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Full Length Research Paper

Exotic multifaceted medicinal plants of drugs and pharmaceutical industries

Donatus Ebere Okwu* and Nnamdi Fred Uchenna

Department of Chemistry, Michael Okpara University of Agricultural Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria.

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***Cassia alata* Linn, *Nauclea latifolia*, *Clerodendron splendens* and *Bryophyllum pinnatum* are some of the Nigerian exotic medicinal plants. These plants not only acts as ornamental but also exhibit antiviral, antifungal, antimalarial, antioxidant and anti-inflammatory functions. They are sources of drugs and are used in herbal medicine to treat measles, malaria, asthma, eczema, cough, hepatitis, ringworm, ulcer and scabies. These plants are continuously screened and evaluated for their pharmacological properties. Bioactive compounds comprising flavanoids, alkaloids, steroids, terpenoids and saponins have been isolated and characterized from the plants and are responsible for their biological activity. The importance of these bioactive compounds available in these plants are discussed with respect to their role in herbal medicine in Nigeria.**

Key words: Medicinal plants, antiviral, antifungal, antimalarial, antibacterial, antioxidants, immunomodulators.

INTRODUCTION

There has been a tremendous pressure on medicinal plants for their extensive utilization as sources of raw materials for the pharmaceutical industries. Demands for medicinal plants are rapidly increasing not only in developing countries like Nigeria, Ghana and India, but also in the developed ones. Medicinal plants have various effects on living systems; some are sedatives, analgesic, antipyretics, cardio-protective, anti-inflammatory, antioxidants, antispasmodics and immuno-modulatory functions (Okwu and Ezenagu, 2008).

The research for novel compounds effective against plasmodium strains resistant to widely used synthetic drugs, coronary arteriosclerosis, cardio-vascular, neurological, endocrine, respiratory, immune, ischemia, gastric disorder, tumor progression and carcinogenesis has led to increased interest in new and existing information about the remedies of these diseases from natural sources (Wright and Phillipson, 1990; Phillipson and Wright, 1991; Angerhofer et al., 1992; Adesegun and Coker, 2001; Nunez-Selles, 2005; Okwu and Ezenagu, 2008).

The development of resistance to most of the available antimicrobial agents and the high costs of treatment consequent upon this resistance has necessitated a search for new, safe, efficient and effective ways for the management of infections (El-Mahmood and Doughari, 2008).

Many drugs and chemotherapeutic agents have been developed from plants. Extracts of higher plants have served as good sources of antibiotics against various bacterial and fungal pathogens (Falodun et al., 2006). Plant based antimicrobial compounds have great therapeutic potential as they can serve the purpose without any side effects as associated with synthetic drugs (El-Mahmood and Doughari, 2008).

Plants therefore form the major resort for the treatment of diseases and sicknesses by traditional healers in many societies. Among these plants include *Bryophylum pinnatum*, *Cassia alata Linn*, *Clerodendron splendens* and *Nauclea latifolia*. These plants seemed worthy of an in-depth review because of their wide utilization in herbal medicine for disease treatment in Nigeria.

*Corresponding author. E-mail: Okwudonatus@yahoo.com.

Abbreviations: OCS, Oxidative chemical species; **HBV,** hepatitis B virus; **HCV,** hepatitis C virus; **HIV,** human immunodeficiency virus.

Cassia alata Linn

C. alata Linn (Leguminosae) is an ornamental shrub or

tree growing up to 12 m high (Figure 1a). It is found mainly in the tropics around grassland in towns and villages throughout West Africa. The plant has very important applications in folkloric medicine (Rai, 1987; El-Mahmood and Doughari, 2008). Decoction of the leaves and roots are used extensively to treat diarrhea, dysentery and other gastrointestinal problems (El-Mahood and Doughari, 2008). The macerated juices of the young fresh leaves are used to treat eye infections and parasitic skin diseases (El-Mahood and Doughari, 2008). The decoction of the stem bark and roots are used to treat urinary tract infections, bronchitis and asthma (El-Mahood and Doughari, 2008).

In Nigeria, the root, stem bark and leaves are used by practitioners of herbal medicines to treat burns, skin and wound infections, diarrhea, gastrointestinal and upper respiratory tract infections (El-Mahood and Doughari, 2008). It have been reported (Benjamin and Lamikaura, 1981) that the leaves and roots of *C. alata* can be used as a remedy for boils, wound, eye, urinary and gastrointestinal tract infections, diarrhea and scarlet fever. Recent publications have credited the use of *C. alata* successfully in the treatment of hemorrhoids, constipation, inguinal hernia, intestinal parasitesis, blennorrhagia, syphilis and diabetes (Makinde et al., 2007). The leaf extract exhibited various antifungal activities (Reezal et al., 2002). The traditional usage varies greatly in different countries. The leaves are shown to be the choice for treatment rather than the flowers, barks and seeds (Lindley, 1981). In the tropics, infusion of the roots is used to treat rheumatism, inflammation and as laxative. The pounded fresh leaves are applied or rubbed on skin infections. They are used to treat itching, eczemas, crawcraw and ringworm (Esimone et al., 2008).

The leaves are also boiled and drunk by women to hasten delivery (Esimone et al., 2008). *C. alata* is very effective and efficient to treat ringworm, as antihelminthic, for uterus disorders, bites of poisonous snakes, laxative actions and as tonics (Reezal et al., 2002). The juice of the fresh leaves are universally recognized by the local healers as a remedy for parasitic skin diseases and is used in the treatment of many eruptive and particular skin conditions by simply rubbing the crushed leaves either alone or mixed with lime juice or an oil on the skin (Oliver-Bever, 1986).

Bryophyllum pinnatum (Kalach of Pinnata Lamarck)

B. pinnatum (Crassulaceae) is an erect, succulent, perennial shrub that grows about 1.5 m tall (Figure 1b) and reproduces via seeds and also vegetatively from leaf bulbils (Okwu and Josiah 2006; Okwu, 2007). It has tall hollow stems, freshly dark green leaves that are distinctively scalloped and trimmed in red and bell-like pendulous flowers (Egereonu and Mokwe, 2005). *B. pinnatum* can easily be propagated vegetatively (through stems or leaf cutting). It is an introduced ornamental plant that is now growing as a weed around plantation crops (Okwu and Josiah, 2006; Okwu, 2007). *B. pinnatum* is used in ethnomedicine for the treatment of earache, burns, abscesses, ulcer, insect bites, whitlow, diarrhea and cithiasis (Agoha, 1974; Ofokensi et al., 2005; Okwu and Josiah, 2006; Okwu, 2007). In Southeastern Nigeria, this herb is used to facilitate the dropping of the placenta of new born babies (Okwu and Josiah, 2006). The lightly roasted leaves are used externally for skin fungus and inflammations and the leaf infusion is an internal remedy for fevers (Egereonu and Mokwe, 2005).

Ethnomedically, *B. pinnatum* is used to induce vomiting of blood, cut umbilical cord in a new born baby, expel worms, cure acute and chronic bronchitis, pneumonia and other forms of respiratory tract infections (Mudi and Ibrahim, 2008). The plant is considered a sedative, wound-healer, diuretic, anti-inflammatory and cough suppressant (Egereonu and Mokwe, 2005; Okwu and Josiah, 2006). It is used for all sorts of respiratory conditions such as asthma, cough and bronchitis. It is employed for the treatment of kidney stones, gastric ulcers and oedema of the leg (Nassis, 1992). The leaf juice is mixed with coconut oil and then rubbed on the forehead for headache. It is heated and applied to boils and skin ulcers. Many of the traditional uses of *Bryophyllum* can be explained by the clinical research conducted on the plant. Several biological activities have not only been immunosuppressive effects (Rossi - Bergemann et al., 1994), hepa-toprotective activity (Yadav and Dixit, 2003), acetylcholinesterase inhibition (Barbose-Filho et al., 2006), but it also protects against progressive infection with *Leishmania amazonrnsis* (Da-Silva et al., 1999). The plant is widely used against rheumatism and inflammatory process and therefore, showed protection against oedema, boils and hemorrhage (Almeida et al., 2006).

Clerodendron splendens (A. Cheval)

C. splendens belongs to the family of verbenaceae. It is a climbing evergreen bush plant with attractive red flowers (Figure 1c) produced during the dry seasons of the year (Starr et al., 2003). It is made up of small trees, shrubs and herbs commonly used in the tropics as ornamental plant (Brickell and Zuk, 1997). This is because of the bright red coloured flowers it produces. The leaves and barks are used in traditional medicine to treat diseases, infections and inflammations of the urinary tracts (Shrivastava and Patel, 2007). The roots and leaves decoction of *C. splendens* are used in Nigeria to treat tumors, skin disorders, ulcers, abdominal pains and inflammation (Okwu and Iroabuchi, 2008). Traditional healers in South Eastern Nigeria have reported on the use of *C. splendens* in the treatment of fibroid (Okwu and Iroabuchi, 2008). The plant is used to treat gonorrhea and syphilis (Okwu and Iroabuchi, 2008). It has also been

Figure 1. Pictures of some medicinal plants. **a)** *Cassia alata*; **b)** *Bryophyllum pinnatum*; **c)** *Clerondendron splendens*; **d)** *Nauclea latifolia*.

used to treat malaria in Nigeria due to the presence of the bitter principle (Okwu and Iroabuchi, 2008).

Roots and leaf extracts of *C. splendens* have been used for the treatment of rheumatism, asthma and other inflammatory diseases (Shrivastava and Patel, 2007). The plant is used to treat cough, scrofulous infection, buboes problems, venereal infections, skin diseases and as a vermifuge, febrifuge and also to treat beriberi disease (Shrivastava and Patel, 2007; OKwu and Iroabuchi, 2008).

Nauclea latifolia Smith

N. latifolia Smith (Rubiaceae) is a shrub or small spreading tree that is widely distributed in both savannah and tropical forests of West Africa (Figure 1d). It is a versatile African medicinal plant growing in different parts of Nigeria (Morah, 1994). It is a shrub or small spreading tree that is widely distributed in both savannah and tropical forests of West Africa. In Nigerian local medicine, the fruit is sometimes dried and used in the treatment of piles and dysentery (Oliver-Bever, 1986). The fruits act as an emetic when eaten in excess. Different parts of *N. latifolia* are used for different medicinal purposes in different parts of Africa. One of the major medicinal uses is in the treatment of measles by the Ibo race of Nigeria (Morah, 1994). The drug is prepared by roasting the succulent ripe fruits of *N. latifolia* in a pot over a hot firewood flame until the whole fruit is charred. Special care is normally taken to avoid over-roasting which usually results in loss of activity (Morah, 1994).

The powdered drug which looks like charcoal is dispensed by the practitioner who usually conceals the origin of the drug from the patients. The drug is normally taken orally and also applied externally on the skin as a thick paste in palm oil. It is normally used for the therapeutic purposes. It is also successfully employed for prophylactic

purposes during measles epidemics (Morah, 1994). The local inhabitants believe that it is more potent than the drugs employed in orthodox medicine against measles (Morah, 1994).

N. latifolia stem bark and leaf extract is used as a tonic for fever medicine and in the treatment of dysentery, diarrhea and malaria (Ntrejumokwu and Kolawole, 1990). The leaves are used as an ingredient in the preparation of fever "teas". They are also used as part of the pot herb used in steam treatment for malaria. Decoctions from the stem bark are used in rural communities, for the treatment of stomach pains, fever and diarrhea (Ntiejumokwu and Kolawole, 1990). Phytochemical studies revealed that the stem bark contains alkaloids and tannins which are noted for their anti-inflammatory property and as a remedy for leucorrhoea (Ntiejumokwu and Kolawole, 1990).

In Southern Nigeria, the stem is used as a chew sticks and the presence of bioactive compounds comprised of saponins, tannins, flavonoids and alkaloids. These phyto constituents are responsible for the effectiveness of the chewing sticks. Chewing sticks when used without toothpaste are very efficient, effective and reliable in cleaning the teeth of many people in Southern Nigeria. The teeth of the users of chewing sticks are usually strong, clean, fresh and devoid of dental plagues and carries (Okwu and Ekeke, 2003). A decoction of the root bark is recommended as a mouth wash for swollen gums and a decoction of the leaves makes an efficacious gargle for swollen gums and ulceration of the mouth (Ntijumokwu and Kolewole, 1990).

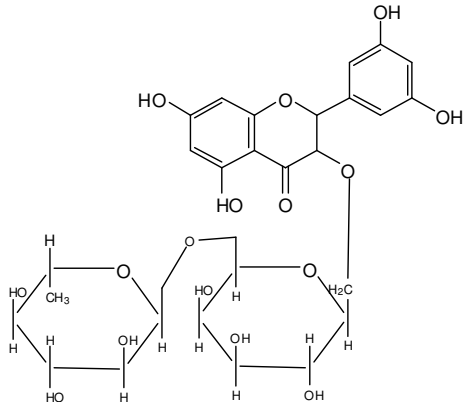
PHYTOCHEMISTRY REVIEWED

C. alata, *N. latifolia*, *C. splendens* and *B. pinnatum* like other higher plants have complex phytochemical profile (Figure 2). The predominant phytochemical compounds include alkaloids, flavonoids, tannins, saponins and phenolic compounds (Table 1). Efforts have been devoted and directed by many researches in the isolation and characterization of the biological active principle in the plants. Alkaloids are the most potent therapeutic compounds of natural origin (Devkota et al., 2008). They are an important class of secondary metabolites that occur in plants and also in certain higher animals and marine invertebrates (Devkota et al., 2008).

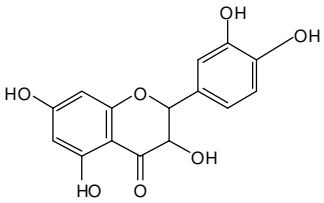
B. pinnatum has been reported to contain a wide range of bioactive compounds. The flavanoid glycoside rutin [1] and quercetin [2] were isolated from *B. pinnatum* (Stewart, 1972). These researchers also isolated quercetins -3 diarabinosible [2] and kaemferol -3- glycoside [3]. These flavonoids have strong inherent ability to modify the body's reaction to allergens, viruses and carcinogens (Okwu, 2008).

They show anti-allergic, anti-inflammatory, anti-microbial and anticancer activity (Okwu, 2005). Quercetin has demonstrated significant anti-inflammatory activity because of direct inhibition of several initial processes of inflammation, for example it inhibits both the production of histamine and other allergic/inflammatory mediators (Del-Rio et al., 1997; Roger, 2002). Quercetin may have positive effects in combating or helping to prevent cancer, prostatitis, heart diseases cataracts, allergies/ inflammations and respiratory diseases such as bronchitis and asthma (Yano et al., 1999). Rutin is also known as rutoside or quercetin -3- rutinoside. In humans, rutin attaches to Fe^{2+} ion and it prevents it form binding to hydrogen peroxide and creating a highly reactive free radical that may damage cells. It is also an antioxidant and therefore plays a vital role in inhibiting some cancer cells. Furthermore, rutin strengthens the capillaries and can reduce the symptoms of hemophilia. It also helps to prevent oedema of the legs (Roger, 2002). The pentacyclic trterpenoids α- and β- amyrin [4] and [5] respectively were isolated from the leaves of *B. pinnatum* (Gaind and Gupta, 1977). Furthermore, α- and β- amyrin acetate [6] and [7], respectively, have also been isolated from the leaves of *B. pinnatum.* Triterpenoids bryophenol [8] and bryophollon [9] were also isolated. Other phytochemicals important in the pharmacology characteristics of *B. pinnatum* include phytosterols and steroidal saponins. The steroidal saponins may be responsible for toxicity of *B. pinnatum.* Steroids such as bryophyllol [10] and bryophyllol acetate [11] were isolated from *B. pinnatum.* Also, isolated include 5 - cholesten - 24 - ethyl - 3β - 25 - diol [12] and the acetate [13]. The hydrocarbons were also isolated. They include 18 α-oleanane [14] and aromatic hydrocarbons comprising decenylphenanthrene [15] and undecenylphananthrene [16]. Another class of constituents are the terpenes, terpenoids such as ψ - taraxasterol [17] and bryophollenone [18]. *C. splendens* has been extensively subjected to chemical investigations and a number of chemical constituents; viz steroids, terpenoids, flavonoids, volatile constituents, cyanogenic glycoside and phenolic compounds were isolated. Research reports denote that the major classes of chemical constituents present in *C. splendens* are steroids such as β- sitosterol [19], β- campesterol [20], colebrin [21] and clerosterol [22] (Yang et al., 2000; Kanchanapoom et al., 2001; Yang et al., 2002; Gao et al., 2003; Pandy et al., 2003; Kanchanapoom et al., 2005; Lee et al., 2006; Shrivastava and Patel, 2007).

Flavonoids are present in *C. splendens* and may be responsible for some of the biological activities of the plant. Hispudilin [23], apigenin [24], acacetin - 7 - 0 - methyl glucuronate [25] were reported to be isolated from the leaf extract of *C. splenden* (Shrivastava and Patel, 2007). Recently, Okwu and Iroabuchi (2008) isolated an antioxidant flavonone diglycoside, apigenin - 7 - 0 - β - D - glucuronopyranoside [26] from the ethanolic leaf extract of *C. splenden.* The bioactive compound [26] is a bitter principle. *C. splendens* has been used to treat malaria in Nigeria due to the presence of the bitter principle. How-



[1]



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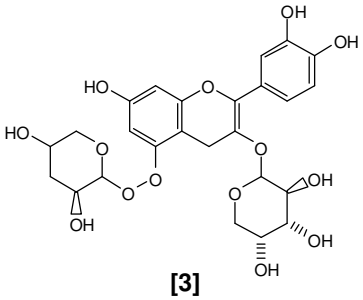
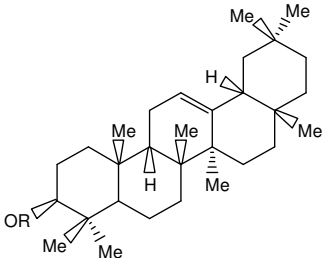
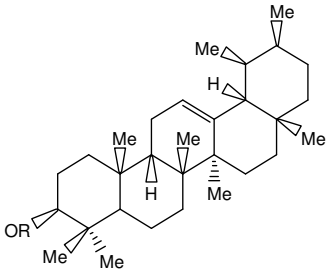


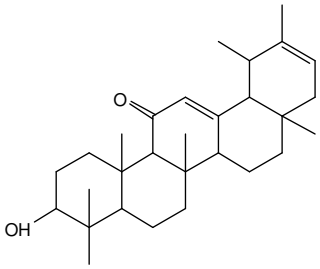
[3]



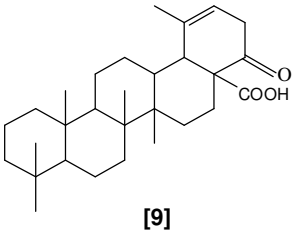
[4] R = H
[7] R = Ac



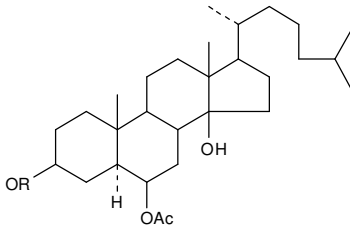
[5] R = H
[6] R = Ac



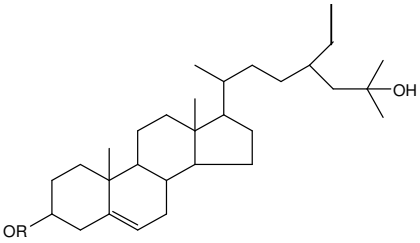
[8]



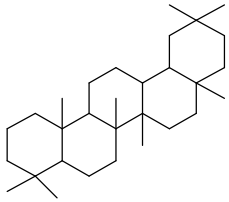
[9]



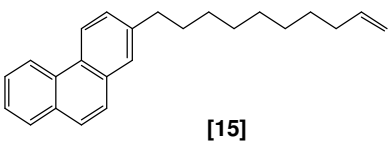
[10] R = H
[11] R =Ac



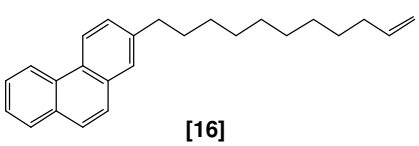
[12] R = H
[13] R =Ac



[14]



[15]



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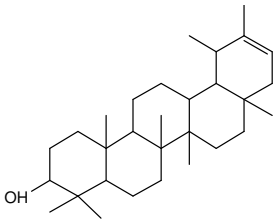

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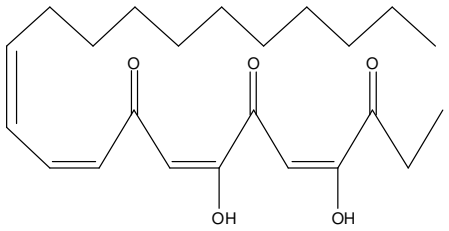

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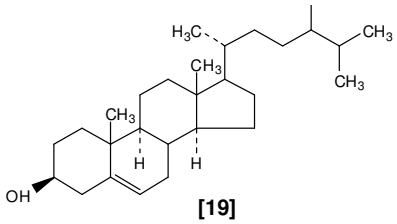
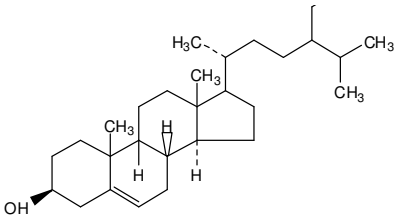
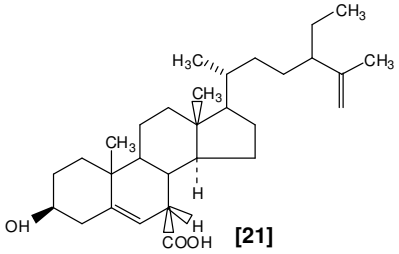


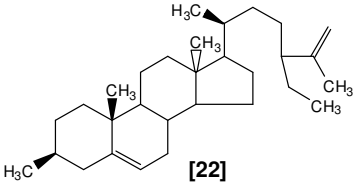
[19]



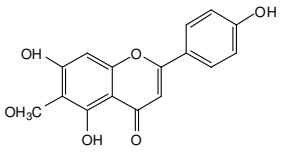
[20]



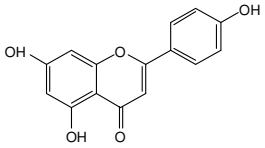
[21]



[22]



[23]



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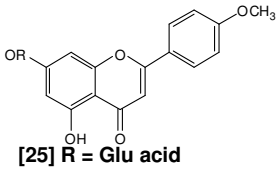
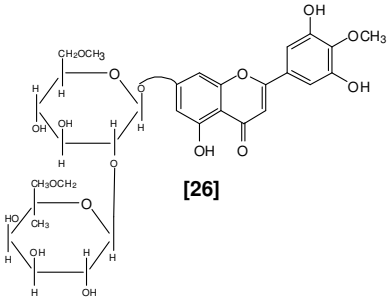
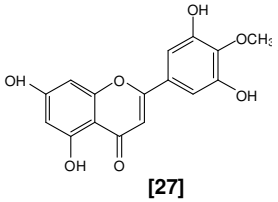


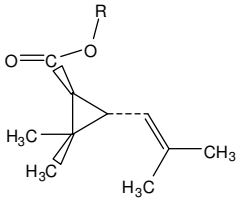
[25] R = Glu acid



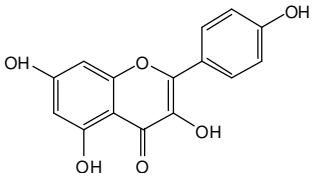
[26]



[27]



[28] R= H
[29] R = CH_3



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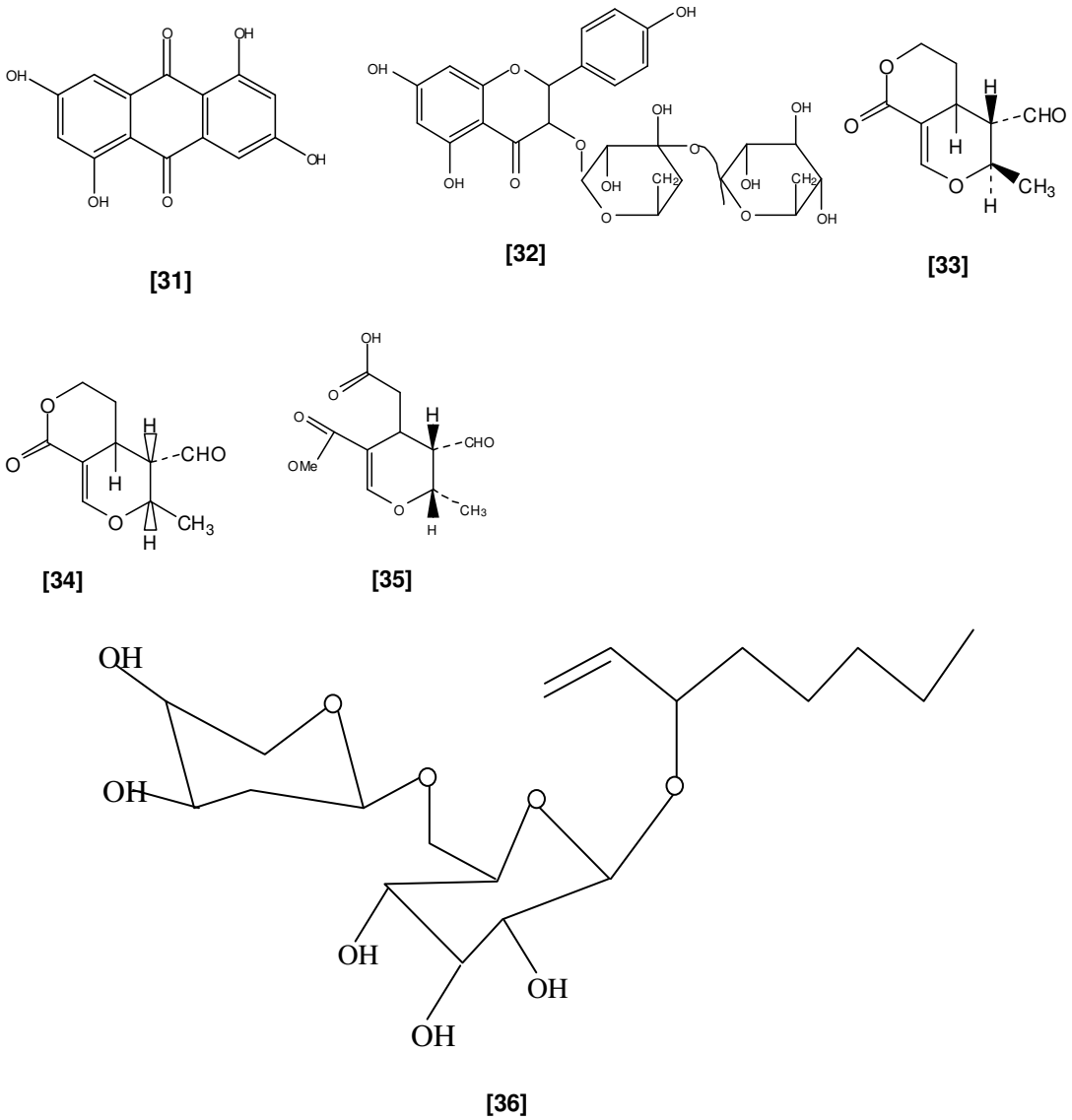

Figure 2. Phytochemicals present in *Cassia alata* Linn, *Nauclea latifolia*, *Cleredendron splendens* and *Bryophyllum pinnatum*.

ever, acid hydrolysis removes the glycoside and produce compound [27], identified as 3, 5, 7 trihydroxy - 4 methoxy flavonone, a non bitter yellow compound with antioxidant activity (Okwu and Morah, 2007; Okwu and Iroabuchi, 2008). Antioxidant compounds are responsible for scavenging free radicals which are produced during normal metabolism or during adverse conditions that can be harmful to biological systems and thus leading to the death of an organism. In present life styles where stress conditions are common leading to excess production of free radicals, these natural products will prove a support to our biological system to sustain and balance metabolism. These findings supported the use of *C. splendens* in phytomedicine as antioxidant and anti-inflammatory agent. Earlier investigation on the bioactive constituents of *C. alata* (Chopra et al., 1980) reported the isolation of chrysanthemic acid [28] and chrysanthemic acid esters [29]. Chrysanthemic acid is a monocyclic terpene containing three member rings. Its esters are also found in the flower heads of pyrethrum, (*Chrysanthemum cinerariceforium*) and are naturally occurring insecticides.

Rahaman et al. (2006) isolated tetrahydroxyflavonone known as luteoline [30] from the leaves of *C. alata*. In another study, alatinone [31], an anthraquinone was isolated (Hemlata et al., 1993) from the leaves of *C. alata*. Hiroyeshi et al. (2001) also isolated Kaempferol 3 - gentio-biolocide (Kaempferol 3 - 0 -β- D glycopyranosyl 1, 6, β- D glucopyranoside) [32].

N. latifolia contains diverse phytochemicals such as alkaloids, flavonoids, steroids and glycosides. Earlier

Table 1. Phytochemical composition of some medicinal plants expressed as mg/100 g dry weights.

Medicinal plants	Family	Part Screened	Alkaloids	Flavonoids	Tannins	Phenols	Saponins	References
Clerondendron splendens	Verbenaceae	Leaf	5.40 ± 0.03	0.70 ± 0.04	3.60 ± 0.02	0.08 ± 0.01	2.10 ± 0.01	Iroabuchi 2008
Bryophyllum pinnatum Kalachoe	Creassulaceae	Leaf	1.48 ± 0.02	1.72 ± 0.11	0.51 ± 0.20	0.06 ± 0.11	1.74 ± 0.20	Okwu and Josiah 2006
Cassia alata Linn	Leguminosae	Seed	3.24 ± 0.01	0.50 ± 0.10	2.46 ± 0.10	0.95 ± 0.10	6.44 ± 0.01	Nnamdi 2008
Nauclea latifolia smith	Rubiaceae	Seed	0.59 ± 0.10	0.56 ± 0.22	0.06 ± 0.11	0.05 ± 0.20	1.34 ± 0.10	Udu 2008
Nauclea latifolia smith	Rubiaceae	Leaves	4.32 ± 0.20	0.36 ± 0.10	0.01 ± 0.20	0.02 ± 0.11	0.98 ± 0.11	Udu 2008
Nauclea latifolia smith	Rubiaceae	Fruit	0.28 ± 0.10	0.81 ± 0.10	0.01 ± 0.11	0.02 ± 0.20	0.42 ± 0.10	Udu 2008

workers on the plant isolated a series of alkaloids from it. *Naucleafoline, nauclechine and naufoline* were isolated from the leaves (Hotellier et al., 1979, 1981). Other alkaloids isolated from the plant include naucletine, nauclefine, naucledidinal and epinaucleidinal, augustine, card-ambine and 3 α dihydrocadambine (Hotellier et al., 1975, 1979, 1980, 1981). These alkaloids may be responsible for the antiplasmodial activity of the plant.

Naucleidal [33] and epinaucleidal [34] have been isolated from an antiviral preparation produced by roasting *Nauclea latifolia* fruits (Morah, 1994). Interest in naucleidal increased when the natural broad spectrum antiviral agent elenolic acid [35] which has the same stereochemistry with epinaucleidal [34] was reported (Mackellar et al. 1973). The occurrence of naucleidal [33] and epinaucleidal [34] in the antiviral preparation against measles is also of interest. The practice of boiling or heating many herbal medicines in Africa by the practitioners is probably to effect detoxification and/or to con-vert certain components into more active forms (Morah, 1994). Almeida et al. (2006) has isolated a rare vinylic O- glycosylated terpenoid 1-Octen-3-0-α-L-arabinopyra-nosyl-(1-6)-β- glycopyranoside [36] from *B. pinnatum. C. alata*, *C. splendens*, *B. pinnatum* and *N. latifolia* have been extensively used in herbal medicine not only for their anti-inflammatory, antimalarial, antiviral, antifungal, antibacterial properties but also protects and regenerates liver cells, viral liver damage and toxic liver damage.

PHARMACOLOGICAL/BIOLOGICAL STUDIES

C. alata, *C. splendens*, *N. latifolia and B. pinnatum* have been extensively used in herbal medicine not only for their oxytoxic, analgesic, anti-inflammatory antimicrobial properties but also provide relief in the treatment of human gastrointestinal, hypermobility and pepetic ulceration (Shrivastava and Patel, 2007; Okwu and Iroabuchi, 2008).

Antiviral agents

Some of the greatest human health risks are caused by viral diseases such as human immunodeficiency virus (HIV), hepatitis B virus (HBV) and hepatitis C virus (HCV), ebola, measles, influenza, dengue fever and yellow fever (Butler, 2008). Hepatitis is the inflammation of the liver cells (Bellow, 2001). It is characterized by elevated transaminase, jaundice and pain (Bellow, 2001). Viral hepatitis is a source of significant morbidity and mortality world-wide. It is also the most common cause of chronic liver disease (cirrhosis and hepatocellular carcinoma) (Bellow, 2001). *N. latifolia*, *B. pinnatum* and *C. splendens* have been extensively used in herbal medicine as antiviral agent for liver treatment. They protect and regenerate liver cells, viral liver damage and toxic liver damage. *N. latifolia* fruits have broad spectrum activity against measles. The occurrence of naucleidal and epinaucleidal in the antiviral preparation against measles is of interest.

Antifungal drug

Fungal related diseases are difficult to eradicate especially in immunosuppressive situations (Irobi and Daramola, 1994; Adekunle, 2001). Crude methanol extracts from the leaves of *C. alata* showed inhibition on fungi pathogens (Phongpaichit et al., 2004). The hyphal growth of *Microsporum gypseum*, *Trichophyton rubrum* and *Penicillium marneffei* were inhibited by methanol leaf extracts of *C. alata* in a concentration dependent manner. *T. rubrun and M. gypseun* were completely inhibited by the extract at a concentration of 10 mg/ml and *P. mar-neffed* at a concentration of 100 mg/ml. The *C. alata* extracts also affected *M. gypseum* conidial germination. At the concentration of 10 mg/ml *C. alata* extract inhibited conidial germination (Phongpaichit et al., 2004). These findings confirm the traditional

therapeutic claims of *C. alata* to treat ringworm and skin diseases. *C. alata* is an excellent candidate for treatment of penicilliosis marneffed (Phongpaichit et al., 2004). Antimicrobial activities against human pathogens have been carried out for *C. alata,* (Khan et al., 2001; Villasenor et al., 2002; Somchit et al., 2003). Aqueous extract from leaves of *C. alata* and some of its constituents; rhein, emodol, 4, 5 dihydroxy-1-hydroxyl methylanthrone and 4, 5-dihydroxy-2- hydroxymethylanthraquinone had antifungal activity against some dermatophytes and yeast (Fuzellier et al., 1982). *C. alata* leaf extract inhibited *Candida albicans, Aspergillus fumigatus, Aspergillus flavus, Mucor* sp*., Rhizopus* sp *and dermatophytes, Trichophyton mentagrophytes, T. rubrum and M. gypseun* (Palanichamy and Nagarajah, 1990).

Anti-bacterial activity

The leaf extract and juice of *B. pinnatum* have demonstrated significant antibacterial activity towards *Staphylococcus auerus, Esterichia coli, Bacillus subtilis, Pseudomonas aerguensa, Klebsiella pneunoniae* and *Salmonella typhi* (Ofokansi et al., 2005). The crude extracts from *C. alata* inhibited the growth of *E. coli*, *S. aureus*, *S. typhi*, *B. subtilis*, *Proteus mirabilis* and *Klebsiella pneumoniae* (El-Mahmood and Doughari, 2008). The activity of the plant extracts against both Gram positive and Gram negative bacteria is an indication of the presence of broad spectrum antibiotic compounds in the plant. The herbal soap formulated with *C. alata* demonstrated high potency against skin flora and indicates the potential of the plant as in the production of antiseptic soaps for combating skin infections especially in the tropics (Esimone et al., 2008).

Anti-malarial activities

The roots, leaves and stem bark extract of *N. latifolia* and *C. alata* showed antiplasmodial activity against *Plasmodium vivax* and *Plasmodium falciparum C. splendens* has been used to treat malaria in Nigeria due to the presence of the bitter principle apigenin -7-0-β-D glucuronopyranoside (Okwu and Iroabuchi, 2008). A series of alkaloids comprising nauclerofoline, nauclechine, naufoline, naucleitine, nauclefine and naucleidinal also showed antiplasmodial activity (Morah, 1999; Adesegun and Coker, 2001). Furthermore, *Cassia alata* leaves, roots and stem bark extracts have anti-malarial action due to its flavonoids content. The plants act by redox perturbbation in the form of composition of substantial oxidant stress during malarial infection (Adesegun and Coker, 2001). These plants may be useful as a source of novel anti-plasmodial drugs.

Oxytoxic activities

Leaf extracts of *C. splendens* showed strong uterine stimulant activity when tested in female rats and rabbits (Shrivastava and Patel, 2007). The ethanolic extracts of *C. splendens* showed uterine contraction activity in guinea pig (Okwu and Iroabuchi, 2009). The uterine contraction increases as the concentration of the plant extract increases. *C. splenden* is used in herbal medicine to accelerate labour in South Eastern Nigeria (Okwu and Iroabuchi, 2009). However, if used during the first month of pregnancy, the plant could have abortifacient properties. If the extracts from this *C. splendens* are administered in high dose, it prepare the uterus and ensures that fatigue disappears, producing strong, regular contraction to facilitate labour during the last month of pregnancy (Okwu and Iroabuchi, 2009). *B. pinnatum* is traditionally used during child birth and may stimulate the uterus (Egereonu and Mokwe, 2005). The plant should not be used in pregnancy.

Anti-inflammatory activities

Inflammation is a very complex pathophysiological process involving a variety of biomolecules responsible for causing it such as leucocytes, macrophages, mast cells, platelets and lymphocytes by releasing cicosanoids and nitric oxide (Shrivastava and Patel, 2007). The ethanolic leaf extract of *C. splendens* produced a marked anti-inflammatory activity. *C. splendens* leaf extracts reduced carrcgeenan-induced paw oedema in rats by 47.83% inhibition. The anti-inflammatory effects of plants may be due to the presence of bioactive compounds such as flavonoids, saponins and phenolic compounds. This agreed with the findings of Somazundram and Sadique (1986) and Shrivastava and Patel (2007) that flavonoid glycosides of *C. splendens* showed modulation in calcium transport in isolated inflamed rat liver and thereby showed reduction in inflammation. Flavonoids significantly inhibit lysosomal enzyme secretion and arachidonic acid release from membranes by inhibiting lipoxygenase, cycloxygenase and physpolipase A_2 (Del-Rio et al., 1997). The inhibition of arachidonic acid release in the inflamed cells would provide less arachidonic substrate for the lipoxygenase and cycloxygenase path ways. This however, leads to a lesser quantity of endoperoxides, prostaglandins, prostacycline and thromboxane as well as hydroperoxyl hydroxycicosatrienoic acids and leucotrienes. Such an effect confirms the decrease in histamine, which is known to act in the first stage of the inflammatory process (Del-Rio et al., 1997). In a study with rats and guinea pigs the leaf juice from *B. pinnatum* was able to protect against chemically induced anaphylactic reactions and death by selectively blocking histamine receptors in the lungs (Egereonu and Mokwe, 2005). *B. pinnatum* leaf extract has been used for gastric, ulcer. The leaf extract protected mice from such ulcer inducers as stress, aspirin, ethanol and histamine (Pal, 1991; Egereonu and Mokwe, 2005). Its anti-inflammatory effects have been attributed to be due to immunomodula-

tory and immune-suppressant effect (Rossi-Bergmann et al., 1994). The compound 1-Octen-3-α-L- arabinopyranosyl -(1-6) -β- glucopyranoside isolated from *B. pinnatum* can play on important role on the immunosuppressive *in vivo* effect of the plant (Alimeida et al., 2000, 2006). These supported the use of the plant in the treatment of oedema, rheumatism, boil and hemorrhage in phyto-medicine.

Anti-oxidant activity

Free radicals can have a noxious effect on cells and it is believed that free radical damage is involved in the etiology of several diseases (Naik et al., 2009). The radicals are a by-product of various endogenous processes that can be stimulated by external factors such as irradiation and xenobiotics (Halliwell and Gutheridge, 1989; Naik et al., 2009). Free radical formation is associated with the normal natural metabolism of aerobic cells. The oxygen consumption inherent in cell growth leads to the generation of a series of free radicals of oxygen, leading to oxidative stress (Del-Rio et al., 1997; Okwu, 2007). The interaction of species with lipids produces new radicals, hydroperoxides and different radicals (Del-Rio et al., 1997). These groups of radicals (super oxides) may interact with biological systems in a clearly cyctoxic manner (Del-Rio et al., 1997).

Research has been conducted on the principle that free radicals can be blocked and/or scavenged (Del-Rio et al., 1997; Okwu, 2007). The different radicals responsible for cell oxidation process comprise the following: singlet oxygen ($^1O_2$), superoxide anion (O^{2-}), hydroxide radicals ($^{\cdot}OH$) and peroxide radical ($ROO^{\cdot}$) (Del-Rio et al., 1997; Okwu, 2007). The hydroxyl radical is the most cytotoxic of all these radicals. Also polyunsaturated fatty acids present in cell membranes are easily oxidized by both enzymatic and oxidative peroxidation through free radical chain reaction (Okwu, 2007). Initiation of lipid peroxidation can be induced by free radicals (super oxide, hydroxyl and singlet oxygen) produced in biological systems (Del-Rio et al., 1997). These electrically inert species have the ability to interaction and alter genetic materials. They exhibit cytotoxic, mutagenic and carcinogenic actions. It has been reported (Del-Rio et al., 1997; Okwu, 2007) that lipid peroxidation can be inhibited by flavonoids, which serve as strong radical scavengers and singlet oxygen quenchers. It has also been proposed that flavonoids react with peroxyl radicals bringing about the termination of the radicals reaction (Del-Rio et al., 1997; Okwu, 2007).

Extracts from the leaf of *C. splendens, N. latifolia*, *B. pinnatum* and *C. alata* are used as antioxidants. Antioxidant compounds are responsible for scavenging free radicals, which are produced during normal metabolism or during adverse conditions that can be harmful to biological systems and leading to death of an organism (Egereonu and Mokwe, 2005; El-Mahmood and Doughari, 2008; Shrivastava and Patel, 2007). The main antioxidant effect of these plants is as protective agent or prophylactics against the oxidative stress due to the high content of polyphenols, sesquiterpenoids, flavonoids, apigenin and hispudilin. It has been suggested (Nunesz-Selles, 2005) that the antioxidant activity of these plants might be due to their ability to scavenge oxidative chemical species (OCS) associated with the initiation of the lipid peroxidation. Organic and aqueous extracts of *C. splendens, C. alata, B. pinnatum and N. latifolia* showed significant inhibition of lipid peroxidation *in vitro* and *in vivo* induced by $FeSO_4$- ascorbic in rats (Egereonu and Mokwe, 2005; Shrivastava and Patel, 2007). This lends credence to the scientific support for the therapeutic use of the plant leaves as claimed in traditional medicine (Morah, 1994; Egereonu and Mokwe, 2005; Shrivastava and Patel, 2007; El-Mahmood and Mokwe, 2008). These plants have been variously reported as having antiallergic activity, anti-inflammatory, sedative, anti-bacterial and fungicidal action. In present life styles where stress conditions are common, leading to excess production of free radicals, these natural products will prove a support to our biological system to sustain and balance metabolism.

CONCLUSION

These plants at the moment grow in the wild. It is very important to conserve these medicinal plants which at the moment grow in the wild. Existing traditional sacred grooves, herbal gardens and forest areas rich in medicinal plants need to be studied to identify species that are at the verge of extinction so that adequate measures may be taken to conserve and multiply these plants. Multiplication techniques of the seeds should be encouraged through research. Information on the phytochemical profiles of these exotic medicinal plants should be disseminated to pharmaceutical firms which have been depending on the wild sources of medicinal plants for drug formulation. These plants offer wide-scope for utilization as raw materials for pharmaceutical industries. The pharmaceutical industries should undertake innovative research into the potential use of these plants for food and drug formulation.

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