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Review Article

A comprehensive overview of the pharmaceutical properties of Indian coastal sand dune flora: Emphasis on anti-virals

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Abstract

Viral infections have an essential function in both humans and other organisms. The persistent rise in viral diseases has made critical damage to human well-being. The present review indicates that viral diseases are been entangled in various cancer developments. Developing safe and effective antiviral medications remains a challenge. As a result, finding therapeutic targets that would interfere with the virus without affecting the host is hard-hitting. The use of natural substances rather than chemicals in the formulation of antiviral medications could significantly minimize the risk of side effects in patients. Coastal dune vegetation is a vital resource, which plays an imperative part in biodiversity. Coastal dunes have various utilizations in restorative and drug development. The drugs from marine are vitally been utilized as medicine due to their substantial antiviral, anticancer, and antimicrobial activities. Though Coastal dunes flora has numerous possessions their antiviral properties are rarely reported. Hence, in this report, we have compiled and highlighted the antiviral properties of 128 Indian coastal dune flora. This review may provide access to a profound understanding of coastal dunes' vegetation resources and their usage in the production of antiviral and anticancer drugs. It may also help to preserve and cultivate these plants.

Introduction

The persistent emergence of some developing or reappearing viral diseases has made unadulterated damage to human well-being. The unique structure of the viral infections and their muddled life cycle made it extremely difficult to explore conclusive therapies against viral diseases. Viral infections are extremely minute toxins that are made of hereditary material within a protein covering, that destroys healthy cells. This can injure, harm, or alter the cells and cause illness to people [1]. Distinctive viral infections can influence numerous zones in the body, including the conceptive, skin, cerebrum, blood, breathing system, liver, respiratory, and gastrointestinal systems [2]. For most popular viral diseases, medicines can just assist with manifestations while the immune system will battle off the viral infection. Antibiotic agents are not significant for viral diseases.

Several studies expose that viral infection is involved in numerous malignant growths such as cancer and tumor [2]. Viral infections cause regular colds, moles, and flu. They likewise cause extreme diseases including Influenza, Dengue, Zika virus, Herpes Simplex Virus (HSV), Chikungunya, Hepatitis A (HSV), Hepatitis B (HSB), Hepatitis C (HCV), AIDS, Ebola, chickenpox, Human Immunodeficiency Infection (HIV) and COVID-19 [1]. Antiviral medications are available for treating some popular viral diseases. Immunizations and vaccines can assist with keeping from getting numerous viral illnesses.

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Due to the recent SARS-CoV-2 pandemic, the entire world is going through a very difficult time. To address this dire situation, therapeutic agents and vaccines against this virus are urgently needed. National Institute of Plant Genome Research, New Delhi, India, helps with research readiness in the fight against this virus. Three research groups are working hard to develop plant-based vaccines against SARS-CoV-2 and to investigate plant natural products that may be anti-viral in nature. The potential anti-SARS-CoV-2 activity of the identified molecule/s is being investigated in collaboration with the International Centre for Genetic Engineering and Biotechnology in New Delhi and the Regional Centre for Biotechnology in Faridabad, India (National Institute of Plant Genome Research (NIPGR), New Delhi, 2020) [3]. Marine plants and animals have a wide range of natural compounds, which are essentially novel, conceptually revolutionary, and have pharmacological effects [1]. To substantiate the above, this study focuses on the popular anti-viral properties of vegetation on coastal sand dunes Figure 1.

Coastal sand dunes vegetation

Coastal sand dunes are naturally dynamic. A coastal sand dune is a slope of sand effort by wind activity and an expansion of the sea shore into the land. While a seashore is firmly connected to the ocean and constrained by waves and tides, the ridges are connected to the land and are constrained by winds [4]. Due to interoperability issues, mobility, substrate versatility, and physical cycles, the coastal sand dunes comprise a variety of microenvironments [1].

Coastal sand dunes serve as a home for certain essential plants and animals (rare and endangered species) [4]. Coastal flora and vegetation are related to resilience to the consistency and saltiness slope of residue, wind, marine vaporization, and the nearness of bitter water [5]. Coastal sand dunes provide fundamental biological system management as environments for local and imperiled species, a site that gives high travel industry esteem, groundwater revives zones, and properties from wave disintegration and tempest flooding [6]. Coastal sand dunes are substantially involved in various vegetation, fauna, and microorganisms [6].

Applications of coastal sand dunes vegetations

The sand dune flora is an extremely essential resource in the healing, therapeutic, and economic [7]. The medications acquired from the ocean have the chance of exploiting in medication since it has enormous antiviral, antimicrobial, and anticancer activities [8]. The applications of coastal sand dunes include nutrients, feed, manure, flooder, nourishment, drug, firm and social uses [7]. Coastal sand dunes have been accounted for to contain a greater assortment of horticultural, agronomical, industrial, pharmaceutical, and chemically significant microorganisms [6].

All the clinical plants of coastal sand dunes were administered intravenously with added substances, for example, oil (coconut, sesame, and castor), milk and milk merchandise (buttermilk and ghee), normal salt, jaggery and nectar or applied remotely as a mixture, decoction, glue, or powder [8]. The greater parts of the plants utilized in medications are either blended in with different fixings or single. Many of these species varieties are known to be utilized in different medicines, as for relieving Jaundice, headache cure, dental abscess, hepatitis, mumps, dermatitis, cut, sinus headache, recuperating wounds, throat contamination, loose bowels, tingles, skin maladies, fix migraine, stomach ulcer, tumor, ear-hurt, eye torment, diabetes, colds, asthma, chest infections, and pneumonia in general [8].

Coastal sand dunes have numerous uses in the medicinal and pharmaceutical industries. Coastal sand dunes vegetations have an assortment of applications in the field of medication and drug ventures, for instance, vegetations of coastal sand dunes can be utilized as moderating, hypocholesterolemic, anti-acne, harm preventive, antihepatotoxicity, nematicide, antihistaminic, against eczematic, against skin break

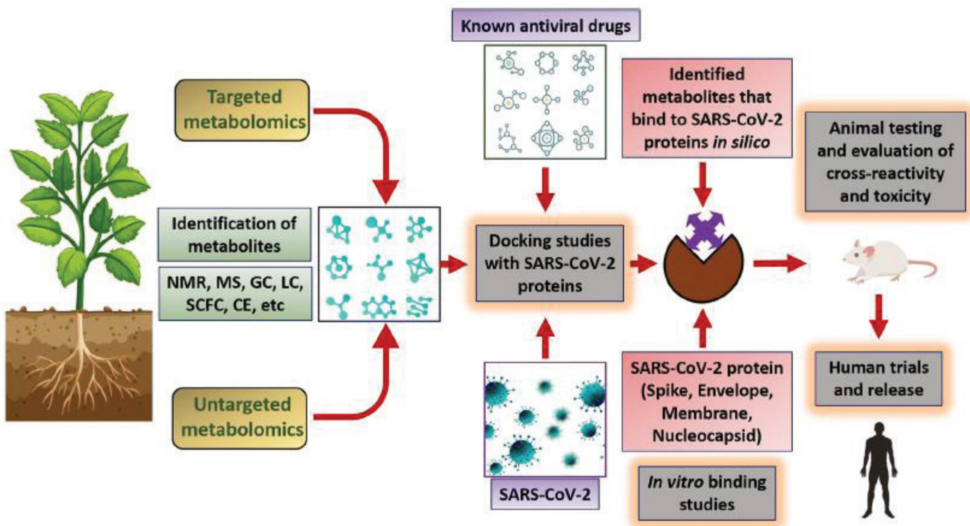

Figure 1: A possible route of identification of antiviral drugs against SARS-CoV-2 (National Institute of Plant Genome research (NIPGR), New Delhi, 2020) [3].

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out, antiarthritic, mitigating, threatening to coronary, antiandrogenic, flavor, hemolytic, spermatogenic, hypocholesterolemic, slightness genic insectifuge, anti-inflammatory, hostile to coronary, immunostimulant, chemo-preventive, pesticide, torment easing, hostile to diabetic, pain relieving, cell support, against dermatitic, antileukemic, antitumor, anticancer, hepatoprotective, antispasmodic, antiasthma, diuretic, 5-alpha reductase inhibitor [9]. Coastal sand dunes have numerous properties or capacities, in spite of the fact that their antiviral properties are seldom referenced.

Antiviral activity and other therapeutic properties of coastal sand dunes vegetation (Table 1)

Challenges and future prospects: There is widespread agreement that plant metabolites have the potential to be novel antiviral agents against many viral diseases. These vegetation are abundant in coastal regions, have long been used in traditional medicine, and are thus prime candidates for the discovery of new bioactive metabolites. Several studies have been conducted to establish a link between the empirical uses of these plants to treat infections and photochemistry evidence of the compounds that underpin antiviral effects. However, efforts to investigate new pharmaceutical compounds and demonstrate their effect in vitro have not yet resulted in an antibiotic that is clinically beneficial and economically profitable. Concerns about drug-resistant microbes have heightened interest in plant-derived, effective antimicrobial compounds. Plants that have been used to treat infectious diseases for centuries now have a new lease on life. The detection and quantification of known, and even the discovery of new, small bioactive molecules produced by plants as secondary metabolites will open up new avenues of treatment for a wide range of infectious and noninfectious diseases. Extraction methods that are appropriate and optimised, susceptibility tests, and clinical trials are still required. The prospects for future research appear promising, with the potential discovery of new and effective treatments leading to significant advances [88,89]. Plant metabolomics based on mass spectrometry is an extremely powerful approach that is likely to provide comprehensive metabolite profiles of medicinal halophytes in the near future. In vitro tests are the first step in screening promising metabolites for antimicrobial effects, whether purified or in mixtures. Because of the complexity and diversity of chemical properties of plant metabolites, a combination of analytical platforms is required to increase the detection coverage of these compounds in biological samples. To detect volatile and nonvolatile metabolites, GC and HPLC coupled with mass spectrometry, as well as other techniques such as UPLC or NMR, are required to ensure that all or the majority of compounds are separated, detected, identified, quantified, and characterised. Each method should also cover a variety of extraction solvents in order to detect both polar and nonpolar compounds. The isolation and chemical characterization of each compound using NMR technologies, as well as testing them in bioassays, are critical steps toward determining each compound's biological activity. Methodological approaches for in vitro tests, on the other hand, must be carefully tailored to the chemical nature of the metabolites or extracts. Protocols must be standardised and validated against representative biological models in order for product comparisons to be reliable and meaningful. Sand dune species serve as extremely important reservoirs. However, these resources have been put at greater risk as a result of forest clearing for industrialization, rapid urbanisation, over-exploitation and anthropogenic activities. So, with the help of local communities and an awareness, necessary steps should be taken to conserve floral diversity. To summarise, the vegetation of coastal sand dunes can be vitally used as therapeutic agents in the medical and pharmaceutical industries, and as such, they must be conserved and further cultivated for the community's benefit.

Credit author statement

Yuvaraj: Conceptualization, Methodology, Vigneshwar and Kowsalya: Writing- Original draft preparation, Sarah and Praveen: Review and revisions. All the authors approved the manuscript.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Antiviral components of coastal sand dunes vegetation and their respective target viral diseases.

S. No.	Plant species	Components	Viral diseases	References
	Abrus precatorius	Abrasine, precision	HSV-1	Bhatia, et al. 2013 [10]
	Abutilon indicum	β-sivtosterol	DENV (Dengue Virus)	Abdul Rahuman, et al. 2008 [11]
	Acacia ampliceps	Parthenolide, Sesquiterpene	HCV	Abdul Rahuman, et al. 2008 [11]
	Acacia auriculiformis	Flavonoids, tannins	HSV-2, HCV	Ahmed, et al. 2015 [12]
	Acacia mellifera	Saponins, flavonoids	Hepatitis B Virus	Chekuri, et al. 2020 [13]
	Acalypha indica	Excoecarianin, Loliolide (tannin)	vesicular stomatitis (VSV), HSV-1 (herpes simplex type-1)	Fenu,, et al. 2012 [4]
	Acanthospermum hispidum	Rhamnose, ribose, arabinose	Pseudorabies virus (PRV), HSV-1, HSV-2, PRV, BHV-1	Chiranjibi, et al.2008 [14]

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	Acanthus ilicifolius L	Baicalin (Flavonoid)	NDV, DENV	Hemanta, et al. 2013 [15]
	Achyranthes aspera	Oleanolic acid, triterpene	herpes simplex virus type 1 (HSV-1) and type 2 (HSV-2)	Hemanta, et al. 2013; Kamel, et al. 2019 [15,16]
	Aeluropus lagopoides	Ursolic acid, Maslinic acid, Saponin	DENV	Al-Omar, et al. 2020 [17]
	Aerva javanica	Ursolic acid, quercetin	PDEV	Giday and Teklehaymanot, 2013 [18]
	Aeschynomene aspera	Dammarenolic acid (Triterpenoid)	Retroviruses	Sheela and Uthayakumari,2013; Prathibha and Rao, 2015 [19,20]
	Aeschynomene indica	Parthenolide, saponins, tannins	HCV	Sahu, et al. 2013 [21]
	Aloe vera	Emodin (anthraquinones)	HSV-2	Sahu, et al. 2013 [21]
	Alternanthera sessilis	sennoside A (glycosides)	herpes simplex type-1 (HSV-1)	Shehzad, et al. 2018 [22]
	Alysicarpus vaginalis	Salicylic acid	rhinoviruses	Sridhar and Arun, 2008 [23]
	Ammophila arenaria	Curcumin	encephalomyocarditis virus	Lakshmi and Narasimharao, 2015 [24]
	Anacardium occidentale	Triterpene, Saponin	HSV-1	Thirunavukkarasu, et al. 2010 [7]; Sheela and Uthayakumari, 2013 [19]
	Apluda mutica	Formalin	Newcastle disease virus (NDV)	Pradeep, et al. 2010 [25]
	Argemone mexicana	Alkaloids and flavonoids	Newcastle disease virus (NDV) and Infectious bursal disease virus (IBDV) in chicken embryo fibroblast (CEF) cell culture	Thirunavukkarasu, et al. 2010 [7]
	Asystasia gangetica	Flavonoids	NDV	Usman, et al. 2016 [26]
	Azadirachta indica	3-Deacetyl-3-cinnamoyl-azadirachtin	Enterovirus B, poliovirus, HCV	Gopalakrishnan, et al. 2010 [27]
	Barringtonia acutangula Gaertn.	Quercetin, gossypetin	HCV	Thirunavukkarasu, et al. 2010 [7]; Sheela and Uthayakumari, 2013 [19]
	Boerhavia diffusa	Quinolone alkaloid	tobacco mosaic virus (TMV) and Respiratory syncytial virus (RSV)	Sheela and Uthayakumari, 2013 [19]
	Borassus flabellifer	Steroidal saponins, polysaccharides, and triterpene	HSV, DENV	Shubhransu, et al. 2019 [28]; Sheela and Uthayakumari, 2013 [13]
	Bulbostylis barbara	Luteolin and quercetin	HIV	Vimalanathan, et al. 2009 [29]
	Caesalpinia bonduc	Flavonoids, stilbenes	Human Rhinoviruses (HRV), Coxsackie B virus (CVB), feline calicivirus	Kiran, et al.2011 [30]
	Caesalpinia pulcherrima	Latisilinoid lupeol, lupeol acetate, myricetin, quercetin and rutin	Echovirus 7 (EV7), Adenoviruses, HSV, HIV, rotavirus	Verma and Awasthi, 2012 [31]
	Calophyllum inophyllum	1,5 dihydroxyxanthone, inophyllum, caloxanthones A, B, macluraxanthone	HIV-1	Verma and Awasthi, 2012 [31]
	Calotropis gigantea	Quercetin (Flavonoids)	herpes simplex type-1 (HSV-1) and vesicular stomatitis (VSV)	Masateru, et al. 2015) [32].
	Calystegia soldanella	Calysolins (Glycosides)	HSV-1	Lee, et al. 2017, Vedavayas, et al. 2012 [33,34]
	Canavalia cathartica	Lectin (Con A), crude lipid	HIV-1	Lakshmi and Narasimharao, 2015; Venkanna, 2012 [24,35]
	Canavalia maritima	Lectin (Con A, Con M)	HIV	Lakshmi and Narasimharao, 2015; Venkanna, 2012 [24,35]
	Canavalia rosea	Lectin (Con A, Con C)	HIV	Lakshmi and Narasimharao, 2015 [24]; Venkanna, 2012 [35]
	Cassia occidentalis	Anthraquinones	HIV-1	Al-Snafi 2015 [36]
	Cassia siamea	Anthraquinones and triterpenoids	HSV-1, poliovirus activity	Balasubramanian, et al. 2010 [37]
	Cassia tora	Tyrosinase	HIV-1	Al-Snafi , 2015 [36]
	Cissus quadrangularis	Quercetin, Luteolin	HSV-1 and HSV-2	Chinelo and Sandra, 2015 [38]
	Citrullus colocynthis	Tannins and flavonoids	HSV- 2	Sheela and Uthayakumari, 2013 [19]
	Cleome viscosa	Saponin	HSV-1	Lima, et al. 2015 [39]
	Clerodendrum inerme	Adenosine glycosidase CIP-29 and CIP-34,	HSV-1, poliovirus I, mouse coronavirus (MCV)	Sheela and Uthayakumari, 2013 [19]; Verma and Awasthi 2012 [31]
	Clitoria ternatea	Saponins, triterpenoids	Herpes simplex virus (HSV) and mouse coronavirus (MCV)	Verma and Awasthi 2012 [31]
	Cocos nucifera	Catechin, epicatechin, polymeric procyanidins (ethyl acetate)	Herpes simplex virus type 1 (HSV-1-ACVr)	Sheila, et al. 2008 [40]
	Crotalaria goreensis	Pyrrolidinone	HIV-1	Wilian, et al. 2018 [41]
	Crotalaria pallida	Flavonoids (cropalliflavones A-C), Alkaloids (usaramine-N-oxide and cropallins A-B)	PEDV	Wilian, et al. 2018 [41]
	Crotalaria retusa L.	Saponins, Tannins, Alkaloids, n-Hexane	VSV	Wilian, et al. 2018 [41]

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	Crotalaria striata	Lectin (Con A)	hPIV-2 (human parainfluenza virus type-2)	Tasnova, 2016 [42]
	Crotalaria verrucosa	Quercetin (Flavonoids)	parainfluenza virus type 3 (Pf-3)	Dingse, et al.2019 [43]
	Croton bonplandianum Baill	Terpinoids, phenolics, flavonoid	yellow vein mosaic virus (YVMV) (plant virus)	Krishnan, et al. 2015 [44]
	Cuscuta reflexa	Glycoproteinaceous, polysaccharides	TMV, TRSV	Krishnan, et al. 2015 [44]
	Cynodon dactylon	Luteolin and apigenin	Chikungunya virus, white spot syndrome virus (WSSV)	Maha and Adel, 2009 [45]
	Cyperus rotundus	Flavonoid, glycosides	HSV	Ali, 2019 [46]
	Dactyloctenium aegyptium	Quercetin, Luteolin	HSV-2, HSV-1 and HAV-10	Lamai, et al.2015 [47]
	Derris trifoliata	Gallic acid	human rhinovirus (HRV)	Rasool, et al. 2019 [48]
	Emilia sonchifolia	Luteolin-7-O-β-d-glucoside, Isoetin 5'-methyl ether	white spot syndrome virus (WSSV) or yellow head virus (YHV)	Lamai, et al.2015 [47]
	Erythrina indica	Erycristagallin and Osajin	DENV	Mohamed, et al. 2019 [16]
	Erythrina variegata	Lutein/zeaxanthin, apigenin	HIV-1	Ghosh, et al. 2016 [49]
	Euphorbia hirta	Capsaicin, Polysaccharides carrageenan	herpes simplex type-1 (HSV-1), HIV-1, HIV-2 and SIV	Lamai, et al.2015 [47]
	Ficus bengalensis	Luteolin, 3-O-methylquercetin	HSV-2	Marius and Chinsembu, 2012 [50]
	Gisekia pharnaceoides	3-phosphoglyceric acid and sugar phosphates	HIV/AIDS	Ain, et al. 2010; Consolacion, et al. 2012 [51,52]
	Glinus oppositifolius	Spinasterol, Squalene, Lutein	hepatitis B virus (HBV)	Krishnan and Siril, 2016 [53]
	Hedyotis herbacea	Anthraquinones, iridoid glycosides	poliovirus types 2	Li, et al. 2009 [54]
	Hedyotis umbellata	Anthraquinones	poliovirus types 2	Li, et al. 2009 [54]
	Hibiscus tiliaceus	Anthraquinone chrysophanic acid	poliovirus	Sangeetha and Rajarajan, 2014 [55]
	Hyptis suaveolens	Apigenin, harrigtonine, narygenin	chikungunya virus	Danmalam, et al. 2009 [56]
	Indigofera tinctoria	Acyclovir	MCV and HSV	Frank and Ryan, 2010 [57]
	Ipomoea aquatica L.	Harrigtonine	Chikungunya virus	Meira, et al. 2012 [58]
	Ipomoea imperati	Glycol-alkaloids	HSV-1	Meira, et al. 2012 [58]
	Ipomoea pes-caprae	Triterpenes	DENV	Ramesh, et al. 2019 [59]
	Lantana camara	Luteolin	Chikungunya virus, white spot syndrome virus (WSSV)	Md Mizanur, et al. 2016 [60]
	Launaea sarmentosa	Flavonoids, Terpenes	HSV	Tsai, et al. 2020 [61]
	Leucas aspera	saponins, triterpenoids	MCV and HSV	Tsai, et al. 2020 [61]
	Lindernia crustacea	Phytol, aloe-emodin, byzantionoside B	HSV and Epstein–Barr virus (EBV)	Tsai, et al. 2020 [61]
	Mucuna pruriens	Phenol	Encephalomyocarditis virus (EMCV)	Lucia, et al. 2012 [62]
	Oldenlandia umbellata	Anthraquinones	vesicular stomatitis virus, herpes simplex virus types 1	Siva, et al. 1998 [63]
	Opuntia stricta	Quercetin, Luteolin	HSV	Kunyanga, et al. 2014 [64]
	Pandanus fascicularis	Lignans and isoflavones, coumestrol, alkaloids	smallpox virus	Prafulla and Bhaskar 2014 [65]
	Pedalium murex	Solanocapsine, Spirostan-3-ol, N-methylsolasodine	Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2), Zika virus (ZIKV)	Ramachandran, et al. 2017 [66]
	Pennisetum orientale	Capsaicin	HSV	Abdelhakim, et al. 2017 [67]
	Phoenix paludosa	Isoquercitrin, β-sitosterol, lupeol	AIDS	Mohamed, et al. 2015 [68]
	Phoenix sylvestris	Lutein	HIV	Mohamed, et al. 2015 [68]
	Phragmites karka	Polyphenols Delphinidin and Epigallocatechin	Zika virus (ZIKV)	Zainul, et al. 2015 [69]
	Prosopis juliflora	3-Methylquercetin	VSV, Poliovirus (PV)	de Brito, et al. 2018 [70]
	Phyla nodiflora	Acyclovir	HSV-2	Sharma and Renu, 2013 [71]
	Posidonia oceanica	Quercetin, hydroxybenzoic acid, phydroxybenzoic acid	HIV, H5N1 virus (influenza virus), Human papillomavirus (HPV)	Farid, et al. 2018 [72]
	Ricinus communis	Quercetin (Flavonoid)	herpes simplex type-1 (HSV-1) and vesicular stomatitis (VSV)	Marwat, et al. 2017 [73]
	Salicornia brachiata	Phenolic and flavonoid	EMCV, SFV, HBV	Patel, 2016 [74]
	Salvadora persica	Benzyl isothiocyanate	HSV-1	Ahmad and Rajagopal, 2013 [75]
	Sesbania bispinosa	Quercetin, myricetin	HSV	Goswami, et al. 2016 [76]

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	Sesuvium portulacastrum	Linolenic acid ester, Hexadecanoic acid	HBV	Manbir, 2015 [77]
	Sida cordifolia	Alkaloids and phytosterols	HSV I & II, HSV TK, Adenovirus type VIII, Poliovirus type-I, Influenza virus type A (H1N1)	Galal, et al. 2015 [78]
	Spinifex littoreus	Flavonoids and terpenoid, polyisoprenoids	AIDS	Thirunavukkarasu, et al. 2010 [7]
	Suaeda maritima	N-methyl-2,3,4-trimethoxy coricidin, flavonoid and terpenoid	Tobacco mosaic virus (TMV), HSV-1	Kokila and Anup, 2010 [79]
	Tephrosia purpurea	Quercetin (Flavonoids)	HSV-1	Kokila and Anup, 2010 [79]
	Terminalia catappa	Kaempferol, acyclovir	HSV-2	Arunkumar and Rajarajan, 2015 [80]
	Thespesia populnea	Flavone	vesicular stomatitis virus, coxsackie B4, respiratory syncytial viruses	Saravanakumar, et al. 2011 [81]
	Tinospora cordifolia	Pepsin, resins, alkaloids and saponins	HIV-AIDS	Anuya and Abhay, 2014 [82]
	Tridax procumbens	Catechins, centaurien	DENV	Saranya, et al. 2020 [83]
	Uniola paniculata	Lectins	HIV	Lonard, et al. 2014 [84]
	Vigna spp.	Iridoids and secoiridoids	HSV-1, RSV	Lim 2015 [39]
	Vitex negundo	Luteolin-7-O-(6”-malonylglucoside), Agnuside, quercetin, myricetin	SARS-CoV-2	Sangeetha and Rajarajan 2014 [55]
	Ziziphus mauritiana	Centaurien	DENV-2	Akassh, et al. 2020 [85] Riffat, et al. 2018 [86]
	Ziziphus jujuba	Betulinic acid (triterpene)	measles virus, Influenza virus	Riffat, et al. 2018 [86]
	Zoysia matrella	Pinosylvin	Influenza virus	Rupa, et al. 2016 [87]

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