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Effect of Seed Methanol Extracts from *Prosopisafricana, Pentaclethramacrophlla* and *Erythrophleumsuaveolens* on Termites Infestation of Some Common Wood Species

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ABSTRACT
The aim of this study was to investigate termicidal properties of seeds of three tropical trees species. Methanol extracts of *P. africana, P. macrophylla*, and of *E. suaveolens* seeds were prepared and applied on three common wood species viz: *FicussppDaniella oliveri* and *Vitellariaparadoxa*.The treated wood sample was buried to a depth of 10 cm for graveyard experiment for a period of 5 months. Spacing was 3 m between holes and 3 m between replicates. Result on percentage extract retention indicated that *E. suaveolens* extract displayed varying absorption percentages across wood species, with differences observed in *D. oliveri* and *V. paradoxa* woods treated with Solignum compared to extracts. Higher extract concentrations correlated with increased absorption. *V. paradoxa*had the highest mean percentage absorption (31.50%) and retention (31.50%) and was recorded for Solignum. Solignum. treatment wood showed comparatively lower (8.02% - 14.22%), weight loss percentages suggesting potential efficacy in mitigating termite-induced damage. Untreated wood samples exhibited significantly higher (46.07% - 58.65%) weight loss percentages, indicating vulnerability to termite infestation. Highest Concentration (1.5 g) of *E.suaveolens* seed methanol extract had moderately low weight of 15.14% ± 9.87% (*D. oliveri*), 19.36% ± 11.98% (*V. paradoxa*), and 20.19% ± 7.04% (*Ficus spp*.). Also, 1.5 g concentration of *P.macrophylla* seed methanol extract had modest weight loss of 12.60% ± 6.78% for *D. oliveri*; 21.00% ± 12.87% for *V. paradoxa* and 21.56% ± 16.40% for *Ficus spp.* In conclusion, 1.5 g concentration of seed methanol extract was relatively the most active and it is recommended for wood treatment against termites.The most susceptible wood species to termite attack was *Ficusspp* and it should be properly treated before employed in service.

Keywords:
Extract,
Methanol,
Termites,
Weight loss,
Wood.

INTRODUCTION

Termite infestation is a major problem affecting wood and wood-based products worldwide and Nigeria to be specific. Synthetic chemicals have traditionally been used to protect wood against termites, but they can be harmful to the environment and human health. As a result, there has been growing interest in exploring natural plant extracts as alternative wood preservatives (Ugbomeh and Diboyesuku, 2019; Kalleshwaraswamy *et al.,* 2022).

Several studies have investigated the efficacy of plant extracts against termites. Mimosa (*Acacia mollissima*) and quebracho (*Shinopsislorentzii*) bark extracts have been shown to effectively protect wood against the subterranean termite *Reticulitermesgrassei* at high retention levels (12% w/w) (Tascioglu*et al*., 2012). Bald cypress (*Taxodiumdistichum*) heartwood extract (Elaigwu *et al*., 2018), southern catalpa (*Catalpa bibnonioides*) heartwood extract (Mahari *et al*. 2024), red louro (*Sextoniarubra*) wood extract (Adiji*et al*., 2023), cinnamon (*Cinnamomum cassia*) bark extract, pepper (Piper sarmentosum) extract (Gorel*et al*., 2015), water pepper (Polygonumhydropiper) leaf extracts (Arizona Termite and Pest Solutions, 2022) and birbira (*Milletiaferruginea*) seed extract have also demonstrated antitermitic properties (Bakaruddin and Ab Majid, 2019 Yanda*et. al.,* 2022). This research

aimed to evaluate the efficacy of seed methanol extracts from *Prosopisafricana, Pentaclethramacrophlla*, and *Erythrophleumsuaveolens* against termites infesting common wood species. These plant species are native to Africa and have been used in traditional medicine and as biopesticides. *Prosopisafricana* (Guill., Perrott, & Rich.) (Taub.) also known as African mesquite, is a tree species native to West Africa. It belongs to the family Fabaceae.*P. africana* is called different names in Nigeria as: *Okpeghe* (Idoma and Tiv), *Ayan* (Yoruba), *Okpei* (Igbo), and *Kiriya or Kiriaya* (Hausa). Its seeds contain various bioactive compounds, including alkaloids, saponins, tannins, and flavonoids, which have been shown to possess antimicrobial, antioxidant, and insecticidal properties (Peters *et al*., 2014; Elango *et al*., 2021).

Pentaclethramacrophlla, commonly called African oil bean, is a leguminous tree found in tropical Africa. It belongs to the family fabaceae. The tree is called African oil bean, Apawa (Yoruba), Congo acacia (English), Ugba, Ogba (Igbo), Apara, Okpagha, and Akpagha (Edo). The seeds are rich in proteins, fats, and carbohydrates, and have been used in traditional medicine to treat various ailments (Olaitan*et al*., 2009). The seed extracts have also been reported to have insecticidal and antifungal activities (Tascioglu *et al*., 2012).

Erythrophleumsuaveolens, or sasswood, in the family of Fabaceaeis a tree species native to West and Central Africa. *E. suaveolens* is known Nigeria as ordeal tree, red-water tree, sasswood (English), Obo, Erun-obo (Yoruba), Oginni, Oginyi (Edo) and Ihi (Igbo). The seeds contain alkaloids, tannins, and saponins, which have been associated with various pharmacological activities, including antimicrobial, antioxidant, and insecticidal properties.

Despite the antimicrobial and medicinal values of these plants, there is not much available study on their termicidal properties. By evaluating the efficacy of these seed extracts against termites infesting common wood species, the proposed research could provide valuable insights into the potential use of these natural products as eco-friendly wood preservatives (Odoh *et al*., 2021). This study was aimed at contributing to the development of sustainable strategies for protecting wood and wood-based products from termite damage.

MATERIALS AND METHODS

Area of the Study

This research work was carried out at University of Agriculture Makurdi, Benue state. Benue State is one of the North Central States and falls within the coordinates of Latitude 7º47' and 10º00'East and Longitude 6º21' and 8º8' North, Benue State lies in the south guinea savanna (Ibrahim and Idoga, (2015). The continuous clearance of the vegetation has led to the development of re-growth vegetation at various stages.The climate of Benue State is of tropical sub humid with two distinct seasons: wet season which start from April and end in October. While the dry season start from November and end March lasting for a period of five (5) months. The annual rainfall in Benue State per year ranges from 1200 mm – 2000 mm. The temperature in Benue State is usually very high in the day with a minimum and maximum (Awoji *et al.,* 2023*).* The vegetation of study area is typically guinea savannah, the land is generally fertile and supports extensive arable cropping and rearing of animals. Trees found in the area include; *Danielliaoliveri*, *P. biglobosa*, *Vitellariaparadoxa*, *Vitexdoniana*, *Prosopisafricana* and *Azadirachtaindica* are also common (Nyagba, 1995). The inhabitants of this area are mostly, rural farmers who subsist on farming. They grow crops such as maize, millet, benniseed, rice, cassava and yam. They also keep animals such as sheep, goats, pigs and poultry (Ekhuemelo *et al.,* 2017).

Plant materials collection and preparation

Prosopisafricana, *Pentaclethramacrophlla* and of *Erythrophleumsuaveolens* pods and seeds was collected from the ground (under trees) in April 2021. The seed pods were air dried under the sun for a period of two (2) weeks. After the seeds were air dried, they were broken to remove the seeds and air dried for another one (1) week. Preparation of the seed powder was done according to the method described by Siddig (1991) and Ahmed (1995). The powder was kept in Polythene for use in the experiment.

Collection of wood materials

Defect free sawn wood of *FicussppDaniella oliveri* and *Vitellaria* were purchased from Timber Shed at New Bridge Makurdi and cross cut into 2 x 2 x 6 cm (width x breadth x length) dimension.

Distillation of Solvents

Methanol solvent used for extraction was bought from ShowcrownLaboratry. Ltd., Ibadan. The solvent was distilled in the laboratory to remove impurity. Distilled solvent was collected and stored in bottles before extraction.

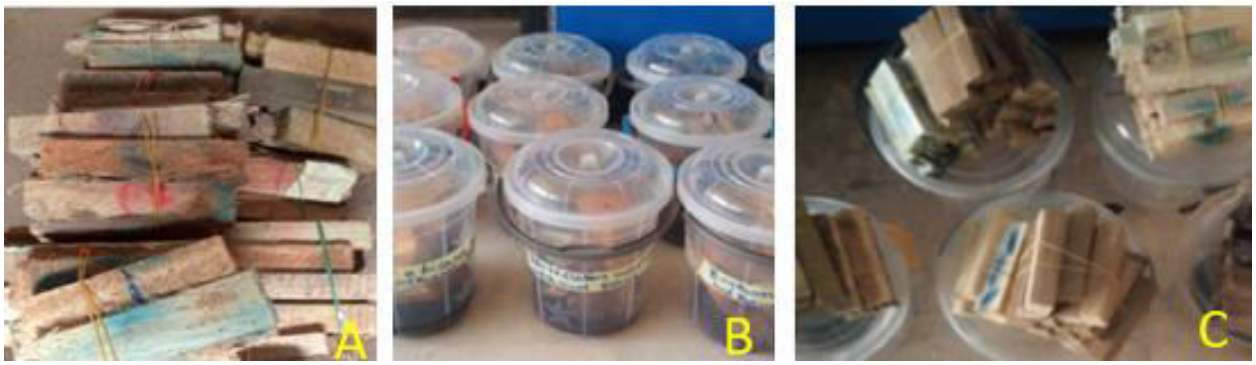

Plate 1: Treated wood samples;
A: Processed wood samples, B: Serial dilution procedure of Plantextracts, C: Wood samples set for drying after treatment

Serial Dilution of extracts and treatment of wood sample

Serial dilution method was used to constitute concentration of extract for the study. Three levels of concentration (1.5g, 1.0g and 0.5g) from *P. africana, P. macrophylla*and *E. suaveolens*seed methanolextract was done by dissolving them in methanol solvent.

Experimental Design

The treated wood samples were layout in a Completely Randomized Design (CRD) with four wood species, 15 treatments and 3 control (methanol and synthetic: + control (Solignum) and untreated wood: - control). The treatment was replicated thrice. Ten wood samples were laid for each treatment given a total of 660 wood samples for a replicate. A total of 2,640 wood samples was used for the three replicates. The method of (Ekhuemelo*et al.*, 2021) with modification will be used for layout of the experiment.

Determination absorption and retention of extracts in treated wood samples

The test wood samples were correctly labeled and soaked in the different treatments for 72 hours, removed and air dried for another 24 hours before burying. Absorption and retention of extracts is calculated and expressed volumetrically using formulae (Eqns. 1 and 2)

$$\text{Percentage Absorption } (kgm-3) = 1000(G)/V \quad \ldots\ldots\ldots\ldots [1]$$

$$\text{Percentage Retention } (kgm-3) = [(G \times C)/V] \times 10 \quad \ldots\ldots\ldots .. [2]$$

Where:
G = (W2-W1) = amount of the treating solution absorbed by the test wood blocks (g),
W1 = is the oven dried weight of the conditioned wood blocks before treatment (g),
W2 = is the weight after treatment,
V = volume of wood test block (cm3).
C = grams of preservative in 100 g of treating solution/concentration of extract

Experimental Layout

The treated wood sample was buried to a depth of 10 cm for graveyard experiment for a period of 5 months. Spacing was 3 m between holes and 3 m between replicates.

Data Collection

Inspection and evaluation of the wood samples were made on weekly basis for a period of five months for any sign of termite attack. At each visit, one treated wood specimen from each treatment was removed from the soil without replacement. The removed sample was cleaned and brushed to examine attack of termites which was used to assess incidence of termite attach.

Incidence of termite attacked on wood samples was recorded with the symbol as follow:
- = Not attacked and,
+ = Attacked.

At the end of the experiment, severity of termite attack was determined by weighing the wood samples to calculate the percentage weight loss as stated in the formula below:

$$\%\ WL = [(W1 - W2)/W1] \times 100 \quad \ldots\ldots\ldots\ldots\ldots [3]$$

Where:
% WL = percentage weight loss
W_1 = air dry weight before field exposure tests,
W_2 = air dry weight after field exposure tests.

Pate 5: Test wood samples after attack

Visual Rating of Treated Woods Sample after Preservative Treatments

The Percentage weight loss resulting from attack by termites was rated according to Ekhuemelo *et al.* (2018) as shown below:

Percentage Damage (%)	Rating	Inference
0 – 6	0	no attack;
1 to 20	1	slightly attacked
21 – 40	2	moderately attacked
41 – 60	3	moderate/severe attacked
61 – 80	4	severely attacked
81 – 99	5	very severely attacked
100	6	complete destruction

Data Analysis

Data from the study was analyzed using descriptive statistics and one-way Analysis of Variance (ANOVA) to determine significant effects of treatment on wood sample. A follow up test was carried out using Duncan Multiple Range Test (DMRT) where significant differences were found.

Percentage absorption of wood samples treated methanol seed extracts

Table 1 presents the percentage absorption of wood samples treated with methanol seed extracts of three plant species: *E. suaveolens, P. africana*, and *P. mycrophylla*, along with a chemical treatment. Concentrations of 1.5 g, 1.0 g, and 0.5 g were utilized for each extract. *Erythropheluemsuaveolens* extract showed varying absorption percentages across wood species: *D. oliveri* absorbed between 9.90% and 19.70%, *V. paradoxa* (10.60% and 17.60%), and *Ficusspp* (11.70% and 19.70%). For *P. africana* seed methanol extract, absorption percentages ranged from 11.00% - 13.40% for *D. oliveri,* 10.30%- 11.80% (*V. paradoxa*), and 11.30% - 13.60% for *Ficus spp.Pentaclethramycrophylla seed* methanol extract displayed absorptions varying from 10.60% to 20.30% for *D. oliveri,* 10.70% to 15.00% for *V. paradoxa,* and 4.50% to 11.70% for *Ficus spp.* The results show that absorption in tested wood is significantly ($p<0.005$) higher in *D. oliveri*and *V. paradoxa*woods treated with Solignum compared to extracts. For the extracts, it was observed that the higher the concentration, the higher the absorption.

RESULTS AND DISCUSSION

RESULTS

Retention of methanol seed extracts and chemical by treated wood samples

Table 2 shows results of the retention levels of methanol seed extracts and a chemical treatment within wood samples of three species: *D. oliveri, V. paradoxa,* and*Ficus spp.* Concentrations of 1.5g, 1.0g, and 0.5g were employed for each extract, and the retention levels were measured. For Erythropheluemsuaveolens Seed Methanol Extract, D. oliveri has retention varied between 3.30±1.25% and 15.60±6.60%; *V. paradoxa* (3.50±1.65% - 13.10±4.77%) and *Ficusspp* (4.10±2.18% - 15.00±10.74%). Also, *Prosopisafricana* Seed Methanol Extract had retention percentage as 3.3±1.42% - 12.6±5.46% in *D. oliveri,* 3.3±1.16% - 10.0±5.48% in *V. paradoxa,* and 3.6±1.43% to

12.2±4.98% in *Ficus spp.* Retention of *P. mycrophylla* seed methanol extract was 3.4±1.65% and 11.3±3.80% (*D. oliveri*), 3±1.49% -13.3±3.65% in *V. paradoxa* and 3.6±1.51% to 10.0±3.77% in *Ficus spp*. The chemical treatment showed consistent retention across wood types, with values ranging from 16.40±5.62% to 21.60±4.70% for the three wood species.

Table 1: Percentage absorption of wood samples treated methanol seed extracts

Treatment/Extract	Conc. (g)	*D. oliveri*	*V. paradoxa*	*Ficusspp*
		Mean±Std.	Mean±Std.	Mean±Std.
Erythropheluemsuaveolens	1.5	14.20±6.55[a]	12.10±4.77[a]	15.50±11.36[a]
seed methanol Extract	1.0	14.40±7.47[a]	17.60±12.68[a]	19.70±11.62[a]
	0.5	9.90±4.01[a]	10.60±5.58[a]	11.70±6.24[ab]
+Chemical (Solignum)		25.30±9.24[b]	31.50±6.95[b]	23.10±8.05[b]
Total		**15.95±8.91**	**17.95±11.42**	**17.50±10.19**
Prosopisafricana	1.5	13.40±5.34[a]	10.30±5.17[a]	13.60±6.48[a]
seed methanol extract	1.0	11.00±4.57[a]	11.80±5.87[a]	11.30±5.91[a]
	0.5	11.90±4.41[a]	11.30±4.37[a]	12.90±5.59[a]
+Chemical (Solignum)		25.30±9.24[b]	31.50±6.95[b]	23.10±8.05[b]
Total		**15.40±8.36**	**16.23±10.48**	**15.23±7.86**
Pentaclethramycrophylla	1.5	12.90±4.91[a]	15.00±4.37[a]	11.70±5.12[ab]
seed methanol extract	1.0	20.30±23.38[ab]	13.10±4.73[a]	4.50±23.48[a]
	0.5	10.60±4.43[a]	10.70±4.79[a]	10.10±4.12[a]
+Chemical (Solignum)		25.30±9.24[b]	31.50±6.95[b]	23.10±8.05[b]
Total		**17.28±13.82**	**17.58±9.73**	**12.35±14.11**

Table 2: Retention of methanol seed extracts and chemical by treated wood samples

Treatment/Extract	Conc. (g)	*D. oliveri*	*V. paradoxa*	*Ficusspp*
		Mean±Std.	Mean±Std.	Mean±Std.
Erythropheluemsuaveolens	1.5	15.60±6.60[c]	13.10±4.77[b]	15.00±10.74[b]
seed methanol Extract	1.0	9.40±4.50[b]	13.10±11.34[b]	12.20±6.30[b]
	0.5	3.30±1.25[a]	3.50±1.65[a]	4.10±2.18[a]
+Chemical		16.50±6.15[c]	21.60±4.70[c]	16.40±5.62[b]
Total		**11.20±7.27**	**12.83±9.10**	**11.93±8.21**
Prosopisafricana	1.5	12.6±5.46[b]	10.0±5.48[b]	12.2±4.98[b]
seed methanol extract	1.0	6.7±2.67[a]	7.0±3.20[b]	7.0±3.68[a]
	0.5	3.3±1.42[a]	3.3±1.16[a]	3.6±1.43[a]
+Chemical		16.5±6.15[b]	21.6±4.70[c]	16.4±5.62[c]
Total		**9.78±6.67**	**10.48±7.92**	**9.8±6.41**
Pentaclethramycrophylla	1.5	11.3±3.80 [b]	13.3±3.65[c]	10.0±3.77[b]
seed methanol extract	1.0	11.7±12.83[b]	7.9±2.77[b]	10.5±10.74[b]
	0.5	3.4±1.65[a]	3.3±1.49[a]	3.6±1.51[a]
+Chemical		16.5±6.15[b]	21.6±4.70[d]	16.4±5.62[c]
Total		**10.73±8.56**	**11.53±7.62**	**10.13±7.67**

Percentage Weight Loss among treated wood samples exposed to termite infestation

Table 3 shows the efficacy of methanol seed extracts and a chemical treatment in mitigating termite-induced weight loss in wood samples of *D. oliveri, V. paradoxa,* and *Ficus spp.* The weight loss percentages were assessed across varying concentrations of extracts and the chemical treatment.Results on *E. suaveolens* seed methanol extract revealed that weight loss trend exhibited an inverse relationship with effectiveness. Higher concentrations of the extract demonstrated notably elevated weight loss percentages: 50.74±30.62% for *D. oliveri,* 72.93±35.30% for *V. paradoxa,* and 36.89±27.38% for *Ficusspp,* suggesting reduced efficacy in preventing termite-induced weight loss. Also, *P. africana*seed methanol extract results showed similar trend that weight loss percentages were higher across concentrations: 11.39±6.23% to 21.53±11.65% for *D. oliveri,* 8.65±9.23% to 19.55±8.76% for *V. paradoxa,* and 10.70±5.77% to 22.09±16.39% for *Ficusspp,* indicating limited effectiveness against termite

infestation. *Pentaclethramycrophylla* seed methanol extract is consistent with the aforementioned extracts, higher concentrations correlated with increased weight loss: 10.33±4.82% to 22.34±15.43% for *D. oliveri,* 12.78±14.39% to 22.92±10.88% for *V. paradoxa,* and 9.40±3.17% to 20.21±15.73% for *Ficusspp,* showing reduced efficacy against termite damage. However, the chemical treatment interestingly demonstrated comparably lower weight loss percentages: 8.02±10.09% to 14.22±14.33% for *D. oliveri*, *V. paradoxa*, and *Ficus spp.* These lower percentages hint at potentially better efficacy in mitigating termite-induced weight loss compared to the seed methanol extracts. Conversely, the untreated wood samples exhibited remarkably higher weight loss percentages across all wood types: 49.12±27.37%, 46.07±30.20%, and 58.65±31.02% for *D. oliveri,V. paradoxa,* and *Ficusspp*, respectively, signifying vulnerability to termite infestation.

Table 3: Weight loss of treated wood samples after exposure to termite infestation

Treatment	Conc. (g)	Percentage weight loss		
		D. oliveri	***V. paradoxa***	***Ficusspp***
		Mean±Std.	**Mean±Std.**	**Mean±Std.**
Erythropheluemsuaveolens	1.5	15.14±9.87^{b}	19.36±11.98^{a}	20.19±7.04^{ab}
seed methanol Extract	1.0	22.00±14.92^{b}	19.14±11.46^{a}	15.035.99^{a}
	0.5	50.74±30.62^{a}	72.93±35.30^{c}	36.89±27.38^{b}
+Chemical (Solignim)		8.02±10.09^{b}	14.22±14.33^{a}	9.40±3.17^{a}
Untreated wood samples		49.12±27.37^{a}	46.07±30.20^{a}	58.65±31.02^{c}
Total		**29.00±26.56**	**34.35±31.50**	**28.03±25.64**
Prosopisafricana	1.5	18.11±14.37^{b}	11.06±4.83^{b}	13.62±17.54^{b}
seed methanol extract	1.0	14.25±13.92^{b}	8.65±9.23^{b}	10.70±5.77^{b}
	0.5	11.39±6.23^{b}	17.46±16.21^{b}	22.09±16.39^{b}
+ Chemical (Solignim)		12.02±6.95^{b}	14.22±14.33^{b}	11.43±6.50^{b}
Untreated wood samples		49.12±27.37^{a}	46.07±30.20^{a}	58.65±31.02^{a}
Total		**20.98±20.85**	**19.49±21.51**	**23.30±25.14**
Pentaclethramycrophylla	1.5	12.60±6.78^{b}	21.00±12.87^{b}	21.56±16.40^{b}
seed methanol extract	1.0	21.53±11.65^{b}	19.55±8.76^{b}	21.87±19.52^{b}
	0.5	22.34±15.43^{b}	22.92±10.88^{b}	20.21±15.73^{b}
+ Chemical (Solignim)		10.33±4.82^{b}	12.78±14.39^{b}	9.40±3.17^{b}
Untreated wood samples		49.12±27.37^{a}	46.07±30.20^{b}	58.65±31.02^{a}
Total		**23.19±20.33**	**24.47±20.07**	**26.34±25.13**

Incidence of termite attack on *D. oliveri, V. paradoxa and Ficusspp*treated methanol extracts

The Table 4 presents the incidence of attacks on different wood species subjected to varying methanol treatments over several months. Wood treated with 1.5 g or 1.0 g of methanol showed no attacks throughout the observation period. However, at 1.0g treatment, there was an incidence of attacks observed from the third to the fifth month on *V. paradoxa* and *Ficus spp.* The wood treated with 0.5g of methanol displayed no attacks except for a mild incidence observed on *V. paradoxa* during the second and third months. The Soligum treatment did not exhibit any attack within the observation period. Conversely, the untreated wood experienced attacks from the first month onwards across all wood species, with increasing severity noticed throughout the five months of observation.

Table 5 shows the efficacy of *Pentaclethramycrophylla* methanol extracts and a synthetic chemical (Soligum) in preventing termite attacks on different wood species over a five-month period. Wood treated with 1.5g of the extract showed no incidence of termite attacks throughout the observation period. At the 1.0g level, initial resistance was observed, but attacks manifested from the second month onwards, reaching a significant incidence in subsequent months.

However, the 0.5g treatment displayed partial protection, with initial vulnerability in the third month, escalating to moderate attacks in the subsequent months, particularly notable for *Ficus spp*. The synthetic chemical treatment (Soligum) demonstrated complete prevention of termite attacks during the observation period. In contrast, the untreated control group exhibited severe and consistent termite attacks across all months, indicating the vulnerability of untreated wood to termite infestation.

Table 6 presents the efficacy of *E. suaveolens* methanol extracts in mitigating termite attacks on various wood species over a five-month investigation. At the highest concentration (1.5g), no termite attacks were observed across all treated wood species throughout the observation period. Wood treated with

1.0 g displayed initial protection against termite attacks in the first month, but subsequent months saw attacks occurring from the eleventh month onwards, albeit with varying intensity among different wood species. Similarly, the 0.5g treatment initially provided protection against termite attacks. However, attacks were noted in the eleventh month, predominantly impacting *D. oliveri* and *V. paradoxa.*

The synthetic chemical treatment (Soligum) showed complete protection of test woods against termite attacks during the observed period. Conversely, the untreated wood consistently experienced severe termite attacks across all months, highlighting its vulnerability to termite infestation. Overall, the higher concentrations of *E. suaveolens* methanol extracts exhibited better efficacy in preventing termite attacks, with the 1.5g concentration demonstrating complete protection throughout the study duration.

Table 4: Incidence of termite attack on *D. oliveri, V. paradoxa and Ficussspp*treated with *Prosopisafricana*methanol extracts

Treatment/Methanol	Duration of exposure of treated wood species in months														
	D. oliveri					*V. paradoxa*					*Ficusspp*				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1.5g	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
1.0g	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	-		+	+	+		+	+	+	+	-	+	+	+	+
0.5g	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	+	+	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
+CT (Soligum)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
-Control	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Key:- -No Attack, + Attack

Table 5: Incidence of termite attack on *D. oliveri, V. paradoxa and Ficussspp* treated with *Pentaclethramycrophylla* methanol extracts

Treatment/Methanol	Duration of exposure of treated wood species in months														
	D. oliveri					*V. paradoxa*					*Ficusspp*				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1.5g	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
1.0g	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	-		+	+	+		+	+	+	+	-	+	+	+	+
0.5g	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	+	+	+	+	–	–	–	+	+

	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
+CT (Soligum)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
-Control	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Key:- -No Attack, + Attack

Table 6: Incidence of termite attack on *D. oliveri, V. paradoxa and Ficussspp* treated with *Erythropheluemsuaveolens* methanol extracts

Treatment/Methanol	**Duration of exposure of treated wood species in months**														
	D. oliveri					***V. paradoxa***					***Ficusspp***				
	1st	**2nd**	**3rd**	**4th**	**5th**	**1st**	**2nd**	**3rd**	**4th**	**5th**	**1st**	**2nd**	**3rd**	**4th**	**5th**
1.5g	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
1.0g	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	-	+	+	+	+		+	+	+	+	-	+	+	+	+
0.5g	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
	–	–	–	+	+	–	+	+	+	+	–	–	–	+	+
	–	–	–	+	+	–	–	–	+	+	–	–	–	+	+
+CT (Soligum)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
-Control	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Key:- -No Attack, + Attack

Visual rating of termite attack on *Danielliaoliveri*, *V. paradoxa* and *Ficussspp* wood sample

Table 7 presents the susceptibility of *Danielliaoliveri, V. paradoxa,* and*Ficusspp* wood samples to termite attacks under varying treatment conditions. The visual ratings, following a defined scale from 0 to 6, depicted the extent of termite infestation and damage across the samples. Wood samples treated with methanol extracts from *P. africana, P. mycrophylla,* and *E. suaveolens* at 1.5% and 1.0% concentrations demonstrated notable resistance to termite attacks, consistently reflecting ratings of 0 or 1. These ratings correspond to no attack or slight attack, respectively, indicating minimal to negligible damage (0-20%).

At lower concentrations (0.5%), the samples treated with *P. africana, P. mycrophylla,and E. suaveolens* still showcased a defensive trend, mostly rated at 0 for no attack. Contrarily, the untreated wood samples (-Control) displayed vulnerability, scoring a visual rating of 3, indicating a moderate to severe attack, with damage ranging from 41% to 60%. Moreover, the Soligum-treated samples (+ Control) mirrored the characteristics of the treated samples, showcasing a robust resistance pattern with consistent ratings of 0 for no attack, aligning with the observations of the treated groups.

Table 7: Visual rating of termite attack on *Danielliaoliveri*, *V. paradoxa* and *Ficussspp* wood samples

Methanol extracts	% Concentration of extracts	Visual rating of wood samples		
		D. oliveri	*V. paradoxa*	*Ficuss sp.*
	1.5	1	1	1
P. africana	1.0	2	2	2
	0.5	3	3	3
	1.5	1	1	1
P. mycrophylla	1.0	2	2	2
	0.5	3	3	3
	1.5	1	1	1
E. suaveol+ens	1.0	1	1	1
	0.5	2	2	2
Soligum treatment (+ **Control)**		0	0	0
Untreated wood (-Control)		6	5	5

Key: 0= No attack (0-6%); 1= Slight attack (1-20% damage); 2 = Moderate attack (21-40% damage); 3= Moderate/ severe attack (41-60% damage); 4 = severely attack (61-80% damage); 5 = Very severely attack (81-99% damage); 6= 100% Failure

DISCUSSION

Percentage absorption and retention of extracts and solignum by treated wood samples

The absorption rates in treated wood varied with different plant extracts and concentrations, implying diverse affinities between extracts and wood species, potentially affecting preservation efficacy. Okanlawon *et al.,* (2020) reported that chemical treatments consistently displayed higher wood absorption rates compared to seed methanol extracts across all wood types. This suggests improved or more consistent wood absorption, vital for preservation. Absorption percentages differed across plant extracts and concentrations for various wood species, highlighting the influence of plant species and treatments on wood preservation effectiveness. The retention levels varied among the extracts and wood types. Notably, the chemical treatment exhibited higher and consistent retention across all wood species compared to the seed methanol extracts, suggesting its potential as a more effective treatment against termite attack or decay (Tascioglu *et al.,* 2021).

Effect of methanol seed extracts and chemical treatments on treated wood samples exposed to termite infestation based on wood percentage weight loss

The findings of the study on the percentage weight loss among treated wood samples exposed to termite infestation show that methanol seed extracts and chemical treatments have varying efficacies in mitigating termite-induced weight loss in wood samples of *D. oliveri, V. paradoxa,* and *Ficus spp.* This finding agrees with study of Faruwa *et al.* (2015). PF6-based demonstrated an inverse relationship between weight loss and effectiveness, with higher concentrations leading to increased weight loss. *P. africana* and *P. mycrophylla* seed methanol extracts also showed an inverse relationship between weight loss and effectiveness, with higher concentrations correlated with increased weight loss. The chemical treatment showed comparably lower weight loss percentages, suggesting potentially better efficacy in mitigating termite-induced weight loss compared to the seed methanol extracts. Untreated wood samples exhibited remarkably higher weight loss percentages across all wood types, indicating vulnerability to termite infestation. These findings are consistent with other studies that have investigated the efficacy of various plant extracts and chemical treatments against termite infestation (Bakaruddin and Ab Majid, 2019; Elango *et al.,* 2021; Khademibami and Bobadilha, 2022). For example, a study on the efficacy of several plants extracts on the tunneling activity and survival of subterranean termites (*Coptotermesgestroi* and *Globitermessulphureus)* found that plants extracted with methanol demonstrated strong repellent properties (Bakaruddin and Ab Majid, 2019). Another study on the fire and termite resistance of wood treated with PF6-based ionic liquids found that the weight loss of IL-treated woods after termite resistance tests was essentially 0% (Miyafuji and Minamoto, 2022). This study on percentage weight loss among treated wood samples exposed to termite infestation highlights the potential of methanol seed extracts and chemical treatments in mitigating termite-induced weight loss. These results align with related studies on the antitermite properties of wood extracts, highlighting the importance of extract concentration in preserving wood against termite damage (Syofuna *et al.,* 2012).

Incidence of termite attack on *D. oliveri, V. paradoxa and Ficussspp*treated with extracts

The findings of the study on the incidence of termite attack on *D. oliveri, V. paradoxa,* and *Ficusspp* treated

with methanol extracts show that different extracts have varying effects on termite resistance in wood samples. No attacks were observed on wood treated with 1.5 g or 1.0 g *P. africana* of methanol extract. At the 0.5 g treatment, there was an incidence of attacks from the second to the fifth month. Also, no attacks were observed on wood treated with 1.5 g *P. mycrophylla*methanol extract but1.0 at g level, initial resistance was observed, but attacks manifested from the second month onwards. The 0.5 g treatment displayed partial protection, with initial vulnerability in the third month, escalating to moderate attacks in the subsequent months. Similarly, for *E. suaveolens* seed methanol extract, no attacks were observed across all treated wood species at the highest concentration (1.5 g) throughout the observation period. Wood treated with 1.0 g displayed initial protection against termite attacks in the first month, but subsequent months saw attacks occurring from the eleventh month onwards, albeit with varying intensity among different wood species. These findings are consistent with other studies that have investigated the efficacy of various plant extracts and natural compounds against termite infestation (Hadi *et al.,* 2016; Mahmoudi *et al.,* 2021).

Visual rating of termite attack on treated wood samples

Wood samples treated with methanol extracts from *P. africana, P. mycrophylla,* and *E. suaveolens* at 1.5% and 1.0% concentrations demonstrated notable resistance to termite attacks. At lower concentrations (0.5%), the treated samples still revealed a defensive trend, mostly rated at 0 for no attack. Contrarily, the untreated wood samples displayed vulnerability, scoring a visual rating of 3, indicating a moderate to severe attack, with damage ranging from 41% to 60%. Moreover, the Soligum-treated samples mirrored the characteristics of the treated samples, showcasing a robust resistance pattern with consistent ratings of 0 for no attack. In relation to other related by study Ekhuemelo *et al.* (2021) on the termicidal effect of *Spondiasmombin* methanol extracts on *Danielliaoliveri* and *Ficuscapensis* wood species in Makurdi, Benue State, Nigeria, revealed that *F. capensis* wood showed more resistance to termite attack than *D. oliveri* wood. Solignum was the most active treatment followed by *S. mombin* bark methanol extract and 0.33% *S. mombin root* methanol extracts. The study by Ali and Endalew (2021) also demonstrated the weight loss in wood samples treated with fractions of *D. stramonium* leaf extract, ranging from 8.20% to 20.27% in different solvent fractions. Additionally, study by Okechukwu *et al.* (2020) on the antimicrobial effect of isolated compounds of *Anadelphiaafzeliana* on selected wood fungi and bacteria in Makurdi, Nigeria, was also studied, showing the effectiveness of the treatment in preventing termite attacks on *D. oliveri* and *F. capensis* woods.

CONCLUSION

Erythrophleumsuaveolens extract displayed varying absorption percentages across wood species, with differences observed in *D. oliveri* and *V. paradoxa* woods treated with Solignum compared to extracts. Higher extract concentrations correlated with increased absorption. *V. paradoxa* had the highest mean percentage absorption and retention and was recorded for Solignum. Solignum treatment showed comparatively lower weight loss percentages suggesting potential efficacy in mitigating termite-induced damage. Untreated wood samples exhibited significantly higher weight loss percentages, indicating vulnerability to termite infestation. Concentration of 1.5 g seed methanol extract was most active extract and it is recommended for wood treatment against termites.The most susceptible wood species to termite attack was *Ficusspp* and it should be properly treated before employed in service.

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