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Potential of Prospective Medicinal Plants of Bangladesh for the Complementary Management of COVID-19

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Abstract:

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has been a healthcare disaster because of the unique and distinct characteristics of the pathogen, the easy and rapid transmission of the virus from humans to humans, the challenges in diagnosis and confirmation of the disease and the inability to invent and distribute safe and effective drugs or vaccines worldwide that would work against all the variants of coronavirus. Bangladesh, despite being a third-world country with limited health resources, has not been one of the worst-hit countries in the world but has still suffered with the loss of nearly eleven thousand people. Traditional and herbal remedies have become popular in this sub-continent since long ago and used for the treatment and management of different diseases including infectious disease. In this review, we have summarized the reports of immunostimulating, anti-inflammatory, antiviral, and respiratory distress syndrome improving activities of prospective indigenous plants of Bangladesh that may be recommended for use as complementary and alternative medicine or may be potential sources for the discovery and development of anti-COVID-19 medicaments. Thus, the review will be beneficial for the researchers, complementary and alternative medicines or herbal medicine manufacturers, formulators to find out and manage the potential herbal/nutraceutical/medicinal agents for the preparation of complementary and alternative medicines, as well as to the scientist for further research for the discovery and development of therapeutics/new drugs for the prevention and treatment of COVID-19 as well as other viral infections.

Keywords: COVID-19, SARS-CoV-2, traditional medicine, herbal medicine, immunomodulation, antiviral, anti-inflammatory, complementary and alternative medicine, medicinal plants, nutraceuticals, bioactive phytocompounds, Bangladesh

Introduction

A unique virus emerged in China at the end of 2019 and spread the COVID-19 (coronavirus disease-2019) outside China by February 2020 and became a pandemic ravaging the whole world (Israfil *et al.*, 2021; Shahriar and Koly, 2021). The virus was named severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) and was different from other coronaviruses, which caused the SARS (severe acute respiratory syndrome) and MERS (middle eastern respiratory syndrome) outbreak. Bangladesh has been hit hard by this deadly disease too (Hossain *et al.*, 2020; Hossain and Rahman, 2020). This disease has claimed the lives of approximately eleven thousand people in Bangladesh and over three million people worldwide (Worldometer, 2021).

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SARS-CoV-2 is a member of the family Coronaviridae and the order Nidovirales. It has a spike protein resembling the shape of a crown, and hence, it has the name coronavirus ('corona' means crown). It has an incubation period of 5-6 days, extending up to 14 days in some cases. It is spread through the droplets of an infected person who may or may not be symptomatic. The droplets can be transmitted through handshake and by being in close contact with other infected persons (Polak *et al.*, 2020; Shahriar *et al.*, 2021).

The symptoms of COVID-19 include dry cough, fever, malaise, and headache in mild cases. However, complicated cases are presented with breathlessness, low blood oxygen level, which may lead to hypoxia, the collapse of the respiratory system, and multi-organ failure in severe cases. Its mild symptoms often coincide with those of common cold and flu, but can be confirmed through reverse transcriptase polymerase chain reaction (RT-PCR) testing or a chest CT (computer tomography). The virus causes direct cell injury as well as indirect cellular damage through immune system dysfunction. Its virulence depends on the non-structural proteins (NSPS) and structural proteins including the spike glycoprotein (S). Besides, the main protease, papain-like protease, helicase, and RNA-dependent RNA polymerase enzymes also participate in the pathophysiological mechanism (Hu *et al.*, 2020; Shahriar *et al.*, 2021).

At the beginning of COVID-19 pandemic, antimicrobial and prospective other drugs were used as repurposed drugs for the treatment of COVID-19 but those drugs were found to have limited efficacy and several adverse-effects (Alam *et al.*, 2021a). There has been no drug invented that can be used safely and effectively to treat COVID-19 in all patients. The newly developed vaccines have shown some adverse-effects (Hossain *et al.*, 2021; Hossain and Rahman, 2020; Alam *et al.*, 2021b; Sultana *et al.*, 2021) and are not found to be 100% effective in controlling the spread of COVID-19 infection. In these circumstances, traditional and herbal medicinal plants can be of great interest. Ayurveda, the ancient Indian medicine system, showed us that it could lead modern scientists towards better medicines from natural sources (Alam *et al.*, 2021b). The traditional Chinese medicine (TCM) system can be of similar help as well (Fabricant and Farnsworth, 2001; Graziose *et al.*, 2010; Khanna *et al.*, 2020). Phytomedicines, medicinal plants, and functional foods are valuable sources for the discovery of lead compounds as well as using as herbal formulations, i.e. antidiabetic, anticancer, anti-inflammatory, immunomodulating, anti-HIV, antioxidant, etc. (Alam *et al.*, 2020; Kaisar *et al.*, 2011; Rahman *et al.*, 2011; Rashid *et al.*, 2000; Rouhi *et al.*, 2017; Sarker and Gohda, 2013; Sarker, 2012; Sarker *et al.*, 2011; Sarker *et al.*, 2015; Sarker *et al.*, 2016). Being a tropical country, Bangladesh is a rich source of medicinal plants. COVID-19 infection is prominently marked by acute respiratory distress syndrome, severe inflammation, vascular edema, multiple organ failure, etc. Immuno-compromised people suffer a lot (Shahriar *et al.*, 2021). Exploring the immunomodulating and antiviral activities, indigenous plants of Bangladesh can be a great source of remedies, especially for the prevention and treatment of COVID-19 infections to an extent (Sarker, 2021). In this review, we have discussed the scientific basis and potentiality of notable medicinal plants of Bangladesh that can be used for the prevention and treatment of COVID-19 infections.

Article Search Strategy

To collect data on medicinal plants of Bangladesh having therapeutic value for the prevention and treatment of COVID-19 and/or COVID-19 related complications, a literature search was performed throughout the PubMed, Web of Science, Scopus, ScienceDirect, Wiley Online Library, and Google Scholar databases. The following keywords were used while searching articles on the above databases: “COVID-19”, “SARS-CoV-2”, “phytomedicines”, “bioactive compounds”, “traditional medicinal plants”, “Bangladesh”, “indigenous medicinal plants”, “herbal medicine,” “anti-COVID-19”, “anti-inflammatory”, “anti-coagulating”, “antiviral” “immunostimulating” and “immunomodulating”.

Articles published in English language only were considered.

Prospective indigenous plants of Bangladesh with immunoboosting and antiviral activities

In this review, we have briefly presented ~~some~~ prospective medicinal plants of Bangladesh that were previously reported to exhibit anti-inflammatory, antiviral, immunostimulanting and respiratory distress syndrome improving properties. All the possible prospective plants have been summarized Table 1 along with their activity reports. It has shown us that the different parts of the plant, extracts, and isolated compounds have the potentials against inflammation, respiratory distress syndrome, viral infections, etc. Some *in-silico* studies have also shown promising ground to work against the coronavirus. The structures of some major bioactive compounds from these plants are also presented in Figure 1.

Basil *(Ocimum sanctum* L., Family: Lamiaceae)*:* Basil ('Tulsi' in Bengali language) is a holy herb according to the Hindu religion. Its medicinal property is well-reported. It has immunomodulatory, anti-inflammatory, antiviral, and adaptogenic effects. 'Tulsi' leaves are often called as 'elixir of life'. Several 'Tulsi' constituents including vicenin, ursolic acid, tulsinol A-G and isorientin 4′-*O*-glucoside 2″-*O*-*p*-hydroxybenzoagte showed strong inhibiting property against SARS-CoV-2 virus *in-silico* (Shree *et al*., 2020; Varshney *et al*., 2020). Using 'Tulsi' leaf preparations may be a beneficial choice against COVID-19.

Black cumin *(Nigella sativa* L., Family: Ranunculaceae): Black cumin or black caraway ('Kalojira' in Bengali language) is a frequently used spice and a medicinal plant. *Nigella sativa* has been reported to show the immunomodulatory, antiviral, and anti-inflammatory activities (Sarker *et al*., 2011). It has a number of bioactive constituents of different types including alkaloids, saponins, and essential oils. Several *in-silico* studies reported that its constituents, e.g., nigelledine, hederagenin, and α-hederin might be used against SARS-CoV-2 (Koshak and Koshak, 2020). Zinc supplement efficiency in managing COVID-19 might be enhanced by black cumin (Rahman, 2020). The antiviral activity of this plant makes it a likely candidate for herbal medicine against COVID-19.

Black mulberry *(Morus nigra* L., Family: Moraceae): Black mulberry ('Toot' in Bengali language) contains phenolic glycosides, prenylated flavonoids, terpenoids, coumarins etc. The jam made of berry fruits has been traditionally used to treat inflammatory diseases, like- cough, asthma, other chest complaints and rheumatism (Lim and Choi, 2019; Nomura, 1988). During COVID-19 pandemic, unani physicians have prescribed gargling with a solution of toot before sleep in the treatment of respiratory distresses (Nikhat and Fazil, 2020).

Black Pepper (*Piper nigrum* L., Family: Piperaceae): Black pepper ('Gol Morich' in Bengali language) fruit is a popular spice. Studies reported that it displayed analgesic, antipyretic and CNS stimulant activities (Emon *et al*., 2021). A study reported that it might be used as an immune booster in COVID-19. The anti-SARS-CoV-2 activity was assumed to take place through piperine, a major constituent of black pepper. It showed higher binding potential with the virus nucleocapsid and subsequent decrease of the virulence (Choudhary *et al*., 2020).

Caraway *(Trachyspermum ammi* L. *Sprague*, Family: Apiaceae)*:* Caraway seeds, also known as Ajwain ('Mouri' in Bengali language), has been proven to be effective in sore throat/dry cough and eradicating infection (Banerjee *et al*., 2020). Its oil has shown antiviral activity against encephalitis virus *in-vitro* (Roy *et al*., 2015). Its immune-boosting activity is also well-reported (Vitali *et al*., 2016). It can be proposed that its nutritional benefit may extend to the case of COVID-19.

Chebulic Myrobalan *(Terminalia chebula* Retz., Family: Combretaceae)*:* Chebulic Myrobalan ('Haritaki' in Bengali language) is a widely-known medicinal plant. Previous studies reported that it showed antiviral, antioxidant and anti-inflammatory potential. Several compounds isolated from this plant showed strong activity against a number of viruses including human immunodeficiency virus (HIV),

hepatitis B and C virus, and influenza A virus (Ajala *et al*., 2014; Ma *et al*., 2010). It is likely that this plant may boost the immunity of the people and help them in this pandemic (Haque *et al*., 2021).

Citron (*Citrus medica* L., Family: Rutaceae): Citron ('Jamir Lebu' in Bengali language) is a common fruit in Bangladesh. Its peels were reported to have phenolic compounds, ascorbic acid, iron, zinc, and other minerals. These constituents have showed immune-boosting activity in several studies (Haridas *et al*., 2021; Karetha *et al*., 2020). Hence, citron may also be used as an immune-booster in this pandemic.

Clove (*Syzygium aromaticum* L. Merr. , Family: Myrtaceae): Clove ('Labongo' in Bengali language) is also a common spice with reports of anthelmintic, antimicrobial and other activities. It was administered alone and with other herbs like metha and citrus to COVID-19 infected patients and results showed that those preparations had immune-boosting properties. Therefore, this plant may be used as a herbal immune booster alone or with other herbs and may help against COVID-19 related complications (Kanyinda, 2020).

Coconut (*Cocos nucifera* L., Family: Arecaceae): Coconut ('Narkel' in Bengali language) is a popular fruit in Bangladesh and its juice is frequently used as a drink. It may also be used as a vegetable. Previous studies reported that fruit and fiber extracts showed antioxidant, antiviral, and antibacterial activities. It was thought to be used in COVID-19 as well. A compound from coconut fruit, α-tocotrienol, was found to have the potential to inhibit COVID-19 progression *in-silico* (Fitriani *et al*., 2020). Besides, *in-vitro* antiviral activity against herpes simplex virus was also displayed by the fiber extracts of coconut (Esquenazi *et al*., 2002). Its use in everyday life may have rewarding consequences.

Creat *(Andrographis paniculata* (Burm.f.) Nees., Family: Acanthaceae)*:* Creat ('Kalomegh' or 'Chirotta' in Bengali language) is a widely used medicinal plant. It has anti-inflammatory, anti-hypertensive, anti-cancer and hepatoprotective properties. Dihydroxy dimethoxy flavone, andrographolide, and neoandrographolide, isolated from this plant, showed strong binding affinity for the SARS-CoV-2 virus active site *in-silico* (Murugan *et al*., 2020; Rajagopal *et al.*, 2020; Sukardiman *et al.*, 2020). Creat extract also showed immune-boosting and antiviral activity *in-vitro* against retro virus (Churiyah *et al.*, 2015). Using 'Kalomegh' preparations for protecting one's heath against COVID-19 may be beneficial.

Flaxseed (*Linum usitatissimum* L., Family: Linaceae): Flaxseed ('Tishi' in Bengali language) has been proven to be a magical food responsible for several potential actions like antihypertensive, cholesterol lowering, antiatherogenic, anti-inflammatory, and relief of arrythmia (Parikh *et al.*, 2018). The main constituent responsible for the variety of activities is proven to be α-linoleic acid, also known as omega-3 fatty acid, which is extremely beneficial for the treatment of arterial disorders and asthma. Thus, flaxseed may possess some activity against SARS-CoV-2 infection by acting as an immune booster (Samal *et al*., 2020).

Garlic (*Allium sativum* L., Family: Amaryllidaceae): Garlic (Roshun in Bengali language) is a common condiment. Studies reported that it as well as its constituents, e.g., allicin and ajoene, displayed antiviral property against influenza A and B virus, HIV, rhinovirus and herpes simplex virus. Computational study found that a number of its constituents showed potential activity against SARS-CoV-2. Its anti-COVID-19 activity may work through constituents like quercetin, allicin and alliin (organosulfur and flavonoid compounds) (Khubber *et al*., 2020; Pandey *et al*., 2021). It also displayed immune-boosting activity which functioned through the enhancement of the activity and number of natural killer cells and several cytokines (Wang *et al.*, 2010). Daily intake of garlic may boost the immune system and protect from this disease (Donma and Donma, 2020).

Giloy (*Tinospora cordifolia* (Willd.) Miers, Family: Menispermaceae): Giloy ('Guloncho' in Bengali language) is popular medicinal plant which has been used to treat disease like rheumatism,

inflammation, allergy and jaundice. Studies also reported that it had immune-booster effects. Berberine and tinocordiside, major constituents of 'Giloy', showed potential for inhibition of viral replication of SARS-CoV-2 *in silico* through modulating viral protease activity (Chowdhury, 2020; Kumar and Chander, 2020; Shree *et al.*, 2020).

Ginger (*Zingiber officinale* L., Family: Zingiberaceae): Ginger ('Ada' in Bangali language) is a 'generally recognized as safe' (GRAS) spice which has been reported to possess anti-inflammatory, antioxidant, anti-emetic, broncho-protective, and several other properties (Mao *et al.*, 2019). A study reported moderate reduction of inflammatory mediators like tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) by ginger preparations resulting in a reduction of exhaustion, inflammation and infection (Magzoub, 2020). Besides, humoral immunity was also found to be boosted by ginger extracts (Carrasco *et al.*, 2009). It is likely that ginger may boost the immune system against SARS-CoV-2 through its anti-inflammatory, antioxidant and immunomodulatory activities.

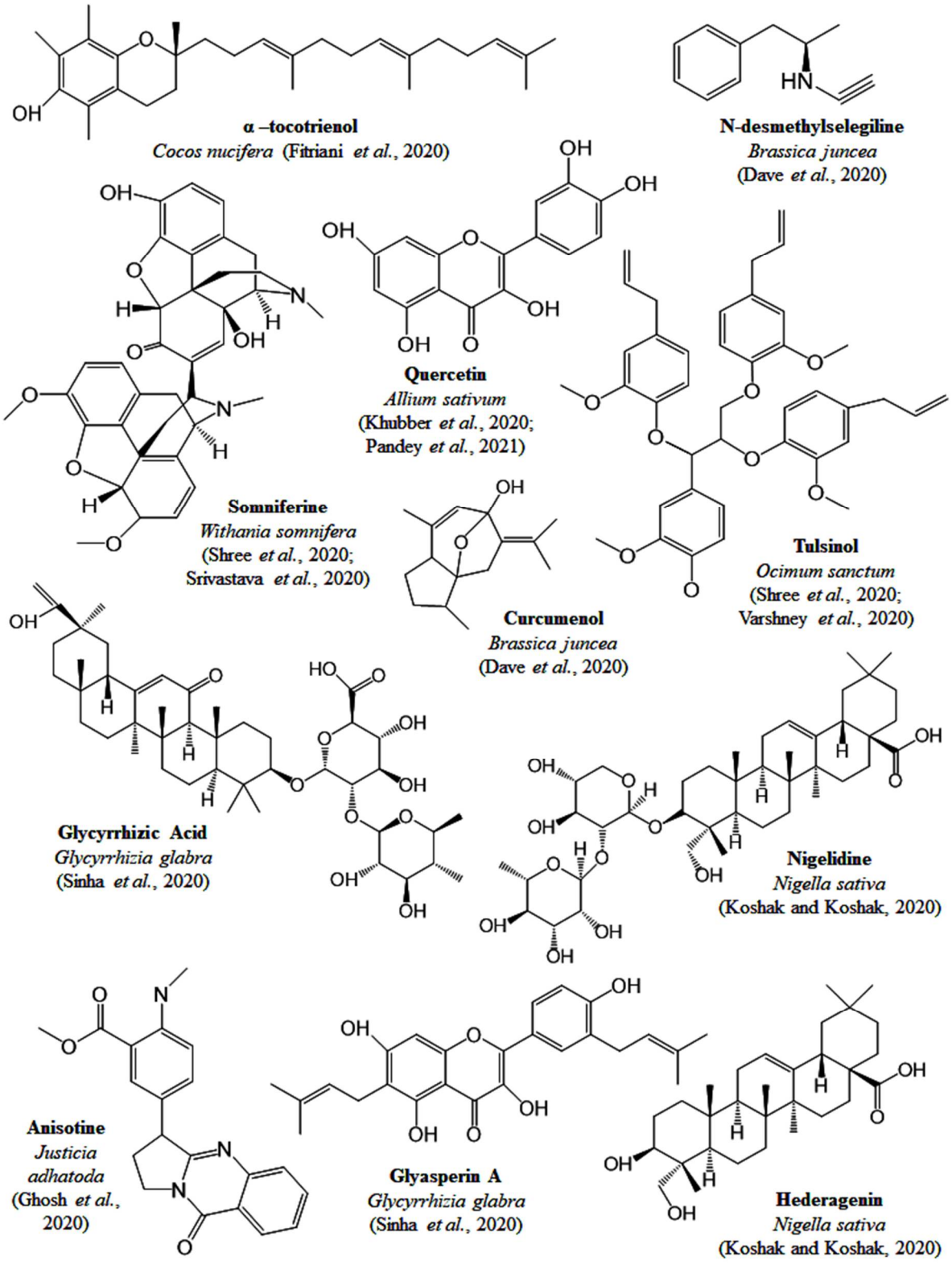
Golden shower tree (*Cassia fistula* L., Family: Fabaceae): Golden shower tree ('Shonalu' in Bangali language) is a flowering plant found in tropical and sub-tropical parts of the world. The plant possesses potential immunomodulatory, antioxidant, hepatoprotective, anti-inflammatory properties etc. (Chaerunisaa *et al.*, 2020; Rahmani, 2015). Moreover, standardized formulations of this plant have been used as hand sanitizers and soaps (Killedar and Nale, 2014). A study reported significant stimulatory effect of *C. fistula* in cell-mediated immunity on rats without affecting the humoral immunity (Jadhav, 2014). In 2020, Tiwari Pandey *et al.* postulated that its leaf extract possesses anti-infective potencies against multidrug resistant strains reported in co-infections with bacterial and fungal origin (Tiwari *et al.*, 2020). Therefore, *C. fistula* would be an effective treatment option in COVID-19 associated co-infections.

Gymnema (*Gymnema sylvestre* R. Br., Family: Apocyanaceae): Gymnema ('Gurmar' in Bengali language) has been used as a medicinal plant in Bangladesh. It has been known for its anti-inflammatory, immunomodulatory, and antioxidant activity (Saneja *et al.*, 2010). Its antiviral activity is also well-reported (Porchezhian and Dobriyal, 2003). Phytochemicals of this plant have the potential to be used in COVID-19 treatment, as found in a computational study (Subramani *et al.*, 2020). Its anti-COVID-19 activity may be characterized through its antioxidant and immunomodulatory properties.

Indian Ginseng (*Withania somnifera* L. Dunal, Family: Solanaceae): Indian Ginseng, which is also called Poison Gooseberry, ('Ashwagandha' in Bengali language) is a common medicinal plant in the Indian subcontinent and known as a rejuvenator and longevity enhancer in Ayurveda, ancient Indian medicine system. This plant was reported to possess anti-inflammatory, neuroprotective, immunomodulatory, and anti-cancer properties. *In silico* studies reported that somniferine and withanoside V, compounds isolated from this plant, showed strong potential for inhibiting COVID-19 disease progression (Shree *et al.*, 2020; Srivastava *et al.*, 2020). Its extracts showed effectiveness against herpes simplex virus (Kambizi *et al.*, 2007). This plant has the potential to be used as an immune booster in this pandemic.

Indian Mustard (*Brassica juncea* L. Czern., Family: Brassicaceae)*:* Indian mustard ('Shorisha' in Bengali language) is a popular condiment in Bangladesh. It is grown as a root and leaf vegetable and as an oilseed. It has phyto-remediating properties (Mazumder *et al.*, 2020). Antiviral activity of this plant against influenza virus was found through *in-vitro* studies (Lee *et al.*, 2014). Curcumenol and *N*-Desmethylselegiline, two constituents of this plant, showed potential to be selective and strong lead compound against COVID-19 *in-silico* (Dave *et al.*, 2020). Further studies are required to make conclusive decision in this regard.

Licorice (*Glycyrrhiza glabra* L., Family: Fabaceae): Licorice ('Joshtimodhu' in Bangali language) is a well-known medicinal plant in



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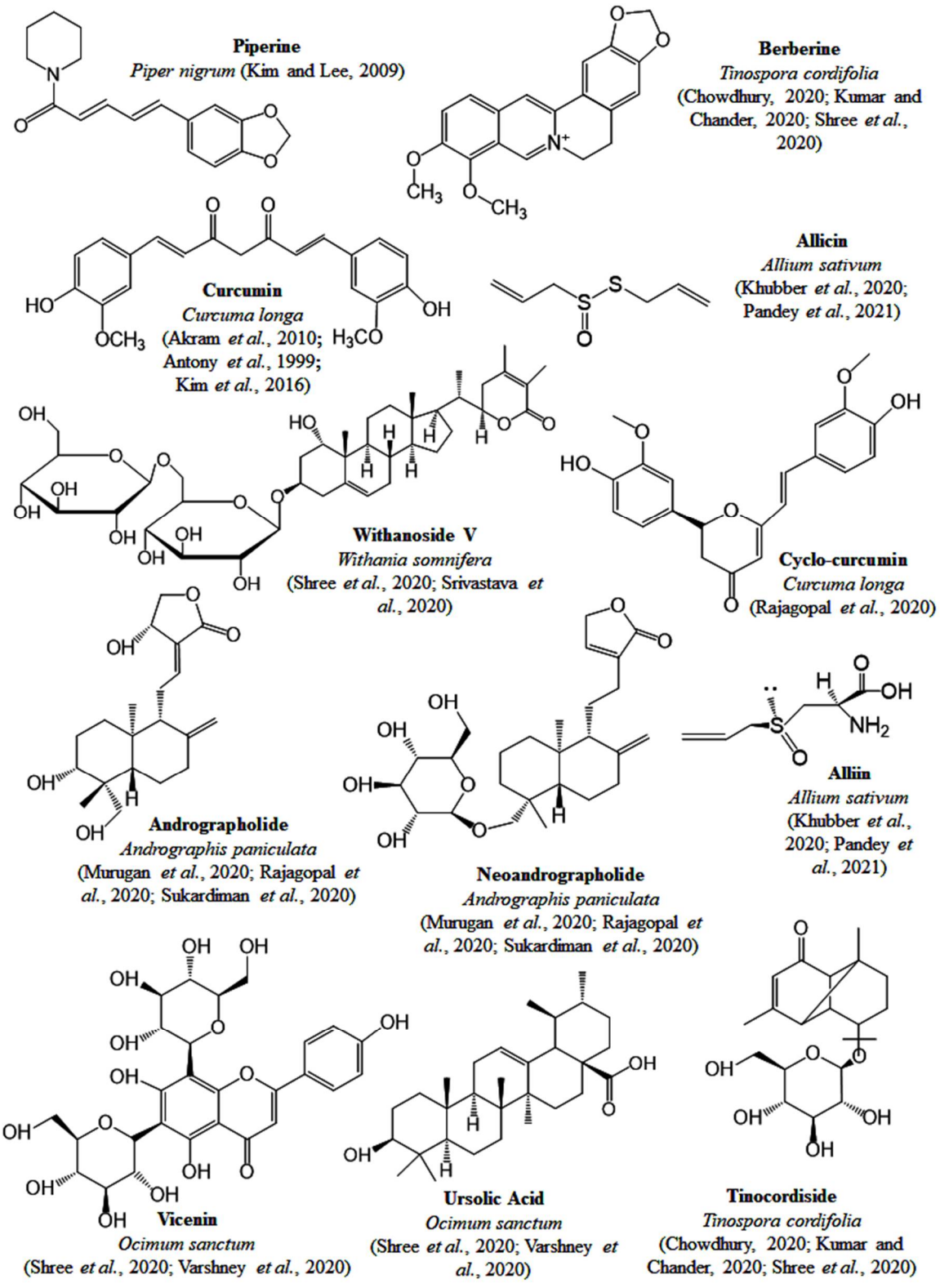

Figure 1. Structures of potential immunostimulating, anti-inflammatory and antiviral phytoconstituents in prospective indigenous plants of Bangladesh

Bangladesh. Its antiviral, antibiotic and immunomodulatory properties are well-reported. Several constituents of licorice, e.g., glyasperin A and glycyrrhizic acid, displayed strong binding potential to SARS-CoV-2 spike protein and non-structural proteins (Sinha *et al*., 2020). Its use in COVID-19 may be advantageous.

Malabar nut (*Justicia adhatoda* L., Family: Acanthaceae): Malabar nut ('Basok' in Bengali language) is a widely-used medicinal plant. Its leaves have been reported to contain alkaloids and other phytochemicals which were found to have antiviral, antibacterial, and immunomodulatory activities. Such an alkaloid, anisotine, was found to be potentially active *in-silico* against SARS-CoV-2 protease enzymes (Ghosh *et al*., 2021). Besides, *in-vitro* studies reported that its extracts were effective against influenza virus (Chavan and Chowdhary, 2014). This plant may be a potentially beneficial immune booster in this pandemic.

Moringa (*Moringa oleifera* Lam., Family: Moringaceae): Moringa ('Shojina' in Bengali language) is a common vegetable in Bangladesh. It has been reported to display anti-inflammatory, antioxiadent, antiviral, and anticancer activities. It is also an immune booster. Studies showed that hand sanitizers made by using its leaves could help prevent the transmission of COVID-19 (Arifan *et al*., 2021). *In-silico* studies found that its compounds, e.g., pterygospermin, quercetin, and kaempferol, might work against SARS-CoV-2 (Fitriani *et al*., 2020; Shaji, 2020). Regular intake of moringa may be advantageous.

Neem (*Azadirachta indica A. Juss., Family: Meliaceae):* Neem ('Neem' in Bengali language), alternatively known as neem or Indian lilac, possesses incredible antiviral activity. The leaf extract of neem was previously proven active against coxsackievirus B-4 due to the possession of azadirachtin. Thus, it might act as an immune booster against COVID-19 (Das *et al*., 2020).

Onion (*Allium cepa* L., Family: Amaryllidaceae): Onion ('Piyaj' in Bengali language) is a widely used condiment in Bangladesh. It has been reported to have antiviral activity in several studies. Phytoconstituents of onion, e.g., alliin, oleanolic acid, and S-propyl cysteine, showed virus protein and genetic material blocking activity. *In-silico* studies also found its potential against COVID-19 virus (Fitriani *et al*., 2020; Pandey *et al*., 2021). Regular use of onion may be useful against COVID-19 through this immune booster property.

Pomegranate (*Punica granatum* L., Family: Lythraceae): Pomegranate ('Anar' in Bengali language) fruit juice possesses antimicrobial, antifungal, antiviral, antioxidant,immunity-boosting, and anti-carcinogenic properties (Bassiri-Jahromi, 2018; Karimi *et al*, 2017; Ricci *et al*, 2006; Singh *et al*., 2002). The fruit contain high amount of vitamin C and E which can defend us from severe infections by augmenting the production of antibodies in our body (Baidya and Sethy, 2020). Unani scholars are prescribing this fruit juice in the treatment of COVID-19, since they asserted that it has cleansing effect on body humors (Nikhat and Fazil, 2020).

Tamarind (*Tamarindus indica* L., Family: Fabaceae): Tamarind ('Tetul' in Bengali language) plants grow naturally and are also cultivated in tropical and sub-tropical regions of the world for their fruits. For centuries, the pulp of the fruit is used to prepare beverages, confectionaries and also widely used as traditional medicine in treating different ailments. The polyphenols and tannins in tamarind have antioxidant, anti-inflammatory and analgesic properties (Siddhuraju, 2007). Furthermore, they contain vitamin C which can potentiate the immune system as well as prevent microbial and fungal infections (De*et al*., 2009).In 1993, Sreelekha, *et al.*, isolated a polysaccharide from *T. indica* which exhibited immunomodulatory properties like phagocytic enhancement and inhibition of leukocyte migration during cell proliferation (Sreelekha *et al.*, 1993). The pulp of the fruit is being prescribed by unani practitioners as health protective drug in COVID-19 epidemic (Nikhat and Fazil, 2020).

Tea (*Camellia sinensis L.* Kuntze, Family: Theaceae)*:* Tea ('Cha' in Bengali language) can provide very proficient immunomodulatory and

Table 1. Medicinal plants/Natural products of Bangladesh with reported anti-inflammatory, antiviral, immunostimulanting, and respiratory distress syndrome improvement activities

Name (Bangla Name)	Scientific Name (Family)	Test sample	Activity	References
Basil (Tulsi)	*Ocimum sanctum* L. (Lamiaceae)	Fixed oils	Anti-inflammatory	Singh (1998)
		Aqueous extract	Anti-inflammatory	Reshma and Brindha (2014)
		Terpenoid and polyphenol extracts from leaves	Antiviral	Ghoke *et al.* (2018)
		Aqueous extract	Immunostimulant	Jeba *et al.* (2011)
		Seed oil	Immunostimulant	Mediratta *et al.* (2002)
		Fixed oil	Resist respiratory tract infection	Saini *et al.* (2009)
		Vicenin, ursolic acid, tulsinol A-G and isorientin 4′-*O*-glucoside 2″-*O*-*p*-hydroxybenzoate	Showed strong inhibiting property against SARS-cov-2 virus *in-silico*	Shree *et al.* (2020); Varshney *et al.* (2020)
Black cumin (Kalojira)	*Nigella sativa* L. (Ranunculaceae)	Aqueous extract	Anti-inflammatory	Al-Ghamdi (2001)
		Seed polyphenols	Anti-inflammatory	Ghannadi *et al.* (2005)
		Aqueous extract	Immunostimulant	Boskabady *et al.* (2011)
		Ethanolic extract	Polyclonal IgM production	Sarker *et al.* (2011)
		Volatile oil	Increases the respiratory rate and the intratracheal pressure	El Tahir *et al.* (1993)
		Nigelledine, hederagenin, and α-hederin.	Moderate anti-covid-19 property found according to *in-silico* study	Koshak and Koshak (2020)
		Seeds	Zinc supplement efficiency in managing covid-19 might be enhanced by black cumin	Rahman (2020)
Black mulberry (Toot)	*Morus nigra* L. (Moraceae)	Total flavonoids extract from fruit powder	Anti-inflammatory	Chen *et al.* (2016)
		Morniga M (mannose-specific lectin) from the bark	Antiviral	Keyaerts *et al.* (2007)
		Crude root bark extract, isolated compounds (Diels-Alder-type adduct) from the root bark extract	Anti-tuberculosis activity	Mascarello *et al.* (2018)
Black pepper (Gol Morich)	*Piper nigrum* L. (Piperaceae)	Essential oil	Anti-inflammatory	Jeena *et al.* (2014)
		Alkaloids isolated from fruit extract	Anti-inflammatory	Pei *et al.* (2020)
		Piperamides isolated from fruit extract and piperine alkaloid extracts from seeds	Antiviral	Mair *et al.* (2016)
		Fruit extract	Immunostimulant	Sunila and Kuttan (2004); Sarker (2012)
		Piperine (isolated compound)	Anti-asthmatic	Kim and Lee (2009)
			Higher binding potential with the virus nucleocapsid and subsequent decrease of the virulence seen as per *in-silico* studies	Choudhary *et al.* (2020)

Name (Bangla Name)	Scientific Name (Family)	Test sample	Activity	References
Caraway (Mouri)	*Trachyspermum ammi* (L.) Sprague (Apiaceae)	Aquo-alcoholic seed extract	Anti-inflammatory	Umar *et al.* (2012)
		Essential oil	Antiviral	Roy *et al.* (2015)
		n-hexane, chloroform, and methanol seed extract	Immunostimulant	Siddiqui *et al.* (2019)
		Novel glycoprotein isolated from aqueous extract	Immunostimulant	Shruthi *et al.* (2017)
		Essential oil	Antibacterial activity against bacterial pneumonia	Mehdi *et al.* (2014)
Chebulic Myrobalan (Haritaki)	*Terminalia chebula* Retz. (Combretaceae)	Hydro-alcoholic fruit extract	Anti-inflammatory	Bag *et al.* (2013)
		Fruit extract, chebulagic acid and chebulinic acid	Antiviral	Kesharwani *et al.* (2017)
		Fruit extract	Immunostimulant	Haque *et al.* (2021); Shivaprasad *et al.* (2006)
		Water-Extracted Polysaccharide from fruit	Antitussive	Nosalova *et al.* (2013)
Citron (Jamir Lebu)	*Citrus medica* L. (Rutaceae)	Fruit extract, flower extract, leaves extract	Anti-inflammatory	Menichini *et al.* (2011)
		Rhoifolin, Naringin, Neohesperidin, Apigenin 6,8-di-C-glucoside, Hesperidin, Xanthin	Antiviral	Haridas *et al.* (2021)
		Fermented fruit extract	Immunostimulant	Huber *et al.* (2012)
		Fruit juice, ethanolic extracts of root, leaf, bark, peel and pulp	Antimicrobial activity against bacterial pneumonia pathogen	Sah *et al.* (2011)
Clove (Labongo)	*Syzygium aromaticum* ((L.) Merr. (Myrtaceae)	Flower bud extract	Anti-inflammatory	Tanko *et al.* (2008)
		Eugeniin	Antiviral	Kurokawa *et al.* (1998)
		Novel green silver nanoparticles produced using aqueous buds extract	Antiviral	Mehmood *et al.* (2020)
		Clove extract and essential oil	Immunostimulant	Bachiega (2012)
		Essential oil	Antibacterial activity in respiratory infections	Inouye *et al.* (2001)
Coconut (Narkel)	*Cocos nucifera* L. (Arecaceae)	Crude extract	Anti-inflammatory	Rinaldi *et al.* (2009)
		Crude extract, polyphenolics from husk fiber extract	Antiviral	Esquenazi *et al.* (2002)
		Coconut protein	Immunostimulant	Vigila and Baskaran (2008)
		Synthesized silver nanoparticles using inflorescence extract	Antibacterial activity	Mariselvam*et al.* (2014)
		α-tocotrienol from coconut fruit	*In-silico* study displayed anti-covid-19 activity	Fitriani *et al.* (2020)
Creat (Kalomegh or Chirotta)	*Andrographis paniculata* (Bum.f.) Nees (Acanthaceae)	Whole plant extract	Anti-inflammatory	Sheeja *et al.* (2006)
		Crude extract, Ent-labdene Diterpenes isolated from extract	Antiviral	Wiart *et al.* (2005)
		Ethanolic extract	Antiviral	Churiyah *et al.* (2015)
		Ethanolic extract	Immunostimulant	Churiyah *et al.* (2015)
		Crude drug, standardized extract	Alleviates symptoms of uncomplicated upper respiratory tract infection (urti)	Coon and Ernst (2004)
		Dihydroxy dimethoxy flavone, andrographolide, and neoandrographolide	Showed strong binding affinity for the sars-cov-2 virus active site *in-silico*	Murugan *et al.* (2020); Rajagopal *et al.* (2020); Sukardiman *et al.* (2020)

Name (Bangla Name)	Scientific Name (Family)	Test sample	Activity	References
Neem	*Azadirachta indica* A. Juss. (Meliaceae)	Leaves and bark extract	Anti-inflammatory	Okpanyi and Ezeukwu (1981)
		Polysaccharides from leaves extract	Antiviral	Faccin-Galhardi *et al.* (2012)
		Neem oil	Immunostimulant	Upadhyay *et al.* (1992)
		Leaf extract	Protective effects against pulmonary inflammation	Lee *et al.* (2017)
Onion (Piyaj)	*Allium cepa* L. (Amaryllidaceae)	Volatile sample extracted from freeze-dried onion sprout	Anti-inflammatory	Takahashi (2008)
		Essential oil	Antiviral	Romeilah *et al.* (2010)
		Scale Extract	Immunostimulant	Elberry *et al.* (2014)
		Methanolic extract	Anti-asthmatic	Oliveira *et al.* (2015)
		Fleshy edible part of the plant	Prevents carbon monoxide-induced lung tissue toxicity	Ogadinma *et al.* (2018)
Pomegranate (Anar)	*Punica granatum* L. (Lythraceae)	Purified pomegranate polyphenol extract	Antiviral	Haidari *et al.* (2009)
		Peel extract	Immunostimulant	Labsi *et al.* (2016)
		Leaf extract	Anti-inflammatory effects on acute lung inflammation	Costa Rodrigues Pinheiro (2018)
		Leaves extract	*In-vitro* anti-cancer effect in lungs	Li *et al.* (2016)
Tamarind (Tetul)	*Tamarindus indica* L. (Fabaceae)	Seeds	Anti-inflammatory	Suralkar *et al.* (2012)
		Stem bark extract	Antiviral	Okoh *et al.* (2017)
		Polysaccharide pst001 isolated from the seed kernel	Immunostimulant	Aravind *et al.* (2012)
		Leaf extract	Anti-asthmatic activity	Tayade *et al.* (2009)
Flaxseed (Tishi)	*Linum usitatissimum* L. (Linaceae)	Fixed oil	Anti-inflammatory	Kaithwas *et al.* (2011)
		Plant extract	Antiviral	Mouhajir *et al.* (2001)
		n-butanol fraction of flaxseed	Immunostimulant	Kasote *et al.* (2012)
		Flaxseed oil	Immunostimulant	Gaber and Badawy (2019)
		Flax seeds derived lignan	Reduction of oxidative lung damage and decreased lung fibrosis	Lee *et al.* (2009)
Garlic (Roshun)	*Allium sativum* L. (Amaryllidaceae)	Garlic oil	Anti-inflammatory	Hussein *et al.* (2017)
		Thiacremone	Anti-inflammatory	Hussein *et al.* (2017)
		Aged garlic extract	Immunostimulant	Londhe (2011)
		Garlic extract	Anti-inflammatory	Weber *et al.* (1992)
		Garlic extract	Antiviral	Meléndez-Villanueva *et al.* (2019)
		Aqueous extract in gold nanoparticles	Antiviral	Shojai *et al.* (2016)
		Aqueous extract	Antiviral	Choi (2018)
		Garlic oil	Antiviral	Hussein *et al.* (2017)
		Raw garlic extract	Immunostimulant	Londhe (2011)
		Diallyl disulfide	Induction of apoptosis in human non-small cell lung carcinoma h1299 cells	Cao *et al.* (2008)
		Quercetin, allicin and alliin	*In-silico* promising activity against covid-19	Khubber *et al.* (2020); Pandey *et al.* (2021)

Name (Bangla Name)	Scientific Name (Family)	Test sample	Activity	References
Giloy (Guloncho)	*Tinospora cordifolia* (Thunb.) Miers *(Menispermaceae)*	Aqueous extract	Anti-inflammatory	Patgiri *et al.* (2014)
		Aqueous extract	Anti-inflammatory	Birla *et al.* (2019)
		Root extract	Antiviral	Mittal *et al.* (2014)
		Ethanol and petroleum ether extract	Immunostimulant	Sudhakaran *et al.* (2006)
		Sedimented aqueous extract	Immunostimulant	Bishayi *et al.* (2002)
		Leaf extract	Toxic against human lung adenocarcinoma cell line a549	Mittal *et al.* (2020)
		Aqueous ethanolic extract	Decreased airway hyper-responsiveness, anti-asthmatic	Tiwari *et al.* (2014)
		Berberine and tinocordiside	Showed potential for inhibition of viral replication of sars-cov-2 *in-silico* through modulating viral protease activity	Chowdhury (2020); Kumar and Chander (2020); Shree *et al.* (2020)
Ginger (Ada)	*Zingiber officinale* Roscoe (Zingiberaceae)	Fresh rhizomes	Anti-inflammatory	Mahluji *et al.* (2013)
		Hydro-alcoholic extract	Anti-inflammatory	Penna *et al.* (2003)
		Hot water extracts of fresh ginger	Antiviral	Chang *et al.* (2013)
		Aquatic plant extract	Antiviral	Kaushik *et al.* (2020)
		Rhizome	Immunostimulant	Amri and Touil-Boukoffa (2016)
		Essential oil	Immunostimulant	Carrasco *et al.* (2009)
		Hydro-alcoholic extract of rhizome	Attenuated rat trachea hyperreactivity (rthr) and exerted anti-inflammatory effect on lung inflammation	Aimbire *et al.* (2007)
Golden shower tree (Shonalu)	*Cassia fistula* L. (Fabaceae)	Aqueous and methanolic extracts	Anti-inflammatory	Ilavarasan and Venkataraman (2005)
		Rhein	Anti-inflammatory	Antonisamy *et al.* (2019)
		Callus culture	Antiviral	Arora *et al.* (2016)
		Hot aqueous extract of pods and leaves	Immunostimulant	Laxmi *et al.* (2015)
Gymnema (Gurmar)	*Gymnema sylvestre* R. Br. (Apocyanaceae)	Aqueous extract of leaves	Anti-inflammatory	Diwan *et al.* (1995)
		Methanolic extract	Anti-inflammatory, Immunostimulant	Khan *et al.* (2019)
		Gymnemagenol	Antiviral	Khanna *et al.* (2011)
		Methanolic extract of leaf	Immunostimulant	Singh *et al.* (2015)
Indian Ginseng (Ashwagandha)	*Withania somnifera* (L.) Dunal (Solanaceae)	Root powder	Anti-inflammatory	Gupta and Singh (2014)
		Hydro-alcoholic extract	Anti-inflammatory	Chandra *et al.* (2012)
		Hydro-alcoholic root extract	Antiviral	Pant *et al.* (2012)
		Water extract from leaves	Antiviral	Mofed *et al.* (2020)
		Withaferin A	Antiviral	Cai *et al.* (2015)
		Ethanolic extract	Immunostimulant	Harikrishnan *et al.* (2012)
		Root extract	Immunostimulant	Zhou and Zhang (2008)
		Bioactive fraction-withanolide D	Significantly inhibited the metastatic colony formation of the melanoma in lungs	Leyon and Kuttan (2004)
		Root powder	Tumor-preventing activity against Urethane-induced lung adenomas	Singh *et al.* (1986)
		Root powder	Protective effect in monocrotaline-induced pulmonary hypertension	Kaur *et al.* (2015)
		Somniferine and withanoside V	*In-silico* studies displayed promising inhibition of covid-19.	Shree *et al.* (2020); Srivastava *et al.* (2020)

Name (Bangla Name)	Scientific Name (Family)	Test sample	Activity	References
Indian mustard (Shorisha)	*Brassica juncea* (L.) (Brassicaceae)	Petroleum ether and ethanolic extracts	Anti-inflammatory	Sindhoor *et al.* (2012)
		Methanolic seeds extract	Anti-inflammatory	Chouhan *et al.* (2014)
		Subcritical water extract	Antiviral	Lee *et al.* (2014)
		Ethanol extract	*In-vitro* anti-cancer activities against lung cancers	Kwak *et al.* (2016)
		Curcumenol and *N*-desmethylselegiline	*In-silico* studies displayed promising inhibition of COVID-19	Dave *et al.* (2020)
Licorice (Joshtimodhu)	*Glycyrrhiza glabra* L. (Fabaceae)	Hydro-alcoholic extract	Anti-inflammatory	Nirmala and Selvaraj (2011)
		Leaf extracts	Anti-inflammatory	Frattaruolo *et al.* (2019)
		Food	Antiviral	Pastorino *et al.* (2018)
		Glycyrrhetinic acid	Antiviral	Pastorino *et al.* (2018)
		Aqueous liquorice extract and its combination with zinc	Immunostimulant	Mazumder *et al.* (2012)
		Aqueous methanolic extract	Immunostimulant	Hussain *et al.* (2017)
		Aquo-alcoholic extract	Effective against lung infection caused by *pseudomonas aeruginosa*	Chakotiya *et al.* (2017)
		Glycyrrhizin extracted from root	Reduced the development of acute lung inflammation (pleurisy)	Menegazzi *et al.* (2008)
		Glycyrrhizin	Anti-inflammatory and protective effects in pulmonary inflammation	Lee *et al.* (2019)
		Glyasperin A and glycyrrhizic acid	Displayed strong binding potential to SARS-cov-2 spike protein and non-structural proteins *in-silico*	Sinha *et al.* (2020)
Malabar nut (Basok)	*Justicia adhatoda* L. (Acanthaceae)	Aqueous extracts from leaves	Anti-inflammatory	Kaur *et al.* (2013)
		Ethanolic extract of roots	Anti-inflammatory	Mulla *et al.* (2010)
		Aqueous extract	Antiviral	Chavan and Chowdhary (2014)
		Methanolic extract	Antiviral	Chavan and Chowdhary (2014)
		Aqueous extract	Antiviral	Wilson *et al.* (2021)
		Methanolic, chloroform and diethyl extracts of leaves	Immunostimulant	Vinothapooshan and Sundar (2011)
		Leaf extract	Cytotoxic effect on human lung carcinoma cell line	Latha *et al.* (2018)
		Anisotine	Found to be potentially active *in-silico* against sars-cov-2 protease enzymes	Ghosh *et al.* (2020)

Name (Bangla Name)	Scientific Name (Family)	Test sample	Activity	References
Moringa (Shojina)	*Moringa oleifera* Lam. (Moringaceae)	Aqueous root extract	Anti-inflammatory	Ndiaye *et al.* (2002)
		Aqueous extract	Anti-inflammatory	Rao *et al.* (1999)
		Alcoholic extract of the dry pulverized flowers	Anti-inflammatory	Alhakmani *et al.* (2013)
		Ethanolic extract	Anti-inflammatory	Usman and Barhate (2012)
		Petroleum ether extract	Anti-inflammatory	Usman and Barhate (2012)
		Distilled water extract	Anti-inflammatory	Usman and Barhate (2012)
		Chloroform extract	Anti-inflammatory	Usman and Barhate (2012)
		Aqueous seed extract	Antiviral	Chollom *et al.* (2012)
		Seeds	Antiviral	Xiong *et al.* (2021)
		Leaves aqueous extract	Antiviral	Nasr-Eldin *et al.* (2017)
		Leaf extract	Antiviral	Younus *et al.* (2016)
		Hot aqueous and ethanolic extract	Immunostimulant	Deshmukh *et al.* (2015)
		Methanolic extract	Immunostimulant	Sudha *et al.* (2010)
		Ethanolic extract	Immunostimulant	Gupta *et al.* (2010)
		Seed kernels	Anti-asthmatic	Agrawal and Mehta (2008)
		Methanolic extract and low doses of gamma radiation	Alleviated amiodarone-induced lung toxicity	Hasan *et al.* (2016)
		n-Butanol extract of seeds	Tidal volume is decreased and respiration rate is increased	Mahajan *et al.* (2009)
Camellia sinensis or Tea (Cha)	*Camellia sinensis* (L.) Kuntze (Theaceae)	Root extract	Anti-inflammatory, Immunostimulant	Chattopadhyay *et al.* (2004)
		Two saponins ts-1&ts-2 isolated from root extract	Anti-inflammatory	Sur *et al.* (2001)
		Ethanol extract & apigallocethechin gallate	Anti-inflammatory	Novilla *et al.* (2017)
		Leaves	Antiviral	Zaher *et al.* (2008)
		Powder	Immunostimulant	Abbas *et al.* (2017)
		Leave extract	Immunostimulant	Rahayu *et al.* (2018)
		Aqueous extract	Potent anti-asthmatic	Heo *et al.* (2008)
Turmeric (Holud)	*Curcuma longa* L. (Zingiberaceae)	Curcumin	Anti-inflammatory	Akram *et al.* (2010)
		Essential oil of turmeric	Anti-inflammatory	Liju *et al.* (2011)
		Aqueous extract	Antiviral	Kim *et al.* (2009)
		Alcoholic extract	Antiviral	Ichsyani *et al.* (2017)
		Curcumin	Immunostimulant	Antony *et al.* (1999)
		Turmerones	Immunostimulant	Yue *et al.* (2010)
		Aqueous extract	Immunostimulant	Sengupta *et al.* (2011)
		N-hexane extract	Activity against lung cancer	Mohammad *et al.* (2010)
		Curcumin	Protective effect on lps-induced acute lung injury	Kim *et al.* (2016)
		Curcumin and cyclocurcumin.	Found to be potentially active *in-silico* against sars-cov-2 protease enzymes. Cyclocurcumin was found to be more potent in this regard than remdesivir, an FDA-approved (for emergency use) drug for COVID-19.	Rajagopal *et al.* (2020)

anti-inflammatory effect on lungs, precisely due to the presence of catechin (Rahardiyan, 2019). Catechin is assumed to be active against SARS-CoV-2 protease and with some other immune booster, prepared tea, especially green tea, can be used as an initial preventive measure against COVID-19 (Das *et al*., 2020).

Turmeric (*Curcuma longa* L., Family: Zingiberaceae): Turmeric ('Holud' in Bangali language) roots (dried and powdered) have been used as a spice, a dye, and a herbal drug for a long time. Studies have reported it's anti-inflammatory, anti-cancer, antioxidant, hypolipidemic, and other health benefits. *In-silico* studies found that several constituents of this plant, e.g., curcumin and cyclocurcumin, showed strong binding potential to the active site of the COVID-19 causing virus. Cyclocurcumin was found to be more potent in this regard than remdesivir, a FDA-approved (for emergency use) drug for COVID-19 (Rajagopal *et al*., 2020). Its immune-enhancing property may help the people fight the virus (Kumar and Chander, 2020).

The reported medicinal plant materials can be used for the preparation of complementary and alternative medicines or can be used individually or collectively with proper scientific evidence of Pharmacological and Toxicological studies for the prevention and treatment of COVID-19 infections.

Conclusion

From the information depicted in the Table1, it is clear that presented plants have scientific evidences to be effective against inflammation, potentiate immunity, counteract viral infection and overcome respiratory distress syndrome to an extent and hence can be used for the preparation of complementary and alternative medicaments for the prevention and treatment of those diseases. It opens the gateway for extensive research to evaluate their potentiality against corona virus, which might lead us to get some lead compounds. Besides, herbal formulators might use this information to formulate new medicaments for treating COVID-19 pathological states. These plants might improve the health conditions before and after COVID-19 infection of general peopleif used as a supplement. This review thus will educate people regarding the potentials and benefits of medicinal plants. Along with vaccines and other medicaments, it might impose the protection and boost the healing against coronavirus infection.

List of Abbreviations

COVID-19: Coronavirus disease 2019; SARS-CoV-2: Severe acute respiratory syndrome coronavirus-2; MERS: Middle Eastern respiratory syndrome; RT-PCR: Reverse transcription polymerase chain reaction; CT: Computer tomography; NSPS: Non-structural proteins; RNA: Ribonucleic acid; HIV: Human immunodeficiency virus, TCM: Traditional Chinese medicine

Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

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MMRS and MAR conceptualized the project. SS and MAS wrote the manuscript draft. TJ, STM and RR performed extensive literature search and collected relevant articles. MSR critically reviewed the manuscript. MMRS and MAR critically evaluated, thoroughly revised the manuscript and supervised the project.

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