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REVIEW PAPER

A review of Cameroonian medicinal plants with potentials for the management of the COVID-19 pandemic

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Abstract

Since the outbreak in December 2019, in Wuhan (China) of COVID-19, approved drugs are still lacking and the world is seeking effective treatment. The purpose of this article is to review the medicinal plants with potential to be used as complementary therapies against COVID-19. Bibliographic information was searched in several databases (Google Scholar, PubMed, Scopus, ScienceDirect, PROTA, ResearchGate and GLOBEinMED), to retrieve relevant papers on (1) plants used to manage common symptoms of COVID-19, (2) plant secondary metabolites with confirmed inhibitory effects on COVID-19 and (3) plants exhibiting pharmacological activities of relevance for COVID-19 management. A total of 230 species was recorded as potential source of ingredients for the fight against the 2019 novel corona virus. Of these species, 30 contain confirmed antiCOVID-19 secondary metabolites, 90 are used traditionally to manage at least 3 common symptoms of COVID-19, 10 have immunostimulant activity, 52 have anti-inflamatory activity, 14 have antiviral properties and 78 species are documented as used to treat malaria. A PCA analysis showing cluster formatting among the recorded species indicates 4 groups of species and an array of possibility of using individual species or a combination of species for their complementary effects. The authors argue that Cameroonian medicinal plants can be of potential contribution to the fight against COVID-19. Further applied research is needed to provide more scientific evidence for their efficacy, to establish standard formulations and clinical studies as part of efforts to develop therapies for COVID-19.

Keywords Medicinal plants · Ethnobotany · Phytochestry · Pharmacological properties · Review

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Introduction

Background on the outbreak and epidemiology of the COVID-19 pandemic

Corona viruses are well known in veterinary medicine. First discovered in the 1960s as parasites of infectious chicken bronchitis, they were later found to be responsible for serious epidemics in humans such as Severe Acute Respiratory Syndrome (SARS) in 2002/2003 and the Middle East Respiratory Syndrome (MERS) in 2012.

Huang et al. (2020) reported in late December 2019, an outbreak of a mysterious pneumonia of unknown cause in the Huanan Seafood Wholesale Market, in Wuhan, Hubei, China. The causal agent of this disease was isolated and identified by Chinese scientists as a new strain of Corona virus, the SARS-CoV-2 or 2019 novel corona virus (2019-nCov). Data obtained on patients with laboratory-confirmed 2019-nCoV infection in the hospital of Wuhan indicated that the common early symptoms of this disease were fever (98% of patients), cough (76%), and myalgia or fatigue (44%). Complications associated with this disease as observed in hospitalized patients included acute respiratory distress syndrome (29%), RNAaemia (15%), acute cardiac injury (12%) and secondary infections (10%).

Because this 2019-nCov is spread by human-to-human transmission via droplets or direct contact (Lai et al. 2020), its emergence in China has caused a large global outbreak. According to the European Centre for Disease Prevention and Control, the worldwide situation update shows that since 31 December 2019 and as of 13 January 2021, a total of 84 532 824cases of COVID-19 have been reported worldwide, including 1,845,597 deaths (ECDC 2020). During the same period, the African continent has reported 2,832,753 cases (26,846 cases reported for Cameroon and 448 deaths); the countries reporting with the greatest number of reported deaths included South Africa (29,577), Egypt (7805), Morocco (7485), Tunisia (4800) and Algeria (2772).

Despite the ongoing efforts to manage the disease, no antiviral drug currently exists for the prevention or treatment (Shio-Shin et al. 2020), and many months may be required for their development. There are actually a number of COVID-19 candidate vaccines for which certain national regulatory authorities have authorized their evaluation or use. However, none have yet received WHO authorization (Calina et al. 2020). However, the spread of the COVID-19 pandemic is very dynamic and growing around the world. In response to this outbreak, the World Health Organization, on January 30, 2020 declared that the pandemic constitutes a public health emergency of international concern and issued temporary recommendations under the International Health Regulations.

Global therapeutic response to COVID-19

Currently, no approved drug for COVID-19 exists and treatments provided worldwide to the affected persons are symptom based. These include antiviral drugs so far used against major groups of viruses like human immunodeficiency virus (HIV), herpes, hepatitis, influenza, SARS-CoV and MERS-CoV, antimalaria drugs, imunostimulants, anti-inflammatory drugs that may be effective against elevated levels of cytokines and useful in inhibiting viral infection (Vellingiri et al. 2020).

Reviews by Vellingiri et al. (2020), Liu et al. (2020) and Wu et al. (2020) reported that the current most clinically used drugs can be grouped into three categories: antiviral agents, supporting agents and miscellaneous agents and therapies (Table 1).

Worldwide, a number of drugs which have so far been proven to be safe for humans, are currently being repurposed to be used for the management of this disease.

The 2019 novel coronavirus genome encodes several structural proteins, including the glycosylated spike (S) protein that functions as a major inducer of host immune responses. This S protein mediates host cell invasion via binding to a receptor protein called angiotensin-converting enzyme 2 (ACE2) located on the surface membrane of host cells. Hence, the interaction between viral S protein and ACE2 on the host cell surface is of significant interest in the therapeutic response process since it initiates the infection process.

Herbal medicine and the COVID-19 challenge: a global overview

Globally, herbal treatments have been proven effective to control contagious disease during the 2003 severe acute respiratory syndrome (SARS) outbreak (Zhang et al. 2020). Therefore, since the outbreak of COVID-19, there has been great attention in investigating metabolites secreted by plants that may be developed as medicines for COVID-19.

Historically, traditional medicine and local beliefs have always played a role in epidemics through time (Zhang 1996). A review by Jassim and Naji (2003) reported numerous potentially useful medicinal plants that need to be evaluated and exploited for therapeutic applications against genetically and functionally diverse virus families. Keyaerts et al. (2007) identified a variety of plant lectins as antiviral compounds against the SARS-CoV. Lelesius et al. (2019) also showed that some extracts of plants including *Thymus vulgaris* and *Desmodium canadense* were effective against avian infectious bronchitis virus, a highly contagious respiratory disease in chickens caused by a corona virus that belongs to the Coronaviridae family. From

Table 1 Current Therapeutic Drugs used in the treatments of COVID-19

Drug name/category	Description
Antiviral agents	
Remdesivir	A broad-spectrum antiviral agent, anti-viral peptide that was used in treatments against Ebola, SARS-CoV and MERS-CoV
Hydroxychloroquine and Chloroquine	An anti-malarial drug, which has been effective in the treatment of avian influenza A;
	Can inhibit the entry of SARSCoV-2 and prevent virus-cell fusion by interfering with glycosylation of the ACE2 receptor and its binding with spike protein;
	Anti-viral and immune modulating properties;
	Can reduce cytokine storm
Lopinavir-Ritonavir	Lopinavir is a protease inhibitor with high specificity for HIV1 protease
	Ritonavir inhibits the enzymes that are responsible for lopinavir metabolism, and its co-administration improves antiviral activity
	Lopinavir was also used along with another flu drug, oseltamivir and resulted in complete recovery of patients showing signs of COVID-19 related pneumonia
Umifenovir (Arbidol)	A drug targeting S protein/ACE2, it is an inhibitor that may disrupt the binding of viral envelope protein to host cells, thus preventing viral entry to the target cell. It has been used earlier as influenza antiviral drug;
	An in vitro antiviral efficacy in widely spreading virus strains such as the Ebola virus, human herpesvirus 8 (HHV-8), hepatitis C virus (HCV), and Tacaribe arenavirus
Favipiravir (Avigan)	A broad spectrum anti-viral drug, a purine nucleoside whose possible mechanism on COVID-19 is through its action as an alternate substrate leading to inaccurate viral RNA synthesis
Oseltamivir (Tamiflu)	A drug approved for treatment of influenza A and B. It inhibits the spread of the influenza virus in the human body
Ribavirin	A broad-spectrum antiviral drug used in the treatment of hepatitis C, in combination with interferon α (IFN)
Sofosbuvir	A drug also used for the treatment of hepatitis C in combination with interferon or RBV
Supporting agents	
Azithromycin	An antibiotic used against many different types of infections caused by susceptible bacteria,
	It has been proven to be active in vitro against Zika and Ebola viruses and to prevent severe respiratory tract infections when administered to patients suffering viral infection
Vitamin C (Ascorbic Acid)	As a potent antioxidant agent, it neutralizes free radicals and helps to prevent or reverse cellular damage
	It has immunomodulatory activity
	An antiviral agent against influenza viruses
Zinc	Inhibits SARS-CoVand retrovirus RNA polymerase activity
	Enhances chloroquine intracellular uptake
Corticosteroids	Anti-inflammatory drug
	Prevent an extended cytokine response and may accelerate resolution of pulmonary and systemic inflammation in pneumonia
Tocilizumab (Actemra)	Immunosuppressive drug, emerged as an alternative treatment for COVID-19 patients with a risk of cytokine storms
Sarilumab	It inhibits IL-6 that might play a role in driving the inflammatory immune response that causes acute respiratory distress syndrome observed in patients with severe COVID-19 infection
Interferon (IFN) Beta 1-Alpha)	It has nonspecific antiviral as well as other complex effects on immunity and cell proliferation
Miscellaneous Agents and Therapies	
Ibuprofen	Activators of ACE2 receptors
Indomethacin	Antiviral activity against SARS-CoV and canine coronavirus (CCoV)

Adapted from Vellingiri et al. (2020), Liu et al. (2020) and Wu et al. (2020)

all over the world, people are witnessing a deep attachment to popular medicine to protect themselves against COVID-19. This is because to date, herbal products have proven to be not only effective, but also widely available to consumers.

Africa is endowed with diverse environmental conditions and a diversity of pathogenic microbial species (bacteria, fungi, and viruses). These microbes are causal agents of a great number of diseases (Cunningham et al. 2008), thus suggesting that African plants could accumulate chemopreventive substances more than plants from the northern hemisphere (Mahomoodally 2013). Basically, more than 80% of the population in this continent is known to rely on traditional medicine for their primary health care needs.

In Burkina Faso, the country's plan to respond to the COVID-19 pandemic does not rule out the use of herbal medicines, and clinical trials are underway on Apivirine, a phytomedicine from Benin which is alleged to be effective against the coronavirus (Sputniknews 2020).

In Algeria, to face the spread of this pandemic, consultation of herbalists in the search of traditional antiviral and anti-flu recipes have significantly increased (Le Point International 2020).

Goothy et al. (2020) supported the possible role of medicinal plants in Ayurveda's medicine for the management of Corona virus disease (COVID-19). Sharma and Kaur (2020) showed that Jensenone from *Eucalyptus* essential oil was a potential inhibitor of 2019 corona virus.

In China, DU Hong-Zhi et al. (2020) argued that traditional chinese medicine is an effective treatment for the 2019 novel coronavirus pneumonia.

More recently, the Malagasy Institute for Applied Research developed an herbal tea based on *Artemisia annua* (COVID Organics), claiming preventive and curative properties against COVID-19 (Midi-Madagascar 2020).

In China, herbal traditional medicine have been proven effective to control contagious disease during the 2003 severe acute respiratory syndrome (SARS) outbreak and a recent screening of a Chinese herbal medicine database have confirmed that herbal treatments classically used for treating viral respiratory infection contain chemical compounds that have potential anti-2019-nCoV activity (Zhang et al. 2020).

In Nigeria, recent reviews on potential plants for treatment and management of COVID-19 have been carried out. The results presented up to a hundred Nigerian indigenous medicinal plants with therapeutic abilities which may serve as effective treatments for COVID-19 due to their antiviral, anti-inflammatory, antioxidant, antipyretic, immunomodulatory and cyto-protective properties (Oladele et al. 2020; Ikpa et al. 2020).

In Cameroon, since the first case was reported in the country, several herbal recipes have been popularized in social media, as alleged solutions to manage COVID 19. According to a recent release from the Cameroon Radio and Television Corporation, the Archbishop of Douala, His grace Samuel Kleda, has made public an attempt at treating symptoms of COVID-19 with a herbal remedy, free of charge and the Ministry of Public Health is showing commitment to support the process of development and homologation of this treatment (Crtv 2020).

As the world is currently seeking treatment for COVID-19, there is an urgent need to boost up research so as to develop effective and affordable therapeutics.

Cameroon's response strategy to COVID-19

In Cameroon, access to health care services is challenging. One out of every 1,000 patients is able to see a specialist and 3 out of 20 patients are able to buy prescribed drugs in hospitals (Kuete and Efferth 2010). In this context, the COVID-19 situation is likely to worsen as the country moves into phase 2 of this pandemic marked by a shift from virus importation to intra-community transmission. Based on this situation, the Government prepared a COVID-19 Preparedness and Response Plan of US$600 million to respond to the crisis, under the leadership of the Ministry of Public Health and with the partnership of international organizations. This health response strategy has eight components:

- Multisectoral and international coordination,
- Surveillance for early detection of cases,
- Investigation and rapid intervention teams,
- Laboratory capacities,
- Infection prevention and control measures in hospitals and in the community,
- Case management,
- Risk communication and community engagement, and
- Logistics.

Several treatment protocols including the Chloroquine-based treatment suggested by Professor Didier Raoult (Colson et al. 2020) are being tested with varying degree of effectiveness.

However, since the outbreak of this disease, ethnobotanical and ethnopharmacological research geared at bringing the potentials of traditional medical knowledge into the debate over the management of this disease has been lacking. Yet Cameroon is a biologically diverse country. This country is located in Central Africa, in the heart of the Congo Basin, the world's second largest rainforest after the Amazon. Its floristic potential scores more than 7850 plant species recorded at the national herbarium. This ranks Cameroon among the countries with the highest levels of biodiversity in Africa. Despite the inaccuracy of statistics, medicinal plants are important elements of health care services. However, access to such plants has so far been largely through traditional healers and herbal markets which are part of an informal economy. The huge volume of published research on medicinal plants in Cameroon surprisingly contrasts with the paucity of approved phytodrugs. Among the pressing challenges that must be tackled for acceptable use of traditional and alternative medicines in modern therapeutics in Cameroon are:

- the increasing use of traditional medicines and the general weakness in translating research into concrete drug discovery and development,

- the evolution of international regulations on access to genetic resources and the growing concern by stakeholders vis-à-vis the demands for patenting rights, evidence of safety, efficacy, good quality traditional medicinal products and a range of other ethical issues,
- the shortage of essential infrastructure in both the public (universities and other governmental institutions) and private sectors,
- the need for integrating and promoting the potential of medicinal plants as a source of health care. So far, there have been significant efforts within the framework of the Cameroon Ethnobotany Network and the Millennium Ecologic Museum, under the leadership of Late Professors Bernard-Aloys Nkongeneck, Daniel Lantum, Jacques Kamsu Kom and Jeanne Ngogang, towards the strengthening the capacity of Cameroonian traditional healers. Series of training were offered geared at improving their knowledge and practice on basic techniques of pharmaceutical sciences. Nowadays and more than ever, it is still an imperative to keep pace with the committments of these pioneering ethnobotanists and to continue adding efforts to boost research and development in the field of medicinal plants. As new and effective drugs are urgently needed, in the fight gainst COVID-19, research programs into alternative therapeutics including medicinal plants investigations need to be encouraged.

Purpose of this review

This review is part of the contribution of ethnobotany and ethnopharmacology sciences in the fight against COVID-19. It aims at providing a preliminary review of available literature on medicinal plants with potentials to be evaluated and developed for the management of COVID-19 in Cameroon.

The findings of this review will provide other researchers with opportunities to identify the right medicinal plants to be evaluated from a perspective of developing new drugs to combat COVID-19.

Methodological approach

Theoretical framework to the selection of potential anti-COVID plants

The theoretical framework for the study is based on a 3-step review approach.

First, we acknowledge that the use of medicinal plants for the treatment of viral infections in our traditional societies is ancient. Meanwhile, COVID-19 is a novel disease and consequently not yet known in our traditional knowledge system on diseases. However, evidence from existing literature supports the management of symptoms similar to those of COVID-19 using a diversity of plant-based recipes. A recent review by Poudel Adhikari et al. (2020) presented the most commonly reported symptoms of COVID-19. Those considered in this review were: fever/malaria, runny nose, cough, myalgia or fatigue, body pains and sore throat. This review is based on the assumption that a plant that has been used to manage at least 3 common symptoms of COVID-19 is a potential source of anti-COVID-19 molecules.

Secondly, the inhibitory effect of some secondary metabolites from medicinal plants on the 2019 novel corona virus protease have been reported by Zhang et al. (2020) in China, Mohammadi and Shaghaghi (2020) in Iran and Khaerunnisa et al. (2020) in Indonesia. In this regard, the identification of Cameroonian medicinal plants with potentials as anti-COVID-19 was based on the investigations of their phytochemical profile to select those that are source materials for these secondary metabolites. Besides the metabolites cited by the above-mentioned studies, alkaloids are also a rich source of active components of plants that have already been fruitfully developed into various chemotherapeutic compounds comprising Chloroquine, an antimalarial drug reported to be effective for the treatment of COVID-19 and many other viral infections (Moradi et al. 2017; Colson et al. 2020; Gao et al. 2020). The mechanism of the antiviral activity of alkaloids is based on the inhibition of replication of viruses. Hence, in this study, a plant known as an important source of alkaloid is also considered as potential anti-COVID-19. Similar bioactivity on 2019-nCov was also reported for hydrolysable tannins, natural polyphénols (Khalifa et al. 2020; Adem et al. 2020) and terpenoids (Shagaghi 2020). Therefore, we also consider of great potential for COVID-19 management, plants that are rich sources of these secondary metabolites.

Thirdly, the use of biologics that stimulate immune responses was suggested by Zumla et al. (2020) as a way to help patients resist the invading virus. There is an abundant literature reporting the use of plants by traditional medicine practitioners to boost the immune system in people living with HIV/AIDS (Anywar et al. 2020). In addition to the important role of boosting the immune system, evidence from the literature reveals the importance of antimalaria and antiviral drugs in the global therapeutics against COVID-19 (Vellingiri et al. 2020). This is also the case for anti-inflammatory drugs that may be effective against elevated levels of cytokines and useful in inhibiting viral infection. Hence, plants with immunostimulant, antiviral, anti-malaria and anti-inflammatory properties are considered in this study as of great potentials for COVID-19 management.

Data collection and computation

This review is based on data available in published literature. Bibliographic information on medicinal plants was searched in several databases including: Google Scholar, PubMed, Scopus, ScienceDirect, Researchgate, PROTA, GLOBEinMED, to retrieve all relevant papers. Key words used included among other, the symptoms of COVID-19 (fever/malaria, runny nose, cough, myalgia or fatigue, body pains and sore throat), immunostimulant, antiviral, anti-malaria, anti-inflammatory, and secondary metabolites with confirmed inhibitory effect on the 2019 nCov (Allicin, Apigenin-7-glucoside, Catechin, Coumaroyltyramine, Curcumin, Desmethoxyreserpine, Diosmin, Epicatechin-gallate, Gingerol, Hesperidin, Kaempferol, Lignan, Luteolin-7-glucoside, Naringenin, Oleuropein, Pedunculagin, Punicalin, Quercetin, N-cis-feruloyltyramine, etc.).

A total of 119 papers were reviewed including books, journal articles, proceedings, preprints. The reference lists of some research articles were exploited to explore additional relevant studies. The database of the Global biodiversity Information Facility (GBIF) was searched to confirm the occurrences and distribution of the plant species recorded.

From the ethnobotanical and ethnomedical literature consulted, plants were selected and recorded based on their uses (focus on plants used to treat symptoms of COVID-19), their phytochemical composition (with a focus on plants rich in alkaloids, tannins, terpenoids and phenolics), their pharmacological activity (focused on plants with anti-inflammatory, immunomodulatory, antimalarial and anti-viral properties). All the plant species recorded were compiled in an Excel database.

The documented uses of each plant, the presence or absence of the targeted secondary metabolites and their documented pharmacological activity were used to generate a new data set which was analyzed by principal component analysis (PCA) to detect cluster formatting and the patterns of variability present in the data sets of the medicinal plant species recorded.

Findings and implication

Confirmed anti-COVID19 molecules and their source plants in Cameroon

The main protease (Mpro)/chymotrypsin like protease (3CLpro) from the 2019 novel corona virus, is reported to be a potential target for the inhibition of its replication (Lu, 2020). Khaerunnisa et al. (2020) showed that luteolin-7-glucoside, demethoxycurcumin, apigenin-7-glucoside, oleuropein, curcumin, catechin, and epicatechin-gallate appeared to have the best potential to act as COVID-19 Mpro inhibitors. Faheem Khan et al. (2020) showed that epigallocatechin gallate (EGCG), a major constituent of green tea (*Camelia sinensis*), was the lead compound that could fit well into the binding sites of docked proteins of SARS-CoV-2 and recommended this molecule as a drug candidate for the treatment of COVID-19.

Mohammadi and Shaghaghi (2020) reported that secondary metabolites including kaempferol, quercetin, luteolin-7-glucoside, demethoxycurcumin, naringenin, apigenin-7-glucoside, oleuropein, curcumin, catechin, epicatechin-gallate, zingerol, gingerol, and allicin were potential inhibitor candidates for COVID-19 Mpro, with Curcumin showing the strongest interaction with the protease enzyme of COVID-19. A recent study by Zhang et al. (2020) has identified several Chinese medicinal plants classified as antiviral/antipneumonia-effective that directly inhibit the novel coronavirus, 2019-nCoV. The metabolites tested for this bioactivity were Betulinic acid, Coumaroyltyramine, Cryptotanshinone, Desmethoxyreserpine, Dihomo-c-linolenic acid, Dihydrotanshinone, Kaempferol, Lignan, Moupinamide, N-cis-feruloyltyramine, Quercetin, Sugiol, Tanshinone IIa.

Khalifa et al. (2020) showed that the Pedunculagin, tercatain, and punicalin, three hydrolysable tannins, successfully inhibit the protease enzyme of 2019 novel Corona Virus.

Adem et al. (2020) evaluated the efficacy of medicinal plant-based bioactive compounds against COVID-19 Mpro by a molecular docking study. They concluded that natural polyphénols including hesperidin, rutin, diosmin, apiin, diacetylcurcumin, (E)-1-(2-Hydroxy-4-methoxyphenyl)-3-[3-[(E)-3-(2-hydroxy-4-methoxyphenyl)-3-oxoprop-1-enyl]phenyl]prop-2-en-1-one, and β,β'-(4-Methoxy-1,3 phenylene)bis(2′-hydroxy-4′,6′-dimethoxyacrylophenone were effective inhibitors of this new Corona Virus.

From the research conducted by these authors, it is clear that Cameroonian medicinal plants can provide source materials for these secondary metabolites. The review of the phytochemical screening done on Cameroonian medicinal plant species shows that 32 species native or naturalized in Cameroon are source materials for most of the above-mentioned secondary metabolites (Table 1). There is also evidence from available literature indicating diverse pharmacological properties for these species including antimicrobial, antiviral, analgesic, anti-inflammatry, antipyretic, antioxidant, and more. (Table 2). Besides Curcumine from turmeric (*Curcuma loonga*), some of those local plant species are interesting as they contain many of those active secondary metabolites. This is the case of *Zanthoxyllum heitzii* containing both Apigenin-7-glucoside and Oleuropein, and Citrus spp, a rich source of Diosmin, Lignan, Naringenin and Quercetin that showed high inhibitory effect on 2019 corona virus.

Cameroonian medicinal plant used to manage symptoms of COVID 19

The review yielded a total of 230 medicinal plants of potential for the management of COVID-19. From this general list

Table 2 Cameroonian or naturalized species containing secondary metabolites with confirmed inhibitory effect on COVID-19

Confirmed anti-Covid19 compounds*	Source plants in Cameroon	Other relevant literature evidence	References
Allicin	*Allium sativum*	Strong antimicrobial activity	Mohammadi and Shaghaghi (2020), Borlinghaus et al. (2014)
		Stimulates the activity of immune cells,	
		Inhibits the release of TNFα-dependent pro-inflammatory cytokines	
		Inhibits the migration of neutrophilic granulocytes into epithelia, which is a crucial process during inflammation	
Apigenin-7-glucoside,	*Zanthoxyllum heitzii*	exerts inhibitory effect on HL-60 cells through the reactive oxygen species (ROS) generation, loss of mitochondrial membrane potential and cell cycle destabilization	Mohammadi and Shaghaghi (2020), Khaerunnisa et al. (2020), Pieme et al. (2014)
Catechin	*Khaya grandifoliola*	n -hexane extract, crude and purified fractions are active antimalarial activities	Mohammadi and Shaghaghi (2020), Khaerunnisa et al. (2020), Agbedahunsi et al. (1998)
		contains ingredients that showed invitro activity against hepatitis C virus	
	Cola nitida	Antimicrobial and antiosydant	Niemenak et al. (2008), Ngoupayo et al. (2018)
	Cola acuminata	Antimicrobial and antiosydant	
	Cola anomala	Antimicrobial	
	Laportea aestuans	Antimicrobial effect of crude extract	Mambe et al. (2016)
Coumaroyltyramine	*Ochthocosmus Africanus*	No data found	Tala Sipowo et al. (2017)
	Solanum melongena	Antipyretic and analgesic effect	Sakah Kaunda and Zhang (2019), Mutalik et al. (2003)
	Solanum torvum	An isoflavonoid sulfate and a steroidal glycoside isolated from the fruits exhibited antiviral activity on herpes simplex virus type 1	Zhang et al. (2020), Damrongkiet et al. (2002), Chah et al. (2000)
		Wide spectrum of antimicrobial activities against human and animal clinical isolates	
Curcumin	*Curcuma longa*	Curcumin has antioxidant, anti-inflammatory, antiviral and antifungal actions. Not toxic to humans	Mohammadi and Shaghaghi (2020), Shaghaghi (2016), Khaerunnisa et al. (2020), Akram et al. (2010), Moghadamtousi et al. (2014)
		Curcumin also enhances immunity	
Desmethoxyreserpine	*Rauwolfia sp.*	produces hypothermia, increased salivation, miosis, and increased gastric acid secretion	Zhang et al. (2020), Khaerunnisa et al. (2020), Packman et al. (2006)
Diosmin	*Cissus quadrangularis*	antagonistic effect on the biochemical mediators of inflammation, antioxidant, antimicrobial activity	Mishra1 et al. (2010),
	Citrus sinensis	anti-inflammatory, antihypertensive, antiviral diuretic, analgesic and hypolipidemic properties	Tarkang et al. (2012), Abonyi et al. (2009)
Epicatechin-gallate	*Parkia biglobosa*	The leaf extract of P. biglobosa contains biologically active principles relevant in the treatment of malaria	Kuete et al. (2018), Tijani et al. (2009), Modupe Builders et al. (2009)
		Antidiarrhoeal and Antibacterial	
	Camellia sinensis	Regular consumption of green tea decreases influenza infection rates and some cold symptoms, and gargling with tea catechins may protect against the development of influenza infection	Mohammadi and Shaghaghi (2020), Faheem Khan et al. (2020), Khaerunnisa et al. (2020), Isemura (2019)
	Laportea aestuans	Antimicrobial effect of crude extract	Mambe et al. (2016)

Table 2 (continued)

Confirmed anti-Covid19 compounds*	Source plants in Cameroon	Other relevant literature evidence	References
Gingerol	*Zingiber officinale*	Gingerols in ginger root have been shown to have chemopreventive effects associated with their antioxidant and anti-inflammatory activities	Mohammadi and Shaghaghi (2020), Mehdi Sharifi-Rad et al. (2017)
Hesperidin	*Acacia senegal*	Used in the management of cough	Mahomoodally (2013)
	Laportea aestuans	Antimicrobial effect of crude extract	
	Citrus spp	Increases antioxidant defenses, scavenges reactive oxygen species, modulates immune system activity	Mohammadi and Shaghaghi (2020), Salehi et al. (2019)
		Dose-dependent inhibitory effect against dengue virus, prevents intracellular replication of chikungunya virus, and inhibits assembly and long-term production of infectious hepatitis C virus particles in a dose-dependent manner	Azantsa Kingue et al. (2017)
Kaempferol	*Bryophyllum pinnatum*	Antimicrobial and antioxidant activity	Zhang et al. (2020), Mohammadi and Shaghaghi (2020), Ndendoung Tatsimo et al. (2012)
	Laportea aestuans	Antimicrobial effect of crude extract	Mambe et al. (2016)
	Tephrosia preussii	No data found	Mba Nguekeu et al. (2017)
	Senna alata	Treatment for Pulmonary Arterial Hypertension diseases	Rhazri et al. (2015)
Lignan	*Echinops giganteus*	Antioxydants	Tene et al. (2004)
	Kigelia africana	Anti-diarrheal, anti-malarial, analgesic, anti-inflammatory and anti-microbial activity	Zhang et al. (2020), Sidjui Sidjui et al. (2015), Saini et al. (2009)
	Zanthoxylum heitzii	No data found	Ngouella et al. (1994)
Luteolin-7-glucoside	*Capsicum annuum*	The extract exhibited considerable anti-HSV-1 and anti-HSV-2 activities	Mohammadi and Shaghaghi (2020), Khaerunnisa et al. (2020), Taghreed et al. (2017)
Naringenin	*Citrus spp*	Increases antioxidant defenses, scavenges reactive oxygen species, modulates immune system activity	Mohammadi and Shaghaghi (2020), Salehi et al. (2019)
		Dose-dependent inhibitory effect against dengue virus, prevents intracellular replication of chikungunya virus, and inhibits assembly and long-term production of infectious hepatitis C virus particles in a dose-dependent manner	Azantsa Kingue et al. (2017)
N-cis-feruloyltyramine,	*Hibiscus esculentus*	Antioxidant	Maganha et al. (2010)
Oleuropein,	*Zanthoxylum heitzii*	Cancer prevention	Mohammadi and Shaghaghi (2020), Khaerunnisa et al. (2020), Farooqi et al. (2017)
Pedunculagin	*Phyllantus spp*	Antiviral, antimicrobial, anticancer, hepatoprotective and anti diabetic	Shakya (2016)
Punicalin	*Terminalia catappa*	Used to treat dermatitis and hepatitis	Mohale et al. (2009)
		Anti-inflamatory activity	
	Combretum glutinosum	Methanolic and water extract from leaves and stem bark have antimicrobial activity	Jossang et al. (1994), Alowanou et al. (2015)
	Terminalia ivorensis	Anti-inflammatory, antioxidant and anti-HIV activities	Assamoi Adiko et al. (2013)

Table 2 (continued)

Confirmed anti-Covid19 compounds*	Source plants in Cameroon	Other relevant literature evidence	References
Quercetin	*Morinda morindoides*	Leaves exhibited antispasmodic effect	Mamadou1 et al. (2011)
	Citrus limon	Treatment of chronic pneumonia (naringenin) Inhibition of cytokine production; Inhibition of inflammation mediator (D-limonene) Inhibition of the virus Herpes simplex	Zhang et al. (2020), Mohammadi and Shaghaghi (2020), Klimek-Szczykutowicz et al. (2020)

*Based on the studies by Khaerunnisa et al. (2020), Faheem Khan et al. (2020), Shagaghi (2020), Mohammadi and Shaghaghi (2020, Zhang et al. (2020), Khalifa et al. (2020) and Adem et al. (2020)

Table 3 Number of medicinal plants cited in the treatment of COVID-19 symptoms

Symptoms	Number of plants recorded	Percentage
Catarrh/Runny nose	20	3.8
Cough	138	26.3
Fever	241	45.9
Myalgia/fatigue	106	20.2
Headache	8	1.5
Pains	4	1.58
Sore throat	3	0.6

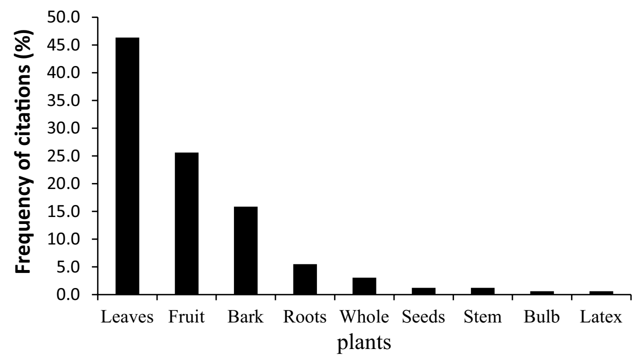

Fig. 1 Frequency of plant parts used in management of COVID symptoms

of plants recorded, 90 species were selected for being mentioned as used to manage at least 3 symptoms of COVID-19, and the remaining species were excluded (Table 4). These 90 species belong to 53 botanical families. The families with the greatest number of representatives are Rubiaceae (8 species), Asteraceae and Euphorbiaceae (6 species), Caesalpiniaceae and Meliaceae (5 species), Solanaceae (4 species), Apocynaceae, Combretaceae, Malvaceae, Sapotaceae and Verbenaceae (3 species).

The greatest number of citations was recorded for three of the six symptoms investigated: fever/malaria, cough and myalgia/fatigue (Table 3).

Various plant parts are used in the different treatments reported in the literature. However, leaves, fruits and bark were the most used parts, indicating that their utilization may not severely affect the sustainability of the resource base (Fig. 1).

Available data on the phytochemical screening of these selected species shows that the most distributed secondary metabolite in this selected sample of plants was alkaloids (36%) (Fig. 2). Previous studies by Ntié-Kang et al. (2013) also confirmed the greater distribution of terpenoids (26%), flavonoids (19.6%) and alkaloids (11.2%) in Cameroon's medicinal plants.

State of knowledge on Cameroonian medicinal plants with confirmed anti-inflammatory, anti-viral and immunostimulant properties

Evidence from research conducted on SARS-COV and COVID-19 shows that the weakening of the immune system is one of the major contributing factors to the increased incidence of COVID complications like pneumonia and mortality in affected patients (Curbelo et al. 2017; Taghizadeh-Hesary and Akbari 2020; Prompetchara et al. 2020). These authors argued that improving the immune system response may be effective in reducing the incidence of pneumonia, and reduction of inflammation may be effective in reducing the mortality rates due to pneumonia. From the literature data compiled, about 10 species have been documented for their beneficial effect in boosting the immune system. Among these species, 3 were also cited to treat at least 3 symptoms of COVID-19: *Azadirachta indica* and *Momordica charantia* and *Vernonia amygdalina* (Table 4). Of the total of 52 species documented for their anti-inflamatory activity, there are also 11 cited as used to treat COVID-19 symptoms. These are: *Acanthus montanus, Eleusine indica, Entandrophragma cylindricum, Eremomastax speciosa, Erythrophleum suaveolens, Jatropha curcas, Kalanchoe crenata, Picralima nitida, Senna alata, Solanum torvum, Spathodea campanulata Vernonia amygdalina,* and *Vitellaria paradoxa* (Table 4). A total of 14 species were cited for their antiviral properties on other virus-induced diseases, of which 5 are traditionally used to manage COVID-19 symptoms: *Anickia chlorantha*, *Artemisia annua, Costus afer, Senna alata* and *Vernonia amygdalina* (Table 5). A total of 78 species have been documented as used to treat malaria. Overall, the leaves, bark and roots are the most used plant parts as noted below (Fig. 3).

Overall, these species belongs to 53 different botanical families. The families with a higher number of representatives are Caesalpiniaceae (10 species), Asteraceae (3 species), Cucurbitaceae and Apocynaceae (3 species), Euphorbiaceae, Lamiaceae, Meliaceae, Acanthaceae, Combretaceae, Euphorbiaceae, Meliaceae and Mimosaceae (2 species).

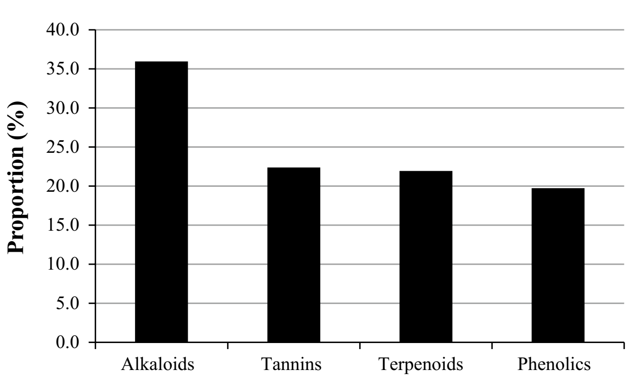

Fig. 2 Distribution of secondary metabolites in the recorded plants

Summary and implication for the fight against COVID-19

From this review, 230 Cameroonian medicinal plant species emerge as promising sources of ingredients for the fight against the 2019 novel corona virus. Among these species, about 32 contain secondary metabolites that have already been confirmed as anti-COVID-19 molecules. These are *Abelmoschus esculentus, Acacia Senegal, Allium sativum, Bryophyllum pinnatum, Camellia sinensis, Capsicum annuum, Cissus quadrangularis,* Citrus spp, *Cola acuminata, C. anomala, C. nitida, Combretum glutinosum, Curcuma longa, Echinops giganteus, Khaya grandifoliola, Kigelia Africana, Laportea aestuans, Morinda morindoides, Ochthocosmus africanus, Parkia biglobosa, Phyllanthus spp, Rauwolfia sp., Senna alata, Solanum melongena, Solanum torvum, Tephrosia preussii, Terminalia catappa, Terminalia ivorensis, Zanthoxyllum heitzii* and *Zingiber officinale*.

Of the 230 species recorded, 102 are already documented for their traditional use to manage at least 3 common symptoms of COVID-19. The PCA analysis separated 4 groups of medicinal plant species with axis 1 and 2 explaining 65.7% of the variability within the sample (Fig. 4).

The first group consists of plants treating at least three symptoms of COVID 19, containing key phytochemicals reported as being of interest for COVID management (alkaloids, phenolics, tannins and terpenoids) and having antimalaria properties. Representative species include *Abelmoschus esculentus, Artemisia annua, Capsicum annun, Curcuma longa, Eucalyptus camaldulensis, Eremomastax speciosa, Kalenchoe crenata, Lippia multiflora, Morinda lucida, Senna alata*, *Solanum torvum*, etc.

The second group consists of highly promising species like *Azadirachta indica, Harungana madagascariensis, Mangifera indica, Momordica charantia, Picralima nitida, Trichilia emetica*. This consists of plants used to treat COVID-19 symptoms which, at the same time are sources of the key phytochemicals and also have relevant pharmacological activities (antiviral, anti-inflammatory, immunostimulant, or containing secondary metabolites with confirmed anti-SARSCOV2 activity). Even when used alone, they can be evaluated and developed as potential remedies, while the other species may be used in association to each other for their complementary effects.

The third group consists of potential anti-malaria agents based on the species *Allium sativum, Psidium guajava, Phyllanthus muellerianus, Occimum gratissimum, Stereospermom acuminatissimum,* etc.

Table 4 Cameroonian medicinal plant species used to manage at least 3 COVID 19 symptoms

Species	Family	Part used*	Symptoms treated	Main phytochemicals**	Reference
Abelmoschus esculentus	Sterculiaceae	L,Fr	Cough, Fever, Myalgia	Tan, Phen, Terp	Bogninou et al. (2018) Tomar (2017), Alamgeer Younis et al. (2018)
Acanthus montanus	Acanthaceae	L	Cough, Fever, Myalgia	Alk	Asongalem et al. (2004), Kuete and Efferth (2010), Etame et al. (2018), Fongod et al. (2013)
Adansonia digitata	Bombacaceae	Bk	Cough, Fever, Myalgia	Alk	Yinyang et al. (2014), Arbonnier (2019), Kamatou et al. (2011)
Ageratum conyzoides	Asteraceae	L	Cough, Myalgia, fever	Alk, Terp	Ming (1999), Jiofack et al. (2008), Yinyang et al. (2014)
Alchornea cordifolia	Euphorbiaceae	L	Cough, Fever, Myalgia	Alk, Tan, Phen	Ngaha et al. (2016), Ngoupayo et al. (2018)
Allium sativum	Liliaceae	Bulb	Cough, Fever, Myalgia	**Alk**	Papu et al. (2014), Khodadadi (2015)
Aloe vera	Aloaceae	L	Cough, Fever, Myalgia	Alk	Sahu et al. (2014), Yinyang et al. (2014)
Alstonia boonei	Sapotaceae	Bk, Lx, L	Cough, Fever, Myalgia	Alk, Tan, Terp	Jiofack et al. (2008, 2009), Dibong et al. (2015)
Amaranthus hybridus	Amaranthaceae	Wp	Cough, Fever, Myalgia	Alk, Terp	Tinitana et al. (2016), Etame et al. (2018)
Ananas comosus	Annonaceae	Epc	Cough, Fever, Myalgia	Alk	Hossain et al. (2015), Yinyang et al. (2014)
Anickia chloranta	Annonaceae	Bk	Cough, Fever, Myalgia	Alk, Phen, Tan	Etame et al. (2018), Njayou et al. (2008)
Annona senegalensis	Annonaceae	Bk	Cough, Fever, Myalgia	Phen, Tan	Tsabang et al. (2012), Njayou et al. (2008)
Annona muricata	Annonaceae	L, Fr, Se, Pulp	Cough, Fever, pains, catharrh	Alk, Tan	Zorofchian Moghadamtousi et al. (2015), Yinyang et al. (2014), Tsobou et al. (2015)
Anogeissus leiocarpus	Combretaceae	Bk	Cough, Fever, body pains	Tan	Ahmad (2014), Ndjonka et al. (2008)
Anthocleista djalonensis	Loganiaceae	Bk	Cough, Fever, Myalgia	Alk, Phen, Tan	Bassey et al. (2009), Leke et al. (2012)
Anthocleista nobilis	Loganiaceae	Bk	Cough, Fever, Myalgia	Alk, Phen, Tan, Ter	Mosango (2007), Sima et al. (2015)
Artemisia annua	Asteraceae	Wp	Cough, Fever, Myalgia	Phen	Jiofack et al. (2008), Iqbal et al. (2012), Sadiq et al. (2014)
Azadirachta indica	Meliaceae	Se, L, Bk	Cough, Fever, Myalgia	Alk, Phen, Tan, Ter	Jiofack et al. (2009, 2008), Dash et al. (2017)
Brassica oleracea	Brassicaceae	L	Cough, Fever, Myalgia Sore throat	Alk	Yinyang et al. (2014)
Bridelia ferruginea	Euphorbiaceae	Bk	Cough, Fever, Myalgia	Alk, Tan, Terp	Ndam et al. (2014), Jose and Kayode (2009), Olumayokun et al. (2012)
Bridelia micrantha	Euphorbiaceae	Bk	Cough, Fever, Myalgia	Alk, Phen, Tan, Ter	Arbonnier (2019), Etono et al. (2019), Maroyi (2017)
Camellia sinensis	Theaceae	L	Cough, Fever, Myalgia	Alk	Yinyang et al. (2014), Namukobea et al. (2011), Sharangi (2009)

Table 4 (continued)

Species	Family	Part used*	Symptoms treated	Main phytochemicals**	Reference
Capsicum annuum	Solanaceae	L, Fr	Cough, Headache, Myalgia	Alk	Salehia et al. (2018), Yinyang et al. (2014)
Capsicum frutescens	Solanaceae	L, Fr	Cough, Headache, Myalgia	Alk, Terp	Salehia et al. (2018), Noumedem et al. (2013)
Carica papaya	Cacicaceae	L, Fr	Cough, Fever, Myalgia	Alk, Tan, Terp	SIvarajah (2015), Sebua and Maroyi (2013)
Catharanthus roseus	Apocynaceae	L	Cough, Sorethroat, Myalgia	Alk	Das and Sharangi (2017), Yinyang et al. (2014)
Chromolaena odorata	Asteraceae	L	Cough, Fever, Myalgia	Alk, Tan, Terp	Vaisakh et Pandey (2012), Tamo et al. (2016),
Cinchona calisaya	Rubiaceae	B, Rt, L, Fr	Cough, Fever, Myalgia	Alk	Eyal (2018), Yinyang et al. (2014)
Cinchona officinalis	Rubiaceae	B, Rt, L, Fr	Cough, Fever, Myalgia	Alk	Eyal (2018), Yinyang et al. (2014)
Cinchona pubescens	Rubiaceae	B, Rt, L, Fr	Cough, Fever, Myalgia	Alk	Eyal (2018), Yinyang et al. (2014)
Citrus aurantifolia	Rutaceae	L, Fr	Headache, colds, coughs, sore throats	Alk	Enejoh et al. (2015), Yinyang et al. (2014)
Cochlospermum planchonii	Cochlospermaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Isah et al. (2013), Usman et al. (2013), Mamidou Koné et al. (2005)
Cola acuminata	Malvaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen	Otoide and Olanipekun (2018), Tchuenguem et al. (2017), Yinyang et al. (2014), Lowe et al. (2014)
Cola nitida	Malvaceae	L, Fr	Headache, Fever, Myalgia	Alk	Olukayode et al. (2017), Yinyang et al. (2014)
Combretum micranthum	Combretaceae	L	Catarrh, Cough, Fever, Myalgia	Alk, Terp	Welch (2010), Chinsembu and Hedimbi (2010), Yinyang et al. (2014), Dawe et al. (2013)
Costus afer	Costaceae	St	Catarrh, Cough, Fever, Myalgia	Phen	Boison et al. (2019), Tchuenguem et al. (2017)
Crossopteryx febrifuga	Rubiaceae	L, Fr	Cough, Fever, Myalgia	Alk	Salawu et al. (2008), Arbonier (2019), Maiga et al. (2006)
Curcuma longa	Zingiberaceae	Rz	Cough, Fever, Myalgia	Terp	Velayudhan et al. (2012), Gardini et al. (2009)
Cymbopogon citratus	Poaceae	L	Cough, Fever, Headache, Sore throat, Myalgia	Alk, Terp	Etame et al. (2018), Yemele et al. (2014), Yinyang et al. (2014), Shah et al. (2011)
Diospyros mespiliformis	Ebenaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan	Hegazy et al. (2019), Ahmed and Mahmud (2017)
Dissotis rotundifolia	Melastomataceae	L	Catarrh, Cough, Fever, Myalgia	Alk, Phen, Tan	Jiofack et al. (2009), Yinyang et al. (2014), Yeboah and Osafo (2017)
Eleusine indica	Poaceae	Wp	Cough, Fever, Myalgia	Alk	Etame et al. (2018), Pattanayak and Maity (2017), Sagnia et al. (2014), Jiofack et al. (2008),
Emilia coccinea	Asteraceae	Wp	Cough, Fever, Myalgia	Alk, Tan, Terp	Nwachukwu et al. (2017), Tsobou et al. (2015),

Table 4 (continued)

Species	Family	Part used*	Symptoms treated	Main phytochemicals**	Reference
Eremomastax speciosa	Acanthaceae	L	Catarrh, Cough, Fever, Myalgia, Pains	Alk, Tan, Terp	Jiofack et al. (2008), Tsobou et al. (2015), Sagnia et al. (2014)
Eucalyptus camaldulensis	Myrtaceae	L, Fr, Bk, Rt	Cough, Fever, Myalgia	Alk, Tan, Phen, Terp	Jiofack et al. (2008), Sani et al. (2014)
Euphorbia hirta	Euphorbiaceae	Wp	Cough, Fever, Myalgia	Alk, Tan, Terp	Tamo et al. (2016), Kumar et al. (2010)
Eurycoma longifolia	Simaroubaceae	L, Fr	Cough, Fever, Myalgia	Alk, Terp	Norhidayah Mohamed et al. (2015), Mohamad et al. (2010)
Faidherbia albida	Mimosaceae	Bk	Cough, Catarrh, Fever	Alk, Tan, Terp, Phen	Ismail et al. (2014), Arbonier (2019), Marwa et al. (2018)
Garcinia cola	Clusiaceae	Fr	Cough, Fever, Myalgia	Alk	Jiofack et al. (2008, 2009), Betti (2002), Yinyang et al. (2014)
Guiera senegalensis	Combretaceae	L	Cough, Fever, Myalgia	Alk, Tan, Phen, Terp	Shafei et al. (2016), Arbonier (2019), Somboro et al. (2011)
Harungana madagascariensis	Hypericaceae	Bk	Cough, Fever, Myalgia	Alk, Phen	Nimenibo-Uadia and Nwachukwu (2017), Ndam et al. (2014)
Hibiscus sabdarifa	Malvaceae	L	Cough, Fever, Myalgia	Alk	Suresh and Ammaan (2017), Yinyang et al. (2014)
Holarrhena floribunda	Apocynaceae	Bk, L	Cough, Fever, Myalgia	Alk	Hoekou et al. (2017), Yinyang et al. (2014)
Hoslundia opposita	Lamiaceae	Rt	Cough, Fever, Sore throat	Phen, Tan	Arbonier (2019), Sadri (2017), Ndjonka et al. (2008)
Hymenocardia acida	Euphorbiaceae	L, Rt	Cough, Fever, Myalgia	Terp	Amoa Onguéné et al. (2013), Tor-Anyiin Terrumun et al. (2013)
Jatropha curcas	Euphorbiaceae	L	Cough, Fever, Headache	Alk, Phen	Arbonier (2019), Abdelgadir and Van Staden (2013), Oskoueian et al. (2011)
Kalenchoe crenata	Crassulacées	L	Cough, Fever, Headache, Myalgia	Alk, Terp	Yinyang et al. (2014), Jiofack et al. (2008), Nguelefack et al. (2006)
Khaya senegalensis	Meliaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Chukwudi Ugoh et al. (2014), Arbonier (2019), Makut et al. (2008)
Lantana camara	Verbenaceae	L	Cough, Fever, Catarrh	Alk, Tan, Terp	Tsobou et al. (2015), Kalita et al. (2012)
Lippia multiflora	Verbenaceae	L	Cough, Fever, Catarrh	Tan, Terp	Gandonou et al. (2017), Djengue et al. (2017)
Mangifera indica	Anacardiaceae	Bk	Cough, Fever, Catarrh	Alk, Terp	Mahalik et al. (2020), Yemele et al. (2014), Yinyang et al. (2014)
Maytenus senegalensis	Celastraceae	L	Catarrh, Cough, Fever	Phen, Tan	Arbonier (2019), Zangueu et al. (2018), Veloso et al. (2017)
Melissa officinalis	Lamiaceae	L, Fr	Catarrh, Cough, Fever	Alk	Miraj et al. (2017), Yinyang et al. (2014)

Table 4 (continued)

Species	Family	Part used*	Symptoms treated	Main phytochemicals**	Reference
Milicia excelsa	Moraceae	Bk	Catarrh, Cough, Fever	Alk, Phen, Tan	Jiofack et al. (2008), Betti (2002), Akinpelu et al. (2020)
Mitragyna inermis	Rubiaceae	L, Bk, Rbk	Catarrh, Cough, Fever	Alk, Phen, Tan, Terp	Mahougnan Toklo et al. (2020), Arbonier (2019), Konkon et al. (2008)
Momordica charantia	Cucurbitaceae	L	Cough, Fever, Pains	Alk, Phen, Tan, Terp	Jiofack et al. (2009), Mozaniel et al. (2018)
Morinda lucida	Rubiaceae	L, Fr	Cough, Fever, Pains	Tan	Adeleye and Ajamu (2018), Ndam et al. (2014)
Myristica fragrans	Myristicaceae	L, Fr	Catarrh, Fever, Myalgia	Alk, Phen,Terp,	Asgarpanah and Kazemivash (2012), Bamidele et al. (2011)
Olax subscorpioidea	Olacaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Osuntokun and Omolola (2019), Banjo et al. (2018),
Paullinia pinnata	Spindaceea	L, Rt	Cough, Fever, Myalgia	Alk, Tan, Ph	Tsobou et al. (2015), MAriame et al.(2016), Arbonier (2019), Ariyo et al. (2020)
Pavetta crassipes	Rubiaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen	Katsayal and Danfodiyo (2002), Arbonier (2019), Bello et al. (2011)
Picralima nitida	Apocynaceae	Fr, Rt	Cough, Fever, Myalgia	Alk, Tan, Terp	Tamo et al. (2016), Tsobou et al. (2015), Erharuyi1 et al. (2014)
Piliostigma thonningii	Caesalpiniaceae	L, Fr	Cough, Fever, Sore Throat	Phen, Tan	Afolayan et al. (2018), Kazhila (2016), Njayou et al. (2008)
Sarcocephalus latifolius	Rubiaceae	Bk, L, Fr	Cough, Fever, Myalgia	Ter, Phen	Arbonier (2019), Yesufu et al. (2014), Kaboré et al. (2014)
Senna alata	Caesalpiniaceae	L, Fr	Cough, Fever, Myalgia	Alk, Tan	Tsobou et al. (2015)
Senna occidentalis	Caesalpiniaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Singh et al. (2019), Musa et al. (2018)
Senna sieberiana	Caesalpiniaceae	L, Fr	Headache, Fever, Myalgia	Alk, Phen, Tan	Archer et al. (2019), Archer et al. (2019)
Solanum nigrum	Solanaceae	L, Fr	Cough, Fever, Myalgia	Alk, Terp	Yinyang et al. (2014), Noumedem et al. (2013), Ramya et al. (2011)
Solanum torvum	Solanaceae	L	Cough, Fever, Myalgia	Alk, Phen, Tan	Kannan et al. (2012), Jaiswal (2012), Kuete and Efferth (2010),
Spathodea campanulata	Bignoniaceae	Bk, L	Cough, Fever, Myalgia	Terp	Yemele et al. (2014)
Terminalia laxiflora	Combretaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Salih et al. (2018), Salih et al. (2017)
Trema orientalis	Ulmaceae	L, Fr	Cough, Fever, Myalgia	Alk, Phen, Tan, Ter	Akin et al. (2016), Adinortey et al. (2013)
Trichilia emetica	Meliaceae	Bk, L	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Arbonier (2019), Kouitcheu et al. (2017), Diarra et al. (2015), Šutovská et al. (2009)
Vernonia amygdalina	Asteraceae	L	Cough, Fever, Myalgia	Terp	Fongnzossie et al. (2017), Yeep et al. (2010)
Vernonia colorata	Asteraceae	L	Cough, Fever, Myalgia	Terp	Tsobou et al. (2015), Cioffi et al. (2014)

Table 4 (continued)

Species	Family	Part used*	Symptoms treated	Main phytochemicals**	Reference
Vitellaria paradoxa	Sapotaceae	Bk, Fr	Cough, Fever, Myalgia	Terp	Mbaveng et al. (2011), Maanikuu and Peker (2017), Israel (2014), Fongnzossie et al. (2017)
Vitex simplicifolia	Verbenaceae	L	Cough, Fever, Myalgia	Alk, Phen, Tan, Terp	Arbonier (2019) Salim and Dikko (2016), Salim and Imam (2016) (
Ximenia americana	Olacaceae	L, Fr	Cough, Fever, Myalgia	Phen, Tan, Terp	Urso et al. (2013), Hunde Feyssa et al. (2012), Monte et al. (2012)

**L* leave, *Bk* bark, *St* Stem, *Rt* roots, *Fr* fruit, *Se* seed, *Fl* flower, *Tbk* root bark, *Wp* whole plant, *Lx* latex

***Alk* alkaloids, *Tan* tannins, *Terp* terpenoids, *Ph* Phenolics

The fourth group consists of immunostimulants, anti-inflamatory, antiviral agents and plants containing some secondary metabolites with confirmed anti-COVID-19 properties, with representative species like *Moringa oleifera, Panda oleosa, Tapinanthus globuliferus, Zanthoxyllum heitzii,* and *Vernonia amygdalina*.

Overall, the recorded medicinal plant species offers an array of possibility of using individual species or combinations of species for their complementary effects, based on the clinical symptoms showed by the patients and the therapeutic objective to be achieved.

Challenges and way forward

In developing countries with poor access to health facilities like Cameroon, medicinal plants are the richest and most available sources for use and even for drug discovery. In such situations when our societies are desperate to discover cures for new and deadly disease like COVID-19, the contribution of herbal medicine in early response strategies should be promoted. Though the country's pharmaceutical potentials are immense, constraints and challenges however exist at all levels. To effectively address these shortcomings, a strong political-will and support of the Cameroonian government will be crucial.

Research and development

Research in ethnobotany, ethnopharmacology and bioactive components of medicinal plants of Cameroon has been ongoing for quite some time by University laboratories, by the Institute of Medical Research and Medicinal Plants Studies (IMPM) and by independent researchers. However, a systematic and concerted approach to this activity has been lacking. Much of this research has been academic and the concept of applied research in plant-based drug development has not received much attention. Although enough has been done in propagation of medicinal plants, research in support of industrial development, appropriate processing technologies to improve quality and yield, new formulations to new products and the marketing of finished products is still poorly developed. Actually, many medicinal plants sourced from Cameroon were involved in patents, most of which are owned by foreign entities (Oldham et al. 2013).

Capacity building and financial support are a necessity at all level in order to stimulate active research on natural medicinal products at the local level. Specifically, efforts have to be geared towards developing and sponsoring applied research on natural products and drug discovery. It is indeed paradoxical that with the country's medicinal plant potentials, herbal drug discovery has not yet reached the expected performance.

Capacity building

One of the main problems facing the use of herbal medicines is the proof requirement of their usefulnes, safety and effectiveness. Unfortunately, research and training activities for traditional medicine practitioners have not received due support and attention. As a result, the quantity, quality, safety and efficacy of herbal preparations are far from sufficient to meet demand. These weaknesses could be corrected by capacity building and low-cost technologies for the industrial production of traditional medicines to make them more effective, stable, reproducible, controlled, and in galenic forms that can easily be transported. Capacity building will be vital for also organizing the stakeholders and integrating their practices into the perspectives of modern research and development continuum. By so doing, the indiscriminate sale and advertisement of herbal products in all forms of media without compliance to the existing regulations would be discouraged.

Table 5 Recorded plants documented for their anti-inflammatory, anti-viral and/or immunostimulant properties

Scientific name	Family	Part used	Existing pharmacological records	References
Acacia polyacantha	Fabaceae	Leaves	Antimalaria	Bashige-Chiribagula et al. (2017)
Acanthus montanus	Acanthaceae	L	Anti-inflammatory	Kuete and Efferth (2010)
Adenocarpus mannii	Caesalpiniaceae	L	Methanol extracts possess immunomodulatory activity	Kuate (2015)
Aframomum citratum	Zingiberaceae	Fruit	Antimalaria	Tane et al. (2005)
Aframomum latifolium	Zingiberaceae	Fruit	Antimalaria	Tane et al. (2005)
Aframomum melegueta	Zingiberaceae	Seeds	Antimalaria	Tane et al. (2005)
Aframomum sceptrum	Zingiberaceae	Fruit	Antimalaria	Tane et al. (2005)
Aframomum zambesiacum	Zingiberaceae	Fruit	Antimalaria	Tane et al. (2005)
Ageratum conyzoides	Asteraceae	L	Antimalaria	Jiofack et al. (2008), Yinyang et al. (2014)
Albizia adiantifolia	Mimosaceae	Leaves	Antimalaria	Bashige-Chiribagula et al. (2017)
Albizia zygia	Mimosaceae	L, Rt	Anti-inflammatory	Asante-Kwatia et al. (2020)
Albizia zygia	Mimosaceae	Leaf	Antimalaria	Titanji et al. (2008)
Alchemilla kiwuensis	Rosaceae	Wp	Anti-inflammatory	Kamtchueng et al. (2017)
Alchornea cordifolia	Euphorbiaceae	L	Antimalaria	Ngoupayo et al. (2015)
Allanblackia monticola	Clusiaceae	Bk	Anti-inflammatory	Kuete and Efferth (2010)
Allanblackia monticola	Clusiaceae	Stem bark	Antimalaria	Titanji et al. (2008)
Allium sativum	Liliaceae	Bu	Anti-inflammatory, antioxidant, bronchitis, chronic fever	Khodadadi (2015)
Allium sativum	Liliaceae	Bulb	Antimalaria	Khodadadi (2015)
Alstonia boonei	Sapotaceae	Bk, Lx, L	Antimalaria	Jiofack et al. (2008, 2009), Dibong et al. (2015)
Anisophyllea pomisofera	Rhizophoraceae	Leaves	Antimalaria	Bashige-Chiribagula et al. (2017)
Annickia chlorantha	Anonaceae	Bk	Antiviral (Hepatitis A,B; C and D)	Ngono Ngane et al. (2011)
Annona muricata	Annonaceae	L, Fr, Se, Pulp	Antimalaria	Yinyang et al. (2014), Tsobou et al. (2015)
Anogeissus leiocarpus	Combretaceae	Leaves	Antimalaria	Ahmad (2014)
Anonidium mannii	Anonaceae	Bk	Antiinflammatory	Mokale Kognou et al. (2020)
Anopyxis klaineana	Rhizophoraceae	Bk	Anti-inflammatory	Asante-Kwatia et al. (2020)
Anthocleista djalonensis	Loganiaceae		Antimalaria	Bassey et al. (2009)
Antidesma laciniatum	Euphorbiaceae	Leaf	Antimalaria	Titanji et al. (2008)
Araliopsis tabuensis	Rutaceae	Stem bark	Antimalaria	Titanji et al. (2008)
Artemisia annua	Asteraceae	L	Anti-HIV activity	Noumi and Manga (2011)
Asystasia intrusa	Acanthaceae	L	Immunomodulatory activity of methanol extracts	Kuate (2015)
Azadirachta indica	Meliaceae	L, Fl, Bk, Se	Anti-inflammatory, antioxidant, immunomodulatory, antimalaria	Agbor et al. (2007), Rahmani et al. (2018), Bashige-Chiribagula et al. (2017)
Bersama engleriana	Melianthaceae	L, Bk, Rt	Methanol extracts from the Laves, bark and roots inhibited at 80% the activity of the Human Immunodeficiency Virus (HIV) enzyme	Mbaveng et al. (2011)
Bersama engleriana	Meliantaceae	Leaf	Antimalaria	Titanji et al. (2008)
Bidens pilosa	Asteraceae	Stem bark,	Antimalaria	Titanji et al. (2008)

Table 5 (continued)

Scientific name	Family	Part used	Existing pharmacological records	References
Bobgunia madagascariensis	Fabaceae		Antimalaria	Bashige-Chiribagula et al. (2017)
Bridelia scleroneura	Euphorbiaceae	Bk, Rt	Anti-inflammatory	Kuete and Efferth (2010)
Cajanus cajan	Fabaceae	Roots, leaf	Antimalaria	Titanji et al. (2008)
Calotropis procera	Apocynaceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)
Capparis erythrocarpos	Capparidaceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)
Carica papaya	Caricaceae	L, Fr	Anti-inflammatory, antimalaria	Sagnia et al. (2014), Sebua and Maroyi (2013)
Cassia alata	Caesalpiniaceae	L	Anti-inflammatory	Sagnia et al. (2014)
Cassia occidentalis	Fabaceae	Leaves	Antimalaria	Bashige-Chiribagula et al. (2017)
Cassia sieberiana	Caesalpiniaceae	Rt	Anti-inflammatory	Asante-Kwatia et al. (2020)
Caucalis melanantha	Apiaceae	L	Immunomodulatory activity of methanol extracts	Kuate (2015)
Ceiba pentandra	Bombacaceae	Bk	Anti-inflammatory	Agbor et al. (2007), Elion Itou et al. (2014)
Clematis chinensis	Ranunculaceae	L	Immunomodulatory activity of methanol extracts	Kuate (2015)
Cleone rutidosperma	Capparidaceae	Leaf	Antimalaria	Titanji et al. (2008)
Combretum molle	Combretaceae	Bk	Anti-inflammatory	Kuete and Efferth (2010)
Commelina diffusa	Commelinaceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)
Costus afer	Costaceae	St	Antiviral (chicken pox, influenza, measles and genital herpes)	Ngono Ngane et al. (2011)
Cucurbita maxima	Cucurbitaceae	L	Anti-HIV activity	Noumi and Manga (2011)
Cucurbita pepo	Cucurbitaceae	L, Rt	Inhibits HIV-1 reverse transcriptase	Noumi and Manga (2011)
Cylicodiscus gabinensis	Mimosaceae	Bk	Anti-oxidant, anti-malarial	Agbor et al. (2007), Mounguengui et al. (2016)
Cylicodiscus gabunensis	Mimosaceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Cymbopogon citratus	Poaceae	L	Antimalaria	Etame et al. (2018), Yemele et al. (2014), Yinyang et al. (2014)
Daucus carota	APiaceae	L	Inhibits HSV-1 replication	Noumi and Manga (2011)
Dichaetanthera africana	Melastomataceae	Bk	Anti-inflammatory	Oguntibeju (2018), Mokale Kognou et al. (2017)
Eleusine indica	Poaceae	L	Anti-inflammatory	Sagnia et al. (2014)
Enantia clorantha	Annonaceae	Stem bark	Antimalaria	Titanji et al. (2008)
Entada abyssinica	Mimosaceae	Leaves	Antimalaria	Bashige-Chiribagula et al. (2017)
Entandrophragma cylindricum	Meliaceae	Bk	Anti-inflammatory	Fogue Kouam et al. (2012), Mokale Kognou et al. (2020)
Enthadrophragma angolense	Meliaceae	Stem bark, leaf	Antimalaria	Titanji et al. (2008)
Eremomastax speciosa	Acanthaceae	L	Anti-inflammatory	Sagnia et al. (2014)
Erythrina addisoniae	Caesalpiniaceae	Bk	Anti-inflammatory	Kuete and Efferth (2010)
Erythrina mildbraedii	Caesalpiniaceae	Rt	Anti-inflammatory	Kuete and Efferth (2010)
Erythrina sigmoidea	Caesalpiniaceae	Rt	Anti-inflammatory	Kuete and Efferth (2010)
Erythrophleum ivorense	Caesalpiniaceae	Not precised	Anti-inflammatory	Asante-Kwatia et al. (2020)
ErythrophLum suaveoLns	Caesalpiniaceae	Bk	Anti-inflammatory	Kuete and Efferth (2010)
Euphorbia hirta	Euphorbiaceae	Wp	Antimalaria	Tamo et al. (2016),
Ficus exasperata	Moraceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)
Ficus exasperata	Moraceae	Leaf	Antimalaria	Titanji et al. (2008)

Table 5 (continued)

Scientific name	Family	Part used	Existing pharmacological records	References
Ficus thonningii	Moraceae	Leaf	Antimalaria	Titanji et al. (2008)
Glossocalyx brevipes -	Monimiaceae	Leaf	Antimalaria	Titanji et al. (2008)
Glyphaea brevis	Tilliaceae	L, Bk	Anti-inflammatory	Asante-Kwatia et al. (2020)
Gossypium spp.	Malvaceae	Cottonseed	Antimalaria	Titanji et al. (2008)
Harungana madagascariensis	Clusiaceae	Bark	ANtimalaria	Weniger et al. (2008)
Harungana madagascariensis	Hypericaceae	Bk	Antimalaria	Ndam et al. (2014)
Hexalobus crispiflorus	Annonaceae	Leaf, seed	Antimalaria	Titanji et al. (2008)
Hilleria latifolia	Phytolacaceae	Wp	Anti-inflammatory	Asante-Kwatia et al. (2020)
Holarrhena floribunda	Apocynaceae	Bk, L	Antimalaria	Yinyang et al. (2014)
Jatropha curcas	Euphorbiaceae	Rt	Anti-inflammatory	Asante-Kwatia et al. (2020)
Kalanchoe crenata	Crassulacées	Not specified	Anti-inflammatory	Kuete and Efferth (2010)
Khaya senegalensis	Meliaceae	L, Fr	Antimalaria	Arbonier (2019), Makut et al. (2008)
Lactuca capensis	Asteraceae	Not specified	Treatment of HIV/AIDS and related opportunistic infections	Tchuenguem et al. (2017)
Landolfia kirkii	Apocynaceae	Leaves, Stem bark	Antimalaria	Bashige-Chiribagula et al. (2017)
Mallotus oppositofolius	Euphorbiaceae	Leaf	Antimalaria	Titanji et al. (2008)
Mangifera indica	Anacardiaceae	Bk	Antimalaria	Yemele et al. (2014), Yinyang et al. (2014)
Milletia griffoniana	Caesalpiniaceae	L	Anti-inflammatory	Kuete and Efferth (2010)
Milletia versicolor	Caesalpiniaceae	L	Anti-inflammatory	Kuete and Efferth (2010)
Millettia griffoniana	Leguminoceae-Papilionoideae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Momordica charantia	Cucurbitaceae	L	Immunomodulatory activity, antiviral (Chicken-pox Measles Genital herpes Shingles)	Mahamat et al. (2020), Ngono Ngane et al. (2011)
Momordica charantia	Cucurbitaceae	L	Antimalaria	Jiofack et al. (2009), Mozaniel et al. (2018)
Moringa oleifera	Moringaceae	L, Se	Boost appetite and immunity, anti-HIV activity	Noumi and Manga (2011)
Musa paradisiaca	Moraceae	Leaf	Antimalaria	Titanji et al. (2008)
Neoboutonia velutina	Euphorbiaceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Newbouldia laevis	Bigoniaceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)
Occimum gratissimum	Lamiaceae	L	Immunomodulatory activity of methanol extracts	Kuate (2015)
Ocimum basilicum	Lamiaceae	L	Inhibits HIV-1 reverse transcriptase	Noumi and Manga (2011)
Ocimum gratissimum	Lamiaceae	Leaves		Bashige-Chiribagula et al. (2017)
Odyendyea gabonensis	Simaroubaceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Pachypodanthium confine	Annonaceae	Leaf	Antimalaria	Titanji et al. (2008)
Palisota hirsuta	Commelinaceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)
Panda oleosa	Pandaceae	Bk	Used in traditional medicine in Kisangani city to treat various diseases including diabetes and HIV/AIDs	Muhoya et al. (2017)
Peniantus longifolius	Menispermaceae	Stem bark	Antimalaria	Titanji et al. (2008)
Pentadiplandra brazzeana	Pentadiplandraceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)

Table 5 (continued)

Scientific name	Family	Part used	Existing pharmacological records	References
Peperomia vulcanica	Piperaceae	Leaf	Antimalaria	Titanji et al. (2008)
Phyllanthus muellerianus	Euphorbiaceae	Wp	Anti-inflammatory	Asante-Kwatia et al. (2020), Ogunwande et al. (2019)
Phyllantus muellerianus	Euphorbiaceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Picralima nitida	Apocynaceae	Se	Anti-inflammatory	Asante-Kwatia et al. (2020)
Picralima nitida	Apocynaceae	Fr, Rt	Antimalaria	Tamo et al. (2016), Tsobou et al. (2015)
Piper nigrum	Piperaceae	Seed	Antimalaria	Titanji et al. (2008)
Piper unbellatum	Piperaceae	Leaf	Antimalaria	Titanji et al. (2008)
Polyscias fulva	Araliaceae	L	Anti-inflammatory	Sagnia et al. (2014)
Prunus africana	Rosaceae	Bk		Agbor et al. (2007)
Pseudocedrela kotschyi	Meliaceae	Bk	Extracts stimulate monocyte proliferation response	Oumar et al. (2010)
Psidium guayava	Myrtaceae	L	Antibacterial, anti-malarial, anti-diarrhoeal, anti-inflammatory, antioxidant activity? antimalaria	Agbor et al. (2007), Titanji et al. (2008), Kaur et al. (2018)
Pteleopsis hylodendrom	Combretaceae	Bk	Antiviral (chicken pox, influenza, measles and genital herpes)	Ngono Ngane et al. (2011)
Pycnanthus angolensis	Myrtaceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Raphanus sativus	Brassicaceae	L, Bk, Rt	Antiviral activity	Noumi and Manga (2011)
Rauvolfia macrophylla	Apocynaceae	Stem bark	Antimalaria	Weniger et al. (2008)
Rauvolfia vomitoria	Apocynaceae	Stem bark	Antimalaria	Titanji et al. (2008)
Reneilmia cincinnata	Zingiberaceae	Fruit	Antimalaria	Titanji et al. (2008)
Schumanniophyton magnificum	Rubiaceae	Stem bark	Antimalaria	Titanji et al. (2008)
Sclerocarya birrea	Anacardiaceae	Bk	Anti-inflammatory	Kuete and Efferth (2010)
Scoparia dulcis	Scrophulariaceae	Whole plant	Antimalaria	Titanji et al. (2008)
Senna alata	Caesalpiniaceae	L	Inhibits HIV-1 reverse transcriptase	Noumi and Manga (2011)
Solanum torvum	Solanaceae	L	Anti-inflammatory	Kuete and Efferth (2010)
Spathodea campanulata	Bignoniaceae	L, Bk	Anti-inflammatory, antioxidant Antiviral (Chicken-pox Genital herpes)	Pone Kamdem (2017), Etame et al. (2018), Ngono Ngane et al. (2011)
Stachytapheta cayenensis	Verbenaceae	Leaf	Antimalaria	Titanji et al. (2008)
Stereospermum acuminatissimum	Bignoniaceae	Bark	Antimalaria	Weniger et al. (2008)
Stereospermum zenkeri	Bignoniaceae	Bark	Antimalaria	Weniger et al. (2008)
Strychnos icaja	Loganiaceae (?)	Root	Antimalaria	Titanji et al. (2008)
Symphonia globulifera	Clusiaceae	Bark	Antimalaria	Weniger et al. (2008)
Synedrella nodiflora		Wp	Anti-inflammatory	Asante-Kwatia et al. (2020)
Tapinanthus globiferus (harvested from Persea americana)	Loranthaceae	L	Anti-inflammatory, immunomodulatory and antioxidant properties	Gounoue et al. (2019)
Thomandersia hensii	Acanthaceae	Leaves, stem bark	Antimalaria	Titanji et al. (2008)
Trichilia emetica	Meliaceae	Bark	Antimalaria	Diarra et al. (2015)
Trichilia monadelpha	Meliaceae	Bk	Anti-inflammatory	Asante-Kwatia et al. (2020)
Turreanthus africanus	Meliaceae	seed	Antimalaria	Titanji et al. (2008)
Uapaca guineensis	Euphorbiaceae	Not specified	Anti-inflammatory	Kuete and Efferth (2010)
Vernonia amygdalina	Asteraceae	L	Anti-inflammatory	Asante-Kwatia et al. (2020)

Table 5 (continued)

Scientific name	Family	Part used	Existing pharmacological records	References
Vernonia amygdalina	Asteraceae	L, Rt	Anti-HIV activity	Noumi and Manga (2011)
Vitellaria paradoxa	Sapotaceae	Bk	Anti-inflammatory	Foyet et al. (2015)
Vitex thyrsiflora		Bk	Anti-inflammatory	Mokale Kognou et al. (2020)
Voacanga africana	Apocynaceae	Bk	Antioxidant	Adu et al. (2015), Agbor et al. (2007)
Xylopia aethiopica	Annonaceae	Fr	Anti-inflammatory	Asante-Kwatia et al. (2020)
Xylopia parviflora,	Annonaceae	Seed	Antimalaria	Titanji et al. (2008)
Xylopia phloiodora,	Annonaceae	Seed	Antimalaria	Titanji et al. (2008)
Xymolox monosperma	Annonaceae	Leaf, stem bark	Antimalaria	Titanji et al. (2008)
Zanthoxylum heitzii	Rutaceae	Bk	Antioxidant, antimalarial, antiinfmalatory, immunorestorative	Agbor et al. (2007), Sadeer et al. (2019), Mokondjimobe et al. (2012)
Zingiber officinale	Zingiberaceae	L, Rt	Antimalaria, anti-HIV-1 activity	Titanji et al. (2008), Noumi and Manga (2011)
Ziziphus abyssinica	Rhamnaceae	Rt	Anti-inflammatory	Asante-Kwatia et al. (2020)

* L = leave, Bk = bark, St = Stem, Rt = roots, Fr = fruit, Se = seed, Fl = flower, Tbk = root bark, Wp = whole plant, Lx = latex

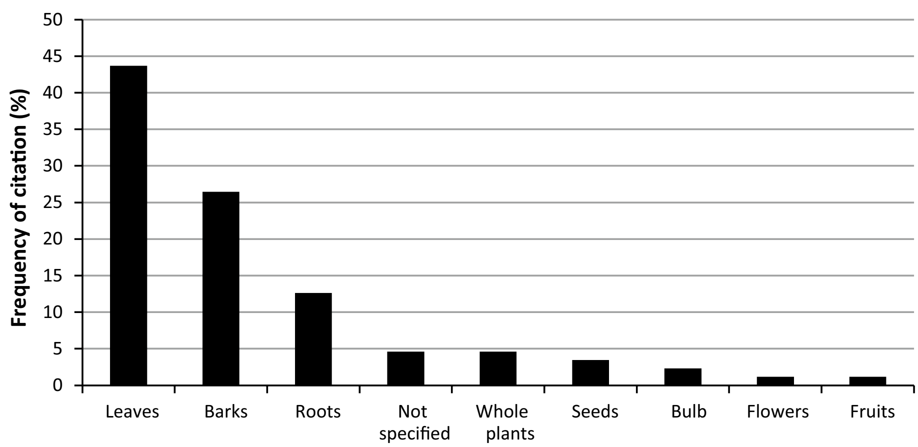

Fig. 3 Frequency distribution of plant parts with imunomodulatory, anti-inflammatory or antiviral properties

Conservation of medicinal plants and documentation of available knowledge on their use

In the face of the current risk of deforestation and degradation, conservation of medicinal plants must be a central focus. In this regard, one of the challenges is the lack of a complete and conserved knowledge repository on the national pharmacopoeia and the immense medicinal metabolite diversity among these plants. Such a repository will be vital in providing the scientific community with comprehensive knowledge about metabolite diversity and exploitation in early response strategies for emerging diseases. Because of the growing environmental degradation and the rapid loss of the natural habitat for some of these plants due to anthropogenic activities, it is becoming increasingly urgent to reinforce medicinal plants conservation and documentation of their uses.

To ensure the sustainability of the resource base and to address potential risk of overexploitation that may result from excessive commercialization and unsustainable practices, conservation measures for medicinal plants will also be required. The effectiveness of the future sustainability of local natural ecosystems that harbour these medicinal plants will depend upon conservation management approaches that value the importance of involving local communities. In this light, there are lessons learned from *Prunus africana* management in the Mount Cameroon area that can fuel our steps forward in the establishment of such a medicinal plant conservation strategy.

The ratification by Cameroon of the Nagoya protocol on access to genetic resources and benefit sharing opens new and promising avenues to achieve the objectives of

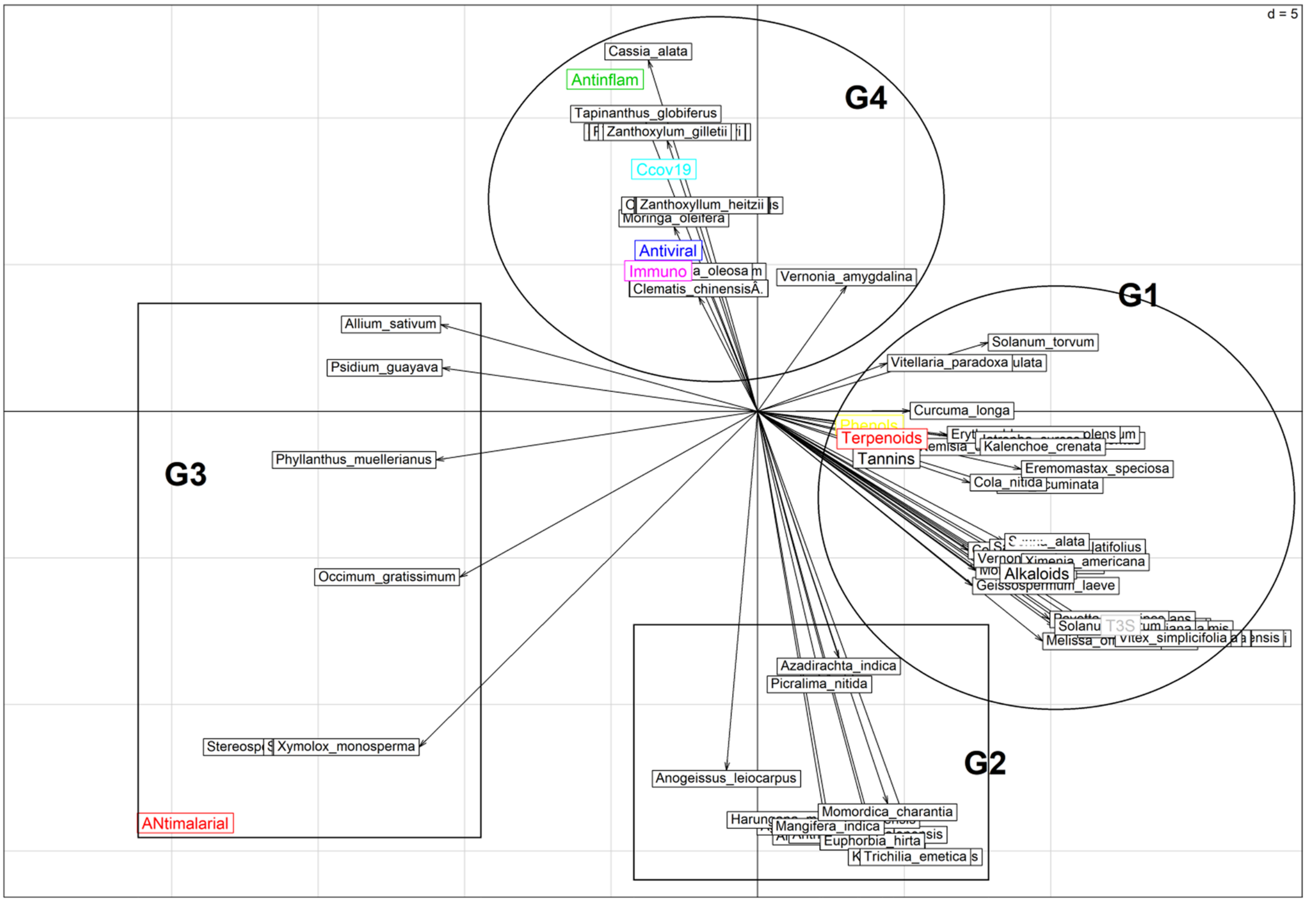

Fig. 4 Results of PCA ordination showing patterns of variability among the 230 species recorded

conserving local medicinal plants, ensuring their sustainable utilization and improving their contribution in livelihoods improvement and economic development.

Encouraging private sector involvement in herbal drug development

There has so far been only very poor participation of the local private pharmaceutical industries in the field of herbal drug development in Cameroon. There should be incentives developed to attract and stimulate their investment in traditional medicine research, development and commercialization.

Conclusion

The purpose of this stock-taking study was to provide a preliminary review on Cameroonian medicinal plants with the potential to be evaluated and developed as remedies for the management of COVID-19. It appears that the country's medicinal plants potential is immense and a promising resource from a perspective of novel drug development against this pandemic. Based on the present findings it can be concluded that medicinal plants can be promising resources for the management of COVID-19 in African herbal medicine in general and Cameroon in particular.

Despite the great potential of local medicinal plants, it is unfortunate that they are still pejoratively refered to as "grand-mother recipes". More than ever, there is a need for applied research to provide more scientific evidence for the efficacy, to establish the standard formulation using the preliminary check list presented in this review and further clinical studies as part of the response strategy for the management of COVID-19.

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