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PHYTOCHEMICAL SCREENING AND ANTIFUNGAL ACTIVITY OF SAWDUST AND STEM BARK EXTRACTS FROM *Erythrophleum suaveolens* (GUILL. & PERR) BRENA

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ABSTRACT

This study was carried out to investigate the antifungal potentials of stem bark and sawdust of Erythrophleum suaveolens. Stem bark was collected from Federal University of Agriculture (FUAM) while sawdust sample was collected from Timber Shed Makurdi. Both samples were air dried while the stem bark was ground into powder for extraction. Extraction of samples was done sequentially by macerating 1000 g and 600 g of stem bark and sawdust, respectively using 1 L (w/v) of n-hexane for 24 hours and filtering off the hexane extract followed by ethyl acetate and methanol in that order for 24 hours each. Extracts were filtered and evaporated to obtain dried extracts and yields calculated. Phytochemical screening of samples was carried out according to AOAC standard methods. Diffusion method was used for antifungal screening of extracts. Sabouraud Dextrose agar was prepared as media in Petri dishes where Zones of Inhibition were observed for fungal growth. Minimum Inhibitory Concentration (MIC) of extracts was determined according to broth dilution technique at 40 mg/mL, 20 mg/mL, 10 mg/mL, 5 mg/mL and 2.5 mg/mL. Minimum Fungicidal Concentration (MFC) determined by sub culturing MIC to determine the least concentration at which fungi were killed. Percentage yield of extract was highest (5.19 %) in stem bark and lowest (0.12 %) in sawdust. Methanol extracts had the highest yield (5.19 % and 3.42 %) for stem bark and sawdust followed by ethyl acetate (1.06 % and 0.36 %) and n' hexane (0.16 % and 0.12 %), respectively. Flavonoids, glycosides, saponins, steroids, and tannins were in the stem bark while, anthraquinones, saponins and tannins were completely absent in the E. suaveolens sawdust. Zones of Inhibition (ZOIs) of antibiotics ranged between 27 mm – 35 mm while ZOIs for crude extracts ranged from 18 mm – 28 mm. At MIC of 5 mg/mL, E. suaveolens stem bark methanol extract inhibited Coniophora puteana and Fomitopsis pinicoca growth. At MFC of 10 mg/mL the same microbes were killed. Erythrophleum suaveolens stem bark methanol can be used in the control of brown-rot decay and stem decay caused by Coniophora puteana and Fomitopsis pinicoca.

Keywords: Antifungal, brown-rot decay, stem decay, *Erythrophleum suaveolens*, *Coniophora puteana*, *Fomitopsis pinicoca*, *Antimicrobial*, *Aspergillus fumigatus.*

INTRODUCTION

Wood is an invaluable resource to humankind on account of its countless excellent material properties (Hill, 2006). Unfortunately, wood is disposed to biodegradation (Daniel, 2016).

Fungi decay wood in a process that involves breaking down complex chemical compounds, primarily cellulose and lignin (Ravindra *et al.* (2013). The fungi that decay wood are the main recyclers of wooden materials in ecosystems. In the absence of these fungi, wood may never decay. Fungi consume cellulose and lignin in wood which results to white rot or brown rot (Ravindra *et al.* (2013). Chemical wood preservatives have been used amongst others as means of wood decay control. These synthetic chemicals are highly toxic and injurious to man and environment. As a result, less toxic, biodegradable and more environmentally friendly fungicide or bio-pesticides derived as wood

preservatives are being sort for as alternatives (Cavdar, 2014).

Erythrophleum suaveolens belong to the family Caesalpinioideae is used in different places for treating some diseases (Nyamukuru *et al.*, 2017). The stem bark of *E. suaveolens* has been reported by Mgbenka and Ejiofor (1999) to be anaesthetic activity. (Fadeyi *et al.*, 2013) noted its use against convulsion. *E. suaveolens* has analgesic and anti-inflammatory properties (Dongmo *et al.*, 2001). The plant contains Erythrophleguine which has been proven to have anti-fungal activity (Onuorah, 2000) and cardiotoxic effects (Collings *et al.*, 1990).

Studies on stem bark of *E. suaveolens* have been reported by Akinpelu *et al.,* (2012); Ogundeko *et al.* (2015); Aiyegoro *et al* (2007). However, only a few studies have been carried out on its heartwood for bio-pesticidal potentials. Sawdust is generated as waste from the wood in timber industry but can be utilized economically. Some heartwood of tropical species posses high amount extractive phyto-constituents (Saha *et al.* 2013). Akhator *et al.* (2017) reported that wood waste generation in Nigeria has constantly increased overtime because of low average percentage timber recovery. Sawdust has become a nuisance to public health and the environment in Makurdi town due to indiscriminate disposal by saw mills along the banks of river Benue. The main objective of this study is to investigate the antifungal activity of stem bark and sawdust extracts of *E. suaveolens* against selected wood fungi.

MATERIALS AND METHODS

Collection and Preparation of plant materials for extraction

The sawdust of *E. suaveolens* was collected from a Timber Shed in Makurdi, Benue State, Nigeria. The collection was done by first identifying species before sawing. During sawing, a mat was spread under the table bearing the circular saw to ensure only *E. suaveolens* was sawdust collected. Stem bark of the species was collected from FUAM campus (7.7322° N, 8.5391° E). Samples were air dried and the stem bark pulverised p to extraction.

Crude extraction of stem bark and sawdust

Extraction of dried sawdust and stem bark samples was carried out in the Chemistry Laboratory at the FUAM. Extraction of *E. suaveolens* stem bark and sawdust was done sequentially by macerating 1000 g and 600 g (Wo) of stem bark and sawdust into 1000 mL (w/v) of n-hexane for 24 hours and filtering off the hexane extract. The marc from the hexane extraction was sequentially macerated again with ethyl acetate and methanol respectively, for 24 hours. The extracts were filtered with Whatman No. 1 filter papers into pre-weighed labelled glass bottles (w_1). The filtrates were evaporated using electric fan (blow dried) to obtain dried extracts and the bottles reweighed (w_2). Percentage extraction yield was calculated according to the formula below adopted by (Anokwuru, *et al.*, 2011).

$$\% \, Extact \; Yield \; = \frac{W2-W1}{Wo} x100 \; \text{....equation 1}$$

Where:

% Yield = Percentage yield of extract; W_2 = Average weight of dried extracts; W_1 = Average weight of filtrate; Wo = weight of the initial dried sample.

Phytochemical screenings of *E. suaveolens* stem bark and sawdust

Qualitative phytochemical screening of the samples was carried out according to AOAC, (2010) standard methods as follows:

Test for alkaloids

To test for alkaloids, 1½ g of stem bark and sawdust extracts was dissolved in 5 mL of 1% HCl on steam bath and 1 mL of the filtrate was treated with some drops of Dragendorff's reagent. Turbidity or precipitation indicated the presence of alkaloids (Akinnibosun and Edionwe 2015).

Test for tannins

Stem bark and sawdust extracts (1.0 g) was stirred with 10 mL sterile distilled water and filtered with Whatman No. 1 filter paper. The resultant blue colouration from the addition of $FeCl_3$ reagent to the filtrate indicated that tannin was present (Akinnibosun and Edionwe 2015).

Test for steroids

Acetic anhydride (2 mL) was added to 0.5 g stem bark and sawdust extracts of *E. suaveolens* with concentrated H_2SO_4 (2 mL). The colour changed from violet to blue or green in some samples indicating the presence of steroids (Akinnibosun and Edionwe 2015).

Test for saponins

From each stem bark and sawdust sample, 1 g was individually boiled with 10 mL of distilled water

in a bottle bath for 10 minutes. The mixture was filtered hot and allowed to cool. From the filtrate, 2.5 mL was diluted to 10 mL with distilled water and shaken strongly for 2 minutes; the formation of froth that was stable for fifteen minutes indicated the presence of saponins in the filtrate (Akinnibosun and Edionwe 2015).

Test for Cardiac Glycosides Legal's test

To the aqueous or alcoholic extract, add 1ml of pyridine and 1ml of sodium nitroprusside. Pink to red colour appears (Dons *et al.*, 2015).

Test for anthraquinones

mLChloroform (5 mL) was added to the stem bark (0.5 g) and sawdust samples (0.5 g). The mixture was shaken for 5 minutes and filtered. The filtrate was shaken with equal volume of 10 % ammonia solution. The presence of a bright pink colour in the aqueous layer indicated the presence of anthraquinones (Akinnibosun and Edionwe 2015).

Test for Flavonoids

Solution of 5 g of extracts was put into a test-tube containing 10 mL ethyl acetate solution. The mixture was heated in boiling water for 1 min and filtered. About 4 mL of filtrate was shaken with 1 mL of 1 % aluminium chloride solution and left to remain for 10 mins. The formation of a yellow colouration in the presence of 1 mL of dilute ammonia solution indicated the presence of flavonoids (Akinnibosun and Edionwe, 2015).

Test for carbohydrates

Three test tubes with 2 mL of plant extract in each separate test tube were added to 5 mL distilled water and 5 - 8 drops of Fehling's solution. This mixture was heated over a water bath. A red brick precipitate indicated the presence of carbohydrates (Berame and Mercado 2017).

Glycosides

Dilute 25 mL of sulphuric acid was added to the 5mL extracts and placed in separate test tubes and boiled for 15 minutes. The mixture was cooled and neutralized with 10% NaOH. Solution of 5 mL of Fehling was added to the plant extracts. The formation of red brick precipitates indicated the presence of glycosides (Berame and Mercado 2017).

Antifungal Screening and Sensitivity on Test fungi

Antifungal screening was done at Nigerian Institute for Leather Science and Technology (NILEST), Zaria. Diffusion method described by Akinpelu and Onakoya (2006) was used to screen extracts. Initial concentration of extracts was done by dissolving sample (0.4 g) in Dimethyl sulfoxide (DMSO) (10 mL) to obtain a concentration of 40 mg/mL for antifungal activity determination. Media were prepared in accordance with manufacturer's manual and purified at 121^{o}C for a period of 15 mins. The media was emptied into germ-free Petri dishes and left to cool and harden. Sabouraud Dextrose agar was seeded with a standard inoculum (0.1 mL) of the test fungi spread uniformly on the surface of the medium with aid of a disinfected swab. Cork borer measuring 6 mm in diameter was utilized to cut a well at the middle of each injected medium. In the well, on the inoculated medium, a solution of 0.1 mL of sample of 40 mg/mL concentration was introduced at 30 ^{o}C for 1-7 days after which media plates observed for ZOI of fungi growth. The zones were measured with a transparent meter rule and results recorded in millimeters.

Determination of minimum inhibitory concentration (MIC)

The MIC of the plant extracts was determined according to broth dilution technique (Andrew, 2001). Standardised suspensions of the test organisms (*Aspergillus fumigatus, Coniophora puteana, Fibroporia vaillantii, Fomitopsis pinicoca, Gloeophyllum sepiarium Phaeolus schweinitzii, Rhizopus* sp., *Serpula lacrymans* and *Sclerotium rolfsii*) were inoculated into plate, including antibiotics (Fulcin, Ketoconazole and Fluconazole) as control. Sabouraud dextrose broth containing plant extracts in decreasing concentrations: 40 mg/mL, 20 mg/mL, 10 mg/mL, 5 mg/mL and 2.5 mg/mL and incubated at 37 ^{O}C for 24 hours. After overnight incubation these tubes were observed for turbidity. The plates showing no minimum turbidity were noted for MIC.

Minimum Fungicidal Concentration (MFC)

The MFC was determined by first selecting tubes that showed no growth during MIC determination; a loopfull from each tube was sub-cultured onto extract free agar plates, incubated for further 24

hours at 37 ^{o}C. The least concentration, at which no growth was observed, was noted as the MFC.

Data Analysis

One-way Analysis of Variance (ANOVA) was used to determine significant ZOI. Follow up test was carried out using Duncan Multiple Range Test (DMRT) where significant differences exist.

RESULTS

Result of percentage yield of *E. suaveolens* extracts is presented in Table 1. It was observed that percentage yield of extract was highest (5.19 %) in stem bark and lowest (0.12 %) in sawdust. The result also showed that methanol solvent had highest extract yield (5.19 % and 3.42 %) in stem bark and sawdust followed by ethyl acetate (1.06 % and 0.36 %) and n' hexane (0.16 % and 0.12 %), respectively.

Phytochemicals in *E. suaveolens* were more in the stem bark compared to sawdust (Table 2). High presence of tannins was observed in *E. suaveolens* stem bark and absent in the sawdust (Table 2). There was moderate presence of glycosides and saponins in the stem bark; these were absent in the sawdust. Steroids and flavonoids were moderate in the stem bark but low in the sawdust. Also, alkaloids and anthraquinones were present in the stem bark and absent in the sawdust. On the contrary, cardiac glycoside was present in sawdust and absent in the stem bark.

Table 1: Percentage Yield of *E. suaveolens* Ethyl acetate, Methanol and N-Hexane Extracts

S/No.	Solvent	Plant Extracts	Weight of Sample before extraction (g)	Weight of Dried Yield of Extract (g)	Percentage Yield of Extracts (%)	Colour
1	Ethyl acetate	*E. suaveolens* stem bark extract	1000	3.6	0.36	Dark Brown
		E. suaveolens sawdust	600	6.4	1.06	Dark Brown
2	Methanol	*E. suaveolens* stem bark extract	1000	51.9	5.19	Dark Brown
		E. suaveolens sawdust	600	20.5	3.42	Purple
3	N-Hexane	*E. suaveolens* stem bark extract	1000	1.6	0.16	Dark Yellow
		E. suaveolens sawdust	600	0.7	0.12	Golden Yellow

Table 2: Qualitative Phytochemical Screening of *Erythrophleum suaveolen* Sawdust and Stem Bark

Phytochemicals	Stem bark	Sawdust
Alkaloids	+	-
Anthraquinones	+	-
Carbohydrates	++	+
Cardiac glycosides	-	++
Flavonoids	++	±
Glycosides	++	-
Saponins	++	-
Steroids	++	±
Tannins	+++	-

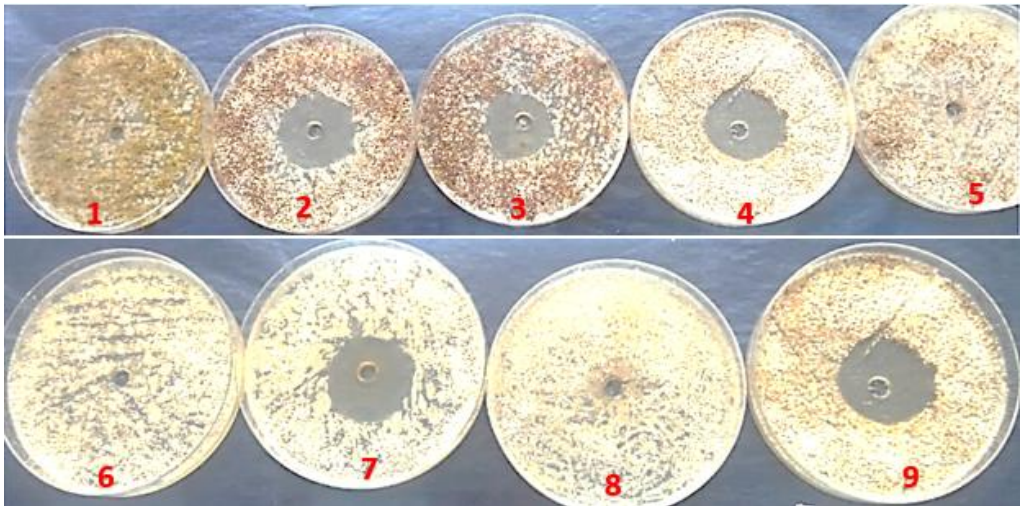
Key: – absent; ± low presence; + slight presence; ++ moderately presence; +++ high presence

Antifungal Activities and Zone of Inhibition (ZOIs) of Standard Antibiotics against Test Fungi

Fulcin was the most potent of the three antibiotics of Fulcin, ketoconazole and Fluconazole against test fungi (Table 3). Fulcin was very active on all fungi microbes at ZOIs of between 29 mm and 35 mm but resistant to *Fibroporia vaillantii* and *Phaeolus schweinitzii*. This was followed by ketoconazole which was very active against *Fibroporia vaillantii*, *Gloeophyllum sepiarium* and *Phaeolus schweinitzii* at ZOIs of 28 mm, 29 mm and 30 mm, respectively. Fluconazole was least active on test fungi. It was active on *Coniophora puteana* and *Sclerotium rolfsii at* ZOIs of 27mm and 28 mm, respectively. ZOIs among the antibiotics were not significant ($p>0.05$).

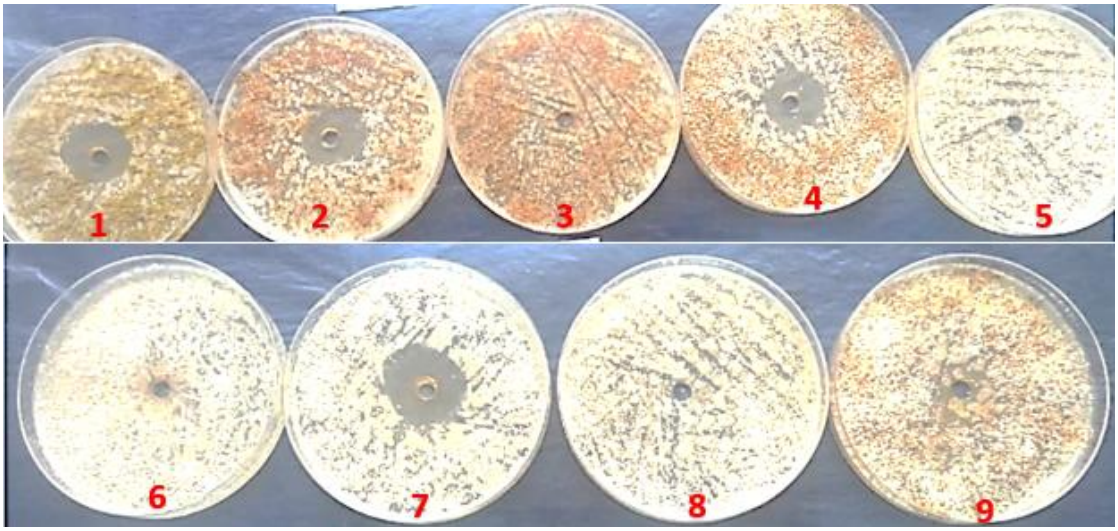
Antifungal activities and Zone of Inhibition (ZOIs) of *E. suaveolens* Crude Extracts against Test Fungi

The photographs of antifungal activities of *E. suaveolens* stem bark and sawdust ethyl acetate crude extracts on test fungi are showed in plates Plates 1 and 2, respectively. *E. suaveolens* stem bark extracts were more active. They were active against *Fibroporia vaillantii* , *Fibroporia vaillantii* , *Phaeolus schweinitzii*, and *Sclerotium rolfsii* at range of ZOIs of 18 mm – 28 mm, while *Aspergillus fumigatus* and *Rhizopus* sp. were sensitive to *E. suaveolens* sawdust extracts at ZOIs of 18 mm - 26 mm (Table 3). The result also revealed that *Coniophora puteana* and *Fomitopsis pinicoca* were sensitive to all *E. suaveolens* stem bark and sawdust extracts at ZOIs of 18 mm – 28 mm. On the contrary, as *Gloeophyllum sepiarium* and *Serpula lacrymans* were resistant to both stem bark an sawdust extracts; *Aspergillus fumigatus* and *Rhizopus* sp. were resistant to only stem bark, while *Fibroporia vaillantii*, *Phaeolus schweinitzii*, and *Sclerotium rolfsii* were resistant to only sawdust extracts. Methanol extracts were most active compare to ethyl acetate and N-hexane extracts. ZOIs among all crude extracts were not significant ($p>0.05$).



Key: 1- *Aspergillus fumigatus,* **2**- *Coniophora puteana,* **3**- *Fibroporia vaillantii*,**4**- *Fomitopsis pinicoca,* **5** - *Gloeophyllum sepiarium,* **6** - *Phaeolus schweinitzii,* **7** - *Rhizopus* sp., **8** - *Serpula lacrymans*,**9** - *Sclerotium rolfsii*

Plate 1: Photograph of antifungal activities of *E. suaveolens* stem bark ethyl acetate crude extract



Key: 1 - *Aspergillus fumigatus*,**2** - *Coniophora puteana*, **3** - *Fibroporia vaillantii*, **4**- *Fomitopsis pinicoca,* **5** - *Gloeophyllum sepiarium,* **6** - *Phaeolus schweinitzii,* **7** - *Rhizopus* sp., **8** - *Sclerotium rolfsii*,**9** - *Serpula lacrymans*

Plate 2: Photograph of antifungal activities of *E. suaveolens* sawdust ethyl acetate crude extract

Table 3: Effect of Antifungal activities and Zone of Inhibition (ZOIs) of *E. suaveolens* Crude Extracts against Test Fungi

S/No.	Test Fungi	ES Ethyl acetate extract	ES Methanol extract	ES N-Hexane extract	ESS Ethyl acetate extract	ESS Methanol extract	ESS N-Hexane extract	Fulcin 100 µm/mL	Keteconazole 100 µm/mL	Fluonazole 100 µm/mL
		AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE	AFA (ZOI) Mean±SE
1	*Aspergillus fumigatus*	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (21.00±1.00^{b})	S (24.00±1.00^{b})	S (18.00±1.00^{b})	S (32.00±1.00^{bc})	R (0.00±0.00^{a})	R (0.00±0.00^{a})
2	*Coniophora puteana*	S (25.00±2.00^{b})	S (28.00±2.00^{b})	S (20.00±5.00^{b})	S (23.00±3.00^{b})	S (26.00±1.00^{b})	S (20.00±3.00^{b})	S (30.00±1.00^{bc})	R (0.00±0.00^{a})	S (27.00±1.00^{b})
3	*Fibroporia vaillantii*	S (24.00±4.00^{b})	S (26.00±1.00^{b})	S (21.00±4.00^{b})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (28.00±1.00^{b})	R (0.00±0.00^{a})
4	*Fomitopsis pinicoca*	S (23.006.00^{b})	S (27.00±1.00^{b})	S (20.00±2.00^{b})	S (20.00±6.00^{b})	S (23.00±6.00^{b})	S (18.00±7.00^{b})	S (31.00±1.00^{bc})	S (29.00±1.00^{b})	R (0.00±0.00^{a})
5	*Gloeophyllum sepiarium*	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (35.00±1.00^{c})	R (0.00±0.00^{a})	R (0.00±0.00^{a})
6	*Phaeolus schweinitzii*	S (24.00±1.00^{b})	S (26.00±3.00^{b})	S (18.00±4.00^{b})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (30.00±1.00^{b})	R (0.00±0.00^{a})
7	*Rhizopus sp*	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (23.00±1.00^{b})	S (26.00±2.00^{b})	S (20.00±3.00^{b})	S (29.00±1.00^{b})	R (0.00±0.00^{a})	R (0.00±0.00^{a})
8	*Serpula lacrymans*	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (34.00±1.00^{bc})	R (29.00±1.00^{b})	R (0.00±0.00^{a})
9	*Sclerotium rolfsii*	S (23.00±2.00^{b})	S (26.00±2.00^{b})	S (18.00±8.00^{b})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	R (0.00±0.00^{a})	S (31.00±1.00^{bc})	R (0.00±0.00^{a})	S (28.00±1.00^{b})

Key: S = Sensitive, R = Resistance, ES=*Erythrophleum suaveolens stem* back ESS = *Erythrophleum suaveolens* sawdust, AFA = Antifungal Activities, ZOI = Zone of Inhibition. When, ZOI < 10 mm is inactive; 10 -13 mm is partially active; 14 -19 mm is active, and >19 mm is very active (Guevara, 2005).Effect of MIC *E. suaveolens* crude extracts against test Fungi, SE = Standard error

Methanol extract of *E. suaveolens* stem bark was the most active of all the crude extracts as it inhibited the growth of *Coniophora puteana* and *Fomitopsis pinicoca* at MIC of 5 mg/mL (Table 4). At MIC of 10 mg/mL, the growth of the majority of test fungi was prevented by all stem bark and sawdust extracts. *Aspergillus fumigatus* and *Fomitopsis pinicoca* growth was only inhibited by sawdust N-hexane extract at MIC of 20 mg/mL. However, *Gloeophyllum sepiarium* and *Serpula lacrymans* growth was not affected by any of the crude extracts. It was also observed that stem bark crude extracts were more active than sawdust crude extracts as the former controlled five test fungi and the later four.

Effect of Minimum Fungicidal Concentration (MFC) of *E. suaveolens* crude extracts against test fungi

Table 5 shows MFC of *E. suaveolens* crude extracts on test fungi. ES Methanol extract was the most potent extract as it was the only extract that completely killed test fungi (*Coniophora puteana*, *Fomitopsis pinicoca* and *Fomitopsis pinicoca*) at MFC of 10 mg/mL. A greater number of test fungi were killed at MFC of 20 mg/mL by stem bark ethyl acetate, ES methanol, sawdust ethyl acetate and sawdust methanol extracts. This was followed by MFC of 40 mg/mL by stem bark N-hexane, sawdust ethyl acetate and ESS N-hexane extracts. It was observed that the growth of *Gloeophyllum sepiarium* and *Serpula lacrymans* was not affected by any of the crude extract.

Table 4: Effect of Minimum Inhibition Concentration (MIC) of *E. suaveolens* crude extracts on Different Fungi Species

S/No	Test Fungi	ES Ethyl acetate extract					ES Methanol extract					ES N-Hexane extract					ESS Ethyl acetate extract					ESS Methanol extract					ESS N-Hexane extract				
		Conentration (mg/mL)					Concentration (mg/mL)					Concentration (mg/mL)					Concentration (mg/mL)					Concentration (mg/mL)					Concentration (mg/mL)				
		40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5
1	*Aspergillus fumigatus*	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	##
2	*Coniophora puteana*	-	-	δ	+	#	-	-	-	δ	+	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#
3	*Fibroporia vaillantii*	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
4	*Fomitopsis pinicoca*	-	-	δ	+	#	-	-	-	δ	+	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	##
5	*Gloeophyllum sepiarium*	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
6	*Phaeolus schweinitzii,*	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
7	*Rhizopus* sp.	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#
8	*Serpula lacrymans*	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
9	*Sclerotium rolfsii*	-	-	δ	+	#	-	-	δ	+	#	-	-	δ	+	#	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

Key: ES = *Erythrophleum suaveolens stem* bark; ESS = *Erythrophleum suaveolens* sawdust; R = Resistance; - = No turbidity (no growth); **δ =** Minimum inhibition concentration (MIC); **+=** Scanty colony growth; **#** = Moderate colony; ## = High turbidity.

Table 5: Effect of Minimum Fungicidal Concentration (MFC) of *E. suaveolens* crude extracts on Different Fungi Species

S/N	Test Fungi	ES Ethyl acetate extract					ES Methanol extract					ES N-Hexane extract					ESS Ethyl acetate extract					ESS Methanol extract					ESS N-Hexane extract				
		Concentration (mg/mL)					Concentration (mg/mL)					Concentration (mg/mL))					Concentration (mg/mL)					Concentration (mg/mL)					Concentration (mg/mL)				
		40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5	40	20	10	5	2.5
1	*Aspergillus fumigatus*	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	δ	+	#	##	##	-	δ	+	#	##	δ	+	#	##	##
2	*Coniophora puteana*	-	δ	+	#	##	-	-	δ	+	#	δ	+	#	##	##	-	δ	+	#	##	-	δ	+	#	##	δ	+	#	##	##
3	*Fibroporia vaillantii*	-	δ	+	#	##	-	δ	+	#	##	δ	+	#	##	##	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
4	*Fomitopsis pinicoca*	-	δ	+	#	##	-	-	δ	+	#	δ	+	#	##	##	δ	+	#	##	##	-	δ	+	#	##	δ	+	#	##	##
5	*Gloeophyllum sepiarium*	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
6	*Phaeolus schweinitzii,*	-	δ	+	#	##	-	δ	+	#	##	δ	+	#	##	##	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
7	*Rhizopus* sspp.	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	-	δ	+	#	##	-	δ	+	#	##	δ	+	#	##	##
8	*Serpula lacrymans*	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
9	*Sclerotium rolfsii*	-	δ	+	#	##	-	δ	+	#	##	δ	+	#	##	##	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

Key: ES = *Erythrophleum suaveolens stem* bark; ESS = *Erythrophleum suaveolens* sawdust; R = Resistance; - = No colony growth; **δ =**Minimum fungicidal concentration (MFC); **+** = Scanty colonies growth; **#** = Moderate colonies growth; ## = Heavy colonies, ## - Very heavy colonies

DISCUSSION

The percentage yield of plant extracts was directly affected by type of solvent used for the extraction in this study. This agrees with Sharma and Cannoo (2016) who reported that extractive yield of extract is influenced by the kind of extraction methods or solvents and their extraction competence. Methanol extracts had the highest percentage yield than ethyl acetate and n-hexane extracts. This result also supports the finding of Anokwuru *et al.* (2011) who observed that methanol was a better solvent for the extraction than ethanol, acetone, and ethyl acetate.

The content rations of flavonoids, glycosides, saponins, steroids, and tannins were more in stem bark while, anthraquinones, saponins and tannins were completely absent in the *E. suaveolens* sawdust. This explains why stem bark extracts were more active compared to sawdust extracts. Saha *et al.* (2013) reported catechin, gallic acid, and pyrogallol in *E. suaveolens* extracts as the major phenolic compounds used as a source of antioxidants with a potential to preserve food.

ZOIs of antibiotics of between 27 mm and 35 mm were as active as crude extracts of *E. suaveolens* with ZOIs that ranged from 18 mm to 28 mm against test fungi. This range is above the one reported by Igbinosa *et al.* (2009) on antifungal activity of *Jatropha curcas* stem bark at ZOI which ranged from 12 mm - 18 mm; 15 mm – 20 mm and 5 mm – 10 mm for ethanol, methanol and water extracts respectively.

At MIC of 5 mg/mL, *E. Suaveolens* stem bark methanol extract inhibited *Coniophora puteana* and *Fomitopsis pinicoca* growth. *Coniophora puteana* and *Fomitopsis pinicoca* were killed by *E. suaveolens* stem back methanol extract at MFC of 10 mg/mL. This result implies that *E. Suaveolens* stem bark methanol can be applied in the control of brown-rot decay and stem decay caused by *Coniophora puteana* and *Fomitopsis pinicoca* respectively. *Aspergillus fumigatus, Coniophora puteana, Fomitopsis pinicoca,* and *Rhizopus* sp. were killed by *E. suaveolens* sawdust extract at 20 mg/mL. Cimanga *et al.* (2004) reported MFC of 0.125 mg/mL and 0.062.5 mg/mL from 80% MeOH and n-hexane crude extract of *Mitracarpus scaber* on *Aspergillus flavus.* Onuorah, (2000) reported that heartwood methanol extract of *E. suaveolens* and *Milicia excelsa* applied on sapwood of *Ceiba pentandra* at 48.056Kg/m^3 or 96.11 kg/m^3 concentrations were active in suppressing the attacks of either *Lenzites trabea* (a brown rot fungus) or *Polyporous versicolor* (a white rot fungus). *Aspergillus fumigatus* is implicated in disease in immuno-deficient individuals (invasive aspergillosis) (Denning, 1998). Activity of sawdust extracts against *Aspergillus fumigatus* is pleasantly surprising as most crude extracts from plants are in-effective against it (Sharanya *et al.*, 2013; Cui *et al.*, 2019).

CONCLUSION

Motivated by ethnobotanical applications of *E. suaveolens* and wood waste mitigation, sawdust and stem bark extracts of the plant were investigated. Percentage yields of extracts were directly affected by plant part and extraction solvent type. Phytochemicals were more in stem bark of *E. Suaveolens* than the sawdust extracts. Methanol crude extracts were most active against fungi and *Coniophora puteana* and *Fomitopsis pinicoca. E. Suaveolens* stem bark methanol can be applied in the control of brown-rot decay and stem decay of wood caused by *Coniophora puteana* and *Fomitopsis pinicoca* respectively. Most notably, saw dust extracts were found to be active against *Aspergillus fumigatus,* a fungus, which is usually resistant to extracts from plants.

Recommendations

Crude extracts of *E. suaveolens* can be used as alternative to synthetic fungicides. Isolation and characterisation of the anti- *Aspergillus* principle from sawdust is a prospect towards realisation of an eco-friendly fungicide is highly recommended.

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