

Full Length Research Paper

Epidemiological status of coronavirus diseases and the remedy potentials of medicinal plants in Africa

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This work aims to explore the epidemiological status of coronavirus disease (COVID-19) and assemblage of various plant species that have prophylactic or therapeutic potentials on the disease. Epidemiological data were obtained from various health authorities worldwide and articles (totaling 103) published in standard journals from 2002-2020 on medicinal plants used in treating the disease and similar diseases. Epidemiological records of COVID-19 regional epidemic in Africa as of 29th July, 2020 indicated South Africa as the epicenter of the disease; its continental index case was in Egypt on 14th February, 2020. This was transmitted via an individual with traveling history from highly COVID burdened nations. Recent records revealed that the new cases of the disease have started trending locally with a person to person contact especially among those without travel history. There were about 874,036 cases in Africa with about 18,498 deaths recorded within the time frame of this study. The age groups mostly affected were 20-49 years with males' frequency marginally surpassing that of females. Seventy-five medicinal plant species from 41 families were recorded. Identified plants are indigenous to both the tropical and subtropical regions. Their medicinal potentials for treating human viral diseases are well described in Africa. Family Lamiaceae have the highest number of plant species (14.6%) used in managing COVID-19 and other related diseases. Asteraceae (12.3%) and Apiaceae (9.7%) families ranked second and third, respectively. Further studies on these plants with promising anti-SARS-CoV 2 properties on different experimental models for subsequent development of nutraceuticals and herbal medicine is imperative.

Key words: Coronavirus, COVID-19, Africa, epidemiology, medicinal plants.

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a viral disease caused by Severe Acute Respiratory Syndrome

coronavirus (SARS – COV 2) (Shereen et al., 2020). It is an enveloped, single-stranded, and a positive-sense

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ribonucleic acid (RNA) virus. A β -coronavirus family was first reported in Wuhan China in December 2019 (Sohrabi et al., 2020). The virus genomic is similar to SARS-CoV, Middle East Respiratory Syndrome Coronavirus (MERS-COV), Mouse Hepatitis Virus (MHV) and it is characterized by fever, cough, shortness of breath followed by dyspnea, persistence pain and pressure in the chest, confusion and fatigue, diarrhea, bluish lips or face followed by death (Shereen et al., 2020).

The novel coronavirus disease is one of the most dangerous respiratory diseases in recent times which may appear between 2-14 days after exposure (Sohrabi et al., 2020). The fatality of this disease is of great health concern and the transmission of the virus from person to person in most cases begins during asymptomatic stages of infection (Daibing et al., 2020; Hellewell et al., 2020; Rothan and Byrareddy, 2020).

The disease has a very high rate of transmission and the mortality is very high especially among the infected older persons and those that have comorbidity effects with other chronic diseases (Assiri et al., 2013). These underlying medical conditions include cancer, diabetes, cardiovascular diseases, chronic respiratory disease, and Human Immunodeficiency Virus (HIV) infection. These may likely lower the body's immune system of any susceptible individuals, thereby, making them prone to severe viral and other infections (Kannan et al., 2020). The estimated mortality rate of COVID 19 is put at 3.4% globally of the number of infected persons (WHO, 2020a).

Global statistics as of 29th July, 2020 revealed that the coronavirus pandemic is in 213 countries with a total number of about 16,558,289 confirmed cases, 215,125 new cases, and 656,093 deaths (WHO, 2020a). Initially, China was the epicenter of the novel coronavirus which was exported by travelers to other parts of the globe. Presently, the United State of America (USA) has the highest number of confirmed cases globally and is the current global epicenter for COVID-19 with over 4,263,531 confirmed cases and 147,449 deaths (ECDC, 2020). The index case in Africa was reported in Egypt on 14th February, 2020. Currently, there are over 874,036 laboratory-confirmed cases in Africa with over 18,498 deaths recorded (WHO, 2020b).

Africa with her inherent weak health facilities trembles at the horrid statistics of morbidities and mortalities recorded in many advanced countries that are currently overwhelmed by the disease burden. Many of the African nations have no access to testing kits and have a lifestyle that helps to spread of the disease. Many African nations attempt to enforce lockdown as a preventive measure but failed due to hunger and poor economic conditions, thus neglecting requisite systems that can help prevent the spread of the disease. What is left for Africa is to access the readily available medicinal plants for managing cases of COVID -19. Since the spread and death cases are

rapidly increasing daily despite a travel ban and lockdown policy in most countries of the world, and also with no effective anti-coronavirus drugs in the market, it is pertinent to include herbal source remedy.

Thus, this paper explores the epidemiological status of COVID-19 and presents several plants with potential for the treatment of the disease. This review also seeks to bridge the knowledge gap and present to both scientists and traditional medicine practitioners several plants that may have potential in the management of COVID-19.

METHODOLOGY

Epidemiological data were mined from the daily updates of the World Health Organization (WHO) (WHO, 2020a), Centre for Disease Control websites, Nigeria Centre for Disease Control (NCDC), and recently published journal articles. The data on confirmed cases and deaths due to COVID-19 were extracted from the European Centre for Disease Control (ECDC) while data on demographic characteristics of patients with COVID-19 cases from NCDC.

The articles published from 2002 to 2020 totaling 242 were included from Web of Science, Elsevier, Scopus, and PubMed and screened for this review; while 103 were considered suitable for use. Relevant keywords like COVID-19, plants possessing antiviral activity against coronavirus, medicinal plant used to manage SARS-CoV and similar viruses, plants used to treat respiratory diseases in Africa, plants used in treating flu in Africa were used in this study. The limitation of this work is that the activities of the plants were not tested against COVID-19 disease. The data collected were analyzed using Microsoft excel 2016 and presented as simple descriptive statistics and charts.

RESULTS

The demographic characteristics of COVID-19 medically confirmed cases in Africa between 25th February to 28th July, 2020 are displayed in Figure 1. The age group between 20-49 years recorded high cases of the disease in Africa with males' frequency marginally surpassed that of females within this time frame. The demographic features of COVID-19 medically confirmed cases in Nigeria as of 29th July, 2020 are shown in Figure 2. Based on this record of patients with epidemiological history, the age group between 21 to 50 years were mostly affected with higher numbers of males than the females.

Figures 3 and 4 show the geographical distribution of cases and deaths due to coronavirus across the five most hit countries in Africa. The highest cases in Africa were recorded in South Africa, followed by Egypt while the lowest cases were recorded in Algeria.

Globally, as of 29th of July, USA has the highest number of cases and the highest number of deaths was from the same country (Figures 5 and 6). These cases and deaths were generally characterized by an upward trend over time. The records from the distribution of

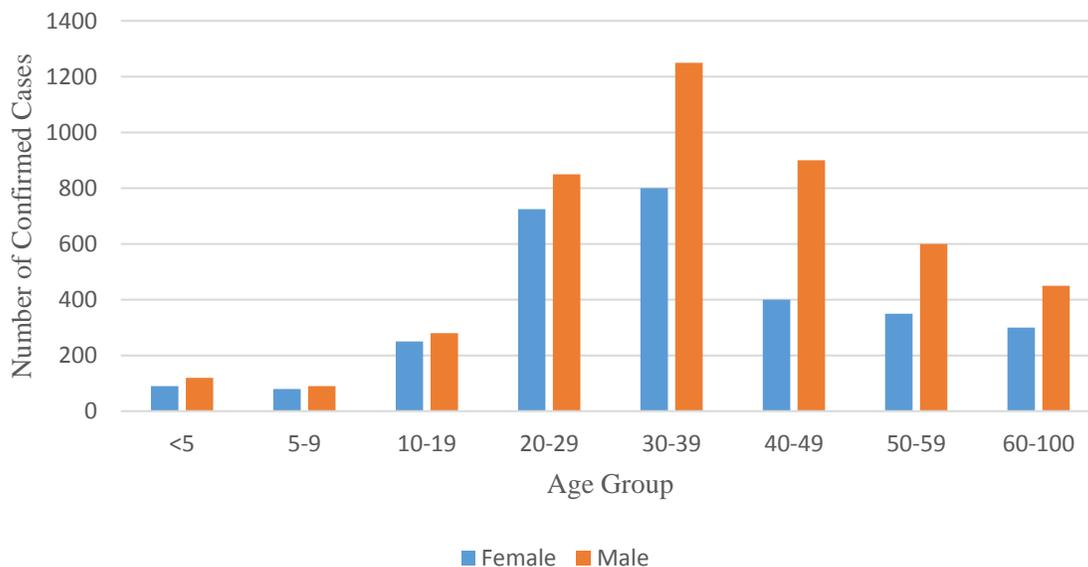


Figure 1. Distribution of Confirmed Cases of COVID-19 in Africa by Sex and Age Group. Data for the Confirmed Cases (between 25th Feb. -28th July, 2020) from COVID-19 World Health Organization African Region External Situation Report 22 (WHO, 2020b).

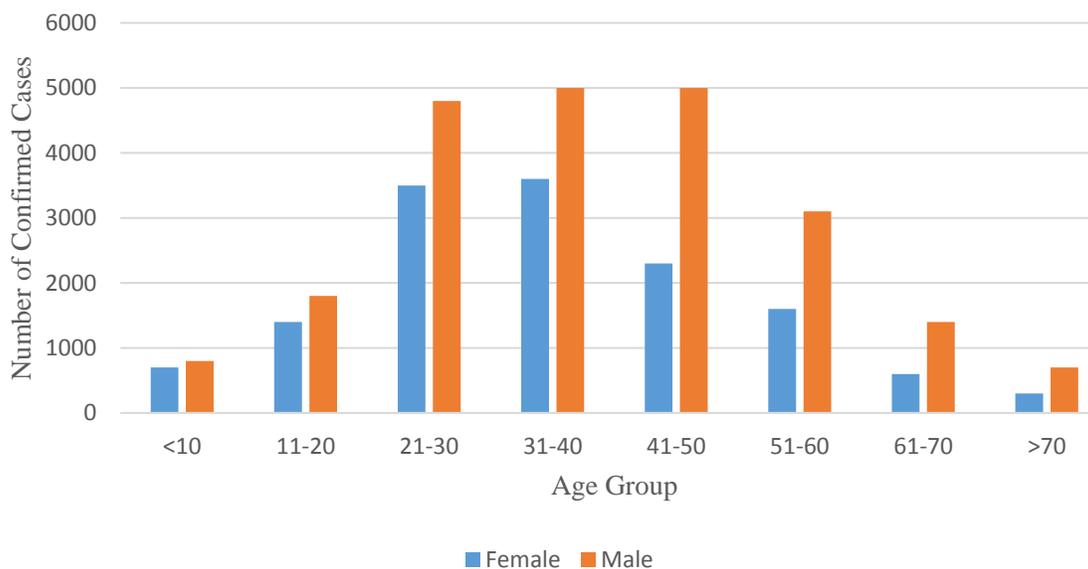


Figure 2. Distribution of Confirmed Cases of COVID-19 in Nigeria by Sex and Age Group as of 29th July, 2020. Data for the Confirmed Cases from COVID-19 Outbreak in Nigeria, Situation Report 152, NCDC (2020).

mortality by various age groups revealed that elderly persons aged 51 and above were mostly affected. The distribution of deaths within these age ranges had a significant increase compared to those below 51 years as shown by the data from Italy and China (Figure 7).

The databases yielded 75 medicinal plant species from

41 families which were used in managing SARS CoV2 and other related diseases with Lamiaceae, Asteraceae, Apiaceae, and Myrtaceae being the most frequently used family (Figure 8). Table 1 shows medicinal plants used worldwide in treating cases of SARS-CoV and other related viral diseases. Plants of the Genus Rheum and

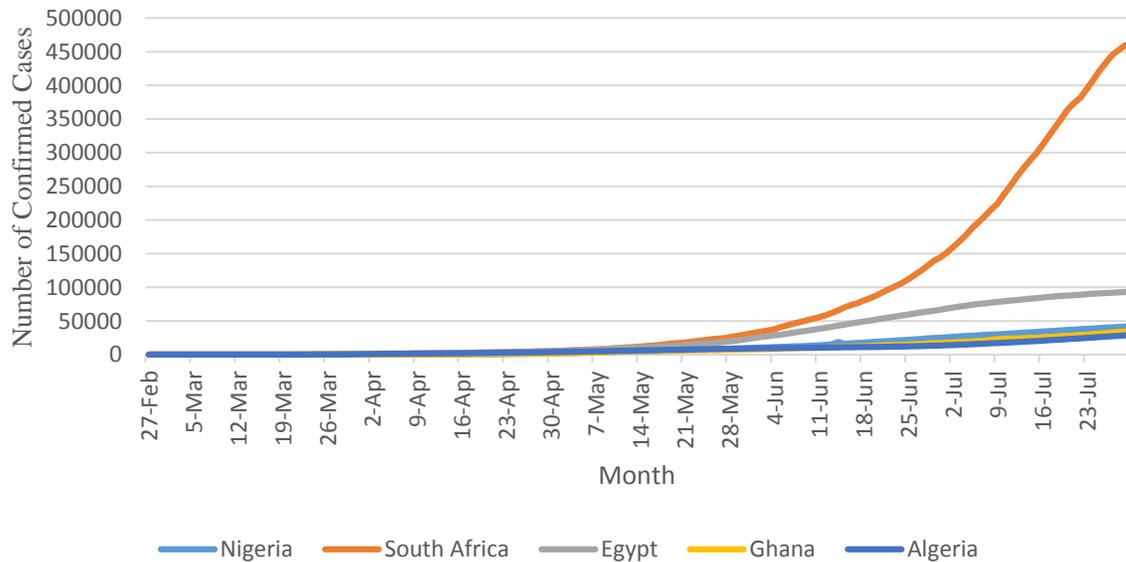


Figure 3. Spatial Distribution of Coronavirus Confirmed Cases across Five Most Hit Countries in Africa between February 27th to July 29th, 2020. Data from the Geographical Distribution of COVID-19 Cases Worldwide (ECDC, 2020)

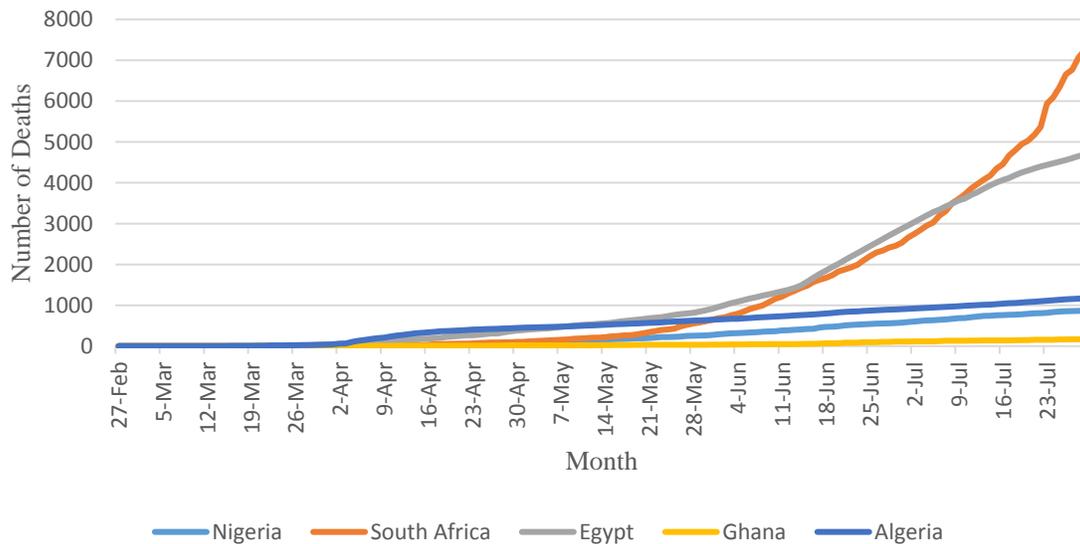


Figure 4. Spatial Distribution of Coronavirus Deaths across Five Most Hit Countries in Africa between February 27th to July 29th, 2020. Data from the Geographical Distribution of COVID-19 Cases Worldwide (ECDC, 2020).

Polygonum were listed among the Traditional Chinese Herbal Medicine (TCHM) which has been tested and showed positive results in treating COVID-19. Tables 2-4 are medicinal plants used in treating some viral diseases, flu, influenza, and respiratory diseases. While Table 5 contains a list of phytochemicals and active compounds

that have shown activities against the SARS-CoV virus.

DISCUSSION

The COVID-19 epidemic cases recorded in Africa were

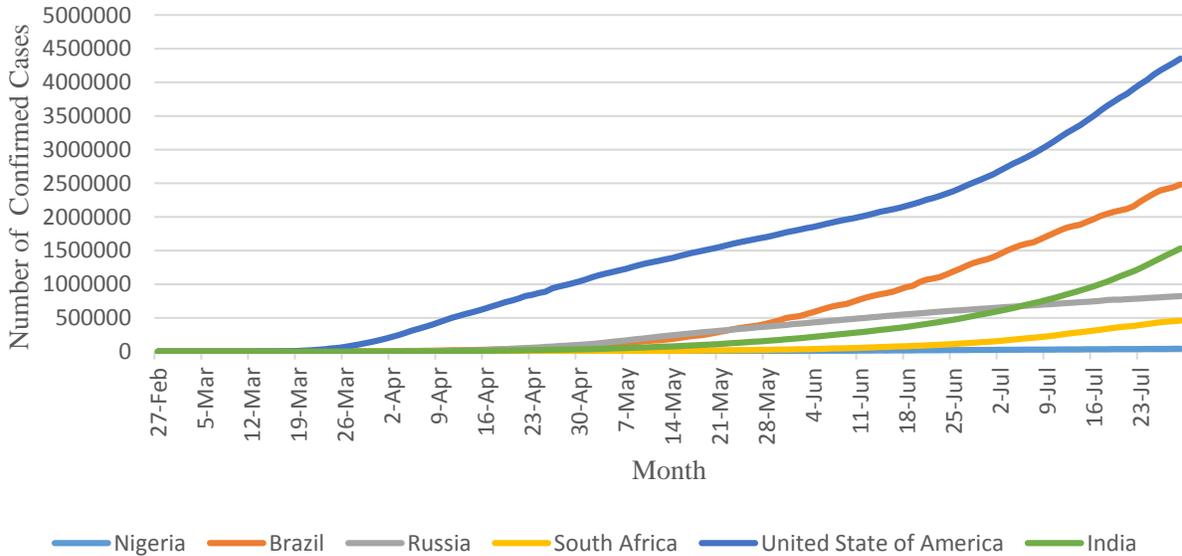


Figure 5. Spatial Distribution of Coronavirus Confirmed Cases across Five Most Hit Countries of the World and Nigeria between February 27th to July 29th, 2020. Data from the geographical distribution of COVID-19 cases worldwide (ECDC, 2020).

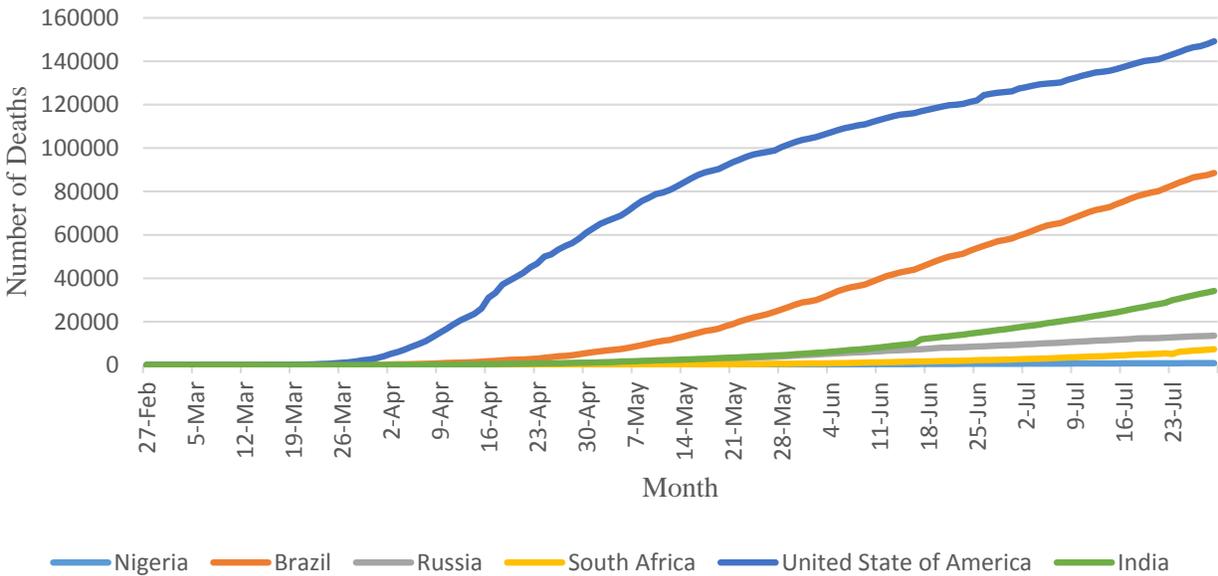


Figure 6. Spatial Distribution of Coronavirus Deaths across Five Most Hit Countries of the World and Nigeria between February 27th to July 29th, 2020. Data on geographical distribution of COVID-19 cases worldwide (ECDC, 2020).

relatively small compared to the number recorded in Europe, Asia, and the USA. But these cases have increased sporadically since the index case in Egypt on February 14th, 2020. Age group 20 - 49 years were most affected. This may possibly lead to lower mortality as the immune system of these age groups is still very strong. The possibility of comorbidity disorder may not be

rampant among the younger patients and hence a fewer number of deaths are likely to be expected. This present result is inconsistent with the one reported in one of the highly burdened nations (Courage, 2020).

Global epidemiological records revealed a geometrical increase in the number of cases in most hit countries while the distribution of deaths by various age groups

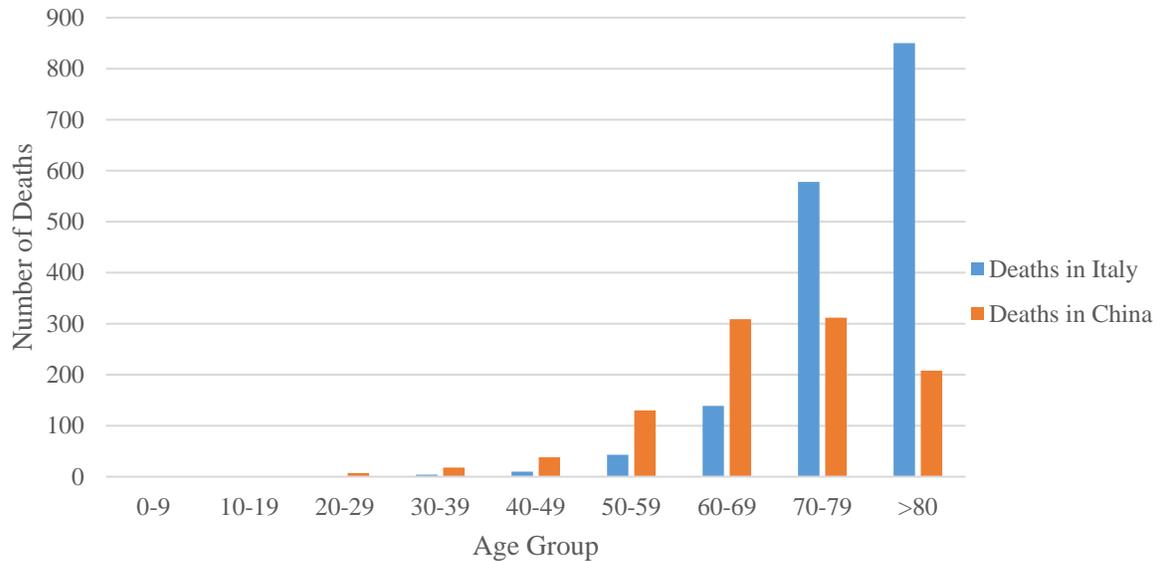


Figure 7. COVID 19 mortality in China (as of 11th February, 2020) and Italy (as of 17th March, 2020). Data on Coronavirus Deaths from the Stark differences in Countries' Coronavirus Deaths Rates (Courage, 2020).

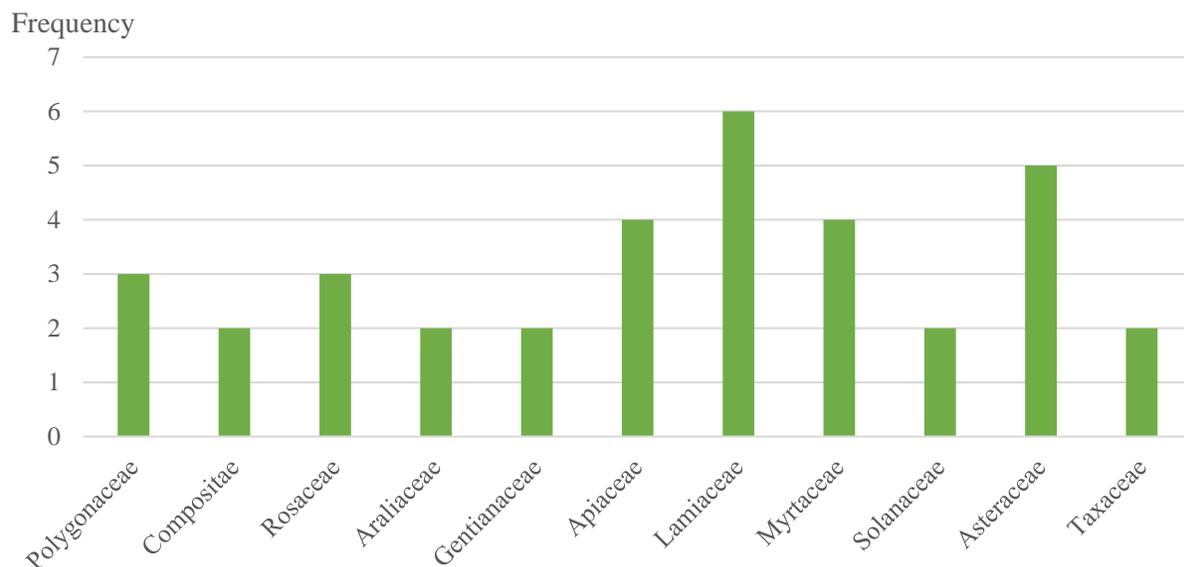


Figure 8. The plant families frequently used to treat COVID 19, related viral disease and manage respiratory diseases.

revealed that elderly persons aged 51 and above were mostly affected (Courage, 2020). This may likely be due to the immune system wane (immunosenescence effect) among the older population (Castelo-Branco and Soveral, 2014). Also, comorbidity with other diseases can also be the likely reason for most of these deaths among the elderly. Studies have shown that underlying comorbidities

might vary in different population groups or settings, at an older age, cardiovascular diseases, diabetes, chronic respiratory disease, and cancer were all associated with an increased risk of death (Jordan et al., 2020).

Medicinal plants are valuable natural resources useful for the management of several human and animal diseases. Usage of herbs in treating different viral

Table 1. Medicinal plants used in the treatment of coronavirus worldwide.

Family	Plant	Part used	Plant activity	References
Polygonaceae	<i>Rheum officinale</i> Baill	Extract of Root tuber	Block ACE2 interaction with SARS-CoV in a dose dependent manner	Ho et al.(2007), Li et al. (2017)
	<i>Polygonum multiflorum</i>	Extract of Root tuber	Block ACE2 interaction with SARS-CoV in a dose dependent manner	Ho et al.(2007)) Luo et al. (2019)
	<i>Polygonum multiflorum</i> Thumb	Extract of the vines	Block ACE2 interaction with SARS-CoV in a dose dependent manner	Ho et al. (2007) Bussmann et al. (2010)
Compositae	<i>Artemisia annua</i> L.	Ethanol extract of whole plants	Antiviral, antiparasitic and used in treating infection of the respiratory tract	Shin-you li et al. (2005) (Muthaura, Keriko, Dereese, Yenesew, & Rukunga, 2011)
Polypodiaceae	<i>Pyrrosia lingua</i> Farwal	Chloroform leaf extract		Li et al. (2005)
Lauraceae	<i>Lindera aggregata</i> (Sims) kastern	Ethanol root extract		Li et al. (2005)
Rosaceae	<i>Rosa nutkana</i> C.Presl	Crude methanolic Branches	Affect enteric coronavirus	Eslami et al. (2011); Mccutcheon et al. (1995)
	<i>Amelanchier alnifolia</i> Sarg.	Crude methonolic Branches	Affect enteric coronavirus	Mccutcheon et al. (1995)
	<i>Potentilla argute</i> Lehm.	Crude methanolic branches	Inhibit respiratory syncytial virus	Chiw (2016); Mccutcheon et al. (1995)
Caprifoliaceae	<i>Sambucus racemosa</i> L.	Crude methanolic branches tip	Inhibit respiratory syncytial virus	Chiw (2016); Mccutcheon et al. (1995)
Araliaceae	<i>Oplopanax horridus</i> (Sm.) Miq.	Inner back extract	Affect coronavirus partially	Mccutcheon et al. (1995); Wu et al. 2018
Polemoniaceae	<i>Ipomopsis aggregate</i> (Pursh) V.E.Grant	Ethanol root extract	Affect influenza virus type 3	Mccutcheon et al. (1995); Mehrbod et al. (2018)
Gentianaceae	<i>Gentiana radiata</i> C.Marquand	Plant extract	Affect SARS-CoV cytopathic effect	Wen et al. (2011)
	<i>Gentiana scabra</i> Bunge	Extract of dried rhizome	Affect SARS-CoV cytopathic effect	Wen et al. (2011)
Dioscoreaceae	<i>Dioscorea batatas</i> Decne.	tuber	Affect SARS-CoV cytopathic effect	Aadil et al. (2018)
Leguminoseae	<i>Cassia tora</i> Linn	Dried seed	Affect SARS-CoV cytopathic effect	Wen et al. (2011)
Loranthaceae	<i>Taxillus chinensis</i> (DC) Tiegh	The dried stem with leaves extract	Affect SARS-CoV cytopathic effect	Wen et al. (2011)
Cibotiaceae	<i>Cibotium barometz</i> (L.) J.Sm	Extract of the dried rhizome	Affect SARS-CoV cytopathic effect	Wen et al. (2011)
Caprifoliaceae	<i>Lonicera japonica</i> Thunb	Flower bud and stem infusion	Has antiviral activity	He et al. (2016)

diseases in Africa is a relic of old and has gotten wider acceptability globally. Plants based on traditional medicine are still dominant in Africa. Herbal remedies are inexpensive to prepare and are effective in the management of several diseases (Akhalwaya et al., 2018). With the

search for drugs and vaccines for COVID 19 ongoing, a complementary or alternative therapeutical source for COVID 19 is highly needed.

Africans are perhaps at a loss to what can be used in treating the ravaging pandemic. Chinese

Traditional Medicine has been able to identify several medicinal plants that can be used as anti-SARS-CoV2 due to their previous exposure to SARS-CoV and MERS-CoV in 2002 and 2012 respectively. This paper seeks to bridge the knowledge gap and present to both scientists and

Table 2. Medicinal plants used in Africa to treat viral diseases related to SARS- CoV 2 and manage respiratory symptoms.

Family	Plant	Method of preparation	Uses	Rceferences
Th	<i>Mangifera indica</i> L.	Infusion drink	Cough	(Polat and Satil, 2012)
Apiaceae	<i>Centella asiatica</i> (L) Urb.	Macerated leaves, decoction drink	Fever, constipation and jaundice and cough	Tariq et al., (2015)
Chenopodiaceae	<i>Chenopodium opulifolium</i> Koch & Ziz	Decoction drink	Malaria and fever and cough	Chinsemu (2016)
Curcubitaceae	<i>Mormodica foetida</i> K. Schum	Decoction and infusion	Malaria, fever, worm, cough and stomach ache and yellow fever.	Tugume and Nyakoojo (2019)
Lamiaceae	<i>Plectanthera floribunda</i> Mart.	Decoction and infusion	Malaria, fever, worm, cough and stomach ache and yellowfever.	Tugume and Nyakoojo (2019)
Melastomataceae	<i>Dissotis Phaeotricha</i> (Hochst) Hook	Decoction, infusion drunk. Oil from seed drunk.	Malaria fever, cough, worm and fever	Tugume and Nyakoojo (2019)
Meliaceae	<i>Azadiracha indica</i> A. juss	Decoction drink	Worm, malaria, fever, jaundice, cough and bronchitis	Tugume and Nyakoojo (2019)
Moraceae	<i>Ficus natalensis</i> Hochst	Decoction drink	Influenza	Keter and Mutiso (2012)
Myrtaceae	<i>Callisteman citrinus</i> (Curtis) Skeels	Decoction drink mixed with <i>Eucalyptus grandis</i> and <i>magnifera indica</i> boiled and inhaled	Cough and common cold.	Tugume and Nyakoojo (2019)
	<i>Eucalyptus grandis</i> W. Hill	Leaves chewed, infusion drink and decoction drink	Cough	York et al. (2011)
Myrtaceae	<i>Eucalyptus globulus</i> Labill	Burning leaves in fire and inhale	Common cold	Proestos and Komaitis (2013)
	<i>Psidium guajava</i> L.	Decoction drink	Cough	de Wet et al. (2010)
Solanaceae	<i>Datura innoxia</i> Mill	Decoction drink, infusion, macerated leaves applied on skin	Cough, asthma, skin disease	Vernay et al. (2008)
Solanaceae	<i>Nicotiana tobacuum</i> L.	Leaves, leaves macerated	Stomach ache, common cold, influenza	Tsouh Fokou et al. (2015)
Alliaceae	<i>Allium sativum</i> L	Inhale Fruit and seed extracts. Decoction of fruit and seed.	Common cold, malaria and dry cough	Barkaoui et al. (2017)

traditional medicine practitioners potential plants that may be useful in the management of COVID 19.

Out of the 41 families of plants, Lamiaceae has the family with the highest number of plant species used in treating SARS-COV and managing respiratory diseases. This family contains

Hyssopus officinalis L. commonly called Hyssop. It produces aromatic flowers that have soothing expectorant and cough suppressant properties. It is also used in managing sore throat. Clinical investigation revealed that extracts of the block ACE2 interact with SARS-CoV in a dose-dependent manner (Ho et al., 2007; Li et al.,

2017).

Ocimum basilicum L is a native to the tropical and warm temperate regions commonly called great basil. It is also an aromatic plant whose leaves are used for cooking. It possesses antiviral, antibacterial, and antifungal effect. It has an immunomodulatory, hepatoprotective effect

Table 3. Medicinal plants used in Africa to treat viral diseases related to SARS-CoV 2 and manage respiratory symptoms

Family	Plant	Part used and method of Preparation	Uses	References
Asteraceae	<i>Artemisia afra</i> Jerk. Ex wild	Inhale the smell of the leave	Common cold	van Wyk (2008)
	<i>Echinops keberico</i> Mesfin	Inhale the burning root	Common cold	Bulut et al. (2017)
Compositae	<i>Guizotia abyssinica</i> (CL) Cass	Decoction of seed powder	Dry cough	Mohamed, 2012; Wubetu, et al. (2017)
Primulaceae	<i>Rapanea melanophloeos</i> (L.) Lam	infusion	Cough and common cold	Wubetu et al. (2017)
Lamiaceae	<i>Clerodendrum glabrum</i> E. Mey.	Leaf infusion	Common cold and fever	Cock et al. (2018); Wubetu et al. (2017)
pittosporaceae	<i>Pittosporum viridiflorum</i> Sims.		Antiviral agent, affect influenza virus HA surface glycoprotein	Wubetu et al. (2017)
Apocynaceae	<i>Tabernaemontana ventricosa</i> Hochst. Ex A.DC.		Treat respiratory diseases	Wubetu et al. (2017)
Araliaceae	<i>Cussonia spicata</i> Thunb.		Treat respiratory diseases	Cock et al. (2018)
amaryllidaceae	<i>Erinum jagus</i> (J. Thomps) Dandy	Bulb	Treatment of tuberculosis, asthma and infection	Cock et al. (2018)
Asteraceae	<i>Agerantum conyzoides</i> L.	leaves	Purgative, pneumonia febrifuge	Okunade (2018)
Crassulaceae	<i>Bryophillum pinnatum</i> (Lam) Oken	Leaves	Cold, pneumonia and respiratory tract infection	Ogbole et al. (2018)
Dilieniaceae	<i>Tetracera alnifolia</i> wild	Leaves	Cough and toothache	Ogbole et al. (2018)
Euphorbiaceae	<i>Croton gratissimus</i> Burch	leaves	Cough, fever and influenza	Ogbole et al. (2018)
Lamiaceae	<i>Hoslundia opposita</i> Vahl	Leaves	Cough and skin infection	Ogbole et al. (2018)
Poaceae	<i>Eleusine indica</i> (L) Gaertn	Leaves	Diabetes and cough	Ogbole et al. (2018)
Lamiaceae	<i>Hyssopus officinalis</i> L.	Aqueous extract	Inhibit viral replication	Mukhtar et al. (2008)
Lamiaceae	<i>Ocimum basilicum</i> L.	Methanolic extract	Inhibit viral replication	Kichu et al. (2015); Mukhtar et al. (2008)
Bignoniaceae	<i>Newbouldia leavis</i> (P.Beauv.) Seem.	Leaves extracts	Cough, worm, malaria and anti-inflammatory	Yemele et al. (2015)
Araceae	<i>Anchomanes difformis</i> (Blume) Engl.	tuber	Fever, worm, diuretics and common cold	Sulaiman et al. (2015)
Mimosoideae	<i>Tetrapleura tetraptera</i> (Schumm. &Thonn) Taub	fruit	Fever, worm common cold, analgesic and anticonvulsant	De Smet (1998)
Asteraceae	<i>Vernonia amygdalina</i> Delile	leaves	Fever, worm and common cold	Namukobe et al. (2011)
Violaceae	<i>Viola odorata</i> L	flower	Cough and flu	Ahmad Jan et al. (2017)

(Aalikhani Pour et al., 2016; Aremu et al., 2010). *Plectanthera floribunda* Mart is a warm climate plant grown as leaves or root vegetables and is used medically to treat cough and respiratory

diseases. Infusion drink of the leaves of *P. floribunda* reduce fever, worms, and malaria (Tugume and Nyakoojo, 2019)

Asteraceae accounts for 12.2% of the families

of plants traditionally used for the management of viral diseases and respiratory symptoms. *Artemisia afra* Jerk. Ex wild and *Artemisia annua* are native to the tropical region; they are non-toxic plants

Table 4. Medicinal plants used in Africa to treat viral diseases related to SARS- CoV 2 and manage respiratory symptoms.

Family	Plants	Part Used	Uses	References
Boraginaceae	<i>Onosma bracteata</i> Wall	root	Cough, bronchitis and flu	Younis et al. (2018)
Ranunculaceae	<i>Nigella sativa</i> L	Oil from the seed	Diuretics, anti-inflammatory, bronchodilator, antimicrobial	Hasani-Ranjbar et al. (2009)
Asteraceae	<i>Artemisia annua</i> L	Whole plant infusion	Malaria, antinflammatory and fever.	Vitalini et al. (2013)
Polypodiaceae	<i>Pyrrhosia lingua</i> (Thunb) Farw.	leaves	Cystitis, bronchi asthma, lung-heat induced cough.	Li et al. (2005)
Apiaceae	<i>Isatis indigotica</i> Fortune ex Lindl.	Root extract	Antiviral agent	Guo (2018)
Taxaceae	<i>Torreya nucifera</i> (L) Siebold and Zucc.	Seed oil	Affect the lungs, intestines and worms	Wen et al. (2011)
Apiaceae	<i>Daucus carota</i> L	Root and seed	Diuretic, stimulant carminative, chronic cough.	Gilca et al. (2018)
Asteraceae	<i>Ehinacea purpurea</i> (L) Moench	Root extract	Immunostimulatory, anti-inflammatory, infectious diseases in both upper and lower respiratory systems and pruritus.	Gilca et al. (2018)
Adoxaceae	<i>Sambucus nigra</i> L	Flowers	Diuretics stomach upset, cough	(Mccutcheon et al. (1995)
Apiaceae	<i>Heteromorpha arborens</i> (Spreng.) Cham. and Schtdl.	Different parts of the plant	Inflammation, pain, respiratory problems antiviral	Elisha et al. (2016); Gilca et al., 2018)
Taxaceae	<i>Torreya taxifolia</i> (Arn.) Henkel and W. Hochst.	Seed oil	Respiratory diseases	Wen et al. (2011)

Table 5. Some phytochemical used in management of SARS-CoV and related viral diseases.

Family	Plant	Phytochemical	Effect	Reference
Saururaceae	<i>Houttuynia cordata</i>	Quercetin	Inhibit mouse hepatitis virus (MHV), Dengue virus type 2 (DENV type2)	Chiw et al. (2016)
Saururaceae	<i>Houttuynia cordata</i>	Quercetrin	Inhibit mouse hepatitis virus (MHV), Dengue virus type 2 (DENV type2)	Chiw et al. (2016)
Saururaceae	<i>Houttuynia cordata</i>	Cinanserin	Inhibit mouse hepatitis virus (MHV), Dengue virus type 2 (DENV type2)	Chiw et al. (2016)
Polygonaceae	<i>Rheum emodi</i> Wall	Emodin (an anthraquinone)	Block S protein of SARS-CoV and Angiotensin Converting Enzyme 2 (ACE2) interaction.	Ho et al. (2007)
Polygonaceae	<i>Rheum emodi</i> Wall	Physcion	Block S protein of SARS-CoV and Angiotensin Converting Enzyme 2 (ACE2) interaction	Ho et al. (2007)
Polygonaceae	<i>Rheum emodi</i> Wall	Rhein	Block S protein of SARS-CoV and Angiotensin Converting Enzyme 2 (ACE2) interaction	Ho et al. (2007)
Apiaceae	<i>Isatis indigotica</i>	Myricetin and scutellarein	Antiviral activities	Keum and Jeong (2012)

used traditionally for the treatment of common cold and pneumonia (Martkoplshvili and Kvavadze, 2015; Muthaura et al., 2011; Rabe and

Staden, 1997; Van, 2008). Pharmacological activities of the compound from these plants have an inhibitory effect on

malaria parasites, *Schistosoma mansoni*, *Schistosoma heamatobium*, and *Schistosoma japonicum* (van Vuuren and Muhlarhi, 2017). The

genus of *Artemisia annua* is known for its aromatic nature; its volatile secondary metabolites have been used in the management of cough and common cold (Mahomoodally et al., 2013; Martkoplshvili and Kvavadze, 2015). Another important member of Asteraceae family is *Ageratum conyzoides*; it is a native of tropical America and considered an invasive weed in Africa. It is commonly called Billy goat weed. It contains pyrrolizidine alkaloids, lycopsamine, and echinatin which are toxic. The plant is used mostly in central Africa in managing pneumonia, to cure wounds and burn. In India, Asia, Africa and South America it is used to treat fever, rheumatism, headache and colic. The whole plant has medicinal uses. Pharmacological investigation of the plant showed it has *in vitro* inhibitory effects on *Staphylococcus aureus*, and *Escherichia coli* (Ogbalu and Williams, 2015; Okunade, 2018).

Another plant genus of the Asteraceae family is *Vernonia amygdalina* and *Echinacea purpurea*. *V. amygdalina* is a small shrub tropical plant. It is commonly called bitter leaf because of its bitter taste. It is eaten as a leafy vegetable. It has been demonstrated to have antioxidant, anti-inflammatory, anthelmintic, antidiarrheal, antihypertensive, and antidiabetic activities. The sap from the leaf has been used to treat pneumonia, bronchitis, and other respiratory diseases (Farombi and Owoeye, 2011; Ijeh and Ejike, 2011; Namukobe et al., 2011).

An isolated compound from *V. amygdalina* leaves like vernnioside has anti-inflammatory effect and is used to treat the gastrointestinal disorder (Habtamu and Melaku, 2018; Lamorde et al., 2010) while *Echinocera purpurea* is a tropical flowering plant, a native of North America. It is commonly called purple coneflower (Cai et al., 2010) Extract of *E. purpurea* has been used in the treatment of acute respiratory infections. Immunostimulant or immunomodulatory properties of *E. purpurea* have been documented Gilca et al. (2018).

Members of the Apiaceae family that are listed in Table 3 include *Centella asiatica*, *Isatis indigotica*, *Daucus carota*, and *Heteromorpha arborens* (Davids et al., 2016). *Centella asiatica* commonly called Indian pennywort is a native of Asia. It is a culinary vegetable and medicinal herb (Roy and Bharadvaja, 2017). While *Isatis indigotica* root has antiviral, cold, anti-inflammatory, antipyretic, and antibacterial properties. It also contains several secondary metabolites that benefit human health like sucrose, amino acid, tryptophan, essential oils like Beta-sitosterol, and isatin (Guo et al., 2018).

Daucus carota is commonly called wild carrot; it is a flowering plant native of Europe, South West Asia, North America, and Australia. It is shown in experimental and clinical studies that it has radioprotective, antioxidant, and anti-inflammatory activities. The roots, seeds, leaves, and flowers also have medical uses. They have antibacterial, antifungal, antiviral, anti-flu anti-anxiety antispasmodic properties (Saliyan et al., 2017; Gilca et al., 2018).

Heteromorpha arborens is a tropical shrub that can tolerate dry climates. An infusion of the inner bark of *H. arborens* is used in the treatment of colic, cold, and chest pain. A decoction of the root is used to treat shortness of breath, cough, and dysentery. The root is used as an aphrodisiac. The plant phytochemistry includes α -terpinene, γ -terpinene, and turreyol, which is responsible for its antiviral and anti-inflammatory activities (Elisha et al., 2016; Maroyi, 2018).

Eucalyptus grandis W. Hill, *Eucalyptus globulus* Labill, and *Psidium guajava* are important medicinal plants in the Myrtaceae family. Eucalyptus species are native to Australia. *E. grandis* and *E. globulus* have smooth, fibrous, stringy bark with leaves that have oily glands. It has antiviral, antitumor, antihistaminic, anticancer, and antibacterial activities (Li et al., 2017; Luiz et al., 2016).

Pharmacologically, they are inhibitory of cytochrome P450 and their hepatoprotective activities have been documented (Luiz et al., 2016). The fruits of *E. globulus* have yielded several compounds like sitosterol, betulinic acid, stigmasterol which have been used in treating mild inflammation, respiratory tract infection, and bronchitis. *Psidium guajava* commonly known as guava is a tropical plant that is grown for abundant fruits. Its leaves are used in the treatment of cough, diarrhea, dysentery, and gastroenteritis. The fruit is rich in Vitamins A and C, iron, phosphorus, calcium, and minerals. *P. guajava* has antiviral, anti-inflammatory, and antimutagenic, antinociceptive activities (Suliman et al., 2010; Zonyane et al., 2013).

Rheum officinale Baill commonly called Chinese rhubarb is of the family Polygonaceae; it has pharmacological activities such as anti-inflammatory, antioxidative and cathartic. The major active ingredient in the plant is emodin which has hepatoprotective activity, it slows liver fibrosis and it has been demonstrated to inhibit SARS CoV activity (Ho et al., 2007; Li et al., 2017).

Emodin has potential effect against atherosclerosis, ulcer, colitis, glomerulitis, pancreatitis, and hepatitis in experimental studies. While *Polygonus multiflorum* Thumb tuber commonly called the fleece flower is a native of northern temperate region from the family of Polygonaceae. The leaves, root tuber, and rhizomes are used as tonic and anti-aging agents; the stem is used to reduce insomnia and has antihyperglycemic activities. *P. multiflorum* Thumb showed various biological activities which include antitumor, anti-SARS-CoV, anti-HIV anti-alopecia activities, and showed an ability to inhibit neurodegenerative diseases (Li et al., 2017; Liu et al., 2018).

The Rosaceae family has the following plants: *Amelanchier alnifolia*, *Potentilla argute*, and *Rosa nutkana*. *Amelanchier alnifolia* is a shrub with edible berry-like fruit, a native to America. A decoction of the stems has been used in treating fever, flu and induce sweating. It has also been used as a contraceptive (Bulut

et al., 2017). *Potentilla argute* is a tall flowering plant, a native of Northern America. The decoction of the leaves and stems is used to manage cases of inflammation of the body and joints. It is an effective remedy for arthritis, menstrual pain, and fever. Due to the astringent nature of its tannins, it is used to treat age marks and wrinkles. It is also effective in treating bacterial infection in the mouth (Avci et al., 2006; Mccutcheon et al., 1995; Mehrbod et al., 2018).

Rosa nutkana is a tall perennial shrub of the Rosaceae family. The plant is a native of North America. Infusion of the root is used to treat sore eyes and sore throat (Eslami et al., 2011). Other plants used in treating common cold include *Guizotia abyssinica* (CL) Cass commonly called noog in Ethiopia (Mohamed, 2012).

Oplopanax horridus also known as devils' club is used by the indigenous people of North America. The extract of the leaves is used as respiratory stimulant and expectorant. Recent pharmacological studies showed that *O. horridus* possesses anticancer, antifungal, antibacterial, and antiarthritic activities (Wu et al., 2018). Another member of the Araliaceae family that shares similar medicinal characteristic with *O. horridus* is *Cussonia spicata*, a native of the tropical region commonly known as spiked cabbage tree. The root decoction is used to treat fever, venereal diseases, diuretic, and also used as a laxative (Tetyana et al., 2002).

Gentia radix is the dried rhizome of *Gentiana lutea* L. It is used to increase appetite during recovery from acute atonic dyspepsia. Extract of the dried rhizome of *G. lutea* and *G. scabra* has shown good outcomes on the treatment of the cytopathic effect of SARS-CoV (Prakash et al., 2017).

Torreya taxifolia native of America and commonly called Florida nutmeg is an endangered species of medicinal plant which is very active in treating respiratory diseases (Ernst et al., 2015). *Lindera aggregate* (Sims). kastern is a tropical plant, a member of Linderaceae family. It is used medicinally as a febrifuge especially in Asia; *Sambucus racemosa* commonly called red elderberry has been used by native America as an emetic, antidiarrheal, cold, and cough remedy. Another North American plant that shared similar medical use in the treatment of cold and cough is *Ipomopsis aggregata*. Glycosides like patuletin, eupalitin and eupalolin isolated from *I. aggregata* have diverse pharmacological activities (Juanita, 2004; Mccutcheon et al., 1995; Shokrzade et al., 2010).

Dioscorea batatas commonly called Chinese yam is a perennial growing invasive plant. It is a temperate and subtropical plant. The root tuber can be boiled and eaten and has been used in the treatment of hyperthyroidism, nephritis, and diabetes. It contains diosgenin, a substance that can be employed in the production of contraceptives. The leaves are used in treating asthma

and arthritis (Aadil et al., 2018; Bruschi et al., 2011; Iranshahy et al., 2017).

Cassia tora Linn is a medicinal plant found in India and other tropical regions. It is of the family Leguminosae which traditionally has been used in treating several viral diseases. It is also used in treating respiratory infection. Many compounds have been isolated from *C. tora* which include anthraquinone, glycosides, naphopyrone glycosides, and other phenolic compounds that have varieties of activities (Hebbar et al., 2004; Shadab et al., 2019).

Taxillus chinensis (DC) Danser also commonly called mulberry mistletoe is a plant in the mistletoe family Loranthaceae; it grows in China, India, and Vietnam. It is used to treat several ailments. Pharmacologically, it has antioxidant, anticancer, anti-inflammatory activities and it supports the immune system. It strengthens the liver, heart, and kidney, relieves joint pains and helps to manage arthritis. Also, this plant may have potential as a candidate for the future development of anti-SARS treatments (Wen et al., 2011; Zhang et al., 2013).

Chibotium barometz also called the golden chicken fern is a tropical plant of South East Asia. It is used in traditional Chinese medicine to treat epilepsy, wound, ulcers, and cough. It also serves as an anti-rheumatic, kidney, and liver tonic. *Lonicera japonicum* commonly known as Japanese honeysuckle is a plant used to treat varieties of ailment in Japanese folkloric medicine. It is used to treat swelling, enteritis, upper respiratory infections including colds, influenza, swine flu, pneumonia other viral, and bacterial infections. The flower buds, leaves, and stem of *L. Japonicum* are used medicinally. The plant potency in lowering body temperature has also been documented (He et al., 2016; Wen et al., 2011).

Nigella sativa L commonly called black cumin is a native to Indian and West Asia. The seed is used as spices in the Middle East. Oil extracted from the seed contains linoleic acid, oleic acid, palmitic acid, and some aromatic oil which includes thymoquinone. The seed oil contains antioxidants, anti-inflammatory, antibacterial and antiviral activities, cholesterol-lowering activity (LDL cholesterol) anticancer properties and unconfirmed evidence showed many COVID-19 patients in Nigeria use *N. sativa* seed oil to treat the disease (Aftab et al., 2013; Almatrafi, 2016; Hasani-Ranjbar et al., 2009; Yimer et al., 2019).

Many phytochemicals and isolated compounds have been identified experimentally to inhibit SARS-CoV spike protein (S) interaction with human ACE 2. Examples include Emodin, physion, and rhein isolated from Rheum and polygonum genus from the family Polygonaceae. Flavonoids like Quercetin, Quercetin, Cinacetrin from *Houtluynia cordata* inhibitory effect on MHV and DENV which are similar to SARS-COV 2 virus (Huang et al., 2015; Yan et al., 2011). Saikosaponin, a saponin from

Bupleurum Chinese and *Bupleurum scorzonerifolium* from the Apiaceae family has shown great antiviral potentials which can be exploited in treating COVID 19 disease.

CONCLUSION

The successful management of human viral diseases is hardly achieved with the use of synthetic drugs; thus only a few antiviral drugs are available in the market for prophylactic or therapeutic use against human viral diseases. Alternative or complementary sources of antiviral agents such as phytochemicals are therefore necessary.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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