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Comparative evaluation of *Khaya senegalensis* extract and a conventional chemical (Solignum) as wood preservatives in Yola, Adamawa State, Nigeria

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Abstract
The study compared the efficacy of *Khaya senegalensis* extracts and solignum as wood preservatives. Extracts were prepared from the seed and bark of *Khaya senegalensis* and compared with solignum. A total of 30 sawn wood samples of *Gmelina arborea* was used for the experiment. The wood samples were first oven dried at 85 °C to constant moisture content and weight of each recorded. Five sets of wood samples were soaked in the aqueous extract from the bark of *Khaya senegalensis*, five sets were soaked in the seed extract (oil), five sets were soaked in solignum, five sets were then soacked in equal proportion of seed and bark extract, another five sets soaked in equal proportion of solignum, seed and bark extract and the last five sets were left without any form of treatment. The type of the extract used, their mixtures and combination with solignum significantly influenced the degree of resistance of the wood (*Gmelina arborea*) to termite attack (p<0.O5). Wood samples treated with seed extract were susceptible to termite attack but their level of resistance to attack was 13.41% better than untreated wood samples Bark extract was classified as effective when compared to seed extract. Combination *Khaya senegalensis* extract with solignum offered the most discernible level of protection. Thus the findings of the study further confirm the claim by wood experts that the non-application of wood preservatives of wood makes it prone to termite infestation and deterioration. The possibility of using *Khaya senegalensis* extracts (seeds, bark extract) as a preservative provides a window for its adaptation as an alternative wood preservative that is safe for human handling and to the environment.

Keywords: *Khaya senegalensis* extract, *Gmelina arborea* (Wood), solignum, seed extract (Oil) and termite

Introduction

Wood has variety of usage and had been directly linked to civilization of man (Tolunay *et al*., 2008) [25]. It is one of the most frequently used materials for construction purposes worldwide. In Nigeria, more than 80% of the timber products are used for constructional purposes such as building, furniture, railway sleeper, transmission poles, pulp and paper, plywood, veneers, composites board, matches, fuel (Coal industries) and fuel wood (Akanbi and Ashiru, 2002) [2] The fact that wood can be used for both indoor and outdoor services and exposed to different weather conditions shows that wood can be used for many years if properly preserved. This quality makes wood more attractive for construction and furniture production. However, due to diversity in nature and character in wood, exploitation of trees for structure and construction purposes was selective and limited to strong and durable species (Oluwafemi and Adebenga, 2007; Kayode, 2007) [20, 11]. One of the factors contributing to this limited selectivity is the question of its long-term natural endurance to processes of natural degradation. When wood is used as a construction material, it is generally treated with a chemical preservative to prevent damages by bio deteriorating agents (Goktas *et al*., 2007) [8].

Wood as construction material is prone to damages by termites, thus posing a lot of social and economic problems since it requires additional labour and expenses to replace damaged woods. A review of the natural durability of 1500 commercial wood species worldwide shows that 191 of the wood species are very resistant to bio-deteriorating agents, 189 resistant, 298 moderately resistant and 826 non-resistant (Scheffer and Morel, 1998) [23]. The implication of this is that majority of the commercial wood species required preservative treatment to increase their service life. *Gmelina arborea* which is widely sorted as construction material in timber market is found to be among the none-resistant category.

Termite is one of the major bio-deteriorating agents affecting wood in service. They are highly destructive polyphagous insect including wood paneling, paper products, cardboard

boxes, art canvases, the paper covering of sheet rock and carpeting. Degradation of wood by termite is a chronic problem in many tropical regions particularly in the sub-Saharan Africa, resulting in serious monetary and material losses with far reaching impact on the increasing demand for timber (Obi *et al*., 2008) [19]. Out of more than 42 genera of termites, subterranean termite, *Coptotermes* appears to be the most prevalent genus foraging around buildings and in houses (Tho and Kirton, 1990) [24], infesting also forest plantation living trees (Kirton *et al.,* 1999) [12]. Additionally, termites of genera *Schedorhinotermes, Globitermes, Aternos, microtermes* and *macrotermes* are important pest in Agriculture.
Wood can be effectively protected from termites' attack by treating the wood with pesticides effective chemicals. There are many effective preservative chemicals used against wood pest in Nigeria, of which solignum is adjudged one of the house hold insecticides used in wood protection against fungal decay, soft rot, insects group termites and borers (Ahmed *et al.,* 2012) [1]. Impregnating wood by applying suitable chemicals, is the most preferred preservation method and present a lot of economic gains (Iya and Kwaghe, 2007) [9], but some toxic chemicals, used for wood preservation poses serious pollution risk to the environment such mammalian toxicity, pesticide residues, insect resistance, insect outbreak (Badshah *et al*., 2005) [6]. Also, apart from the environmental risk posed by some of the chemicals the relatively high cost of procurement and scarcity availability often contributed to their low level of adoption in developing countries like Nigeria.

Statement of Problem

The case of damage by termites due to human development makes reliable protection against termite attack increasingly important. This and changes in building practices, new techniques and new materials, can be the reason why termite damage have been reported from previously affected areas like the middle east. Apart from damage to trees they also cause extensive destructions of buildings. They gain access to the wood work of the building through cracks and breakages on concrete structures. Termites can penetrate lead sheathed cables to seek the cellulose in the woody materials. Irrigation, leaking pipes, condensation from air conditioners and the normally higher humidity levels found under the foundations provide moisture, a necessary requirement for termites' attack. Wood deterioration brought by insects, fungi and marine boring animals can be prevented if the surrounding conditions are unsuitable to the growth of these organisms. Recently, great interest has been focused on some wood preservatives that are relatively cost effective chemicals and have minimal activity to mammals and the environment at large. Considering the toxicity, high cost of procurement and scarcity of the conventional chemicals used for wood preservation, it becomes important that a research should be carried out to focus on some preservatives that are relatively cost effective and have minimal toxicity to mammals and the environment at large. Ability of natural plant extract to protect wood against wood degrading fungi and insects has been one possible approach for developing new wood preservatives (Kartal *et al*., 2004) [10]. The use of plant materials in the management of insect pest such as termite control which is cheap, easily reached and assembled in the developing countries had been reported by Owusu, 2000) [21]. Traditional methods of little use in the developed countries play a significant role in pest control. However, despite the wide array of studies of plant materials such as *Khaya senegalensis* extract' in the management of pest of agricultural produce (Lowery and Isman, 1993; Lale and Abdulrahman, 1999; Meikle *et al*., 2005) [15, 13, 17], there is scarcity of research information on the efficacy of *Khaya senegalensis* extract in wood preservation bearing in mind the need to preserve wood in order to reduce the rate of harvest and avoid cost of replacing termite damaged wood structure. There is therefore a need to intensify promotion of traditional organic control strategies in order to reduce over reliance on conventional insecticides and thus prevent environmental contamination.

Materials and Method

Study area

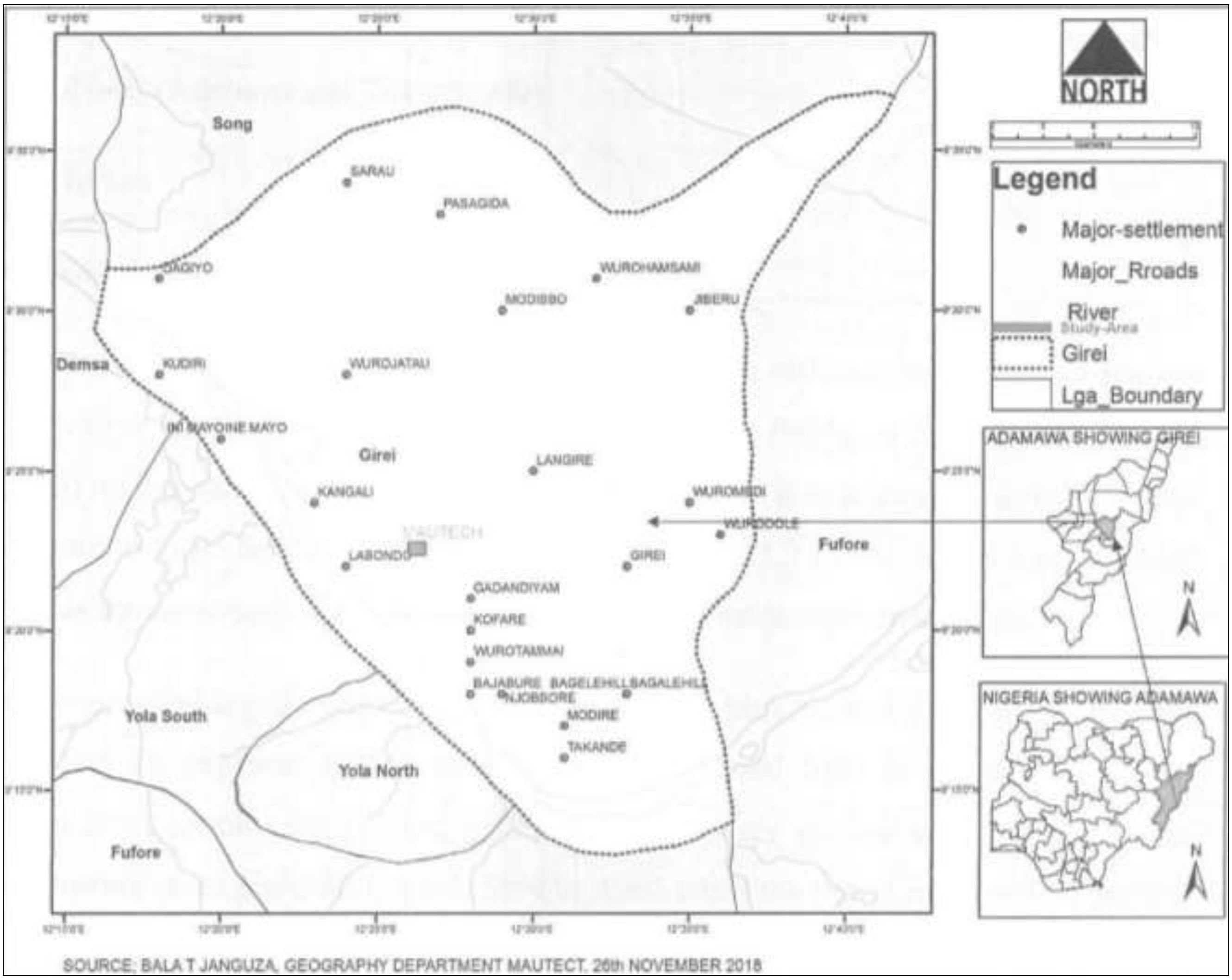
The study was carried out within the campus of Modibbo Adama University Yola (MAU), in Girei Local Government Area of Adamawa state, located between Latitudes 9° 24' and 9° 29' N and Longitude 12° 33' and 12° 35 East.

Materials used

Gmelina arborea is fast growing tree, which grows on different localities and prefers moist fertile valley with 750 - 4500 mm rainfall. It does not thrive on ill-drainea soils and remain stunted on dry-sandy or poor soil; drought also reduces it to a shrubby form The tree attains moderate to large height of up to 30m, with a girth of 1.2 to 4m. It has a chlorophyll layer just under the outer bark which is pale yellow on the outside and white inside.
Gmelina arborea wood is pale yellow to cream coloured or pinkish buff when fresh. Turning yellowish brown on exposure and is soft to moderately hard light to moderately heavy, lustrous when fresh, usually straight to irregular or rarely wavy grained and medium course textured. Flowering takes place during February to April when the tree is more or less leafless whereas fruiting starts from May onward up to June. The fruit is up to 2.5cm long; smooth, dark green, turning yellow ripe and has fruity smell. This tree is commonly planted as a garden and an avenue tree; growing in villages along community agricultural land and on village community land and waste land. It is high demander tolerant of excessive drought, but moderately frost hardy. It has good capacity to recover from frost injury. *Gmelina arborea* trees coppices very well with vigorous growth. Saplings and plants need protection from Deer and Cattles.
Solignum is by- product of cresole. Cresole is bituminous by- product and when further refined, solignum is obtained. Solignum is a wood preservative that penetrate into the wood and remain the active barrier against wood-rot, wood borer and fungal decay as well as termites' attack. It kills fungi and wood borers and preserves the wood from future attack. Timber treated with solignum can be painted if desired. Solignum is not suitable for greenhouse. Solignum can be applied by immersion to a clean bare dry wood.

Wood sample collection

The wood of *Gmelina arborea* was obtained from Yola main timber market. Containers was used for mixing the chemicals and extract from seeds and bark of *Khaya senegalensis* tree, solignum. Mature *Khaya senegalensis* fruits were gathered from vibrant growing *Khaya* stand within the campus and soaked in water for depulping. The depulped seeds was later sun dried and fried after which they were ground into powder.



Source: Department of geography, MAUTEECH, (2018).

Fig 1: Map of girei showing the study area

The powder obtained was then moistened with water and pressed to extract the oil. Similarly, fresh barkwas peeled from vibrant growing *Khaya senegalensis* tree, chipped and air dried at room temperature for two weeks. The air dried bark was thereafter ground and sieved with 2 mm sieve. The powder obtained was tied in white cloth and extracted in 100ml hot water at 100 °C. The aqueous extract was filtered and stored in carefully labelled dark conical flask until used.

Treatment of wood samples with solignum and the natural extract from seed and bark of *Khaya senegalensis*: Thirty sawn wood samples of *Gmelina arborea* obtained from Yola timber market of dimension 2 cm x 2 cm x 1 m were used for the experiment. The wood samples were first oven dried at 85 °C to constant moisture content and the weight of each was recorded. Five wood samples were each soaked in aqueous extract from the bark of *Khaya senegalensis* and seed extract (oil). Similarly, five wood samples were each soaked in a mixture of seed and bark extract, five wood samples were also soaked in solignum, five were soaked in a mixture of seed, bark, and solignum and five wood samples were left without any treatment (control).

Laying out of the experiment

The layouts of the wood samples were done after oven-drying. Thirty wood samples comprising of six pieces treated with seed extract (Oil) T_1, bark extract T_2, solignum T_3, mixture of seed and bark extract T_4, mixture of seed, bark and solignum T_5 and control or untreated T_6. All wood samples were labelled with letter (T_I, T_2, T_6) to indicate the treatment applied. The labelled wood samples were then selected and grouped into five with six (6) pieces of wood in each group. Five termiteria or ant hills were selected, six wood samples; one (1) from each treatment were represented in each ant hill.

Termitaria A
T_1S_5 T_2S_5
T_3S_5 T_4S_5
T_6S_5 T_5S_5

Termitaria D
T_1S_2 T_2S_2
T_3S_2 T_4S_2
T_5S_2 T_6S_2

Termitaria E
T_1S_4 T_2S_4
T_3S_4 T_4S_4
T_5S_4 T_6S_4

Termitaria B
T_1S_3 T_2S_3
T_3S_3 T_4S_3
T_4S_4 T_5S_3

Termitaria C
T_1S_1 T_2S_1 T_3S_1
T_4S_1 T_5S_1 T_6S_1

Fig 2: A layout showing the experiment

Grave-yard field treatment: The grave-yard experiment was carried out for 6 weeks. The wood samples were buried in location where ant hill are seen in the campus, leaving some length above the ground level and mulched with dry grass in order to make the environment conducive for termite infestation, the grass is watered every week. Standard method for evaluation to determine the resistance to subterranean termites (AWPA, 2000) was modified in order to evaluate the degree of resistance of the treated woods to termite's attack. At the end of the field study (6weeks) the percentage weight loss of each of the sample was determined using the formula;

$$\% \text{ weight loss} = \frac{\text{Wb-Wa}}{\text{Wb}} \text{ x } 100$$

Where

Wb weight of oven dried wood samples before grave-yard field experiment. Wa weight of oven dried wood samples after grave- yard field experiment.

Experimental Design:

Complete Randomized Design (CRD) was used in assigning treatment to the samples. The model is;

Yij=μi+Tj+ Σij

Where

Yij = total sum of observation

μi= general mean

Tj = treatment (Solignum and plant extracts)

Σij = error associated with the experiment.

Method of Data Analysis

Data was analyzed using the Complete Randomized Design (CRD) using Statistical Package for Social Science (SPSS) version 20. Findings from the various treatments were as presented below.

Results

Degree of termite (Isoptera) treatment and infestation on wood samples of *Gmelina arborea*

Control: The results of termite infestation on five wood samples under control treatment are presented in Table 1. Results showed that sample 5 (S5) had the highest value of weight before oven-drying with 503.02 g while the least was S4 which had 478.93 g. The dry weight revealed that S5 had 500.34 g which is the highest value while S4 had the least value 472.30 g. After termite infestation shows that S4 had 22.77 g while the least was S2 which had 10.43 g. The percentage weight loss shows that S2 had the highest value 97.88% while the least was S4 which had 93.3 3% weight loss.

Treatment with seed extract (oil): The result of termite infestation on wood samples treated with seed extract is presented on Table 2. It shows that sample (S4) had the highest value of fresh weight with 500.21 g while the least was S3 which had 493.95 g. The dry weight revealed that S4 had 498.12 g which is the highest value while S3 had the least value 490.25 g. After termite infestation shows that S1 had 92.02 g which is the highest value while the least was S5 which had 7 1.91 g. The percentage weight loss shows that SS had the highest value 85.39% while the least was S1 which had 81.52% weight loss.

Treatment with Bark extract: The result of termite infestation on wood samples treated with extract from bark *of Khaya senegalensis* in Table 3 shows that S2 had the highest fresh weight of 51 0.32 g, while the least was S5 which had 495.85 g. The dry weight revealed that S1 had 498.7 1g which is the highest value, while S2 had the least value 492.01 g. After termite infestation S5 weighed 120.56 g which is the highest value while the least was S4 which had 89.14 g. The percentage weight loss shows that S4 had the highest value 82.06% while the least was S5 which had 75.55% weight loss.

Table 1: Results from untreated wood (Control)

S/N	Fresh Weight Drying (g)	Dry Weight (g)	Weight After Infestation (g)	Percentage Weight Loss (%)
S1	500.19	497.88	16.98	96.58
S2	479.00	492.72	10.43	97.88
S3	500.10	498.02	22.77	95.43
S4	478.93	472.30	31.48	93.33
S5	503.02	500.34	12.00	97.60

Source: Field Survey (2022)

Table 2: Treatment Using Seed Extract

S/N	Fresh Weight (g)	Dry Weight (g)	Weight After Infestation (g)	Percentage Weight Loss (%)
S1	500.11	497.90	92.02	81.52
S2	500.13	492.71	90.10	81.82
S3	493.95	490.25	83.11	83.05
S4	500.21	498.12	79.75	81.99
S5	495.88	492.03	71.91	85.39

***Source*:** Field Survey (2022)

Table 3: Treatment Using Extract from the Bark of *Khaya senegalensis*

S/N	Fresh Weight (g)	Dry Weight (g)	Weight After Infestation (g)	Percentage Weight Loss (%)
S1	502.02	498.71	98.67	80.21
S2	510.32	492.01	100.93	79,49
S3	498.97	493.77	108.31	78.06
S4	501.04	497.00	89.14	82.06
S5	495.85	492.31	120.56	75.55

***Source*:** Field Survey (2022)

Treatment with solignum
The result of termite infestation on wood samples in Table 4 showed that sample 1 (S1) had the highest value of fresh weight 510.41 g while the least was S5 which had 498.54 g. The dry weight revealed that S1 had 505 g which is the highest value while S5 had the least value 494.14 g. After termite infestation shows that S2 had 208.41 g which is the highest value while the least was S4 which had 171.15 g. The percentage weight loss shows that S5 had the highest value 70.03% while the least was S2 which had 5 8.24% weight loss.

Treatment with seed and Bark extract
The result of termite infestation on different wood samples in Table 5 showed that sample 1 (S1) had the highest value of fresh weight with 505.42 g, while the least was S3 which had 492.14 g. The dry weight revealed that S1 had 501.97 which is the highest value, while S5 had the least value 490.15 g. After termite infestation shows that S3 had l15.48 g which is the highest value while the least was S1 which had 50.3 8 g. The percentage weight loss shows that SI had the highest value 89.96% while the least was S2 which had 71.36% weight loss:

Treatment with bark extract and solignum
The result of termite infestation on wood samples in Table 3 shows that sample 5 (S5) had the highest value of fresh weight with 507.05 g, while the least was S2 which had 500.08 g. The dry weight revealed that S5 had 502.1 8 g which is the highest value while S2 had the least value 490.26. After termite infestation shows that S5 had 500.02 g which is the highest value while the least was S2 which had 490.26 g. The percentage weight loss shows that S1 had the highest value 1.43% while the least was S5 which had 0.43% weight loss.

Table 4: Treatment with solignum

S/N	Fresh Weight (g)	Dry Weight (g)	Weight After Infestation (g)	Percentage Weight Loss (%)
S1	510.41	505.34	202.91	59.85
S2	502.15	499.10	208.41	58.24
S3	500.27	496.93	173.16	65.15
S4	500.55	497.31	171.15	65.53
S5	498.54	494.14	148.07	70.03

Source: Field Survey (2022)

Table 5: Treatment with Oil and Bark Extract

S/N	Fresh Weight (g)	Dry Weight (g)	Weight After Infestation (g)	Percentage Weight Loss (%)
S1	505.42	501.97	50.38	89.96
S2	501.06	499.13	142.95	71.36
S3	492.14	490.19	115.48	76.44
S4	500.34	496.22	93.11	81.24
S5	493.37	490.15	102.24	79.14

Source: Field Survey (2022)

Table 6: Treatment with Oil, Bark and Solignum

S/N	Fresh Weight (g)	Dry Weight (g)	Weight After Infestation (g)	Percentage Weight Loss (%)
S1	501.81	499.19	492.07	1.43
S2	500.08	497.14	490.26	1.38
S3	503.14	498.93	493.91	1.01
S4	500.73	492.64	489.21	0.70
S5	507.05	502.18	500.02	0.43

Source: Field Survey (2022)

Analysis of Variance (ANOVA) on comparison and infestation rate
Analysis of Variance (ANOVA) carried out on the six treatments indicates that there exists a significant difference among the treatments at a p≤ 0.001(Table 7). Figure 3 is a histogram showing weight loss of wood samples treated with different preservatives. Duncan's Multiple Range Test (DMRT) as adapted by Steel and Tome (1984) was used to determine the level of significance at α 0.05 (Table 9). The result shows that wood samples treated with a mixture of seed, bark and solignum is different from other treatments, similarly, wood samples treated with solignum and the wood samples used as control are significantly different, while wood samples treated with seed extract, bark extract and a mixture of seed and bark extracts are not significantly different.

Table 7: Results Obtained from Analysis of Variance (ANOVA)

Sources of Treatment	Degree of Freedom	Sum of Squares	Mean Square	F Value	Pr(>F)
Treatment	5	2888.59	5772	423.9**	<2e- 16**
Error	24	327	14		
Total	29	29186			

α =0.001

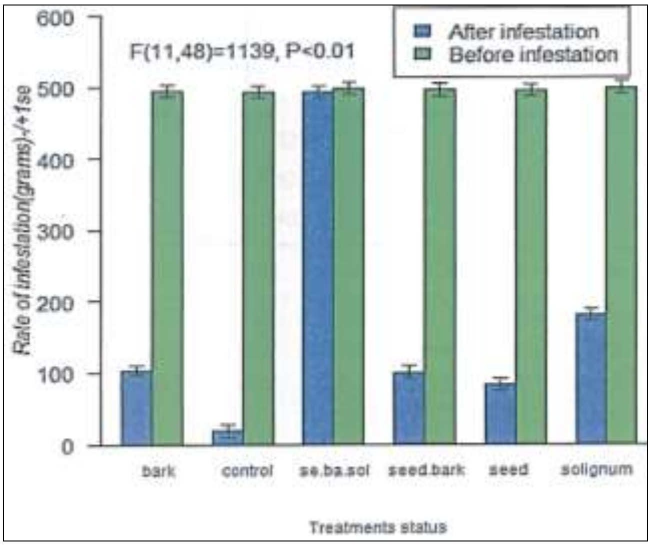


Fig 3: Mean weight loss of wood samples, comparison of wood weights before and after experiment

Table 8: Treatment Means and Standard Deviation

Treatments	Mean of Treatment	STD
Bark Extract	79.07	2.44
Control	96.16	1.85
Seed, Bark	79.63	6.86
Seed, Bark, Solignum	0.99	0.43
Seed Extract	82.75	1.58
Solignum	63.77	4.75
Total	402.37	17.91

Table 9: Duncan Multiple Ranges Test for Mean Weight Loss (%) Mean Square Error: 13.61504

Treatment	Weight Loss (Mean)	Standard Deviation	Minimum	Maximum	Group Super Script
Control	96.164±1.85	1.85	93.33	97.88	d
Bark	79.074±2.44	2.44	75.55	82.06	c
Seed, Bark	79.628±6.86	6.86	71.36	89.96	c
Seed, Bark, Solignum	0.990±0.43	0.43	0.43	1.43	a
Seed Extract	82.753±1.58	1.58	81.52	85.39	c
Solignum	63,779±4.75	4,75	58,24	70.03	b

Alpha: 0.04l D F Error: 24.

Discussions

Comparison between the six treatments

Control

The findings revealed that there were weight losses for untreated samples of *Gmelina arborea.* They are wood samples that never had any type of preservative applied on them before their exposure to termite infestation. It was observed that there were differences in weights between the pre-infestation weight (weight before infestation) weights and the post- infestation (weight after infestation) weights. The weight losses recorded by *Gmelina arborea* wood after infestation could therefore be attributed to the destructive activity of termites to which they were exposed for over a period of six weeks. This finding agrees with the position of Wong and Cheok (2001) [27] opined that termites was one of the most destructive agent of wood with consequence of weight loss after infestation.

Seed extract (oil)

The weight loss of wood samples treated with seed extract (oil) of *Khaya senegalensis* were noted to be a bit low compared with untreated (control) wood samples which were all exposed to the same ambient condition and termites infested locations. The *Gmelina arborea* wood samples treated with *Khaya senegalensis* seed extract (oil) recorded a mean percentage weight loss of (82.75%). This result showed that resistance to termite was enhanced with the application of *Khaya* seed extract treatment being the only substance applied before exposure to termite infestation. The drop in weight losses percentage of *Khaya senegalensis* seed extract treated *Gmelina arborea* wood samples implied that the service life of wood is lengthened and this makes *Khava senegalensis* seed extract fit into description of being called a wood preservative as defined by wood preservative experts who described a wood preservative as any substance that is applied on wood to increase or prolong its service life. The high percentage weight loss observed in samples treated with seed extract could be attributed to fact that *Khaya senegalensis* oil does not penetrate wood samples readily in its raw state. This behavior of oil according to Lale and Mama (2003) [14] tends to reduce its overall efficacy in providing uniform control of insect pests.

Mixture of *Khaya senegalensis* extract (seed and bark)

The degree of protection offered by mixture of *Khaya senegalensis* seed and bark was 84.38% (Table 5). Although the level of protection offered by *Khaya senegalensis* oil was low, it was seen to be far better than untreated wood (control). From this result, though *Khaya senegalensis* extract did not provide absolute protection to the wood samples, the level of protection offered is comparable to that of cashew nuts (Venmalarand and Nagaveni, 2005) [26] *Chromolaena odorata, Carica papaya* (Owosu *et al*., 2008) [22]; meanwhile each of the treatment was mixed with solignum, the level of protection was greatly improved. For example, though (0.99%) weight loss was observed on wood treated with mixture of seed, bark and solignum, no visible termite attack was observed. The implication of this is that loss in weight could be attributed to factors such as soil. Similarly, in wood samples treated mixture of seed, bark extract and solignum, only a few nibbles were seen on the surface of the wood. Conventional chemicals like solignum could be added to *Khaya senegalensis* extract to enhance its potency level.

Comparison of the effectiveness of natural plant extracts from *Khaya senegalensis* and solignum on *Gmelina arborea*

Among the *Khaya senegalensis* extracts, wood samples treated with bark extract gave the most discernable protection Table3. The percentage weight loss in wood samples treated with bark extract was 6.32%less than samples treated with seed extract and 5.29% less than wood samples treated with a mixture of seed and bark extracts. Thus, the weight loss of wood samples treated with bark extract can be termed effective the higher protection offered by bark extract could be attributed to the higher penetrability of bark extract. It could be the reason why termite doesn't build their mounds around *Khaya senegalensis* tree. Therefore, depending on the potency of the material, the degree of protection offered is a function of its penetrability.

The untreated samples (control) were highly susceptible to termite attack over the six- week period of the assessment. The attack on the untreated wood sample started manifesting within week I of the exposure to the grave-yard test. The implication of this is that wood of *Gmelina arborea* is very susceptible to termite attack. The low resistance of *Gmelina arborea* to termite attack might be one of the reasons why it was classified among non-durable species (Scheffer and Morel, 1998) [23]. Similarly, it was evident that wood samples treated with *Khaya senegalensis* oil (seed extract) began to show some level of susceptibility in the second week of exposure to the grave-yard test, while mixture of seed and bark extract began to show symptoms of superficial attack the third week. This corroborates the appreciable weight loss observed in wood treated with both the *Khaya* seed and bark extracts. Bark extract on the other hand was able to protect the wood samples up to the fourth week after which it began to develop few nibbles, whereas, solignum treated samples remain protected through the fifth week of exposure. Overall at the end of the sixth week, 82.75% cross section of the wood treated with *Khaya* seed extract was degraded, while 79.07 and 84.38% of cross section of wood samples treated with bark and seed extracts respectively were degraded. Meanwhile, when the mixture of the extracts was used, appreciable level of protection was achieved. Hence, the degree of resistance of wood treated with mixture of *Khaya senegalensis* extracts greatly increased as depicted by 0.99% of the cross section of wood samples treated with mixture of *Khaya* oil, bark extracts and solignum. This finding confirmed the effectiveness of modified neem *(Azadirachta indica)* extracts reported by Moyin-Jesu (2010) [18]. The degree of protection offered by solignum when used singly could be responsible for the great resistance observed as presented in Table 4 and illustrated in Figure 1. The implication this finding is that solignum offers an effective against termite attack. But it has shown that solignum contains sulfur which is highly toxic impurity and thus, harmful (Allender and Keegan, 1991; Ambrus *et al.,* 2003) [3, 4]. Therefore, the level of protection offered when *Khaya senegalensis* extract (seed, bark) was combined or mixed with solignum suggested that low level of chemical could be combined with plant extract to achieve high level of protection against termite attack thereby reducing the harmful effect of the chemical. This could be more effective if used in modified form with mixture of extracts.

Under review, it was observed that some of the *Gmelina arborea* wood mple2 treated with a mixture of equal proportion of solignum, seed and bark extract from *Khaya senegalensis* were only slightly infested all throughout the period of the experiment as could be seen in Table 5. It was observed that the rate of infestation by termites were very slow during the first two weeks when compared to the infestation rate towards the end of the experiment when the destructive effect of the termite was recorded to be high and when the preservative strength of the treatments has reduced over time. It was also observed that the activities of termites increased when there is rain, which conform to the finding of Jorn, (1990) [28] that the higher humidity levels found under foundations provide moisture which is a necessary requirement for termite attack.

The graph reveals the various treatments on wood and their percentage weight loss. The untreated wood samples show to be having the highest percentage weight loss, followed by those woods treated with extract from seed, bark *Khaya senegalensis,* while those treated with bark, solignum, seed extract had the lowest percentage weight loss followed by those treated with solignum. Analysis of Variance carried out between treatments showed that there is a significant difference between the treatments at a P-value < 0.005. *Gmelina arborea* wood samples treated with extracts from seeds and bark of *Khaya senegalensis* and solignum has the least mean percentage weight loss (0.99) thus, it is the most effective preservative followed by samples treated with solignum (63.77) and control had the highest weight loss (96.16). The wood samples treated with mixture of equal proportion of extract from seeds and bark of *Khaya senegalensis* were destructively infested, the mean percentage weight loss i

The result obtained from ANOVA test shows that there is a significant difference between treatments, means were separated using Duncan's multiple range tests in order to provide information as to the best treatment combinations. The degree of infestation on the wood samples as a result of the termite infestation was measured in terms of weight loss. On the average, the infestation on untreated wood samples was considerably high as depicted by *95.97%* weight loss, samples treated with seed extract of *Khaya senegalensis* show (82.75% weight loss) which are the most attacked treated samples. Thus, termite infestation was generally less on treated samples compared to untreated samples. This confirmed the effectiveness of extract solutions in enhancing termite attack resistance of wood (Goktas *et al.,* 2007) [8]. Means with the same letter are not significantly different. i.e. wood samples treated with bark extract, mixture of seed and bark extract and seed extract are not significantly different from each other, while wood samples treated with solignum, mixture c' bark extract and solignum and control shows significant difference. This finding revealed that wood samples treated with a mixture of equal proportion of seed, bark extracts and solignum shows no significant weight loss after infestation, wood samples treated with solignum offered great protection against termite infestation as the wood samples shows reasonable weight after infestation by termites. Among the natural extracts, wood samples treated with bark extract offered the best protection as the wood samples still had a good weight left after infestation, while wood samples used as control was shown to be highly susceptible to termite attack as only a small percentage weight of the samples was left after termite infestation.

Conclusion

The findings of the study further confirm the claim by wood experts that the non- application of wood preservatives on wood makes it prone to termite infestation and deterioration. This fact was established in the case of untreated *Gmelin arborea* wood species which suffered different levels of termite attack as compared to the treated ones which had significant levels of preservation against termite infestation. The possibility of using *Khaya senegalensis* extracts (seeds, bark extract) as a preservative provides a window for its adoptation as an alternative wood preservative that is safe for human handling and to the environment. The predominant timber of *Gmelina aborea* had its resistance to termite infestation increased with the application of *Khaya senegalensis* extracts therefore it can be inferred that *Khaya senegalensis* extracts has the potential of being an effective wood preservative.

Recommendation

Based on the findings of the study, the following recommendations are made: *Khaya senegalensis* extract should be brought to limelight by wood related research institutes as a new innovation that needs to be explored as alternative to the toxic chemical preservatives.

Competing Interest

Author have declare that no competing interest exist

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