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REVIEW PAPER

Nigerian polyherbal-based hydrotherapy: a panacea to infectious diseases

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Summary

A global society, including developed countries, continues to struggle with fatal diseases that are difficult to treat with Western medicine. A variety of infectious diseases have existed for ages, but in Africa they had been limited thanks to the Indigenous Knowledge System (IKS) prior to the introduction of cosmopolitan medicine. Influenza virus repression has been demonstrated by a number of herbal antivirals, yet the invaluable therapeutic potential of herbal medicine has been underestimated. Despite various reliable methods offered by Western medicine, the globally destructive COVID-19 pandemic requires a successful fight. The wisdom of African IKS used in tackling epidemics that have broken out in the past is brought to mind again. Pneumonia – a COVID-19 symptom, could be treated with polyherbal fomentation. Selected plants cultivated across Nigeria for hydrotherapy are under consideration to be used in proper doses. Given the potential associated with IKS, a multi-disciplinary approach involving experts in phytomedicine, ethnobotany, phytochemistry, plant physiology and ecology is necessary to unlock the therapeutic potential of traditional medicine.

Key words: ***COVID-19, indigenous knowledge system, influenza, fomentation, phytomedicine, coronavirus***

Słowa kluczowe: ***COVID-19, wiedza odziedziczona, grypa, okłady, fitoterapia, koronawirus***

The narrative of the indigenous knowledge system and modern medicine

For decades, infectious diseases have been cured in Africa according to the Indigenous Knowledge System, prior to the introduction of modern medicine and vaccines [1]. This medical system was applied by herbalists in African and other countries, for example China and India. Abdullahi [2] opined that traditional medicine, which is a custom-based healing method used in various diseases including life-threatening ones, has stood the test of time as the healthcare system of ancient times. Humans were able to select diverse wild plants, referred to as herbs, in their environment for specific uses in healthcare through a long process of trial and error. And through verbal communication, while literary provision was yet unavailable to them, information on the medicinal use of plants was handed down from one generation to another [2].

However, a significant change occurred in the narrative of the Indigenous Knowledge System and its healthcare system in Africa since the arrival of the Europeans [2]. When European medical systems were introduced, pre-existing African systems were disregarded and marginalised [3-6]. Despite the continued development of the Western healthcare system, the world (including developed American, European, and Asian countries) still faces deadly and sporadic infectious diseases which can not be cured with western medicine, which also took advantage of the un-standardized and un-empirically proven methods of traditional medicine.

Influenza: A typical infectious disease

Influenza virus, commonly known as the flu, originated in Southeast Asia amongst birds and other animals such as pigs [7] is typical: an erratic outbreak of new viral strains in regions outside Africa spread from person to person [8, 9].

In 20th century, three influenza pandemics occurred. The Spanish influenza in 1918 claimed approximately 100 million lives worldwide; Asian influenza caused 2 million deaths in 1957 and Hong Kong influenza led to the death of about 1 million people in 1968 [10-12]. An outbreak of a new type of influenza A/H1N1 in America (June 2009) was declared a pandemic by the World Health Organization [13]. Contagion®, an integrated news resource covering all areas of infectious disease in America, reported the latest data from the US Centres for Disease Control and Prevention (CDC) which indicated that there have been at least 32 million cases of influenza in 2019-2020 US flu seasons [14]. CDC also estimated the U.S. burden of influenza to be 9–45 million ailments, 140 000–810 000 hospitalizations, and 12 000–61 000 annual deaths since 2010 [8].

Traditional medicine: potent yet undermined

Human influenza virus has drastically evolved and developed resistance to current commercially available antivirals due to its high mutation rate [15]. As a result, alternative compounds that possess antiviral effects against this virus have been researched by the scientific community. Ju-Young *et al.* [16], in particular, reviewed numerous herbal extracts that revealed antiviral effects against the virus. Oseltamivir, a standard antiviral drug also known as Tamiflu, was compared with some herbal extracts. Matrix 2 proteins, hemagglutinin and neuraminidase were the specific targets the herbal antivirals found to inhibit, in some instances, the reproduction of oseltamivir-resistant strains, while higher antiviral activity greater than oseltamivir was observed in certain pentacyclic triterpenes of the extracts. Thus, copious amounts of herbal antivirals inhibited influenza virus [16], however, the invaluable therapeutic potential of herbal medicine has been underestimated at critical times when scientists and health professionals need solutions to deadly infectious diseases, which pose a threat to the global society, economics and health.

Perfect and holistic health solution: where does it lie?

Currently, the highest burden of disease is recorded in Africa for the paradoxical fact that Africa is a gravely hit casualty of diseases – SARS and bird flu from Asia, and swine flu (H1N1) from Mexico – that broke out from outside its borders [17]. The issue is that Africa suffers health setbacks alien to her and worse still, her traditional solution method, which has proved effective over the centuries before the inception of western medicine, is stigmatized and undermined [3-6]. Thus, the continent is prevented from looking inwards to the environmental nature which has been its trusted saviour from epidemics from time immemorial.

Yet, the hostility towards the Indigenous Knowledge System is understandable – in a civilized world

where empirical tests are applied to prove all sciences because it is believed that antiquated Traditional Medicine (TM) in Africa which although believes in the supremacy of God as a creator and healer incorporates spirituality (connection with living or dead spirits) led to the ban of this health system in South Africa [23]. Evidence suggests that the designation of TM aetiology was both natural and metaphysical [18-21]. While the spiritual aspects may not be proven, scientific methods involving conventional empirical tests can be used to validate the physical aspects [22].

As it was noted by Hassim *et al*. [23], between 1953 and 1970 in South Africa, TM was declared unconstitutional through the Witchcraft Suppression Act. However, 'Onísègún' (traditional doctors who practice pure herbalism – the therapeutic use of herbs – in Yoruba, a major ethnic group in Nigeria) have been esteemed and sought after for ages because of their knowledge on the therapeutic uses of various plants.

With a view to standardize and regulate TM in Nigeria, in 1966 the Federal Government through the Ministry of Health mandated the University of Ibadan to explore the medicinal properties of local herbs [24]. Recently, as efforts were made to recognise the role of TM in healthcare delivery of some African countries, research development into herbal indications has been established. And as demand increases for TM in Burkina Faso to treat neurological and rheumatic conditions [25] as well as high blood pressure in Nigeria [26], policies have been enacted to accredit and register TM practitioners [2]. About 70% of the population in Ghana depends primarily on TM [27]. TM is also employed among 27 million South Africans (usually the black South Africans) to treat a variety of ailments [28, 29]. WHO [8] also reported the existent TM first-line treatment for 60% of paediatric high fever in some West African countries.

COVID-19 global trends and African traditional healing system

As of June 30, 2020, Worldometer and Corona Scanner recorded the trends of 215 countries in the world in regard to the COVID-19 pandemic. Two Asian, three South American and four European countries are amongst the 10 hardest-hit countries listed on the world coronavirus pandemic log. USA – a North American country – is ranked 1st with approximately 3 million infection cases [30, 31]. The available data on COVID-19 cases of 5 countries, ordered according not the number of infections across three continents (Asia, Europe and Africa) is presented in table 1.

It has been observed that of the selected countries in Asia where the disease originated, and Europe, the average number of infection cases so far runs in hundreds of thousands, while in Africa, only tens of thousands of infection cases are recorded. The average percentage convalescent cases of Asia, Europe and Africa are 67.52, 70.65 and 51.88%, respectively, i.e., Europe has the highest percentage of recovered patients on average, and Africa, the lowest. The average percentage death cases (and average infection cases), on the other hand, in Asia, Europe and Africa are 2.49% (265 333), 7.86% (261 930) and 3.15% (53 414), respectively, which means on average, the highest percentage deaths are in Europe and the lowest in Asia.

It is clear that Europe, which is arguably more developed and has better healthcare facilities than Asia is facing great difficulty in containing the ravaging virus as it spreads and kills more people in European countries. This outcome could be the result of the population variation of aged people in three continents. It is known that compromised immune system and underlying health conditions which predispose coronavirus patients to severe illness leading to death are common in elder people [32]. Kaseje [33] observed the differences in the demographic structure of some regions in the world. In Africa, the median age of the 1.3 billion population was 19.7 years, in China 38.4 years and in European Union 43.1 years. Moreover, WHO [8] reported that the elderly and patients with preexisting health conditions, such as diabetes, asthma and heart disease, tend to be more susceptible to the severity of the infection. In agreement with this fact, about 80% of deaths associated with the virus, as estimated by China's National Health Commission (NHC), were in patients older than 60, while 75% of them had underlying medical conditions such as cardiovascular diseases and diabetes [34]. Despite the different treatment methods offered by western medicine such as symptomatic distress management, convalescent plasma, allopathic drugs like chloroquine, vaccines and curative medicine, none of these methods have yet proven significantly successful against the pandemic. Moreover, it is obvious that the pandemic behaves differently in Africa, as compared to other regions of the world considering its spread and contagion rate (especially in Nigeria which has a number of recovered patients of 9 402 (37.41%) out

Table 1.

COVID-19 cases in Asia, Europe and Africa in the order of infection numbers as at June 30, 2020

S/N	Country	Infection case	Total Death	Currently Infected	Total Recovered	Recovery [%]	Death [%]
	Asia						
1	India	568 473	16 919	215 898	335 656	59.05	2.98
2	Iran	227 662	10 817	28 087	188 758	82.91	4.75
3	Turkey	198 613	5 115	21 689	171 809	86.50	2.58
4	Saudi Arabia	186 436	1 599	57 719	127 518	68.18	0.86
5	Bangladesh	145 483	1 847	84 012	59 624	40.98	1.27
Average		***265 333***	***7 259***	***81481***	***176 673***	***67.52***	***2.49***
	Europe						
1	Russia	647 849	9 320	225 879	412 650	63.70	1.44
2	Italy	240 436	34 744	16 496	189 196	78.69	14.45
3	Germany	195 399	9 041	7 258	179 100	91.66	4.63
4	France	164 260	29 813	58 798	75 649	46.05	18.15
5	Belarus	61 710	387	16 190	45 213	73.17	0.63
Average		***261 930***	***16 661***	***64 924***	***180 361***	***70.65***	***7.86***
	Africa						
1	South Africa	144 264	2 529	71 121	70 614	48.95	1.75
2	Egypt	66 754	2 872	45 931	17 951	26.89	4.30
3	Nigeria	25 133	573	15 158	9 402	37.41	2.28
4	Ghana	17 351	112	4 245	12 994	74.89	0.65
5	Algeria	13 571	905	2 992	9 674	71.28	6.76
Average		***53 414***	***1 398***	***27 889***	***24127***	***51.88***	***3.15***

Source: [30, 31]. Note: As at June 30, 2020, UK and Spain ranked 2nd and 3rd on the log of coronavirus cases in Europe but were not included in the table because of unavailability of data for active and convalescent cases.

of 25 133 infected persons as for June 30, 2020, but it is as yet unclear which factors majorly contribute to the comparatively lower infection rates in Africa.

The similarity of traditional remedies and modern drugs in disease prevention

The National Health Commission of the People's Republic of China stated that COVID-19 started in Wuhan, China in December 2019 and Worldometer indicates that it has spread across 215 countries of the world [31, 34]. This pandemic has stalled and stifled social, political and economic activity around the world. Preventive and management measures, which have been strongly advised by global health agencies such as World Health Organization (WHO), Centres for Disease Control and Prevention (CDC), in order to slow down the pandemic include, among others : personal hygiene, movement restrictions (lockdown), social distancing, contact tracing and isolation of infected persons for treatment. These measures have successfully brought to mind again the wisdom and efficacy of the Indigenous Knowledge System of African ancestors used in tackling epidemics that broke out in the past.

Although Africa's youthful population may be considered to be a significant protective factor in the pandemic, another essential potential factor is the exposure to the natural environment and the utilization of tested varieties of product options which nature offers. On April 6, 2020, in an interview with Fresh FM, in Ibadan, the Governor of Oyo State, Nigeria, Engr. Seyi Makinde, who recovered from the deadly COVID-19 after being tested positive but asymptomatic 8 days earlier, described how he used a local preparation – a mixture of blackseed oil (*Nigella sativa*) with honey – to boost his immune system [35]. However, one of the renowned monarchs in the South-Western part of Nigeria, Ooni of Ife, Oba Adeyeye Enitan Ogunwusi, on 30th of March 2020, stated: "The pandemic (outbreak of

COVID-19) showed that there is no perfect system globally. The developed world was also exposed. It is a lesson for world leaders and we should all contribute towards making a better nation". He went further to urge government at federal and state levels to collaborate with herbalists on treatment for the devastating COVID-19 pandemic [36]. He re-echoed the importance of traditional medicine in combating this pandemic in Nigeria along with with Lawal *et al*. [37], who noted that traditional medicines are readily available and still play a significant role in meeting the basic health requirements of the African community.

Furthermore, it could be based on the several treatment claims of local herbs and concoctions against the novel coronavirus that the Nigeria Health Minister, Dr Osagie Ehanire, on April 7, 2020, said: "The Federal Government through the department of Traditional, Complementary and Alternative Medicine in the Ministry of Health will consider "serious" stakeholders in traditional medicine in the treatment of COVID-19" [38]. In reference to the symptoms and mechanism of action of COVID-19, using indigenous herbs of Africa will be an advantage to Nigerians, Africans and the world at large.

Herbal medicine and polyherbal mixtures

In general, herbs are valued as food and medicines [39]. Herbal medicine, which involves the use of various plant extracts, serves as an alternative therapy. The folkloric use of many plants is highly valued, including *Clausena anisata* leaves for the treatment of respiratory tract infections and other bacterial diseases [40], *Enantia chlorantha* bark for antiviral effects [81, 82], *Citrus aurantifolia* fruit for the management of cardiovascular system conditions [94, 95], *Azadirachta indica* oil for anti-stimulant effect [103], *Blighia sapida* leaves for the treatment of diarrhoea and cutaneous infection [111], among a great many others. As it was reported by Ahmad *et al.* [41] and Panda *et al*. [110], there is a growing trend in the production of herbal formulations obtained from medicinal plants and minerals for the treatment of different ailments in many countries due to their acceptability as a result of their natural source, synergistic product and supposedly limited side effects. It must be noted that many effective therapeutic agents for maladies in Nigeria have been found in polyherbal formulations (PHF) – which involves the use of more than one herb in a medicinal preparation. Subramani *et al.* [42] pointed out that this specific concept of PHF is also found in Ayurvedic and other traditional medicinal systems dating back to 1300 A.D., where multiple herbs in specific ratio combinations are used to treat illnesses. PHFs are comparatively cheaper, more eco-friendly and more readily available than allopathic drugs due to their natural origin. They are also more affordable and accessible, especially in rural areas and developing countries where modern treatments are inaccessible or unaffordable, which accounts for their increasing demand.

Herbal-based hydrotherapy

One of the important methods used in the traditional healthcare system is hydrotherapy, in which polyherbal formulation is actively engaged. Hydrotherapy, the internal and external application of water at various temperatures includes: hot and cold showers, steam baths, foot baths, steam inhalation, saunas, contrast therapy and water therapy [43, 44]. Fomentation is a hydrotherapy method which involves the application of moist heat and is used for chest cold and flu [43]. Therefore, it could be engaged in the treatment of the symptomatic distress of pneumonia associated with COVID-19, although Butler [43] opined that topical application of hydrotherapy may not be suitable in fever, hypertension, pregnancy, acute injuries and kidney disease conditions.

Herbal-based hydrotherapy is not only engaged in internal application but also involves topical application. Butler [43], for example, demonstrated that tight muscles can be relaxed and blood vessels in skin dilated when a hot compress (a cloth immersed in boiled herb-infused water) is applied to the skin while cold compresses constricts those vessels. External hydrotherapy also involves steam inhalation of herbs infused in hot water, which appeals to the sense of smell with therapeutic effect (aromatherapy) [45]. Some health conditions and their respective hydrotherapy applications are presented in table 2.

Herbal medicines strengthen the human immune system to remove toxins from the body [46]. According to Butler [43], the immune system boosting can be achieved by hydrotherapeutic alternation of water temperatures. The process of blood movement away from the body's surface tissue and deeper tissue due to the cold and hot temperature alternation keeping the circulation active and (temporarily) increasing the number of white blood cells which

Table 2.

Typical hydrotherapy applications in the management of health conditions

S/N	Conditions	Application mode	Recipe: hydrotherapy formulation/use/effect
1.	Cramps	External (topical)	Warm water; calves and thigh jets: *Muscles are directly treated with warm low/medium pressure. The affected parts are gently massaged by the jets, stimulating blood circulation and flushing out lactic acid, thus, relieving the cramp* [43].
2.	Fever	Internal (ingestive)	*Nauclea latifolia* (leaves and bark), *Morinda lucida* (leaves and bark), *Enantia chlorantha* leaves and *Citrus aurantifolia* fruits/oil boiled in water for 30 minutes: *The decoction (15 mls) is taken orally twice per day to allay fever.*
3.	Angina pectoris	External	Water temperature not higher than 37°-38°C (body temperature); shoulder, back and foot jets with cool low pressure, essential oil of *Citrus sinensis* and *Lavandula angustifolia*: *Relaxing in the buoyant atmosphere of the hydrotherapy system will relieve the stress related factors, which play a part in this disease. Orange and lavender essential oils may be added to the bath for their calmative effect engaged in aromatherapy* [43, 113].
4.	Sore throat and flu	Internal and external	*Citrus aurantifolia* (leaves and fruits), *Eucalyptus camadulensis* leaves/oil boiled in water for 15-20 minutes: *The tea is ingested for the management of sore throat and flu. The polyherbal steam can be inhaled to dispel nasal congestion.*
5.	Immune system	External	Hot water, cold water; shoulder, back, hip and foot jets: *Alternating hot and cold water can have the effect of boosting the immune system. This effect is achieved by starting hydrotherapy system with a temperature of 40°-43°C and after 10-15 min, the temperature is steadily decreased with the use of medium to high jets* [43].
6.	Diabetes	Internal	Leaves of *Andrographis paniculata*, *Azadirachta indica* and *Morinda lucida* boiled in water for 30 minutes: *The decoction (10 ml) is taken thrice daily for 2 weeks to treat diabetes.*
7.	Parkinson's disease	External	Moderately hot water, pressure jets: *Hydrotherapy system of 37°-38°C temperature, which can be reduced gradually with low to medium pressure jets before getting out is appropriate.* **Note:** *In the beginning of hydrotherapy sessions, 10 minutes may be carefully spent in the bath and gradually increased to 20 minutes later. The jets, by reflexology (massage), must be directed to work on the head and spine reflexes in conjunction with shoulder, back and hip jets* [43, 112].

helps the immune system of the body. To achieve this effect, it is important to start the hydrotherapy with a temperature of 40–43°C for 10–15 minutes, then steadily decrease the temperature using medium to high jets [43].

Selected plants with potential in COVID-19

Plant parts such as leaves, fruits, bark, stem, roots have been used either directly in the treatment of illness or indirectly for drug development. The young generation of Africans (especially in Nigeria and Cameroon) who have accepted the strong yet safe healing power of herbal medicines have also been impacted by global trends in the use of herbal medicines [47]. Murray and Pizzorno [48] noted that the widespread herbal medicine use is not limited to developing countries, as 70% of all medical professionals in France and Germany regularly prescribe herbal medicines.

Some plants from the Forestry Research Institute of Nigeria (FRIN), Ibadan which possess quinine alkaloids have been considered to be used for the management of the ongoing COVID-19 pandemic. Based on the report of Jianjun *et al.* [49] in a briefing held on February 17, 2020 by the State Council of China that chloroquine phosphate, a synthetic chemical compound of quinine (an old drug popular for its antimalarial effect), had shown considerable effect and acceptable safety in the management of COVID-19. Current trials have been reported inadequate in the treatment of patients with COVID-19, so, various trials are ongoing for drugs

integration, which include hydroxychloroquine and azithromycin, an antibiotic used in the treatment of COVID-19 patients. Emergency Use Authorization, for these drugs in coronavirus treatment, has been granted by the US Food and Drugs Administration, but they are yet to be approved by WHO.

Many synthetic drugs not only cure a disease but also cause severe side effects to the human body [51-54]. This has been a major concern about the use of chloroquine by medical experts as it causes unwanted or severe side effects [50, 55], which most plant remedies are free from [56-59]. Table 3 shows the list of selected plants: *Azadirachta indica, Citrus aurantifolia, Enantia chlorantha, Morinda lucida, Rauvolfia vomitoria, Nauclea latifolia,* and so forth, which possess quinine (anti-paludism) alkaloids.

Table 3

Selected plants which possess quinine alkaloids

S/N	Scientific Name	Parts Used	Area (Geopolitical Zones in Nigeria)	Chemical Constituents
1.	*Allium cepa* L. *Amaryllidaceae*	Bulb	NW, NE, NC	Quercetin [72]
2.	*Alstonia boonei* De Wild. *Apocynaceae*	Bark	NE, SW, SE, SS.	Echitamidine [69]
3.	*Azadirachta indica* A. Juss. *Meliaceae*	Bark and leaves	All zones.	Azadirachtin and nimbolinin [68]
4.	*Carica papaya* L. *Caricaceae*	Leaves	NC, SW, SE, SS	Phytol [70]
5.	*Citrus aurantifolia* (Christm. Swingle) *Rutaceae*	Roots, barks, stem-twigs, fruits and leaves	All zones	D-limonene [64]
6.	*Citrus aurantium* L. *Rutaceae*	Roots, bark, stem-twigs, leaves and fruit	NC, SW, SS	Synephrine [62]
7.	*Enantia chloranta* (Oliv.) Setten & Maas *Annonaceae*	Leaves	SW, SE.	Jatrorrhizine [60]
8.	*Harungana madagascariensis* Lam. *Hypericaceae*	Bark and leaves	NE, NC, SW, SE, ; and some African countries such as Cameroon, Ghana and Madagascar	Harunganin [65]
9.	*Khaya senegalensis* (Desr.) A. Juss. [African mahogany] *Meliaceae*	Bark and leaves	NW, NC, SW, SE	Limonoids [66]
10.	*Lecaniodiscus cupanioides* Planch. *Sapindaceae*	Leaves, root	NW, NC, SW, SE	Tripenoid [67]
11.	*Mangifera indica* L. *Anacardiaceae*	Bark, leaves	All zones	Mangiferone [71]
12.	*Morinda lucida* Benth. *Rubiaceae*	Leaves	NC, SW, SE, SS	1,8-cineole [74]
13.	*Nauclea latifolia* Sm. *Rubiaceae*	Roots, barks and leaves	SS, SE	Nauclefolinine [63]
14.	*Rauvolfia vomitoria* Afzel *Apocynaceae*	Roots, bark and leaves	SW, SE, SS.	Isoajmaline, reserpinine [61]
15.	*Sphenocentrum jollyanum* Pierre *Menispermaceae*	Leaves	SW, SE.	Columbin and fibleucin [62]
16.	*Tetrapleura tetraptera* (Schumm. & Thonn.) Taub. *Fabaceae*	Leaves	All zones	Oleanolic acid [73]

Key: NW – North-West, NE – North-East, NC – North-Central, SW – South-West, SE – South-East, SS – South-South

Effects of selected phytopharmaceuticals on the respiratory tract infection with COVID-19

Active plant ingredients which indicated the possibility of potential drug development are the primary source of a variety of pharmaceutical compounds. Therefore, a credible line of defence against COVID-19 can be fashioned out of phytochemical constituents. In spite of the fact that there is no certified drug for the management of deadly coronavirus infection yet, allopathic regimen and immunotherapy have been utilised to suppress or evacuate the symptomatic distress exhibited by coronavirus patients. The World Health Organization [75] pointed out that pneumonia, fever, cough, sore throat and headaches are the symptoms caused by the virus and, in severe cases, hypoxia and deaths can occur. Wu and McGoogan [76] classified the disease by its symptoms and severity into 3 clinical manifestations: mild disease which occurred in 81% of cases; severe disease (14%); and critical disease (5%). Cascella *et al*. [77] noted that amongst severe clinical signs, are severe pneumonia, acute respiratory distress syndrome (ARDS), sepsis (life-threatening organ dysfunction), septic shock, and respiratory tract symptoms such as cough and shortness of breath. Fever is associated with severe dyspnoea, respiratory distress, and hypoxia [77] with more than one third of patients showing neurological symptoms, as reported by Mao *et al*. [78]. These symptoms are classified as central nervous system manifestations (acute cerebrovascular disease, dysfunctional consciousness, muscular incoordination, giddiness, and headache); peripheral nervous system manifestations (nerve pain, dysfunctional vision, taste and smell); and skeletal muscular injury manifestations. Table 4 shows the pharmacological activities as well as the ethno-medicinal value of the selected plants and the therapeutic effect they confer for the treatment of coronavirus.

Table 4

Ethno-medicinal and pharmacological importance of some of the selected plants for COVID-19 management

S/N	Selected plants	Ethnomedicinal use	Pharmacological effect	Note
1.	*Azadirachta indica* *Meliaceae*	Cardio-protective properties [98].	Antioxidant activity [99]; hepatoprotective effect (leaf extract) [100]; neuro-protective effects [101]; nephron-protective effect [102]; immunostimulant (oil) [103]; antidiabetic activities [104]; cardio-protective properties [98].	Bark possessed complex phenolic contents than leaves with higher antioxidant activity [105]. Gautret *et al.* [106] showed that hydroxychloroquine was significantly associated with viral load reduction until viral disappearance.
2.	*Citrus aurantifolia* *Rutaceae*	Suppression of cold fevers, sore throats, sinusitis and bronchitis, as well as helping asthma [91, 92].	Antioxidant properties (peel and leaves) [93]; cardiovascular effects (fruit) [94]; respiratory effect [95].	Ten percent of *Citrus aurantifolia* juice produced a 1000-fold reduction in HIV activity in a laboratory sample [96].
3.	*Enantia chlorantha* *Annonaceae*	Antimalarial.	Analgesic and antipyretic [79]; convulsions and inflammation reversal [80]; bark possesses antiviral effects [81, 82]; antioxidant property [83].	Fever associated with COVID-19 as well as respiratory inflammation can be suppressed while immune response is triggered by antioxidant.
4.	*Lecaniodiscus cupanioides* *Sapindaceae*	Fever and inflammation [114].	Antioxidant activity [97].	The structural integrity of body cells and tissues can be protected.
5.	*Mangifera indica* *Anacardiaceae*	Antimalarial.	Anti-inflammatory, antidiabetic, antioxidant, hepatoprotective, immunomodulatory effects [107].	Immune response can be modified against the respiratory virus as well as other underlying health conditions.
6.	*Morinda lucida* *Rubiaceae*	Diabetes and fever.	Antipyretic and analgesic property [108]; antioxidant and hepatoprotective property [109].	Fever and pain associated with COVID-19 can be suppressed while the body build up defence mechanism against the disease.
7.	*Nauclea latifolia* *Rubiaceae*	Management of fever, malaria, hypertension and diabetes (root) [84]; respiratory illnesses such as tuberculosis, asthma, bronchitis, cough and cold [85].	Antiviral activity [86]; antioxidant property [87]; anticonvulsant, anxiolytic and sedative activity of root bark [88]; antidepressant [89]; antinociceptive, anti-inflammatory and anti-pyretic activities [90].	Neurologic and viral loads as well as respiratory symptoms and fever in patients can be suppressed.

Table 5.

Polyherbal formulations across geographical/geopolitical zones of Nigeria

Geographical/geopolitical Zones	Polyherbal mixture	Posology
North (North-West, North-East, North-Central)	*Azadirachta indica* (bark and leaves); *Khaya senegalensis* (leaves); *Mangifera indica* (bark and leaves); *Allium cepa* (bulb); *Citrus aurantifolia* (sliced fruit); *Tetrapleura tetraptera* (leaves); *Harungana madagascariensis* (bark); *Lecaniodiscus cupanioides* (leaves and root); *Azadirachta indica* (leaves and root).	Polyherbal mixture can be prepared in steam bath in the morning and evening for hydrotherapy and also made into decoction and posology of 10 ml twice daily taken orally.
South (South-West, South-East, South-South)	*Rauvolfia vomitoria* (root, bark, leaves); *Azadirachta indica* (bark and leaves); *Morinda lucida* (leaves); *Khaya senegalensis* (leaves); *Alstonia boonei* (bark); *Enantia chlorantha* (leaves); *Carica papaya* (leaves); *Nauclea latifolia* (leaves); *Mangifera indica* (bark and leaves); *Citrus aurantium* (leaves and root); *Citrus aurantifolia* (sliced fruit).	

The polyherbal formulations obtainable in the geographical/geopolitical zones of Nigeria

The polyherbal formulations of the selected plants which can be used for the management of infectious diseases including COVID-19 are classified in table 5 based on their availability across the six geopolitical zones in Nigeria.

CONCLUSION

"Hen survived on certain feed before the corn came" is a popular African proverb which agrees with the present situation of traditional medicine. It has been in existence for ages before modern medicine and has proven efficacious in the past, and even recently, in treating deadly diseases. Considering the fact that herbal medicines pose little or no side effects, as compared to synthetic drugs, this review argues that indigenous knowledge systems can be effectively explored to mitigate the ongoing pandemic and future health needs. Thus, a multi-disciplinary approach involving expertise from fields such as phytomedicine, ethnobotany, phytochemistry, plant physiology and ecology is imperative to unlock the therapeutic potential of herbal medicines.

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