

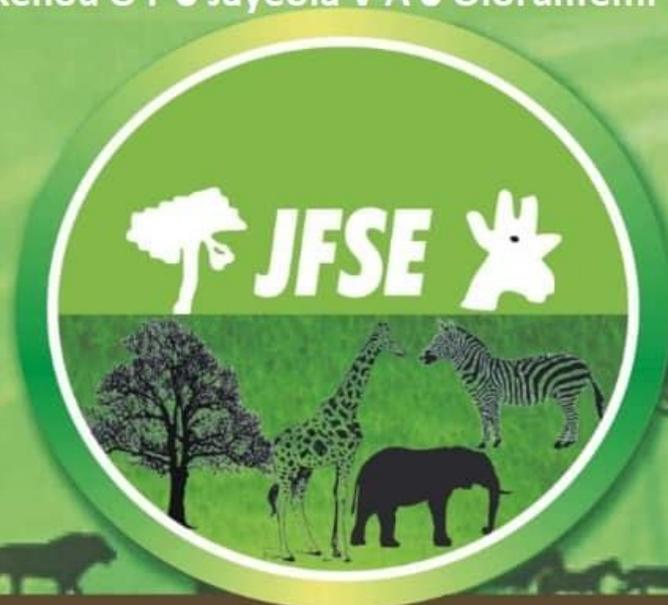


ISSN 2635-3296

Journal of Forest Science Environment.
Volume 7 (2022): 82 – 90

**Termiticidal Effect of *Enterolobium cyclocarpum*
(Jacq.) Griseb Bark Extract on *Anogeissus*
leiocarpus (DC.) Guill and *Gmelina*
arborea (Roxb.) Wood Species**

Ogunjobi K M ● Olufemi O O ● Chikwendu M U ●
Gakenou O F ● Jayeola V A ● Olorunfemi O



© Forestry and Wildlife Department, University of
Maiduguri, Nigeria

Website: www.jfseunimaid.com.ng



TERMITICIDAL EFFECT OF *ENTEROLOBIUM CYCLOCARPUM*
(JACQ.) GRISEB BARK EXTRACT ON *ANOGEISSUS*
LEIOCARPUS (DC.) GUILL AND *GMELENA ARBOREA* (ROXB.)
WOOD SPECIES

OGUNJOBI K M^a • OLUFEMI O O^a • CHIKWENDU M U^b • GAKENOU O F^c •
JAYEOLA V A^c • OLORUNFEMI O^a

^aDepartment of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Nigeria

^bDepartment of Forestry and Environmental Management Michael Okpara University of Agriculture Umudike, P.M.B 7267, Umuahia, Abia State, Nigeria

^cDepartment of Forestry and Wood Science, Stellenbosch University, South Africa

Corresponding author: ogunjobikm@funaab.edu.ng +2348033617468

ABSTRACT: The Termiticidal of *Enterolobium cyclocarpum* used as preservatives for termites attack on *Anogeissus leiocarpus* and *Gmelina arborea* were investigated. The bark of *E. cyclocarpum* were obtained from Nursery Unit of Department of Forestry and Wildlife Management, Federal University of Agriculture Abeokuta, Ogun State. Bark extract collected were air-dried and ground into powdered form and aqueous extract were prepared by boiling method at various concentrations of 24%,32%,40% and 48%. Wooden samples were collected and converted into 15 cm × 5 cm × 5 cm from local sawmill within Camp. FUNAAB. Samples were air-dried to 12% to reduce moisture content and treated with various concentration level and then left to dried before buried on the grave yard for six weeks. The retention level, absorption level, and percentage weight loss were assessed. A Randomized Complete Block Design (RCBD)with two fixed factors and 3 replicates were used for the experiment Data obtained were subjected to a descriptive statistics and Analysis of Variance (ANOVA) at P<0.05. From results obtained revealed that both the highest absorption level at (9.6%) and lowest absorption level (6.3%) was found in the wood billet of *A. leiocarpus* while the highest weight loss at (17.7%) was recorded in *G. arborea* and the lowest weight loss (12.3%) in *A. leiocarpus* respectively. Analysis of Variance indicated that the type of species and concentration level had significant effects at (P<0.05) on the retention capacity of the bark extracts. The phytochemical result reveals a high concentration of tannin and the least concentration of terpene. The effectiveness of the bark extract depends on the species and the concentration of the preservatives. Therefore, *E. cyclocarpum* extract could be exploited to develop new wood preservatives to protect wooden structures, timbers as these are less harmful and eco-friendly and promotes sustainability.

Keywords: Termite, Grave yard, Weight loss, Retention capacity and absorption level.

1. INTRODUCTION

The importance of wood to the survival of man is crucial and multifaceted. Man uses wood at all stages of life, from birth, and in most cases eventually conveyed in a wooden coffin in death. Man has been making use of wood for diverse purposes from time immemorial (Ogunjobi *et al.*, 2018). Despite the increase in the use of steel and plastic and plastic composite materials in building industries, wood is the most important renewable natural resource (Adetogun *et al.*, 2010). Due to diversity in nature and character in wood, exploitation of trees for structural and construction purposes was selective and limited to strong and durable species (Oluwafemi and Adegbeniga, 2007). Unfortunately, wood is naturally prone to damage by termites, decay fungi, harmful insects, or marine borers. These reduce the life span of wood and increase the pressure on the forest leading to deforestation and an increasing the rate of climate change. Therefore, wood needs to be protected by applying preservatives to protect timber against attack by termites and other economic problems (Faruwa *et al.*, 2015).

Wood is one of the oldest best known structural materials and one of the few renewable natural resources (Ekhuemelo *et al.*, 2020). Jerrold (2005), reported that wood is an extremely versatile material with a wide range of physical and mechanical properties; it is also a renewable resource with an exceptional strength to weight ratio. According to Jerrold, (2005) the demand for wood and wood products is increasing because it is valued for use in construction and bioenergy.

Wood preservation is the process of conditioning wood to increase its resistance to invading destructive organisms (fungi, insects, marine borers, and animals). The life span of wood in service can be improved by the use of chemicals (Femi-Ola *et al.*, 2008). Wood extracts are of considerable interest for wood protection because of their indigenously known pesticidal properties (Ejikeme *et al.*, 2014). However, plants produce a diverse number of secondary metabolites which play vital roles in defense against plant diseases (Ogunjobi and Thompson, 2016).

Termite is one of the major bio-deteriorating agents affecting the wood. It feeds on the wood component thereby reducing its structural ability and its appearance (Obi *et al.*, 2008). Termites had done a lot of damage to the trees by feeding on the bark, dead branches, the root, and the stem. Degradation of wood by termites is a chronic problem in many tropical regions and other countries, resulting in serious monetary and material losses with far-reaching impact on the increasing demand for timber (Obi *et al.*, 2008). It has therefore become

imperative to develop strategies towards elongating the life span of wood without jeopardizing the current and future health of the people.

Protection of wood and wood-based products against biological agents (*e.g.*, termites, insects) requires various synthetic chemicals worldwide. However, synthetic chemicals create environmental problems and negatively affect many beneficial insects and organisms (Abdullahi *et al.* 2012). Wood Extractives of Several wood species have a high natural resistance to decay due to the presence of diverse extractable chemical compounds collectively referred to as extractives. Extractives are diverse non-structural wood components produced by trees as defensive agents against environmental stresses and are mainly located in the heartwood (Singh and Singh, 2012).

Extractives isolated from naturally resistant heartwood and some plant species may provide alternatives in pest control because of their bioactive chemicals. In addition, plant extractives are biodegradable and they seem to help resolve environmental problems caused by synthetic pesticides (Ahmed *et al.*, 2009 and Ogunjobi *et al.*, 2020). The utilization of natural extracts for pest and termites' control has long been studied in the field of wood preservation. It has been reported that the extractives retain repellency and toxicity against some termite species (Tascioglu *et al.*, 2012; Okere *et al.*, 2021). Adeduntan, (2015) correlated the lower extractive content with reduced termite resistance.

This study was focused on using plant extracts as against chemical preservatives which contribute to global warming and environmental degradation. Plant extracts are natural, odourless, environmentally-friendly and less harmful to man. Therefore, this study evaluated the potentials of the bark of *E. cyclocarpum* at varying concentration levels.

2. MATERIALS AND METHODS

2.1. The study Area

The study was carried out at the Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta (FUNAAB). The land area of FUNAAB is about 10,000 hectares which is located next to Ogun-Osun River Basin Development Authority (ORBDA) along Alabata road in North Eastern part of the town, in Odeda local government, FUNAAB lies on latitude 7° 30'N and longitude 3° 54'E. It lies within the humid lowland forest region with two distinct seasons. The mean annual rainfall is 1113.1 mm with mean temperature range of 22.9 °C to 36.32 °C and relative

humidity is about 82.54% with. (Ufoegbune and Fabiyi, 2016).

2.2. Extract Preparation

The freshly bark of *E. cyclocarpum* of tree stand at diameter at breast height of 1.3m were collected from the Nursery Unit of department Forestry and Wildlife Management, (FUNAAB). The wood sample were washed with water and rinsed with distilled water. The bark was air dried for 4 weeks and later grind with Hammer mill. The powdered wood sample were sieve in a 2mm mesh to get the uniform fine dust particle. Soxhlet extraction method was used to extract the bark content based on the procedure adopted by (Janfa *et al.*, 2015). The weight of powdered bark extract measured were 120 g, 100 g, 80 g, 60 g and was diluted with 500ml of water respectively in a beaker. The solution was left for 24 hours and clean cheese cloth was used to place on four different conical flasks to obtain the pure solution respectively. The amount of powder mixed with 500ml of water were calculated on weight by volume to obtain the percentage concentration; 48%, 40%, 32% and 24% respectively.

2.3. Preparation and Treatment of Material

Freshly sawn timbers were collected from a local sawmill in Camp, Abeokuta, Ogun State, Nigeria and the samples were taken to the Wood Laboratory in the Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta for identification and authentication. The wood sample of *G. arborea* and *A. leiocarpus* species were cut and planned into 15 cm × 5 cm × 5cm. Only the sapwood was selected for the study because it is very susceptible to insect and fungal attack. The wood was measured using the weighing balance in order to obtain the different weight. The wood sample were oven dried at temperature of 103±2 °C for 24 hours to reduce its moisture content to 12% and for sterilization of the wood from possible inherent bio deteriorating agents. The samples were soaked in different solution of the extract and left for 18 hours for it to absorb the solution.

After soaking, the extract was filtered using layered muslin cloth into a beaker. The filtrate was evaporated in water bath at 35°C. The samples were drained of excess preservatives, weighed again and the weight of the treated wood were recorded to determine the level of absorption of the extracts. The treated wood samples were allowed to dry and weighed again. After six weeks of exposure, the test wood blocks were removed, rinsed and scrubbed to remove all soil particles after which it was oven dried and measurement were recorded. The

preservatives absorption, weight loss, retention and resistance of each species of termites were determined.

2.4. Grave Yard Experiment

The wood samples were buried 5 m radius round a termitarium and mulched with dry grass leaving a few centimeters above the ground level. In order to make the environment conducive for termite infestation, the grass was watered regularly. Standard method for laboratory evaluation to determine resistance to termites was modified in order to evaluate the degree of resistance of the treated woods to termite attack as suggested by (Sotannde *et al.*, 2011). The test samples were marked using water proof marker as a means of identification. The wood sample were exposed to termite attack for 6 weeks. The wood sample were then removed from the termite mould, cleaned, oven dried and re weighed.

The treated wood sample were immediately weighed to determine gross solution uptake. The preservative retention and percentage weight loss were calculated.

Parameter assessed are:

$$\text{Absorption weight loss (\%)} = \frac{A_2 - A_1}{A_1} \dots \dots \dots \text{eq. 1}$$

$$\text{Moisture content (\%)} = \frac{T_1 - T_2}{T_2} \dots \dots \dots \text{eq. 2}$$

$$\text{Weight loss (\%)} = \frac{W_3 - W_4}{W_4} \dots \dots \dots \text{eq. 3}$$

Where;

T₁= Initial weight of the wood before treatment

T₂=Initial weight of wood plus treatment

(A₁-A₂) =Amount of the solution absorbed by the test wood blocks

W₃= Is the oven dry weight before field exposure tests

W₄= Is the oven dry weight after field exposure tests.

2.5. Phytochemical Analysis

The constituents of the bark extract were determined using American Standard Method (ASTM) as described by Gusthinnadura *et al.*, (2017).

2.5.1. Tannin

A few drops of 1% gelatin solution containing sodium chloride was added to the plant extract. The formation of white precipitate indicates the presence of tannins.

2.5.2. Alkaloids

Two drops of Mayer's reagent are added along the sides of test tube into few amounts of plant extract. The presence of alkaloids was indicated by a white creamy precipitate.

2.5.3. Flavonoid

A small amount of the extract was treated with few drops of sodium hydroxide and the intense yellow color solution becomes colorless on addition of dilute acid; this indicates the presence of flavonoids.

2.5.4. Saponin

The plant extract (50 mg) was diluted with distilled water up to 20 ml and this was shaken for 15 minutes in a graduated cylinder. The formation of 2cm thick foam indicates the presence of saponins.

2.5.5. Steroid

Extract was treated with chloroform and the filtrate was treated with few drops of acetic anhydride. Then the solution is boiled and cooled, green color indicates the presence of steroids.

2.5.6. Terpenoids

Extract was treated with chloroform and the filtrate of that is treated with few drops of acetic anhydride. Then the solution was boiled and cooled and the formation of brown ring at the junction indicates the presence of terpene.

2.6. Statistical Analysis

An analysis of variance (ANOVA) test was applied to evaluate the effect of extract on wood species and concentration level using SPSS software version 20. Significant differences between variables were determined by Fisher's Least Significant Difference ($LSD_{0.05}$) at the $P < 0.05$ level. All results were expressed as means \pm Standard Deviation (SD).



Figure 1: Selected samples of *Anogeisus leiocarpus*



Figure 2: Selected samples of *Gmelina arborea*



Figure 3: Termite infested *Gmelina arborea*



Figure 4: Termite infested *Anogeisus leiocarpus*

3. RESULTS

Table 1 shows the result of a two-way ANOVA which was conducted to investigate the effect of wood species (WS), concentration levels (CL) and species concentration level (SCL) on absorption rate, weight loss

(WL) and retention capacity (RC). The influence of wood species and CL was significant on the RC and SCL, there is also significantly influenced on CL at the absorption rate at ($P < 0.05$). Result revealed that influence of species and concentration levels on weight loss were not significant.

Table 1: ANOVA Showing the Influence of the Bark Extract on Percentage Absorption, Weight Loss and Retention Capacity of *Gmelina arborea* and *Anogeissus leiocarpus*

Source of Variation	DF	Absorption Rate	Weight Loss	Retention Capacity
Wood Species	1	0.560 ^{ns}	0.001 ^{ns}	10.956*
Cont. level	4	20.291*	0.364 ^{ns}	48.188*
Species Con level	4	0.660 ^{ns}	0.045 ^{ns}	1.558 ^{ns}
Error	20			
Total	30			

Values followed by * Significant while those with ns are not significant at ($P < 0.05$).

Table 2 shows that the mean percentage absorption rate of the extract by *Gmelina arborea* ranged from $8.9 \pm 3.40 - 7.7 \pm 0.68\%$, weight loss $17.7 \pm 1.58 - 13.0 \pm 9.56\%$ and retention rate was $100.4 \pm 31.50 - 47.1 \pm 7.67 \text{ g/cm}^3$ while *A. leiocarpus* absorption rate $9.6 \pm 0.32\% - 6.3 \pm 3.74\%$, weight loss $16.0 \pm 15.23 - 13.24 \pm 1.48\%$ and retention rate was $135.8 \pm 2.85 - 50.8 \pm 29.48 \text{ g/cm}^3$. The highest percentage of concentration at 24% for *G. arborea* and *A. leiocarpus* was at 48% concentration rate. With respect to the absorption capacity, weight loss and retention rate of the wood species for the preservatives used in this study, an inverse trend is observed in Figure 5. The retention rate and weight loss of *A. leiocarpus* wood species was higher at 48% concentration with mean value

$135.8 \pm 2.85 \text{ g/cm}^3$ and $12.3 \pm 1.60\%$ and their *G. arborea* has the least mean retention rate at 48% concentration with mean value $100.4 \pm 31.50 \text{ g/cm}^3$ and $13.0 \pm 9.56\%$ respectively.

The results of qualitative and quantitative phytochemical analysis of *Enterolobium cyclocarpum* bark extracts are presented in Table 3. The results showed the presence and mean values of $230.00 \pm 13.23 \text{ mg/100 g}$, $33.33 \pm 2.89 \text{ mg/100 g}$, $57.05 \pm 18.46 \text{ } \mu\text{g/mg}$, $156.67 \pm 44.81 \text{ mg/100 g}$, $151.67 \pm 7.64 \text{ mg/100 g}$ and $34.90 \pm 0.36 \text{ GAE/g}$ for tannins, alkaloids, flavonoids, saponins, and terpene respectively.

Table 2: Mean Values of Percentage Absorption, Weight Loss and Retention Capacity of the Treated Wood Species

Species	Concentration	Absorption (%)	Weight loss (%)	Retention (g/cm^3)
<i>Gmelina arborea</i>	24 %	8.9 ± 3.40^a	14.0 ± 7.84^b	47.1 ± 7.67^c
	32 %	8.5 ± 1.77^{ab}	13.9 ± 8.87^c	57.8 ± 13.53^c
	40 %	7.7 ± 0.68^b	17.7 ± 1.58^a	75.1 ± 11.79^b
	48 %	8.8 ± 2.37^a	13.0 ± 9.56^c	100.4 ± 31.50^a
<i>Anogeissus leiocarpus</i>	24 %	6.3 ± 3.74^c	13.3 ± 1.48^b	50.8 ± 29.48^c
	32 %	7.5 ± 2.27^{bb}	16.0 ± 15.23^a	84.9 ± 12.72^b
	40 %	7.8 ± 0.58^b	15.7 ± 13.24^a	103.8 ± 7.64^{ab}
	48 %	9.6 ± 0.32^a	12.3 ± 1.60^c	135.8 ± 2.85^a

Mean values with sharing the same alphabets in the same column under each species are not significantly different at ($P < 0.05$).

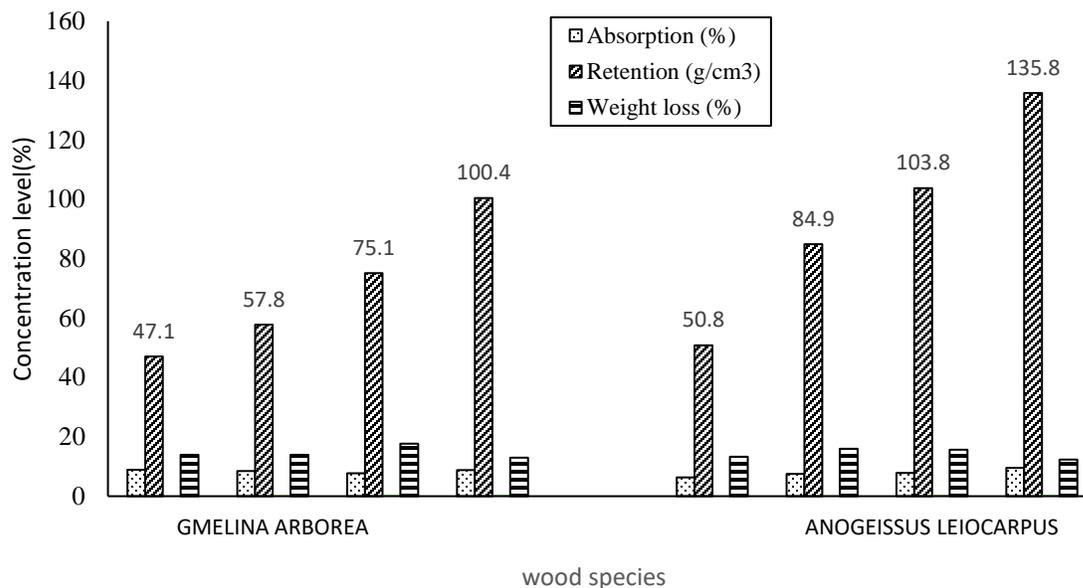


Figure 5. Comparative study of *G. arborea* and *A. leiocarpus* treated with bark extract

Table 3: Phytochemical analysis of *E. cyclocarpum* bark extract.

Phytochemical	Qualitative Value	Quantitative Value Mean±SDV
Tannin mg/100g	+	230.00±13.23
Alkaloid mg/100g	+++	33.33±2.89
Steroidm µg/mg	+	57.05±18.46
Saponin mg/100g	+++	151.67±7.64
Flavonoids mg/100g	++	156.67±44.81
Terpene GAE/g	+	34.90±0.36

+++heavy present; ++slight present; + Present; * Mean ± Standard Deviation of three replicate samples

4. DISCUSSION

The mean percentage absorption rate of the extract by *Gmelina arborea* ranged from 8.9 ± 3.40 - $7.7 \pm 0.68\%$, weight loss 17.7 ± 1.58 - $13.0 \pm 9.56\%$ and retention rate was 100.4 ± 31.50 - 47.1 ± 7.67 g/cm³ while *A. leiocarpus* absorption rate $9.6 \pm 0.32\%$ - $6.3 \pm 3.74\%$, weight loss 16.0 ± 15.23 - $13.24 \pm 1.48\%$ and retention rate was 135.8 ± 2.85 - 50.8 ± 29.48 g/cm³. The difference in absorption could be as a result of the extractives deposited in the wood samples, cell wall organization and density (Khazaei, 2008). This range of values is less than the values reported by Faruwa *et al.*, (2018) reported percentage absorption of preservative on wood *Cieba pentandra*, *Triplochiton scleroxylon* and *Gmelina arborea* has highest on absorption at 113.61 ± 8.02 , 55.25 ± 10.14 and 32.80 ± 14.80 respectively. This could be due to the difference in anatomical structure since anatomical structure of wood exhibit a lot of influences

on the absorption and retention of wood preservatives (Faruwa *et al.*, 2015). This corroborates with the findings of Owoyemi and Kayode, (2007) that the nature of preservative chemicals affects the quantity absorbed by wood. According to Sotannde *et al.* (2011), the type of extract used influenced the percentage absorption by wood samples.

The influence of the rate of termite attack on the weight loss is due to higher penetration and retention of the preservatives solution (Falemara *et al.*, 2015). *G. arborea* shows higher percentage weight loss of 17.7 ± 1.58 (40%) concentration and *A. leiocarpus* at 16.0 ± 15.23 (32%) and lowest percentage weight loss in both species were seen in *A. leiocarpus* at 12.3 ± 1.60 (48%) concentration. High concentration of preservatives in wood against termites is necessary especially where colour is not important. Wood samples is not only determined by the retention level of each preservative but also the chemical

constituent of the preservatives (Faruwa *et al.*, 2015). The effectiveness of preservative treatment depends on chemical formulation selected, method of application, wood species, moisture content before and after treatment, pretreatment methods, amount of preservative retained and depth of penetration and distribution (Falemara *et al.*, 2014). The values recorded in this study may also be due to the fact that *G. arborea* is moderately resistant to termite.

The retention ability by *G. arborea* increased as the concentration of the extract increased. The mean value ranged from 100.4 g/cm³ - 47.1 g/cm³. The same trend was also observed in the retention ability of *A. leiocarpus* which ranged from 135.8 - 50.8 g/cm³. The retention ability by *G. arborea* and *A. leiocarpus* increased as the concentration of the extract increases. The retention capacity of wood species is significantly different. This agrees with the result obtained by Faruwa *et al.* (2015). That wood exhibit variation in absorption and retention of chemical preservatives when treated wood species. This variations in retention capacity may occur due to anatomical structures such as cell wall thickness and vessel wall which greatly affect the density of wood. In view of these *Anogeissus leiocarpus* is more susceptible for termites attack and this might attributed to the differences in the physical properties of the two wood species used for the study. Retention level or quantity of preservatives in wood is an important factor because high content of these in wood will prevent absorption of chemicals and the retention of that chemical in the effectiveness of preservatives against bio-deteriorating agents. From this study, 48% concentration of the extract gave the highest retention in *G. arborea* having 100.4 g/cm³ and *A. leiocarpus* 135.8 g/cm³. This shows that as the concentration of the extract increased the retention values increases. According to Tascioglu *et al.*, (2012), retention value depends on solution concentration, extractives species, and the wood species used. Species in lower density result in higher retention values.

The phytochemical analysis of the bark extract revealed the presence of alkaloids, saponins, steroid, tannin, terpene and flavonoids. Saponins have also been reported as deterrent for biological activity against insects. Several researchers (Singh and kumar 2008; Sotannde *et al.* 2011; Djenontin *et al.*, 2012; Addisu *et al.*, 2014; Faruwa *et al.*, 2015) have reported efficacy of plants extracts as bio-preservative against fungi and termite attacks. Saponins is a natural antibody produced by plant as a mechanism to stop attack by foreign pathogen (Okwu and Emenike, 2006). Other reports reveal that tannin as observed in *G. arborea* seed have been reported by Barbehenn and Constabel, (2011) to possess anti-termite and anti-fungal properties. Alkaloids acts as attractants and as well act as deterrents for insects (Boyejo *et*

al., 2019) Flavonoids have antioxidants and antimicrobial properties. Flavonoids are known to protect wood against inflammable, allergies and microbial infection. The extracts of medicinal plants are known as home for some natural occurring chemicals that could be used as termite controlling agents and this is attributed to its phytochemicals of different chemical structure that have repellent (Mazharet *et al.*, 2013).

Convincingly, the phytochemical constituents present in the bark from which the extracted resins used in treating the *G. arborea* and *A. leiocarpus* can be attributed to its efficacy against termite attack. Hence, the highest quantity of tannins present suggests that it is the most contributing phytochemical against termite attack.

5. CONCLUSIONS AND RECOMMENDATIONS

1. This study revealed that application of bark extract of *Enterolobium cyclocarpum* influences the percentage absorption and retention capacity of different wood species used due to its anatomical structures and physical properties. Wood samples are not only determined by the retention level of each preservative but also the chemical constituent of the preservatives.
2. Based on the percentage weight loss and retention rate, the highest protection for *G. arborea* was observed with treatment at 40% and 48% concentration respectively while for *A. leiocarpus*, 32% and 48% concentration gave highest protection based on percentage weight loss and retention capacity of the wood.
3. The level of effectiveness exhibited by the bark extract thus encourage its use as alternative and environmentally friendly plant for locally preserve wood and wood-based products to save both direct and indirect cost.
4. Therefore, there is need to exploit the development of other forms of natural base plant preservatives for protection of wood and wood products and services.

REFERENCES

- Abdullahi, N. Yahya, S., Yushau, M. and Tukur, Z. (2012). Laboratory evaluation of the effect of *Khaya senegalensis* and *Cassia occidentalis* ethanolic leaves extracts against worker termites (Isoptera: Rhinotermitidae) on treated wood sample. *Journal of Stored Products and Postharvest Research*. 3(11):152–155.
- Addisu, S., Mohamed, D. and Waktole, S. (2014). Efficacy of Botanical Extracts against Termites, *Macrotermes spp.*, (Isoptera: Termitidae) under

- Laboratory Conditions. *International Journal of Agricultural Resources*, 9(2): 60-73.
- Adeduntan, S. A. (2015). The termiticidal effect of some plant material on some selected wood species. *International Journal of Biological and Chemical Sciences*, 9(2): 986-995.
- Adetogun, A. C, Omole, O.A Adegeye, A.O and Ogunjobi, K.M (2010): Evaluation of wood preservative potential of leaf extract of *Cymbopogon citratus* (Stapf) Published by Scientific journal of the tree club, Department of Forest Resources, University of Ibadan, Ibadan. *Obeche Journal* 28 (2): 147-150.
- Ahmed, R.N. Sani, A. and Igunnugbemi, O. O. (2009). Antifungal Profiles of Extracts of *Vitellaria paradoxa* (Shea-Butter) Bark. *Ethnobotanical Leaflet*. 13: 679-88.
- American Wood Protection Association (2015). Standard Method for Laboratory Evaluation to Determine Resistance to Subterranean Termites. AWPAA Book of standard, Woodstock, MD,: 387-395.
- Barbehenn, R.V, Constabel, P.C. (2011). Tannins in plant – herbivore interactions. *Phytochemistry*. 72:1551 – 1565.
- Boyejo, A. O., Azeez, I.A., Owolabi, S.L., and Issah, A.O. (2019). Antifungal and Phytochemical Screening of Extract from *Vitellaria Paradoxa* (Shea Butter Tree) Leaves, Barks and Roots on Dermatophytes. *International Journal of Scientific and Research Publications*, 9(6): 884 – 891.
- Djenontin, T. S., Amusant, N., Dangov, J., Wotto, D.V., Avlessi, F., Dahouenon-Ahoussi, E., Lozano, P., Pioch, D. and Sohounhloue, K.C.D. (2012). Screening of Repellent, Termiticidal and Preventive Activities on Wood of *Azadirachta indica* and *Carapa procera* (Meliaceae) Seeds oils. *ISCA Journal of Biological Science*, 1(3): 25-29.
- Ejikeme, C.M, Ezeonu, C.S and Eboatu, A.N. (2014) Determination of physical and phytochemical constituents of some tropical timbers indigenous to Niger Delta Area of Nigeria. *European Scientific Journal* 10: 247–270.
- Ekhuemelo, D. O., Kiyam, A. S. and Abu, V. (2020). Eantitermitic Properties of *Vitellaria paradoxa* (C. F. Gaertn.) Stem Bark Extracts on *Daniellia oliveri* (Rolfe) Hutch. & Dalziel AND *Vitex doniana* Sw. WOODS. *Journal of Research in Forestry, Wildlife & Environment*. 12(3):145-153
- Ekhuemelo, D.O., Onuche, M.U., Tembe, E.T. (2017). Crude Extracts of *Eucalyptus Camaldulensis* (Dehnh) Leaves and Bark on *Anogeissus Leiocarpus* (Dc) Guill&Perr and *Daniellia Oliveri* Rolfe, Hutch Wood in Control of Termite (Isoptera: Termitidae). *International Journal of Science and Engineering Investigation*, 6(66):29-36.
- Emerhi, E.A., Adedeji. G.A. and Ogunsanwo, O.Y. (2015). Termites' resistance of wood treated with *Lagenaria breviflora* B. Robert fruit pulp extract. *Nature and Science*, 13(5): 105-109
- Falemara, B.C., Obidike-Ugwu, E.O., Ukanyirioha, C.J. and Musab, S.M. (2014). Evaluation of different Treatment Techniques on Preservative Absorption of *Triplochiton scleroxylon* (Obeche) against Fungi Attack. In the book of proceedings; Sudano-Sahelian Landscape and Renewable Natural Resources Development in Nigeria. 37th Annual conference of Forestry Association of Nigeria. 525-537.
- Falemara, B.C., Ampitan, T. and Oyeleye, I.O. (2015). Effects of Hot and Cold Treatment Techniques on Preservative Absorption of *Triplochiton Scleroxylon* (Obeche) Against Fungi Attack. *Appl Trop Agric J* 20(1): 146-151.
- Faruwa, F.A., Egbuche C.T., Umeojiakor A.O. and Ulocha O.B. (2015). Investigation into the Effectiveness of Selected Bio-Based Preservatives on Control of Termite and Fungi of Wood in Service. Agriculture, Forestry and Fisheries. Special Issue: *Environment and Applied Science Management in a Changing Global Climate*. 4 (3): 59-63.
- Femi-Ola, T.O., Ajibade, V.A. and Afolabi, A. (2008): Chemical Composition and Termiticidal Properties of *Parkiabiglobosa*(Jacq.) Benth. *Journal of Biological Sciences*. 8(2): 494-497.
- Gusthinnadura, O.D., Achala, T.A. and Malamige, M.W. (2017). Extraction methods, qualitative and quantitative techniques for screening of phytochemicals from plants. *American Journal of Essential Oils and Natural Products*. 5(2): 29-32.
- Janfa, N., Falemara, B.C., Mathias, O. Akpala, A.A., and Kambai, C. (2015). Termiticidal Effects of *Moringa oleifera* seed Oil Extract on *Gmelina arborea* (Roxb). Wood *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*. 9(8): 95-100
- Jerrold, E.W. (2005): Wood Properties In: Arntzen, Charles J., Ed. Encyclopaedia of Agricultural Science. Orlando, FL: *Academic Press*: 4:549-561.
- Khazaei, J. (2008). Water absorption characteristics of three wood varieties. *Cercetări Agronomice în Moldova* XLI (2): 5-16.
- Mazharet, A., Muhammad S., Munawar, I., Fozia, A., Sumaira, S., Sohail, A. and Tajnees, P. (2013). Antitermitic activity and phytochemical analysis of fifteen medicinal plant seeds. *Journal of Medicinal Plants Research*. 7(22): 1608-1617.
- Obi, J.C., Ogunkunle, A.O. and Meludu, N.T. (2008). Effect of termite infestation on the farming system characteristics of an endemic area in the guinea savanna region of Nigeria. *Am-Euras. J. Sci. Research*, 3: 1-6.
- Ogunjobi, K.M, Abdulwahab, S.O, Gakenou, O.F, Thompson, O.E & Olorunfemi, O (2020) Qualitative and quantitative evaluation of the phytochemical

- constituents of three wood species in Ogun state, Nigeria. *Tropical Plant Research* 7(3): 627–633.
- Ogunjobi, K.M. and Thompson, O.E. (2016) Fungicidal Effects of *Spondia monbin* Linn Stem extract on some selected wood deteriorating fungi. *Journal of For. Sci. Env.* 1 (2) 60-66.
- Ogunjobi, K.M., Shittu, A.T., Gakenou, O.F., Ashade, O.C and Adetogun, A.C. (2018) Preference of wood species used for furniture making in Abeokuta, Ogun State, Nigeria. *Journal of For. Sci. Env.* 3 (1) 36-42.
- Okere, C. I. Adaijbe, V. C., Aneni, T. I. Ogbemor, C. O. and Aghayedo, C. O. (2021) Efficacy of Two Selected Botanical Extracts to Protect Wood from Damage When Exposed to Termite Attack. *International Journal of Agriculture and Earth Science.* 7 (1): 1-10.
- Okwu, D.E. and Emenike, I.N. (2006). Evaluation of the phytonutrients and vitamin contents of citrus fruits. *Int. J. Mol. Med. Adv. Sci.* 2(1):1-6.
- Oluwafemi, O.A. and Adegbeniga, S.O. (2007). Preliminary report on utilization potential of *Gliricidia sepium* (Jacq.) steud for timber. *Res. J. Forestry*, 1: 80-85.
- Owoyemi, J.M. and Kayode, J.O. (2007): The Effects Chromated Copper Arsenate and Solignum Oil on the Resistance of *Gmelina arbores* (Roxb) to Termites' Attack. *Nigeria Journal of Forestry.* 37 (1): 30 – 37.
- Singh, N. and Kumar, S. (2000). Antitermite activity of *Jatropha curcas* Linn. Biochemicals. *Journal of Applied Sciences and Environmental Management*, 12(3), 67-69.
- Singh, T. and Singh, A.P(2012). A review on natural products as wood protectant. *Wood Sci. Technol.* 46: 851–870.
- Sotannde, O. A., Yager, G. O., Zira, B. D. and Usman, A. (2011). Termiticidal Effect of Neem Extracts on the Wood of *Khaya senegalensis*. *Research Journal of Forestry*, 5(3): 128-138.
- Tascioglu, C., Yalcin, M., de Troya, T., and Sivrikaya, H. (2012). "Termiticidal properties of some wood and bark extracts used as wood preservatives," *BioRes.* 7(3): 2960-2969.
- Ufoegbune, G.G. and Fabiyi, S. (2016). Identification of Land Areas suitable for Fadama at Federal University of Agriculture, Abeokuta, Nigeria using GIS, *Journal of Applied Sciences and Environmental Management*, 20 (4), 1027-1032.