BMJ Global Health

# Experiences and challenges of African traditional medicine: lessons from COVID-19 pandemic

Polydor Ngoy Mutombo ,[1] Ossy Muganga Julius Kasilo ,[2] Peter Bai James,[1] Jon Wardle,[1] Olobayo Kunle,[3] David Katerere,[4] Charles Wambebe,[5] Motlalepula Gilbert Matsabisa,[6] Mohammed Rahmatullah,[7] Jean-Baptiste Nikiema,[8] Immaculee Mukankubito,[9] Rick Sheridan,[10] Rokia Sanogo,[11] Veeranoot Nissapatorn,[12] Chaisith Sivakorn,[13] Satyajit Tripathy,[6] Ramesh Goyal,[14] Mahaveer Dhobi[14]

**To cite:** Mutombo PN, Kasilo OMJ, James PB, *et al*. Experiences and challenges of African traditional medicine: lessons from COVID-19 pandemic. *BMJ Glob Health* 2023;**8**:e010813. doi:10.1136/bmjgh-2022-010813

**Handling editor** Seye Abimbola

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjgh-2022-010813).

Received 29 September 2022
Accepted 24 April 2023



For numbered affiliations see end of article.

**Correspondence to**
Dr Polydor Ngoy Mutombo; polydorngoymutombo@gmail.com

## ABSTRACT

Management of COVID-19 in Africa is challenging due to limited resources, including the high cost of vaccines, diagnostics, medical devices and routine pharmaceuticals. These challenges, in addition to wide acceptability, have resulted in increased use of herbal medicines based on African traditional medicines (ATMs) by patients in Africa. This is in spite of the often-significant gaps in evidence regarding these traditional medicines as to their efficacy and safety for COVID-19. African scientists, with some support from their governments, and guidance from WHO and other bodies, are addressing this evidence gap, developing and testing herbal medicines based on ATMs to manage mild-to-moderate cases of COVID-19. Such efforts need further support to meet public health needs.

## SUMMARY BOX

- ⇒ African traditional medicines (ATMs) or therapies are widely used on the continent to meet healthcare needs because of ease of access, low cost and cultural acceptance. However, there is a paucity of clinical evidence on their safety, efficacy and quality to support their use in general. As a result of the COVID-19 pandemic, there was increased use of ATMs as people tried to protect themselves and their families.
- ⇒ The WHO issued position statements acknowledging the importance of traditional medicine, established a Regional Expert Advisory Committee on Traditional Medicine for COVID-19 Response, strengthened the capacity of experts and researchers through a series of regional consultations on the contribution of traditional medicine to COVID-19 and is providing technical support and guidance for clinical testing of ATMs.
- ⇒ This paper highlights some of the ATM-based interventions that were used and identifies the obstacles to the integration/mainstreaming of traditional medicines proposed for COVID-19 as the absence or paucity of clinical data on the safety, efficacy and quality as well as the lack of resources (human and financial) for robust clinical trials.
- ⇒ There is a need for resources to be invested in mainstreaming ATMs as part of pandemic preparedness and response in Africa given the low access to, and high cost of, vaccines and conventional medicines. Such resources would include building and strengthening the capacity of researchers and clinicians to conduct research into plant-based remedies, capacitating national regulatory authorities, increased funding of clinical research to validate medicinal claims.
- ⇒ There is a need to create collaboration between conventional and traditional healthcare workers so that there is complementarity to the benefit of African patients.
- ⇒ This paper aims to draw attention how ATMs can be mainstreamed by conducting appropriate clinical testing and providing adequate regulation to ensure that good quality, safe and efficacious remedies are promoted. Additionally, this will build and maintain trust in traditional health workers.

## BACKGROUND

Since the emergence of COVID-19 in China in 2019, the health, social and economic impacts of the disease have been felt across the globe. While there has been rapid and unprecedented progress in development of vaccines and new therapies, access to these products in sub-Saharan Africa is constrained. Global therapeutics and vaccine inequities and the emergence of new variants have created challenges in controlling COVID-19 across the African continent.[1–5]

Thus, in considering Africa's pandemic preparedness, it is important to understand and learn from, the current experiences from COVID-19. At the onset of COVID-19, there was general concern about how Africa would manage the pandemic given its limited resources, and poorly developed and fragile healthcare systems.[6 7] The balance between protecting livelihoods while managing the pandemic with non-pharmacological measures such as lockdowns and social distancing; was also of concern, and debate

still rages on the effectiveness of the latter and long-term impact of the former.[8] COVID-19 disease management was largely limited to supportive treatment for symptomatic cases, with severe cases more likely to have higher mortality due to the lack of specialised care and access to basic treatments such as corticosteroids, antibiotics, oxygen and ventilators.[9]

With limited access to conventional health products and amid a deadly global pandemic, some Africans turned to the use of traditional therapies such as herbal medicines, one of the few therapies to which they had easy access. This is not unprecedented, as the use of traditional medicines in Africa has been reported recently for patients with AIDS symptoms in Malawi, South Africa, Uganda and Zimbabwe and as the main source of healthcare for mental illnesses in Uganda.[10] Due to the high proportion of patients using herbal medicines (as high as 70% in Ghana for example), some health facilities have initiated the use of herbal medicines as a component of healthcare delivery.[10 11] More recently, in the context of infectious diseases with some similarity to COVID-19, Ebola survivors in West Africa appeared to turn to herbal medicines not only for treatment but also to fill the gaps in conventional healthcare services.[12]

The practice of traditional medicine has always been popular in Africa though it remains largely sidelined from the formal healthcare system for various reasons, chief among them being the paucity of data on the safety, efficacy and quality of most medicinal plants; stigmatisation due to poor perceptions and attitudes; inadequate efforts to conserve medicinal plants and Indigenous knowledge; modernisation; exploitation of communities that own the knowledge; the history of colonialism and secrecy in traditional medicine practices with few reports or documentations of adverse reactions.[10] However, the future of African traditional medicines (ATMs) is bright if viewed in the context of service provision, an increase of healthcare coverage, economic potential and poverty reduction. Formal recognition and integration of traditional medicine into conventional medicine will ensure a promising future.

Due to the increased health needs and largely unknown nature of COVID-19, the WHO and its partners called on African scientists to urgently accelerate research and development (R&D) of traditional medicines for COVID-19.[13 14]

## ATM-BASED THERAPIES IN THE MANAGEMENT OF COVID-19 IN AFRICA

ATMs can complement healthcare systems if they are proven to be safe, effective and of high quality through R&D, a process that has been completed for malaria, HIV/AIDS, diabetes, hypertension and sickle-cell disease.[15 16] Such advancement in R&D has resulted in more than 40 herbal medicines being included in national essential medicines lists across the WHO-AFRO region.[17] In the absence of curative conventional medicines for COVID-19, most African communities in Eastern,[18] Southern and West Africa, reported wide use and perceived high efficacy of traditional medicines to prevent and treat suspected symptoms of COVID-19.[19] These were generally obtained from preparations that were indicated in traditional African medicine systems for 'respiratory diseases' with antiviral, anti-inflammatory, antioxidant, antipyretic, immunomodulatory and cytoprotective properties. Early research appeared to support the potential of African medicinal plants. For example, investigators in Nigeria reported at least a hundred indigenous medicinal plants with potential therapeutic value in the treatment of COVID-19 based on their antiviral, anti-inflammatory, antioxidant, antipyretic, immunomodulatory and cytoprotective properties.[20 21] The herbal medicines were used alone or combined with public health recommendations, and were relatively easy to use. The oral route was the most common means of administration, with the most commonly used plants being spices such as cinnamon, clove, garlic, ginger, lemon and leaves of plants such as eucalyptus, guava, lemon, lemongrass, local mint plant and neem. The most commonly reported parts used for herbal medicine were seeds, followed by leaves.

In addition, inhalation of vapour produced by boiling a combination of plant parts or spices while covered up with cloth was also used as a means of administration of herbal medicines for COVID-19 in several countries such as Tanzania, Zambia and Uganda.[18 22]

In some countries, shea butter was applied on the nose of children to relieve congestion.[22] Other herbal medicines used include onion (Ghana), honey mixed with plants (Algeria) and lemon leaves (Mali).[22 23]

This flexibility, accessibility and relative ease of administrative options resulted in high utilisation of ATMs. A study conducted in Ethiopia, for example, indicated that almost half (46.2%) of the participants used traditional medicines to prevent and treat COVID-19 cases.[24] This finding mirrored results globally—in Hong Kong, for example, 44% of the surveyed participants were found to have practised traditional medicines to prevent and treat COVID-19.[25]

With fewer resources to contain the spread of COVID-19 in Africa, the potential for new variants and endemicity, and underlying support for integration, there is a strong case for enhanced R&D of ATMs-derived herbal medicines for the prophylactic and therapeutic management of the disease, particularly as a complementary treatment measure.[13 14] The results of early scientific examination suggest, for example, that traditional medicines from ATMs and other traditions can be effective as adjuvant symptomatic treatment for some clinical manifestations of COVID-19.[26] Reverse pharmacology approach to investigate medicinal plants used in ATMs with putative anti-viral properties could serve to identify new preventive and therapeutic agents for inhibition of SARS-CoV-2 and the treatment of COVID-19. Ethnopharmacological evidence highlights the extensive use of specific

medicinal plants for COVID-19-like symptoms by certain ethnic groups in Africa, which may assist with identifying candidate medicinal plants or plant recipes for further R&D.[27] Results may have regional or even global significance, as there is anecdotal evidence suggesting that some traditional medicines are effective across various diseases and sociocultural contexts.[28 29] The shared flora between Africa and other continents with similar cross-cultural therapeutic uses may further help refine potential resources for examination.[29] For example, *Zingiber officinale* (*ginger*), which is found in Africa is used in the traditional medicine systems of Bangladesh[30] and Thailand[31] for the symptomatic treatment of COVID-19.

Several ATMs-based therapies are undergoing evaluation for their role in the treatment/management of COVID-19, including clinical trials by scientists.[32] Clinical trials of herbal medicines as adjuncts in the treatment of COVID-19 are either completed or ongoing in Burkina Faso, the Democratic Republic of Congo (DRC), Ghana, Guinea, Madagascar, Nigeria (which has the only privately funded study), South Africa, United Republic of Tanzania and Uganda, while clinical observational studies were conducted in Benin, Burkina Faso, Congo and DRC.[33] In South Africa and Tanzania, multicentre clinical trials of herbal medicines are ongoing. In some countries such as DRC, Guinea, Madagascar and Uganda, some of these products have received marketing authorisation.

## BENEFITS AND CHALLENGES ASSOCIATED WITH THE USE OF ATMS

The easy access to ATMs by most Africans, regardless of demographic and socioeconomic status,[10 34 35] is largely due to its affordability and roots in the culture of the people. Such attributes make it a potentially valuable component of the healthcare system, especially in responding to health emergencies, as with the COVID-19 pandemic. Studies have also shown that traditional health practitioners (THPs) are more accessible to the populace with a significantly higher proportion of THPs (1:500 persons) than conventional medical practitioners (1:40 000 persons).[35] Further, Africa has high biodiversity, which enriches the *materia medica* of the continent with over 5000 of the 40 000–45 000 000 known plant species found on the African continent, believed to have medicinal properties.[36] Studies have indicated that some of these plant species might have a role in managing COVID-19 (online supplemental table 1) due to their antiviral activities and its associated symptoms (online supplemental table 2). In some African countries, the use of these herbal medicines is reported to have been useful in the early management of the pandemic before the introduction of standard treatment guidelines.

Despite the abundant natural resources and the anecdotal value of traditional medicine, ATMs remains under-represented and underused in conventional health settings in Africa,[26] as demonstrated during the pandemic. While there are several reasons for this,[11 37] in the course of the COVID-19 pandemic, the challenges observed include widely publicised unsubstantiated claims of therapeutic activity, insufficient preclinical data, lack of clinical data to validate ethnobotanical claims and insufficient regulatory oversight.[38] Therefore, research needs to be directed at addressing these issues, especially the generation of clinical data to validate the use, while regulatory capacity should be strengthened. In addition, ethical and regulatory requirements for approval of national clinical trial protocols across Africa should be harmonised by the WHO.

The absence of a two-way referral system and linkage between ATMs and conventional health systems in most African nations creates mistrust between the two systems to the detriment of patients. As a result, most patients may not disclose ATMs use, thus increasing the potential for adverse reactions and the possibility of delayed diagnosis, among other risks.[39 40] The unregulated status of many THPs and their medicines also creates accountability gaps increasing the potential for sub-standard and counterfeit products, professional malpractice and unethical conduct.

While there are ongoing efforts at undertaking the necessary research to validate the claims of efficacy of ATMs derived herbal medicines for COVID-19, they are hampered by the fact that many of the governments in these countries cannot afford to invest adequate financial resources to conduct phase III clinical trials. Second, the substantial reduction in the number of COVID-19 patients has made it difficult to obtain the sample size adequate to obtain robust data on the safety and efficacy of required to validate therapeutic claims according to universally accepted standards. Multicentre and multi-country clinical trials can be a way of addressing this challenge. The WHO, Africa CDC, the African Union Commission and the international community should jointly support countries fast track R&D and mobilise financial resources so that the products confirmed to be safe, efficacious and quality-assured (category 3 herbal medicines) can be locally manufactured and commercialised regionally and internationally.

### Lessons learnt from the pandemic

The recourse to the use of ATMs in the early days of the pandemic in Africa demonstrated its continued acceptance by the general public. The poor documentation and validation of the claimed therapeutic value of the ATMs-derived herbal medicines limited their value in the fight against the pandemic. There is an urgent need to encourage and provide the resources needed for continuous research into ATMs-based herbal medicines with a view to provide necessary safety and efficacy data. This is particularly important for infectious disease outbreaks, where traditional medicines are often embraced enthusiastically by the public, and research demonstrates a potential role only after the acute phase.[41] Strategies should therefore be implemented to maintain the enthusiasm that resulted in the provision of resources by most

African governments for the study of herbal medicines for COVID-19 during the pandemic.

The pace of R&D of herbal medicines will be enhanced by the establishment of consortia of researchers, the private sector and state institutions. In addition, regional collaborations will provide better access to resources and clinical trial participants to achieve the needed statistical power for studies.

There is a need to urgently strengthen the capacity of the National Regulatory Authorities and Ethics review committees to effectively and efficiently regulate the development and use of herbal medicines.

## CONTRIBUTION OF WHO TO THE DEVELOPMENT OF ATMS FOR COVID-19

The WHO, in acknowledgement of the potential value of ATMs, is collaborating with partners to encourage and guide the development of ATMs for COVID-19 while alerting of the dangers of using non-approved herbal remedies without clinical evidence of their safety, efficacy and quality.[42]

In collaboration with Africa Centers for Disease Control and Prevention (Africa CDC) and the African Union Commission (AUC) for Social Affairs, WHO set up a Regional Expert Advisory Committee on traditional medicine for COVID-19 Response (REACT) as a coordinating mechanism to elevate the standards of R&D through the pooling of expertise across the African continent for multicentre studies. Membership of the Committee which comprises country experts in various disciplines related to clinical trials on traditional medicines-based therapies includes the Africa Academy of Sciences and African scientists within the EDCTP (European & Developing Countries Clinical Trials Partnership).

As a demonstration of its support for the use of scientifically proven ATMs in the management of COVID-19, WHO, in collaboration with Africa CDC and the European and Developing Countries Clinical Trial Partnership (EDCTP), developed the standard protocols for the randomised, double-blind placebo-controlled phase III multicentre clinical trials to evaluate the safety and efficacy of herbal medicine compared with the standard of care for the treatment of hospitalised patients with mild-to-moderate cases of COVID-19; as well as a protocol for Clinical Observational Studies for preliminary assessment of the safety and efficacy of herbal medicines for the treatment of mild to moderate cases of COVID-19. The committee endorsed the protocols and charter for establishing the data and safety monitoring board, which the WHO Ethics Review Committee and the other relevant Ethics Committees and National Regulatory Authorities subsequently approved at regional and national levels.

A series of regional consultations organised by the WHO during 2020–2022 have encouraged experience sharing by countries in areas such as: Preclinical safety and efficacy studies of ATMs; Ethical and regulatory requirements for approvals and conditional registration of herbal medicines for clinical trials of COVID-19; Clinical trials of ATMs for COVID-19; and Requirements of local manufacturing and good manufacturing practices.

WHO, Africa CDC and African Union continued to work together to harmonise the process for joint support to countries for conducting the clinical trials. Joint field missions composed of WHO, REACT, Africa CDC/AUC and EDCTP to monitor clinical trials of ATMs for COVID-19 were conducted.

Several informal and formal meetings of REACT held between 2020 and 2022, which culminated in the meeting on fast-tracking R&D of ATMs for COVID-19 and local manufacturing of herbal medicines convened by WHO in July 2022, resulted in the development of the criteria for selecting proposed COVID-19 traditional medicines that could be fast-tracked for R&D and local manufacturing. The REACT developed terms of reference for the selection of centres of excellence and hubs for the R&D and local manufacturing of herbal medicines in Africa as well as strategies to mobilise resources for fast-tracking R&D and local manufacturing of herbal medicines.

## CONCLUSION

The devastating nature of COVID-19 forced countries to reconsider the resilience, capacity and available infrastructure of their health systems. Some countries employed innovative and unconventional interventions agents. In Africa and some parts of Asia, this has led to a repurposing of herbal medicines since traditional medical practice is already widely accepted and trusted in those regions. For instance, in Bangladesh and Thailand similar medicinal plants have been repurposed to combat COVID-19. An example is *Andrographis paniulata*, known locally in Thailand as 'Fah Talai Jone' has been used to treat COVID-19 in both Thailand and Indian traditional medicine systems.[43] Also, *Z. officinale* is used in folk medicine of Bangladesh and Thailand for symptomatic treatment of COVID-19.[30 31] These examples strongly suggest traditional systems of medicine of other regions need to be considered and harnessed to facilitate drug discovery and development to tread COVID-19.

There was also widespread political support for such practices by African governments in the face of their populations' low access to vaccines and conventional pharmaceuticals. However, few governments could mobilise resources for the relevant laboratory infrastructure to enable testing of the remedies people were using. Thus, while the potential contribution of ATMs to the COVID-19 response cannot be ignored, its credibility hinges on research to validate its use and establish the efficacy and safety of the products which are touted as being useful. To do this requires a strategy that provides resources to researchers, creates mutually beneficial collaborations between THPs and researchers and the active involvement of regulators in directing what needs to be done.

It is evident that African scientists collaborating with WHO and other bodies are addressing this evidence gap,

developing and testing herbal medicines to manage mild to moderate cases of COVID-19, though such efforts need further support to meet public health needs. Some early reports from preclinical safety and efficacy studies on ATMs have been encouraging. However, more funding for larger clinical trials is required to complete the evaluation that would provide evidence to inform clinical use. Collaborations between biomedical scientists, THPs and the private sector are critical to achieving this goal. Several research challenges in this field have been identified by African researchers, including limited funding for phase III clinical research, lack of involvement of knowledge holders (healers) and lack of implementation of enabling policies around mainstreaming ATMs and intellectual property and Indigenous knowledge protection and governance. Other challenges unrelated to resources include laborious administrative processes required by national ethics committees and national regulatory authorities to process clinical trial research protocols for ATMs can delay the research results of ATMs.

Mistrust between THPs, conventional medical practitioners and scientists remains a barrier to mainstreaming, product development and testing ATMs. Furthermore, the lack of specific training in ATMs in many academic and health institutions may reduce the potential for the inclusion of ATMs in scientific and research agendas.

To fully develop and exploit the potential of ATMs in the fight against COVID-19 and other priority diseases, African governments must take ownership of the development process and facilitate the building of a robust industry and attract private investment. This can be achieved by prioritising strengthening of research capacity in the national budgets of African countries. ATMs should also be explicitly included in national research strategies with aggressive fund mobilisation. It is only when ATMs products can be commercialised regionally, and internationally that they can gain global acceptance.

The COVID-19 pandemic has resulted in increased appreciation and use of ATMs and demonstrates the wide acceptability and confidence in its usefulness. In preparing for the next pandemic, given its wide acceptance and popularity, it is important to position ATMs to better serve as part of the response mechanism.

It is obvious that the infrastructure and attention set up in response to the challenges brought by the COVID-19 pandemic, would be equally suitable to other African health priority areas, where lack of adequate research capacity into ATMs derived herbal medicines has hampered development.

We conclude that traditional medicines can complement conventional pharmaceuticals in a time of crisis if they are proven to be proven to be safe and efficacious. The integration of such therapies is explicitly promoted in the Alma Ata declaration in 1978 and reaffirmed—and further expanded on—by the Astana Declaration of Primary Health Care in 2018. This will, however, require the generation of robust scientific data from well-designed studies. There is a need for the development of new protocols, modification of existing ones, or the endorsement of appropriate existing protocols to ensure integration is done in a way that maximises the potential benefits of ATMs while minimising the risks of inappropriate promotion and misuse. The protocols developed by the WHO Regional Office for Africa specifically for testing ATMs for clinical efficacy in COVID-19 are a useful tool in this regard.

**Author affiliations**
[1]Faculty of Health, National Centre for Naturopathic Medicine, Southern Cross University, Lismore, New South Wales, Australia
[2]Universal Health Coverage Life Course Cluster, World Health Organization Regional Office for Africa, Brazzaville, Congo
[3]Pharmaceutical Technology and Raw Materials Development, National Institute for Pharmaceutical Research and Development, Abuja, Federal Capital Territory, Nigeria
[4]Pharmaceutical Science, Tshwane University of Technology, Pretoria, South Africa
[5]Pharmacology & Therapeutics, School of Biomedical Sciences, International Biomedical Research Institute (IBRI), Abuja, Nigeria
[6]Pharmacology, University of the Free State, Bloemfontein, Free State, South Africa
[7]Biotechnology & Genetic Engineering, University of Development Alternative, Dhaka, Bangladesh
[8]Medicines Supply, Health Infrastructure and Equipment Maintenance (MIM) Unit, Universal Health Coverage/Life Course Cluster, World Health Organization Regional Office for Africa, Brazzaville, Congo
[9]Medicines Supply, Health Infrastructure and Equipment Maintenance (MIM) Unit, World Health Organization Regional Office for Africa, Brazzaville, Congo
[10]EMSKE Phytochem, Nairobi, Kenya
[11]Médecine Traditionnelle, Institut National de Recherche en Sante Publique, Bamako, Mali
[12]School of Allied Health Sciences and World Union for Herbal Drug Discovery (WUHeDD), Walailak University, Thai Buri, Thailand
[13]Intensive Care Unit, University College London Hospitals NHS Foundation Trust, London, UK
[14]School of Pharmaceutical Sciences, Delhi Pharmaceutical Sciences and Research University, Delhi, India

**Twitter** David Katerere @hwesa001

**Acknowledgements** Special thanks to Maria de Lourdes PEREIRA from the CICECO-Aveiro Institute of Materials & Department of Medical Sciences, University of Aveiro, Aveiro, Portugal; Arletha W. LIVINGSTON from the Innovation Learning Laboratory for Population Health, Morehouse School of Medicine; Rianasoambolanoro RAKOTOSAONA from the Ecole Supérieure Polytechnique d'Antananarivo and Centre National d'Application de Recherches Pharmaceutiques CNARP, Antananarivo, Madagascar; and Polrat WILAIRATANA from the Department of Clinical Tropical Medicine, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand)

**Contributors** All coauthors made substantial contribution to the conceptualisation, literature search, writing—original draft, editing and review.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not applicable.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available.

**ORCID iDs**
Polydor Ngoy Mutombo http://orcid.org/0000-0003-0208-3770
Ossy Muganga Julius Kasilo http://orcid.org/0000-0003-1538-9293

## REFERENCES

1 Moore JP, Offit PA. SARS-Cov-2 vaccines and the growing threat of viral variants. *JAMA* 2021;325:821–2.
2 Moore JP. Approaches for optimal use of different COVID-19 vaccines: issues of viral variants and vaccine efficacy. *JAMA* 2021;325:1251–2.
3 Abdool Karim SS, de Oliveira T. New SARS-Cov-2 variants - clinical, public health, and vaccine implications. *N Engl J Med* 2021;384:1866–8.
4 Orsi A, Domnich A, Pace VD, *et al*. Outbreak of SARS-Cov-2 lineage 20I/501Y.V1 in a nursing home underlines the crucial role of vaccination in both residents and staff. *Vaccines* 2021;9:591.
5 Garcia-Beltran WF, Lam EC, St Denis K, *et al*. Multiple SARS-Cov-2 variants escape neutralization by vaccine-induced humoral immunity. *MedRxiv* 2021:2021.02.14.21251704.
6 Yang W, Shaman JL. COVID-19 pandemic Dynamics in South Africa and Epidemiological characteristics of three variants of concern (beta, Delta, and Omicron). *Elife* 2022;11:e78933.
7 Kupferschmidt K, Wadman M. Delta variant triggers new phase in the pandemic. *Science* 2021;372:1375–6.
8 Sardar S, Abdul-Khaliq I, Ingar A, *et al*. Covidd-19 Lockdown: A protective measure or Exacerbator of health inequalities? A comparison between the United Kingdom and India.' a commentary on "the socio-economic implications of the Coronavirus and COVID-19 pandemic: A review" *Int J Surg* 2020;83:189–91.
9 WHO. Clinical management of COVID-19. living guidelines. 2022. Available: https://www.who.int/publications/i/item/WHO-2019-nCoV-clinical-2022-1 [Accessed 6 Sep 2022].
10 Kasilo OMJ, Wambebe C, Nikiema J-B, *et al*. Towards universal health coverage: advancing the development and use of traditional medicines in Africa. *BMJ Glob Health* 2019;4(Suppl 9):e001517.
11 James PB, Wardle J, Steel A, *et al*. Traditional, complementary and alternative medicine use in sub-Saharan Africa: a systematic review. *BMJ Glob Health* 2018;3:e000895.
12 James PB, Wardle J, Steel A, *et al*. Utilisation of and attitude towards traditional and complementary medicine among Ebola survivors in Sierra Leone. *PLoS One* 2019;14:e0223068.
13 WHO. Expert panel endorses protocol for COVID-19 Herbal medicine clinical trials. 2020. Available: https://www.afro.who.int/news/expert-panel-endorses-protocol-covid-19-herbal-medicine-clinical-trials [Accessed 20 Aug 2022].
14 WHO. WHO affirms support for COVID-19 traditional medicine research. 2021. Available: https://www.afro.who.int/news/who-affirms-support-covid-19-traditional-medicine-research
15 WHO. General guidelines for Methodologies on research and evaluation of traditional medicine. World Health Organization: Geneva, 2000.
16 WHO. Clinical study of traditional medicines in the African region. World Health Organization AFRO: Brazzaville, Republic of Congo, 2004.
17 WHO. Regional Committee for Africa. progress report on the implementation of the regional strategy on enhancing the role of traditional medicine in health systems 2013–2023: information document. World Health Organization AFRO: Brazaville, Republic of Congo, 2020.
18 Mshana G, Mchome Z, Aloyce D, *et al*. Contested or complementary healing paradigms? women's narratives of COVID-19 remedies in Mwanza, Tanzania. *J Ethnobiol Ethnomed* 2021;17:30.
19 Mchome Z, Mshana G, Peter E, *et al*. Women's narratives about COVID-19, preventive practices and sources of information in northwestern Tanzania. *Int J Environ Res Public Health* 2021;18:5261.
20 Oladele JO, Ajayi EI, Oyeleke OM, *et al*. A systematic review on COVID-19 pandemic with special emphasis on curative potentials of Nigeria based medicinal plants. *Heliyon* 2020;6:e04897.
21 Ikpa C*et al*. Potential plants for treatment and management of COVID-19 in Nigeria. *J Chem* 2020.
22 Peer A. Natural cold and flu remedies from around the world. 2020. Available: https://www.worldvision.org/health-news-stories/natural-cold-flu-remedies-world [Accessed 20 Feb 2023].
23 Belhouala K, Benarba B. Medicinal plants used by traditional Healers in Algeria: A Multiregional Ethnobotanical study. *Front Pharmacol* 2021;12:760492.
24 Umeta Chali B, Melaku T, Berhanu N, *et al*. Traditional medicine practice in the context of COVID-19 pandemic: community claim in Jimma zone, Oromia, Ethiopia. *Infect Drug Resist* 2021;14:3773–83.
25 Lam CS, Koon HK, Chung VC-H, *et al*. A public survey of traditional, complementary and integrative medicine use during the COVID-19 outbreak in Hong Kong. *PLoS One* 2021;16:e0253890.
26 Wang J-B, Andrade-Cetto A, Echeverria J, *et al*. Editorial: Ethnopharmacological responses to the Coronavirus disease 2019 pandemic. *Front Pharmacol* 2021;12:798674.
27 Attah AF, Fagbemi AA, Olubiyi O, *et al*. Corrigendum: therapeutic potentials of antiviral plants used in traditional African medicine with COVID-19 in focus: A Nigerian perspective. *Front Pharmacol* 2021;12:721060.
28 Orisakwe OE, Orish CN, Nwanaforo EO. Coronavirus disease (COVID-19) and Africa: acclaimed home remedies. *Sci Afr* 2020;10:e00620.
29 Boozari M, Hosseinzadeh H. Natural products for COVID-19 prevention and treatment regarding to previous Coronavirus infections and novel studies. *Phytother Res* 2021;35:864–76.
30 Jahan R, Paul AK, Bondhon TA, *et al*. Zingiber Officinale: Ayurvedic uses of the plant and in Silico binding studies of selected Phytochemicals with MPRO of SARS-Cov-2. *Natural Product Communications* 2021;16:1934578X211031766.
31 Chaiyasit K, Torkaew W, Boonsiri K. Medicinal plants and the communication on precautionary use of herbs during COVID-19 outbreak in Thailand. *Bioactive Compounds in Health and Disease* 2021;4:180.
32 Yimer G, Ekuadzi E, Fasinu P, *et al*. Traditional medicines for COVID-19: perspectives from clinical Pharmacologists. *Br J Clin Pharmacol* 2021;87:3455–8.
33 WHO. Report of the fourth meeting of the world health organization regional expert advisory committee on traditional medicine for COVID-19 response on fast-tracking research and development and local manufacturing of Herbal medicines for COVID-19, held at Kintele. Brazzaville, Republic of Congo WHO Regional Office for Africa (publication in process; 2022Jul4.
34 Zhandire T, Gqaleni N, Ngcobo M, *et al*. Attitudes and perceptions of traditional health practitioners towards documentation of patient health information in their practice in eThekwini municipality, Kwazulu-natal, natal province, South Africa. *Health Inf Manag* 2023;52:41–9.
35 Mushebenge AG-A, Kadima MG, Mashamba-Thompson T, *et al*. Evidence on collaboration of traditional and BIOMEDICAL practitioners in the management of antimicrobial resistance in sub-Saharan Africa over 15 years: a systematic review protocol. *Syst Rev* 2021;10:158.
36 UNEP. State of Biodiversity in Africa. 2010. Available: https://www.cbd.int/iyb/doc/celebrations/iyb-egypt-state-of-biodiversity-in-africa.pdf [Accessed 11 Sep 2022].
37 Abdullahi AA. Trends and challenges of traditional medicine in Africa. *Afr J Tradit Complement Altern Med* 2011;8(5 Suppl):115–23.
38 Kapepula PM, Kabengele JK, Kingombe M, *et al*. *Artemisia* Spp. derivatives for COVID-19 treatment: anecdotal use, political Hype, treatment potential, challenges, and road map to randomized clinical trials. *Am J Trop Med Hyg* 2020;103:960–4.
39 Chung VCH, Ho LTF, Leung TH, *et al*. Designing delivery models of traditional and complementary medicine services: a review of international experiences. *Br Med Bull* 2021;137:70–81.
40 Belayneh YM, Yoseph T, Ahmed S. A cross-sectional study of Herbal medicine use and contributing factors among pregnant women on Antenatal care follow-up at Dessie referral hospital, northeast Ethiopia. *BMC Complement Med Ther* 2022;22:146.
41 James PB*et al*. The need for research on the use of traditional, complementary and integrative medicine in emerging and re-emerging infectious disease outbreaks: Ebola as a case study. In: *Public Health and Health Services Research in Traditional, Complementary and Integrative Health Care*. *p*. n.d.: 239–54.
42 WHO. WHO supports scientifically-proven traditional medicine. 2020. Available: https://www.afro.who.int/news/who-supports-scientifically-proven-traditional-medicine [Accessed 22 Feb 2023].
43 Intharuksa A, Arunotayanun W, Yooin W, *et al*. A comprehensive review of Andrographis Paniculata (BURM. F.) Nees and its constituents as potential lead compounds for COVID-19 drug discovery. *Molecules* 2022;27:4479.

# Supplement material

**Table 1: Medicinal plants from African Traditional Medicine used against viral respiratory pathogens, with potential in the management of COVID-19**

| Medicinal Plant | Family | Parts used | Formulations | Antiviral/other activity reported | Results | References |
|---|---|---|---|---|---|---|
| *Acokanthera schimperi* (A.DC.) Schweinf. | Apocynaceae | Leaves | Multiple solvent extracts were tested | Antiviral activity | Inhibited 50% parainfluenza at a 1 in 10 dilution | [1] |
| *Aframomum melegueta* K. Schum. | Zingiberaceae | Seed. | Ethanol extract | Extract inhibited measles and yellow fever virus | Inhibited measles and yellow fever viruses at MICs of 125 and 250 µg/mlLrespectively | [2] |
| *Alepidia amatymbica* Eckl. & Zeyh | Apiaceae | Rhizomes and roots. | Aqueous extract | Isolated compound has moderate anti-HIV activity. | The extract contains rosmarinic acid with promising anti-HIV activity | [3] |
| *Allium sativum* L. | Amaryllidaceae | Bulb | Hexane extract | HIV-1 reverse transcriptase inhibitory effect of hexane extract | Inhibited HIV-1 reverse transcriptase activity. $IC_{50}$ = 64.08 µg/mL | [1] |
| *Artemisia afra* Jacq. ex Wild | Asteraceae | Leaf | Tea infusions | Anti-HIV activity | Infusions showed anti-HIV activity | [1,4] |
| *Artemisia annua* L. | Asteraceae | Leaf | Tea infusions | Anti-HIV activity | Infusions showed anti-HIV activity. $IC_{50}$ = 2.0 µg/mL | [4] |
| *Aspalathus linearis* (Burm.f.) R. Dahlgren | Fabaceae | Herbal tea made from dried leaves | Fermented and unfermented aqueous, Methanol and Ethanol extracts, infusions | Anti-HIV activity | Consumption of herbal tea can suppress human immunodeficiency virus (HIV) infections | [5] |
| *Aspalathus linearis* (Burm.f.) R. Dahlgren | Fabaceae | Leaves | Leaf infusions | Antiviral activity | The extract inhibited influenza virus A and B production by 50% at 0.2% of the extract | [6] |
| *Aspilia pluriseta* Schweinf | Asteraceae | Leaf | Ethanol extract | Anti-HIV activity | The extract showed a complete cell protection against HIV-induced cytopathic effect | [7] |
| *Bambusa vulgaris* Schrad. ex J.C. Wendl | Poaceae | Leaf | Ethanol extract | Antiviral activity | Inhibition of measles virus at an MIC of 62.5 µg/mL | [8] |
| *Barleria prionitis* L. subsp. *delagoensis* (Oberm.) Brummitt & J.R.I. Wood | Acanthaceae | Whole plant | Compound isolated from the Dichloromethane extract (6-*O*-trans-p-coumaroyl-8- *O*-acetylshanzhiside methyl ester and its cis isomer) | Antiviral activity | The compound inhibited syncytial virus (RSV) production ($EC_{50}$ ¼ 2.5 µg/mL). | [9] |
| *Burkea africana* Hook. | Fabaceae | Bark | Purified saponins from Bark extract | Antiviral activity | Bark extracts and eight individual saponins purified from the bark produced potent inhibition of H3N2 influenza Hong Kong strain, with $IC_{50}$ values 0.05–0.27 µM. | [10] |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Carissa spinarum* L. | Apocynaceae | Leaves | Multiple solvent extracts | Antiviral activity | Inhibited 25% parainfluenza production at a 1 in 10 dilution. | [11] |
| *Clerodendrum glabrum* E. Mey. var. *glabrum* | Lamiaceae | Leaves | Methanol extract | Antiviral activity | $EC_{50}$ value 110 µg/mL against both pre- and post-penetration phases of viral replication. Solvent extracts were substantially more potent than aqueous extracts. No direct interaction with viral hemagglutinin glycoprotein. | [12] |
| *Costus afer* Ker-Gawler | Costaceae | Stalk | Decoction | Antiviral activity | Chicken pox, measles, influenza and genital herpes treatment | [13] |
| *Crassula globularioides* subsp. *argyrophylla* (Diels ex Schϵonland & Baker f.) Toelken | Crassulaceae | Aerial parts | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >6 µg/mL | [14] |
| *Cucumis metuliferus* E. Mey ex Naudin | Cucurbitaceae | Fruit | Fruit powder | Antiviral activity | The alkaloids of the plant inhibited the replication of Infectious bursal disease virus (IBDV) | [15] |
| *Cussonia spicata* Thunb. | Araliaceae | Leaves | Methanol extract | Antiviral activity | $EC_{50}$ values of 5–15 µg/mL effective against both pre- and post-penetration phases of influenza virus A replication. Solvent extracts more potent than aqueous extracts. No direct interaction with viral hemagglutinin glycoprotein | [12] |
| *Ekebergia capenses* Sparm. | Meliaceae | Bark | Extracted with multiple solvents of varying polarity | Antiviral activity | Inhibited 75% parainfluenza production at a 1 in 10 dilution | [16] |
| *Enantia chlorantha* Oliv | Annonaceae | Stem | Decoction | Antiviral activity | Hepatitis A, B, C and D treatment | [17] |
| *Helichrysum armenium* DC | Asteraceae | Leaves | Aqueous and ethanolic extracts | Antiviral activity | Inhibited parainfluenza virus production. MIC= 4 µg/mL | [18] |
| *Helichrysum melanacme* DC. | Asteraceae | Leaves | Ethanol extract | Antiviral activity | Inhibited influenza virus A production. $IC_{50}$ = 10 µg/mL | [18] |
| *Heteromorpha arborescens* (Spreng.) Cham. & Schltdl. | Apiaceae | Root bark | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >25 µg/mL | [18] |
| *Holarrhena pubescens* Wall. ex G. Don | Apocynaceae | Bark | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >10 µg/mL | [18] |
| *Jasminum fluminense* Vell. | Olacaceae | Stems | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >50 µg/mL | [18] |
| *Momordica charantia* L | Cucurbitaceae | Entire plant | Palm wine and water macerate of plant, decoction, plant juice | Antiviral activity | Chicken pox, measles, genital herpes, shingles treatment | [19] |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Pelargonium sidoides* DC. | Geraniaceae | Unspecified | A proprietary preparation named EPs 7630 was tested | Antiviral activity | EPs 7360 at 100 µg/mL inhibited the replication of H1N1and H3N2 influenza virus, parainfluenza virus, HRSV and human coronavirus strain 229E, but did not affect H5N1 influenza strain, adenoviruses and rhinoviruses | [18] |
| *Pittosporum viridiflorum* Sm**.** | Pittosporaceae | Leaf | Aqueous, methanol, ethanol and acetone extracts | Antiviral activity | $EC_{50}$ 3–82 µg/mL against both pre- and post-penetration phases of influenza virus A. replication. Solvent extracts were substantially more potent than aqueous extracts. No direct interaction with viral hemagglutinin glycoprotein. | [12] |
| *Polygala lancifolia* A. St. -Hil. & Moq. | Polygalaceae | Aerial parts | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >12 µg/mL. | [14] |
| *Pteleopsis hylodendron* Mildbr. | Combretaceae | Bark | Decoction | Antiviral activity | Chicken pox treatment | [20] |
| *Pterocarpus angolensis* DC. | Fabaceae | Bark | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >12 µg/mL | [18] |
| *Rapanea melanophloeos* (L.) Mez. | Primulaceae | Leaves and twigs | Aqueous, methanol, ethanol and acetone extracts | Antiviral activity | $EC_{50}$ 113 µg/mL against both pre- and post-penetration phases of influenza virus A. replication. No direct interaction with viral hemagglutinin glycoprotein. | [12] |
| *Spathodea campanulata* P. Beauv. | Bignoniaceae | Bark | Decoction | Antiviral activity | Chicken pox, genital herpes treatment | [21] |
| *Steganotaenia araliacea* Hochest. | Apiaceae | Root | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >60 µg/mL | [14] |
| *Tabernaemontana ventricosa* Hochst. ex. A.DC. | Apocynaceae | Leaves | Extracted with multiple solvents of varying polarity | Antiviral activity | $EC_{50}$ values of 0.05 µg/mL against both pre- and post-penetration phases of influenza virus A. replication. Solvent extracts were substantially more potent than aqueous extracts. No direct interaction with viral hemagglutinin glycoprotein | [18] |
| *Vernonia amygdalina* Del. | Asteraceae | Leaf, root | Aqueous methanol extract | Anti-HIV activity | Extract contains phenols (caffeoylquinic acids) with antiviral activity | [1] |
| *Xanthocercis zambesiaca* (Baker) Dumaz-le- Grand | Fabiaceae | Leaves | Methanol and Dichloromethane extracts | Antiviral activity | Dichloromethane extract strongly inhibited rhinovirus type 2 production in HeLa cells at concentrations >60 µg/mL | [18] |

**Table 2 Medicinal plants used in African Traditional Medicine for some common COVID-19 related symptoms**

| Symptoms | Plant name | Family | Countries reported from | Parts used/ Formulations/anti-viral activities | Additional common uses |
|---|---|---|---|---|---|
| Fever | *Centella asiatica* (L.) Urb | Apiaceae | Nearly all African countries | Whole plant; a combination of *Centella asiatica and Mangifera indica* aqueous extracts showed anti-herpes simplex virus activities.[22] | Wounds, ulcers, leprosy, TB, lupus, skin disorders, eye illnesses, fever, asthma, inflammation, rheumatism, hypertension, syphilis, epilepsy, diarrhea, leprosy, and mental illness have all been treated with *C. asiatica* in the past. It's also used as a spice and eaten as a vegetable.[5] |
| | *Crinum macowani* Baker | Amaryllidaceae | East, Central and Southern Africa | Bulb. Methanolic extract of bulbs showed activity against yellow fever virus and Japanese encephalitis virus. [23] | *Crinum macowanii*'s bulbs, roots, and leaves are used to treat a variety of ailments throughout much of Africa, including back pain, as an emetic, and to increase lactation in both humans and animals, bodily swelling, urinary tract disorders, itchy rashes, acne, boils, diarrhoea, fever, tuberculosis, and sexually transmitted infections. The extracts of the plant show only moderate antifungal action, according to in vitro experiments.[24] |
| | *Vernonia amygdalina* Del. | Asteraceae | Cameroon, Uganda | Leaf, root. Traditionally used for HIV. Scientifically found to produce antioxidants in AIDS patients.[25] | Antiidiabetic, anthelminthic, antiplasmodial, antibacterial, cardiovascular, immunomodulatory, antiplasmodial, antioxidant, and antianaemic activities have been reported in *V. amygdalina* Del.[26,27] |
| Dry cough/coughs | *Acacia senegal* (L.) Willd | Leguminosae-Mimosoideae | Southern to Northern Nigeria, North Africa | Gum | Various components of the *A. senegal* plant have been used to cure infections such as bleeding, bronchitis, diarrhoea, gonorrhoea, leprosy, typhoid fever, and upper respiratory tract infections for millennia.[5] |
| | *Tulbaghia violacea* Harv. | Amaryllidaceae | Southern Africa and Tanzania | Leaf. Used in traditional medicine for respiratory problems and also as an anti-viral, though specific viruses were not mentioned[28] | In African traditional medicine, *Tulbaghia violacea* Harv. (Alliaceae), a herbaceous plant also known as "wild garlic," "society garlic," and "sweet garlic," has been used to manage, regulate, and/or treat a range of human ailments, including hypertension and as an antifungal agent.[29] |
| | *Mangifera indica* L. | Anacardiaceae | Tanzania, Uganda | Bark, leaf. Dried fruit pulp extract inhibit influenza virus;[30] mangiferin, obtained from fruit peels, exhibited inhibition of polio virus type 1 (PV-1);[31] aqueous extract of leaf showed inhibitory activity against Newcastle disease virus (NDV) and infectious bursal disease (IBD) virus.[32] | *M. indica* leaves are said to have anti-diabetic, antibacterial, antifungal, anthelmintic, antiparasitic, antitumor, anti-HIV, antispasmodic, antipyretic, antidiarrheal, antiallergic, immunomodulation, antimicrobial, and hepatoprotective properties, and have been used for centuries to treat malaria, throat infections, burns, and scalds. In the past, mango stem bark was used to cure menorrhagia, scabies, diarrhoea, syphilis, diabetes, skin problems, and anemia.[33] |

| | | | | | |
|---|---|---|---|---|---|
| | *Cascabela thevetia* (L.) Lippold | Apocynaceae | Uganda | Root | An emetic made from a bark or leaf decoction is used to relax the bowels and is reported to be an excellent therapy for intermittent fevers. In Senegal, water with macerated leaves and bark is used to treat amenorrhea, while in Ghana, decoctions of the leaves are used to treat jaundice, fever, and as a purgative for intestinal worms. Latex is used in Mali to soften corns and calluses. The leaf sap is used as eye and nose drops in Benin and Côte d'Ivoire to treat strong headaches; it is also poured into the nostrils to revive patients who have fainted and to treat colds. To treat colds, the Luo people of Kenya drink water that has been crushed with leaves. Purgative properties are possible with the seeds. Because hazardous doses are just slightly greater than therapeutic doses, caution should be exercised in all medical applications, particularly those used internally. |
| | *Acacia tortilis* (Forssk.) Schweinf. | Fabaceae | Djibouti | Plant is applied on burning charcoal and smoke inhaled nasally for dry coughs; same thing is done with roots for coughs with phlegm. | Diabetes mellitus is treated using polysaccharide extracted from gum exudates. For fungal illness, use stem bark. Diarrhoea is treated with Bark Tannins, Infectious Disease Stem Bark, Cough and Diphtheria with wood. Malaria treatment with root bark, hypercholesterolemia treatment with aqueous extract, and inflammation treatment with aqueous extract and methanol extract of *Acacia tortilis* for Leishmania and parasitic illness.[27,34] |
| | *Guiera senegalensis* J.F. Gmel. | Combretaceae | Tropical Africa in dry areas from Senegal to Sudan | Decoction of leaves, roots and gall of the plant are used in the treatment of cough and tuberculosis [35-37]<br>*Guiera senegalensis* J.F. Gmel is a broad-spectrum African folk-medicinal plant, having activities against fowlpox and herpes viruses and *G. senegalensis* leaves extract (GSLE) have potential for anti-hepatitis B virus (HBV).[38] | The extract from the leaves is used to treat jaundice, which accounts for more than 51.5 percent of the disorders treated; diabetes mellitus, hypertension, cough, arthritis, enteritis, diarrhoea, and malaria account for 48.5 percent of the other ailments treated. *Guiera senegalensis* root powder is used to heal wounds such as diabetic sores, skin inflammation, and injuries.[39] Antitussive, bronchodilating, anti-infectious, analgesic, antipyretic, and anti-inflammatory qualities of the *Guiera senegalensis* could explain its use in the treatment of cough, bronchitis, tuberculosis, and colds.[40] |
| | *Sterculia setigera* Del. | Sterculiaceae | East Africa, Ethiopia, Senegal, Sudan-Sahel, Sudan-Guinea, Nigeria and Togo | Décoction of stem barks of the plant[41]<br>[Leaves, roots, bark of *S. setigera* have been found to possess anti-viral activity against three human and three animal viruses (Poliovirus (type 1), astrovirus, human herpes simplex virus (type 1), equine herpes simplex virus, bovine parvovirus and canine parvovirus have also been reported.[42] | Cough, stomachaches, gonorrhea, acne, diarrhoea, rickets, wounds, and epilepsy are some of the conditions that *S. setigera* can help with. Stomachaches, heart palpitations, coughs, and rachitis are all treated with the bark. The stem bark decoction is used to treat asthma, bronchitis, wounds, fevers, toothaches, gingival sores, abscesses, and diarrhoea. To cure constipation, gum is utilized in the preparation of sauce. The gum is used to make couscous and sauces by Senegalese housewives. The herb is used to alleviate constipation in southwest Nigeria. Gum powder was used by Sudanese in the south-eastern part of the country to treat toothaches.[43] |

| | | | | | |
|---|---|---|---|---|---|
| | *Bridelia ferruginea* Benth. | Euphorbiaceae | Benin, Nigeria, Burkina Faso and Ivory Coast | Infusion of roots of the plant.[44] | *Bridelia ferruginea* is often used to cure a range of conditions in both general African and West African traditional medicine, including bladder difficulties, diabetes, diarrhoea, arterial hypertension, and rheumatic pain.[45] |
| | *Terminalia avicennioides* Guill. & Perr. | Combretaceae | Nigeria, South Africa and Tanzania | Maceration of leaves of the plant.[41] | Bronchitis and TB are treated with trunk bark and guis of *Terminalia avicennioides*. Extracts of *Terminalia avicennioides* have been shown to have antimicrobial effects in vitro against bacteria isolated from individuals with respiratory disease problems, as well as anti-Mycobacterium tuberculosis activity in extracts of triterpenoids obtained from root bark. Antimicrobial activity has also been discovered in flavonoids and saponosides extracted from root bark. |
| | *Euphorbia hirta* L. | Euphorbiaceae | | Whole plant parts are used[46] The aqueous and 50% MeOH extracts of Euphorbia hirta demonstrated a specific inhibition of three types of immunodeficiency viruses: SIVmac251, HIV-1 and HIV-2 replication in MT4 cells in vitro[47] | Intestinal parasites, diarrhoea, peptic ulcers, heartburn, vomiting, and amoebic dysentery are all treated with Euphorbia hirta decoction or infusion, as well as respiratory disorders like asthma, bronchitis, hay fever, laryngeal spasms, emphysema, coughs, and colds. The leaves are used to treat urogenital diseases (kidney stones, menstrual problems, sterility, and venereal diseases); skin and mucous membrane affections (including warts, scabies, tinea, thrush, aphthae, and fungal afflictions); and measles, Guinea-worm, and as an antiseptic to treat wounds, sores, and conjunctivitis. The herb is used as an analgesic, antipyretic, and anti-inflammatory to treat severe headaches, toothaches, rheumatism, colic, and pains during pregnancy. It's used to cure jaundice, hypertension, oedema, anemia, and malaria, as well as hart an aphrodisiac and to make childbirth easier. The plants are commonly used as a galactagogue in West Africa, and they are even sold as such in Nigeria. To induce labor during childbirth in Uganda, whole herbs are consumed.[48] |
| Tiredness | *Crassocephalum vitellinum* S. Moore | Asteraceae | Uganda, Burundi, Cameroon, Kenya, Rwanda, Tanzania, Zambia, Democratic Republic of Congo | Leaf. Mode of use not given for energy boosting effect. | Fever, diarrhoea, oral candidiasis, syphilis, energy boosting, tumors, uterine pains, and headaches are all symptoms of herpes zoster. Essential oil and fractions were also found to have potent antifungal activity against *C. neoformans* and *C. albicans*. On the yeasts, the fractions were more active than the pure oil. The study found that after further fractionation of *C. vitellinum* essential oils, the hexane soluble fractions had the maximum sensitivity to *C. neoformans*. The water and ethanol extracts, on the other hand, were ineffective against the bacterial strains tested. The 38 ethanolic extract has poor antibacterial action in *C. vitellinum*, according to similar observations.[48] |

| | | | | | |
|---|---|---|---|---|---|
| Aches and pains | *Aloe ferox* Mill. | Xanthorrheaceae | South Africa, Lesotho | Gel applied topically. Aqueous extract of plant active against herpes simplex virus type 1.[49] | It's best recognized for its laxative qualities and as a skin, eye, and mucous membranes topical treatment. Scientific investigations have backed up many of the traditional applications. The cosmetic industry's interest in *A. ferox* gel has recently increased. *A. ferox* gel, according to sources, has at least 130 medicinal compounds with anti-inflammatory, analgesic, calming, antiseptic, germicidal, antiviral, antiparasitic, antitumor, and anticancer activities, spanning all traditional uses and scientific studies on *A. ferox* and its constituents.[5] |
| | *Artemisia herba-alba* Asso[5] | Asteraceae | Tunisia | Herbal tea (tea made from boiling leaves in water). | It is used to treat arterial hypertension and diabetes in Moroccan herbal medicine, and diabetes, bronchitis, diarrhea, hypertension, and neuralgias in Tunisian traditional medicine. Herbal tea has been used in traditional medicine as an analgesic, antimicrobial, antispasmodic, and hemostatic agent. During an ethno-pharmacological survey among the Bedouins of the Negev desert, *A. herba-alba* was discovered to be used to treat stomach problems.[5] |
| Sore throat | *Acacia senegal* (L.) Willd[5]. | Leguminosae-Mimosoideae | Northern Nigeria, North Africa | Gum | For millennia, the gum of *A. senegal* has been used to treat infections such as hemorrhage, bronchitis, diarrhoea, gonorrhoea, leprosy, typhoid fever, and infections of the upper respiratory tract.[5] |
| Diarrhoea | *Acacia senegal* (L.) Willd[5555] | Leguminosae-Mimosoideae | Northern Nigeria, West and | Gum | |
| | *Artemisia herba-alba* Asso | Asteraceae | Tunisia | Herbal tea (tea made from boiling leaves in water) | Cough, stomach and intestinal disturbance, the common cold, measles, diabetes, yellowed skin (jaundice), nervousness, irregular pulse, and muscle weakness are all treated with *Artemisia herba-alba*. Roundworms, pinworms, tapeworms, hookworms, and flukes are among the parasitic infections treated with it.[5] |
| | *Mangifera indica* L. | Anacardiaceae | Tanzania, Uganda | Bark, leaf | The leaves of *Mangifera indica* are used to cure diabetes in Nigerian traditional medicine. According to studies, it contains anti-diabetic, antioxidant, antiviral, cardiotonic, hypotensive, and anti-inflammatory properties. Antibacterial, antifungal, anthelmintic, antiparasitic, antitumor, anti-HIV, antibone resorption, antispasmodic, antipyretic, antidiarrheal, antiallergic, immunomodulation, hypolipidemic, antimicrobial, hepatoprotective, and gastroprotective characteristics have all been looked at.[50] |
| | *Alepidia amatymbica* Eckl. & Zeyh. | Apiaceae | South Africa | Bark, root. | Also used for the treatment of digestive system disorders, which include indigestion, constipation, stomach aches, diarrhoea, and vomiting. Other uses include treatment of cold, coughs, influenza, and chest pain. Fresh roots and rhizomes may be chewed three times a day for common cold and cough. Dried roots are also boiled and ½ cup of the decoction is taken twice daily for constipation.[51] |
| | *Tithonia diversifolia* (Hemsl.) A. Gray | Asteraceae | Rwanda | Leaf | |

| | | | | | |
|---|---|---|---|---|---|
| | *Vernonia amygdalina* Del. | Asteraceae | Tanzania, Uganda | Leaf, root | Flavonoids from VA have been shown to have strong antioxidant properties, while its saponins have been shown to have antitumoral properties in leukemia cells. VA peptides are known to be powerful inhibitors of mitogen-activated protein kinases (MAPKs), which are important for breast tumor growth and also serve as a critical regulatory point for the tumor.[52,53] |
| Conjunctivitis/Eye infections | *Aloe ferox* Mill. | Xanthorrheaceae | South Africa, Lesotho | Fresh bitter sap applied directly.[5] | |
| | *Acacia etbaica* Schweinf. | Fabaceae | Djibouti | Leaves are grounded in water and the eye washed with the water.[27,54] | The extracts exhibited high cytotoxic, antibacterial, wound healing and antifungal activity.[55] |
| | *Aloe mcloughlinii* Christian | Aloaceae | Djibouti | Fresh leaves are soaked in water and the water used as eye drop. Exudate also used for eye infections in Ethiopia.[27] | |
| Headache | *Vernonia amygdalina* Del. | Asteraceae | Uganda | Leaf. Formulation not given.[56] | |
| Loss of taste or smell (ageusia, anosmia)i | No such plants as direct remedy for loss of taste or smell are known for African medicinal plants. African medicines treatments are holistic and treatment of colds which includes loss of smell associated with the condition. Again, the loss of taste can also be as a result of cold and flu.<br>Ayurveda recommends garlic, lemon juice, mint or ginger to get relief from cold and so restore the sensory loss of taste or smell during cold. From that viewpoint, African plants against cold can be tried. | | | | |
| A rash on skin, or discolouration of fingers or toes | *Vernonia amygdalina* Del. | Asteraceae | Tanzania, Uganda | Leaf, root [56,57] | Also used traditionally by AIDS patients for chronic diarrhoea, herpes zoster and herpes simplex in Bukoba rural district, Tanzania; also used by AIDS patients for treatment of fever, general rash, pain (headache, back), cough, and stomach ache in Kabarole district, Western Uganda. [57] |
| | *Elaedendron transvaalense* (Burtt Davy) R.H. Archer | Celastraceae | South Africa | Roots. Root extract | Also inhibits HIV Type 1 reverse transcriptase and integrase.[58] |
| Difficulty breathing or shortness of breath | *Acacia senegal* (L.) Willd. | Leguminosae-Mimosoideae Fabaceae | Northern Nigeria | Gum | |
| | *Aspalathus linearis* (Burm.f.) R. Dahlgren | Fabaceae | South Africa | Herbal tea made from dried leaves. *In vitro* data has shown that the daily intake of the alkaline extracts of the red rooibos tea could suppress HIV infections in the extract.[5] | It has anti-inflammatory, immunomodulating, and chemopreventive properties. The plant is mineral-rich and tannin-free. There is mounting evidence that the flavonoids included in the plant have a significant role in the prevention of cardiovascular disease and other age-related diseases. Aspalathin has been demonstrated in recent research to have favorable effects on glucose levels. homeostasis in Type 2 diabetes by boosting glucose absorption in muscle tissues and insulin release from pancreatic beta-cells, according to evidence-based complementary and alternative medicine. In vitro and in vivo studies have shown that rooibos tea has bronchodilator, antispasmodic, and blood pressure-lowering properties. The antispasmodic effect through potassium ionchannel activation has been reported.[5] |

| | | | | | |
|---|---|---|---|---|---|
| Chest pain or pressure | *Acacia mellifera* (Vahl) Benth[59595859] | Fabaceae | Djibouti | Fresh leaves are chewed[27] | In traditional Kenyan medicine, *Acacia mellifera* is a valuable medicinal shrub. Syphilis and pneumonia are treated using the plant's stem bark. The triterpenoids found in this plant have been isolated and found to be cytotoxic and antimalarial.[60] |
| Loss of speech (dysphasia/dysarthria) or movement (paresis) | *Diospyros sanza-minika* A. Chevalier | Ebenaceae | Sierra Leone, Ghana, Cameroon, Gabon and Congo | Leaf (for paresis). The possesses an anti-HBV activity and exerts its antivirus effects via inhibition of HBV transcription.[61] | The antimalarial activity of the pure constituents of *Diospyros sanza-minika* and of the methanol extract from the stem bark of is reported for the first time. The results provide interesting baseline information for the potential use of the crude extract well as some of the isolated compounds in the search for novel antimalarial compounds.[61] |

Note: The claims in Tables 1 and 2 are based on data from preclinical studies and ethnobotanical surveys which have not been subjected to verification through randomized control clinical trials.

## References

1. Tegen D, Dessie K, Damtie D. Candidate Anti-COVID-19 Medicinal Plants from Ethiopia: A Review of Plants Traditionally Used to Treat Viral Diseases. *Evidence-Based Complementary and Alternative Medicine* 2021; **2021**.
2. Omotuyi IO, Nash O, Ajiboye BO, et al. Aframomum melegueta secondary metabolites exhibit polypharmacology against SARS-CoV-2 drug targets: in vitro validation of furin inhibition. *Phytotherapy Research* 2021; **35**(2): 908-19.
3. Wintola O, Afolayan A. Alepidea amatymbica Eckl. & Zeyh.: A review of its traditional uses, phytochemistry, pharmacology, and toxicology. *Evidence-Based Complementary and Alternative Medicine* 2014; **2014**.
4. Lubbe A, Seibert I, Klimkait T, van der Kooy F. Ethnopharmacology in overdrive: the remarkable anti-HIV activity of Artemisia annua. *J Ethnopharmacol* 2012; **141**(3): 854-9.
5. Mahomoodally MF. Traditional medicines in Africa: an appraisal of ten potent African medicinal plants. *Evidence-Based Complementary and Alternative Medicine* 2013; **2013**.
6. Rahmasari R, Haruyama T, Charyasriwong S, Nishida T, Kobayashi N. Antiviral activity of Aspalathus linearis against human influenza virus. *Natural product communications* 2017; **12**(4): 1934578X1701200432.
7. Attah AF, Fagbemi AA, Olubiyi O, et al. Therapeutic Potentials of Antiviral Plants Used in Traditional African Medicine With COVID-19 in Focus: A Nigerian Perspective. *Frontiers in pharmacology* 2021; **12**.
8. Ojo O, Oluyege J, Famurewa O. Antiviral properties of two Nigerian plants. *African Journal of Plant Science* 2009; **3**(7): 157-9.
9. Chen JL, Blanc P, Stoddart CA, et al. New iridoids from the medicinal plant Barleria prionitis with potent activity against respiratory syncytial virus. *Journal of natural products* 1998; **61**(10): 1295-7.
10. Mair CE, Grienke U, Wilhelm A, et al. Anti-influenza triterpene saponins from the bark of Burkea africana. *Journal of natural products* 2018; **81**(3): 515-23.
11. Wangteeraprasert R, Lipipun V, Gunaratnam M, Neidle S, Gibbons S, Likhitwitayawuid K. Bioactive compounds from Carissa spinarum. *Phytotherapy Research* 2012; **26**(10): 1496-9.
12. Mehrbod P, Abdalla MA, Njoya EM, et al. South African medicinal plant extracts active against influenza A virus. *BMC complementary and alternative medicine* 2018; **18**(1): 1-10.
13. RA NN, ML KM, PR MC, et al. Ethnobotanical survey of some Cameroonian plants used for treatment of viral diseases. *African Journal of Plant Science* 2011; **5**(1): 15-21.
14. Beuscher N, Bodinet C, Neumann-Haefelin D, Marston A, Hostettmann K. Antiviral activity of African medicinal plants. *J Ethnopharmacol* 1994; **42**(2): 101-9.
15. Gupta S, Kanwar SS. Plant protease inhibitors and their antiviral activities-Potent therapeutics for SARS CoV-2. *Journal of Medical Discovery* 2021; **6**(1): 1-14.
16. Bagla VP, McGaw LJ, Eloff JN. The antiviral activity of six South African plants traditionally used against infections in ethnoveterinary medicine. *Veterinary microbiology* 2012; **155**(2-4): 198-206.
17. Mpiana PT, Tshibangu DS, Kilembe JT, et al. Aloe vera (L.) Burm. F. as a potential anti-COVID-19 plant: a mini-review of its antiviral activity. *European Journal of Medicinal Plants* 2020: 86-93.
18. Cock IE, Van Vuuren SF. The traditional use of southern African medicinal plants for the treatment of bacterial respiratory diseases: A review of the ethnobotany and scientific evaluations. *J Ethnopharmacol* 2020: 113204.
19. Dossou-Yovo HO, Kindomihou V, Sinsin B. Application of Ethnobotanical Indices to Assess the Diversity of Medico-magic Knowledge on Four Herbaceous Species in Benin. 2020.
20. Nana HM, Ngane RN, Kuiate J, et al. Acute and sub-acute toxicity of the methanolic extract of Pteleopsis hylodendron stem bark. *J Ethnopharmacol* 2011; **137**(1): 70-6.
21. FEDOUNG EF, BIWOLE A, BIYEGUE CFN, et al. Searching nature-based solutions to emerging diseases: a preliminary review of Cameroonian medicinal plants with potentials for the management of COVID-19 pandemic. 2020.
22. Yoosook C, Bunyapraphatsara N, Boonyakiat Y, Kantasuk C. Anti-herpes simplex virus activities of crude water extracts of Thai medicinal plants. *Phytomedicine* 2000; **6**(6): 411-9.

23. Duri ZJ, Scovill JP, Huggins JW. Activity of a methanolic extract of Zimbabwean Crinum macowanii against exotic RNA viruses in vitro. *Phytotherapy Research* 1994; **8**(2): 121-2.
24. Maroyi A. A review of ethnoboatany, therapeutic value, phytochemistry and pharmacology of Crinum macowanii Baker: A highly traded bulbous plant in Southern Africa. *J Ethnopharmacol* 2016; **194**: 595-608.
25. Laila U, Akram M, Shariati MA, et al. Role of medicinal plants in HIV/AIDS therapy. *Clinical and Experimental Pharmacology and Physiology* 2019; **46**(12): 1063-73.
26. Danladi S, Hassan MA, Masa'ud IA, Ibrahim UI. Vernonia amygdalina Del: A mini review. *Research Journal of Pharmacy and Technology* 2018; **11**(9): 4187-90.
27. Hassan-Abdallah A, Merito A, Hassan S, et al. Medicinal plants and their uses by the people in the Region of Randa, Djibouti. *J Ethnopharmacol* 2013; **148**(2): 701-13.
28. Krstin S, Sobeh M, Braun MS, Wink M. Tulbaghia violacea and Allium ursinum extracts exhibit anti-parasitic and antimicrobial activities. *Molecules* 2018; **23**(2): 313.
29. Moodley K, Mackraj I, Naidoo Y. Cardiovascular effects of Tulbaghia violacea Harv.(Alliaceae) root methanolic extract in Dahl salt-sensitive (DSS) rats. *J Ethnopharmacol* 2013; **146**(1): 225-31.
30. Amin A. AL Dulaimi and Marwa AA AL Rawi, Antiviral Activity of Mangifera Extract on Influenza Virus Cultivated in Different Cell Cultures. *J Pure Appl Microbiol* 2019; **13**(1): 455-8.
31. Rechenchoski D, Galhardi L, Cunha A, Ricardo N, Nozawa C, Linhares R. Antiviral potential of mangiferin against poliovirus. *Int J Pharmacol Res* 2018; **8**: 34-9.
32. Gupta A, Chaphalkar SR. Virucidal potential of Prosopis spicigera and Mangifera indica on human peripheral blood mononuclear cells. *Journal of HerbMed Pharmacology* 2016; **5**(4): 162-5.
33. Kuete V. Medicinal spices and vegetables from Africa: therapeutic potential against metabolic, inflammatory, infectious and systemic diseases: Academic Press; 2017.
34. Verma S. A review study on Acacia Tortillis. *Life* 2016; **50**: 22.
35. Nadembega P, Boussim JI, Nikiema JB, Poli F, Antognoni F. Medicinal plants in baskoure, kourittenga province, Burkina Faso: an ethnobotanical study. *J Ethnopharmacol* 2011; **133**(2): 378-95.
36. Diop EA, Queiroz EF, Kicka S, et al. Survey on medicinal plants traditionally used in Senegal for the treatment of tuberculosis (TB) and assessment of their antimycobacterial activity. *J Ethnopharmacol* 2018; **216**: 71-8.
37. Sanogo R, De Pasquale R, Germano M. The antitussive activity of Guiera senegalensis JF Gmel (Combretaceae). *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives* 1998; **12**(2): 132-4.
38. Parvez MK, Alam P, Arbab AH, Al-Dosari MS, Alhowiriny TA, Alqasoumi SI. Analysis of antioxidative and antiviral biomarkers β-amyrin, β-sitosterol, lupeol, ursolic acid in Guiera senegalensis leaves extract by validated HPTLC methods. *Saudi pharmaceutical journal* 2018; **26**(5): 685-93.
39. Alshafei NK, Ahmed S, Abdelfattah N. Preliminary Observations on the Uses of Guiera Senegalensis as a Traditional Medicinal Plants in Western Kurdofan, Sudan. *Journal of Plant Biochemistry and Physiology* 2016.
40. Haidara M, Diarra ML, Doumbia S, et al. Plantes médicinales de l'Afrique de l'Ouest pour la prise en charge des affections respiratoires pouvant se manifester au cours de la Covid-19. *International Journal of Biological and Chemical Sciences* 2020; **14**(8): 2941-50.
41. Zerbo P, Millogo-Rasolodimey J, Nacoulma-Ouerdraogo O, Van Damme P. Contribution à la connaissance des plantes médicinales utilisées dans les soins infantiles en pays San, au Burkina Faso. *International Journal of Biological and Chemical Sciences* 2007; **1**(3): 262-74.
42. Babalola IT, Adelakun EA, Wang Y, Shode FO. Anti-TB activity of Sterculia setigera Del., leaves (Sterculiaceae). *Journal of Pharmacognosy and Phytochemistry* 2012; **1**(3): 17-21.
43. Atakpama W, Batawila K, Dourma M, et al. Ethnobotanical knowledge of Sterculia setigera Del. in the Sudanian zone of Togo (West Africa). *International Scholarly Research Notices* 2012; **2012**.
44. Koné M, Atindehou K, Téré H, Traoré D. Quelques plantes médicinales utilisées en pédiatrie traditionnelle dans la région de Ferkessédougou (Côte d'Ivoire). *Bioterre* 2002; **30**: 30-6.
45. Alowanou G, Olounlade A, Azando E, Dedehou V, Daga F, Hounzangbe-adote M. A review of Bridelia ferruginea, Combretum glutinosum and Mitragina inermis plants used in zootherapeutic remedies in West Africa: historical origins, current uses and implications for conservation. *Journal of Applied Biosciences* 2015; **87**: 8003-14.

46. Mann A, Amupitan J, Oyewale A, Okogun J, Ibrahim K. An Ethnobotanical survey of indigenous flora for treating tuberculosis and other respiratory diseases in Niger State, Nigeria. *Journal of Phytomedicine and Therapeutics* 2007; **12**: 1-21.
47. Gyuris A, Szlavik L, Minarovits J, Vasas A, Molnar J, Hohmann J. Antiviral activities of extracts of Euphorbia hirta L. against HIV-1, HIV-2 and SIVmac251. *in vivo* 2009; **23**(3): 429-32.
48. Asiimwe S. Nutri-medicinal plants used in the management of HIV/AIDS opportunistic infections in Western Uganda: documentation, phytochemistry and bioactivity evaluation: KTH Royal Institute of Technology; 2015.
49. Kambizi L, Goosen B, Taylor M, Afolayan A. Anti-viral effects of aqueous extracts of Aloe ferox and Withania somnifera on herpes simplex virus type 1 in cell culture: research in action. *South African Journal of Science* 2007; **103**(9): 359-60.
50. Shah K, Patel M, Patel R, Parmar P. Mangifera indica (mango). *Pharmacognosy reviews* 2010; **4**(7): 42.
51. Buwa-Komoren LV, Mayekiso B, Mhinana Z, Adeniran AL. An ethnobotanical and ethnomedicinal survey of traditionally used medicinal plants in Seymour, South Africa: An attempt toward digitization and preservation of ethnic knowledge. *Pharmacognosy Magazine* 2019; **15**(60): 115.
52. Adaramoye OA, Akintayo O, Achem J, Fafunso MA. Lipid-lowering effects of methanolic extract of Vernonia amygdalina leaves in rats fed on high cholesterol diet. *Vascular health and risk management* 2008; **4**(1): 235.
53. Burkill HM. The useful plants of west tropical Africa, Vols. 1-3. *The useful plants of west tropical Africa, Vols 1-3* 1995; (2. ed.).
54. Belayneh A, Demissew S, Bussa NF, Bisrat D. Ethno-medicinal and bio-cultural importance of aloes from south and east of the Great Rift Valley floristic regions of Ethiopia. *Heliyon* 2020; **6**(6): e04344.
55. Kayed AM, Genady EA, Kadry HA, Elghaly E-SM. New phytoconstituents, anti-microbial and cytotoxic activities of Acacia etbaica Schweinf. *Natural Product Research* 2020: 1-10.
56. Langlois-Klassen D, Kipp W, Jhangri GS, Rubaale T. Use of traditional herbal medicine by AIDS patients in Kabarole District, western Uganda. *The American journal of tropical medicine and hygiene* 2007; **77**(4): 757-63.
57. Kisangau DP, Lyaruu HV, Hosea KM, Joseph CC. Use of traditional medicines in the management of HIV/AIDS opportunistic infections in Tanzania: a case in the Bukoba rural district. *Journal of Ethnobiology and Ethnomedicine* 2007; **3**(1): 1-8.
58. Bessong PO, Obi CL, Andréola M-L, et al. Evaluation of selected South African medicinal plants for inhibitory properties against human immunodeficiency virus type 1 reverse transcriptase and integrase. *J Ethnopharmacol* 2005; **99**(1): 83-91.
59. Hassan-Abdallah A, Merito A, Hassan S, et al. Medicinal plants and their uses by the people in the Region of Randa, Djibouti. *J Ethnopharmacol* 2013; **148**(2): 701-13.
60. Mutai C, Bii C, Vagias C, Abatis D, Roussis V. Antimicrobial activity of Acacia mellifera extracts and lupane triterpenes. *J Ethnopharmacol* 2009; **123**(1): 143-8.
61. Tangmouo JG, Ho R, Matheeussen A, et al. Antimalarial activity of extract and norbergenin derivatives from the stem bark of Diospyros sanza-minika A. Chevalier (Ebenaceae). *Phytotherapy Research* 2010; **24**(11): 1676-9.