

Antibacterial activities of sawdust and stem bark of Sasswood tree (*Erythrophleum suaveolens*, Guill. & Perr. Brenan, 1917) extracts against selected wood bacteria

*Ekhuemelo, D. O.¹, and Ekhuemelo C.² Tembe E.T.¹

¹Department of Forest Production and Products, Federal University of Agriculture Makurdi, Nigeria.

²Department of Crop and Environmental Protection, Federal University of Agriculture Makurdi, Nigeria

Abstract

This study assessed the antibacterial properties of sawdust and stem bark of *Erythrophleum suaveolens* extracts on selected wood bacteria. *Erythrophleum suaveolens* samples were collected, dried and macerated by dissolving 1 Kg and 0.60 Kg of stem bark and sawdust respectively into 1 L of n-hexane, ethyl acetate and methanol. Sporfloxacin ciprofloxacin and cefuroxime antibiotics were used as control. The mixture was left for 24 hours then filtered and the filtrates evaporated to dryness. Qualitative phytochemical screening, zone of inhibition, minimum inhibitory and Bactericidal Concentrations (MIC/MBC) were determined according to standard methods. Tannins, steroids, saponins, glycosides, flavonoids, carbohydrates anthraquinones and alkaloids phytochemicals were present in *E. suaveolens* extracts. Zone of inhibition (32 – 37 mm) of antibiotics on test bacteria compared favourably with 17 – 24 mm of *E. suaveolens* extracts. *Erythrophleum suaveolens* ethyl acetate and methanol *E. suaveolens* extracts inhibited *Staphylococcus aureus*, *Ralstonia solanacearum*, *Proteus mirabilis*, *Enterococcus faecium* and *Acidobacterium capsulatum* growth at MIC of 10 mg/mL and n-hexane extracts at 20 mg/mL. At MBC of 20 mg/mL methanol stem bark extract completely killed most test bacteria. Methanol extracts were the most active extracts. The study has shown that *E. suaveolens* extracts can be explored in the control of plant diseases caused by test bacteria in the study.

Key words: Antibacterial, *E. suaveolens*, extract, phytochemicals, zone of inhibition

*Correspondent email: davidekhuemelo@gmail.com; +234-07031332803

Introduction

Wood is an essential and renewable natural resource. It is common in our daily lives with high economic importance and used in many areas such as in furniture and wood-frame houses. It is natural resources for the production of books, newspapers, textile fabrics; and magazines. It has application in bridge construction and railroad ties. Wood is also used as utility poles, fence posts and source of organic chemicals. Wood and wood products store carbon, therefore helping to reduce carbon dioxide in the atmosphere (Durbak et al. 1998).

Despite its remarkable usefulness, wood is decomposed by a range of biological agents, including insects, bacteria and fungi (Ekhuemelo et al., 2019). Bacteria are known as the principal degraders of wood and wooden structures mainly those recovered from oxygen-deficient environments (Singh et al., 2016). The relationship between bacteria and wood has been known since as six decades ago (Clausen, 1996). However, not much interest has been given to the activities of bacteria on deterioration of wood in relation to the extent of deterioration caused by wood degrading fungi. Wood is inhabited by bacteria which are associated with wood degradation

and could have an indirect influence on wood decay process. Bacteria can affect wood permeability, damage wood structure, or work in association with some bacteria and soft-rot fungi to dispose wood to fungal attack (Clausen, 1996).

Bacteria infecting wood may affect the permeability resulting in loss of strength, damage and destruction of wood structure (Greaves, 1971). Bacterial population varies depending on the state of wood decay as bacterial communities increase as the wood decomposition progresses (Hoppe et al., 2015). Bacteria that attack wood structure known as tunneling bacteria, degrade wood cell wall from the area of cell lumen where they start to multiply (Clausen, 1996). These bacteria are usually present in terrestrial and aquatic environments and can inhabit and degrade wood found in oxygenated environments and under conditions with very low levels of oxygen (Singh et al. 2016).

Erythrophleum suaveolens (Guill. & Perr. Brenan) tree belongs to the family Fabaceae. It is a very common medicinal plant in Africa. The tree bark is used as arrow poisons while the leaves are used as fish poison. Various preparations of the bark have been used to treat inflammations caused by Filaria, heart failure, headache, and body pains. The wood is appropriate for furniture, flooring, dock work, railway sleepers, turnery, construction, harbour and bridges, boat building and wheel hubs (Burkill, 1985; Akinpelu et al. 2012).

Synthetic chemicals such as creosote, Copper Chrome Arsenic (CCA), Alkaline Copper Quaternary (ACQ) and synthetic pyrethroids are persistent and toxic to the environment and human. The uses of bio-pesticides from this study are eco-friendly, biodegradable, cost effective, less toxic and readily available for wood preservation in Nigeria. This has resulted in the need for the use of bioactive compounds as alternatives (Clausen, 1996). Although extracts from this plant have been used for medicinal purposes, there is dearth of information on its antibacterial activities on wood tunneling and erosion bacteria. This study therefore focused on assessing the effect of the sawdust and stem bark extracts in the management of wood degrading bacteria.

Materials and Methods

Plant collection and preparation for extraction

The sawdust of *E. suaveolens* was obtained from a Timber Shed in Makurdi, Benue State, Nigeria. *Erythrophleum suaveolens* logs were first identified at the Timber Shed while the sawdust was carefully collected during sawing. Stem bark of the tree was collected from the Federal University of Agriculture; Makurdi campus located at Latitudes 7° 45' N to 7° 52' N and longitude 8° 35' E to 8° 4' E (Uleh et al. 2017). The samples collected were air dried and the stem bark crushed prior to solvent extraction.

Crude extraction of stem bark and sawdust

The extraction of *E. suaveolens* stem bark and sawdust was done by macerating 1 Kg and 0.60 Kg of the stem bark and sawdust into 1 L of n-hexane separately for 24 hours and filtered. The residue from the hexane extraction was equally macerated again with ethyl acetate and methanol respectively within 24 hours. The extracts were filtered and dried before antibacterial test.

Phytochemical screening of stem bark and sawdust of Erythrophleum suaveolens

Phytochemical tests for alkaloids, tannins, steroids, saponin, cardiac glycosides, anthraquinones, flavonoids, carbohydrates and glycosides of stem bark and sawdust samples were performed using standard methods adopted by Ekhuemelo et al. (2019).

Antibacterial Screening and Sensitivity on test bacteria

Antibacterial screening was carried out on *Staphylococcus aureus*, *Ralstonia solanacearum*, *Pseudomonas syringae*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Enterococcus faecium*, *Bacillus subtilis*, *Agrobacterium tumefaciens*, *Actinobacterium* sp. and *Acidobacterium capsulatum* using diffusion method described by Akinpelu and Onakoya (2006). The initial concentration of extracts was obtained by dissolving 0.4 g extract in 10 mL Dimethyl sulfoxide to give a concentration of 40 mg/mL.

Media were prepared in accordance with producer's guide and purified at 121 °C for a period of 15 minutes. The prepared media was poured into germ-free Petri dishes and left to cool and harden. Muller Houston agar was seeded with a standard inoculum (0.1 mL) of the test bacteria spread uniformly on the surface of the medium with the 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. Thereafter,

0.1 mL sample solution of 40 mg/mL concentration was introduced into the well of the inoculated medium and incubated at 37 °C for 24 hours. The media plates were observed for zone of inhibition (ZOI) of bacteria growth. The ZOI were measured and readings were recorded in millimeters.

Determination of minimum inhibitory and Bactericidal Concentrations (MIC/MBC)

The MIC of the *Erythrophleum suaveolens* extracts was determined using broth dilution technique (Andrew, 2001). Standardized suspensions of the test bacteria were inoculated into plates containing antibiotics (sporfloxacin, ciprofloxacin and cefuroxime) as control. Five concentrations of 40 mg/mL, 20 mg/mL, 10 mg/mL, 5 mg/mL and 2.5 mg/mL of the crude extracts were used to determine the minimum bactericidal concentration (MBC). The inoculated plates were incubated for 24

hours. Plates that showed no bacterial growth were recorded for MIC.

Data Analysis

Data on zone of inhibition was analyzed by one-way Analysis of Variance for significance differences. Mean separation was done using Duncan New Multiple Range Test (DNMRT) where significant means were recorded.

Results

Phytochemical screening of *Erythrophleum suaveolens* stem bark showed the presence of tannins, steroids, saponins, glycosides, flavonoids, carbohydrates anthraquinones and alkaloids. Cardiac glycosides were not present in the stem bark extract of *E. suaveolens*. The result also revealed that the sawdust extract contained steroids, flavonoids, cardiac glycosides and carbohydrates while tannins, saponins, glycosides, anthraquinones and alkaloids were absent.

Table 1: Phytochemical Screening of *Erythrophleum suaveolens* sawdust and stem bark

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

Key: – = Absent; + = Present

Sensitivity and Zone of inhibition of standard antibiotics and antibacterial activities against test bacteria

Sporfloxacin was active on all test bacteria at ZOI of between 32 – 35 mm with the exception of *Agrobacterium tumefaciens*, and *Ralstonia solanacearum* which were sensitive to ciprofloxacin at ZOI of 29 mm and 32 mm, respectively (Table 2). Cefuroxime had the highest ZOI of 37 mm on *Enterococcus faecium*. Although *Acidobacterium capsulatum* and *Pseudomonas aeruginosa* were resistant to ciprofloxacin and cefuroxime they were sensitive to Sporfloxacin at ZOI of 32 mm and 30 mm, respectively. There was no significant difference ($p > 0.05$) in the Zone of inhibition among the antibiotics.

The result in Table 2 shows that *E. suaveolens* extracts were sensitive to all test bacteria except *Pseudomonas syringae*, *Staphylococcus aureus*, *Ralstonia solanacearum*, *Proteus mirabilis*, *Enterococcus faecium*, *Actinobacterium sp.* and *Acidobacterium capsulatum* were sensitive to *E. suaveolens* stem bark extracts at zone of inhibition of 16 – 24 mm; while *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Enterococcus faecium*, *Bacillus subtilis*, *Agrobacterium tumefaciens* and *Acidobacterium capsulatum* were sensitive to *E. suaveolens* sawdust bark extracts at zone of inhibition of 17 – 21 mm. Although *Pseudomonas syringae* was resistant to all extracts, it was sensitive to sporfloxacin at zone of inhibition of 30 mm.

Table 2: Sensitivity and Zone of Inhibition of *E. suaveolens* Extracts and Standard Antibiotics against Test Bacteria

S/No	Test Bacteria	ES Ethyl acetate extract	ES Methanol extract	ES N-Hexane extract	ESS Ethyl acetate extract	ESS Methanol extract	ESS N-Hexane extract	Sporfloxacin	Ciprofloxacin	Cefuroxime
		ABA(ZOI)	ABA(ZOI)	ABA(ZOI)	ABA(ZOI)	ABA(ZOI)	ABA(ZOI)	ABA(ZOI)	ABA(ZOI)	ABA(ZOI)
1	<i>Staphylococcus aureus</i>	S (22.00±1.00 ^b)	S (24.00±1.00 ^{bc})	S (18.00±2.00 ^b)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	S (35.00±8.00 ^b)	S (32.00±8.00 ^{bc})	R (0.00±0.00 ^a)
2	<i>Ralstonia solanacearum</i>	S (21.00±1.00 ^b)	S (23.00±4.00 ^{bc})	S (18.00±3.00 ^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 (32.00±2.00 ^a)	R (0.00±0.00 ^a)
3	<i>Pseudomonas syringae</i>	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 (30.00±2.00 ^b)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)
4	<i>Pseudomonas aeruginosa</i>	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	S (21.00±4.00 ^b)	S (21.00±6.00 ^b)	S (19.00±2.00 ^b)	S (30.00±3.00 ^b)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)
5	<i>Proteus mirabilis</i>	S (20.00±2.00 ^b)	S (21.00±2.00 ^b)	S (18.00±4.00 ^b)	S (19.00±1.00 ^b)	S (20.00±1.00 ^b)	S (17.00±1.00 ^c)	S (32.00±5.00 ^b)	S (32.00±2.00 ^{bc})	R (0.00±0.00 ^a)
6	<i>Enterococcus faecium</i>	S (20.00±5.00 ^b)	S (22.00±1.00 ^{bc})	S (16.00±4.00 ^b)	S (20.00±3.00 ^b)	S (20.00±3.00)	S (17.00±2.00 ^c)	S (32.00±2.00 ^b)	R (0.00±0.00 ^a)	S (37.00±1.00 ^{cd})
7	<i>Bacillus subtilis</i>	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	S (19.00±7.00 ^b)	S (20.00±6.00 ^b)	S (17.00±3.00 ^c)	S (30.00±2.00 ^b)	S (31.00±1.52 ^{bc})	R (0.00±0.00 ^a)
8	<i>Agrobacterium tumefaciens</i>	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	S (20.00±5.00 ^b)	S (22.00±2.00 ^b)	S (18.00±8.00 ^c)	R (0.00±0.00 ^a)	S (29.00±1.00 ^b)	S (34.00±2.00 ^b)
9	<i>Actinobacterium sp.</i>	S (19.00±4.00 ^b)	S (21.00±1.00 ^b)	S (18.00±6.00 ^b)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)	S (35.00±1.00 ^b)	R (0.00±0.00 ^a)	S (35.00±2.00 ^{bc})
10	<i>Acidobacterium capsulatum</i>	S (20.00±1.00 ^b)	S (23.00±1.00 ^{bc})	S (17.00±1.00 ^b)	S (18.00±1.00 ^b)	S (20.00±2.00 ^b)	S (17.00±3.00)	S (32.00±1.00 ^b)	R (0.00±0.00 ^a)	R (0.00±0.00 ^a)

Key: S = Sensitive, R = Resistance, ES = *Erythrophleum suaveolens* stem bark, ESS = *Erythrophleum suaveolens* sawdust, ABA = Antibacterial Activities, ZOI = Zone of Inhibition, 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

Effect of Minimum Inhibitory Concentration (MIC) of E. suaveolens sawdust and stem bark extracts against test bacteria

The ethyl acetate and methanol *E. suaveolens* crude extracts of stem bark and sawdust effectively inhibited the growth of *Staphylococcus aureus*, *Ralstonia solanacearum*, *Proteus mirabilis*, *Enterococcus faecium* and *Acidobacterium capsulatum* at MIC of 10 mg/mL while their growth was inhibited at 20 mg/mL for hexane extracts (Table 3). At MIC of 20 mg/mL, the growth of the rest bacteria was controlled with the exclusion of *Pseudomonas syringae* which was resistant to all crude extracts.

Effect of Minimum bactericidal concentration (MBC) of E. suaveolens sawdust and stem bark extracts against test bacteria

Stem bark methanol extract was the most effective extract as it completely killed *Acidobacterium capsulatum*, *Ralstonia solanacearum* and *Staphylococcus aureus* at MBC of 20 mg/mL (Table 4). The remaining crude extracts became effective at MBC of 40 mg/mL on the test bacteria with the exception of *Pseudomonas syringae* which was completely resistant to all extracts.

Table 3: Effect of Minimum Inhibitory Concentration (MIC) of *E. suaveolens* Sawdust and Stem Bark Extracts against Test Bacteria

S/No.	Test Bacteria	ES					ES					ES					ESS					ESS					ESS				
		Ethyl acetate extract					Methanol extract					N-Hexane extract					Ethyl acetate extract					Methanol extract					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	<i>Staphylococcus aureus</i>	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
2	<i>Ralstonia solanacearum</i>	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
3	<i>Pseudomonas syringae</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
4	<i>Pseudomonas aeruginosa</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***
5	<i>Proteus mirabilis</i>	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***	-	δ	+	#	***	-	-	δ	+	#	-	δ	+	#	***
6	<i>Enterococcus faecium</i>	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***
7	<i>Bacillus subtilis</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	-	δ	+	#	***	-	-	δ	+	#	-	δ	+	#	***
8	<i>Agrobacterium tumefaciens</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***
9	<i>Actinobacterium sp.</i>	-	δ	+	#	***	-	-	δ	+	#	-	δ	+	#	***	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
10	<i>Acidobacterium capsulatum</i>	-	-	δ	+	#	-	-	δ	+	#	-	δ	+	#	***	-	δ	+	#	***	-	-	δ	+	#	-	δ	+	#	***

Key:

ES = *Erythrophleum suaveolens* stem bark, ESS = *Erythrophleum suaveolens* sawdust, γ = Resistance, - = No turbidity (no growth), δ = Minimum inhibition concentration (MIC), + = Light growth, # = Moderate turbidity, *** = High growth, ## = Very High growth

Table 4: Effect of Minimum Bactericidal Concentration of *E. suaveolens* Sawdust and Stem Bark Extracts against Test Bacteria
Key

S/No.	Test Bacteria	ES Ethyl acetate extract Concentration (mg/mL)					ES Methanol extract Concentration (mg/mL)					ES N-Hexane extract Concentration (mg/mL)					ESS Ethyl acetate extract Concentration (mg/mL)					ESS Methanol extract Concentration (mg/mL)					ESS N-Hexane extract 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	<i>Pseudomonas aeruginosa</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##
2	<i>Proteus mirabilis</i>	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##
3	<i>Staphylococcus aureus</i>	δ	+	#	+++	##	-	δ	+	#	+++	δ	+	#	+++	##	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
4	<i>Pseudomonas syringae</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
5	<i>Enterococcus faecium</i>	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##
6	<i>Ralstonia solanacearum</i>	δ	+	#	+++	##	-	δ	+	#	+++	δ	+	#	+++	##	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
7	<i>Bacillus subtilis</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##
8	<i>Agrobacterium tumefaciens</i>	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##
9	<i>Actinobacterium sp.</i>	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
10	<i>Acidobacterium capsulatum</i>	δ	+	#	+++	##	-	δ	+	#	+++	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##	δ	+	#	+++	##

ES = *Erythrophleum suaveolens* stem bark, ESS= *Erythrophleum suaveolens* sawdust. γ = Resistance, - = No colony growth, δ = Minimum Bactericidal concentration (MBC), + = Scanty colonies growth, # = Moderate colonies growth, +++ = Heavy colonies growth, ## = Very Heavy colonies growth

Discussion

Tannins, steroids, saponins, glycosides, flavonoids, carbohydrates anthraquinones and alkaloids phytochemicals were present in *Erythrophleum suaveolen* stem bark. Ukwubile et al. (2013) reported the presence of flavonoids, saponins, tannins, alkaloids, and anthraquinones in the fruit extract of *Raphia farinifera*. Tannins obtained from different parts of diverse plants have been reported by Lin et al, (2004) to possess prospective antiviral. Several authors also reported tannins as antibacterial and antiparasitic (Bhagavathi et al., 1999; Akiyama et al., 2001; Yang et al., 2000; Funatogawa et al., 2004; Tanimura et al, 2005). Flavonoids are phenolic chemical substances generally found in all vascular plants (Taleb-Contini, 2003). Okwu and Omodimiro, (2005) reported flavonoids to be active against platelet aggregation, allergies inflammation, and microbial infection. Saponins were reported to also exhibit the ability to kill or prevent cancer (Nwinuka et al., 2005; Okwu and Nnamdi, 2008). The phytochemicals found in *Erythrophleum suaveolens* plant implies that they could be important bioactive agents against wood bacteria.

The Zone of inhibition (32 – 37 mm) of antibiotics on test bacteria in this study compared favourably with 17 – 24 mm of *Erythrophleum suaveolens* extracts. Guevara, (2005) reported that when zone of inhibition of pesticides are < 10 mm; 10 -13 mm, 14 -19 mm, and >19 mm they are said to be inactive, partially active, active and very active, respectively. It therefore implies that the crude extracts of stem bark and sawdust of *E. suaveolens* in this study ranged from been active to very active, while the antibiotics were very active. Aiyegoro et al. (2007) obtained lower zone of inhibition of 10, 9, 10, 12, 9, 14, 11, 13 and 15 mm from aqueous fraction of *Erythrophleum suaveolens* on *Klebsiella pneumoniae*; *Pseudomonas putida*; *Escherichia coli*; *Micrococcus luteus*; *Streptococcus faecalis*; *Staphylococcus aureus*; *Staphylococcus aureus* (ATCC 5538); *Staphylococcus aureus* (NCIB 8588) and *Bacillus subtilis* (NCIB 3610) bacteria, respectively. Abubakar (2010) also reported lower ZOI for *Eucalyptus camaldulensis* aqueous extract against *Escherichia coli* (7 mm), *Klebsiella pneumoniae* (9 mm), *Proteus mirabilis*

(13 mm), *Salmonella typhi* (12 mm) and *Staphylococcus aureus* (12 mm) while acetone extract had ZOI *Escherichia coli* (12 mm), *Klebsiella pneumonia* (13 mm), *Salmonella typhi* (14 mm), *Proteus mirabilis* (15 mm) and *Staphylococcus aureus* (14 mm). Alhaji (2015) reported higher zone of inhibition from *Erythrophleum africanum* crude ethanol extract against *Staphylococcus aureus*, *Enterococcus faecalis*, *Enterobacter cloacae*, *Proteus mirabilis* and *Candida stellatoidea* as 25, 27, 29, 22 and 24 mm, respectively.

Minimum Bacterial Concentration is used to assess efficiency of test extract. Lower MBC indicates higher efficacy, while a higher MBC depicts lower effectiveness of extract. It therefore implies that MBC of *Erythrophleum suaveolens* methanol extract (20 mg/mL) obtained in this study was very active. *Erythrophleum suaveolens* crude ethyl acetate and methanol extracts were active at MIC of 10 mg/mL for most of the test bacteria while it was 20 mg/mL for hexane extracts. At MBC of 20 mg/mL methanol stem bark extract completely killed most test bacteria. Aiyegoro et al., (2007) reported the antibacterial potency of *Erythrophleum suaveolens* on some bacterial isolates with an MIC of the aqueous fraction of extract that ranging from 0.625 to 2.5 mg/mL and chloroform fraction ranging from 0.313 to 5.0 mg/mL. Abubakar (2010) observed a higher MIC of *Eucalyptus camaldulensis* aqueous extracts of 50, 25, 50, 50, and 25 mg/mL for *E. coli*, *P. mirabilis*, *S. typhi*, *S. aureus*) and *K. pneumoniae*, respectively.

A higher MBC from *Eucalyptus camaldulensis* aqueous extract was reported by Abubakar (2010) as 100 mg/mL for *E. coli*, and 50 mg/mL for *P. mirabilis*, *K. pneumoniae*, *S. typhi* and *S. aureus*, respectively. Similarly, *Eucalyptus camaldulensis* ethanolic extract as reported by Abubakar (2010) recorded a higher MBC of 50 mg/mL for *E. coli*, 25 mg/ml for *P. mirabilis*, 50 mg/ml for *K. pneumoniae*, *S. typhi* and *S. aureus*, respectively compared to the MBC obtained in this study. *Eucalyptus camaldulensis* acetone extract also recorded higher values of MBC of 50 and 12.5mg/mL for *E. coli* and *P. mirabilis* respectively and 25 mg/mL for *K. pneumoniae*, *S. typhi*, and *S. aureus* (Abubakar, 2010).

This study has demonstrated that *Erythrophleum suaveolens* extracts can be explored in the control of wood deterioration caused by the bacteria screened in this study such as wood-decay, cellulolytic and lignin-modifying activities, bacterial wilt, leaf-spot, soft rot and bark canker diseases.

Conclusion

This study has shown some bioactive phytochemicals such as tannins, steroids, saponins, glycosides, flavonoids, carbohydrates anthraquinones and alkaloids as been present in *Erythrophleum suaveolens*. *Erythrophleum suaveolens* methanol extracts were more active in comparison with ethyl acetate and n-hexane extracts. The finding from the study has revealed that *Erythrophleum suaveolens* extracts could control some bacteria of plants and animal disease.

References

Abubakar E.M. (2010). Antibacterial potential of crude leaf extracts of *Eucalyptus camaldulensis* against some pathogenic bacteria. African J. of Pl. Sci., 4(6): 202-209.

Aiyegoro, O. A. Akinpelu, D. and I Okoh A. I. (2007). In vitro Antibacterial Potentials of the Stem Bark of Red Water Tree (*Erythrophleum suaveolens*). J. of Biol. Sci. 7(7): 1233 – 1238.

Akiyama H, Kazuyasu F, Yamasaki O, Oono T and Iwatsuki K (2001) Antibacterial action of several tannins against *Staphylococcus aureus*. J. Antim. Chemo., 48 (48), 487-491.

Akinpelu B.A., Dare C.A., Adebesein F.I, Iwalewa E.O, Oyedapo O.O (2012). Effect of stem – bark of *Erythrophleum suaveolens* (Guill. & Perri.) saponin on fresh water snail (*Lanistes lybicus*) tissues. Afric. J. Env. Sci. & Tech. 6(11), 446-451.

Akinpelu D.A. and Onakoya T.M. (2006). Antimicrobial activities of medicinal plants used in folklore remedies in south-western. Afri. J. of Biotech., 5 (11): 1078-1081.

Alhaji, S. A. (2015). Phytochemical and antimicrobial studies of the stem bark extract of *Erythrophleum africanum* (Welw. ex Benth)

Harms. A Master degree Dissertation Ahmadu Bello University, Zaria. Pp 127.

Andrews, J. M. (2001). Minimum Inhibitory Concentrations. J. of Antim. Chemo., 49(6):1049.

Bhagavathi A, Narayanana, Otto Geoffroya, Mark C Willingham, Gian G. Reb, and Daniel W Nixona(1999) p53/p21 (WAF1/CIPI) expression and its possible role in G1 arrest and apoptosis in ellagic acid treated cancer cells. Cancer Letters. 136, 215-221.

Burkill H (1985). The Useful Plants of West Tropical Africa, 3: 116-120.

Clausen, C. A. (1996). Bacterial associations with decaying wood: a review. Int. Bio, and Biodeg., 101-107,

Durbak, I., Green, D. W., Highley, T. L., Howard, J. L., McKeever, D. B., Miller, R. B., Pettersen, R. C., Rowell, R. M., Simpson, W. T., Skog, K. E., White, R. H., Winandy, J. E., Zerbe, J. I. (1998). Wood. In: Kirk-Othmer Encyclopedia of chemical technology, 4th Ed. Vol. 25:627-664. J. Wiley & Sons, NY, NY.

Ekhuemelo, D. O., Agbidiye, F. S., Tee N.T., Tembe E.T., Ekhuemelo C. and Anyam, J. V. (2019). Phytochemical screening and antifungal activity of sawdust and stem bark extracts from *Erythrophleum suaveolens* (Guill. & Perr) Brena. J. of Res. in For., Wild. & Env., 11(1): 1-10.

Funatogawa K, Hayashi S, Shimomura H, Yoshida T, Hatano T, Ito H and Iría Y (2004) Antibacterial activity of hydrolysable tannins derived from medicinal plants against *Helicobacter pylori*. Microbiol. Immunol. 48 (4), 251-261.

Greaves, H. (1971). Bacterial factor in wood decay. W. sci. techn., 5: 6-16.

Guevara, B. Q. (2005). A Guidebook to Plant Screening: Phytochemical and Biological, Revised Edition, UST Publishing House, Manila. Pp 156.

Hoppe, B., Krüger, D., Kahl, T., Arnstadt, T., Buscot, F., Bauhus, J., and Wubet, T. (2015). A

pyrosequencing insight into sprawling bacterial diversity and community dynamics in decaying deadwood logs of *Fagus sylvatica* and *Picea abies*. Sci. Rep., 5(1). doi:10.1038/srep09456.

Lin LU, Shu-wen L, Shi-bo J and Shu-guang W. (2004) Tannin inhibits HIV-1 entry by targeting gp41. Acta Pharmacol Sin., 25 (2): 213-218.

Nwinuka N.M, Ibeh G.O, and Ekeke G.I. (2005). Proximate composition and levels of some toxicants in four commonly consumed spices. J. Appl. Sci. Env.. Manage. 9(1):150-155.

Okwu D.E, and Nnamdi F.U (2008). Evaluation of the chemical composition of *Dacryodes Edulis* and *Raphia Hookeri* Mann and Wendl exudates used in herbal medicine in South Eastern Nigeria. Afr. J. Trad. Comp. Alt. Med. 5(2):194-200.

Okwu DE, Omodamiro DO (2005). Effect of Hexane extract and phytochemical content of *Xylopi aethiopica* and *Ocimum gratissimum* on uterus of guinea pig. Bio.Res. 3(2): 40-44.

Singh, A. P., Kim, Y. S., and Singh, T. (2016). Bacterial Degradation of Wood. Secondary Xylem Biology, 169–190. doi:10.1016/b978-0-12-802185-9.00009-7.

Taleb-Contini, S. H., Salvador, M. J., Watanabe, E., Ito, I. Y., and Oliveira, D. C. R. de. (2003). Antimicrobial activity of flavonoids and steroids isolated from two *Chromolaena* species. Revista Brasileira de Ciências Farmacêuticas, 39(4), 403 – 408.

Tanimura S, Ryoji Kadomoto, Takashi Tanaka, Ying-Jun Zhang, Isao Kouno, and Michiaki Kohno (2005) Suppression of tumor cell invasiveness by hydrolyzable tannins (plant polyphenols) via the inhibition of matrix metalloproteinase-2/-9 activity. Biochem. Biophys. Res. Commun. 330, 1306 – 1313.

Ukwubile A. C, Olatu O. J, Babalola J. B. (2013). Evaluation of Ichthyotoxicity activity of *Raphiafarinifera*, (Gaertn.)Hyl. (Arecaceae) fruits extract. Stan, Res. J. of Toxi. and Env. Heal. Sci., 1(1): 17-20.

Uleh M., Ikyese C. and Ekhuemelo D. (2017). Ethnomedical study of plants used by indigenous people of Nyiev and Mbawa Districts, Makurdi, Benue State, Nigeria. GSC Biological and Pharmaceutical Sciences, 01(03), 001– 011.

Yang, C. L. and Kun-Ying Y. (2000). Induction of apoptosis by hydrolyzable tannins from *Eugenia jambos* L. on human leukemia cells. Cancer Letters. 157, 65-75.