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Pharmacological and phytochemical potentials of endophytic fungi from Nigerian medicinal plants: A review

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Abstract

Investigation of microorganisms for natural product is the new paradigm in drug discovery research. Microorganisms are obtained from different sources for this purpose, and plants are one of these sources. Endophytes usually present in the plant's cell walls have been confirmed to synthesize secondary metabolites similar or sometimes different from those of their host plants. This movement from plants to their endophytes for potential drug molecules led some researchers in Nigeria to investigate the endophytes (especially fungal endophytes) of some Nigerian medicinal plants for bioactive secondary. The current study tries to summarize the research so far conducted on fungal endophytes of Nigerian medicinal plants, and correlate the endophytes' secondary metabolites and their pharmacological activities with those of the host plants. To achieve this, research articles written in English were sourced from Google Scholar, PubMed, Science Direct and Scopus from the time scientific study on fungal endophytes started in Nigeria till date. Out of over 7000 plant species in the Nigerian biodiversity, only about only a few have had their endophytes scientifically explored for pharmacological activities and some of them generated novel bioactive compounds.

Keyword: Endophytic fungi; Secondary metabolites; Medicinal plants; Antimicrobial

1. Introduction

The continuous search for new therapeutic interventions for the management of a variety of human ailments have been the driving force behind the relentless research efforts directed towards discovering novel bioactive molecules (Okoye *et al*., 2013). This has led to scientist looking at unusual places, in order to discover the secondary metabolites of endophytic fungi. Endophytes are microorganisms associated with living plant tissues that produces no apparent indication of its presence in the plant and seems not to cause harm to the host (Bacon and White, 2000). They spend all or part of their life residing asymptomatically within the host plant tissues (Debbab *et al*., 2012) which allow them to generate a wide range of secondary metabolites, many of which have important biological activities and can be studied

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further for human health benefits (Ezebiora *et al*., 2021). Endophytes are an under-investigated group of microorganisms that represent a plentiful and renewable source of bioactive and chemically new compounds with potential for exploitation in a wide variety of medical, agricultural, and industrial realms (Strobel *et al*., 2004). There are approximately 300,000 different plant species inhabiting our planet and hence expected that each individual one has a complex community of one or more cultivable or uncultivable endophytic microorganisms (Strobel and Daisy, 2003; Ling *et al*., 2005).

Nigeria is rich in plant biodiversity, and these plants which are hosts to millions of endophytic microbial communities, present the opportunity to discover a plethora of pharmacological important compounds while also providing a sustainable source of natural products (Petrini and Petrini, 1985; Okoye *et al*., 2015; Abba *et al*., 2016; Eze *et al*., 2018 (a) and (b)). Studies on the endophytic fungal populations of Nigerian medicinal plants have highlighted the enormous potentials possessed by these organisms as sources of novel bioactive molecules, and the need to further explore Nigeria's plant biodiversity for endophytes producing biologically important molecules (Bazugbe *et al*., 2018). Several researchers in Nigeria have worked with a variety of native medicinal plants in pursuit of endophytes that could develop antimicrobial, anti-inflammatory, anticancer, antioxidative, and anti-leishmanicidal bioactive compounds (Ezebiora *et al*., 2021). These interests are borne out of the ecological, structural diversity and complexity of isolated compounds from endophytic population (Yuan *et al*., 2011).

Endophyte biology in recent time has attracted scientific attention and interest arising from approaches and methods used in classical plant pathology (Walker, 1957). Endophytes are believed to be obtained from all types of plant tissues and are believed to influence the development and, the ability of a plant to resist disease, drought, heat, cold and other insults (ASM, 2003) as well produce important compounds of pharmaceutical and commercial interest notably anticancer agents, antibiotics, novel immunosuppressive compounds, volatile antibiotic mixtures, antioxidants and most recently—fuel related hydrocarbons among others (Strobel, 2003 and Strobel, 2014). Strains of endophytic fungi are believed to have beneficial characteristics to their host plants as a result of the metabolites they produce either singly or in collaboration with their host plant (Kaul *et al*., 2012; Kusari *et al*., 2012). A typical example is the discovery of taxol-producing fungi, an anticancer agent indicated in the treatment of many types of cancer including breast cancer (Weaver, 2014; Roopa *et al*., 2015) as well as the subsequent production of cytotoxic quinone dimer, torreyanic acid isolated from the endophytic fungus, *Pestalotiopsis microspora* among others (Strobel *et al*., 1996).

Endophytic fungal populations of Nigerian medicinal plants have been studied and documented with their enormous potential as sources of novel bioactive molecules and the need to further explore Nigeria's plant biodiversity for endophytes producing biologically significant molecules highlighted (Uzor *et al.,* 2016 and Okoye, *et al.,* 2015). Therefore, this study present a detailed review that primarily focuses on Nigerian fungal endophytes population *viz-a-viz* reviewing the reported pharmacological activities of their induced secondary metabolites with a view to opening the frontiers for future scientific investigations and directions is a welcome development for the bioprospecting of fungal and bacterial endophytes for useful compounds.

2. Fungal endophytes from Nigerian medicinal plants

The many potentials of fungal endophytes as an alternative source of vast chemodiversity can reduce the timeline in the natural product drug discovery (Tiwari & Bae, 2022) . The advantage of fungal endophytes over higher plants in bio-prospecting of novel compounds is that they are a sustainable source of specific secondary metabolite and can be manipulated easily to produce other analogues of the active metabolite (Croteau, et al., 2006). This is possible through molecular and biotechnological processes such as genome mining and engineering, microbial culturing advances and optimization (Silber et al., 2016). Hence, they are prolific producers of bioactive metabolites of different chemical classes such as alkaloids, coumarins, flavonoids, glycosides, lignans, phenylpropanoids, quinones, saponins, terpenoids, and xanthones (Singh, et al., 2021). A good deal of research efforts has been spent on isolating and characterizing some of the fungal endophytes colonizing medicinal plants in Nigeria. However, the focus of this report is to summarize some of the findings of several researchers concerning fungal endophytes discovered from Nigerian medicinal plants as shown in table 1

Table 1 Fungal endophytes from Nigerian medicinal plants

Name of plant	**Plant part used**	**Fungal endophytes isolated**	**Refs.**
Loranthus micranthus (Loranthaceae)	Leaves	*Aspergillus* sp., *Nigrospora* oryzae	(Abba *et al.,* 2016); Ebada *et al*., 2016)
Vernonia amygdalina (Asteraceae)	Leaves	fungal endophyte	(Okezie *et al*., 2017)
Annona muricata (Annonaceae)	Leaves	*Pseudofusicoccum* sp. (family Botryosphaeriaceae)	(Abba et al., 2018)
Moringa oleifera	Leaves	*Aspergillus* sp.	(Abonyi et al., 2018)
Carica papaya (Caricaceae)	leaves	*Colletotrichum gloeosporioides* (anamorph), *Fusarium equiseti, Epicoccum sorghinum* and *Aspergillus aculeatus.*	(Abonyi et al., 2019; Eze, et al., 2019 a,b; Okezie, et al.,2021)
Catharanthus roseus L (Apocynaceae)	Leaves	unidentified fungal endophyte	.(Akpotu et al., 2017)
Euphorbia hirta L (Euphorbiaceae)	Leaves	unidentified fungal endophyte	.(Akpotu *et al.*, 2017)
Cola nitida vent (Malvaceae)	Leaves	*Trichoderma harzianum, Trichophyton sp.*	(Chen *et al.,* 2015; Damour *et al.,* 2015; Nwobodo *et al.*, 2017)
Psidium guajava inn. (Myrtaceae)	leaves, stem	unidentified endophyte, *Lasiodiplodia theobromae*	(Enyi *et al*., 2019; Ujam *et al.,*2020)
Newbouldia laevis (P. Beauv.) (Bignoniaceae)	Leaves	unidentified fungal endophyte	(Eze *et al*., 2019; Ibrahim *et al*., 2021)
Ocimum gratissimum (Lamiaceae)	Leaves	unidentified fungal endophyte	(Eze *et al*., 2019)
Gongronema latifolium (Asclepiadaceae)	Leaves	*Corynespora cassiicola*	(Okoye, *et al.,* 2013a,b)
Ageratum conyzoides L. (Asteraceae)	Leaves	fungal endophyte unidentified	(Ujam *et al.,* 2019)
Azadirachta indica	Leaves	*Aureobasidium* sp*., Aspergillus* sp*., Penicillium* sp and *Sordaria* sp	(Nnanna *et al*., 2018; Ujam *et al.*, 2020)
Combretum dolichopetalum)Engl. and Diels (Combretaceae),	Leaves	*Nigrospora oryzae*	(Uzor *et al.,* 2015)
Anthocleista djalonensis	Leaves	*Colletotrichum gloeosporioides*	(Uzor *et al.,* 2016)
Fagara zanthoxyloides (Rutaceae)	Leaves	*Pestalotiopsis thea*	(Uzor *et al*., 2016)
Morinda lucida	Leaves	*Neurospora discrete*	(Sowemimo *et al.,* 2008)
Bryophyllum Pinnatum	Leaves	*Diaporthe phaseolorum*	(Sowemimo *et al.,* 2008)
Jatropha gossypiifolia	Leaves	*Aspergillus japonicas*	(Sowemimo *et al.*, 2008)

Alstonia Boonei	Stem barks	*Macrophomina* sp.,*Trichoderma* sp., *Aspergilus niger*	(Tolulope *et al.,* 2018)
Enantia chlorantha	Stem barks	*Penicillium citrinum*	(Tolulope *et al.*, 2018)
Kigelia Africana	Stem barks	*Penicillium nigricans*	(Tolulope *et al*., 2018)
Albizia zygia (Fabaceae)	Leaves	unidentified fungal endophyte	(Ibrahim *et al.,* 2021
Alchornea cordifolia (Euphorbiaceae)	Leaves	unidentified fungal endophyte	(Ibrahim *et al.,* 2021)
Ficus exasperata Vahl (Moraceae)	Leaves	unidentified fungal endophyte	(Ibrahim *et al.*, 2021)
Millettia thonningii (Fabaceae)	Leaves	unidentified fungal endophyte	(Ibrahim *et al.*, 2021)
Euphorbia hirta.L. (Euphorbiaceae)	Leaves	unidentified fungal endophyte	(Akpotu, *et al.*, 2017)
Garcinia kola ((Guttiferae)	Leaves	*Collectotrichum* sp*Aspergillus* sp., and *Fusarium* sp.	(Nwobodo, *et al*., 2020)

3. Pharmacological properties of extracts/secondary metabolites of the fungi

There are several pharmacological activities of endophytic fungi previously reported, which have established the use of endophytic fungi as alternative sources of therapeutic secondary metabolites outside medicinal plants. Some reported pharmacological activities of Nigerian medicinal plants endophytic fungi includes antimicrobial, antioxidant, immunomodulatory and cytotoxicity which have been extensively studied as shown in table 2.

3.1. Antimicrobial activities

Five different endophytic fungi extract coded CR-MR1B, CR-MR1, CR-MR3, CR-MRB2 and CR-LC isolated from *catharantus roseus* demonstrated good antimicrobial activities against test microorganisms. CR-MR1 showed mic of 0.5 mg/ml against *S. typhi*, *E. coli*, *A. fumigatus* and *C. albicans* whereas *S. aureus* and *B. subtilis* were not inhibited. CR-MR1B showed MIC of 1 mg/ml against *S. aureus*, *B. subtilis*, *S. typhi* and *A. fumigatus* whereas *C. albicans* was 0.5 mg/ml. CR-MRB2 showed MIC of 1 mg/ml against only *B. subtilis*. CR-MR3 showed MICs of 0.25mg/ml against *S. aureus*, *B. subtilis*, *S. typhi*, *C. albicans* whereas *E.coli* was 0.5mg/ml. CR-LC showed MICs of 0.0625ng/ml against *S. aureus*, 0.03125mg/ml against *B. subtilis*, 0.25 mg/ml against *S. typhi*, 0.125mg/ml against *E.coli* but *A. fumigatus* and *C. albicans* were not inhibited at any concentration. The result indicated that CR-LC and CR-MR3 possesses antibacterial properties and CR-MR1 and CR-MR1B are good candidates for further development as antifungal agents (Akpotu et al., 2017). The extract of *aspergillus spp.* isolated from *moringa olifeira* showed antimicrobial activities comparable to standard ciprofloxacin and miconazole. At concentration range of 1-4 mg/mL, only *B. subtilis* and *K. pneumonia* were inhibited with IZDs ranging from 1-5 mm but *S. aureus*, *E. coli*, *S. pneumonia* were not inhibited. At concentration range of 2-4 mg/mL *C. albicans* was inhibited with an IZD of 3-5 mm but *A. niger* was not inhibited. If the extract is be purified further, the activities could improve significantly as against the standard drugs (Abonyi et al., 2018). Two endophytic fungi extract labeled LA(1) and LC(2) were isolated from *Euphorbia hirta* exhibited antimicrobial activities. LA(1) recorded MICs ranging from 0.25-0.5mg/ml against all test microorganisms but LC(2) recorded mic of 1mg/ml against *S. typhi* and *E. coli*. From the result the extract of LA(1) demonstrated broad spectrum antimicrobial activities as it inhibited gram positive and gram negative bacteria and fungi used in the assay (Akpotu et al., 2017). The extract of *pseudofusicoccum spp.,* an endophytic fungus isolated from *Anona muricata* showed mild antimicrobial activities. At concentration of 1 mg/mL, it inhibited *B. subtilis*, *S. typhi* and *C. albicans* with IZDs of 2 mm, 3 mm and 2 mm respectively but *S. aureus*, *E.coli* and *A. niger* were not inhibited. The standard drug ciprofloxacin used at concentration of 50 µg/ml inhibited all test organisms with IZDs ranging from 5-14 mm (Abba et al., 2018). Extracts of endophytic fungi labeled GA and GC isolated from *Psidium guajava* were subjected for antimicrobial activites against pathogenic microorganisms. The result showed that at 1 mg/mL concentration, GA inhibited all the test organisms: *E. coli*, *S. aureus*, *B.subtilis*, and *S.typhi* with IZDs of 5 mm, 6 mm, 5 mm, and 4 mm respectively but GC inhibited only *S. aureus* with IZD of 7 mm. From the result,

GA demonstrated broad spectrum antimicrobial activities compared to GC (Enyi et. al., 2019). Extract of endophytic fungi *Colletotrichum gloeosporiodes* isolated from *Carica papaya* was subjected to antimicrobial assay by agar well diffusion method. The result showed that at concentration ranging from 1-4mg/ml only *K. pneumonia* was inhibited with IZD ranging from 1-5mm but *S. aureus*, *B. subtilis*, *S. pneumonia*, *P. aeruginosa*, *E. coli*, *A. niger* and *C. albicans* were not inhibited at any concentration (Abonyi et al., 2019). Four endophytic fungi coded AILI, AISI, AIS2 and AIL3 were subjected to antimicrobial activity against some pathogenic microorganisms. The results of the mics showed that AIL1 had MIC of 0.125 mg/mL for *K. pneumoniae*, 0.25 mg/mL for *C. albicans* and 0.25 mg/mL for *P. aeruginosa*. Extract of AIL3 had an MIC of 0.25 mg/ mL for *S. aureus* and *B. subtilis*; 0.125 mg/mL for *S. typhi* and 0.0625 mg/mL for *P. aeruginosa* and *K. pneumoniae*. Extract of AIS1 showed MIC of 0.25 mg/mL for *B. subtilis*, *S. typhi* and *C. albicans* and 0.125 mg/mL against P. aeruginosa. Extract of AIS2 had MIC of 0.125 mg/mL for *B. subtilis*, *P. aeruginosa*, *S. typhi* and *K. pneumonia* and MIC of 0.5 mg/mL for *C. albicans.* It can be concluded from this results that extract of AIL3 had the best antibacterial activity while extract of AILI gave better antifungal activity (Ujam et al., 2020). The extract of *Aspergillus* isolated from *Loranthus micranthus* was subjected to antimicrobial evaluation against four bacterial and two fungi. The results showed that at concentration of 1.25 mg/mL, *S. aureus*, *K. pneumonia*, and *B. subtilis* recorded IZDs of 2 mm, 2 mm and 4mm respectively. *B. subtilis*only recorded IZD of 3 mm at concentration of 0.625 mg/mL. There was no inhibition zone diameter recorded for *C. albicans* and *A. fumigatus*. This establishes that the *aspergillus* endophyte isolated from *Loranthus micranthus* had no antifungal activity (Abba et al., 2016). Extract of *Lasiodiplodia theobromae* isolated from stem of *Psidium guajava* were screened for antimicrobial activity. The MIC determination showed that *S. aureus*, *S. typhi*, *K. pneumonia* and *C. albicans* were inhibited at concentration of 0.25mg/ml but *P. aeruginosa* had MIC at concentration of 0.0625mg/ml. *B. subtilis* and *A. niger* were not inhibited at any concentration (Ujam et al., 2020). An endophytic fungus with code name ACL4 isolated from *Ageratum conyzoides* was subjected to antimicrobial activity against bacterial and fungal clinical isolates. The antimicrobials test showed that at concentration of 1mg/mL, *P. aeruginosa* and *S. typhi* were inhibited with IZDs of 8 mm and 5 mm and *C. albicans* and *A. niger* were inhibited with IZDs of 3 mm and 2 mm respectively. The MIC recorded for *P. aeruginosaand S. typhi* were 0.0625 mg/mL and 0.0312 mg/mL respectively whereas MICs of 0.5 mg/mL and 1 mg/mL were recorded for *C. albicans* and *A. niger*.

3.2. Antioxidants activities

Seven endophytic fungi coded CP1-CP7 were isolated from *Carica papaya* leaves. The free radical scavenging capacity of the extracts of the isolated endophytic fungi on DPPH were evaluated. The results showed that at highest concentration of 100µg/ml the percentage inhibition recorded for as follows: Cp1 54.7±3.2, Cp5 51.3±3.5, Cp2 51.0±2 and Cp7 50.0±3 respectively. This suggested a concentration dependent inhibition of extract of endophytes against radical scavengers. The extracts of Cp3, CP4 and CP6 did not inhibit free radical scavenging capacity at any concentrations (Okezie et al., 2020). Extracts of endophytic fungi labeled GA and GC isolated from *Psidium guajava* were screened for antioxidant activity using DPPH. The result suggested that both endophytic fungi extract showed significant antioxidant activity with inhibition value of 56.7% and 55.2% respectively (Enyi et al., 2019). In another antioxidant activity investigation involving *pseudofusicoccum spp* isolated from *A. muricata*, the result showed good antioxidant activity with inhibition value of 96%. Three phenolic compounds isolated from the endophytic fungi corroborated the observed activity as phenolic compounds are known to exhibit antioxidant activity (Abba et al., 2016). The extract of endophytic fungi, *C. gloeosporioides* isolated from *Carica papaya* showed weak antioxidant activity with an inhibition value of 28% using DPPH anti-oxidant assay (Abonyi et. al., 2019). Also, Abonyi et al., 2018 isolated *Aspergillus spp* from *Moringa olefeira* which was afterwards screened for antioxidant activity and the result showed good antioxidant activity with inhibition value of 72.1%.

3.3. Cytotoxicity study

Three compounds isolated from an endophytic fungus *Trichoderma harzianum* of *Cola nitida* origin were subject to cytotoxicity assay against murine lymphoma cell line (L518Y), ovarian cancer A2780 sens and A2780 CinS cell lines. The result showed that 18-deoxycytochalasin H demonstrated best cytotoxic effect with IC_{50} value of 6.55µm whereas 4-hydroxy-deacetyl-18- deoxycytochalasin H and deacetyl-18- deoxycytochalasin H had IC50 values of 0.19 and 0.42 µm respectively (Huiquin et al. 2015). The extract of endophytic fungi *C. gloeosporioides* isolated from *Carica papaya* was screened for cytotoxicity against ovaria cancer lines A2780 sens and A2780 CinR with growth inhibition value 35.42% and 15.7% respectively. The result indicated moderate cytotoxicity effect of the extract (Abonyi et al., 2019). Secalonic acids D&F, Asperdicgrome, RF 3192C were compounds isolated from endophytic fungus *Aspergillus aculeatus* from *Carica papaya*. The result showed that the four compounds demonstrated cytotoxicity with IC_{50} of 3.4, 1.4, 7.3 and 23.7 µm respectively. About 19 other compounds isolated from this endophytic fungus which proved to be inactive at concentration of 10 µm (Hao et al. 2018). Two compounds pretrichodermaamide A and Nafuredin were isolated from *trichoderm spp* of *cola nitida* were screened for cytotoxicity against mouse lymphoma cell line using microculture tetrazolium MTT assay. The result showed that none of the compounds exhibited cytotoxicity at concentration of 10 µm (Damour 2015). The extract of aspergillus sp endophytic fungus isolated from was screened for cytotoxicity against

cisplatin sensitive ovarian cancer cell line A2780 sens and cisplatin sensitive ovaria cancer A2780 CinR. The result showed that at 100 µm the extract exhibited good cytotoxicity with growth inhibition of 105% and 105.5% respectively. The result suggested a concentration dependent because at 10 µm the extract showed very poor cytotoxic with inhibition of 8.69% and 3.04% respectively (Abonyi et al., 2018).

Table 2 Pharmacological activity of compounds isolated from endophytic fungi of some Nigerian medicinal plants

Name of plants	Part used	Endophytes	Compound isolated	Bioassay conducted	Inference	Reference(s)
Gongronema latifoliium	Leaf	*Corynespora cassiicola*	Corynesidone A,C&D Cornether	Inhibition of inflammatory mediators	active	(Okoye et al., 2013)
Psidium guajava	Leaf	*KL-1.1*	cytochalasin			Okoye et al 2015
Carica papaya	Leaf	*Aspergillus aculeatus*	Aculeatine A-J	Cytotoxicity	Inactive	Hao et al 2018
			Secalnoic acid D&F	Cytotoxicity	Active	
			Asperdichrome	Cytotoxicity	Active	
			RF 31920	Cytotoxicity	Active	
		Fusarium equiseti	Equisetin 5'-equisetin	-	-	(Eze et al., 2019)
		Epicoccum sorghinum	Tenuazonic acid	-	-	
Loranthus micranthus	Leaf	*Nigrospora oryzae*	Guaijaverin Isoquercetin Hyperin			Sheriff et al 2016
Cola nitida	Leaf	*Trichoderma spp*	Pretrichodermamide A	Cytotoxicity	Inactive	(Damour et al., 2015)
			Nafuredin	Cytotoxicity	inactive	
		Trichoderma harzianum	4-hydroxy-deacetyl-18-deoxycytochalasin H	Cytotoxicity	Active	Huiqin et al.,2015
			deacetyl-18-deoxycytochalasin H	Cytotoxicity	Active	
			18-deoxycytochalasin H	Cytotoxicity	Active	
Moringa oleifera	Leaf	*Aspergillus spp*	4-hydroxyphenylacetic acid	Antimicrobial Antioxidants	Inactive Active	(Abonyi et al., 2018)
			Ferulic acid	Antioxidants Antifungal Antibacterial	Active Active Inactive	
Anona muricata	Leaf	*Pseudofusicoccum spp*	Tryosol	-	-	(Abba et al., 2018)
			Protocatechuic acid	-	-	

			p-hydroxyphenylacetic acid	-	-	
Athocleista djalonensis	Leaf	*Colletotrichum gloeosporioides*	4-hydroxy benzoic acid	Antiviral	Active	(Uzor et al., 2016)
			Vanillic acid	Antiviral	Active	
			Ferulic acid	Antiviral	Active	
			N-acetyltryptamine	Antiviral	Active	
Fagara zanthoxyloides	Leaf	*Pestalotiopsis thea*	Chloroisosulochrin	Antiviral	Active	(Uzor *et al.*, 2016)
			Ficipyrone A	Antiviral	Active	
			Pestheic acid	Antiviral	Active	
Combretum dolichopetalum	Leaf	*Nigrospora oryzae*	4-dehydroxyaltersolanol A S-7-hydroxyabscisic acid s-abscisic acid	-	- -	(Uzor *et al.*, 2015)
Morinda lucida	Leaves	*Neurospora Discrete*	Multiforisin I and 4-hydroxyphenylacetic acid	Cytotoxic activity	Active	(Sowemimo *et al.,* 2008)
Bryophyllum pinnatum	Leaves	*Diaporthe phaseolorum*	cytochalasin D and (3*R*,4*R*)-3,4,5-trihydroxy-1-tetralone	Cytotoxic activity	Active	(Sowemimo *et al*., 2008)
Jatropha gossypiifolia	leaves	*Aspergillus japonicus*	(+)-eupenoxide and microsphaerone C	Cytotoxic activity	Active	(Sowemimo *et al.*, 2008)

4. Compounds isolated from endophytic fungi

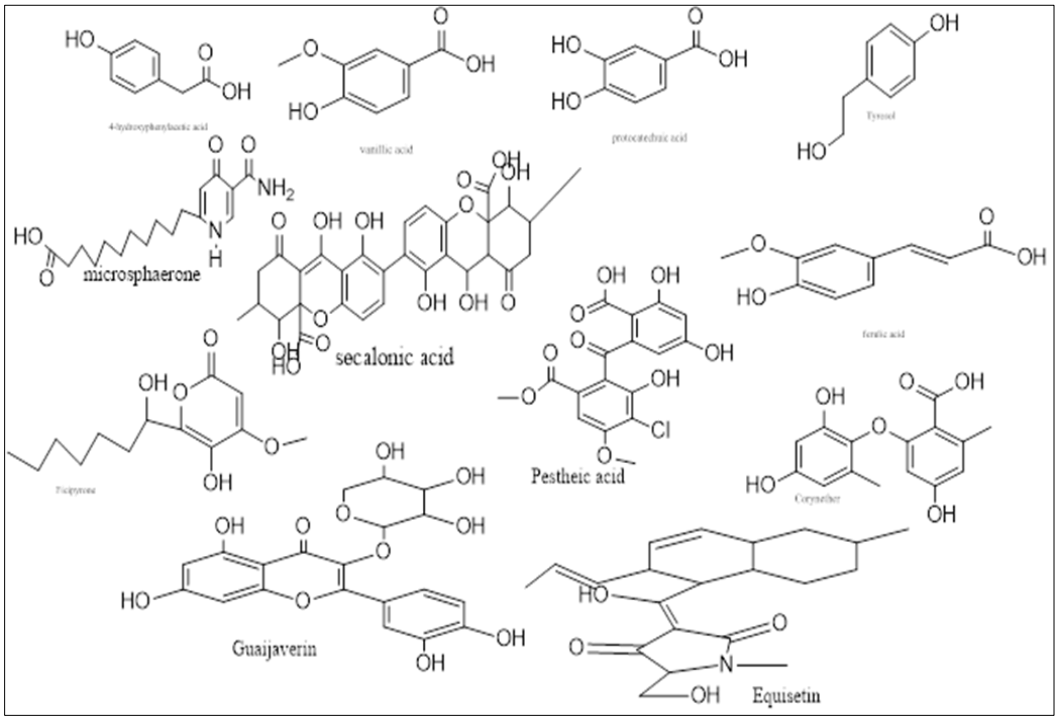

Figure 1 Some structures of compounds isolated from endophytic fungi from medicinal plants

Several class of compounds have been isolated from Nigerian medicinal plant fungi endophytes. These compounds have been studied in details for pharmacological activity and a hand full of them gave a good result. The followings are some of the isolated and characterized compounds as shown in figure 1.

5. Conclusion

The study has demonstrated that Nigerian medicinal plant habour endophytic fungi with copious amount of secondary metabolites. This showed that such can serve as alternative route for the search of novel bioactive compounds intended for the development of new drug molecules.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest by the authors .

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