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Review of Antiviral Medicinal Plants used in Taraba State Nigeria: A Possible Source for COVID-19 Drug Discovery

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Abstract

Purpose: *Coronavirus also known as COVID-19 is a viral infection that has been tagged as the greatest pandemic since the existence of humans by the WHO, resulting in the deaths of thousands of people globally; with the USA one of the highest. The full biology of the virus is yet to be known. This study reviews sixteen natural antiviral plants used in Taraba State to manage viral infections locally.*

Subjects and Methods*: Sixteen medicinal plants popularly used as antiviral agents in Taraba State, Nigeria were surveyed based on a field-trip experience with herbal medicine practitioners in the three zones of the state. Plants that were in both zones were counted as the same. The plants that are majorly used for various viral infections are Allium sativum, Zingiber officinale, Camellia sinensis, Hibiscus sabdariffa, Cirus lemon, Azardirachta indica, Ocimum tenuiflorum, Curcuma longa, Haematostaphis barteri, Olea europaea, Melastomastrum capitatum, Astragalus canadensis, Carissa edulis, Spondias venulosa, Vitellaria paradoxa, and Euphorbia hirta.*

Results: *Of the sixteen plants, ten have been reported to have antiviral properties against at least one of these viruses avian or bird flu, human influenza virus, infectious bronchitis virus (a type of coronavirus), herpes virus, hepatitis C virus and HIV.*

Conclusion: *The study revealed that further research on these antiviral plants used traditionally might pave the way for the discovery of potent antiviral drugs against COVID-19.*

1. Introduction

The use of medicinal plants in human health care is as old as human civilization and frantic efforts are being made to improve medicinal plants or their herbal products of improved quality from various technologies (Schippmann et al., 2006; Rasool, 2012). Currently, there are over 200,000 natural products of plant origin known and many more are being identified from the angiosperms, gymnosperms and microorganisms. Some plant-based drugs have been used for centuries as alternative medicines for some diseases such as viral infections, hypertension, avian-human influenza, malaria, bacterial infections, among others. It is estimated that the number of medicinal plants has been on the range of 40,000 to 70,000 (Damtoft et al., 1996; Iwu, 2014).

which implies that almost 25% of all plants have some sort of medicinal use somewhere in the world. Traditional medicine has been passed from the ancestors to the present generations and has continued to develop in orthodox medicine therapy, resulting in the isolation of pure bioactive compounds and finally in the development of novel synthetic compounds such as some alkaloidal drugs like cocaine, morphine, ergotamine, ephedrine, vincristine, vinblastine, quinine and narcotine, which are used for various therapeutic purposes as antimalarial, antiviral, anticancer, a bronchodilator, analgesics, CNS depressants, etc. The holistic approaches of medicinal plants in attacking diseases from all sides are the fundamental basis of their increase utilization in Africa especially, Taraba State, Nigeria. This approach is already used in traditional systems of medicine like Ayurveda and Unani (Iwu, 2014). Besides, the incorporation of modern technologies with the ancient uses of medicinal plants is of the utmost importance if one wishes to use traditional skills for the well-being of humans (Neuwinger, 2000).

Regardless of the advances in technological developments, herbal drugs still occupy a preferential place in a majority of the population in Africa and other third world countries, as well as patients with terminal illnesses in the western worlds (Iwu, 2014). Herbal drugs, in addition to being cost-effective and easily accessible, have been used since time immemorial and have passed the test of time with little or no any adverse toxicological effects unlike orthodox medicines. Medicinal plants have a promising future because there are more than one million plants globally in which the biological activities of most of them are yet to be evaluated (Neuwinger, 2000; Ashutosh, 2007), and their pharmacological properties could be decisive in the treatment of present pandemics like COVID-19 virus or future disease outbreak(Dalziel, 1955). Coronavirus disease 2019 (also known as COVID-19) is an infectious disease that is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Coronavirus Disease , C*entre for Disease Control and Prevention, 2020*), a member of the family *Coronaviridae.* The disease was first identified in December 2019 in Wuhan, the capital of China's Hubei province, and has since spread globally, resulting in many deaths with the USA and the European countries, having the highest mortalities from the infections. The disease was described by the WHO as world pandemic. The first confirmed case of what was then an unknown coronavirus was traced back to November, 2019 in Hubei province (Han, 2020). The naming of this dreaded virus by the WHO as COVID-19 as the on 11th February, 2020, followed the guidelines previously developed with the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO).

Like most viral infections, the COVID-19 pandemic has symptoms like fever, abnormally high temperature, sore throat, cough, and shortness of breath (Han, 2020). Other symptoms may include fatigue, muscular pains, diarrhoea, loss of smell, and abdominal pain. The time from exposure to onset of symptoms is typically around 5 days but may range from 2 to 14 days. While the majority of cases result in mild symptoms, some progress to viral pneumonia and failure. The virus is ordinarily spread between people during close contact, mostly through small droplets produced from coughing, sneezing, or talking. People may also catch the virus by touching contaminated surfaces, and then touching their eyes, nose, or mouth. It has been reported that the COVID-19 virus can survive on surfaces for up to 72 hours (World Health Organization, 2020). It is most contagious during the first three days

after the onset of symptoms, although spread may be possible before symptoms appear and in later stages of the disease (Han, 2020). The recommended preventive measures from the infection include frequent hand washing with running water and soaps, using alcohol-based hand sanitizers, maintaining social distancing from others, covering coughs and sneezes with a tissue or inner elbow, and avoiding touching faces with unwashed hands. The use of nose masks is recommended for those who suspect they have the virus and their health-care staff and those in the frontline. As at the time of this study, there is no acceptable vaccine or specific antiviral treatment for COVID-19 globally (Han, 2020).

However, treatment of viral infections with similar symptoms as COVID-19 using some natural antiviral medicinal plants from various plant families such as *Zingiberaceae*, *Malvaceae*, *Meliaceaea*, among others has been very promising in traditional medicine in the management of symptoms unlike current therapeutic regimes like supportive care, isolation, and experimental measures adopted globally in managing COVID-19 pandemic. In some cases, hydroxychloroquine has also been used even though this drug was not approved by various drug administrations and health institutions like FDA (USA), NHS (UK) and NAFDAC (Nigeria). Despite this therapeutic regime, treatment of viral infections with synthetic antivirals is very difficult as in the case of COVID-19 pandemic.

Therefore, a review of the natural antiviral from medicinal plants used to treat viral infections in Taraba State Nigeria will help to explore more antiviral drugs that might be very potent on COVID-19 and related strains, hence, the aim of this present study.

2. Methodology and Procedures

Study Area

Indigenous medicinal plants used in Taraba State, North-east Nigeria for treating viral infections were surveyed in randomly selected communities in council areas from the three senatorial zones of the State from January to June, 2019. The surveyed council areas include: Bali, Gashaka, Sarduana, Takum, Zing, Gassol, Wukari, Jalingo, and Donga. The population of the study area is over seven million people comprising people of various beliefs. The study was based on information gathered from the field and ethnomedicinal records from herbal medicine practitioners in the studied areas.

Ethnobotanical Survey of Antiviral Medicinal Plants

Short field trips were embarked upon in the study areas of the State to herbal homes and traditional medicine practitioners to know medicinal plants used in managing and treating viral infections from time immemorial. The parts of plants used, time of collection and their mode of preparations were documented following prescribed procedure for an ethnobotanical survey of the plant. Information here was derived from oral interviews, records of herbal medicines, and field trips.

Data analysis

Information obtained from the documentary evidence, field trips, and oral interviews were recorded in the results in terms of description of plants, uses, and mode of preparations.

3. Results and Discussion

From the analysis of study, the following sixteen medicinal plants were identified as potential antiviral medicinal plants popularly used in Taraba State, Nigeria since time immemorial for managing and treating various types of viral infections. These medicinal plants were briefly described below:

3.1 Allium sativum Linn. *(Family: Amaryllidaceae); Garlic:*

Garlic is an herbaceous plant that is grown in many countries around the world. It is related to the onion. It is native to Central Asia and Northeast Iran but can be found in other parts of the world including northern Nigeria. Garlic is most commonly used for conditions related to the heart and blood system as well as bronchitis.

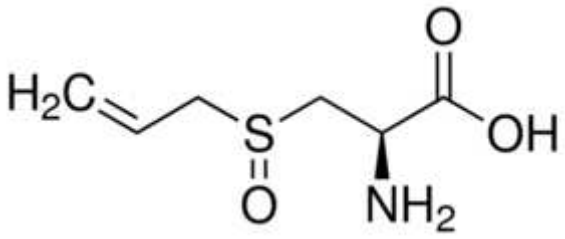
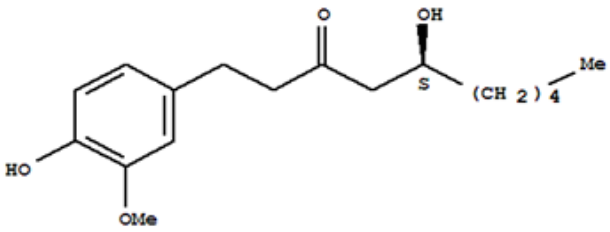


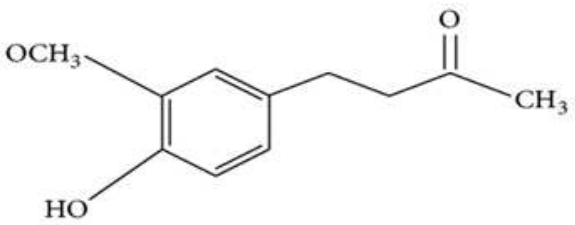
Figure1: Chemical structure of allicin from garlic extract (Cavallito & Bailey, 1944).

3.2. Zingiber officinale Ros. (Zingiberaceae); Ginger

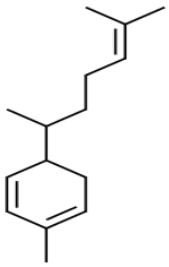
Ginger is a member of the Zingiberaceae family. It is a popular spice used worldwide especially in Asian countries. It is a perennial herbaceous plant. Chemical analysis of ginger shows that it contains over 400 different compounds. The rhizome is the most important part of the plant with most of the biological activities.



a. gingerol



b. shogaol



c. zingiberene

Figure 2: Chemical structures of compounds from the ginger extract.

3.3 Curcuma longa Linn. *(Zingiberaceae); turmeric*

It is a small perennial herb that is native to India. The plant has many rhizomes on its root and these are the main source of its culinary spice called turmeric used in cooking excellent dishes. It grows wind in Mambila Plateau in Taraba State Nigeria at low-temperature conditions and in the tropical rainforest zones of southern Nigeria (Abolaji et al., 2017).

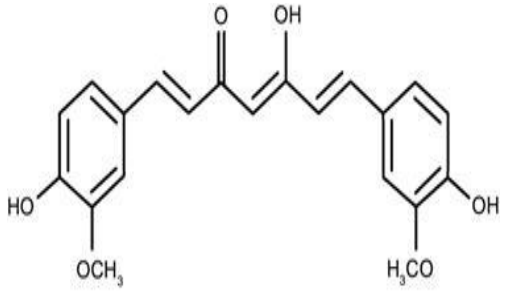
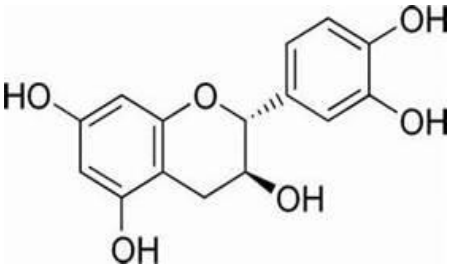


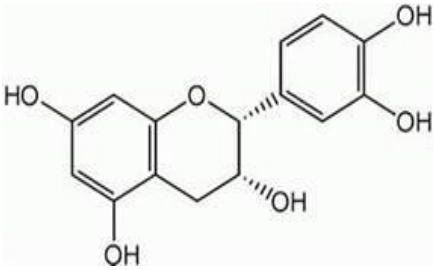
Figure3: Chemical structure of curcumin from Curcumalonga.

3.4 Camellia sinensis (L.) O. Kuntz (Theaceae); Green tea

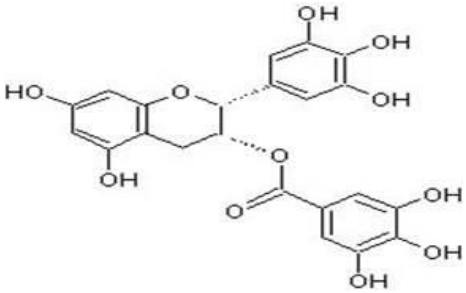
Camellia sinensis is a plant which a member of the Theaceae family. It is abundant in Nguroje within the Mambila plateau in Taraba State. The family has about 450 species with more than 50 genera among the angiosperms. The leaf is popularly used as green tea and as anti-oxidant and anticancer in traditional medicine. Its anti-carcinogenic, antibacterial, anti-diabetic, anti-tumor and anti-hypertensive activities have also been reported (Ukwubile et al., 2018; Aslam, 2014).



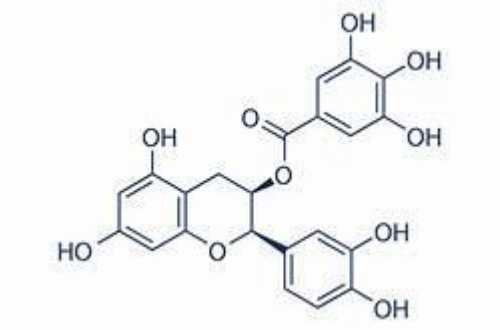
a. catechin



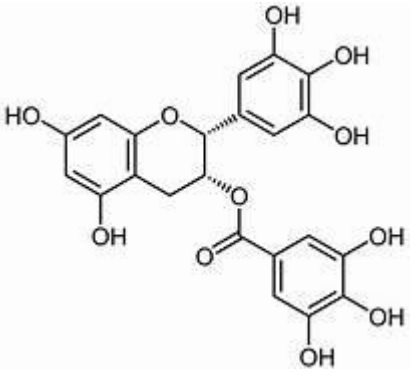
b. epicatechin



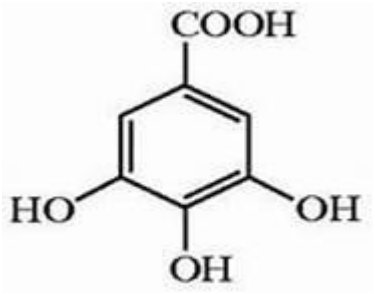
c. epigallocatechin



d. epicatechin-3-gallate



e. epigallocatechin-3-gallate

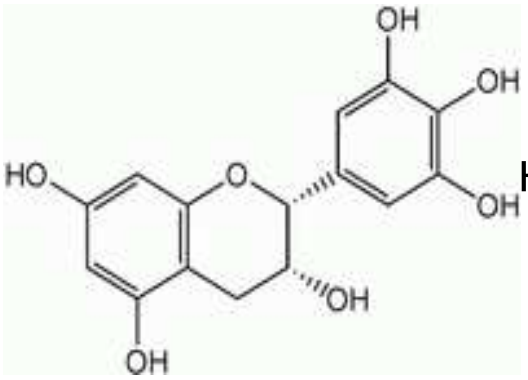


f. gallic acid

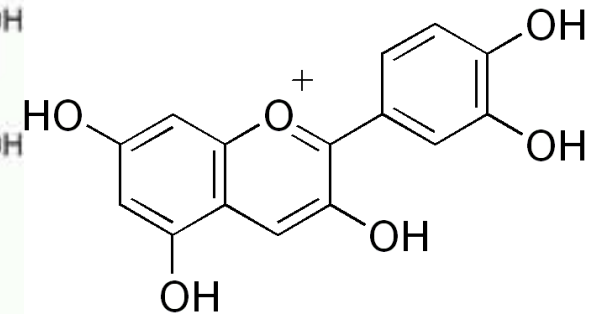
Figure 4: Compounds from Camellia sinensis leaf extract (Hassan et al., 2017).

3.5 Hibiscus sabdariffa Linn. *(Malvaceae); Roselle*

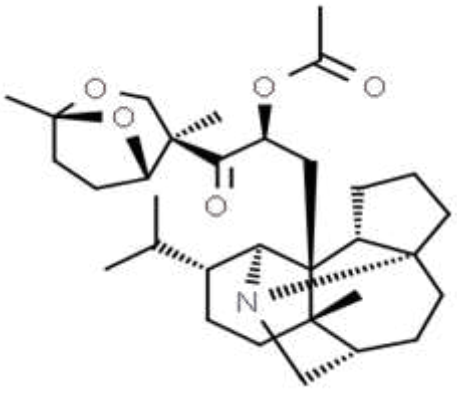
It is native to old world tropics, probably in the East Indies or Africa, but now cultivated throughout the tropics. However, Roselle may be domesticated in Western Sudan before 4000 BC; it was first recorded in Europe in 1576 AD. Now, it was said that *Hibiscus sabdariffa* is grown in all parts of the world (Takeda et al., 2020). It grows well all states in Northern Nigeria.

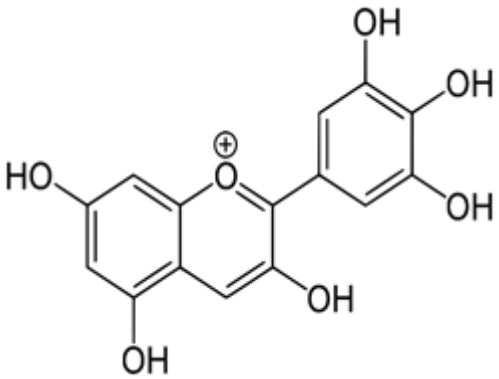


a. flavan-3-ol

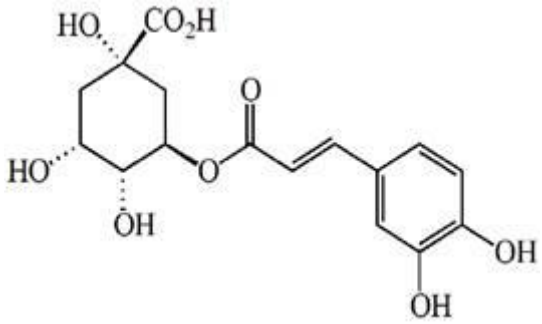


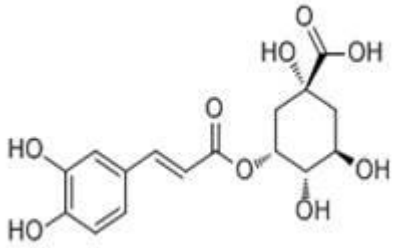
b. anthocyanidin





c. daphniphylline d. delphinidin





e. chlorogenic acid f. neochlorogenic acid

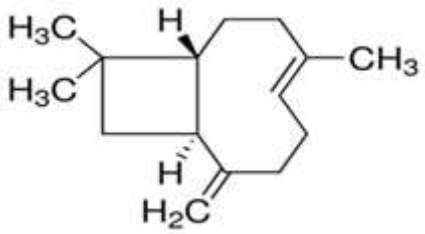
Figure 5: Structures of some compounds from Hibiscus sabdariffa leaves and calyces.

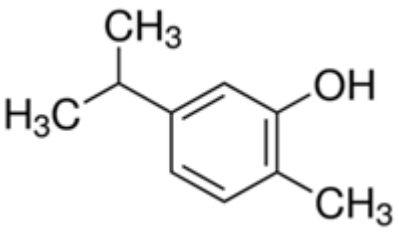
3.6 Haematostaphis barteri Hook.f. (Anacardiaceae); Blood plum

It is a tree to 8 m high by 65 cm girth, of rocky situations of the dry savannah of Northern Nigeria to regions in Cameroun and Sudan. The bark contains a clear gum. The fruit is a red-purple drupe, nearly 2·5 cm long like the temperate plum. The pulp is thin, edible with acid but resinous taste. The kernels are somewhat oily and are also edible (Dalziel, 1955; Busson, 1965).

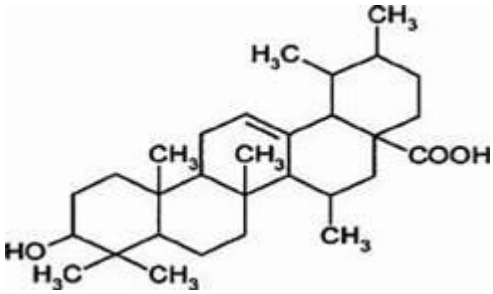
3.7 Ocimum tenuiflorum Linn. (Lamiaceae); Holy basil or Tulsi or Tulasi

The plant is also called Holy basil or Tulsior Tulasi. It is a flowering plant belonging to Family Lamiaceae the mint family. It is grown for its aromatic leaves. It is native to the Indian subcontinent and grows throughout the world. The plant parts are widely used in Ayurveda and traditional medicine, usually, as a herbal tea for various ailments. It is considered sacred in Hinduism . The plant is described as a small annual or short-lived perennial shrub, up to 1m (3.3ft) in height. The stems are hairy and bear simply toothed or entire leaves oppositely along the stem. The fragrant leaves are green or purple, depending on the variety.

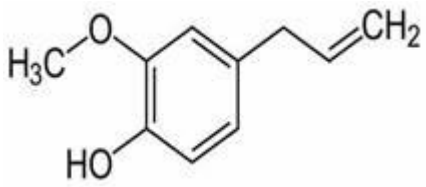




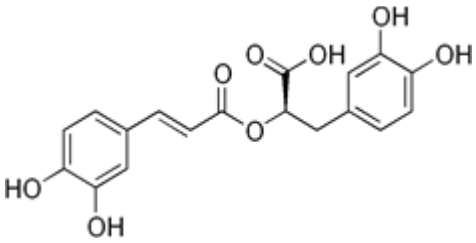
a. beta-caryophyllene b. carvacrol



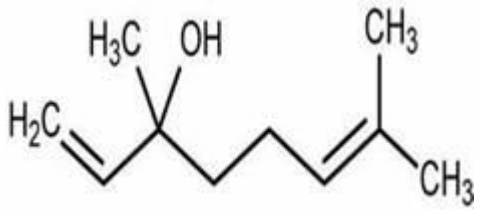
c. ursolic acid



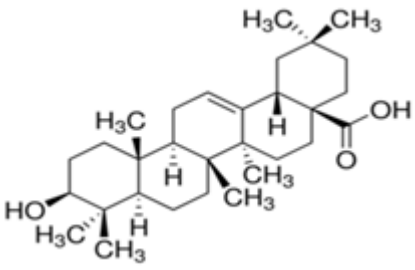
d. eugenol



e. rosamarinic acid



f. linalool

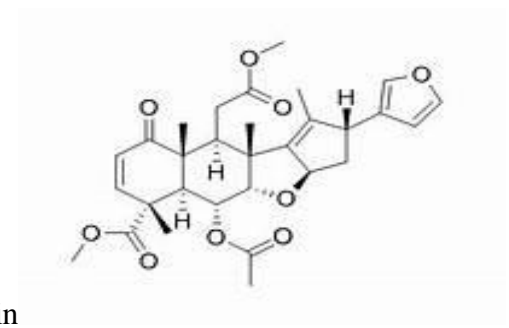


g. oleanolic acid

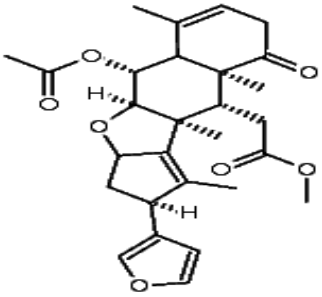
Figure 6: Compounds from Holy basil extracts

3.8 Azardirachta indica A. Juss. (Meliaceae); Neem

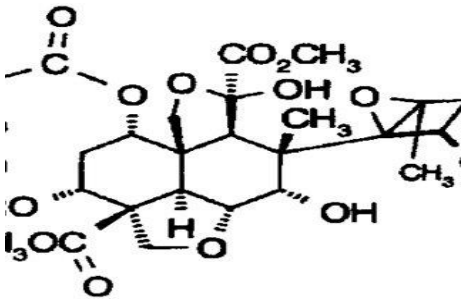
It is also called Neemor Margosa. Neem is a fast-growing tree belonging to the family Meliaceae (the mahogany family) (Iwu, 2014). It is native to the Indian and distributed dry savannah of northern Nigerian States like Katsina, Kano, Jigawa, Taraba, Gombe, Bauchi, Sokoto, Zamfara, as well as the Southern Nigerian States. The plant seems to be distributed all over the globe due to its medicinal and agricultural importance.



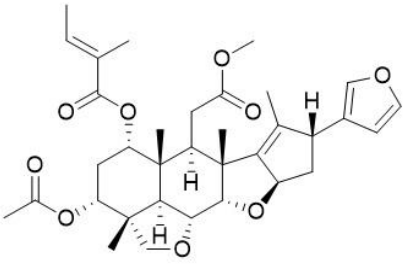
a. nimbin



b. nimbidinin



a.azadirachtin

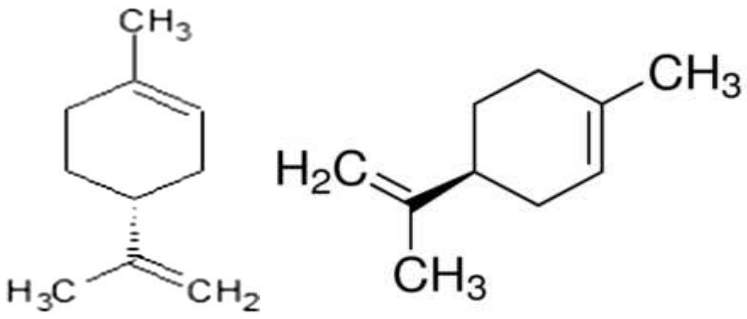


d. salannin

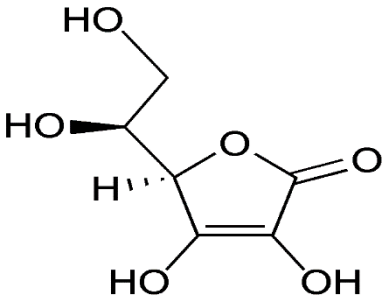
Figure 7: *Compounds from Azardiracha indica extracts.*

3.9 Citrus limon (L.) Burm.f (Rutaceae); Lemon

It is an evergreen tree that originated from Asia, and today it is distributed in almost every continent. Lemon is a small plant of 3 to 6 m high. The young leaves are oval and have reddish colour which later turned green. The flowers have a sweet scent and are solitary or borne in small clusters in the axils of the leaves. Lemon juice contains 6.7 to 8.6 % of citric acid. The juice also contains sugar, gum, and few potashes as well as Vitamin-C. Oil of lemon is dextrogyre. It contains 7 to 8 % of *citral*, an aldehyde yielding geraniol upon reduction, a small amount of pinene and citronellal, etc. Lemon juice is arguably the best of all anti-scorbutic, being almost a specific in scurvy (Iwu, 2014).



a.r-limonene **b**.s-limonene

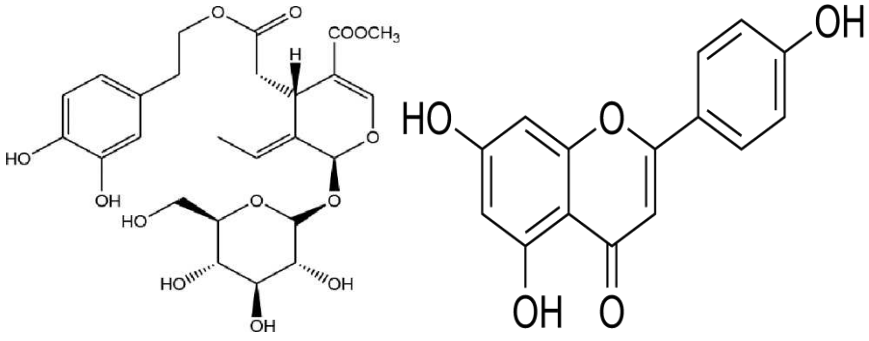


c.ascorbic acid

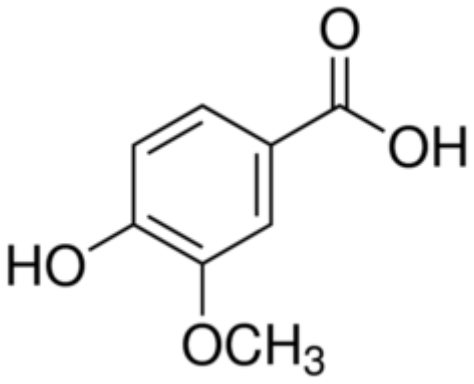
Figure 8: Compounds from Citrus limon, (Lemon).

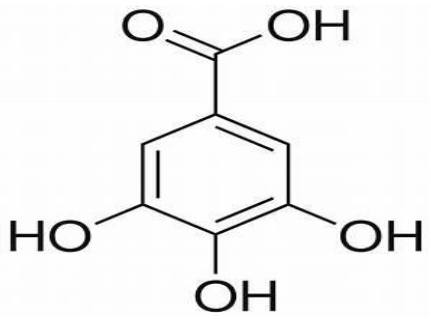
3.10 Olea europaea Linn. *(Oleaceae); African olive*

Olea europaea is an evergreen tree that is 7-9m high. They grow very well in northeast cities of Maiduguri, Jalingo, Bali, Damaturu, and other parts of the world especially Iraq, Saudi Arabia, among others where it often cultivated as a shade plant. It resembles figs on a close observable from the trunk and leaves. The plant is a hermaphrodite and grows on clay soil or mixture of clay and sandy soil. Flowers are borne at the axils somewhat conic in nature. The fruit is a drupe containing seed commonly referred to as a pit, a rock or a stone.



a. oleuropein **b.** apigenin





c. vanillic acid **d**. gallic acid

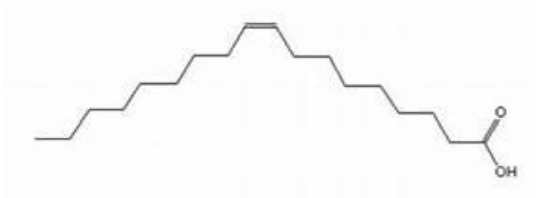
Figure 9: Compounds from Olea europaea plant parts.

3.11 *Spondias venulosa(Engl).Mart. ex Engl. (Anacardiaceae); Plum*

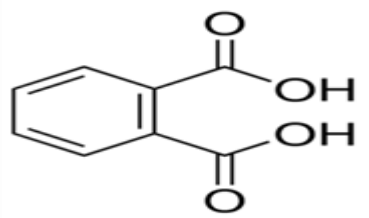
It is a semi-deciduous tree with a roundish crown and pendant branches with height 12–18m high. The straight, cylindrical bole ranges from 40 - 60cm in diameter with a slightly corky bark. Though it is a rare species of the genus, the tree is usually cultivated in Taraba State Nigeria, and more often harvested from the wild, for its edible fruit, which is consumed locally, and its numerous medicinal uses. It is also distributed in South American countries such as Brazil, Bolivia, Peru, Colombia and Ecuador (Iwu, 2014).

3.12 Melastomastrum capitatum (Vahl) A. & R. Fern. *(Melastomataceae)*

It is an erect or sub-erect perennial herb or a shrub of up 60 cm high. The Leaf-lamina is 5–13 cm, ovate to narrowly elliptic, acute at the apex, acute or roundish at the base, membranous to somewhat rigid, dark green above. The taste of the leaf is sour and sweet. The leaves also have multi-colour with red and green at the apex. It grows well in Mambila Plateau Taraba State, Nigeria in wet vegetation, and also found in various parts of Nigeria with swamps as well as other African countries. The flowers are purple and develop into fruits like a cone.

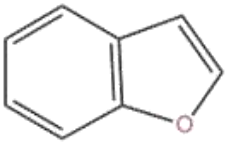


a. oleic acid



b. phthalic acid

c. octadecadienoic acid



d. benzofuran

Figure 10: Compounds from leaf extract of M. capitatum.

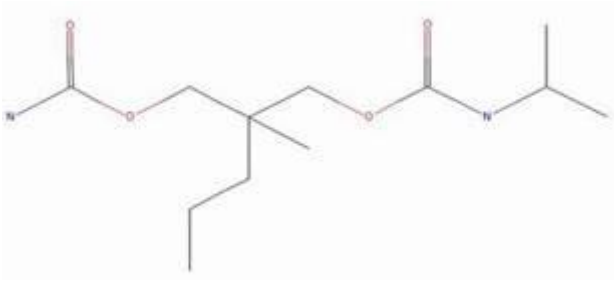
3.13 Astragalus canadensis Linn. *(Fabaceae); Canada Milk vetch*

It is an exotic perennial herb of 30-100cm high with slight branches. The rough stem has hairs. Leaves are compound and alternate in arrangement with odd-pinnate, and pinkish when matured. It has about 18-30 leaflets. The plant has semblances with *Crotalaria retusa* except for the variation in flower colour. Flowers are raceme with white colours in bract. A typical raceme is crowded with about 15-25 white flowers, which may have yellow or green tints. Each flower is about 5cm long and tubular-shaped. It has five petals. The flowering period occurs between December and February, after which the flowers are replaced by stout oval pods with long pointed tips like those of rattle box, which are held nearly erect on the stalk. There is no scent in the floral parts. The plant has a taproot system and grows in moist sandy-clay soil in savannah, burnt vegetation, woodland, under canopies of trees. In Nigeria, it is distributed in Mambila Plateau in Taraba State, Numan in Adamawa State, and other savannah zones of Northern-east Nigeria.

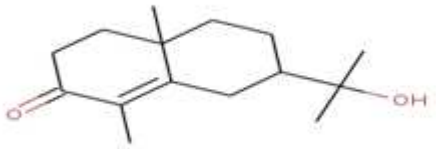
3.14 Carissa edulis (Forssk.) Vahl *(Apocynaceae); Small num-num*

It is a fast-growing, spiny shrub with glossy leaf with white flowers. *Carissa edulis* is a much-branched spiny evergreen shrub or small tree, usually multi-stemmed, often

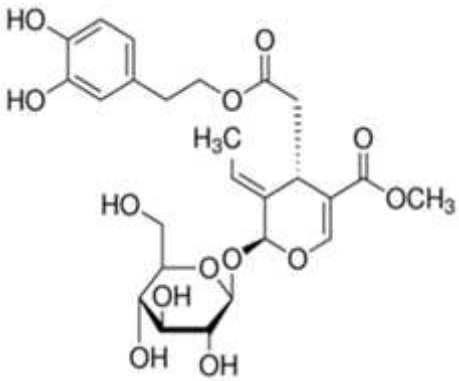
scrambling up to 6 m tall and forming a dense canopy. All parts of the plant release white, non-toxic, milky latex. Young branches are green, smoothly covered with short hair, but older branches and stem become light brown and corky with deep cracks. The plant is armed with rigid spines up to 70 mm long and nearly always simple, not forked as with other species. Leaves are simple and opposite, leathery, dark green above and paler below, with or without hair; and leaf base is shallowly lobed; margins are smooth; leaf-stalk up to 5 mm long (Tolo et al., 2006). Flowers in terminal heads up to 40 mm in diameter, white tinged pink to purple and up to 20 mm long; corolla with lobes overlapping to the right, with a strong sweet jasmine-like scent. They flower in spring and early summer from September to December, and their fruits are fleshy, ovoid, 6-11 mm in diameter, red to purplish black berries 2- to 4-seeded. Unripe fruits are green with red to purplish marks. Ripe fruits are dark red to purplish-black and are edible with a unique sour taste. The plant occurs in the bushveld, often in riverine vegetation or at the base of anthills, and common in deciduous to evergreen forests and grows well on clay-loamy soil. It is distributed in the savannah zones of Nigeria States such as Taraba, Plateau, Kaduna, Borno and from Senegal and East Africa in the north to Mpumalanga and Limpopo in the south. Also in Asia to India and Thailand, and on some Indian ocean islands (Iwu, 2014).



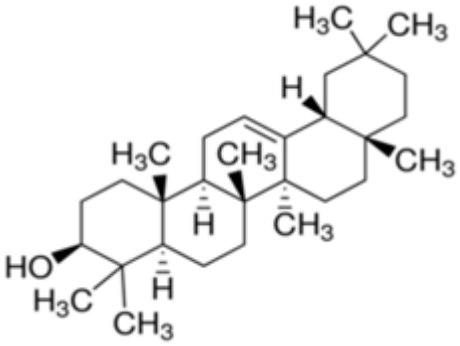
a. carissol



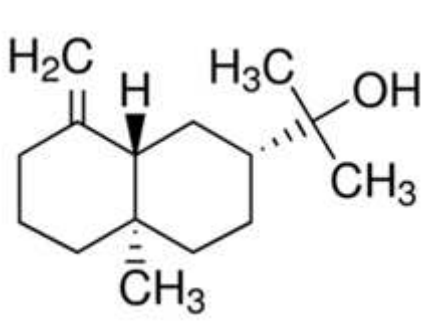
b.carissone



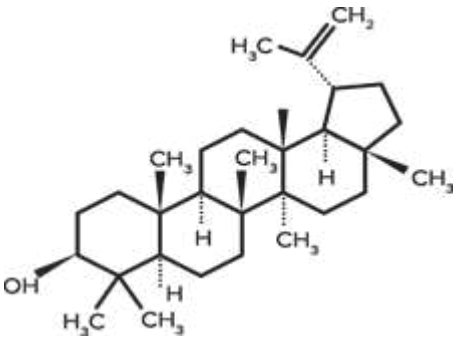
c.oleuropein



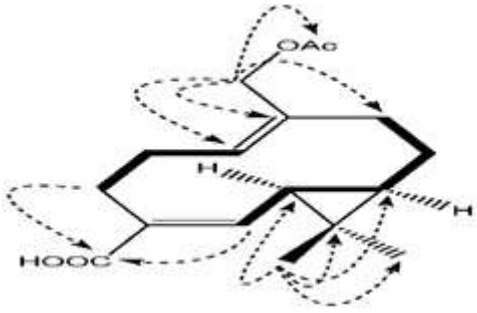
d. β-amyrin



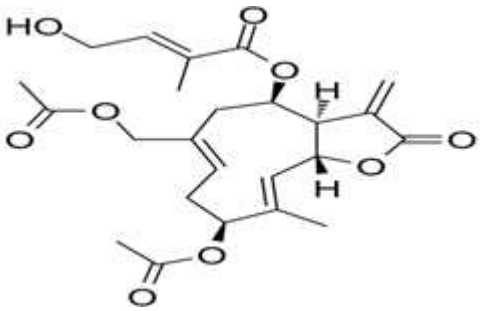
e.β-eudesmol



f. lupeol



g. germacrane



h. terpenoid

Figure 11: Compounds from Carissa edulis extract.

3.15 Vitellaria paradoxa C.F. Gaertn. *(Sapotaceae); Shea butter tree*

Vitellaria paradoxa (formerly *Butyrospermum parkii*), commonly known as shea tree, shea tree, is a tree of the family Sapotaceae. It is the only species in the genus *Vitellaria* and is indigenous to Africa. The shea fruit consists of a thin, tart, nutritious pulp that surrounds a relatively large, oil-rich seed from which shea butter is extracted. It is a deciduous tree usually 7–15 m tall, but has reached 25 m and a trunk diameter of 2 meters.

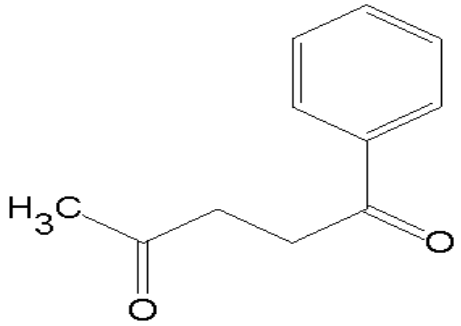


Figure 12: Chemical structure of 1-phenyl-1, 4-pentanedione.

3.16 Euphorbia hirta Linn. (Euphorbiaceae); Asthma plant

Euphorbia hirta is a common weed, native to India. It is a hairy herb that grows in open grasslands, roadsides and pathways, this annual herb can grow up to 60 cm long. It has a hairy stem that produces abundant white latex (Kumar, 2010). *Euphorbia hirta* is a common weed, native to India. It is a hairy herb that grows in open grasslands, roadsides and pathways, this annual herb can grow up to 60 cm long. It has a hairy stem that produces abundant white latex (Kumar, 2010).

Table 1: Antiviral Medicinal Plants Used in Taraba State, Nigeria

Plant Name	Antiviral Part	Compounds	Antiviral Study	Toxicity
Allium sativum	Bulbs	Allicin	Influenza virus, cytomegalovirus, rhinovirus, HIV, viral pneumonia, herpes simplex I & II, rotavirus.	NT
Zingiber officinale	Rhizome	Zingiberene, *β*-bisabolene, *α*-farnesene, *β*-sesquiphellandrene, *α*-curcumene, gingerols, paradols, shogaol.	herpes, hepatitis C	NT
Curcuma longa	Rhizome, & leaves	Curcumin	HIV, herpes	NT
Camellia sinensis	Leaves	Catechins, gallic acid,	Human influenza,	NT
Hibiscus sabdariffa	Calyces	Quercetin, kaempferol, gossypetin, hibiscetine, sabdaretine	avian flu, adenovirus, norovirus. HSV-2, hepatitis A, murine norovirus, human influenza 1.	NT
H.barteri	Leaves & stem	FA	Not known	NT
Ocimum tenuiflorum	Leaves	OA, rosamarinic acid, ursolic acid, eugenol, carvacrol, linalool, β-caryophyllene, β-elemene.	H1N1 flu, viral hepatitis, human influenza.	NT
Azardirachta indica	Leaf, Stem.	Azadirachtin, nimbin, nimbidinin, mellantriol, salannin meliacin.	Coxsackie virus B, HSV-1, dengue	ST
Citrus limon	Leaf, peels, roots	R & S-Limonene, Ascorbic-C Citral.	NDV,Influenza	NT

Olea europaea	Leaf, stem, root	Apigenin, apigenin, caffeic acid, cinnamic acid, o-coumaric acid, luteolin, rutin, vanillic acid, syringic acid, tyrosol, oleuropein.	VHSV, HIV, NDV.	ST
Spondias venulosa	leaves	Not known	HBV, human influenza virus	Not known
M. capitatum	Leaves	Not known	Herpes 1	NT
Astragalus canadensis	Leaves, Roots.	Not known	SARS-Cov-2	NK
Carissa edulis	Leaves	Lupeol, carissol β-amyrin, oleuropein, β-eudesmol, germacrane.	CDV, FHV-1	NT
Vitellaria paradoxa	Fruits	2-O-butyl-1-O-(2'-ethylhexyl) benzene-1,8-dicarboxylate, 1-phenyl-1,4-pentanedione.	HSV-1	ST
Euphorbia hirta	WP	Gallic acid, quercetin, 3,4-di-O-galloylquinic acid, 2,4,6-tri-O-galloyl-D-glucose 1,2,3,4, 6-p-O-galloyl-β-D-glucose.	HIV-1, HIV-2, SIVmac251.	ST

NT= nontoxic, ST = slightly toxic.

Source: Authors

4. Discussion

The use of medicinal plants with therapeutic inclusions is as old as human existence. Plant and animal products are the major sources of synthetic drug development for a long period globally. Recently, the use of complementary or alternative medicine to improve health conditions is increasing in both developing and developed nations. Many medicinal plants from various parts of the globe are being evaluated with the view to discovering and developing drugs or vaccines with improved therapeutic potentials. Screening of medicinal plants for their biological activities have resulted in discovering plants with activities such as antimalarial, anticancer, antitumor, antihypertensive, among others from where vital pure compounds have been isolated and elucidated structurally. Currently, Taraba State is among the States out of the 36 States in Nigeria with the lowest COVID-19 cases (17 cases) with zero death. The reason for this low rate of COVID-19 pandemic in the State may not be unconnected with much attention being given to the use of herbal medicines as palliatives for many ailments like viral infections, cancers, malaria, hypertension, and diabetes.

Medicinal plants have been used successfully to treat many diseases such as viral diseases, bacterial infections, cancer, malaria, hypertension, inflammation, ulcer, piles, liver cirrhosis, sickle cell anaemia, infertility, etc. In this study, we reviewed the traditional

medicinal plants used in Taraba State, Nigeria for treating and managing viral infections from time immemorial. Many medicinal plants have been used in various parts of the state to treat diseases caused by viruses, but the major ones used according to this current review are *Allium sativum* (AS) (garlic), *Zingiber officinale* (ZO) (ginger), *Curcumalonga* (CL) (turmeric or curcuma), *Camellia sinensis* (CS) (green tea), *Hibiscus sabdariffa* (HS) (Roselle), *Ocimum tenuiflorum* (OT) (holy basil), *Cirus limon* (CLM)(lemon), *Haematostaphis barteri* (HB) (blood plum), *Azardirachta indica* (AL) (neem), *Spondias venulosa* (SM) (plum), *Olea europaea* (OO) (olive), *Melastomastrum capitatum* (MC), *Astragalus canadensis* (AC) (Canada milk vetch), *Carissa edulis* (CE) (small num-num), *Vitellaria paradoxa* (VP) (shea butter), and *Euphorbia hirta* (EH) (asthma plant) (Table 1).

A number of compounds have been isolated from the plants obtained in this review, most of which show antiviral activity (figs.1-12). Allicin (fig. 1) obtained from *Allium sativum* is one of such compounds reported by this review to have antiviral activity as corroborated by the work of Weber *et al.* (1992). On the *in vitro* virucidal effects of *Allium sativum*. Similarly, gingerol (fig. 2a), isolated from *Zingiber officinale* has been shown to have antiviral activity against the human respiratory syncytial virus (HRSV) in a research carried out by Chang *et al*. (2013), and by Moa *et al*. (2019). This is also in agreement with the findings of this review because ginger extract forms a major recipe in antiviral herbal remedies by traditional medicine practitioners in Taraba State, Nigeria. The antiviral activity of curcumin (fig. 3), isolated from *Curcuma longa* has also been shown in a similar review carried out by Moghadamtous et al. (2014), as well as a research carried out by Praditya et al. (2019). Chlorogenic acid (fig. 5e), isolated from *Hibiscus sabdariffa* shown to have antiviral activity has been corroborated by a research "Antiviral activity of chlorogenic acid against influenza A (H1N1/H3N2) virus and its inhibition of neuraminidase" conducted by Ding *et al*. (2017).

In a similar way, eugenol (fig. 6d), a bioactive compound from leaf extract of *Ocimum tenuiflorum* shown to possess antiviral activity by this review is corroborated by a research carried out under the supervision of Benencia and Courrèges (2000), on the *in vitro* and *in vivo* activity of eugenol on human herpes virus. Azadirachtin (fig.7c), an isolate from the plant *Azardirachta indica* reported by this review to have antiviral activity goes in line with a research carried out on the in *vitro* antiviral activity of neem (*Azardirachta indica* L.) bark extract against herpes simplex virus type-1 infection" by Tiwari et al. (2010). Every part of this medicinal plant is used in traditional medicine in Taraba State, Nigeria for various ailments.

Limonene (fig. 8a), isolated from *Citrus lemon* extract shown by this review to have antiviral activity, is corroborated with the findings of Astani et al. (2014), who reported the antiviral activity of monoterpenes beta-pinene and limonene against herpes simplex virus *in vitro*.Biologically, viruses are the smallest microorganisms that are even smaller than bacteria. They are not visible to the naked eye unless with the aid of the electron microscopes. Viruses can only reproduce when they get inside a living host. Majority of viruses are composed of DNA or RNA that is enclosed by a coat of protein. There are many types of viruses some of which are not known. For instance, the coronavirus (Covid-19) is a novel type of virus which only surfaced in Wuhan (China) in December 2019. The coronaviruses are a group of viruses that cause mild sickness like the common cold.

However, certain types of coronavirus can infect the lower airway, causing serious disease like pneumonia or bronchitis in humans. The virus that causes COVID-19 is known as SARS-CoV-2. This virus has an approximately 26,000 to 32,000 bases or RNA in length, and are surrounded by a fatty outer layer with a crown or corona club-shaped spikes on the surfaces from where the name coronavirus was derived. The severity of the virus results from the ability to replicate its single RNA strand using RNA-dependent RNA polymerase enzyme (Corthout et al., 1992; Chen et al., 2020). There is currently no drug or vaccine available to treat coronavirus (COVID-19) because the molecular biology of the virus seems not to be fully understood by the scientist.

From this study, out of the sixteen plants used as antiviral in Taraba State, ten of them have been reported to have shown antiviral activities against different types of viruses *in vitro* and *in vivo*. Four plants HB, SV, MC, and AC, have not been reported to show antiviral activities. Preliminary antiviral screening on the extracts VP and EH have been reported (Corthout et al., 1992; Chen et al., 2020). It is possible that investigating these medicinal plants for antiviral activities against COVID-19 virus, biologically active compounds could be derived which will can successfully prevent RNA replication by the virus, hence kill or eradicate it from the body cell. The use of products derived from these plants either singly or in combination might pave way for the production or development of antiviral drugs that will act effectively on the coronavirus and the likes with little or no side effects. Despite the previous antiviral studies on these ten plants, none have been carried out on COVID-19 virus except for garlic which has shown potency against infectious bronchitis a type of coronavirus (Corthout et al., 1992; Ferguson et al., 2020).

Similarly, the study reviewed a novel plant *Spondias venulosa* (SV) in which no biological activity has been reported before on the plant. *Euphorbia hirta* has been used in traditional medicine to treat bronchial asthma and cardiac congestion. There is the possibility that extract from *E. hirta* can be used to treat SARS-CoV-2 related infection if tested on any of the strains, since the plant extract can clear respiratory pathways within shortest time in ethnomedicine. Antiviral activity of *Vitellaria paradoxa* has not been evaluated on SARS-CoV-2 viruses but the fruits have been used to treat throat sores resulting from viral respiratory infections in Taraba State. This claim has not been proven scientifically. Garlic, ginger, green tea, turmeric, neem and hibiscus extracts have used regularly to treat viral infections such as severe bronchitis and pneumonia in Taraba State either alone or in mixed proportions in traditional medicine. This type of therapeutic measure has yielded results in short time intervals, unlike conventional drugs.

For instance, the WHO had begun a trial of the long-used antimalarial drugs chloroquine and hydroxychloroquine, as well as a new antiviral drug called remdesivir (Gilead pharmaceutical, USA) and a combination of two HIV drugs lopinavir and ritonavir. The HIV drugs will also be tested in combination with an antiviral called interferon beta. Other treatment option involving the use of antibodies doses from COVID-19 recovered patients is also being considered at Johns Hopkins University, USA (2020). It is, therefore, not a surprising thing that the methods of combining various drugs by the WHO had been into use in traditional medicine. There are no doubts that if these trials by the WHO yielded the desired results, the possibilities of drug side effects cannot be completely ruled out. Our review showed that these plants (figs. 1-12) except for few possessed bioactive compounds

that are mainly flavonoids and terpenes with proven antiviral properties as well as other biomedical functions such as anticancer, hepatoprotective, antimalarial, antibacterial, etc. The extracts from these plants have been reported and shown to be safe when used in disease conditions in traditional medicine, unlike conventional drugs. Apart from the low toxicity of natural antiviral medicinal plants and products, they are easily accessible, cheap and easy mode of preparation. Most of these plants are prepared using decoction and infusion only unlike most orthodox antiviral that has to undergo specific scientific procedures which are normally very costly.

Our present study showed that despite the investigations carried out on the antiviral activities of some of these plants; little or no studies were carried out to determine the antiviral activities of these locally used antiviral medicinal plants in Taraba State Nigeria on COVID-19 virus. The review also showed that no effort was made by the WHO to encourage research based on natural antiviral medicinal plants to fight the COVID-19 pandemic. Therefore, it is important to screen these medicinal plants for anti-COVID-19 activity with a view to discovering and developing drugs that are capable of halting the metabolic activities of the virus and its closely related species in future.

Conclusion and Suggestion

Our review study showed that previous studies on these antiviral plants locally used in Taraba focused mainly on other biological activities as mentioned in the results. Antiviral studies were only carried out on other viral strains not COVID-19. Until much attention are directed towards exploiting the potentials endowed in antiviral medicinal plants, the pandemic caused by viruses might remain, and viral infections treatment illusive. Therefore, this study revealed that comprehensive investigations into the effects of these plants on COVID-19 virus might provide lasting drug alternative and remedy towards combating coronavirus (COVID-19) pandemic. Drugs that will be developed from these antiviral medicinal plants are no doubts with little or no side effects when used in tackling viral infections.

Significance statement

Traditional medicine has been used in the health-care systems of many countries for managing and treating various illnesses. When this aspect of medicine is neglected by health authorities and policymakers globally, the consequences could be far-reaching especially in obtaining solutions for some pandemic like coronavirus. This review is useful to natural product researchers to focus attention on these plants for possible drug discovery and development against covid-19 virus. This will provide drugs with long-lasting effects on diseases with no side effects.

Abbreviations

NDV= Newcastle disease virus; **CDV**= Canine distemper virus; **FHV-1** = Feline herpes virus 1; **VHSV** = Viral hemorrhagic septicaemia rhabdo virus; **HSV-1** = Herpes simplex virus 1; **HIV** = Human immune virus.

Author's Contribution

UCA - Research plan, field study, plant identification, manuscript preparation, literature search, and revision/approval of final manuscript; MTS - Research plan, literature search and revision/approval of final manuscript; AAE – Field study, plant identification, literature search, and revision/approval of final manuscript; OO – Literature search and revision/approval of final manuscript; BMS – Literature search, field study and revision/approval of final manuscript.

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Conflict of Interest

We have no competing interests.

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