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

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Received: 10 September 2020 / Accepted: 18 February 2021 / Published online: 26 March 2021
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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-inflammatory 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 · Phytochemistry · Pharmacological properties · Review
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 Coronavirus, 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%), RNAemia (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 84,532,824 cases 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 cases 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, immuno-stimulants, 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
A review of Cameroonian medicinal plants with potentials for the management of the COVID-19... 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 syndome (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, anti-pyretic, 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 Effert 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 Millenium 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 Cameroon 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 commitments 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 against 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 Cameroon 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 polyphenols (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, antimarial, anti-inflammatory, and secondary metabolites with confirmed inhibitory effect on the 2019 nCov (Allicin, Apigenin-7-gluco side, Catechin, Coumaroyltarimine, Cur cumin, Desmethoxyreserpine, Diosmin, Epic catechin-gallate, Gingerol, Hesperidin, Kaempferol, Lignan, Luteolin-7-glu coside, Naringenin, Oleuropein, Pedunculagin, Punicalin, Quercetin, N-cis-feruloyltarimine, 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-glucose, demethoxycurcumin, naringenin, apigenin-7-glucose, 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, Coumaroyltarimine, Cryptotanshinone, Desmethoxyreserpine, Dihomo-c-linolenic acid, Dihydrotanshinone, Kaempferol, Lignan, Moupinamide, N-cis-feruloyltarimine, Quercetin, Sugiol, Tanshinone Ilia.

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 polyphenols including hesperidin, rutin, diosmin, apin, 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-inflammatory, antipyretic, antioxidant, and more. (Table 2). Besides Curcumine from turmeric (Cur cuma loonga), some of those local plant species are interesting as they contain many of those active secondary metabolites. This is the case of Zanthoxylum 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 neutrophil granulocytes into epithelia, which is a crucial process during inflammation | |
| Apigenin-7-glucoside, *Zanthoxylum 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 Contains ingredients that showed in vitro activity against hepatitis C virus | Mohammadi and Shaghaghi (2020), Khaerunnisa et al. (2020), Agbedahunsi et al. (1998) |
| *Cola nitida*                     |                           | Antimicrobial and antioxidant     | Niemenak et al. (2008), Ngoupayo et al. (2018) |
| *Cola acuminata*                  |                           | Antimicrobial and antioxidant     | |
| *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) |
| Solarium melongena                |                           | Antipyretic and analgesic effect  | Sakah Kaunda and Zhang (2019), Mutalik et al. (2003) |
| Solarium torvum                   |                           | An isoflavonoid sulfate and a steroidal glycoside isolated from the fruits exhibited antiviral activity on herpes simplex virus type 1 Wide spectrum of antimalarial activities against human and animal clinical isolates | Zhang et al. (2020), Damrongkiet et al. (2002), Chah et al. (2000) |
| Curcumin                          | *Curcuma longa*           | Curcumin has antioxidant, anti-inflammatory, antiviral and antifungal actions. Not toxic to humans Curcumin also enhances immunity | Mohammadi and Shaghaghi (2020), Shaghaghi (2016), Khaerunnisa et al. (2020), Akram et al. (2010), Moghadamtousi et al. (2014) |
| 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 | Mishra 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) |
| *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) |
| 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 Shagagh (2020), Mehdi Sharifi-Rad et al. (2017) |
| Hesperidin                      | *Acacia senegal*          | Used in the management of cough | Mahommoodally (2013) |
|                                 | *Laportea aestuans*       | Antimicrobial effect of crude extract | |
| Citrus spp                      |                           | Increases antioxidant defenses, scavenges reactive oxygen species, modulates immune system activity | Mohammadi and Shagagh (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 Shagagh (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) |
| Sena alata                      |                           | Treatment for Pulmonary Arterial Hypertension diseases | Rhazri et al. (2015) |
| Lignan                          | *Echinops giganteus*      | Antioxidants                     | Tene et al. (2004) |
|                                | *Kigelia africana*        | Anti-diarrheal, anti-malarial, analgesic, anti-inflammatory and antimicrobial activity | Zhang et al. (2020), Sidjui Sidjui et al. (2015), Saini et al. (2009) |
|                                | *Zanthoxyllum heitzii*    | No data found                    | Nguella et al. (1994) |
| Luteolin-7-glucoside            | *Capsicum annuum*         | The extract exhibited considerable anti-HSV-1 and anti-HSV-2 activities | Mohammadi and Shagagh (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 Shagagh (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-feruloylyrnozime,         | *Hibiscus esculentus*     | Antioxidant                      | Maganha et al. (2010) |
| Oleuropein,                     | *Zanthoxyllum heitzii*    | Cancer prevention                | Mohammadi and Shagagh (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-inflammatory 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) |
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-inflammatory 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 belong 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).

**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 annum*, *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*, *Zanthoxylum 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 annum*, *Curcuma longa*, *Eucalyptus camaldulensis*, *Eremomastax speciosa*, *Kalanchoe 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*, *Stereospermmum 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), Fong 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), Khoda-dadi (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             | Tintiana 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), Njouyou et al. (2008)                               |
| *Annona senegalensis*         | Annonaceae       | Bk         | Cough, Fever, Myalgia                  | Phen, Tan             | Tsabang et al. (2012), Njouyou et al. (2008)                              |
| *Annona muricata*             | Annonaceae       | L, Fr, Se, Pulp | Cough, Fever, pains, catarrh          | Alk, Tan              | Zorofochian Moghad-amtousi 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                  | 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), Yin-yang 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        | Silvarajah (2015), Seuba and Maroyi (2013) |
| *Catharanthus roseus*    | Apocynaceae   | L          | Cough, Sorethroat, Myalgia| Alk                   | Das and Sharangi (2017), Yin-yang 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), Yin-yang et al. (2014) |
| *Cinchona officinalis*   | Rubiaceae     | B, Rt, L, Fr| Cough, Fever, Myalgia     | Alk                   | Eyal (2018), Yin-yang et al. (2014) |
| *Cinchona pubescens*     | Rubiaceae     | B, Rt, L, Fr| Cough, Fever, Myalgia     | Alk                   | Eyal (2018), Yin-yang et al. (2014) |
| *Citrus aurantifolia*    | Rutaceae      | L, Fr      | Headache, colds, coughs, sore throats | Alk       | Enejoh et al. (2015), Yin-yang et al. (2014) |
| *Cochlospermum plancho-nii* | Cochlospermiaceae | 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), Yin-yang et al. (2014), Lowe et al. (2014) |
| *Cola nitida*            | Malvaceae     | L, Fr      | Headache, Fever, Myalgia  | Alk                   | Olukayode et al. (2017), Yin-yang et al. (2014) |
| *Combretum micranthum*   | Combretaceae  | L          | Cough, Fever, Myalgia     | Alk, Terp             | Welch (2010), Chinsembu and Hedimbi (2010), Yin-yang et al. (2014), Dawe et al. (2013) |
| *Costus afer*            | Costaceae     | St         | 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), Yin-yang 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) |
| *Diossotis rotundifolia* | Melastomataceae | L        | Cough, Fever, Myalgia     | Alk, Phen, Tan        | Jiofack et al. (2009), Yin-yang et al. (2014), Yeo boah and Osafo (2017) |
| *Eleusine indica*        | Poaceae       | Wp         | Cough, Fever, Myalgia     | Alk                   | Etame et al. (2018), Pattanayak and Maity (2017), Sagna 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), |
| 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, Phen, Terp       | Shaefi et al. (2016), Arbonier (2019), Somboro et al. (2011)              |
| Harungana madagascariensis    | Hypericaceae   | Bk         | Cough, Fever, Myalgia            | Alk, Phen             | Nimenibo-Udia 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)                               |
| Hostundia opposita           | Lamiaceae      | Rt         | Cough, Fever, Sore throat        | Phen, Tan             | Arbonier (2019), Sadri (2017), Ndjionka 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)                                |
| 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*    | Spindaceae   | 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), Erharuyi 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), Kabore 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 Effert (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), Koutiche 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)                               |
The fourth group consists of immunostimulants, anti-inflammatory, 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 usefulness, 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.

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**Table 4**

| Species                  | Family          | Part used* | Symptoms treated   | Main phytochemicals** | Reference                           |
|--------------------------|-----------------|------------|--------------------|------------------------|-------------------------------------|
| *Vitellaria paradoxa*    | Sapotaceae      | Bk, Fr     | Cough, Fever, Myalgia | Terp                   | Mbaveng et al. (2011), Maanikku 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
| 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-Kwafia et al. (2020)                     |
| *Albizia zygia*                | Mimosaceae      | Leaf        | Antimalaria                                              | Titani et al. (2008)                           |
| *Alchemilla kiuwaensis*        | Rosaceae        | Wp          | Anti-inflammatory                                         | Kamchugu 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                                              | Titani 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)               |
| *Anickia 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          | Anti-inflammatory                                       | Mokale Kgnou et al. (2020)                     |
| *Anopxyxis klaineana*          | Rhizophoraceae  | Bk          | Anti-inflammatory                                       | Asante-Kwafia et al. (2020)                     |
| *Anthocleista djalonensis*     | Loganiaceae     | Bk          | Anti-inflammatory                                       | Bassey et al. (2009)                           |
| *Antidesma laciniatum*         | Euphorbiaceae   | Leaf        | Antimalaria                                              | Titani et al. (2008)                           |
| *Araliopsis tabuensis*         | Rutaceae        | Stem bark   | Antimalaria                                              | Titani et al. (2008)                           |
| *Artemisia annua*              | Asteraceae      | L           | Anti-HIV activity                                        | Noumi and Manga (2011)                         |
| *Astillasia 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), Rahman et al. (2018), Bashige-Chiribagula et al. (2017) |
| *Bersama engleriana*           | Meliaceae       | L, Bk, Rt   | Methanol extracts from the Laves, bark and roots inhibited at 80% the activity of the Human Immuno-deficiency Virus (HIV) enzyme | Mbaveng et al. (2011) |
| *Bersama engleriana*           | Meliaceae       | Leaf        | Antimalaria                                              | Titani et al. (2008)                           |
| *Bidens pilosa*                | Asteraceae      | Stem bark   | Antimalaria                                              | Titani et al. (2008)                           |
| Scientific name                  | Family                 | Part used | Existing pharmacological records                                                                 | References                        |
|---------------------------------|------------------------|-----------|---------------------------------------------------------------------------------------------------|-----------------------------------|
| Bobgunia madagascariensis       | Fabaceae               | Anti-Covid | Bashige-Chiribagula et al. (2017)                                                                 |                                   |
| Bridelia scleroneura            | Euphorbiaceae          | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Cajanus cajan                   | Fabaceae               | Anti-Inflamm | Tamo et al. (2016), Sebua and Maroyi (2013)                                                       |                                   |
| Calotropis procera              | Apocynaceae            | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| Capparis erythrocarpus          | Capparidaceae          | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| Carica papaya                   | Caricaceae             | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| Cassia alata                    | Caesalpiniaceae        | Anti-Inflamm | Sagnia et al. (2014)                                                                              |                                   |
| Cassia occidentalis             | Fabaceae               | Anti-Inflamm | Bashige-Chiribagula et al. (2017)                                                                 |                                   |
| Cassia sieberiana               | Caesalpiniaceae        | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| Caucalis melanantha             | Apiaceae               | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Ceiba pentandra                 | Bombacaceae            | Anti-Inflamm | Sagnia et al. (2014)                                                                              |                                   |
| Clematis chinensis              | Ranunculaceae          | Anti-Inflamm | Agbor et al. (2007), Elion Itou et al. (2014)                                                      |                                   |
| Cleome rutidosperma             | Capparidaceae          | Anti-Inflamm | Titani et al. (2008)                                                                              |                                   |
| Combretum molle                 | Combretaceae           | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Commelina diffusa               | Commelinaceae          | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| Costus afer                     | Costaceae              | Anti-Inflamm | Ngono Ngane et al. (2011)                                                                        |                                   |
| Cucurbita maxima                | Cucurbitaceae          | Anti-HIV    | Noumi and Manga (2011)                                                                            |                                   |
| Cucurbita pepo                  | Cucurbitaceae          | Anti-HIV    | Noumi and Manga (2011)                                                                            |                                   |
| Cylicodiscus gabinensis         | Mimosaceae             | Anti-Inflamm | Agbor et al. (2007), Mounguengi et al. (2016)                                                     |                                   |
| Cylicodiscus gabunensis         | Mimosaceae             | Anti-Inflamm | Titani et al. (2008)                                                                              |                                   |
| Cymbopogon citratus             | Poaceae                | Anti-Inflamm | Etame et al. (2018), Yemel et al. (2014), Yinyang et al. (2014)                                   |                                   |
| Dauca carota                    | Apiaceae               | Inhibits HSV | Noumi and Manga (2011)                                                                            |                                   |
| Dickea antennata africana        | Melastomataceae        | Anti-Inflamm | Oguntibeju (2018), Mokale Kognou et al. (2017)                                                    |                                   |
| Eleusine indica                 | Poaceae                | Anti-Inflamm | Sagnia et al. (2014)                                                                              |                                   |
| Entania clorantha               | Annonaceae             | Anti-Inflamm | Titani et al. (2008)                                                                              |                                   |
| Entada abyssinica               | Mimosaceae             | Anti-Inflamm | Bashige-Chiribagula et al. (2017)                                                                 |                                   |
| Entandrophragma cylindricum     | Meliaceae              | Anti-Inflamm | Fogue Kouam et al. (2012), Mokale Kognou et al. (2020)                                             |                                   |
| Entandrophragma angolense       | Meliaceae              | Anti-Inflamm | Titani et al. (2008)                                                                              |                                   |
| Eremomastax speciosa            | Acanthaceae            | Anti-Inflamm | Sagnia et al. (2014)                                                                              |                                   |
| Erythrina addisoniae            | Caesalpiniaceae        | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Erythrina mildbraedii           | Caesalpiniaceae        | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Erythrina sigmoidea             | Caesalpiniaceae        | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Erythrophleum ivorense          | Caesalpiniaceae        | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| ErythrophLum suaveolus          | Caesalpiniaceae        | Anti-Inflamm | Kuete and Efferth (2010)                                                                          |                                   |
| Euphorbia hirta                 | Euphorbiaceae          | Anti-Inflamm | Tamo et al. (2016), Sebua and Maroyi (2013)                                                       |                                   |
| Ficus exasperata                | Moraceae               | Anti-Inflamm | Asante-Kwata et al. (2020)                                                                         |                                   |
| Ficus exasperata                | Moraceae               | Anti-Inflamm | Titani et al. (2008)                                                                              |                                   |
| 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 | Tilliacae | L, Bk | Anti-inflammatory | Asante-Kwatia et al. (2020) |
| Gossypium spp. | Malvaceae | Cottonseed | Antimalaria | Titanji et al. (2008) |
| Harungana madagascarensis | Clusiaceae | Bark | ANtimalaria | Weniger et al. (2008) |
| Harungana madagascarensis | Hypericaceae | Bk | Antimalaria | Ndam et al. (2014) |
| Hexalobus crispiflorus | Annonaceae | Leaf, seed | Antimalaria | Titanji et al. (2008) |
| Hilleria latifolia | Phytolaccaeae | 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 Efferd (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 oppositifolius | 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 Efferd (2010) |
| Milletia versicolor | Caesalpiniaceae | L | Anti-inflammatory | Kuete and Efferd (2010) |
| Millettia griffoniana | Leguminaceae-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 | Kuete (2015) |
| Ocimum basilicum | Lamiaceae | L | Inhibits HIV-1 reverse transcriptase | Noumi and Manga (2011) |
| Ocimum gratissimum | Lamiaceae | Leaves | Antimalaria | Bashige-Chiribagula et al. (2017) |
| Odendynea gabonensis | Simaroubaceae | Leaf, stem bark | Antimalaria | Titanji et al. (2008) |
| Pachypodium confluens | Annonaceae | Leaf | Antimalaria | Titanji et al. (2008) |
| Palisota hirsuta | Commelinaceae | L | Anti-inflammatory | Asante-Kwatia et al. (2020) |
| Pandanola ossea | Pandaceae | Bk | Used in traditional medicine in Kisangani city to treat various diseases including diabetes and HIV/AIDS | Muhoya et al. (2017) |
| Peniantis 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-Kwatai et al. (2020), Oguwande et al. (2019) |
| *Phyllanthus muellerianus*     | Euphorbiaceae      | Leaf, stem bark| Antimalaria                                                                                     | Titanji et al. (2008)                           |
| *Picralima nitida*             | Apocynaceae        | Se            | Anti-inflammatory                                                                               | Asante-Kwatai 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            | Extracts stimulate monocyte proliferation response                                               | Agbor et al. (2007)                             |
| *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 hyloidendrom*      | 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)                          |
| *Rauwolfia macrophylla*        | Apocynaceae        | Stem bark     | Antimalaria                                                                                     | Weniger et al. (2008)                           |
| *Rauwolfia vomitoria*          | Apocynaceae        | Stem bark     | Antimalaria                                                                                     | Titanji et al. (2008)                           |
| *Renelnia cincinnata*          | Zingiberaceae      | Fruit         | Antimalaria                                                                                     | Titanji et al. (2008)                           |
| *Schumannophyton 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*                  | Caesalpiniae       | L             | Inhibits HIV-1 reverse transcriptase                                                              | Noumi and Manga (2011)                          |
| *Solanum torvum*               | Solanaceae         | L             | Anti-inflammatory                                                                               | Kuete and Efferth (2010)                        |
| *Spathodea campanulata*        | Bignoniaeae        | 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)                           |
| *Stereospermea cuminatisum*    | Bignoniaeae        | Bark          | Antimalaria                                                                                     | Weniger et al. (2008)                           |
| *Stereospermea zemkeri*        | Bignoniaeae        | Bark          | Antimalaria                                                                                     | Weniger et al. (2008)                           |
| *Strychnos icaja*              | Loganiaceae (?)    | Root          | Antimalaria                                                                                     | Titanji et al. (2008)                           |
| *Symphonia globulifera*        | Clusiaceae         | Bark          | Antimalaria                                                                                     | Weniger et al. (2008)                           |
| *Syndreptrila nodiflora*       | Wp                 | Anti-inflammatory                               | Asante-Kwatai et al. (2020)                     |
| *Tapinanthus globiferus*       | Loranthaceae       | L             | Anti-inflammatory, immunomodulatory and antioxidant properties                                   | Gounoue et al. (2019)                           |
| (harvested from Persea americana) |                    |               |                                                                                                  |                                                 |
| *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-Kwatai et al. (2020)                     |
| *Turreanthus africana*         | 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-Kwatai et al. (2020)                     |
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
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 referred 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.

**Acknowledgements** The authors are grateful to Carol J. Pierce Colfer (Center for International Forestry Research in Bogor, Indonesia and Cornell University in Ithaca, New York, United States of America) for the valuable comments during the writing of the paper and for proof-reading the final manuscript.

**Funding** The authors declare that they did not receive any funding for carrying out this research.
Declarations

Ethical statement This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest Fongnzossie Fedoung Evariste has no conflict of interest. Biwole Achille Bernard has no conflict of interest. Nyango-no Biyegue Christine Fernande has no conflict of interest. Ngansop Tounkam Marlène has no conflict of interest. Patrick Akono Ntonga has no conflict of interest. Ngisinde Pierre Marie has no conflict of interest. Tize Zra has no conflict of interest. Boum Alexandre Teplaira has no conflict of interest. Ngono Ngane Annie has no conflict of interest. Sandrine Bouelet has no conflict of interest. Tize Zra has no conflict of interest. Betti Jean Lagarde has no conflict of interest. Boum Alexandre Teplaira has no conflict of interest. Momo Solefack Marie Caroline has no conflict of interest. Betti Jean Lagarde has no conflict of interest. Ngisinde Pierre Marie has no conflict of interest. Nneme Nneme Lean-dre has no conflict of interest. Ngisinde Pierre Marie has no conflict of interest. Ngisinde Pierre Marie has no conflict of interest.

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