



Article Info

Received: 23rd October 2024

Revised: 19th November 2024

Accepted: 19th November 2024

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Cite this: CaJoST, 2025, 1, 189-193

Efficacy of Neem Seed Oil and *Khaya senegalensis* Bark Extracts on *Afrormosia laxiflora* Wood Species Exposed to Termites Infestation

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This study aimed to determine the absorption rate and to estimate the weight loss of *Afrormosia laxiflora* and *Triplochiton scleroxylon* exposed to subterranean termites after treatment with these extracts over varying durations. Many wood species are vulnerable to termite infestations, and synthetic wood preservatives pose health and environmental risks, making plant-based extracts a promising alternative. The study was conducted at Shehu Shagari College of Education in Sokoto, Nigeria, the research involved collecting wood samples from Kara Market and extracting bioactive materials from the plants. A non-pressurized brushing method applied four treatments: five samples each of neem seed oil, *Khaya senegalensis* extract, a synergistic mix, and untreated controls, all replicated five times in a complete randomized design (CRD). The treated samples were exposed to termite attack for 12 weeks, with assessments every two weeks. Results showed significant differences among treatments ($P < 0.05$). Neem seed oil had the lowest mean weight loss of 423.40 g, followed by *Khaya senegalensis* at 394.00, and the synergistic treatment (AC1) at 367.00 g. The untreated control (ACo) recorded the highest loss of 132.80 g. Visual assessments confirmed that both neem seed oil and *Khaya senegalensis* significantly reduced weight loss compared to controls. This study highlights the potential of these plant-derived extracts as effective, environmentally friendly alternatives for wood preservation and sustainable pest management.

Keywords: Neem seed oil (NSO), *Khaya senegalensis* bark extract, termite, weight loss.

1. Introduction

Termites are the most dominant arthropod decomposers and have an extraordinary ecological impact on both agricultural and non-agricultural ecosystems, playing a significant role in the global carbon cycle, the decomposition process, and the mineralization of nutrient-rich cellulose (Traoré *et al.*, 2018). Termites originated from Sub-Saharan Africa, with the highest species diversity found in rainforest habitats (Poulsen, 2015). Based on their habitat, they are categorized as subterranean termites (which live beneath the soil), dry wood termites (which spend their lives in dry wood), and damp wood termites (which prefer to live in moist wood) (Govorushko, 2019). Despite their beneficial role, termites often cause significant damage to humans, as they can damage anything containing cellulose, such as books, stored timber, wooden structures, buildings, stored grain products, crops, standing trees, and forests (Ravan *et al.*, 2015). It is estimated that termites cause approximately 0 billion USD in annual damage worldwide (Van Huis, 2017), and over 30 Billion in the USA alone in 2023 (Bazen & Parkman 2024)

Wood is usually protected from the attack of decay fungi, harmful insects or marine borers by applying

preservatives, such treatment can greatly increase the lifespan of wood products, thus reducing replacement costs and allowing more efficient use of forest resources. The use of conventional synthetic insecticides still remains the most effective means of controlling field and stored product insect pests despite their draw backs inclusive of high mammalian toxicity and environmental pollution (Malgwi *et al.*, 2014). Currently, research on insecticide product development focuses on materials of plant origin which are effective, readily available, affordable and environmentally friendly (Oaya *et al.*, 2019). Extractives have been shown to play a pivotal role in the inherent durability of naturally durable wood species (Arango *et al.*, 2006). The aim of this study is to investigate the efficacy of neem seed oil extract and *Khaya senegalensis* bark extract on *Afrormosia laxiflora* (Koro-Koro) and *Triplochiton scleroxylon* (Obeche) as preservatives against termites.

2. Materials and Methods

2.1. Study area

The study was conducted in Sokoto Metropolis in three laboratories located in two different institutions

within the metropolis (Usman Danfodio University Sokoto and Shehu Shagari College of Education Sokoto). Sokoto metropolis lies in the extreme northwestern part of Nigeria between Latitudes 120° 46'N to 130° 08'N and Longitudes 50° 14'E to 50° 30'E, Sokoto metropolis covers 16 km radius from Kangiwa square and it The area is also characterized by the Sudan Savannah type of vegetation (Olayinka, 2003), with abundant grasses and shrubs interspaced by short woody trees around the metropolis. Its annual rainfall is between 625 to 700mm, which normally starts in June and ends in October while average daily temperature is about 36°C (Umar, 2013).

2.2. Collection of extract materials

Two distinct extract materials were procured. First, the seeds of *Azadirachta indica* were harvested from trees located in the main campus of Usmanu Dan Fodiyo University Sokoto during the dry season. The seed coats underwent decortication and were subsequently air-dried at ambient temperature for approximately two weeks. After drying, the seeds were finely ground into a powder using mortar and pestle.

Similarly, fresh stem bark of *Khaya senegalensis* was carefully obtained from healthy trees within the premises of Umbaru Aliyu Shinkafi Polytechnic in Sokoto State. The bark was air-dried at room temperature for about two weeks. Following this, the dried stem bark was ground and sieved through a wire mesh. A 200 g sample of the resulting powder was then stored in a dark bottle for future use.

2.3. Phytochemical screening of *A. indica* seed oil and *K. senegalensis* bark extract

The phytochemical analysis was conducted in biochemistry laboratory of Usmanu Danfodiyo University Sokoto. Phytochemical screening of neem seed oil and *Khaya senegalensis* bark extract was carried out following the procedure stated by (Donovan *et al.*, 2007). This was conducted in order to determine the presence and concentration of alkaloids, saponins, tannins, steroids, terpenoids, flavonoids and phenolic compounds, the neem seeds and *Khaya senegalensis* bark extract were grounded before being exposed to phytochemical screening.

2.4. Extraction of Neem Seed Oil

The extraction was carried out in Biochemistry laboratory of Usmanu Danfodiyo University Sokoto. Two hundred (200 ml) of n-Hexane was poured into round bottom flask. 40g of the sample was placed in the thimble and was inserted in the centre of the extractor. The soxhlet was heated at 65 °C. When the solvent was boiling, the vapour rose through the vertical tube into the condenser at the top. The liquid condensate drips into the filter paper thimble in the centre, which contains the solid sample to be extracted. The extract seeps through the pores of the thimble and fills the siphon tube,

where it flows back down into the round bottom flask. This was allowed to continue for 6 h. It was then removed from the tube, allowed to cooled and weighed to determine the amount of oil extracted (Adegoke *et al.*, 2015).

2.5. Preparation of NSO and *K. senegalensis* bark extract

The maceration procedure described by Dahchar *et al.* (2016) was used to prepare the interaction of the extracts using the maceration method; 50 g of *K. senegalensis* bark powder was sampled and 200 ml of NSO was used to soak it for a period of 30 minutes in a dark cupboard under room temperature. To ensure appropriate mixing, the substance was shake at regular intervals. The treatment concentrations were used.

2.6. Wood samples collection

Quality planks of straight-grained *Afrormosia laxiflora* were sourced from Sokoto Kara Market. The planks were precisely planed, and test samples were cut to dimensions of 30 x 5 x 5 cm (length x width x height) using a measuring tape and handsaw. A total of twenty (20) defect-free test samples were prepared from this wood species.

2.7. Collection of subterranean termites

Termites were collected from the garden behind the Agricultural Science Department at Shehu Shagari College of Education Sokoto, following the method outlined by Oaya (2020). This involved using wooden traps specifically designed for termite collection. The infested stakes were placed inside these wooden trap boxes, which were left in place for several days until termites began to infest the wood. The traps were then collected for analysis.

2.8. Experimental treatment and Design

The dried wood was processed into test samples and treated using a non-pressurized brushing method, where each sample was brushed with the respective treatment. A total of five samples were treated with neem seed oil (NSO), five samples with *Khaya senegalensis* bark extract (LBI 1), five samples with a combination of NSO and LBI 1, and five samples served as a control. After treatment, the samples were air-dried for five days to ensure retention of the treatments. the samples were placed. The wood samples were then subjected to termite attack for a duration of 12 weeks in a ventilated plastic jar consisted of termites (including workers and soldiers of equal quantity) and 1 kg of moist mound material from termitaria.

2.9. Data Collection

Data collection consisted of physically observing the treated samples and recording their weights before and after treatment. Additionally, the weights of the samples were measured biweekly over a twelve-

week period following exposure to termite infestation, as outlined by Tsoho B. (2008).

2.10. Visual Observation and Rating System

The severity of termite attacks on the wood samples was assessed using the American Society for Treatment and Material ASTM D2017-05 standard rating system, which is a widely recognized protocol for evaluating the resistance of wood to termites. The visual rating was conducted at each observation point (weeks 0, 2, 4, 6, 8 and 10) based on the following scale:

- **10** – Sound, with surface nibbles permitted.
- **9** – Light attack, where there is evidence of superficial feeding.
- **7** – Moderate attack, characterized by boreholes in the wood surface.
- **4** – Heavy attack, where significant wood damage is visible.
- **0** – Complete failure, indicating that the wood has been fully compromised by termite activity.

These ratings allowed for effective measure of the bio-insecticides' efficacy in preserving the wood samples.

2.11. Statistical analysis

ANOVA was used to determine significant differences among the treatments applied to the wood. Subsequently, Duncan's Multiple Range Test (DMRT) was employed to identify which groups differed significantly at an alpha level of 0.05, specifically when the ANOVA revealed significant differences among the treatments.

3. Results and Discussion

3.1. Results

3.1.1. Treatment Absorption

Table 1 shows the absorption rates for the two different species of wood under different treatments. The absorption rates are represented with mean values and standard deviations. Statistical significance is denoted by different superscripts, indicating numerical differences between absorption rates ($p < 0.05$).

Table 1: Absorption Rates of Different Species under Various Treatments

Wood species	Treatment	Absorption (g/m ³)
<i>Afrormosia laxiflora</i>	AA	10.4 ± 3.58 ^a
	AK	8.40 ± 3.61 ^a
	AC1	6.40 ± 1.52 ^a

The visual assessment results from this study displayed in Figure 1 indicate that both bio-insecticides, Neem Seed Oil and *Khaya* bark extract, were effective in preventing and limiting termite attack on the treated wood samples compared to the control (untreated) samples. Over the 12-week period, the control samples showed a gradual but continuous decline in visual ratings, indicating progressive termite damage, while the treated samples maintained higher visual ratings throughout the testing period.

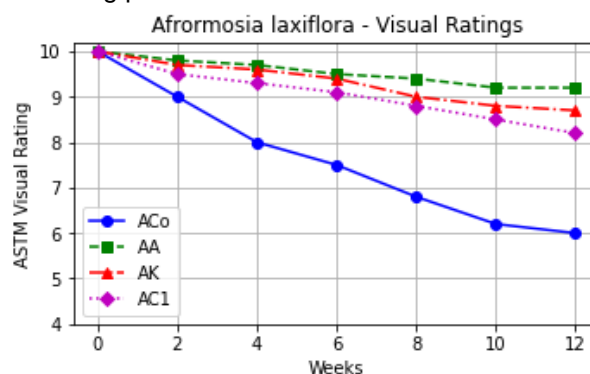


Figure 1: Visual ratings of *Afrormosia laxiflora* treated with the wood preservatives

The degree of attack on the wood sample as a result of termite invasion is measured in terms of weight loss. The weight loss on treated and untreated samples is shown in Table 2. Termites were most active on untreated wood samples and the average attack on that wood samples were considerably high as depicted by 132.80g weight loss compared to treated samples. Samples treated with NSO had the least weight loss of 423.40g compared to those treated with *Khaya senegalensis* and synergistic effect of Neem seed oil and *Khaya senegalensis* bark extract which recorded 394.00g and 367.00g respectively. There was significant difference ($p < 0.05$) among the treatments, since from weeks 2 to 12 with control having drastic decreases in weight throughout the experiment 308.40, 232.80, 194.20, 170.40, 150.40 and 132.80 at 2,4,6,8,10 and 12 weeks respectively. Samples treated with NSO seldomly decrease in weight but had least weight loss of 479.40, 453.40, 448.60, 441.00, 433.00 and 423.40 from week 2 to 12. This was followed by *Khaya senegalensis* bark extract, observed for weight loss amounting to 430.40, 416.20, 411.00, 406.00, 400.40 and 394.0 from week 2 to 12. Then synergistic effect of Neem seed oil and *Khaya senegalensis* bark extract with the following weight loss 480.60, 424.00, 386.60, 377.20, 371.20 and 367.00 on week 2,4,6,8,10 and 12.

Table 2: Effects of *Azadirachta indica* and *Khaya senegalensis* Bark Extracts on Weight Loss (g) of *Afrormosia laxiflora* exposed to termite infestation

Treatment	2WAE	4WAE	6WAE	8WAE	10WAE	12WAE
AA	479.40 ± 33.80 ^a	453.40 ± 37.45 ^a	448.60 ± 39.02 ^a	441.00 ± 35.76 ^a	433.00 ± 34.77 ^a	423.40 ± 34.14 ^a
AK	430.40 ± 44.11 ^a	416.20 ± 54.26 ^a	411.00 ± 56.27 ^a	406.00 ± 58.46 ^a	400.40 ± 60.39 ^a	394.00 ± 60.27 ^a
AC1	480.60 ± 36.89 ^a	424.00 ± 39.83 ^a	386.60 ± 56.77 ^a	377.20 ± 57.69 ^a	371.20 ± 58.02 ^a	367.00 ± 57.98 ^a
ACo	308.40 ± 56.11 ^b	232.80 ± 29.30 ^b	194.20 ± 12.48 ^b	170.40 ± 20.70 ^b	150.40 ± 22.48 ^a	132.80 ± 20.50 ^b

Mean values in columns with different superscript are significantly different (P<0.05)

Table 3 illustrate the effect of different treatments on weight loss of wood samples exposed to termite infestation. Treatment AC1 recorded the lowest mean weight loss of 90.6 ± 17.20, indicating the most effective preservative effect and statistically significant differences (P<0.05) compared to the other treatments. Treatment AK followed with a mean weight loss of 112.6 ± 12.77, while treatment AA showed a mean weight loss of 165.4 ± 21.7. The control treatment (Aco) had the highest mean weight loss at 358.6 ± 76.10, demonstrating the least effectiveness among the treatments.

Table 3: Effect of Neem Seed Oil and *Khaya senegalensis* Bark Extract on Mean Weight and Mean Weight loss on *Afrormosia laxiflora*

Treatment	Initial weight(g)	Final Weight(g)	Mean Weight Loss
AA	532.4	423.40 ± 34.14 ^a	165.4 ± 21.7 ^a
AK	506.6	394.00 ± 60.27 ^a	112.6 ± 12.77 ^b
AC1	514	367.00 ± 57.98 ^a	90.6 ± 17.20 ^b
Aco	491.4	132.80 ± 20.50 ^b	358.6 ± 76.10 ^c

Means in column with different superscript are significant different (P<0.05).

3.2. Discussion

Analysis of treatment absorption rates revealed numerical differences among *Afrormosia laxiflora* wood samples. *Afrormosia laxiflora* treated with neem seed oil exhibited higher absorption rates, with mean value of 10.4 ± 3.58 for AA while, 8.40 ± 3.61 for AK and 6.40 ± 1.52 for AC1, exhibit lower rates. This suggests that *Afrormosia laxiflora* has a greater capacity to absorb preservatives, potentially improving treatment efficacy. These findings align with Umar *et al.* (2023), who noted that absorption rates vary among wood species, influencing preservative performance. Garcia and Smith (2018) supported this by showing how absorption dynamics affect natural extract distribution in hardwoods, while Martinez *et al.* (2020) highlighted the importance of optimizing absorption rates for effective wood protection. White and Brown (2019) observed that higher absorption rates enhance preservative distribution, thus preventing wood degradation. Further, Black *et al.* (2021) examined the relationship between treatment absorption and mechanical properties, emphasizing the impact on wood durability and strength. Additionally, compared to the control (untreated) samples, the visual evaluation results of this study demonstrated that both bio-insecticides, neem seed oil and khaya bark extract, were successful in restricting and preventing termite attack on the treated wood samples. The

treated samples maintained higher visual ratings throughout the testing period, whereas the control samples gradually but steadily declined over the course of the 12-week period, indicating progressive termite damage. The study also highlights the significant efficacy of neem seed oil and *Khaya senegalensis* bark extract in preserving *Afrormosia laxiflora* against termite infestation. The findings demonstrate that both treatments markedly reduced weight loss compared to the control, indicating their potential as effective bio-insecticides. Specifically, treatment with neem seed oil resulted in the least weight loss (423.40 ± 34.14 g), followed closely by *Khaya senegalensis* (394.00 ± 60.27 g). These findings align with the research of Okanlawon *et al.* (2022), which emphasized neem seed oil's efficacy in minimizing wood weight loss due to termite activity. The combination of both extracts (AC1) also showed promising results, suggesting a synergistic effect that warrants further investigation. The interaction between treatment type and exposure duration significantly influenced weight loss, as supported by Wahedi and Oaya (2020), who noted that prolonged exposure to neem and Khaya extracts enhances their effectiveness against termite damage. Patel and Sharma (2018) reported that natural extracts significantly mitigated termite-induced damage in wood samples, reinforcing the promising application of these treatments in wood preservation. The progressive decline in visual ratings of the untreated control (Aco) supports the hypothesis that untreated wood is highly susceptible to termite damage. Statistical analysis confirmed significant differences among treatments, indicating that the bio-insecticides effectively preserved wood integrity. This aligns with previous studies suggesting that plant-based extracts can serve as sustainable alternatives to conventional synthetic insecticides, which often pose environmental risks and high toxicity to non-target organisms.

4. Conclusion and Recommendation

In conclusion, this study substantiates the effectiveness of neem seed oil and *Khaya senegalensis* bark extract in protecting *Afrormosia laxiflora* from termite attacks. The notable reduction in weight loss and improved visual ratings of treated samples indicate their potential as eco-friendly preservatives in wood protection. It is recommended that further research be conducted to explore the

long-term effects of these treatments and their applicability to other wood species. Additionally, future studies should examine the mechanism of action of these extracts against termites and consider combining them with other natural substances to enhance efficacy. Promoting the use of plant-based preservatives can contribute to sustainable forestry practices and reduce reliance on synthetic chemicals.

Conflict of interest

The authors declare no conflict of interest.

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