

Cucurbitaceae	*Momordica charantia*	Aerial parts	DENV-1	[26]
Cucurbitaceae	*Momordica charantia Lin*	Leaves	HBV and liver cancer	[166]
Cucurbitaceae	*Momordica charantia*	Leaves	Zika virus	[99]
Cucurbitaceae	*Wilbrandia ebracteata Cogn.*	Root	HSV-l, HSV-2, PV VSV, and AD	[51]
Cucurbitaceae	*Ecbalium elaterium*	Whole plant	HSV-l and HSV-2	[55]
Cucurbitaceae	*Coccinia grandis*	Leaves and stem	HBV	[109]
Cucurbitaceae	*Corallocarpus epigeus*	Leaves	HBV	[109]
Cucurbitaceae	*Cucumis melo L. var. cantalupensis*	Aerial parts	HCMV	[167]
Cucurbitaceae	*Dendrosicyos socotrana Balf. f.*	Leaves and stem	HSV-1 and influenz-A	[17]
Cucurbitaceae	*Sechium edule (Jacq.) Sw.*	Leaves and stem	Chikungunya	[18]

in both clinical and experimental settings. Several isolated phytochemicals, such as α and β-momorcharin, lectin, MRK 29, and MAP 30, have demonstrated anti-viral action (Table 23) in vitro against herpes, HIV, Zika virus, and polioviruses, with MAP 30 showing promise in chikungunya activity [17, 18, 26, 51, 55, 99, 109, 166, 167].

Cupressaceae, Cyperaceae Davalliaceae, Dilleniaceae, Dioscoraceae, and Dryopteridaceae Cupressaceae is the largest family of conifers. Numerous Cupressaceae species' essential oils have been found to possess a range of biological traits, including antibacterial activity. Five cyclolignans produced from Cupressaceae species were used in anti-viral research on herpes simplex (Table 24) virus type infecting fibroblasts of monkey kidney (HSV-1/CV-1) and vesicular stomatitis virus infecting fibroblasts of hamster kidney (VSV/BHK). Anti-viral activity was shown in all transtetralinelactones [32, 101, 168]. *Dillenia* is a genus of roughly 100 species of evergreen and deciduous plants and shrubs with a discontinuous distribution from Madagascar's seasonal tropics to South and Southeast Asia, Malaysia, North Australia, and Fiji. Historically, this genus' species have been employed as hair tonics, remedies for viral infections, and cancer treatments (Table 24).

Ebenaceae, Elaecarpaceae, Elaeagnaceae, Elaeocarpaceae, Ephedraceae, and Equisetaceae Different extracts of *Euclea schimperi* (Ebenaceae), *Elaeocarpus grandiflorus Sm.* (Elaecarpaceae) *Sloanea guianensis* (Elaeocarpaceae), *Ephedra alata Decne.* (Ephedraceae), *Equisetum arvense L.* (Equisetaceae), *and Equisetum giganteum L.* (Equisetaceae) were studied for anti-viral property (Table 25) against herpes virus by several researchers [55, 71, 73, 76, 113, 173]. Torelli and coworker

Table 24 List of plants of the family Cupressaceae, Cyperaceae Davalliaceae, Dilleniaceae, Dioscoraceae, and Dryopteridaceae with anti-viral activity

Cupressaceae	*Cupressus sempervirens*	All parts	HSV-1	[168]
Cupressaceae	*Tetraclinis articulata Mast.*	Leaves, stems, and roots	HSV-1, HSV-2	[101]
Cupressaceae	*Juniperus phoenicea L.*	Aerial part	HSV-1	[32]
Cupressaceae	*Chamaecyparis Lawsoniana*	Green part	HIV-2	[169]
Cupressaceae	*Thuja orientalis*	Leaves	H1N1	[126]
Cupressaceae	*Taxodium distichum L. Rich.*	Cone, stem, and leaves,	H1N1	[170]
Cyperaceae	*Cyperus esculentus L.*	Tuber	HSV-1	[113]
Cyperaceae	*Kyllinga brevifolia Rottb.*	Whole plant	HSV-1 RSV	[15]
Davalliaceae	*Davallia chaerophylloides (Poir.)*	Leaves	Herpes simplex Sindbis Polio	[111]
Davalliaceae	*Davallia chaerophylloides (Poir.) Steud.*	Leaves	HSV	[123]
Dilieniaceae	*Tetracera alnifolia Willd.*	Leaves	Echovirus	[44]
Dilleniaceae	*Tetracera macrophylla*	Leaves	H3N1 and H1N1	[62]
Dioscoraceae	*Tamus communis L.*	Rhizomes	VSV, HRV1B	[171]
Dioscoraceae	*Tacca chantrieri Andre´*	Rhizome and root	PEDV	[47]
Dryopteridaceae	*Rumohra standishii*	Aerial and underground part	HSV-1 and HSV-2	[30]

Table 25 List of plants of the family Ebenaceae, Elaecarpaceae, Elaeagnaceae, Elaeocarpaceae, Ephedraceae, and Equisetaceae with anti-viral activity

Ebenaceae	*Euclea schimperi*	Leaves	CVB3 and HSV-1	[73]
Elaeagnaceae	*Elaeagnus rhamnoides (L.) A.Nelson*	Bud	H1N1	[172]
Elaeocarpaceae	*Sloanea guianensis*	Leaves and stems	HSV-1 and rabies Virus	[71]
Elaeocarpaceae	*Elaeocarpus grandiflorus Sm.*	Leaves	HSV-1	[76]
Ephedraceae	*Ephedra alata Decne.*	Aerial part	HSV-1	[113]
Equisetaceae	*Equisetum arvense L .*	Aerial part	HSV-1	[55]
Equisetaceae	*Equisetum giganteum L.*	Root and stem	HSV-2	[173]

reported anti-viral property of *Elaeagnus rhamnoides (L.) A. Nelson* bud extract against cell-cultured influenza virus [172].

Ericaceae, Erythroxylaceae, Eucommiaceae, and Eupedraceae Recently, several novel grayanane diterpenoids from Ericaceae plants were discovered. They have

Table 26 List of plants of the family Ericaceae Erythroxylaceae Eucommiaceae and Eupedraceae with anti-viral activity

Ericaceae	*Cassiope fastigiata D. Don*	Aerial parts	HSV-1 and influenza	[33]
Ericaceae	*Rhododendron anthopogon D. Don*	Aerial part	HSV-1 and influenza	[33]
Ericaceae	*Rhododendron lepidotum Wall. & G. Don*	Aerial part	HSV-1 and influenza	[33]
Ericaceae	*Vaccinium myrtillus,*	Fruits	PV-1 and cox virus B1 (CV-B1)	[174]
Ericaceae	*Vaccinium vitis-idaea L*	Fruits	PV-1 and cox virus B1 (CV-B1)	[174]
Ericaceae	*Erica multiflora L.*	Aerial part	HSV-1	[32]
Ericaceae	*Dittrichia viscosa*	Leaves	HIV	[175]
Ericaceae	*Rhododendron ferrugineum L.*	Whole plant	HSV	[176, 177]
Erythroxylaceae	*Erythroxilum deciduum*	Leaves	HSV-1, EHV-1, and SuHV-1	[65]
Erythroxylaceae	*Erythroxylum laurifolium*	Leaves and stem	HSV-1, PV	[34]
Eucommiaceae	*Eucommia ulmoides*	Stem bark	HAV	[46]
Eupedraceae	*Ephedra sinica*	Herbaceous twigs	H1N1	[178]

unique carbon skeletons and exhibit a variety of biological properties, including anti-viral activity (Table 26).

Euphorbiaceae One of the big blooming plant families, Euphorbiaceae has a wide range of vegetative forms, some of which are very significant plants. The anti-viral properties of many Euphorbiaceae species, including those that are resistant to herpes, HIV, hepatitis C, dengue, influenza, cytomegalovirus, echovirus, polio, measles, and cox viruses, have been investigated (Table 27).

Fabaceae In indigenous and urban populations around the world, the Fabaceae family is extremely important ethnobotanically. Fabaceae is one of the most important ethnopharmacological families. Important chemical ingredients that act in the therapy and/or healing of numerous body systems emerge from this plant category. Different species of the Fabaceae family were studied for anti-viral property including herpes, HIV, hepatitis B, hepatitis C, varicella-zoster, dengue, influenza, cytomegalovirus, echovirus, polio, measles, rotavirus, vesicular stomatitis, and Cox viruses (Table 28).

Fagaceae, Flacourtiaceae, Frankeniaceae, Fumariaceae, and Ganodermataceae Different extracts of plants of the Fagaceae family were studied for anti-viral activities against herpes virus (Table 29). Extracts of *Fagus crenata, Quercus brantii*

Table 27 List of plants of the family Euphorbiaceae with anti-viral activity

Euphorbiaceae	*Phyllanthus orbicularis*	Aerial parts	HSV-1	[179]
Euphorbiaceae	*Euphorbia denticulata Lam.*	Aerial part	HSV-1	[180]
Euphorbiaceae	*Melanolepis multiglandulosa (Reinw. ex Blume) Rchb. & Zoll.*	Stem	HCV	[181]
Euphorbiaceae	*Pedilanthus tithymaloides*	Leaves	HSV	[182]
Euphorbiaceae	*Euphorbia hirta L.*	Aerial parts	HIV-1, HIV-2	[37, 44]
Euphorbiaceae	*Cladogynos orientalis*	Whole plant	DENV	[183]
Euphorbiaceae	*Euphorbia spinidens Bornm*	Aerial parts	HSV-1	[184]
Euphorbiaceae	*Euphorbia thymifolia L.*	Dried herb	HSV-2	[185]
Euphorbiaceae	*Euphorbia hirta L.*	Leaves	HSV-1	[37]
Euphorbiaceae	*Ricinus communis L.*	Leaves	HSV-1, VSV	[37]
Euphorbiaceae	*Securinega suffruticosa*	Aerial part	HSV-1, HSV-2	[30]
Euphorbiaceae	*Euphorbia Heterophyla*	Stem and leaves	HSV-2	[186]
Euphorbiaceae	*Euphorbia Cyatophora*	Leaves/ Stem	HSV-2	[186]
Euphorbiaceae	*Euphorbia Graminea*	Leaves/ Stem	HSV-2	[186]
Euphorbiaceae	*Euphorbia Tirucalli*	Stem and leaves	HSV-2	[186]
Euphorbiaceae	*Euphorbia Cotinifolia*	Stem and leaves	HSV-2	[186]
Euphorbiaceae	*Euphorbia Arenaria*	Stem and leaves	HSV-2	[186]
Euphorbiaceae	*Euphorbia Cestrifolia*	Stem and leaves	HSV-2	[186]
Euphorbiaceae	*Euphorbia Pulcherrima*	Leaves/ Stem	HSV-2	[186]
Euphorbiaceae	*Euphorbia Cf. Cotinifolia*	Leaves/ Stem	HSV-2	[186]
Euphorbiaceae	*Discoglypremna caloneura*	Stem, bark, and root	HCV	[145]
Euphorbiaceae	*Euphorbia abyssinica*	Aerial parts	HSV-1	[56]
Euphorbiaceae	*Euphorbia cooperi*	Flower	HSV-1	[56]
Euphorbiaceae	*Ricinus communis*	Aerial parts	HSV-1	[56]
Euphorbiaceae	*Hura crepitans L.*	Leaves	HSV-1	[76]
Euphorbiaceae	*Aleurites Moluccana Willd.*	Stem leaves, husk, and seed	HIV-1	[91]
Euphorbiaceae	*Indigofera tinctoria L.*	Aerial parts	HSV and MCV	[92]
Euphorbiaceae	*Jatropha unicostata Balf. f.*	Bark	HSV-1 and influenz-A	[17]
Euphorbiaceae	*Jatropha multifida L.*	Stem	H1N1	[187]
Euphorbiaceae	*Hymenocardia acida Tul.*	Root	HSV-1 and ASFV	[66]

(continued)

Table 27 (continued)

Euphorbiaceae	*Petalostigma pubescens*	Leaves and fruit	MS2 bacteriophage	[188]
Euphorbiaceae	*Petalostigma triloculare*	Leaves and fruit	MS2 bacteriophage	[188]
Euphorbiaceae	*Trigonopleura malayana*	Leaves	H3N1 and H1N1	[62]
Euphorbiaceae	*Trigonopleura malayana*	Leaves	H3N1 and H1N1	[62]
Euphorbiaceae	*Baccaurea angulata*	Stem	H3N1 and H1N1	[62]
Euphorbiaceae	*Phyllanthus orbicularis*	Leaves and stem	HSV-1 and HSV-2	[189]
Euphorbiaceae	*Euphorbia australis*	Aerial parts	CMV and RRV	[121]
Euphorbiaceae	*Macaranga kilimandscharica*	Leaves	HSV, Cox, and measles	[19, 20]
Euphorbiaceae	*Eriosema montanum*	Leaves	HSV, Cox, measles, polio, SFV, and VSV	[19, 20]
Euphorbiaceae	*Sebastiania brasiliensis*	Ground plant	HSV	[60]
Euphorbiaceae	*Sebastiania klotzschiana*	Ground plant	HSV	[60]
Euphorbiaceae	*Macaranga barteri Mull. Arg.*	Leaves	Echovirus	[44]
Euphorbiaceae	*Euphorbia graminea Jacq*	Leaves	Echoviruses	[44]
Euphorbiaceae	*Euphorbia hirta L*	Leaves	Echoviruses	[44]
Euphorbiaceae	*Euphorbia humifusa Willd*	Leaves	Echoviruses	[44]
Euphorbiaceae	*Mallotus barbatus Mu¨ll. Arg.*	Root	PEDV	[47]
Euphorbiaceae	*Croton kongensis Gagnep.*	Stem and leaves	PEDV	[47]
Euphorbiaceae	*Euphorbia tirucalli L.*	Root	HSV-1	[24]
Euphorbiaceae	*Phyllanthusorbicularis*	Stem and leaves	HSV-1 and HSV-2	[190]

Lindl, Quercus brantii L acorn. Quercus infectoria, and Olivier were evaluated for their anti-herpes activity [30, 70, 204, 205]. Because of their chemical diversity and pharmacological properties, Flacourtiaceae plants are often employed as folk remedies in traditional medicine systems. Flacourtiaceae plants are utilized as traditional treatments for ulcers, malaria, and rheumatism in a variety of cultures. Various extracts and isolated individual compounds displayed anti-viral (Table 29), anticancer, antioxidation, and anti-inflammatory effects in pharmacological tests [10, 51].

Gentianaceae Gentianaceae is a huge plant family that is found all over the world. Gentianaceae in the largest Gentianaceae tribe, with 939–968 species, and the Qinghai-Tibet Plateau and surrounding areas are the most diverse places for Gentianeae. Traditional Tibetan medicine makes extensive use of Gentianeae

Table 28 List of plants of the family Fabaceae with anti-viral activity

Fabaceae	*Glycyrrhiza glabra L.*	Root	VZV	[191]
Fabaceae	*Glycyrrhiza radix*	Root	VZV	[192]
Fabaceae	*Pueraria lobata*	Root	HIV-1	[193]
Fabaceae	*Acacia nilotica*	Pod	HCV	[70]
Fabaceae	*Acacia catechu*	Stem bark	HIV-1	[56]
Fabaceae	*Erythrina speciosa*	Leaves	HAV-H10 and HSV-1	[194]
Fabaceae	*Tephrosia madrensis*	Aerial parts	Dengue virus	[195]
Fabaceae	*Tephrosia crassifolia*	Aerial parts	Dengue virus	[195]
Fabaceae	*Copaifera reticulate Ducke*	Stem, bark, and leaves	HSV-2	[173]
Fabaceae	*Tephrosia viridiflora*	Aerial parts	Dengue virus	[195]
Fabaceae	*Lupinus termes L.*	Whole plant	HSV-1 HAV-27	[151]
Fabaceae	*Oxytropis williamsii I. T. Vassilchenko*	Whole plants	HSV-1 and influenza	[33]
Fabaceae	*Cassia angustifolia*	Leaves	HSV-1	[196]
Fabaceae	*Glycine max (L.) Merrill var Hikariguro)*	Seed	ADV-1 and Cox virus B1	[197]
Fabaceae	*Acacia oerfota*	Stem	HBV	[109]
Fabaceae	*Indigofera caerulea*	Aerial parts	HBV	[109]
Fabaceae	*Sesbania grandiflora*	Flowers	HSV	[198]
Fabaceae	*Retama raetam (Forssk.) Webb*	Flowers	CMV and Cox B-3	[199]
Fabaceae	*Sophora flavescens*	Root	HAV	[46]
Fabaceae	*Acacia nilotica*	Flowers	HSV-1	[56]
Fabaceae	*Acacia nilotica*	Leaves	HSV-1	[56]
Fabaceae	*Acacia nilotica*	Pods	HSV-1	[56]
Fabaceae	*Acacia albida*	Leaves	HSV-1	[56]
Fabaceae	*Cassia roxburghii*	Seeds	HSV-1	[56]
Fabaceae	*Hymenaea courbaril*	Leaves	Rotavirus	[57]
Fabaceae	*Pithecellobium clypearia (Jack.) Benth.*	Leaves	HSV-1 RSV	[15]
Fabaceae	*Caesalpinia sappan L.*	Wood	RSV	[16]
Fabaceae	*Glycine max (L.) Merr.*	Seed	RSV	[16]
Fabaceae	*Sophora flavescens Ait.*	Root	RSV	[16]
Fabaceae	*Clitoria ternatea L.*	Aerial parts	HSV and MCV	[92]
Fabaceae	*Cynometra cauliflora*	Leaves	HSV-1	[200]
Fabaceae	*Albizia corniculata*	Stem	H3N1 and H1N1	[62]
Fabaceae	*Crotalaria cf. CaudataWelw. ex Baker.,*	Leaves	VSV	[24]
Fabaceae	*Poinciana regia*	Leaves	HSV-1	[25]
Fabaceae	*Erythrina crista-galli L.*	Leaves, Stem	HSV-l , HSV-2, PV VSV, and AD	[51]
Fabaceae	*Aspalathus linearis (Burm.f.) R.Dahlgren,*	Leaves	Rotavirus	[201]
Fabaceae	*Bauhinia candicans*	Aerial parts	HSV-1	[36]

(continued)

Table 28 (continued)

Fabaceae	*Sesbania punicea*	Aerial parts	HSV-1	[36]
Fabaceae	*Caragana sinica*	Root	HSV-1 and HSV-2	[30]
Fabaceae	*Sophora flavescens*	Underground part	HSV-1 and HSV-2	[30]
Fabaceae	*Pueraria thunbergiana*	Whole herb	Coxsackievirus B3	[28]
Fabaceae	*Stryphodendron adstringens*	Leaves	HSV-1, EHV-1, and SuHV-1	[65]
Fabaceae	*Anthyllis vulneraria L*	Flower bud	HSV-1	[55]
Fabaceae	*Desmodium canadense*	Herb	IBV	[112]
Fabaceae	*Arachis hypogaea L.*	Skin	H1N1 and H3N2	[202]
Fabaceae	*Aganope balansae (Gagnep.) P.K.Loc*	Stem	PEDV	[47]
Fabaceae	*Senna angustifolia*	Leaves	DENV2	[21]
Fabaceae	*Pithecellobium clypearia*	Leaves	HSV-1 and PV-2	[203]
Fabaceae	*Ulex europaeus*	Stems and leaves	HSV-1 and PV	[206]

Table 29 List of plants of the family Fagaceae, Flacourtiaceae, Frankeniaceae, Fumariaceae, and Ganodermataceae with anti-viral activity

Fagaceae	*Fagus crenata*	Stem	HSV-1 and HSV-2	[30]
Fagaceae	*Quercus brantii Lindl*	Fruit	HSV-1	[204]
Fagaceae	*Quercus brantii L acorn.*	Fruit	HSV-1	[206
Fagaceae	*Quercus infectoria, Olivier*	Gall	HSV	[70]
Flacourtiaceae	*Dovyalis abyssinica (Rich.)*	Leaves	HIV-1 and HIV-2	[10]
Flacourtiaceae	*Casearia sylvestris Swartz*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Flagellariaceae	*Flagellaria indica*	Whole plant	DENV	[183]
Frankeniaceae	*Frankenia pulverulenta L.*	Whole plant	HSV-1	[32]
Fumariaceae	*Fumaria parviflora*	Leaves and stem	HBV	[109]
Ganodermataceae	*Ganoderma lucidum*	Carpophores	HSV-1, HSV-2, Flu A, and VSV	[207]

species. Different extract of *Centurium erythreae L, Exacum affine Balf. f.,* and *S. mussotii*.

Chironia krebsii were studied for anti-viral activities against herpes, influenza, polio, and rhinovirus type 2 viruses [17, 67, 69, 208].

Table 30 List of plants of the family Geraniaceae with anti-viral activity

Geraniaceae	*Geranium sanguineum L*	Root	Influenza	[209]
Geraniaceae	*Pelargonium graveolens*	Leaves	Adenoviruses	[210]
Geraniaceae	*Geranium thunbergii*	Aerial part	HSV, HIV-1, and DENV2	[211]
Geraniaceae	*Geranium sanguineum L.*	Aerial root	HSV-1	[212]
Geraniaceae	*Pelargonium citrosum*	Aerial parts	DENV-1	[26]
Geraniaceae	*Geranium macrorrhizum*	Herb	IBV	[112]
Geraniaceae	*Pelargonium sidoides*	Root	HIV-1	
Geraniaceae	*Erodium glaucophyllum*	Aerial part	HAV	[213]

Geraniaceae Several studies have been performed for anti-viral activities of various species of Geraniaceae against herpes, influenza, adenoviruses, HIV, hepatitis A, and dengue viruses (Table 30).

Ginkgoaceae, Globulariaceae, Gnetaceae, Goodeniaceae, Gralllineae, and Gramineae In Chinese medicine, ginkgo biloba has been used for a very long time. The chemical components of the plant are being researched as a potential treatment for Alzheimer's disease after ginkgo extract allegedly improved memory in various countries at the turn of the twentieth century. Seo and colleagues investigated the anti-viral efficacy of *G. biloba* (Ginkgoaceae) leaf extract against the hepatitis A virus [46]. Soltan and colleagues reported anti-herpes property of the Egyptian medicinal plant *Globularia arabica* (Globulariaceae) [113]. The anti-viral efficacy of ethanol and aqueous extracts of the Vietnamese folk remedy *Gnetum montanum Markgr* against the swine epidemic diarrhea virus was examined by Trinh and coworkers [47].

Some of the most beautiful wildflowers on the Australian continent are from the Goodeniaceae family. Indigenous societies have long used several plants for medicinal purposes, and the phytochemistry of several of them has been studied. Anti-viral activity *of Scaevola Sericea Forst., Scaevola spinescens,* and *Scaevola spinescens* extracts against HIV, cytomegalovirus, and Ross River viruses was investigated [91, 121, 214]. The second-largest monocotyledon family, the Gramineae, contains a variety of plants that are essential to both human and animal existence. Almost all grasses were employed in the area for fodder and medical uses such as fever, stomach disorders, respiratory tract infections, high blood pressure, and viral infections. Researchers investigated the anti-viral properties of the seeds and leaves of *Eleusine indica (*L.) Gaertn., *Sorghum bicolor L.*, and *Lophatherum gracile Brongn*. against respiratory syncytial viruses and Bovine herpes type 1, herpes virus [16, 37, 215].

Grossulariaceae and Guttiferae *Ribes Linn*, a member of the Grossulariaceae family, has 160 species that are mostly found in temperate and cold climates in the Northern Hemisphere. In Southwest, Northwest, and Northeast China, there are 59 species. Ribes species have been used in the treatment of glaucoma, hepatitis,

cardiovascular disease, stomach aches, anti-viral infection, and other disorders as traditional and local medicines. Extracts of leaves, fruits, and aerial parts of *Ribes* genus were studied for anti-viral activities against HIV, influenza, polio, and herpes viruses [148, 216–219]. The Guttiferae family produces anti-viral compounds, and species of *Hypericum* have long been used in traditional medicine. Virus infections, such as polio herpes and cytomegalovirus, are widely treated using plant extracts and isolated compounds from the *Hypericum* species [76, 220, 221].

Hamamelidaceae, Hippocastanaceae, Hydrangeaceae, and Hymenochaetaceae Tannins from the bark of *H. virginiana* (Hamamelidaceae) were tested for their anti-viral effectiveness against the human papillomavirus and influenza A virus [222]. Wei and coworker studied the anti-viral efficacy of flavonoids from the sSeeds of *Aesculus chinensis* (Hippocastanaceae) [223]. Woo and coworker investigated the anti-viral property of *Hydrangea serrata for. acuminata* and *Schizophragma hydrangeoides* (Hydrangeaceae) stem and leaves extracts against herpes virus [30]. Ali and coworker investigated the anti-viral activity of *I. hispidus (Bull.: Fr.) Karst* (Hymenochaetaceae) against influenza virus [224].

Hypericaceae *Hypericum* genus (Hypericaceae family) is one of the oldest species used and most extensively investigated medicinal herbs of this family. It is also used in folk medicine for cuts, burns, skin ulcers, and topically for viral infections. Another herb has been used for centuries in traditional medicine in Turkey, Iran, and the Republics of Central Asia, but it is not recognized in mainstream medicine. The anti-viral effects of several extracts from the genus *Hypericum* against the herpes virus types 1 and 2 as well as against hepatitis, norovirus, influenza, vesicular stomatitis, and Semliki Forest viruses have been investigated [19, 20, 32, 55, 93, 166, 212, 225, 226].

Labiatae Several diseases are treated with plants from the Labiatae family. The anti-viral property (Table 31) of extracts from several mint plants (Labiatae) was

Table 31 List of plants of the family Labiatae with anti-viral activity

Labiatae	*Ajuga integrifolia Ham.-Buch.*	Leaves	HIV-1 and HIV-2	[10]
Labiatae	*Plectranthus amboinicus (Lour.) Spreng.*	Leaves	VSV	[37]
Labiatae	*Mentha aruensis L.*	Leaves	HSV-1 and VSV	[37]
Labiatae	*Orthosiphon aristatus (BI.) Miq.*	Leaves	HSV-1 and VSV	[37]
Labiatae	*Rosmarinus officinalis*	Aerial part	HSV-1	[93]
Labiatae	*Mynthostachys vertialata*	Leaves and branch	Herpes suis virus	[124]
Labiatae	*Hoslundia opposite, Vahl,*	Leaves	SFA7	[24]
Lacistemataceae	*Lacistema hasslerianum*	Leaves	HSV-1, EHV-1, and SuHV-1	[65]

investigated. *Ajuga decumbens Thunb* (Labiatae) found in China, Korea, and Japan was investigated for its anti-inflammatory, antibacterial, anti-viral, cytotoxic, anti-cancer, and insecticidal actions, which are among the many pharmacological properties of this plant.

Lamiaceae The biological and therapeutic benefits of several fragrant spices, including thyme, mint, oregano, basil, sage, rosemary, self-heal, hyssop, and lemon balm, belong to the Lamiaceae family of herbs. It is one of the best-known and most-studied phytochemicals and ethnopharmacological families, as it contains multiple compounds of significant biological significance and many key biological properties. This family is extremely important in terms of ethnopharmacology. The essential oil of these species is known to have high antibacterial and antioxidant capabilities, while the polar fraction components have anti-viral (Table 32), anti-cancer, and anti-inflammatory characteristics.

Laminariaceae, Lauraceae, Lecythidaceae, and Leeaceae A well-known marine plant called *Laminaria japonica* is frequently eaten as food because of its high carbohydrate, mineral, and vitamin content. The polysaccharides of *L. japonica* have been found to have potent anti-viral and antibacterial properties. There are no effective treatments for enterovirus 71 (EV71), the infection that causes severe hand, foot, and mouth disease (HFMD) in children. *Laminaria japonica* polysaccharide extract has been shown to have anti-viral properties against the respiratory syncytial virus by Cao et al. [248].

There are about 50 genera and 2500–3000 species in the large woody plant family Lauraceae, which is found in tropical and subtropical climes (except from the herbaceous parasite *Cassytha*). Some Lauraceae species have been discovered to have biological effects such as antitumor, antibacterial, fungicidal, cytotoxic, cruzain inhibitory, and anti-viral [51, 65, 161, 249, 250]. Hamidi et al. reported anti-viral activity of Malaysian indigenous medicinal plant *Bertholletia excelsa Hump. & Bonpi.* and *Leea indica (Burm. f.) Merr.* (Lecythidaceae) leaves extract against vesicular stomatitis and herpes virus [37]. Lopez and colleagues investigate the effectiveness of an *Eschweilera rufifolia* bark extract as an anti-viral treatment for the herpes virus [154].

Leguminosae Leguminosae, sometimes known as Fabaceae, is a Fabales order with 727 genera and 19.327 species. The Fabaceae family of higher plants is the third largest. It has applications in a variety of fields, including food and herbal medicine. The major elements of the Fabaceae family are flavonoids. Several components of plants in the Fabaceae family are responsible and useful for the therapy of several ailments in folk medicine. Antimicrobial, anti-leishmanial, and anti-viral (Table 33) activities have been discovered in studies connected to specie.

Liliaceae Traditional Chinese medicine has used several Liliaceae preparations for generations. *Aloe barbadensis, Aloe vera, Lilium candidum*, and other members of

Table 32 List of plants of the family Labiatae with anti-viral activity

Lamiaceae	*D. tanguticum*	Aerial parts	HSV-2	[208]
Lamiaceae	*Teucrium buxifolium*	Aerial parts	HSV-1 and VSV	[132]
Lamiaceae	*Ajuga parviflora Benth*	Leaves	HCV	[130]
Lamiaceae	*Satureja obovata*	Aerial parts	HSV-1 and VSV	[132]
Lamiaceae	*Sideritis phoetens*	Aerial parts	HSV-1 and VSV	[132]
Lamiaceae	*Origanum acutidens*	Herbal parts	IV	[227]
Lamiaceae	*Salvia officinalis L.*	Whole plant	HSV-1	[228]
Lamiaceae	*Nepeta nepetella*	Aerial parts	HSV-1 and VSV	[157]
Lamiaceae	*Nepeta coerulea*	Aerial parts	HSV-1 and VSV	[157]
Lamiaceae	*Nepeta tuberosa*	Aerial parts	HSV-1 and VSV	[157]
Lamiaceae	*Lemon Balm L*	Leaves	HSV-1	[229]
Lamiaceae	*Marrubium alysson L*	Leaves	HCMV and CoxB-3	[230]
Lamiaceae	*Cunila spicata Benth.*	Aerial part	HSV-l, HSV-2, PV VSV, and AD	[51]
Lamiaceae	*Hyptis mutabilis (L. C. Rich.) Brig.*	Whole plant	HSV-l, HSV-2, PV VSV, and AD	[51]
Lamiaceae	*Hyptis suaveolens (L.) Poit*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Lamiaceae	*Glechon marifolia Benth.*	Whole plant	HSV-l	[83]
Lamiaceae	*Glechon spathulata Benth.*	Whole plant	HSV-l	[83]
Lamiaceae	*Phlomis kurdica*	Whole plant	HSV-l and HSV-2	[55]
Lamiaceae	*Thymus fallax*	Aerial part	HSV-l and HSV-2	[55]
Lamiaceae	*Ocimum basilicum L. (OB),*	Whole plant	HSV, ADV, HBV, CVB1, and EV71	[231]
Lamiaceae	*Melissa ofiicinalis*	Whole plant	Herpes simplex and vaccinia	[232]
Lamiaceae	*Marrubium deserti*	Leaves	HCMV, CoxB-3	[127]
Lamiaceae	*Melissa officinalis L*	Aerial part	HSV-1	[55]
Lamiaceae	*Hyssopus officinalis L*	Leaves and flowers	HSV-1	[69]
Lamiaceae	*Vitex doniana*	Aerial parts	HSV-1	[56]
Lamiaceae	*Melissa oficinalis*	Leaves	Vaccinia and HSV	[233]
Lamiaceae	*Ajuga decumbens Thunb.*	Whole plant	RSV	[16]
Lamiaceae	*Callicarpa nudiflora Hook. et Arn.*	Whole plant	RSV	[16]
Lamiaceae	*Mentha haplocalyx Briq.*	Whole plant	RSV	[16]
Lamiaceae	*Schizonepeta tenuifolia Briq.*	Aerial parts	RSV	[16]
Lamiaceae	*Satureja boliviana*	Whole plant	HSV-1 and VSV	[95, 96]
Lamiaceae	*Leucas aspera Spr.*	Aerial parts	HSV and MCV	[92]
Lamiaceae	*Ocimum sanctum, Linn.*	Aerial parts	HSV-1 and HSV-2	[78]
Lamiaceae	*Ocimum americanum L.*	Leaves	Chikungunya	[18]

(continued)

Table 32 (continued)

Lamiaceae	*Melissa officinalis L.*	Oil	H9N2	[234]
Lamiaceae	*Coleus kilimandschari*	Leaves	HSV	[19, 20]
Lamiaceae	*D. heterophyllum*	Aerial parts	HSV-2	[208]
Lamiaceae	*Thymus daenensis Celak*	Root	HIV-1	[235]
Lamiaceae	*Ocimum basilicum*	Leaves	HSV-1	[25]
Lamiaceae	*Ajuga chamaepitys ssp. chia var. ciliata*	Whole plant	HSV-1 and PI-3	[125]
Lamiaceae	*Mentha pulegium L*	Aerial parts	HSV-1	[225]
Lamiaceae	*Salvia officinalis L*	Aerial parts	HSV-1	[225]
Lamiaceae	*Salvia cedronella*	Aerial parts	IV	[236]
Lamiaceae	*Orthosiphon stamineus*	Whole plant	HSV-1	[237]
Lamiaceae	*Ocimum sanctum*	Leaves	DENV-1	[26]
Lamiaceae	*Vitex negundo*	Leaves	Zika virus	[99]
Lamiaceae	*Callicarpa japonica*	Aerial part	HSV-1 and HSV-2	[30]
Lamiaceae	*Clinopodium chinense var. parviflorum*	Whole plant	HSV-1 and HSV-2	[30]
Lamiaceae	*Elsholtzia ciliata*	Aerial part	HSV-1 and HSV-2	[30]
Lamiaceae	*Teucrium veronicoides*	Aerial part	HSV-1 and HSV-2	[30]
Lamiaceae	*Origanum vulgare*	Leaves	HSV-1	[238]
Lamiaceae	*Salvia officinalis*	Leaves	HSV-1	[238]
Lamiaceae	*Prunella vulgar*	Whole herb	HSV-1	[239]
Lamiaceae	*Melissa officinalis*	Leaves	HSV-l HSV-2	[240]
Lamiaceae	*Mentha x piperita*	Leaves	HSV-l HSV-2	[240]
Lamiaceae	*Prunella vulgaris*	Leaves	HSV-l HSV-2	[240]
Lamiaceae	*Rosmarinus officinalis*	Leaves	HSV-l HSV-2	[240]
Lamiaceae	*Salvia officinalis*	Leaves	HSV-l HSV-2	[240]
Lamiaceae	*Thymus vulgaris*	Dried herb	HSV-l HSV-2	[240]
Lamiaceae	*Hysopp officinalis*	Leaves	HIV	[175]
Lamiaceae	*Origanum vulgare*	Leaves	EAV, EIV, FCV, CDV, CAV, and CCoV	[241]
Lamiaceae	*Rosmarinus officinalis Lam.*	Leaves, Roots and fruits	HSV-1and HSV-2	[242]
Lamiaceae	*Hyssop officinalis*	Leaves	HIV	[243]
Lamiaceae	*Mentha cordifolia*	Leaves	HIV	[244]
Lamiaceae	*Satureja montana*	Herb	IBV	[112]
Lamiaceae	*Thymus vulgaris*	Herb	IBV	[112]
Lamiaceae	*Hyssopus officinalis*	Herb	IBV	[112]
Lamiaceae	*Nepeta cataria*	Herb	IBV	[112]
Lamiaceae	*Salvia officinalis*	Herb	IBV	[112]
Lamiaceae	*Mentha piperita L.*	Leaves	RSV	[245]
Lamiaceae	*Perilla frutescens (L.) Britt.*	Leaves	RSV	[16]
Lamiaceae	*Prunella vulgaris L.*	Fruit spike	RSV	[16]

(continued)

Table 32 (continued)

Lamiaceae	*Scutellaria baicalensis Georgi.*	Root	RSV	[16]
Lamiaceae	*Anisomeles indica (L.) Kuntze*	Stem and leaves	PEDV	[47]
Lamiaceae	*Prunella vulgaris*	Herb	HIV	[27, 246]
Lamiaceae	*Melissa officinalis L.*	Oil	HSV-2	[247]
Lamiaceae	*Satureja thymbra L*	Leaves and flowers	HSV-1	[69]
Lamiaceae	*Calamintha origanifolia vis*	Leaves and flowers	HSV-1	[69]
Lamiaceae	*Sideritis perfoliata L*	Leaves and flowers	HSV-1	[69]
Lamiaceae	*Salvia acetabulosa L*	Leaves and flowers	HSV-1	[69]
Lamiaceae	*Scutellaria barbata D. Don*	Whole plant	HSV-1 RSV	[15]
Lamiaceae	*Scutellaria indica L.*	Aerial part	HSV-1 RSV	[15]

this family have medicinal properties. The therapeutic properties of *Aloe barbadensis* are the best. Aloe vera includes a variety of minerals and vitamins, as well as immunomodulatory, anti-viral (Table 34), and anti-inflammatory effects.

Campanulaceae, Scrophulariaceae, Loganiaceae, and Loranthaceae Locher et al. studied the anti-viral activity of Hawaiian medicinal plants leaves extract, *Clermontia Aborescens Mann (*Campanulaceae*)*, against the HIV 1 virus [91]. Simões and coworker investigated the anti-viral activities of the South Brazilian medicinal plant *Buddleia brasiliensis Jacq. ex. Speng*. (Scrophulariaceae) leaves extract against herpes virus type 1 and type 2 [51]. Boff et al. reported anti-herpes property of the Brazilian medicinal plant *Strychnos pseudoquina A. St. Hil.* (Loganiaceae) [260]. Loranthaceae is known for its parasitic behavior on trees and shrubs. Leaves extracts of *S. ferruginea Danser, E. tubaeflora Ridley, E. globosa Blume, T. bangwensis*, and *P. capitata* were studied for anti-viral efficacy against herpes, polio, and hepatitis C viruses [145, 220].

Lythraceae *Cuphea* is the largest of the 32 Lythraceae genera, with over 260 species. *Cuphea* plants are commonly utilized for their traditional therapeutic properties. Plants of this species are harvested and utilized for anti-viral and other therapeutic purposes in their native countries. Herpes, rabies, norovirus coxsackievirus B3, polio, adenovirus Mayaro, and hepatitis viruses have all been investigated extensively using plant extracts from the Lythraceae family (Table 35).

Magnoliaceae, Malaceae, and Malphigiaceae Magnoliaceae members have long been and continue to be utilized in traditional herbal medicine in Asia and North America. Many Magnolia taxa produce lignans and sesquiterpene lactones, some of

Table 33 List of plants of the family Leguminosae with anti-viral activity

Leguminosae	*Albizia anthelmintica*	Leaves	HSV-1	[56]
Leguminosae	*Retama raetam*	Leaves	HSV-1	[56]
Leguminosae	*Glycine max*	Seeds	HSV-1 and rabies virus	[71]
Leguminosae	*Detarium microcarpum Guill. & Perr*	Stem bark	HCV	[252]
Leguminosae	*Pterocarpus angolensis*	Stem bark	PV and HRV-2	[67]
Leguminosae	*Xanthocercis zambesiaca*	Leaves	PV and HRV-2	[67]
Leguminosae	*Calpurnia aurea (Ait.)*	Arial part	HIV-1 and HIV-2	[10]
Leguminosae	*Melilotus elegans Salzm. ex Ser*	Seed	HIV-1 and HIV-2	[10]
Leguminosae	*Melilotus elegans*	Leaves	CVB3 and HSV-1	[73]
Leguminosae	*Adenanthera pavonina (L.)*	Seed	Poliovirus	[251]
Leguminosae	*Calliandra selloi (Spreng.) Macbride*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Leguminosae	*Caesalpinia pulcherrima*	Aerial parts	HSV-1, HSV-2, ADV-3, ADV-8, and ADV-11	[252]
Leguminosae	*Vachellia nilotica*	Bark	HSV-2 and HPV-16 P	[253]
Leguminosae	*Acacia pennata L. Willd.*	Leaves	HSV-1	[76]
Leguminosae	*Cassia siamea Lam.*	Leaves	HSV-1	[76]
Leguminosae	*Glycyrrhiza uralensis Fisch.*	Root	RSV	[16]
Leguminosae	*Pueraria labata (Willd.)*	Root	RSV	[16]
Leguminosae	*Millettia erythrocalyx*	Leaves	HSV-1 and HSV-2	[254]
Leguminosae	*Chamaechrista nigricans*	Aerial parts	HSV-1 and ASFV	[66]
Leguminosae	*Senna podocarpa (Guill. & Perr.) Lock*	Leaves and root	HSV-1 and ASFV	[66]
Leguminosae	*Cassia sieberiana DC.*	Aerial parts and root	HSV-1 and ASFV	[66]
Leguminosae	*Entada africana*	Stem bark	HSV-1 and ASFV	[66]
Leguminosae	*Erythrina senegalensis*	Root	HSV-1 and ASFV	[66]
Leguminosae	*Piliostigma thonningii (Schum.) Milne-Redhead*	Stem, bark, and aerial part	HSV-1 and ASFV	[66]
Leguminosae	*Archidendron jiringa (Jack) I.C.Nielsen*	Seed	Chikungunya	[18]
Leguminosae	*Parkia speciosa Hassk.*	Seed and Pod	Chikungunya	[18]
Leguminosae	*Bauhinia thonningii (Schum.)*	Leaves	PV, ASV, HSV 1, Equine HSV, BPV, and CPV	[61]
Leguminosae	*Detarium senegalense (Gmel.)*	Leaves	PV, ASV, BPV, and CPV	[61]
Leguminosae	*Cassia goratensis L.*	Leaves	PV, ASV, HSV 1, Equine HSV, BPV, and CPV	[61]

(continued)

Table 33 (continued)

Leguminosae	*Bauhinia varigata*	Leaves	HSV-1	[25]
Leguminosae	*Cassia Fistula*	Leaves	HSV-1	[25]
Leguminosae	*Lupines termis*	Leaves	HSV-1	[25]
Leguminosae	*Lupines termis*	Leaves	HSV-1	[25]
Leguminosae	*Phaseolus vulgaris*	Leaves	HSV-1	[25]
Leguminosae	*Trifolium alexandrinum*	Leaves	HSV-1	[25]
Leguminosae	*Vicia faba*	Leaves	HSV-1	[25]
Lessoniaceae	*Ecklonia cava. Kjellman*	Whole plant	HIV	[255]

Table 34 List of plants of the family Liliaceae with anti-viral activity

Liliaceae	*Aloe barbadensis*	Leaves	HSV-1	[196]
Liliaceae	*Smilax gracilis*	Aerial parts	HSV-1	[36]
Liliaceae	*Lilium candidum*	Fruit	HSV-1, HSV-2, and VZV	[256]
Liliaceae	*Fritillaria imperialis (Lutea) L.*	Bulb	HSV-1 and VSV	[43]
Liliaceae	*Fritillaria imperialis (Rubra) L.*	Bulb	HSV-1 and VSV	[43]
Liliaceae	*Dianella longifolia var. grandis*	Root	CMV and RRV	[121]
Liliaceae	*Dianella longifolia,*	Root	PV	[257]
Liliaceae.	*Aloe burbadensis*	Leaves	CMV	[258]
Liliaceae.	*Aloe vera*	Leaves	HSV-2	[259]

Table 35 List of plants of family Lythraceae with anti-viral activity

Lythraceae	*Lafoensia pacari*	Leaves	HSV-1 and rabies virus	[71]
Lythraceae	*Cuphea carthagenensis*	Aerial parts	HSV-1	[88]
Lythraceae	*Punica granatum*	Peel	Norovirus	[226]
Lythraceae	*Woodfordia Fruiticosa*	Whole herb	Coxsackievirus B3	[28]
Lythraceae	*Lagerstroemia indica L.*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Lythraceae	*Prunus granatum*	Fruit and peel	PV, HSV-1, and HV-A	[31, 261]
Lythraceae	*Punica granatum*	Fruit	MAYV	[262, 263]
Lythraceae	*Lythrum anceps*	Aerial part	HSV-1 and HSV-2	[30]

which have significant in vitro bioactivities. Mohamed et al. studied the anti-herpes property of *Magnolia grandiflora* L. (Magnoliaceae) leaves extract [178, 264]. Activity against influenza virus in bark extract of Magnolia obovate was also studied by Park [178].

Malpighiaceae is a flowering plant family rich in secondary metabolites such as alkaloids, flavonoids, carbohydrate-like substances such as vitamin C, pro-anthocyanidins, and phenolic compounds that have anticancer, anti-inflammatory, antioxidant, anti-viral, and antimicrobial activities. Various extracts of *Byrsonima verbascifolia, Banisteriopsis variabilis, Byrsonima intermedia*, and *Byrsonima verbascifolia* were studied for anti-viral activity against herpes, rotavirus, equine herpes, swine herpes type 1, and vesicular stomatitis viruses [57, 65, 154].

Malvaceae The Malvaceae family contains 4225 species of plants, shrubs, and trees divided into 244 genera. India has around 22 genera of the family, several of which have ethnomedicinal potential. The WHO acknowledged the advantages of medications made from natural ingredients. Malvaceae ethnomedicinal plants *Hibiscus sabdariffa, Abutilon Indicum, Sida acuta,* and *Sida rhombifolia* are extensively utilized in Indian traditional medicine. Traditionally, tribal communities in India employed these herbs in the form of extracts/powder/paste to cure common ailments such as inflammations, cough and cold, kidney, liver issues, fever, stomach, aches, wounds, and so on.

Hibiscus sabdariffa leaf ethanolic extract has an anti-viral activity in vitro against a virus extract made up of Hep-2 cells. In a virus-induced cytopathic experiment, methanolic extract of Sida acuta leaf showed anti-viral efficacy against the herpes simplex virus. Along with these, there are several plant species from Malvaceae that exhibit anti-viral activity against polio, influenza, hepatitis, HIV, respiratory syncytial, and molluscum contagiosum viruses. (Table 36).

Melanthiaceae and Melastomataceae Various extracts of plants from the family Melanthiaceae *viz Veratrum patulum* and *Paris polyphylla Sm. var. yunnanensis (Franch.)* were studied for anti-viral property against herpes and respiratory syncytial viruses [16, 30]. *Memecylon* is a complex genus of flowering plants that is important in traditional medicine. Identification of *Memecylon* species has become extremely challenging due to the variety of morphological features. Several actions involving *Memecylon* species (*Miconia hyemalis St. HiI*, *Melastoma malabathricum Linn)* including *Memecylon malabaricum* have been described. *Memecylon malabaricum cogn* is an antibacterial substance used in ethnomedicine to treat bacterial infections, inflammation, and skin illnesses like herpes and chickenpox [51, 220].

Meliaceae, Meliaceae, and Melianthaceae A family of trees and shrubs, the Meliaceae, has 51 genera and over 575 species. Meliaceae plants are widespread worldwide despite being native to tropical and subtropical areas. Numerous reports have been made about the folk and traditional influence. The most well-known members of the Meliaceae family are *Azadirachta indica* and *Melia azedarach*, both of which have been demonstrated to have medicinal properties. Depending on the sickness, extracts from the leaves, roots, or fruits of Meliaceae plants have been used to cure a range of illnesses. In particular, some extracts or pure compounds from Meliaceae plants have anti-viral action against coxsackievirus, herpes simplex, polio,

Table 36 List of plants of the family Malvaceae with anti-viral activity

Malvaceae	*Hibiscus fuscus*	Leaves	VSV	[19, 20]
Malvaceae	*Sida acuta Burm. f.*	Leaves	Herpes simplex, Sindbis, and polio	[111]
Malvaceae	*Hibiscus sabdarifab e*	Flower heads	HSV-1 and VSV	[132]
Malvaceae	*Althaea officinalis L*	Leaves	H5N1	[265]
Malvaceae	*Alcea rosea L.*	Leaves	HIV-1 and HIV-2	[10]
Malvaceae	*Abelmoschus manihot (L) medik*	Flower	HBV	[266]
Malvaceae	*Abutilon figarianum*	Leaves	HBV	[109]
Malvaceae	*Sterculia lychnophora*	Seed	RSV	[16]
Malvaceae	*Abutilon indicum G. Don.*	Aerial parts	HSV and MCV	[92]
Malvaceae	*Hibiscus sabdariffa L.*	Leaves	IAV	[267]
Malvaceae	*Sida acuta Burm. f.*	Leaves	HSV	[123]
Malvaceae	*Abutilon pictum*	Leaves	HSV-1	[25]
Malvaceae	*Althea rosea*	Leaves	HSV-1	[25]
Malvaceae	*Hibiscus rosa sinensis*	Leaves	HSV-1	[25]
Malvaceae	*Ficus decora*	Leaves	HSV-1	[25]
Malvaceae	*Ficus nitida*	Leaves	HSV-1	[25]
Malvaceae	*Ficus religiosa*	Leaves	HSV-1	[25]
Malvaceae	*Morus alba*	Leaves	HSV-1	[25]

vesicular stomatitis, and foot and mouth disease viruses (Table 37). The medicinal herbs *Bersama abyssinica Fresen* and *Stephania abyssinica* (Quart. Dill. ex Rich.) Walp from the Melianthaceae and Menispermaceae families, respectively, were studied for their anti-HIV activity by Asres et al. [10].

Menispermaceae and Mimosaceae The Menispermaceae family has around 400 species, all of which are said to have considerable therapeutic potential. The presence of diverse types of alkaloids could be the primary cause of these biological potentials, which are of great interest to a variety of study groups. Alkaloids found in the Menispermaceae family include alkaloids like benzylisoquinoline, protoberberine, aporphine, and others. Analgesic, anthelmintic, anti-viral [10, 273], anti-inflammatory, antimicrobial, antimalarial, and antiproliferative activities are all found in Menispermaceae species. Different extracts of Menispermaceae species were studied for several anti-viral activities against HIV, dengue, herpes, and respiratory syncytial viruses (Table 38). Several extracts of *Entada abyssinica, Acacia tortilis (Forsk.) Hyne,* and *Dichrostachys glomerata (Chiev.)* of Mimosaceae plants were studied for anti-viral activity against herpes, Cox, measles, polio, Semliki Forest, vesicular stomatitis, bovine papilloma, and canine parvo viruses (Table 38).

Moraceae Around 40 genera and 1,000 species of deciduous and evergreen trees and shrubs make up the mulberry family (Moraceae), which is mostly found in

Table 37 List of plants of the family Meliaceae with anti-viral activity

Meliaceae	*Toona sureni. (Blume) Merr*	Leaves	HCV	[181]
Meliaceae	*Melia azedarach L.*	Leaves	VSV and HSV-1	[268]
Meliaceae	*Azadirachta indica*	Whole herb	Coxsackievirus B3	[28]
Meliaceae	*Cedrela tubiflora*	Leaves	HSV-2 and VSV	[269]
Meliaceae	*Trichilia catigua*	Bark	HSV-1, BoHV-1, and PV	[270]
Meliaceae	*Trichilia dregeana*	Root	HCV	[145]
Meliaceae	*Azadirachta indica*	Leaves and seed	HSV-1	[271]
Meliaceae	*Aglaia odorata Lour.*	Leaves	HSV-1	[76]
Meliaceae	*Azadirachta indica A.*	Leaves	HSV-1	[76]
Meliaceae	*Azadiracta indica, A. Juss*	Leaves and stem	HSV-1 and HSV-2	[78]
Meliaceae	*Azadirachta indica*	Leaves	Chikungunya	[18]
Meliaceae	*Azardirachta indica L.*	Bark	HSV-1	[272]
Meliaceae	*Trichilia cipo*	Leaves	HSV-1 and 2 VSV	[143]
Meliaceae	*Khaya senegalensis (A. Juss.)*	Bark	PV, ASV, HSV 1, and equine HSV	[61]
Melianthaceae	*Bersama abyssinica Fresen*	Bark	HIV-1 and HIV-2	[10]

Table 38 List of plants of the family Menispermaceae and Mimosaceae with anti-viral activity

Menispermaceae	*Stephania abyssinica (Quart. Dill. ex Rich.)*	Leaves	HIV-1 and HIV-2	[10]
Menispermaceae	*Cissampelos pariera Linn*	Aerial part	DENV	[273]
Menispermaceae	*Iryanthera megistophylla*	Bark	HSV	[154]
Menispermaceae	*Pericampylus glaucus*	Stem and leaves	PEDV	[47]
Menispermaceae	*Tinospora sinensis (Lour.)*	Stem	PEDV	[47]
Menispermaceae	*Tinospora capillipes*	Root	RSV	[16]
Mimosaceae	*Entada abyssinica*	Leaves and stem	HSV, Cox, PV, measles, and SFV	[19, 20]
Mimosaceae	*Acacia tortilis (Forsk.)*	Stem bark	Cox B2	[24]
Mimosaceae	*Dichrostachys glomerata (Chiev.)*	Leaves	PV, ASV, HSV 1, equine HSV, BPV, and CPV	[61]

tropical and subtropical regions. Several biological actions have been documented from various sections of Moraceae plants, listed in (Table 39).

Table 39 List of plants of the family Moraceae with anti-viral activity

Moraceae	*Artocarpus integrifolia L.*	Bark	Simian (SA-11) and human (HCR3) rotaviruses	[48]
Moraceae	*Cecropia catarinensis Cuatrecasas*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Moraceae	*Ficus ovata Vahl*	Root bark	Herpes simplex, Sindbis, and Polio	[111]
Moraceae	*Ficus carica*	Fruit	HSV-1, ECV-11, and ADV	[274]
Moraceae	*Ficus fistulosa Reinw. ex*	Leaves	HCV	[181])
Moraceae	*Morus alba*	Leaves	HSV-1	[56]
Moraceae	*Ficus Prolixa Forst.*	Fruit	HIV-1	[91]
Moraceae	*Morus alba var. alba*	Leaves and stem bark	HCoV, PV-1, HPeV1 and 3, and Echo 11	[275]
Moraceae	*Morus alba var. rosea*	Leaves and stem bark	HCoV, PV-1, HPeV1 and 3, and Echo 11	[275]
Moraceae	*Morus rubra*	Leaves and stem bark	HCoV, PV-1, HPeV1 and 3, and Echo 11	[275]
Moraceae	*Artocarpus lakoocha*	Heartwood	HSV-1 and HSV-2	[254]
Moraceae	*Ficus deltoidea Jack*	Leaves	Chikungunya	[18]
Moraceae	*Ficus semicordata Buch.-Ham. ex Sm.*	Bark and leaves	PEDV	[47]
Moraceae	*Ficus sycomorus L.,*	Stem bark	HSV-1 and VSV	[24]
Moraceae	*Ficus ovata Vahl*	Root and bark	HSV and PV	[123]
Moraceae	*Artocarpus heterophyllus*	Leaves	HCV	[276]
Moraceae	*Ficus binjamina*	Leaves	VZV	[256]
Moraceae	*Ficus benjamina*	Leaves	HSV-1 and HSV-2	[277]

Moringaceae, Myoporaceae, Myristicaceae, Myrothamnaceae, and Myrsinaceae *Moringa* is a tiny genus of trees and shrubs with 13 species found in Africa and Asia. The species of *Moringa* are utilized for a variety of purposes, including oil production, food, cosmetics, and medicine. There are many different therapeutic uses for different components, as well as pharmacological effects including anti-viral (Table 40) and medicinal chemical sources. In the field, Myrsinaceae can be identified by the presence of glands beneath the blade. A fascinating characteristic is the ability of the Myrsinaceae family and the Ardisia species to create a rare sequence of benzoquinones with a startling array of pharmacological effects, including anti-viral activity (Table 40).

Myrtaceae The Myrtaceae family contains roughly 140 genera and 3,400 species that are mostly found in subtropical and tropical climates. Phytoconstituents such as flavonoids, glycosides, saponins, steroids, tannins, terpenes, alkaloids, and others have been documented to exhibit pharmacological actions in several Myrtaceae plant species. Several extracts have been documented for their anti-viral efficacy toward

Table 40 List of plants of the family Moraceae with anti-viral activity

Moringaceae	*Moringa oleifera Lam*	Leaves	HBV and liver cancer	[166]
Moringaceae	*Moringa oleifera*	Leaves, roots, and fruits	HSV-1 and HSV-2	[242]
Moringaceae	*Moringa oleifera*	Leaves and stem bark	EHV-1	[82]
Moringaceae	*Moringa peregrina (Forssk.) Fiori*	Seed	HSV-1	[113]
Moringaceae	*Mangifera indica L.*	Leaves	HSV-1	[76]
Moringaceae	*Moringa oleifera Lam.*	Leaves	HSV-1	[76]
Myristicaceae	*Myristica fragrans Houtt*	Seed	Human (HCR3) rotaviruses	[48]
Myristicaceae	*Myristica fatua*	Leaves and bark	DENV	[29]
Myristicaceae	*Virola multineria*	Resin and bark	HSV	[154]
Myrothamnaceae	*Myrothamnus flabellifolia*	Aerial part	HSV-1	[176, 177]
Myrsinaceae	*Badula insularis*	Leaves	PV and HRV-2	[67]
Myrsinaceae	*Rapanea melanophloeos (L.) Mez*	Leaves	H1N1	[77]
Myrsinaceae	*Embelia ribes Burm. f*	Fruit	H1N1	[278]
Myrsinaceae	*Embelia schimperi*	Fruit	HCV	[70]
Myrsinaceae	*Maesa lanceolata*	Leaves	HSV1- HSV-2 and VSV	[279]

various herpes viruses, hepatitis C virus, rotaviruses, HIV, Zika virus, adeno, polio, varicella-zoster, porcine reproductive and respiratory syndrome, etc (Table 41).

Nelumbonaceae, Nyctaginaceae, and Ochnaceae The anti-viral effects of various extracts of *Nelumbo nucifera Gaertn* (Nelumbonaceae), *Mirabilis jalapa L. Mirabilis jalapa* (Nyctaginaceae), and *Ouratea lucens* (Ochnaceae) have been studied by several researchers [25, 37, 143, 201].

Oleaceae, Onagraceae, Orchidaceae, Osmundaceae, and Oxalidaceae The family Oleaceae consists of about 600 species grouped in 25 genera. Ma et al. [16] evaluated the anti-viral activity in vitro of glucosides secoiridoids, lucidumoside C, oleuropein, oleoside, lucidumoside A, and ligustroside of *Ligustrum lucidum* (Table 42). Also, several extracts of plants have been evaluated for anti-viral activities against polio, herpes, rotavirus, HIV, Cox, respiratory syncytial, viral hemorrhagic septicemia, chikungunya, rabies, Semliki Forest type A7, etc. (Table 42).

Table 41 List of plants of family Myrtaceae with anti-viral activity

Myrtaceae	*Eugenia jambosb*	Leaves	HSV-1 and VSV	[132]
Myrtaceae	*Psidium guajava L.*	Leaves	Human (HCR3) rotaviruses	[48]
Myrtaceae	*Eugenia singampattiana*	Leaves	PRRSV	[280]
Myrtaceae	*Syzygium aromaticum (L.) Merr. & L.M. Perry*	Fruit	HSV	[70]
Myrtaceae	*Eugenia michelii Lamk.*	Leaves	HSV-1 and VSV	[37]
Myrtaceae	*Campomanesia xanthocarpa*	Leaves	HSV-1, EHV-1, and SuHV-1	[65]
Myrtaceae	*Syzygium aromaticum (L.) Merr*	Flower bud	HSV-1	[55]
Myrtaceae	*Psidium guayava*	Seeds	HSV-1	[56]
Myrtaceae	*Eugenia dysenterica*	Leaves	Rotavirus	[57]
Myrtaceae	*Eugenia Malaccensis L.*	Leaves and bark	HIV-1	[91]
Myrtaceae	*Kunzea sinclairii*	Leaves and twigs	HSV-1 and PV-1	[281]
Myrtaceae	*Kunzea ericoides*	Leaves and twigs	HSV-1	[281]
Myrtaceae	*Myrteola nummulari*	Aerial part	HSV	[154]
Myrtaceae	*Myrcianthes cisplatensis*	Ground plant	RSV	[60]
Myrtaceae	*Psidium guajava*	Leaves	Zika virus	[99]
Myrtaceae	*Psidium luridum*	Aerial parts	HSV-1	[36]
Myrtaceae	*Eucalyptus camaldulensis*	Leaves	HSV-1, HSV-2, and VZV	[282]
Myrtaceae	*Synzium aromaticum*	Flower buds	EHV-1	[82]
Myrtaceae	*Camponesia aurea Berg.*	Fruit	HSV-l, HSV-2, PV VSV, and AD	[51]
Myrtaceae	*Psidium cattleianum Sabine*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Myrtaceae	*Psidium guajava L.*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]

Paeoniaceae, Palmae, Pandanaceae, Papaveraceae, Papilionacea, Passifloraceae, Pedaliaceae, Periplocaceae, and Phyllanthaceae The Paeoniaceae family is found in our country's diverse flora and has been used for a variety of therapeutic purposes. Lee et al. [141] used a tissue culture system to test the anti-viral effect of a solvent made from the roots of *Paeonia lactiflora* Pall. Anti-hepatitis B activity was found in the ethylacetate fraction. Other species of Paeoniaceae viz *Paeonia lactiflora* and *Paeonia suffruticosa Andr.* were also studied for anti-viral action against hepatitis type A and respiratory syncytial viruses [16, 46].

Table 42 List of plants of family Oleaceae, Onagraceae, Orchidaceae, Osmundaceae, and Oxalidaceae with anti-viral activity

Oleaceae	*Jasminum fluminense*	Stem	PV, HRV-2, and HSV	[67]
Oleaceae	*Olea europaea L.*	Leaves	Rotavirus	[201]
Oleaceae	*Ximenia americana L.*	Stem bark	HIV-1 and HIV-2	[10]
Oleaceae	*Nyctanthus arbortrtis*	Whole herb	Coxsackievirus B3	[28]
Oleaceae	*Forsythia suspensa*	Fruit	RSV	[16]
Oleaceae	*Syringa amurensis Rupr.*	Stem cortex	RSV	[16]
Oleaceae	Ligustrum lucidum	Dried fruits	HSV-1, FluA, and RSV	[16]
Oleaceae	*Nyctanthes arbortristis, L.*	Leaves and stem	HSV-1 and HSV-2	[78]
Oleaceae	*Olea europaea*	Leaves	VHSV	[283]
Oleaceae	*Olax psittacorum*	Leaves and stem	HSV-1 and PV	[34]
Olacaceae	*Heisteria acuminata*	Whole plant	HSV-1	[95, 96]
Onagraceae	*Epilobium pyrricholophum*	Whole plant	HSV-1 and HSV-2	[30]
Orchidaceae	*Arundina graminifolia*	Leaves	Chikungunya	[18]
Osmundaceae	*Osmunda japonica*	Aerial and underground part	HSV-1 and HSV-2	[30]
Oxalidaceae	*Oxalis corniculate*	Whole herb	Coxsackievirus B3	[28]

African traditional medicine makes prominent use of palms (Palmae), which helps to improve the health of rural and urban residents. Esquenazi and coworker studied the anti-herpes activity of *Cocos nucifera Linn* husk fiber extract [284]. The anti-viral effects of several plant extracts from the *Palmae Phoenix dactylifera* and *Areca catechu* species against the herpes and influenza viruses have been studied [25, 178]. *Freycinetia malaccensis Ridl*. (Pandanaceae), a plant utilized in traditional Malaysian medicine, was studied by Hamidi et al. for its anti-herpes activity [37]. *Chelidonium majus L* (Papaveraceae) is evaluated for its anti-viral efficacy by Parsania and colleagues [225] against acyclovir-resistant herpes simplex virus type 1. Maregesi et al. looked at the anti-viral properties of various Tanzanian medicinal plant extracts of *Indigofera colutea (Burm.f.) Merr, Rhynchosia sublobata (Schum.) Meikle,* and *Ormocarpum kirkii S. Moore* from Papilionaceae family against Cox, herpes, vesicular stomatitis, and Semliki Forest viruses [24]. The root extract of the South American plant *Passiflora edulis* (Passifloraceae) was also evaluated for anti-herpes and anti-rabies activity [71]. Cos and colleagues revealed that the Rwandan medicinal herb *Sesamum angolense* has anti-viral action against HIV-1 (HIV-1) [19, 20].

The Phyllanthaceae family, which includes 12 Phyllanthus species, has a long history of use in Indian traditional medicine [285, 286]. Phyllanthin is found in almost all Phylllanthus species including *Glochidion eriocarpum and Champ. ex Benth*. *It has been demonstrated that Phyllanthus niruri, P. urinaria, and P. amarus Schumacher* possess anti-viral qualities. Leave extracts of *Mondia whitei (Hook.f.) Skeels* (Periplocaceae) and *Phyllanthus amarus Schumach. & Thonn* (Phyllanthaceae) were found to have anti-viral action against echovirus by Ogbole et al. [44].

Phytolaccaceae, Picornaviridae, Pinaceae, Piperaceae, and Pittosporaceae The anti-viral property of *Piper sarmentosum* was demonstrated in vitro by infecting the whole plant extract with dengue virus type 2 (Table 43). In Vero cells, dichloromethane and ethanol extracts of *Piper sarmentosum* at equal concentrations (12.5g/ml) showed no inhibitory effect against DENV2. With a MIC value of 0.02 mg/ml, the ethanolic extract of *Piper sarmentosum* leaves also demonstrated anti-viral activity against the vesicular stomatitis virus (VSV), although it had no effect on herpes simplex virus type 1 [37].

Plantaginaceae and Plumbaginaceae The anti-viral effect of *Plantago* species major aqueous extract and purified components were investigated for anti-viral

Table 43 List of plants of the family Phytolaccaceae, Picornaviridae, Pinaceae, Piperaceae, and Pittosporaceae with anti-viral activity

Phytolaccaceae	*Phytolacca dioica L.*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Phytolaccaceae	*Phytolacca dodecandra*	Leaves	Cox V	[19, 20]
Picornaviridae	*Tanacetum Vulgare L.*	Aerial parts	CVB1, HSV-1, and IAV (H3N2)	[287]
Pinaceae	*Abies spectabilis Spach.*	Leaves	HSV-1 and influenza	[33]
Pinaceae	*Pinus thunbergii*	Stem and leaf	H1N1	[126]
Pinaceae	*Paeonia delavayi Franch*	Root	Influenza	[288]
Pinaceae	*Pinus yunnanensis*	Pine cone	HIV-1	[289]
Piperaceae	*Piper aduncum Linn.*	Leaves	HSV-1 and poliovirus	[220]
Piperaceae	*Piper retrofractum*	Whole plant	DENV	[183]
Piperaceae	*Piper sarmentosum Roxb.*	Leaves	VSV, HSV-1, and DENV2	[37]
Piperaceae	*Piper Methysticum Forst.*	Leaves, stem, andrRoot	HIV-1	[91]
Piperaceae	*Piper cordulaturn*	Leaves	HSV-1 & 2 and VSV	[143]
Piperaceae	*Piper cubeba L*	Fruit	HSV	[70]
Pittosporaceae	*Pittosporum phylliraeoides var. microcarpa*	Leaves	CMV and RRV	[121]
Pittosporaceae	*Pittosporum viridiflorum*	Leaves	H1N1	[77]

Table 44 List of plants of family Phytolaccaceae, Picornaviridae, Pinaceae, Piperaceae, and Pittosporaceae with anti-viral activity

Plantaginaceae	*Plantago brasilensis*	Leaves and branch	Herpes suis virus	[124]
Plantaginaceae	*Plantago mayor L*	Leaves and branch	Herpes suis virus	[124]
Plantaginaceae	*Plantago major L*	Whole plant	RSV	[290]
Plantaginaceae	*Plantago coronopus L. ssp. eu-coronopus Pilger var. vulgaris G.G.*	Whole plant	HSV-1	[32]
Plantaginaceae	*Reichardia tingitana (L.) Roth ssp. discolor (Pom.) Batt.*	Whole plant	HSV-1	[32]
Plantaginaceae	*Plantago asiatica L.*	Whole plant	HSV-1 RSV	[290]
Plantaginaceae	*Plantago major*	Whole plants	HSV-1, HSV-2, ADV-3, ADV-8, and ADV-11	[252]
Plantaginaceae	*Plantago asiatica*	Whole plants	HSV- type 1 and 2 and ADV-3, 8, and 11	[252]
Plantaginaceae	*Plantago major*	Leaves	HSV-1	[25]
Plumbaginaceae	*Plumbago zeylanica*	Leaves	CVB3 and HSV-1	[73]
Plumbaginaceae	*Limonium brasiliense*	Aerial parts	HSV-1	[36]
Plumbaginaceae	*Plumbago indica L*	Stem	H1N1	[291]

activity. The findings revealed that *Plantago major's* pure components are generated from phenolic chemicals, particularly caffeic acid. Its mechanism of action against HSV-2 and ADV-3 was found to be at the stage of proliferation, with SI values more than 400, indicating that it may be utilized to treat these viruses' infections (Table 44). Chathuranga et al. [290] investigated the anti-viral potential of *Plantago asiatica* and its component verbascoside, which may be found in quite large amounts in *Plantago media*, against the respiratory syncytial virus, with in vivo experiments pointing to a putative anti-viral approach.

Poaceae The second-largest monocotyledon family, the Poaceae, contains a variety of species that are essential to both human and animal existence. Almost all grasses were employed in the area for fodder and medical uses including anti-viral activity (Table 45).

Polemoniaceae and Polygalaceae Plant from Polemoniaceae family *Ipomopsis aggregata* root extract shows good anti-viral activity against parainfluenza virus type 3 [147]. The extract of the aerial parts and root of *Polygala stenopetala, Polygala virgata, and Securidaca Iongepedunculata* (Polygalaceae) exhibited

Table 45 List of plants of the family Poaceae with anti-viral activity

Poaceae	*Cymbopogon citratus*	Aerial parts	HAdV-5	[292]
Poaceae	*Cymbopogon nardus*	Aerial parts	HAdV-5	[292]
Poaceae	*Phragmites communis (L.) Trin.*	Rhizome	RSV	[16]
Poaceae	*Cymbopogon citratus*	Root	DENV	[29]
Poaceae	*Agropyron repens*	Leaves	HSV-1	[25]
Poaceae	*Cymbopogon citrates*	Aerial parts	DENV-1	[26]
Poaceae	*Phyllostachys bambusoides*	Whole herb	Coxsackievirus B3	[28]
Poaceae	*Lophatherum gracile*	Stem and leaves	RSV	[39]

anti-viral activity at lower concentrations [67]. *Securidaca longepedunculata Fresen*, a Polygalaceae plant native to Ethiopia, has been studied for its potential anti-viral properties against both HIV-1 and HIV-2 by Asres et al. [10].

Polygonaceae The family is made up of about 51 genera and 1200 species that are found all over the world, primarily in temperate temperatures in the Northern Hemisphere and, less frequently, in the Southern Hemisphere. Since they have been used for a long time to treat a variety of diseases, the *Persicaria* species from the Polygonaceae family play an important role as alternative medicines. One of the crucial medicinal plants, polygonum, has anti-viral properties against the herpes simplex type 1 virus and vesicular stomatitis (Table 46).

Primulaceae, Pteridaceae, Punicaceae, Quercaceae, and Quillajaceae A Primulaceae plant, *Anagallis arvesnsis* belongs to this family. It is an annual summer plant that can be found all over the world. Anagallis arvensis has antimycotic, antibiotic, antileishmanial, and anti-viral properties, among others. For both poliovirus and HSV type 1, the anti-viral activity of *Anagallis* arvensis has been mentioned in favor of extract prepared with ethanol (Table 47). *Pteris multifida Poir* (Pteridaceae), a traditional medicinal herb used in Southern Mainland China to treat herpes and respiratory syncytial virus, was found to have anti-viral properties by Li et al. [15].

Punica granatum, also referred to as the pomegranate, is a member of the Punicaceae family and is a native of Central and Western Asia. Pomegranate extracts are effective anti-viral agents against the influenza and herpes viruses. A topical microbiocide for HIV prophylaxis may also be created (Table 47). Punicalagin, the major ellagitannin found in pomegranate fruits, is a herpes simplex virus 1 target and inactivator. Rahman et al. studied the anti-viral activity on *Quercus lusitanica* (Quercaceae) extract against DENV-2 replication [299]. The anti-viral properties of aqueous extracts from the Chilean soapbark tree (Quillaja saponaria Molina) (Quillajaceae) were studied by Roner et al. [300].

Ranunculaceae The Ranunculaceae plant family contains roughly 60 genera and 2200 species, the majority of which are herbs. The chemical composition of

Table 46 List of plants of the family Polygonaceae with anti-viral activity

Polygonaceae	*Albizia anthelmintica*	Aerial parts	HSV-1	[56]
Polygonaceae	*Polygonum chinense.*	Whole plant	H1N1	[293]
Polygonaceae	*Rumex vesicarius*	Aerial parts	HSV-1	[56]
Polygonaceae	*Rheum tanguticum Maxim. ex Balf.*	Root	IV A	[294]
Polygonaceae	*Polygonum equisetiforme*	Leaves	HSV-1	[56]
Polygonaceae	*Polygonum spectabile*	Aerial parts	DEN-2 and VACV-WR HHV-1	[295]
Polygonaceae	*Rumex bequaertii*	Leaves	HIV-1	[19, 20]
Polygonaceae	*Bistorta affinis Greene*	Root	HSV-1 and influenza	[33]
Polygonaceae	*Polygonum minus Huds.*	Leaves	HSV-1 and VSV	[37]
Polygonaceae	*Rheum officinale*	Rhizome	HSV-1	[196]
Polygonaceae	*Polygonum acre H. B. K.*	Whole plant	HSV-l, HSV-2, PV VSV, and AD	[51]
Polygonaceae	*Polygonum cuspidatum Sieb. & Zucc.*	Aerial parts	HSV-1 and VSV	[43]
Polygonaceae	*Homalocladium platycladum (F.Muell.) L.H.Bailey.*	Stem	Chikungunya	[18]
Polygonaceae	*Polygonum punctatum*	Aerial part	HSV	[154]
Polygonaceae	*Adiantum latifolium*	Aerial part	HSV	[154]
Polygonaceae	*Polygonum punctatum*	Aerial part	HSV and RSV	[60]
Polygonaceae	*Rumex obtusifolius ssp. subalpinus*	Whole plant	HSV-1 and PI-3	[125]
Polygonaceae	*Polygonum punctatum*	Aerial parts	HSV-1	[36]
Polygonaceae	*Pleuropterus multiflorus*	Whole plant	HAV	[46]
Polygonaceae	*Polygonum cuspidatum Sieb. et Zucc.*	Root	RSV	[16]
Polygonaceae	*Polygonum multiflorum Thunb.*	Root	RSV	[16]
Polypodiaceae	*Pyrrosia lingua*	Leaves	SARS-CoV.	[161]
Portulacaceae	*Portulaca pilosa L.*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]

Ranunculaceae plants is complex, which has taxonomic consequences. This family's plant systematics, phytochemistry, chemotaxonomy, and anti-viral properties (Table 48) have all been studied extensively. The anti-viral effect of Nigella sativa murine cytomegalovirus (MCMV) model was investigated by administration of seed extract [304].

Table 47 List of plants of the family Primulaceae with anti-viral activity

Primulaceae	*Androsace strigilosa Franch.*	Whole plant	HSV-1 and Influenza	[33]
Primulaceae	*Anagallis arvensis*	Whole plant	HSV-1, ADV-6, vaccinia, VSV, and PV	[296]
Primulaceae	*Primula longipes*	Stem and root	Baculovirus	[297]
Primulaceae	*Lysimachia foenum-graecum Hance*	Whole plant	RSV	[16]
Pteridaceae	*Pteris multifida Poir.*	Whole plant	HSV-1 RSV	[15]
Punicaceae	*Punica granatum*	Peels	HSV-1	[56]
Punicaceae	*Punica granatum L.*	Fruit cortex	HSV-1 RSV	[15]
Punicaceae	*Punica granatum, Linn.*	Fruit juice, peel, and seed oil	HSV-1 and HSV-2	[78]
Punicaceae	*Punica protopunica Balf. f.*	Leaves and fruit	HSV-1 and influenz-A	[17]
Punicaceae	*Punica granatum L,*	Fruit	HSV	[298]
Punicaceae	*punica granatum*	Leaves	HSV-1	[25]
Punicaceae	*Punica granatum L*	Peel and fruit	HSV-1	[55]
Punicaceae	*Punica granatum*	Fruits	MAYV	[262, 263]
Quercaceae	*Quercus lusitanica*	Galls	DENV-2	[299]
Quillajaceae	*Quillaja saponaria Molina*	Aerial parts	HIV-1 and HIV-2 virus	[300]

Table 48 List of plants of the family Ranunculaceae with anti-viral activity

Ranunculaceae	*Thalictrum cultratum Wall.*	Roots and stem	HSV-1 and Influenza	[33]
Ranunculaceae	*Clematis cirrhosa L.*	Leaf, stems, and roots	HSV-1 and HSV-2	[101]
Ranunculaceae	*Coptis chinensis Franch*	Root	HCV	[301]
Ranunculaceae	*Hepatica maxima*	Aerial part	HSV-1 and HSV-2	[30]
Ranunculaceae	*Trollius chinensis Bunge*	Flower	Parainfluenza 3	[302]
Ranunculaceae	*Ranunculus sceleratus*	Whole plant	HBV and HSV	[303]
Ranunculaceae	*Anemone coronaria L.*	Bulb	HSV-1 and VSV	[43]
Ranunculaceae	*Anemone tanguticum*	Aerial parts	HSV-2	[208]
Ranunculaceae	*Paeonia lactiflora*	Root	H1N1	[178]
Ranunculaceae	*Cimicifuga heracleifolia*	Root	HSV-1 and HSV-2	[30]
Ranunculaceae	*Clematis apiifolia*	Aerial part	HSV-1 and HSV-2	[30]
Ranunculaceae	*Nigella sativa*	Seed	H5N1	[304]
Ranunculaceae	*Ranunculus sieboldii*	Whole plant	HBV and HSV	[303]
Ranunculaceae	*Coptis chinensis*	Herb	HIV	[27]
Ranunculaceae	*Swertia chirata*	Leaves and stem	HSV-1	[305]

Rhamnaceae and Rhizophoraceae The Rhamnaceae family, sometimes known as the Buckthorn family, consists of about 50 genera and 900 species of flowering plants, mostly trees, shrubs, some vines, and one herb. There are few studies on the biological activity of chemicals identified from Rhamnaceae. Alkaloids and triterpenes are among the principal members of this family. Particularly pentacyclic triterpenes have a range of biological effects, such as anti-HIV, antitumor, antibacterial, and anti-viral qualities (Table 49).

Rhizophoraceae belongs to the true mangrove family, which contains 21 species in 4 genera. White spot syndrome, HIV-1, and dengue fever were all evaluated in vitro using extracts from different parts of mangroves. *Ceriops tagal* and *Rhizophora apiculata Blume* leaves both showed broad-spectrum anti-viral activity. Plants in the Rhizophoraceae family, in general, are a source of possible anti-viral compounds (Table 49).

Rosaceae There are more than six genera in the Rosaceae family. *Rosa* (Rosaceae family) is a genus of roughly 200 species found all over the world, each with its own set of benefits in medicine and food. Several researchers have focused on flavonoids, triterpenes, tannins, polysaccharides, phenolic acids, fatty acids, organic acids, carotenoids, and vitamins thus far. Anticancer characteristics, liver protection, antibacterial activity, and anti-viral activity (Table 50) are some of the pharmacological effects.

Olenolic acid, a typical triterpene found in several *Rosa* plants, suppressed the replication of HIV-1. Other triterpenes found in the *Rosa* genus have anti-viral efficacy against herpes simplex virus type 1 and HIV-1.

Table 49 List of plants of the family Rhamnaceae and Rhizophoraceae with anti-viral activity

Rhamnaceae	*Rhamnus davurica*	Stem and leaves	HSV-1 and HSV-2	[30]
Rhamnaceae	*Scutia buxifolia Reiss*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Rhamnaceae	*Ventilago denticulata Willd.*	Leaves	HSV-1	[76]
Rhamnaceae	*Rhamnus glandulosa Ait.*	Leaves	HSV-1 and ASFV	[66]
Rhamnaceae	*Ampelozizyphus amazonicus*	Leaves	HSV	[154]
Rhamnaceae	*Scutia buxifolia*	Bark and leaves	HSV-1	[306]
Rhamnaceae	*Ziziphus mucronata (Willd)*	Leaves	PV and ASV	[61]
Rhamnaceae	*Rhamnus frangula*	Bark	HSV-1	[196]
Rhizophoraceae	*Ceriops tagal*	Leaves	WSSV	[307]
Rhizophoraceae	*Rhizophora mangle (mangrove)*	Aerial parts	HIV-1	[308]
Rhizophoraceae	*Rhizophora apiculata*	Whole plant	DENV	[183]
Rhizophoraceae	*Rhizophora apiculata Blume*	Leaves	HIV	[309]

Table 50 List of plants of the family Rosaceae with anti-viral activity

Rosaceae	*Rubus idaeus*	Fruits	PV-1 and coxsackievirus B1 (CV-B1)	[174]
Rosaceae	*Fragaria vesca*	Fruit	PV	[31]
Rosaceae	*Prunus dulcis Miller D. A.*	Almond skin	HSV-1	[310]
Rosaceae	*Malus domestica*	Fruit	PV	[31]
Rosaceae	*Rubus imperialis*	Leaves	HSV-1 and rabies	[71]
Rosaceae	*Amelanchier alnifolia*	Whole plant	Corona virus	[147]
Rosaceae	*Potentifla arguta*	Whole plant	RSV	[147]
Rosaceae	*Sanguisorba minor magnolii*	Aerial parts	HSV-1 and VSV	[157]
Rosaceae	*Aronia melanocarpa*	Leaves	Norovirus	[226]
Rosaceae	*Aronia melanocarpa*	Fruit	Norovirus	[226]
Rosaceae	*Margyricarpus pinnatus*	Aerial parts	HSV-1	[36]
Rosaceae	*Cotoneaster integrifolius (Roxb.) Klotz*	Fruits	HSV-1 and influenza	[33]
Rosaceae	*Rosa macrophylla Lindl.*	Flower	HSV-1 and influenza	[33]
Rosaceae	*Fragaria vesca*	Fruits	PV-1, coxsackievirus B1 (CV-B1)	[174]
Rosaceae	*Potentilla cryptotaeniae*	Whole plant	HSV-1 and HSV-2	[30]
Rosaceae	*Pyrus calleryana var. fauriei*	Stem	HSV-1 and HSV-2	[30]
Rosaceae	*Rubus urticifolius Poiret*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Rosaceae	*Alchemilla vulgaris L*	Aerial parts and roots	Orthopoxviruses	[311]
Rosaceae	*Crataegus azarolus L.*	Leaves	HSV-1	[55]
Rosaceae	*Agrimonia pilosa*	Whole plant	H1N1 and H3N2	[312]
Rosaceae	*Prunus persica*	Fruit	PV	[31]
Rosaceae	*Prunus domestica*	Fruit	PV	[31]
Rosaceae	*Rubus idoeus*	Fruit	PV	[31]
Rosaceae	*Agrimonia pilosa*	Whole plant	HAV	[46]
Rosaceae	*Agrimonia pilosa Ledeb. var. japonica (Miq.) Nakai*	Whole plant	HSV-1 RSV	[15]
Rosaceae	*Rhaphiolepsis Indica Lindl.*	Leaves	HIV-1	[91]
Rosaceae	*Prunus armeniaca L.*	Seed	RSV	[16]
Rosaceae	*Agrimonia pilosa Ledeb*	Whole plant	H1N1 and HV A-B	[312]
Rosaceae	*Rubus eubatus cv. "Hull"*	Seed	HSV-1	[313]
Rosaceae	*Filipendula ulmaria Maxim.*	Whole plant	HSV-1 and VSV	[43]
Rosaceae	*Fragaria virginiana Duchesne*	Whole plant	HSV-1 and VSV	[43]
Rosaceae	*Geum triflorum Pursh.*	Aerial parts	HSV-1 and VSV	[43]
Rosaceae	*Waldsteinia fragarioides Tratt.*	Whole plant	HSV-1 and VSV	[43]
Rosaceae	*Rosa damascena*	Leaves	Adenoviruses	[210]
Rosaceae	*Sanguisorba minor magnolii*	Aerial parts	HIV-1	[151]
Rosaceae	*Crataegus crus-galli*	Fruit	AIV	[148]
Rosaceae	*Fragaria vesca*	Fruit	AIV	[148]

Rubiaceae The Rubiaceae family is part of the Gentianales, the fourth biggest angiosperm family. Many plants, including iridoids, triterpenes, anthraquinones, flavonoids, indole alkaloids, and other phenolic derivatives, can be employed as therapeutic plants since they contain a significant variety of bioactive chemicals. *Uncaria, Psychotria, Hedyotis, Ophiorrhiza,* and *Morinda* are the most common genera from which these chemicals have been isolated. Anti-viral, immunostimulatory, and antibacterial characteristics are characterized in pharmacological research. It was discovered that the quinovic acid glycoside from *Uncaria tomentosa* had anti-rhinovirus type 1B activity. Asperuloside is a secondary metabolite that belongs to the iridoid glycoside family and is found in the Rubiaceae plant family. Asperuloside's biological and pharmacological effects have been studied in vitro and in vivo in several investigations. Plant extracts containing asperuloside have been found to inhibit viral infections (Table 51).

Rutaceae Citrus plants belong to the Rutaceae family, and the most frequent members of this family include orange, lime, mandarin, sour orange, lemon, and grapefruit, all of which contain several useful elements that humans ingest. It is well known that plants of the Rutaceae family have contributed significantly to both food and medicine. Flavonoids are the family's most significant metabolites. Flavonoids have been identified and researched for a variety of bioactivities, including anticancer, antibacterial, anti-viral (Table 52), analgesic, and more. Family Rutaceae is a plant that has been widely reported to have acted as an anti-viral hepatitis C. Several studies have reported that family Rutaceae has activity as an anti-hepatic virus C among others like *Melicope latifolia* and *Ruta angustifolia.*

Santalaceae and Sapindaceae The Santalaceae family includes the sandal tree, also known as *Santalum album L*. The santalols are the fragrant substances found in sandalwood oil. The essential oil of *Santalum album L*, sandalwood oil, was investigated for its in vitro anti-viral activity against herpes simplex viruses-1 and 2. Mistletoe (*Viscum album ssp. album*) extracts are tested by Karagöz for their anti-viral effectiveness against human parainfluenza virus type 2 in Vero cells [321]. Both the anti-influenza activity of santalol and an in vitro experiment showing inhibition of herpes simplex virus type 2 were investigated. Sandalwood oil's anti-viral effectiveness was demonstrated by Benencia et al. [322] who found that it inhibited herpes simplex virus type 1 and type 2 copies (Table 53). By preventing ERK phosphorylation, the low molecular weight polyphenol oligonol, which is derived from lychee fruit, possesses anti-influenza activities [324]. Different other extracts of the plant belonging to Sapindaceae were studied for anti-viral activity against different viral strains viz herpes, polio, HIV, and hepatitis (Table 53).

Sapotaceae, Saururaceae, Schizaceae, and Scrophulariaceae Sapotaceae is one of the latex-yielding families, known for the production of *Gutta percha*, chicle (chewing) gum, timber, edible flowers, fruits, and oilseeds. Various species from Sapotaceae have been studied for anti-viral activity (Table 54). Ethanol extract from *Vitellaria paradoxa* (Sapotaceae) inhibited 50% of human poliovirus (type 1) and

Table 51 List of plants of the family Rubiaceae with anti-viral activity

Rubiaceae	*Asperula glomerata*	Leaves	HSV-1	[69]
Rubiaceae	*Pavetta Owariensis*	Bark	HSV and coxsackie	[314]
Rubiaceae	*Mitragyna inermis*	Leaves	PV, HRV-2, and HSV	[67]
Rubiaceae	*Heterophyllaea pustulata Hook f.*	Aerial parts	SLEV and HSV-1	[315]
Rubiaceae	*Hedyotis auricularia L.*	Leaves	HSV-1	[37]
Rubiaceae	*Morinda elliptica Ridl.*	Leaves	VSV	[37]
Rubiaceae	*Chiococca alba (L.) Hitch.*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Rubiaceae	*Richardia brasiliensis Gomes*	Root	HSV-l, HSV-2, PV VSV, and AD	[51]
Rubiaceae	*Rubia cordifolia*	Aerial parts	Rotavirus	[316]
Rubiaceae	*Mitracarpus villosus (Sw.)*	Leaves	Herpes simplex, Sindbis, and polio	[111]
Rubiaceae	*Mitracarpus villosus (Sw.) DC.*	Leaves	HSV and PV	[123]
Rubiaceae	*Mussaenda pubescens Ait. f.*	Whole plant	HSV-1 RSV	[15]
Rubiaceae	*Morinda Citrofolia Chev.*	Fruit	HIV-1 and HCV	[91]
Rubiaceae	*Psychotria Hawaiiensis Gray*	Bark and leaves	HIV-1	[91]
Rubiaceae	*Uncaria tomentosa*	Bark	VSV and HRV1B	[317]
Rubiaceae	*Guettarda platypoda*	Bark	VSV and HRV1B	[317]
Rubiaceae	*Gardenia ternifolia Schumach.*	Root	HSV-1 and ASFV	[66]
Rubiaceae	*Pavetta oblongifolia (Hiern) Bremek.*	Root and aerial part	HSV-1 and ASFV	[66]
Rubiaceae	*Sarcocephalus latifolius (Smith) Bruce*	Root	HSV-1 and ASFV	[66]
Rubiaceae	*Diodella sarmentosa (Sw.) Bacigalupo & Cabral ex Borhidi*	Leaves and stem	Chikungunya	[18]
Rubiaceae	*Mussaenda elmeri*	Whole plant	H3N1 and H1N1	[62]
Rubiaceae	*Alseis blackiana*	Leaves	HSV-1, HSV-2, and VSV	[143]
Rubiaceae	*Duroia hirsuta*	Leaves	HSV	[154]
Rubiaceae	*Pavetta ternifolia*	Leaves and root	HSV and Cox V	[19, 20]
Rubiaceae	*Virectaria major*	Leaves	Cox V, measles, and VSV	[19, 20]
Rubiaceae	*Ixora coccinea L*	Leaves	Echoviruses	[44]
Rubiaceae	*Hedyotis capitellata Wall. ex G. Don*	Stem and leaves	PEDV	[47]
Rubiaceae	*Hedyotis auricularia*	Leaves	DENV2	[21]
Rubiaceae	*Gardenia jasminoides Ellis*	Root	RSV	[16]
Rubiaceae	*Coffea arabica L.*	Seed	HSV	[318]
Rubiaceae	*Myonima violacea*	Leaves	PV and HRV-2	[67]

Table 52 List of plants of the family Rutaceae with anti-viral activity

Rutaceae	*Citrus limon*	Aerial parts	DENV-1	[26]
Rutaceae	*Zanthoxylum zanthoxyloides*	Root and bark	Herpes simplex, Sindbis, and polio	[111]
Rutaceae	*Melicope latifolia (DC.) T.G. Hartley*	Leaves	HCV	[181])
Rutaceae	*Poncirus trifoliata*	Seed	Influenza	[319]
Rutaceae	*Zanthoxylum zanthoxyloides (Lam.)*	Root and bark	HSV	[123]
Rutaceae	*Clausena lansium (Lour.) Skeels*	Leaves	HSV-1 RSV	[15]
Rutaceae	*Evodia lepta (Spreng) Merr.*	Root	HSV-1 RSV	[15]
Rutaceae	*Clausena excavata Burm.*	Leaves	HSV-1	[76]
Rutaceae	*Citrus hystrix*	Leaves	HSV-1 and PV	[34]
Rutaceae	*Zanthoxylum chalybeum*	Seed	Measles virus	[146]
Rutaceae	*Citrus bergamia (BSext)*	Seed	HTLV-1	[320]

Table 53 List of plants of the family Santalaceae and Sapindaceae with anti-viral activity

Santalaceae	*Viscum album ssp. Album*	Leaves	HPIV-2	[321]
Santalaceae	*Iodina rhombifolia Hook et Am.*	Leaves	HSV-l , HSV-2, PV VSV, and AD	[51]
Santalaceae	*Santalum album L.*	Wood	HSV-1 and HSV-2	[322]
Sapindaceae	*Zanha Africana*	Root	PV and HRV-2	[67]
Sapindaceae	*Dodonaea angustifolia L.f.*	Leaves	HIV-1 and HIV-2	[10]
Sapindaceae	*Allophyllus edulis (St. Hil.) Radkl*	Whole plant	HSV-l , HSV-2, PV VSV, and AD	[51]
Sapindaceae	*Paullinia pinnata L.*	Whole plant	Herpes simplex, Sindbis, and polio	[111]
Sapindaceae	*Harpullia arborea (Blanco) Radlk.*	Leaves	HSV-1	[76]
Sapindaceae	*Paullinia pinnata L.*	Whole	HSV	[123]
Sapindaceae	*Cardiospermum Halicacabum L.*	Leaves	HIV and HBV	[323]
Sapindaceae	*Litchi chinensis*	Fruit	Influenza	[324]

astrovirus. The extract, on the other hand, proved ineffective against human herpes simplex type 1 virus, canine parvovirus, bovine parvovirus, and horse herpes simplex virus [61]. *Mimusops elengi Linn*. (Sapotaceae), an Indian native tree, has a long history of use in traditional medicine. The triterpenes and triterpene glycosides are the main chemicals of interest in this plant. Mimusopic acid, a triterpene with a new migrating oleanane skeleton called mimusopane, has anti-HIV [325] activity, and its modification could lead to more potent bioactive compounds. Benassi-Zanqueta et al. study the anti-viral activity of *Houttuynia cordata* against herpes, HIV, and influenza viruses [326]. Activity against dengue viral also has been

Table 54 List of plants of family Santalaceae and Sapindaceae with anti-viral activity

Sapotaceae	*Labourdonnaisia glauca*	Leaves	PV and HRV-2	[67]
Sapotaceae	*Sideroxylon puberulum*	Leaves	PV and HRV-2	[67]
Sapotaceae	*Crysophyllum marginatum aguai-vermelho*	Leaves and stem	HSV-l, HSV-2, PV VSV, and AD	[51]
Sapotaceae	*Manilkara zapota (L.) P. Royen*	Fruit	Chikungunya	[18]
Sapotaceae	*Butyrospermum parkii L.*	Bark	PV and ASV	[61]
Sapotaceae	*Vitellaria paradoxa Gaertn*	Herb	Polio virus	[61]
Sapotaceae	*Pouteria viridis*	Leaves	HIV	[14]
Sapotaceae	*Mimusops elengi L*	Bark	HIV	[325]
Saururaceae	*Houttuynia cordata*	Aerial parts	HSV-1, IV, and HIV-1	[326]
Saururaceae	*Houttuynia cordata*	Whole plant	DENV	[183]
Schizaceae	*Anemia tomentosa*	Leaves	Herpes suis virus	[124]
Scrophulariaceae	*Lagotis brevituba*	Aerial parts	HSV-2	[208]
Scrophulariaceae	*Digitalis lamarckii*	Whole plant	HSV-1 and PI-3	[125]
Scrophulariaceae	*Scrophularia buergeriana*	Root	HSV-1 and HSV-2	[30]
Scrophulariaceae	*Scrophularia koraiensis*	Underground	HSV-1 and HSV-2	[30]
Scrophulariaceae	*Eremophila latrobei subsp. glabra*	Stem	CMV and RRV	[121]

studied by Klawikkan and coworkers [183]. *Anemia tomentosa* (Saururaceae) leaf extract has been shown by Zanon et al. to have anti-herpes action [124].

Scrophulariaceae contain a considerable number of medicinal plants. *Eremophila* (Scrophulariaceae), sometimes known as Fuchsia bush, Emu bush, or Poverty bush, is an indigenous Australian genus with 214 species. Anti-viral activity of different species (*Lagotis brevituba, Digitalis lamarckii, Scrophularia buergeriana, Scrophularia koraiensis,* and *Eremophila latrobei subsp. glabra*) from Scrophulariaceae were studied by the various researcher (Table 54).

Selaginellaceae, Simaroubaceae, Simmondsiaceae, and Smilacaceae The Selaginellaceae family, which the genus *Selaginella* belongs to, is renowned for the wide range of biological effects and distinctive structural classes of its natural products. Selaginellaceae extracts from *Selaginella sinensis* (Desv.) Spring and *Selaginella tamariscina* (Beauv.) Spr. were tested by Ma et al. for their ability to combat the respiratory syncytial virus [16]. The Simaroubaceae family contains 32 genera and around 170 trees and brush species with a pantropical range. The presence of quassinoids, secondary metabolites responsible for a wide range of biological actions including anticancer, antimalarial, anti-viral, insecticide, amebicide, antiparasitic, and herbicidal, distinguishes this family. Some quassinoids have anti-viral action in vitro at high concentrations. Yarmolinsky and coworkers

Table 55 List of plants of the family Selaginellaceae, Simaroubaceae, Simmondsiaceae, and Smilacaceae with anti-viral activity

Compositae	*Tanacetum parthenium*	Aerial part	HSV-1	[327]
Selaginellaceae	*Selaginella sinensis (Desv.) Spring*	Whole plant	RSV	[16]
Selaginellaceae	*Selaginella tamariscina (Beauv.) Spr.*	Whole plant	RSV	[16]
Simaroubaceae	*Selaginella moellendorffii*	Whole herbs	CVB3	[328]
Simaroubaceae	*Eurycoma longifolia*	Root	Dengue virus	[329]
Simaroubaceae	*Ailanthus triphysa (Dennst.) Alston*	Leaves	Chikungunya	[18]
Simarubaceae	*Harrisonia abyssinica Oliv.*	Leaves	Herpes simplex, Sindbis, and polio	[111]
Simarubaceae	*Harrisonia abyssinica*	Leaves	HSV	[123]
Simmondsiaceae	*Simmondsia chinensis*	Leaves	HSV-1 and HSV-2	[156]
Smilacaceae	*Smilax sieboldii var. inermis*	Stem	HSV-1 and HSV-2	[30]

investigated the anti-herpes activity of leaves extract of *Simmondsia chinensis* (Simmondsiaceae) [156] (Table 55).

Solanaceae There are more than 2000 species in the Solanaceae family of plants, shrubs, and herbs, which has 90 genera. The Solanaceae family is well known for having a wide variety of alkaloids. *Solanum, Atropa, Capsicum, Datura, Withania, Hyoscymus, Nicotiana, and Miscellaneous* are the genera that contain medicinally significant species of the Solanaceae family. Various nations have long employed *Solanum* species as anti-herpes and anticancer medications. Numerous ethnomedical uses of *Solanum paniculatum* are practiced in Brazil, including the management of viral illnesses (Table 56).

HSV-1 replication was suppressed by *Solanum paniculatum* leaves extract [330]. Chikungunya, herpes simplex virus (HSV), human papillomavirus (HPV), parainfluenza-3, hemagglutinin type 1, and neuraminidase type 1 are some of the viruses that cause chikungunya. *Withania somnifera* phytochemicals have been shown to be effective against the SARS-CoV and SARS-CoV-2 viruses as well as the hepatitis C virus [10].

Staphyleaceae, Sterculiaceae, Styracaceae, Tamaricaceae, Theaceae, Thymelaeaceae, Tiliaceae, and Tropaeolaceae The Sterculiaceae is one of the most significant families of flowering plants. Its members have been used to treat a variety of diseases and wounds since many of them have therapeutic characteristics. It has been discovered that different extracts and isolated compounds from this family exhibit a variety of biological effects, including antibacterial and anti-viral properties [61, 132]. Woo and colleagues tested the anti-herpes activity of *Staphylea*

Table 56 List of plants of the family Solanaceae with anti-viral activity

Solanaceae	*Solanum paniculatum*	Leaves	HSV-1	[330]
Solanaceae	*Withania somnifera (L.)*	Root	HIV-1 and HIV-2	[10]
Solanaceae	*Hyoscyamus niger var. agrestis (Kit.) Beck*	Flower	HSV-1 and Influenza	[33]
Solanaceae	*Solanum americanum Mill.*	Leaves	HSV-1	[37]
Solanaceae	*Capsicum annuum*	Dried fruits	HSV-1 and HSV-2	[331]
Solanaceae	*Datura suaveolens Humb.*	Leaves and stem	HSV-l, HSV-2, PV VSV, and AD	[51]
Solanaceae	*Solanum fastigiatum Willd.*	Whole plant	HSV-l, HSV-2, PV VSV, and AD	[51]
Solanaceae	*Solanum granuloso-leprosum Dunal*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Solanaceae	*Solanum sisymbrifolium Lam.*	Leaves	HSV-l, HSV-2, PV VSV, and AD	[51]
Solanaceae	*Withania somnifera*	Root	HSV-1	[94]
Solanaceae	*Solanum nigrum*	Seed	HCV	[332, 333]
Solanaceae	*Solanum Niger L.*	Leaves and stem	HIV-1	[91]
Solanaceae	*Withania adunensis Vierh.*	Leaves and fruit	HSV-1 and influenz-A	[17]
Solanaceae	*Withania riebeckii Schweinf. ex Balf. f.*	Leaves and fruit	HSV-1 and influenz-A	[17]
Solanaceae	*Solanum nigrum*	Fruit	AIV	[148]
Solanaceae	*Datura metel*	Leaves	HSV-1	[25]
Solanaceae	*Datura metel*	Leaves	HSV-1	[25]
Solanaceae	*Nicotiana glauca*	Leaves	HSV-1	[25]
Solanaceae	*Petunia hybrida*	Leaves	HSV-1	[25]
Solanaceae	*Solanum nigrum*	Leaves	HSV-1	[25]
Solanaceae	*Withania somnifera*	Leaves	HSV-1	[25]
Solanaceae	*Withania somnifera*	Leaves	HSV-1	[25]

bumalda (Staphyleaceae) stem extract [30]. *Staphylea bumalda* (Staphyleaceae) and *Schima wallichi* (DC.) Korth. (Theaceae), two Thai medicinal plants, were examined by Lipipun and colleagues for their anti-herpes activity against herpes virus type 1 [76]. Simes and coworkers tested the anti-viral activity of *Styrax leprosus Hook et Arn.* (Styracaceae) stem extract against herpes type 1 and 2, polio, adeno, and vesicular stomatitis virus [51]. Moradi and coworkers tested the anti-herpes activity of *Camellia sinensis (L.) Kuntze* (Theaceae) leaf extract against herpes virus type 1 [55]. El-Toumy and coworkers tested the anti-herpes activity of *Tamarix aphylla* (Tamaricaceae) extract against herpes type 1 virus [56].

Umbelliferae Despite having a range of pharmacological properties, including antibacterial and anticancer properties, plants in the Umbelliferae family lack information on their anti-viral activity (Table 57). *Coriandrum sativum* L., a member of

Table 57 List of plants of the family Umbelliferae with anti-viral activity

Umbelliferae	*Lomatium dissectrun*	Root	Rotavirus	[147]
Umbelliferae	*Heteromorpha trifoliata*	Root bark	PV and HRV-2	[67]
Umbelliferae	*Steganotaenia araliacea*	Root	PV and HRV-2	[67]
Umbelliferae	*Coriandrum sativum L.*	Fruit	HIV-1 and HIV-2	[10]
Umbelliferae	*Daucus maritimus*	Seed	Dengue, West Nile, HCV, and HIV	[68]
Umbelliferae	*Centella asiatica (L.)*	Leaves	VSV and HIV	[37, 334]
Umbelliferae	*Oenanthe javanica DC.*	Leaves	VSV	[37]
Umbelliferae	*Angelica tenuissima*	Root	HSV-1 and HSV-2	[30]
Umbelliferae	*Eryngium horridum Malme*	Aerial part	HSV-l, HSV-2, PV VSV, and AD	[51]
Umbelliferae	*Eryngium pandanifolium caraguata*	Aerial part	HSV-l, HSV-2, PV VSV, and AD	[51]
Umbelliferae	*Centella asiatica*	Aerial part	HSV-1 and HSV-2	[30]
Umbelliferae	*Angelica archangelica*	Leaves and root	IBV	[112]
Umbelliferae	*Coriandrum sativum*	Whole plant	HAV	[46]
Umbelliferae	*Torilis japonica*	Whole plant	HAV	[46]
Umbelliferae	*Foeniculum vulgare*	Seed	H5N1	[304]
Umbelliferae	*Angelica dahurica (Fisch. Ex Hoffm.)*	Root	RSV	[16]
Umbelliferae	*Bupleurum chinense*	Root	RSV	[16]
Umbelliferae	*Sanicula europaea L.*	Leaves	H1N1	[335]
Umbelliferae	*Daucus carota*	Roots and leaves	HSV-1	[336]
Umbelliferae	*Hydrocotyle bonartensts*	Leaves and branch	Herpes suis virus	[124]

the Umbelliferae family, is one of the most important essential oil–bearing spices and medicinal plants. The anti-HIV efficacy of *Coriandrum sativum* seeds extract was investigated [10]. The plant parts of *Angelica*, which belongs to the Umbelliferae family, are mostly used for medical purposes. Flavanones chalcones, flavanones, coumarins, acetylenes, sesquiterpene, and terpenes are bioactive components of this genus. It is known to have anti-viral, antibacterial, and hepatoprotective properties [16, 30, 112].

Urticaceae, Usneaceae, and Valerianaceae Due to its numerous phytoconstituents and beneficial medical uses, the family Urticaceae has great biological significance to angiosperms. Triterpenes, flavonoids, sterols, sesquiterpenes, alkaloids, lignans, simple phenolic compounds, and other main constituents isolated from Urticaceae species are in charge of its biological activities, which include cytotoxicity, antimicrobial (anti-viral [Table 58], antibacterial, and antifungal), as well as wound healing.

Table 58 List of plants of the family Urticaceae, Usneaceae, and Valerianaceae with anti-viral activity

Urticaceae	*Pipturus Albidus Gray*	Bark and leaves	HIV-1	[91]
Urticaceae	*Obetia ficifolia*	Leaves	HSV-1 and PV	[34]
Urticaceae	*Melochia umbellata (Houtt) Stapf var. Visenia*	Stem and bark	DENV	[337]
Urticaceae	*Urtica dioica L.,*	Root	AIDS	[150]
Urticaceae	*Parietaria diffusa M. et K*	Root	AIDS	[150]
Urticaceae	*Urtica dioica L.*	Root	Rotavirus	[201]
Usneaceae	*Usnea complanta*	Whole plant	HSV-1	[93]
Usneacese	*Usnea barbata*	Whole plant	Herpes suis virus	[124]
Valerianaceae	*Valeriana jatamansi Jones*	Roots	HSV-1 and influenza	[33]

Nineteen species of *Usnea* have been identified as valuable folk remedies around the world. The genus *Usnea* has been utilized for numerous purposes for millennia, as evidenced by the comparative study of the sought literature, and its lengthy and traditional medicinal history has been well documented in the past. Usnic acid, polyphenols, and depsides have been identified as the primary effective components for biological activities. In addition, the pharmacological study demonstrated that additional *Usnea* species pure chemicals and crude extracts are potent anti-viral agents (Table 58).

Verbenaceae The *Lippia* genus (Verbenaceae) produces a large number of metabolites, some of which have been demonstrated to have biological value. Triterpenoids, phenols, flavonoids, phenylpropanoids, and steroids, among other compounds, have been found in this species according to numerous phytochemical studies [44, 66, 88, 124]. According to the literature, *Duranta repens L.* has been associated with a variety of medicinal characteristics. The entire plant is used to treat pneumonia and malaria, and as an anthelmintic. *D. repens* also has anti-shigellosis, anti-viral [25], antibacterial, and antimicrobial properties against human diseases. Other plants in the Verbenaceae family have also been investigated for their potential anti-viral properties against viruses such herpes, HIV, VSV, adenovirus, influenza, echovirus, molluscum contagiosum, human respiratory syncytial, and bovine viral diarrhea (Table 59).

Violaceae and Vitaceae In traditional medicine, an essential medicinal herb from the Violaceae family has been utilized for a variety of therapeutic purposes, including the treatment of bruises and ulcers as well as blood cleansing. It is also advised for use against cancer problems in the Chinese system of medicine. Herpes simplex virus types 1 and 2 replication is inhibited by an extract from *Cayratia japonica*

Table 59 List of plants of the family Verbenaceae with anti-viral activity

Verbenaceae	*Lippia alba*	Leaves	HSV-1	[88]
Verbenaceae	*Vitex pubescens Vahl.*	Leaves and bark	HSV-1 and polio virus	[220]
Verbenaceae	*Clerodendron discolour (Kolotzsch) Vatke*	Leaves	HIV-1 and HIV-2	[10]
Verbenaceae	*Verbena of®cinalis L.*	Arial part and root	HIV-1 and HIV-2	[10]
Verbenaceae	*Premna odorata Blanco*	Leaves	VSV	[37]
Verbenaceae	*Stachytarpheta cayennensis L. C. Rich.)*	Aerial part	HSV-l, HSV-2, PV VSV, and AD	[51]
Verbenaceae	*Aloysia gratissima (Gill. & Hook.)*	Whole plant	HSV-l	[83]
Verbenaceae	*Vitex trifolia L.*	Aerial parts	HSV and MCV	[92]
Verbenaceae	*Clerodendrum inerme (L.) Gaertn*	Aerial parts	HSV and MCV	[92]
Verbenaceae	*Clerodendrum glabrum E. Mey. var. glabrum*	Leaves	H1N1	[77]
Verbenaceae	*Aloysia gratissima*	Flower	Herpes suis virus	[124]
Verbenaceae	*Lippia turbinata*	Leaves and branch	Herpes suis virus	[124]
Verbenaceae	*Verbascum thapsus*	Leaves and branch	Herpes suis virus	[124]
Verbenaceae	*Lippia chevalieri Moldenke*	Aerial parts and root	HSV-1 and ASFV	[66]
Verbenaceae	*Lippia multiflora Moldenke*	Leaves	Echovirus	[44]
Verbenaceae	*Duranta plumier*	Leaves	HSV-1	[25]
Verbenaceae	Duranta repens L.	Leaves	HSV-1	[25]
Verbenaceae	*Lippia graveolens*	Leaves	ACVR-HHV-1, HRSV, BoHV-2, and BVDV	[338]

(Vitaceae) by inhibiting an early step in the virus replication cycle [30]. The therapeutic index (T1) values of the ethyl acetate and n-butanol extracts of *Tetrastigma hemsleyanum* (Vitaceae) against the respiratory syncytial virus were found to be 128 and 64, respectively. *Tetrastigma hemsleyanum* extracts (petroleum ether, ethyl acetate, dichloromethane, and n-butanol extracts) inhibited the hepatitis B virus (HBV) by lowering HbsAg and HbeAg secretion. By lowering exogenous virus damage to cells, boosting spleen T cell proliferation, and NK cell killing activity, an alcohol extract from the root tuber of *Tetrastigma hemsleyanum* may increase the chance that influenza A H1N1-infected mice will survive [341]. Several other plant species from Violaceae and Vitaceae family were studied for their anti-viral activities against herpes, HIV, VSV, influenz-A, SARS-CoV-2, influenza, Zika, and hepatitis viruses (Table 60).

Table 60 List of plants of family Violaceaea and Vitaceae with anti-viral activity

Violaceae	*Rinorea anguifera (Lour) Kuntze*	Leaves	HSV-1	[76]
Violaceae	*Viola yedoensis Makino*	Whole plant	RSV	[16]
Violaceae	*Hybanthus prunifolius*	Leaves	HSV-1, HSV-2, and VSV	[143]
Violaceae	*Viola tricolor*	Leaves	HSV-1	[25]
Violaceae	*Viola yedoensis*	Herb	HIV	[27]
Vitaceae	*Cissus erosa*	Stem and leaves	DENV and Zika virus	[339]
Vitaceae	*Vitis vinifera*	Fruit	PV	[31]
Vitaceae	*Cissus hamaderohensis Radclife-Smitha*	Leaves	HSV-1 and influenz-A	[17]
Vitaceae	*Vitis vinifera*	Leaves	HSV-1	[25]
Vitaceae	*Vitis vinifera*	Leaves	HSV-1	[25]
Vitaceae	*Cayratia japonica*	Arial part	HSV-1 and HSV-2	[30]
Vitaceae	*Vitis vinifera*	Fruit	HAV	[46]
Vitaceae	*Vitis vinifera*	Leaves	SARS-CoV-2 and HSV-1	[340]
Vitaceae	*Tetrastigrna hypoglaucum*		RSV	[341]

Zingiberaceae *Curcuma longa, Aframomum melegueta*, and *Zingiber officinale* are Zingiberaceae plants that have a variety of biological functions, including anti-viral activity. According to the result of various studies, these edible plants have anti-viral properties against a variety of viruses, including rhinovirus, hepatitis B and C, HSV type 1 and 2, HIV, enterovirus 71, ebola, HCV, chikungunya, Epstein-Barr virus, Japanese encephalitis virus, RSV, fish VHSV, influenza, coronavirus SARSCoV-1, and others (Table 61).

Zygophyllaceae The alkaloids come from *Peganum harmala* (Zygophyllaceae), a plant used as an emmenagogue and alimentary tract medication that can also cause hallucinations. However, their anti-viral activities [127, 345] have recently attracted more attention than their known CNS activity. Ben Sassi et al. [32] discovered that *Zygophyllum album* L. (Zyphyllaceae) has strong anti-viral activity, which they attribute to the presence of triterpenoid saponin. Zygophyllum album extract provided full cell protection against HSV-1 in anti-viral trials [32]. Various extracts *of Zygophyllum quatarense, Peganum harmala, Fagonia luntii Baker,* and *Urtica dioica* were also investigated for their anti-viral properties against influenz-A and herpes types 1 and 2 [17, 55]. Although medicinal plants have been used all throughout the world, they have only been widely employed in China, India, Japan, Pakistan, Sri Lanka, Thailand, and a few African nations. National initiatives worldwide that are important to the priorities for using medicinal plants have already been explained in detail. A growing number of developed nations are promoting the use of natural medicines derived from plants in their health care systems [346].

Table 61 List of plants of family Zingiberaceae with anti-viral activity

Zingiberaceae	*Curcumin longa Lin*	Rhizome	HBV and liver cancer	[166]
Zingiberaceae	*Curcuma longa Linn,*	Rhizome	PRRS virus	[342]
Zingiberaceae	*Costus speciosus (Koenig) Smith*	Leaves	HSV-1 and VSV	[37]
Zingiberaceae	*Curcuma longa*	Rhizomes	SARS-CoV-2	[140]
Zingiberaceae	*Curcuma longa*	Roots	HSV-1	[56]
Zingiberaceae	*Alpinia katsumadai*	Seed	Rotaviruses	[343]
Zingiberaceae	*Alpinia katsumadai*	Seed	H1N1	[344]
Zingiberaceae	*Curcuma longa, Linn.*	Rhizomes	HSV-1 and HSV-2	[78]
Zingiberaceae	*Curcuma longa L.*	Rhizome	Chikungunya	[18]
Zingiberaceae	*Zingiber officcinale*	Rhizomes	H5N1	[304]
Zingiberaceae	*Zingiber officinale. Roscoe*	Rhizomes	HIV	[155]

5 Medicinal Plants in Emerging Viral Infections

A serious threat to humankind is posed by newly emerging viral diseases. The anti-viral discovery initiatives for this virus could include medicinal plants with widespread anti-viral properties. One such example is the bioactive ingredient in liquorice, glycyrrhizin (*G. uralensis Fisch*), and lycorine (*L. radiata L.,* Amaryllidaceae), which was previously employed for various purposes but demonstrated potent anti-SARS-CoV action. When tested against recently discovered/resistant virus strains, some plants were found to have broad-spectrum anti-viral effects.

Plant-derived medicines have been used for ages to treat a variety of ailments. Natural materials have been investigated for anti-infective and, more especially, anti-viral activity throughout the past few decades. The protective impact of naturally occurring chemicals produced from plants against viral infection is highly supported by basic research in experimental models using a variety of biological systems. Even though hundreds of plant species have been tested as potential novel anti-viral medicines, more research is still required because viral diseases are quickly growing to be a greater hazard to humanity. The projection of medicinal plants as potential alternatives to traditional sources of anti-viral medicines is growing in this regard. Unfortunately, a lot of the anti-viral substances that are now being used in clinical settings have variable toxicity, a limited therapeutic use, and a narrow spectrum of activity. The identification of a broad-spectrum plant-based anti-viral in combination with a delivery method that ensures its stability and bioavailability will determine whether natural anti-virals will become a viable alternative medicine or a synergistic combination therapy with already-existing anti-viral therapy [347].

Perhaps primarily on historical and anecdotal grounds, medicinal herbs have been used to cure viral infections. The three main traditional medical systems in India-Ayurvedic, Siddha, and Unani-all have established protocols for treating

clinical jaundice. One or more dried plant extracts are administered orally as tablets or capsules as part of these treatments. Plant extracts have been utilized for the same purpose by numerous other cultures throughout the world. Extracts from the genus *Phyllanthus* in the family Euphorbiaceae make up the majority of the components in Indian medicine. The plants have long been used in folk medicine to treat conditions including diabetes, renal and urinary bladder problems, intestinal illnesses, as well as viral, bacterial, and parasite infections. They are extensively distributed in the majority of tropical and subtropical nations. According to conventional medical concepts, a variety of medicinal plants and herbs are frequently given in composite formulations as a method of neutralizing or lowering the toxicity of harmful herbs. The medicinal benefits of various plant assemblages can differ. Although medicinal plant preparations are frequently utilized singly or in combination in many regions of the world, information regarding how medicinal plants interact with biological systems is lacking. It is the unique instance of an indigenous group using a specific plant or phytochemical to treat a condition. Although most people believe that herbal medicines are safe, there have been reports of hepatotoxicity linked to them [348].

Even if some viral infections can be controlled with life-extending medications today, they are nonetheless lethal. The majority of developing nations still lack the financial resources to afford these pricy anti-viral medications. Given that many viruses are still incurable and have high death rates, including as HIV and hepatitis, the development of safe, efficient, and affordable anti-viral medicines that operate as RT inhibitors is arguably one of the top global goals in drug research.

The Boots drug company in England began looking for plant-based anti-virals in 1952 and discovered that 12 plant extracts may prevent the influenza A virus from amplifying. Numerous global screening initiatives have been carried out over the past 50 years to assess the in vitro and in vivo anti-viral activities of thousands of ethnomedicinal plants. Grape, apple, and strawberry juices were found to have anti-viral properties against HSV, poliovirus 1, coxsackievirus B5, and echovirus 7, according to Canadian researchers. While the RNA virus poliomyelitis and numerous DNA viruses, including smallpox, chickenpox, poxvirus, and HSV, were found to be inhibited by *A. indica* leaf extract (Meliaceae). Respiratory syncytial virus (RSV) and rotavirus are inhibited by the British Columbian ethnomedicines *P. arguta* (Rosaceae) and *S. racemose* (Adoxaceae), whereas *Cardamine angulate* (Brassicaceae), *C. conicum* (Conocephalaceae), *P. glycyrrhiza* (Polypodiaceae), and *B. verbascifolia* (Malpighiaceae) extract, a treatment for skin infections, was discovered to have strong anti-HSV action. Human rotavirus, RSV, and influenza type A are prevented by *E. coccus senticosus* (Araliaceae) root extracts, while *S. europaea* (Umbelliferae) prevents influenza virus by impeding RNA-dependent enzymes.

On the other hand, aqueous extracts of Iberian Peninsula plants *S. minor magnolii* (Rosaceae), *N. nepitella* (Lamiaceae), and *D. viscosa* (Asteraceae) inhibit HSV-1 and vesicular stomatitis virus (VSV). While influenza H7N7 was shown to be significantly inhibited by a combination of *V. thapsiforme* (Scrophulariaceae) flower infusion and amantadine (antidyskinetic medication), HSV-1-induced ocular illness was found to be controlled by meliacine from *M. azedarach* (Meliaceae) leaf extract.

Extracts from *L. yadoriki* (Loranthaceae) are said to have greater virucidal efficacy than the anti-viral medicine ribavirin against the coxsackievirus B3 (CoxB3). While the antipyretic and anti-inflammatory plants *R. officinale* (Polygonaceae) and *P. suffruticosa* (Paeoniaceae) prevent HSV attachment and penetration, influenza A and HSV are inhibited by the Nepalese ethnomedicine *N. indicum* (Apocynaceae). It was discovered that the asteraceous plant *S. ambavilla* (Asteraceae) has anti-HSV-1 and anti-polio virus 2 properties. According to studies, giving influenza A–infected Balb/c mice extract from *T. occidentalis* (Cupressaceae), *B. tinctoria* (Leguminosae), and *E. purpurea* (Asteraceae) enhances survival rates and mean survival times while lowering virus titers. In contrast, extracts from Thailand's *A. odorata* (Meliaceae), *M. oleifera* (Moringaceae), and *V. denticulate* (Rhamnaceae) plants inhibit TKD and phosphonoacetate-resistant HSV-1, delay the onset of skin lesions, lengthen the mean survival times, and lower mortality rates in infected mice. Taiwanese adenoviruses (ADV 3, 8, and 11) and HSV are inhibited by extracts of *B. gracilis* (Basellaceae) and *S. japonica* (Rubiaceae), whereas ADV-8 replication is best inhibited by extracts of *A. squamulosa* (Primulaceae) and *A. princeps* (Asteraceae). Interestingly, the Chinese folk remedy *C. willmottianum* (Plumbaginaceae) inhibits the adsorption, replication, and transcription of HSV-1, although Radix Glycyrrhizae inhibits RSV replication in a dose-dependent manner. *S. petersiana* (Fabaceae) extracts, a traditional treatment for STDs, have potent anti-HSV activity, while the polyphenol-rich fraction of *G. sanguineum* (Geraniaceae) extract has potent anti-influenza virus (IV) activity [348].

Hepatitis, cirrhosis, chronic liver disease, and primary hepatocellular cancer have all been linked to the hepatitis B virus (HBV) (PHC). Around 450 million people worldwide are chronic HBV and HCV carriers, however many of them are asymptomatic. There is no viable treatment for HBV carriers despite the existence of a reliable and effective vaccination. Since the genus *Phyllanthus* has historically been used to treat liver conditions including jaundice that are retroactively caused by HBV, numerous *Phyllanthus* species have been tested for anti-HBV activity. Aqueous extracts of *P. amarus* (Phyllanthaceae), *P. niruri, P. debilis, P. fraternus* (Phyllanthaceae), *P. urinaria, and P. mimicus* (Phyllanthaceae) have been demonstrated to block the DNA polymerase of hepadnaviruses in vitro in about 300 ethnobotanical studies. Aqueous extracts of *P. amarus (P. niruri*) from Madras, India, inhibit viral DNA polymerase in vitro and remove any detectable virus from the serum of Marmota monax (woodchuck) that has been infected with the woodchuck hepatitis virus either acutely or chronically. Strong anti-HCV properties are present in the extracts of the Chinese ethnomedicinal plants *A. euchroma* (Boraginaceae), *T. arvense* (Brassicaceae), and *P. trifoliata* (Rutaceae), while *P. vulgaris* (Labiatae) spike can prevent HIV-1 adsorption and replication by inhibiting reverse transcriptase and lowering proviral DNA copies. *M. japonicus* (Euphorbiaceae) and *A. Pilosa* (Rosaceae), two traditional Korean medicines, strongly block the HIV-1 reverse transcriptase and RNase H enzymes (RNH). While *H. officinalis* (Lamiaceae) and *D. viscosa* (Asteraceae) reduce HIV-1-induced infections, *C. paniculatum* (Combretaceae), an anti-infective plant native to Ethiopia, strongly inhibits HIV-1 and HIV-2 replication. *A. pluriseta* (Asteraceae) and *R. bequaertii* (Polygonaceae),

which are utilized in Rwandan traditional medicine to treat infections and rheumatic illnesses, both have potent anti-HIV-1 activity. It is interesting to note that further fractionation of an anti-virally inactive *T. diversifolia* (Asteraceae) extract results in an aqueous fraction with high anti-HIV-1 activity, suggesting that some ethnomedicines' cytotoxicity may lessen the anti-viral properties of the active compounds in crude extracts. While the stem bark extract of the Korean ethnomedicine *A. altissima* (Simaroubaceae) inhibits HIV-1 fusion, the ethnomedicinal herbs *C. cassia* (Lauraceae) and *C. helicacabum* (Sapindaceae) suppress HIV-1 and 2. Similar to zidovudine, extracts of *O. gratissimum* (Labiatae) and *A. cordifolia* (Euphorbiaceae) limit reverse transcriptase activity and proviral DNA copying to inhibit the cytopathicity of HSV-2. Additionally, *H. cochinchinensis* (Salicaceae) root bark extracts tremulacin and cochinchiside B block HIV-1 fusion [348].

6 Major Class of Anti-Viral Agents from Plants

Traditional ethnomedicines can be investigated as a source of supplemental antivirals due to their astounding structural diversity and wide spectrum of bioactivities. Several DNA and/or RNA viruses' replication cycles and cellular components can be stopped by ethnomedicinal plants with a variety of chemical components [348].

6.1 Phenolics and Polyphenols

Caffeic acids, cinnamic acids, and other simple bioactive phytochemicals with a single substituted phenolic ring are part of a large class of phenylpropanes that are in the highest oxidation state and have a variety of anti-viral actions. By way of the polyphenols rosmarinic, chlorogenic, and caffeic acid derivatives, pure aloe emodin, an anthraquinone and isomer of emodin found in aloe latex, suppresses HSV-1, pseudorabies, varicella zoster (VZV), and influenza virus. While proanthocyanidin A-1 of *V. vitis-idea* (Ericaceae) can prevent HSV-2 attachment and infiltration, polyphenols and proanthocyanidins of *H. virginiana* (Hamamelidaceae) exhibit exceptional anti-HSV-1 and anti-HIV-1 reverse transcriptase activity. Hudson discovered that polyphenols more effectively bind to the protein coat of the virus, contrary to Cadman's theory that the anti-viral activity of *R. idaeus* (Rosaceae) leaf is caused by the clumping of the virus particles by polyphenols. According to Sakagami et al., polyphenols prevent viral adsorption or attachment to host cell proteins and suppress viral enzymes including HIV reverse transcriptase and influenza RNA polymerase. The Bulgarian folk remedy *G. sanguineum* (Geraniaceae) has been linked to the most notable in vitro anti-influenza and anti-herpes activity of polyphenols, although these broad in vitro anti-viral activities of polyphenols do not match their in vivo activities. The site(s) and some hydroxyl groups on phenols are responsible for their anti-viral action, as is obvious with catechol and pyrogallol, according to the structure-activity analyses. While the Peruvian plant *S. cauliflora* (Combretaceae) has anti-HCV NS3 protease activity because of oligophenols, the

polyphenols isolated from the extracts of Southern Mainland Chinese plants *A. Pilosa* (Rosaceae), Pithecellobium clypearia, and *P. granatum* (Punicaceae) show anti-HSV-1 activity. However, anti-RSV activity has been found in polyphenols isolated from *B. laciniata* (Asteraceae), *E. scaber* (Asteraceae), and *S. indica* (Lamiaceae) [349–351].

6.2 Coumarins

Coumarins (2H-chromen-2-on) are phenolics with fused benzene molecules that have two adjacent hydrogen atoms changed to a chain resembling a lactone. They are what gives vanilla its distinctive sweet aroma and bitter flavor. Toxic coumarin derivatives can be safely eliminated in human urine because they have a "species-dependent metabolism." As seen with the oral anticoagulant warfarin, which stops the recurrence of cold sores caused by HSV-1 in humans, it is claimed that coumarins can stimulate macrophages and so exert an indirect influence on viral infections. Although coumarins rarely possess specific anti-viral activities, some coumarins, such as those found in *P. tschimganica* (Apiaceae), show anti-HIV activity. The most intriguing natural reverse transcriptase inhibitors come from the tropical rainforest trees *C. lanigerum* (Calophyllaceae) var. austrocoriaceum and *C. inophyllum* (Guttiferae) of Sarawak on Borneo Island of Malaysia. These compounds are known as 4-propyldipyranocoumarins, or calanolides. According to the C-4 substituent on the lactone ring, calanolides, inophyllums, and cordatolides are different types of caophyllum coumarins. Studies on the link between structure and activity reveal that the anti-HIV-1 activity is caused by methyl groups at C-10 and C-11 and a hydrogen bond at C-12. Calanolide A is a unique natural non-nucleotide reverse transcriptase inhibitor that exhibits strong efficacy against HIV-1 reverse transcriptase and may be useful in combination with other antiretroviral medications [348].

6.3 Quinones

Quinones produce stable free radicals and permanently attach to the nucleophilic amino acids in proteins, inactivating them and causing them to lose their functionality. As a result, quinones have a wide spectrum of anti-viral actions, and it is likely that they will affect several viral enzymes as well as the virus attachment site. Chrysosplenol C is a powerful and targeted inhibitor of picornaviruses and rhinoviruses, the common cold viruses, whereas hypericin, an antidepressant anthraquinone from *H. perforatum* (Hypericaceae) (St. John's wort), exhibits anti-viral activity. The hydrophobic C-6 and the methyl group at the C-3 of the chrysophanate molecule of the Australian plant *D. longifolia* (Asphodelaceae) and chrysophanic acid from *P. sphacelatum* (Asteraceae) impede the replication of poliovirus 2 and 3. The fluoroquinolone's anti-viral effect is caused by the addition of an aryl group to the piperazine moiety; it specifically affects HIV by impairing transcription and tat activities. Aryl-piperazinyl-6-amino-quinolone, a selective and powerful inhibitor

of HIV-1 replication via interfering with tat-TAR interactions, was produced by replacing the fluorine at position C-6 with an amine group [348].

6.4 Flavones, Flavonoids, and Flavonols

A flavonol is produced by adding a 3-hydroxyl group to a flavone, which is a hydroxylated phenol with one carbonyl group. Plants produce flavonoids, which have a broad range of antibacterial properties, as a C6-C3 unit connected to an aromatic ring in response to microbial infection. The ability of flavones to bind to extracellular and soluble proteins and partially owing to interference with virus-cell interaction, as seen in glycyrrhizin, are what give them their anti-viral properties. Many essential stages of the viral life cycle, including viral integrase, protease, and reverse transcriptase, can be inhibited by flavonoids. Flavanones missing an OH group at C-3, such aromadendrin, are more specifically inhibitors of CD4/gp120 contact, whereas flavanones with an OH group at C-3 (taxifolin) inhibit the protease, reverse transcriptase, and CD4/gp120 interactions. The ability of (-)-epigallocatechin 3-O-gallate to impair post-adsorption entry and inhibit viral protease and reverse transcriptase accounts for its nonspecific anti-HIV-1 action. The steroidal glycoside torvoside H and the C-4-sulphated isoflavonoid torvanol A of *S. torvum* (Solanaceae) fruits exhibit potent anti-HSV-1 action. While isoquercitrin from *W. fragarioides* (Rosaceae) shows anti-HSV activity, swertifrancheside, glycyrrhizin, and chrysin show anti-HIV properties, galangin, a 3,5,7-trihydroxyflavone isolated from *H. aureonitens* (Asteraceae), inhibits HSV-1 and co-coxsackie B virus. Hesperetin prevents the growth of poliovirus 1, HSV, parainfluenza 3, and RSV. However, catechin and quercetin prevent the infection of RSV and HSV-1, whereas catechin also prevents the replication of all four viruses. While indole-3-carboxylic acid, dihydroxyoleanoic acid, and (-)-catechin isolated from *B. nantoensis* (Begoniaceae) inhibit HIV replication, oxyresveratrol from *M. erythrocalyx* (Fabaceae) and *A. lakoocha* (Moraceae) inhibits both HSV and HIV-1, making it the most effective inhibitor of poliovirus genomic. The flavone glycoside dihydroxy-trimethoxyflavone-β-d-xylopyranosyl-β-d-glucopyranoside has also demonstrated broad-spectrum anti-viral action in *B. monosperma* (Leguminosae) seed. Wogonin, a natural antioxidant monoflavonoid, possesses anti-inflammatory, anticancer, neuroprotective, and anti-viral effects [348]. It also has rapid tissue distribution and a slow plasma clearance rate.

The flavonol iridoid glycosides luteoside extracted from *B. prionitis* (Acanthaceae) and *M. lutea* (Bignoniaceae) root have strong anti-RSV activity, whereas the antioxidant flavonoid theaflavin from black tea has been found to neutralize bovine rotavirus and coronavirus. Amentoflavone and robustaflavone inhibit HSV, amentoflavone, robustaflavone, and agathisflavone inhibit influenza virus, and rhusflavanone and succedaneflavanone inhibit measles and VZV, respectively, in flavones derived from *R. succedanea* (Anacardiaceae) and *G. multiflora* (Clusiaceae) [348]. Baicalein and baicalin, flavonoids derived from the Chinese plant *S. baicalensis* (Labiatae), interacted with HIV envelope glycoproteins and

chemokine coreceptors to prevent virus entrance into CD4 cells and limit HIV-1 replication. While cinnamoylbenzaldehyde and lawinal of Desmos spp. inhibit HIV-1 replication, and mulberroside C and leachianone G isolated from *M. alba* (Moraceae) root inhibit HSV-1, bioflavonoids inhibit the arctiin, liquiritin, phillyrin, genistein, glycitrin, daidzein, and chlorogenic acid. RSV and influenza A are inhibited by the flavonoids in *A. chinensis* (Sapindaceae) seed extract, while morin, a different flavonoid group from *M. cochinchinensis* (Moraceae), has potent anti-HSV-2 activity. According to the SAR investigation, the majority of these flavonoids (quercentin, baicalein, and myricetin) block HIV-related cellular DNA or RNA polymerases as well as the virus-associated reverse transcriptase, with the level of inhibition varying depending on the flavonoid's structure and side chain. Ursolic acid, a triterpene found in the rose family plant *Geum japonicum*, inhibits the action of the HIV-1 protease enzyme while betulinic acid, oleanolic acid, and ursolic acid, as well as their derivatives also work to keep the gp120/gp41 complex stable [348].

6.5 Tannins

Nearly every plant part contains tanins (or tannoids), a category of polymeric phenolic macromolecules with molecular weights of 500–3000 that may tan leather or precipitate gelatin from solution. They are categorized as condensed tannins or hydrolysable tannins. Condensed tannins (proanthocyanidins) are formed from flavonoid monomers, while hydrolysable tannins are based on gallic acid. As a result of tannins' ability to stimulate phagocytic cells, inhibit tumor growth, and inhibit a wide range of microbes by forming complexes with microbial proteins through hydrophobic interactions, covalent bonds, and hydrogen bonds, tannin-containing beverages like green tea and red wine are said to treat or prevent a variety of infections. The anti-HSV-1 and HIV-1 reverse transcriptase inhibitors strictinin, shephagenin, and hippophaenin of *Shepherdia argentea* (Elaeagnaceae) share this mechanism of action by inactivating transport proteins, adsorption, polysaccharides, and reverse transcriptase enzyme (Elaeagnaceae). Acyclovir-resistant and thymidine kinase–deficient HSV-1, wild HSV-2, and Epstein-Barr virus can all be inhibited by the phenolic eugeniin from *Geum japonicum* (Rosaceae) and *S. aromaticum* (Myrtaceae) plants (EBV). Nepalese *B. ligulata* (Saxifragaceae) rhizome extracts suppress RNA and protein synthesis in a dose-dependent way to prevent the reproduction of influenza viruses. Similar to this, the gallotannin geraniin from *P. amarus* (Phyllanthaceae) blocks reverse transcriptase in a dose-dependent manner to suppress HIV-1 replication. Camelliiatannin H, a hydrolysable tannin isolated from the pericarp of *C. japonica* (Theaceae), inhibits HIV-1 protease while being virucidal and blocking HSV-2 attachment and penetration. By preventing the formation of the gp41 six-helix bundle, an essential step in the fusion of the membranes of HIV and the target cell, tannin extracted from *P. vulgaris* (Labiatae) and *R. cibotte* (Cibotiaceae) prevents HIV-1 entrance to CD4 cells [348].

6.6 Lignans

Lignans are large group of low molecular weight polyphenols that are widely distributed in plants. There are several lignans in plants, and many of them have anti-viral properties. Schizarin B, Taiwanschirin D, and Rhinacanthin E and F are peltatins identified from *J. procumbens* (Acanthaceae), *P. peltatum* (Berberidaceae), and *K. matsudai* (Schisandraceae), which suppress HIV, hepatitis B virus, and influenza A by preventing the virus from replicating. A highly effective anti-hepatitis C substance called honokiol was discovered in the Magnoliaceae family's *Magnolia officinalis*. Honokiol prevents hepatitis C growth by interfering with the HCV life cycle. Additionally, 3-hydroxy caruilignan, a weakly effective lignan molecule, was found in the stems of *Swietenia macrophylla* (Meliaceae). This substance reduced RNA levels and inhibited the hepatitis C virus [351]. The extracts of *R. javanica* (Anacardiaceae) display anti-HSV-2 activity similar to acyclovir, while those of *L. tridentates* (Zygophyllaceae), *R. nasutus* (Acanthaceae), and *K. matsudai* (Schisandraceae) demonstrate anti-HIV, anti-herpes, and anti-influenza properties [348].

6.7 Polysaccharides

Various viruses are protected from attack by extracts containing polysaccharides isolated from *A. flaccida* (Asteraceae), *A. barbadensis* (Asphodelaceae), *B. montagnei* (Rhodomelaceae), *C. tubiflora* (Meliaceae), *P. vulgaris* (Lamiaceae), *S. glucanicum,* and *S. rebaudiana* (Asteraceae). Their effects are thought to be caused by immunostimulation of antibody production against nonenveloped picornavirus capsid protein epitopes as well as suppression of virus attachment to cells and syncytia formation. There have also been reports of polysaccharides with anti-viral properties from marine sources. From *C. crenulate* (Halymeniaceae), Talarico et al. [353] identify an L-galactan hybrid C2S-3 that has significant anti-viral activity against three dengue virus serotype 2 strains [352].

6.8 Terpenoids and Essential Oils

The quinta essentia, also known as essential oils, are what give plants their scent. Essential oils are defined as phenolic compounds having a C-3 side chain, reduced levels of oxidation, and no oxygen. Terpenes are oils that are significantly richer in the isoprene structure. As well as hemi (C-5) and sesquiterpenes, they also exist as di-(C-20), tri-(C-30), and tetraterpenes (C-40) (C-15). They are referred to as terpenoids when they include oxygen and are effective against a number of viruses. While ovatodiolide obtained from *A. indica* (Lamiaceae) shows anti-HIV action and the triterpenoid betulinic acid inhibits HIV, the furanoditerpene caesalmin, from *C. minax* (Fabaceae) seeds, inhibits parainfluenza 3 virus. Furanoditerpenoid lactone is less powerful than the tetracyclic furanoditerpenoid caesalmin. Arganine C, a

triterpene saponin isolated from *T. heckelii* (Sapotaceae) fruits, inhibits HIV entry into host cells whereas the triterpene vaticinone isolated from *V. cinerea* (Dipterocarpaceae) of Vietnam inhibits HIV-1 replication, indicating their potential as anti-viral agents. The virucidal effects of the iridoid maesasaponin of *Maesa lanceolata* (Primulaceae) against HSV-1 and the suppression of VSV by saikosaponins, iridoids, and glycosides isolated from *B. rigidum* (Apiaceae) and *S. scorodonia* (Scrophulariaceae) are related to diacylation. The essential oil from the Italian food plant *S. insularis* (Asteraceae) inhibits the spread of herpes viruses from cell to cell, while the pulegone from *M. verticillate* (Lamiaceae) inhibits the growth of HSV-1 and pseudorabies virus. Sandalwood oil from *S. album* (Santalaceae) exhibits dose-dependent anti-HSV-1 activity. Both eucalyptus oil and terpinen-4-ol, two essential oils that affect HSV before or during adsorption, have powerful antivirucidal effects on HSV-1 and HSV-2. Terpinen-4-ol is found in the tea tree *M. alternifolia* (Myrtaceae). While essential oils isolated from *A. douglasiana* (Asteraceae) and *E. patens* (Asteraceae) inhibit HSV-1 and dengue 2 viruses, respectively, and *M. officinalis* (Lamiaceae) oil inhibits HSV-2 replication, the essential oils from the Argentinean plants *L. junelliana* (Verbenaceae) and L. turbinata are virucidal against the Junin virus [348]

6.9 Alkaloids

Heterocyclic nitrogen compounds are alkaloids. While berberine prevents intestinal infections linked to AIDS, solamargine and michellamine B, glycoalkaloids derived from *S. khasianum* (Solanaceae) berries, inhibit HIV. While matairesinol and harman extracted from *S. setchuensis* (Symplocaceae) prevent HIV replication, *T. hypoglaucum* (Celastraceae) and a clinically used extract of T. wilfordii demonstrate strong anti-HIV action. The skimmianine in *Z. chalybeum* (Rutaceae) seed extract suppresses the Swartz and Edmonston measles virus strains. The isoquinoline alkaloid thalimonine, isolated from *T. simplex* (Ranunculaceae), inhibits influenza A virus replication by reducing the expression of viral neuraminidase, hemagglutinin, nucleoprotein, and virus-specific protein synthesis. On the other hand, the aromoline alkaloid isolated from *S. cepharantha* (Menispermaceae) root tuber is used in folk medicine. While drymaritin from *D. diandra* (Caryophyllaceae) exhibits anti-HIV activity, the lycorine, homolycorine, and acetyllycorine hemanthamine isolated from *L. vernum* (Amaryllidaceae) exhibits significant antiretroviral activities with little therapeutic utility. Surprisingly, *O. nicobarica* (Rubiaceae), a folkloric plant from the Little Andaman Islands, completely inhibits plaque formation and delays the eclipse phase of herpes virus replication in both its entire extract and harman alkaloid part. Cepharanthine is a biscoclaurine alkaloid that was discovered in the Chinese folklore plant *S. cepharantha* (Menispermaceae). It has significant anti-viral activity against SARS coronavirus, coxsackie B3, and HSV-1 as well as immunosuppressive and anticancer properties. Cepharanthine has been shown in scientific studies to have substantial anti-viral effect against RNA and DNA viruses [348].

6.10 Polypeptides, Lectins, and Sugar-Containing Phytoconstituents

Meliacine (a glycopeptide) has been found to have potent anti-HSV-1 eye disease activity. It was originally isolated from the leaves of *Melia azedarach* (Meliaceae) in Argentina. It is also said to prevent virus fusion and viral propagation, hence preventing the multiplication of the Junin virus and the foot-and-mouth disease virus. By preventing host-viral contact, the bigger mannose-specific lectins MAP30 (a 30 kDa protein of *Momordica charantia*), GAP31 (a 31 kDa protein of *Gelonium multiflorum*), and jacalin reduce the growth of HIV and CMV. HIV reverse transcriptase is inhibited by xylanase, a 15-kDa protein isolated from *P. notoginseng* (Araliaceae), and 5-kDa peptides obtained from pinto and red beans. The protein MRK29 from Thai bitter gourd inhibits HIV-1 reverse transcriptase, and its salt-precipitated fraction significantly lowers viral p24 expression in cells infected with HIV-1 while increasing TNF activity, demonstrating its immunomodulatory effect. The N-acetylglucosamine (NAG)-specific lectins isolated from *U. dioica* (Urticaceae) and the mannose-specific lectins isolated from *C. hybrid* (Orchidaceae), *E. helleborine* (Orchidaceae), *Hippeastrum* (Amaryllidaceae), and *L. ovata* (Orchidaceae) all interact with specific glycosylation sites within. HIV budding is prevented by polysaccharides extracted from the bark and leaves of *R. mucronata* and *R. apiculata* (Rhizophoraceae), respectively. On the other hand, aloe poly-mannose derived from *A. barbadensis* (Asphodelaceae) increases antibody levels against enteroviruses and poliovirus vaccine strains and potentiates antibody formation for capsid protein epitopes of nonenveloped picornaviruses. While the acidic polysaccharides isolated from *C. tubiflora* (Meliaceae) inhibit HSV-2 and vesicular stomatitis virus (VSV), the heterogeneous anionic polysaccharide with different ionic charges stevian isolated from *S. rebaudiana* (Asteraceae) and *A. flaccida* (Asteraceae) inhibit the replication of HSV-1 and four serotypes.

7 Future Directions for Medicinal Plants' Anti-Viral Properties

The importance of medicinal plants may be seen in the statistic that more than 80% of the world's population derive their health care needs from phytomedicinal sources, as per estimates from the World Health Organization (WHO). In nations where plants and their products are trained for therapeutic needs, programs focused at integrating medicinal plants into peoples' health care needs should be supported. Scientific studies devoted to new pharmacological discoveries from phytochemicals should be sponsored by countries with high traditional medicine usage. The anti-infectious/anti-viral properties of medicinal plants can be screened using better separation technologies. The discovery of new anti-viral drugs from medicinal plants is no longer hindered by a number of issues that were once regarded to be obstacles. For instance, there was always a risk of unintentional worker infection when evaluating the anti-viral potentials of plant extracts. The use of vector-based assay approaches, such as recombinant viral vectors that mimic an infection and produce

the firefly luciferase marker gene, has proved particularly effective in overcoming these screening challenges [353, 354].

The creation of medicinal medications based on proteins and vaccinations is an inventive use of plants. Plants may provide a useful starting point for the creation of peptides/proteins of medicinal grade, according to numerous scientific papers [355]. While the first subunit vaccination for the HBV surface antigen was being produced in 1992, numerous other vaccine antigens were also successfully grown in plants, and their safety had already been examined in both animals and people. However, as the bulk of viral vaccines are based on attenuated or inactivated viral particles, caution must be exercised while contemplating the ability of plants to treat human viral infections. Due to these limitations, efforts have been concentrated on expressing the coat proteins of different viruses, which are thought to accumulate as antigenic virus-like particles (VLP) in plants. Other factors, such as how protein should be processed for expression in plants, must be taken into account.

Prior to the translational practice of medicinal plants in the developed world, further difficulties must be resolved. The isolation of powerful compounds linked to a particular plant's therapeutic properties is one such topic. The effectiveness of using unprocessed plant extracts in health care is well established in several parts of the world, and they have no negative side effects. Although it will be difficult to get these plant extracts approved by international regulatory bodies like the Food and Drug Administration (FDA) of the USA or other European counterparts, government-sponsored studies will help as a gateway for the fusion of modern drug discovery with conventional Chinese/Eastern medicine in countries with limited resources. Additionally, considering the challenges the industrialized world faces, such as medication resistance and disappointment in the search for an effective vaccine against a fatal infectious agent like HIV, the cause of devastating AIDS, phytomedicinal products may provide hope. Despite the widespread usage of herbal remedies, either alone or in combination, throughout the world, there is no information on how medicinal herbs interact with living organisms. It is the only time that the indigenous people have used a specific plant or phytochemical to treat a condition. Hepatotoxicity is impacted by clinical discoveries like the coadministration of the medicinal plant's kava kava and St. John's Wort [356]. Although many findings indicate hepatotoxicity associated with herbal medicine, herbal medicines are typically perceived as being nontoxic [357]. It is important to promote the publication of studies pertaining to the cytotoxicities of using medicinal plants and include these studies into a global database system. Furthermore, before using a specific herbal cure in combination with other treatments for people, bigger randomized, double-blind, placebo-controlled multicenter clinical trials should be conducted.

8 Conclusion

There are still a huge variety of plants with anti-viral properties in nature, making it fertile and abundant. They are extremely diverse; each geographical area has its own unique species of plants that are not found anywhere else in the globe. To optimize

the useful results and minimize time and effort, it is preferable to concentrate on plants known for their medicinal benefit in folk medicine while screening for plant anti-virals. The plant extract requires additional research in order to separate the various chemicals and identify the active ingredients using accepted scientific methods. Chemical virucide is not a panacea for plant virus illnesses, but it is an essential link in the chain of the control system, and it may even be expected to have the upper hand. When doing research and producing chemical virucides, it is important to consider environmentally responsible practices. On the other hand, we can employ the various plant anti-viral agents that have been successfully used as anti-viral compounds for people and animals, especially those that have a broad-spectrum anti-viral action, to increase the number of plant anti-viral agents used as a virucide. Time will be saved, and the food and medicine requirements will be successfully met. Currently, nanotechnology is primarily used in the pharmaceutical and medical fields, but over the next ten years, it will play a significant role in agriculture as researchers work to create antibacterial and anti-viral medicines that are better, safer, and more effective.

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