World Journal of Applied Chemistry
2017; 2(3): 101-108
http://www.sciencepublishinggroup.com/j/wjac
doi: 10.11648/j.wjac.20170203.15

Termiticidal Evaluation of *Jatropha curcas* (Linn), *Thevetia peruviana* (Pers) and *Moringa oleifera* (Lam) Seed Extracts on *Gmelina arborea* (Roxb) and *Daniellia oliveri* (Rolfe) Wood

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To cite this article:

David Oriabure Ekhuemelo, Veronica Eyakamo Abu, John Vershima Anyam. Termiticidal Evaluation of *Jatropha curcas* (Linn), *Thevetia peruviana* (Pers) and *Moringa oleifera* (Lam) Seed Extracts on *Gmelina arborea* (Roxb) and *Daniellia oliveri* (Rolfe) Wood. *World Journal of Applied Chemistry*. Vol. 2, No. 3, 2017, pp. 101-108. doi: 10.11648/j.wjac.20170203.15

Received: July 26, 2017; **Accepted**: August 11, 2017; **Published**: September 1, 2017

Abstract: This study was intended at developing cheap and eco-friendly wood preservatives from *Jatropha curcas*, *Thevetia peruviana* and *Moringa oleifera* seed extracts for the control of termites on *Gmelina arborea* and *Daniellia oliveri* wood species. Seeds were collected from Makurdi Timber Shed, dried, and pounded into powder. Seed extracts were prepared using n hexane and hot water extraction methods. The oil extracts were vaporized and 10%, 20% and 30% were constituted. Wooden samples of *Gmelina arborea* and *Daniellia oliveri* were cut to 2 cm x 2 cm x 4 cm, air dried for 3 days and soaked in each plant extracts for 24 hours. Randomized Complete Block Design (RCBD) with three replicates was used with a total of 21 treatments including untreated, solvent treated and Solignum treated wood. Phytochemical screening of seed extracts showed the presence of flavonoids and steroids. Incidence of termites attack on *Daniellia oliveri* wood started from week 3 on 10% *Jatropha curcas*, *Thevetia peruviana, Moringa oleifera* oil treated, n hexane treated and untreated. While attack on *Gmelina arborea* wood started in week 5 on n hexane treated and untreated. Whereas attack on 30% *Jatropha curcas*, *Thevetia peruviana, Moringa oleifera* oil treated wood started in week 7. Percentage weight loss of *Gmelina arborea* wood (17.44%) and *Daniellia oliveri* wood (25.85%) were least with 30% *Thevetia peruviana* n hexane treatment compared with unteated *Gmelina arborea* and *Daniellia oliveri* wood (58.06% and 69.36%) respectively. It was observed that *Gmelina arborea* was more resistant to termite attack than *Daniellia oliveri.*

Keywords: Wood, Termites, Seed Extracts, Extraction, Control, N Hexane, Hot Water

1. Introduction

Wood as a natural renewable resource plays an important role in the world economy, particularly in the construction and furniture fields. It is a natural, cellular, renewable resource, has excellent strength to weight properties, a relatively low price and it is used for producing botanical composite materials [1]. Wood possesses unique structural and chemical characteristics that render it desirable for a broad variety of end users [1]. It is used for a variety of purposes such as roofs, ceilings, furniture, doors and windows. However, its strength and beauty can be devastated by a termite invasion [2]. Wood as a ligno-cellulolytic material is liable to degradation as a result of microbial agents and termites are noted for causing significant losses [3].

Termites are reported as extremely destructive since they tunnel their way into wooden structures, in which they burrow to obtain food. Over time, they will feed on the wood until nothing is left but a shell, which causes collapse or damage of the wooden members of the building [2]. Termites negatively affect the economy by causing damage to physical structures such as buildings, bridges, dams, railway sleepers, furniture, and even roads. They are serious threat to agriculture as they damage crops, forest trees and rangelands causing significant losses to annual and perennial crops. The damage caused by termites alone is reported to be more than the combined annual destruction

caused by fires, tornadoes and earthquakes in monetary terms [4, 5].

There is a need to preserve wood in service to increase its durability and to also preserve it against wood deteriorating agents. This also will help reduce the pressure on forests [6]. Strategies of termite control vary greatly from place to place across the world. Generally, termite control is best achieved in buildings by providing physical barriers and chemical control [7]. There are various types of physical barriers and their implementation is based on the behaviour of target termites. The physical barrier method however does not exterminate the termites and if not properly constructed may be ineffective. The chemical control procedures include chemical treatment of the soil area, the application of preservatives for the preservation of wood and baiting. For example, the use of insecticides to treat soil to make it lethal or repulsive to termites and impregnation of timber prior to its use are effective against subterranean termites and dry wood termites respectively. Various synthetic insecticides offer reasonable protection against termites [8].

However, the use of these synthetic chemicals pose a lot of problems such as toxicity to non-target organisms, development of termite resistance to the substances used and health hazards [9]. Problems associated with the use of pesticides have led to an increasing interest in the development of alternative termite control methods and plants with pesticidal properties may be one such alternative [10]. Thus there is the need to develop alternative preservatives, which are environmental friendly, cheap and available to the users. Consequently, various environmentally friendly treatments or naturally durable plant species are being evaluated. This study therefore, evaluated seed oil extracts from *Jatropha curcas, Thevetia peruviana and Moringa oleifera* on the treatment of *Gmelina arborea* and *Daniellia oliveri* wood samples against termites.

2. Materials and Methods

2.1. Study Area

The study was carried out at Federal University of Agriculture, Makurdi (FUAM) Benue State. The University was established in 1989. It is located at Nyiev District, North-East of Makurdi Local Government Area. The University lies at latitude 8°35"E and 8°41"E and Longitude 7°45"N and 7°52"N of the Middle Belt region of Nigeria and it covers a land mass of 7,978 km^2. It is bounded on the North East by Guma Local Government Area and by River Benue in the South. Topographically, the study area is characterized by gentle hills, clay soils, and a tropical climate with two main seasons (rainy and dry seasons). The land is generally fertile and supports extensive arable cropping and rearing of animals. 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 [12].

2.2. Collection of Materials

Daniellia oliveri and *Gmelina arborea* wood were purchased from Timber Shed at New Bridge Makurdi and cross cut into 2 x 2 x 4 cm (width x breadth x length) dimension. The seeds used for extracts were collected within the campus of FUAM.

2.3. Preparation of Materials

The wood samples were air-dried for 3 days. The seeds of *Thevetia peruviana* and *Jatropha curcas* were removed from mesocarps and washed with distilled water. While, *Moringa* seeds were removed from pods. The three seeds were air-dried for 21 days to obtain moisture free seeds according to [13] and also to ensure sufficient air flow to avoid damping as stated by [14]. After drying, the seeds were weighed and size reduced with a mortar and pestle.

2.4. Method of Extraction of Seed Oil

Two methods of oil extraction were carried out: a) Solvent extraction in which n-Hexane was used as carried out by [14] and b) Hot water extraction according to the method described by [15] and as reported by [16].

a. n- Hexane extraction method

The ground seeds (1 Kg) of a plant was dissolved in 1800 mL of Hexane in a ratio of 5:9 (w/v). The mixture was shaken immediately and kept for 48 hours for extraction to take place. At the end of extraction period, the extracted oil-solvent mixture was filtered with Whatman (number 1) filter papers and evaporated in a fumehood to obtain solvent-free oil. Three levels of concentration of 10%, 20% and 30% seeds oil were prepared.

Figure 1. *(a) Mixture of n Hexane and powered seed for extraction (b) Filtration of extracts.*

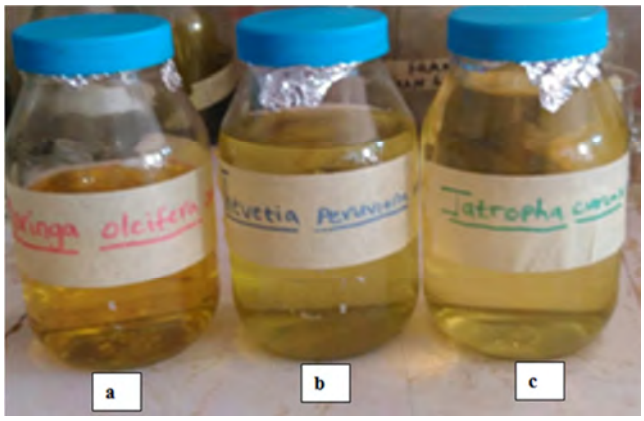

Figure 2. *(a) Moringa oleifera seed oil hexane extract (b) Thevetia peruviana seed oil hexane extract (c) Jatropha curcas seed oil hexane extract.*

Figure 3. *(a) Evaporated Thevetia peruviana seed oil hexane extract (b) Evaporated Moringa oleifera seed oil hexane extract.*

b. Hot water extraction process

Different concentrations of water extract were made by dissolving 100 g, 200 g and 300 g each of the ground seed samples in water (2 L) and boiled for 14 minutes at 100ºC. The mixture was allowed to cool under room temperature and filtered with a sieve.

Figure 4. *Hot water extract at different concentrations.*

2.5. Determination of Physical and Phytochemical Properties of Seed Oil

The visual method was used to evaluate the physical properties of the seeds oil extracts. Phytochemical analysis was conducted at the laboratory using Salkowski's and Liebermen-Burchard's test for steroids, steroids and terpenoids respectively.

2.6. Preparation of Solignum for Treatment

Solignum was purchased from the market. Undiluted 900mL of concentrated solignum was measured in a glass bottle and was used to soak wood sample.

2.7. Treatment of Materials

The wood samples were labeled and soaked in the different treatments for 24 hours. They were removed and air dried for another 24 hours the before grave yard experiment.

Figure 5. *Soaked wood samples in treatment bottles.*

2.8. Experimental Design

The treated wood samples were laid in a Randomized Complete Block Design (RCBD) with two wood samples and 21 treatments. The treatments were replicated thrice as R1, R2, and R3. Six samples were laid for each treatment to give a total of one hundred and twenty six test samples for a replicate. A total of 378 wood samples were used for the three replicates. The treatments were as follows:

The treated wood samples were buried in the soil for a period of 7 days. At each position of test block, the soil was excavated according to [10] to a depth of 10 cm which enabled the test block to be completely buried. Spacing was 1 m between holes and 3 m between replicates.

2.9. Data Collection

Inspection and evaluation of the wood samples were made on weekly basis for a period of seven weeks for any sign of termite attack. At each visit, specimens were removed from the soil and cleaned while attack on each of the wood specimen assessed in two ways as follows:

(a) Incidence of termite attacked was recorded as:
- = Not attacked and,
+ = Attacked.

(b) Severity of termite attack was recorded by weighing the wood samples. A camera was used to capture images of specimen on each visit.

$$\text{Wood block weight loss\%} = [(W1 - W2)/W1] \times 100 \quad (1)$$

where:
W1 = is the air dry weight before field exposure tests,
W2 = is the air dry weight after field exposure tests.

2.10. 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.

3. Results

Table 1 presents results of seed oil extracted with hexane in the laboratory. From the results, oil yield in volume (72.00 mL) and weight (59.20 g) were highest in *Jatropha curcas.* This was followed by *Moringa oleifera* (62.90 mL, 49.10 g) and *Thevetia peruviana* (60.00 mL, 45.50 g). The colours of the oil were golden, deep yellow and dark green for *Moringa oleifera*, *Thevetia peruviana* and *Jatropha curcas* respectively. The tree oil extracts had sweet odours. The oil from *Moringa oleifera* tended to congeal faster at room temperature indicating that a higher proportion of the oil was saturated; *Jatropha curcas* oil remained as liquid at room temperature, showing that it posed a higher fraction of unsaturated acyl chains. Phytochemical tests on oil extracts showed the presence of flavonoids and steroids.

Results of incidence of termites attack on *Daniellia oliveri* and *Gmelina arborea* treated wood samples within the seven weeks of experiment are presented in table 2. The result reveal that attack on *Daniellia oliveri* started from week three with few wood samples attacked. There was attack on *Daniellia oliveri* wood samples treated with Solignum and 20% *Jatropha curcas* hexane extract at week 6 and 7 only. Termites attack on *Gmelina arborea* started at week six (5) with hexane treated and untreated wood. Attack on *Gmelina arborea* treated with Solignum started at week 6. 30% extracts of both hot water and hexane extracts treated *Gmelina arborea* and *Daniellia oliveri* wood showed attack at week seven only. There were attacks on all wood samples at week seven (table 2).

Table 1. *Physicochemical Properties of Moringa oleifera, Thevetia peruviana and Jatropha curcas extracts from n hexane extract.*

S/No.	Parameters	*Moringa oleifera*	*Thevetia peruviana*	*Jatropha curcas*
1	Oil yield in volume	62.90 mL	60.00 mL	72.00 mL
2	Oil yield in weight	49.10 g	44.50 g	59.20 g
3	Colour	Deep yellow	Light green	Golden yellow
4	Odour	Sweet	Sweet	Sweet
5	Degree of unsaturation	Saturated (a strong tendency to congeal at room temperature)	Moderately saturated (Weakly congealing at room temperature)	Unsaturated (Liquid at room temperature)
6	Phytochemicals	Flavonoids and steroids	Flavonoids and steroids	Flavonoids and steroids

Table 2. *Incidence of termite attack on seed extract treated wood samples.*

Treatments		*Daniellia oliveri*							*Gmelina arborea*						
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7
Jatropha curcas hexane extract	10%	-	-	-	+	+	+	+	-	-	-	-	-	+	+
	20%	-	-	-	-	-	+	+	-	-	-	-	-	-	+
	30%	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Thevetia peruviana hexane extract	10%	-	-	-	+	+	+	+	-	-	-	-	-	+	+
	20%	-	-	-	-	+	+	+	-	-	-	-	-	+	+
	30%	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Moringa oleifera hexane extract	10%	-	-	-	+	+	+	+	-	-	-	-	-	+	+
	20%	-	-	-	-	+	+	+	-	-	-	-	-	+	+
	30%	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Jatropha curcas hot water extract	10%	-	-	+	+	+	+	+	-	-	-	-	-	+	+
	20%	-	-	-	+	+	+	+	-	-	-	-	-	+	+
	30%	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Thevetia peruviana hot water extract	10%	-	-	+	+	+	+	+	-	-	-	-	-	+	+
	20%	-	-	-	+	+	+	+	-	-	-	-	-	+	+
	30%	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Moringa oleifera	10%	-	-	+	+	+	+	+	-	-	-	-	-	+	+

Treatments		*Daniellia oliveri*							*Gmelina arborea*						
		Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7
hot water extract	20%	-	-	-	+	+	+	+	-	-	-	-	-	+	+
	30%	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Solignum treated wood + control		-	-	-	-	-	+	+	-	-	-	-	-	+	+
Hexane treated wood + control		-	-	+	+	+	+	+	-	-	-	-	+	+	+
Untreated wood – control		-	-	+	+	+	+	+	-	-	-	-	+	+	+

Key: Wk = week, + = Attacked, - = Not attacked

The results of percentage weight loss of treated wood samples are shown in table 3. The result showed that mean percentage weight loss of *Gmelina arborea* wood was lower with all 30% hexane extracts of *Jatropha curcas* (24.23%), *Thevetia peruviana* hexane (17.44%), and *Moringa oleifera* hexane (25.78%). Similarly, percentage weight loss of *Gmelina arborea* wood was lower with all 30% hot water extracts of *Jatropha curcas* (26.55%), *Thevetia peruviana* (29.30%) and *Moringa oleifera (*33.14%). The result of 30% *Thevetia peruviana* extract treated *Gmelina arborea* had the lowest percentage weight loss of 17.44%, while untreated *Gmelina arborea* wood has the highest (58.06%). However, mean percentage weight loss of Solignum treated *Gmelina arborea* was 37.53% the value higher than all 30% extracts seed oil. There was no significant difference ($p<0.05$) between oil extracts and Solignum.

Table 3 further shows mean percentage weight loss of *Daniellia oliveri* treated wood samples. From the the result, percentage weight loss of *Daniellia oliveri* treated wood samples were lower with every 30% extracts of *Jatropha curcas* hexane (27.53%), *Thevetia peruviana* hexane (25.85%), and *Moringa oleifera* hexane (28.97%). Correspondingly, percentage weight loss of *Daniellia oliveri* treated wood were lower among every one of 30% hot water extracts of *Jatropha curcas* (32.52%), *Thevetia peruviana* (31.25%) and *Moringa oleifera (*38.86%). Again, the result of 30% percentage weight loss of *Daniellia oliveri* treated wood with 30% *Thevetia peruviana* treated *Gmelina arborea* had the lowest percentage weight loss of 25.85%, while untreated *Daniellia oliveri* wood had the highest (69.36%) percentage weight loss. However, mean percentage weight loss of Solignum treated *Daniellia oliveri* wood was 55.93%. This mean value was higher than all 30% extracts seed oil.

Mean percentage weight loss of *Gmelina arborea* wood for all 20% hexane extracts ranged between 32.79% - 38.13%, while the values ranged between 40.26% - 43.44% for all 20% hot water extracts. Similarly, mean percentage weight loss of *Daniellia oliveri* wood for all 20% hexane extracts ranged between 41.77% - 49.88%, while all the mean values ranged bwtween 49.10% - 61.95% for 20% hot water extracts.

The results also shows that mean percentage weight loss of *Gmelina arborea* wood for the three 10% hexane extracts varied from 38.71% - 45.90%, whereas, it was between 43.24% - 51.13% for 10% hot water extracts. In the same vein, the mean values ranged between 44.70% - 63.81% in *Daniellia oliveri* wood treated with every 10% n haxane extracts, as it varies between 60.69% - 65.63% for every one of 10% hot water extracts. It was also observed in table 3 that *Gmelina arborea* wood was more resistant to termite attack than *Daniellia oliveri.*

Table 4 shows visual rating of termite attack on *Gmelina arborea* and *Daniellia oliveri* wood. The result illustrates that *Gmelina arborea* wood treated with 30% *Thevetia peruviana* hexane seed oil extract was slight attack (1-20% damaged). Whereas 10%, 20% and 30% *Jatropha curcas* hexane seed oil extracts, 20% and 30% of *Moringa oleifera* hexane seed oil extracts and hot water *Jatropha curcas* seed oil extract, 30% hot water *Thevetia peruviana* hexane seed oil extracts and *Gmelina arborea* wood treated with Solignum were moderately attacked (21-40% damage). However, *Gmelina arborea* wood treated with 10% *Moringa oleifera* hexane seed oil extract, 10% *Jatropha curcas* hot water seed oil extract, 10% and 20% *Thevetia peruviana* and *Moringa oleifera* hot water seed extracts with the untreated had moderate/ severe termite attack (41-60% damaged).

Table 3. *Percentage (%) weight loss of treated Gmelina arborea and Daniellia oliveri wood samples.*

Method of extraction	Extracts	% Concentration of extracts	Wood species	
			Gmelina arborea **Mean ±SDV.**	***Daniellia oliveri*** **Mean ±SDV.**
Hexane	*Jatropha curcas* seed oil extract	10	39.95 ± 6.61^{efg}	$48.53\pm9.22d^{ef}$
		20	34.13 ± 4.36^{de}	44.07 ± 7.10^{de}
		30	24.23 ± 3.82^{ab}	27.53 ± 7.47^{a}
	Thevetia peruviana seed oil extract	10	38.71 ± 6.08^{efg}	44.70 ± 10.57^{de}
		20	32.79 ± 7.90^{ce}	41.77 ± 4.93^{bcd}
		30	17.44 ± 6.06^{a}	25.85 ± 8.83^{a}
	Moringa oleifera seed oil extract	10	45.90 ± 2.56^{ghi}	63.81 ± 12.11^{gh}
		20	38.13 ± 5.54^{eg}	49.88 ± 11.15^{ef}
		30	25.78 ± 3.46^{bc}	28.97 ± 4.41^{ab}

Method of extraction	Extracts	% Concentration of extracts	Wood species	
			Gmelina arborea Mean ±SDV.	*Daniellia oliveri* Mean ±SDV.
Hot water	*Jatropha curcas* seed extract	10	43.24±12.74^{fgh}	63.90±6.54^{ghi}
		20	40.26±8.88^{efg}	49.10±11.76^{ef}
		30	26.55±6.47^{bcd}	32.52±5.69^{abc}
	Thevetia peruviana seed extract	10	49.88±3.91^{ghij}	60.69±9.91^{fghi}
		20	42.76±5.97^{fgh}	57.53±17.99^{fgh}
		30	29.30±4.11^{bcd}	31.25±12.90^{ab}
	Moringa oleifera seed extract	10	51.13±7.15^{hj}	65.63±7.32^{fghi}
		20	43.44±4.67^{fgh}	61.95±3.77^{ghi}
		30	33.14±13.48^{cde}	38.86±6.28^{bcd}
	+ Control	Treatment with Solignum	37.53±11.88^{ef}	55.93±9.92^{fg}
	+ Control	Treatment with hexane	53.31±8.46^{hj}	67.47±8.70^{hi}
	- Control	Untreated	58.06±10.58^{j}	69.36±10.66^{i}
	Total		38.37±12.36	49.013±16.61

* Means followed by the same letter are not significantly different ($p > 0.05$)

Table 4. *Visual rating of termite attack on Gmelina arborea and Daniellia oliveri wood.*

Method of extraction	Extracts	% Concentration of extracts	Visual rating of Wood samples	
			Gmelina arborea	*Daniellia oliveri*
Hexane	*Jatropha curcas* seed oil extract	10	2	3
		20	2	3
		30	2	2
	Thevetia peruviana seed oil extract	10	2	3
		20	2	3
		30	1	2
	Moringa oleifera seed oil extract	10	3	4
		20	2	3
		30	2	2
Hot water	*Jatropha curcas* seed extract	10	3	4
		20	2	3
		30	2	2
	Thevetia peruviana seed extract	10	3	3
		20	3	3
		30	2	2
	Moringa oleifera seed extract	10	3	4
		20	3	4
		30	2	2
	+ Control	Solignum treatment	2	3
	+ Control	N hexane treatment	3	4
	- Control	Untreated	3	4

Key:
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

4. Discussion

This study showed that there was incidence of termite attack as the treated wood samples were exposed to termite infested site. This finding confirms the presence of termites on this site as reported by [15] who worked on the same site. All plant extracts at varying concentrations showed termiticidal effect when compared with untreated wood. This is in line with [17] who reported that botanicals (oils, leaves, resins, roots and woods) inhibit termite growth rates, reduce the frequency of termite feeding and have high toxicity levels.

Oil extracted from *Moringa oleifera* was yellow in colour, *Jatropha curcas* was golden colour and oil extracted from *Thevetia peruviana* was light green. This does not exactly agree with [13] who reported that oil from *Thevetia peruviana* oil is light gold and *Jatropha curcas* is yellow in colour. This may be as a result of presence of impurities in the seeds during processing or method of extraction. The highest oil yield was observed in *Jatropha curcas.* The seed oils from this study had sweet odours which confirms report by [13]. It was found from the result that oil from *Moringa oleifera* was probably highly saturated judgung from its tendency to rapidly congeal at room temperature, whereas those from *Thevetia peruviana* were apparently moderately saturated while oil from *Jatropha curcas* was unsaturated.

These observations on the congealing properties of the oils are in line with reports by [13] who expressed the percentage degree of saturation of *Jatropha curcas* to be lower (21.89%) than percentage degree of saturation of *Thevetia peruviana* (26.78%). There was presence of steroids in all the seed oils derived from n-hexane extracts. This finding is in agreement with [17] who ascribed insecticidal principles of oils to triterpene and sterol activity.

Daniellia oliveri wood was more susceptible to termite attack than *Gmelina arborea* wood samples in all treatments. This result concurs with accounts by [15] and [6]. [15] in their study on cold water extracts of *Moringa oleifera* in treatment of *Ceiba petandra* and *Gmelina arborea* wood and found out that *Gmelina arborea* was more resistant to attack. Similarly, [6] reported that *Gmelina arborea* was least attacked by termites in his study on treatment of *Gmelina arborea, Ceiba petandra* and *Triplochiton scleroxylon* with *Allium sativum* extracts. This also confirms the study by Preston and Nicholas, [18], that natural chemical substances were present in some woods in sufficient quantities to drive away termites while other woods may only have sufficient amounts to repel termites after they have eaten a minute particle. Since *Daniellia oliveri* was more susceptible to termite attack, efforts should be made to protect it from biological deterioration before its usage while *Gmelina arborea* which was more resistant should be cultivated and used to meet increasing demand of wood.

It was observed that all 30% concentrations of plant extracts in both water and hexane extraction were better in protection of wood against termite than Solignum. This conforms with the study by [15] who observed that plant extracts of *Moringa oleifera* were better termiticides than chlorpyrifos®. This finding suggests an alternative to the use of toxic chemicals which have dire environmental implications.

The present study showed significant difference in resistance to termites attack between the two methods of extraction (solvent extraction using hexane and hot water extraction). Solvent extraction showed higher efficacy to termite attack when compared to hot water extract. This observation is comparable to account by Trinity, [10] who reported that solvent extracts impart a more robust resistance on wood than water extracts. Concentration of 30% *Thevetia peruviana* hexane exracts had the least percentage weight loss. [10] also found out that *Thevetia peruviana* was observed to be the least susceptible to termite destruction and suffered the least termite attack.

Attack on wood sample commenced from week 3 and 5 for *Daniellia oliveri* and *Gmelina arborea* respectively. There was also no significant difference of loss in mean weight in both wood samples in week 1, 2 and 3. This finding is at variance with the finding [15] on the same site. In the previous work, attack on wood samples started earlier with significant difference in weight loss. This may be attributed to the season of study. The present study was carried out in the dry season while the previous study was done during the rainy season. [19] reported on effect of climate on termite attacks as studied by [20]. From their study, rainfall, temperature and relative humidity were the climatic parameters that had the most significant effect on termite attacks. Rainfall had a limited effect on foraging in the winter months but a very strong effect on foraging in the summer months as the number of termites observed dropped sharply at a temperature above 33°C.

5. Conclusion

This work has shown that *Thevetia peruviana, Moringa oleifera* and *Jatropha curcas* seed oil extracts were effective in the control of termites. Nevertheless, hexane extracts were better in termite control than cold water extracts. All 30% concentrations of seed oil extracts were better than Solignum in treament of wood against termite attack. However, 30% concentration of *Thevetia peruviana* hexane extract was the most effective in termite control. *Daniellia oliveri* wood is more susceptible to termite attack than *Gmelina arborea* wood. Consequently, the wood should always be treated before use since it is the commonest wood species used in the study area. The use of plant extracts could be exploited to develop new wood preservatives to protect wooden structures, timbers, plants and trees, as these are less harmful to the environment and humans.

Recommendations

Large scale cultivation of *Thevetia peruviana, Moringa oleifera* and *Jatropha curcas* should be encouraged in the study area as this would serve as additional sources of termite control. Higher concentrations of plant extracts should be formulated since all 30% concentrations of extracts were effective.

Competing Interests

The authors declare that they have no competing interests.

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