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Original Article

Termicidal activities of *Jatropha curcas* and *J. gossypiifolia* (Physic nut) seeds against termites, workers and soldiers of *Macrotermes subhyalinus* L. (Blattodea: Termitidae)

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ABSTRACT

The anti-termite potential of *Jatropha curcas* and *J. gossypiifolia* seed powders and extracts against termite (workers and soldiers) *Macrotermes subhyalinus* L, (Blattodea:Termitidae) was investigated under ambient laboratory conditions. Powders were tested at the rate of 2.5, 5, 7.5, 10, 12.5 and 15g and extracts were applied at a concentration of 2.5, 5, 7.5, 10, 12.5 and 15% v/v in n-hexane to samples of wood shavings. For each treatment including the control, there were four replications and twenty termites were released into each replicate in a completely randomised design. The results showed that the powders at the tested rates showed termite mortality ranging from 32.5 to 100%. *J. curcas* seed powder was the most potent against workers and soldiers of *M. subhyalinus* attaining a greater percentage mortality at 12.5g than *J. gossypiifolia,* comparable to the positive control (Chlorpyrifos granules), which caused 100% mortality of both soldiers and workers of *M. subhyalinus*. At 5g application, *J. curcas* caused 42.5 and 37.5% mortality of worker and soldier termites after 24h of exposure respectively, while *J. gossypiifolia* evoked 37.5 and 32.5% mortality of worker and soldier termites after 24h of exposure respectively. The n-hexane seed extract of both *J. curcas* and *J. gossypiifolia* at 7.5 and 15% concentration, caused 100% mortality of worker and

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soldier termites after 72h of exposure comparable to the positive control (synthetic chemical insecticide), Chlorpyrifos granules. The results of the *J. curcas* and *J. gossypiifolia* seed powders and extracts showed that the plants were effective in preventing termite infestation. Further study is recommended for the characterization and isolation of the chemical ingredients responsible for the insecticidal activity of the seed powders and extracts.

Keywords: Chlorpyrifos granules, positive control, soldiers, infestation, workers

INTRODUCTION

Termites are insects that are capable of recycling wood and materials containing cellulose. They are found across the world with the highest occurrence in the tropical regions where their recycling activity poses serious problems by destroying wooden structures and plants (Tadele et al., 2014). They can be severe pests of crops, trees, rangeland, household furniture and wooden building structures (Tadele et al., 2014).

According to Tadele et al. (2014) there are approximately 2,800 named termite species in 282 genera worldwide but the most important termites found in Africa belong to the Genera *Macrotermes, Odnotermes, Pseudocanthotermes, Ancistrotermes* and *Microtermes*. A species of note is the *Macrotermes* species, established as the largest species of termites, known for the building of mounds (Osipitan & Oseyemi, 2012). They are known to damage books, wooden furniture, wooden building structures, wooden utility poles, trees, wooden fences and farm crops (Wong et al., 2001; Mitchell, 2002; Cox, 2004).

The damage caused by termites leads to a lot of loss especially economic losses due to destruction of agricultural crops, wood and wooden products. For instance, *Macrotermes* has been reported to sometimes cause damage of up to to a 100% loss of agricultural crops and other wooden domestic products (Michael, 2000; Sekamatte, 2001; Nyeko et al., 2010). To mitigate against these losses, there is a need to devise appropriate control measures aimed towards managing termite infestations. Several control methods have been devised, the main one being the use of synthetic chemicals known as chemical termiticides such as aldrin and dieldrin that have been withdrawn from the market due to their non-biodegradable, persistent nature in the environment. These chemicals negatively impact human health, non-targeted organisms and the environment resulting in pollution due to their overuse causing the development of resistance in the termites that they are used on (Addisu et al., 2014). Hence, there is need to shift to approaches that do not constitute any imminent danger to man, other organisms or the environment. Botanical insecticides or termiticides offer such options as they are easily degradable in the environment due to their plant origin. Examples of plants that have been successfully used as biotermiticides include neem (*Azadirachta indica*) leaves and seeds; garlic (*Allium sativum*) bulbs and physic nut (*Jatropha* spp.) seeds making it possible to make use of plant materials that are indigenous and locally available (Dubey et al., 2008; Owusu et al., 2008).

Jatropha spp. also known as the physic nut is a medicinal plant belonging to the family Euphorbiacea. All parts of *Jatropha* (seeds, leaves and bark) have been utilized extensively in west and central Africa as folk and traditional medicine in the treatments of different types of ailments such as malaria/fever, gout, tumour, mouth infections, jaundice, guinea worm sores, wound healing, toothache, blood coagulation, ringworm, diarrhea, laxative, and joint rheumatism. The plant extract is used in the treatment of allergies, burns, cuts, wound inflammation, wound healing, tumor, leprosy, leucoderma and smallpox. The seeds are used for treating ascites, gout, paralysis, skin diseases and as a purgative, anthelminthic and abortifacient. While the seed oil is applied to treat eczema and skin diseases and rheumatic pain (Abdelgadir & Van Staden, 2013). Aside from the medicinal potentials of the plant, various researchers have documented its molluscicidal, nematicidal, insecticidal, acaricidal, and fungicidal properties (Valdez-Ramirez et al., 2023; Aljedani, 2023).

Despite the efficiency of some botanical extracts against termites, their effect is not comparable to many conventional chemical insecticides in action, there is therefore the need to search for other plants that could compete with the chemical insecticides. The objectives of the research are to investigate the anti-termite potential of *J. curcas* and *J. gossypiifolia* seed powders and extracts on the mortality of adult termites (workers and soldiers) *M. subhyalinus*.

MATERIALS AND METHODS

Collection of Termites

M. subhyalinus termites were extracted from a termitarium in Oba Afunbiowo Estate, Akure, Ondo State, Nigeria, and were put in a clean transparent plastic container. The termites (soldiers and workers) that were extracted were immediately transported to the laboratory and kept for three days at a temperature of 28+2°C (Alemu & Terefe, 2025; Aljedani, 2023). The container's sides were sprayed with water to maintain a relative humidity of more than 80%. After 72h, amture workers (psuedergates larger than the third instar, based on size) were taken out of the container and sorted with a soft camel hair brush.

Preparation of Plant Materials

Seeds of *J. curcas* and *J. gossypiifolia* were gathered from a farm located in Idanre, Akure, Ondo State, Nigeria. The seeds were identified at the Department of Forestry Technology, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria where a specimen voucher was deposited. In the laboratory with adequate ventilation, the seeds were crushed with a mortar and pestle, air dried and further pulverize into a fine powder using an electric crusher machine (Ubulom et al., 2021). To obtain a fine powder the particles were sieved using a sieve with 1mm^2 perforations. Before being used, the powders were kept in a refrigerator at 4°C, sealed inside plastic containers.

Preparation of Plant Extracts

The cold n-hexane extraction procedure was used to obtain extracts from the seeds of *J. curcas* and *J. gossypiifolia*. Separately, about 150g of the seed powders were soaked in an extraction bottle filled with 500mL of 100% n-hexane. After 72h, the extraction process was stopped and the mixture was periodically stirred with a glass rod. The mixture was then filtered through two layers of Whatman No. 1

filter paper, and the solvent was removed using a rotary evaporator set to run at 30 to 40°C for eight hours at a speed of 3 to 6rpm. Excess solvent was removed using a rotating vacuum evaporator. The yield of n-hexane extract was 2.63g. Different extract concentrations of 2.5, 5, 7.5, 10, 12.5, and 15% were produced sequentially from this stock solution in the following ways: 2.5, 5, and 7.5% were achieved by diluting 0.25, 0.5 and 0.75mL of the extract in 9.75, 9.5, and 9.25mL of hexane respectively, 10% was achieved by diluting 1mL of extract in 9mL of hexane, 12.5% was achieved by diluting 1.25mL of extract in 8.75mL of hexane, and 15% was achieved by diluting 1.5mL of extract in 8.5mL of hexane (Ebtisam & Hamadttu, 2013).

Termites Bioassay

Anti-termite Efficacy of J. curcas and J. gossypiifolia Seed Powders on % Mortality of M. subhyalinus Workers and Soldiers

Plastic containers, 500mL, containing 2.5, 5, 7.5, 10, 12.5, and 15g of powdered *J. curcas* and *J. gossypiifolia* were used to treat wood shavings separately.

Chlorpyrifos granules of equal weight as the seed powders were used as the positive control, untreated shavings were the negative control. Prior to the application of the powder and Chlorpyrifos granules, the wood shavings were sprinkled with a film of water to enable the powder to stick to the wood shavings. Each plastic container having wood shavings treated with plant powders, wood shavings treated with the synthetic chemical termicide (Chlorpyrifos granules) as a positive control, and untreated wood shavings were stocked with twenty (20) acclimatized termites (workers and soldiers). Four replicates of the setup were placed in a completely randomized design. Termite mortality was documented at 24, 48, and 72h intervals following exposure. Abbott's formula (Abbott, 1925) was used for calculating the percentage mortality.

Anti-termite Efficacy of J. curcas and J. gossypiifolia Seed Extracts on % Mortality of M. subhyalinus Workers and Soldiers

In a laboratory setting, four replicates of plastic containers filled with wood shavings were set up in a completely randomized design under ambient conditions. Sterilized Petri dishes were filled with wood shavings that had been separately treated with 3mL of the plant extracts at concentrations of 2.5, 5, 7.5, 10, 12.5, and 15%. Each Petri dish containing treated wood shavings had twenty acclimated termites added, and the treatments were replicated four times. The potency of seed extracts from *Jatropha* spp. was compared using the untreated control and the positive control (Chlorpyrifos 20% EC). The synthetic chemical was applied to the wood shavings at 10mL per litre of water. Termites were exposed for 24, 48, and 72h before their mortality was observed and documented. Abbott's formula (Abbott, 1925) was used for calculating the percentage mortality.
Correct mortality rates ($Pc = 100 \times (Po-Pt)/100-Pt$).

Where: Pc = corrected mortality (%);
Po = mortality observed in the test;
Pt = mortality observed in the control.

Phytochemical Screening of the Plant Samples

Using standard laboratory procedures as described by Adesina et al. (2015), the powdered plant samples were screened for the qualitative presence of phytochemicals such as tannin, saponin, cardiac glycosides, flavonoid, and anthraquinone.

For tannin, 5g of each portion of plant powder was stirred with 1mL of distilled water and filtered, followed with the addition of few drops of 5% ferric chloride. Blue black, green, or blue-green precipitate confirmed the presence of tannins. About 0.5g of the extracts was dissolved in 2mL of chloroform prior to the cautious addition of 1% (v/v) H_2SO_4 to form a lower layer of reddish-brown colour at the interface confirmed cardiac glycoside presence.

For Alkaloids determination, 0.5g of each extract was stirred with 5mL of 5% aqueous HCl on water bath and filtered; 1mL of the filtrate was treated with a few drops of Dragendorff's reagent. Precipitation or turbidity was taken as preliminary evidence for the presence of alkaloids. Saponins. About 0.5g of each plant extract was shaken with 10mL of distilled water in a test tube, to produce persistent Frothing on warming as evidence of saponins presence. Flavonoids presence was confirmed, by stirring 0.5g of the extract with few drops of Mg strips and addition of conc. HCl to produced reddish coloration.

Data Analysis

The data collected were analyzed using one-way analysis of variance (ANOVA), and means were separated using New Duncan's Multiple Range Tests in cases where significant differences ($p \leq 0.05$) observed.

RESULTS

Termicidal Properties of J. curcas and J. gossypiifolia Seed Powders on Percentage Mortality of M. subhyalinus (Workers and Soldiers)

The data in Table 1 shows the toxicity of *J. curcas, J. gossypiifolia* seed powders and Chlorpyrifos granules on the % mortality of workers and soldiers of *M. subhyalinus*. Termite mortality increased with increase in length of exposure and was concentration dependent. Botanical powders at the tested concentrations showed termite mortality ranging from 32.5% to 100%. There were significant differences ($p < 0.05$) among the treatments after 24h of exposure. Among the *Jatropha* species tested, *J. curcas* seed powder was the most lethal to workers and soldiers of *M. subhyalinus* attaining greater % mortality at an application rate of 12.5g comparable to Chlorpyrifos granules, which caused 100% mortality of both soldiers and workers of *M. subhyalinus*. With application of 5g, *J. curcas* caused 42.5% and 37.5% mortality of worker and soldier termites after 24h of exposure respectively. *J. gossypiifolia* evoked 37.5% and 32.5% mortality of worker and soldier termites after 24h of exposure respectively. At a rate of 15g, *J. curcas* and *J. gossypiifolia* caused 100% mortality of worker and soldier termites after 24h of exposure comparable to Chlorpyrifos granules, which caused 100% mortality of both soldiers and workers of *M. subhyalinus*.

Table 1. Termicidal activities of *J. curcas* and *J. gossypiifolia* seed Powders on % Mortality of *M. subhyalinus* (workers and soldiers)

Application Rate (g)	Plants Powders	% Mortality ± SE rate after					
		24 Hours		48 Hours		72 Hours	
		Workers	Soldiers	Workers	Soldiers	Workers	Soldiers
2.5	*J. curcas*	37.50±2.67 ^{b}	30.00±2.27 ^{b}	42.50±2.55 ^{b}	40.00±2.27 ^{c}	50.00±2.27 ^{c}	45.00±2.29 ^{c}
	J. gossypiifolia	32.50±2.55 ^{b}	27.50±2.67 ^{b}	37.50 ±2.67 ^{b}	35.00±2.29 ^{c}	45.00±2.29 ^{c}	40.00±2.27 ^{c}
	Chlorpyrifos	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{g}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
5.0	*J. curcas*	42.50±2.55 ^{bc}	37.50±2.67 ^{bc}	47.50±2.67 ^{cd}	45.00±2.29 ^{c}	55.00±2.29 ^{c}	50.00±2.29 ^{c}
	J. gossypiifolia	37.50±2.67 ^{b}	32.50±2.55 ^{b}	42.50 ±2.55 ^{c}	40.00±2.27 ^{c}	50.00±2.27 ^{c}	45.00±2.29 ^{c}
	Chlorpyrifos	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
7.5	*J. curcas*	50.00 ±2.27 ^{c}	45.00±2.29 ^{c}	57.50±2.67 ^{d}	50.00±2.27 ^{d}	65.00±3.29 ^{d}	57.50±2.67 ^{d}
	J. gossypiifolia	45.00±2.29 ^{bc}	40.00±2.27 ^{c}	50.00±2.27 ^{d}	45.00±2.29 ^{cd}	60.00±3.27 ^{d}	52.50±2.55 ^{cd}
	Chlorpyrifos	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
10	*J. curcas*	70.00±3.37 ^{d}	67.50±3.67 ^{d}	87.50±3.67 ^{ef}	80.00±3.27 ^{e}	100.00±0.00 ^{e}	95.00±3.39 ^{e}
	J. gossypiifolia	67.50±3.67 ^{d}	60.00±3.27 ^{d}	80.00±3.27 ^{e}	75.00±3.29 ^{e}	90.00±3.27 ^{e}	87.50±3.67 ^{e}
	Chlorpyrifos	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
12.5	*J. curcas*	90.00±3.27 ^{ef}	87.50±3.67 ^{e}	100.00±0.00 ^{f}	97.50±2.50 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
	J. gossypiifolia	85.00±3.039 ^{e}	80.00±3.027 ^{e}	92.50±3.55 ^{f}	90.00±3.37 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
	Chlorpyrifos	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
15.0	*J. curcas*	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
	J. gossypiifolia	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
	Chlorpyrifos	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{f}	100.00±0.00 ^{d}	100.00±0.00 ^{e}	100.00±0.00 ^{e}
0.0	Untreated	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}

Each value is a mean ±standard error of four replicates. Means within the same column followed by the same letter(s) are not significantly different at p>0.05 using New Duncan Multiple Range Test.

At 48h of exposure, *J. curcas* powder was more toxic to both workers and soldiers of *M. subhyalinus* and significantly more toxic than *J. gossypiifolia* as the concentration increased. At an application rate of 10g, *J. curcas* evoked 87.5% and 80% mortality of worker and soldier termites after 48h of exposure respectively. *J. gossypiifolia* evoked 80% and 75% mortality of worker and soldier termites after 48h of exposure respectively. A similar trend was observed at 72h of treatment. However, with the application of 10g, *J. curcas* evoked 100% and 95% mortality of worker and soldier termite. While *J. gossypiifolia* evoked 90% and 87.5% mortality of worker and soldier termites after 72h of exposure respectively. With the application of 12.5g and 15g, *J. curcas* and *J. gossypiifolia* caused 100% mortality comparable to Chlorpyrifos granules, which caused 100% mortality of both soldiers and workers of *M. subhyalinus*.

Termicidal Properties of J. curcas and J. gossypiifolia Seed Extracts on % Mortality of M. subhyalinus

Toxicity of *J. curcas, J. gossypiifolia* seeds extracts and Chlorpyrifos on the % mortality of workers and soldiers of *M. subhyalinus* is presented in Table 2. Termite mortality increased with increase in length of exposure and was concentration dependent. Seed extracts at all tested concentrations showed termite mortality ranging from 40% to 100%. There were significant differences ($p<0.05$) among the treatments after 24h of exposure. Among the *Jatropha* species tested, *J. curcas* seed extract was the most potent to workers and soldiers of *M. subhyalinus* attaining greater % mortality at a concentration of 7.5% comparable to Chlorpyrifos granules, which caused 100% mortality. At 24h of exposure, the 5% concentration of *J. curcas* caused 70% and 62.5% mortality and *J. gossypiifolia* evoked 62.5% and 57.5% mortality of worker and soldier termites respectively. While at 12.5%, both species caused 100% mortality comparable to Chlorpyrifos granules, which also caused 100% mortality of both soldiers and workers of *M. subhyalinus*.

At 48h of exposure, *J. curcas* extract was more toxic to both workers and soldiers *M. subhyalinus* and significantly more toxic than *J. gossypiifolia* as concentration increases. At concentration 7.5%, *J. curcas* evoked 92.5% and 87.5% mortality and *J. gossypiifolia* evoked 87.5% and 80% mortality of workers and soldiers termite respectively. At rate 10%, *J. curcas* and *J. gossypiifolia* caused 100% mortality of termite after 24h of exposure comparable to Chlorpyrifos granules, which caused 100% mortality of both soldiers and workers of *M. subhyalinus*.

At 72h of treatment, *J. curcas* extract was more toxic to both workers and soldiers *M. subhyalinus* and significantly more toxic than *J. gossypiifolia* as concentration increases. At concentration 5%, *J. curcas* evoked 90% and 82.5% mortality and *J. gossypiifolia* evoked 82.5% and 75% mortality of workers and soldiers termite respectively. At concentration 7.5% and 15%, *Jatropha* species caused 100% mortality same as Chlorpyrifos granules.

Table 2: Termicidal activities of *J. curcas* and *J. gossypiifolia* seeds Extracts on Percentage Mortality of *M. subhyalinus* (workers and soldiers)

Conc. (%)	Plants Extracts	Mortality rate after					
		24 Hours		48 Hours		72 Hours	
		Workers	Soldiers	Workers	Soldiers	Workers	Soldiers
2.5	*J. curcas*	50.00 ± 2.27^{b}	42.50 ± 2.55^{b}	65.00 ± 3.29^{c}	52.50 ± 2.55^{c}	77.50 ± 3.67^{d}	67.50 ± 3.67^{c}
	J. gossypiifolia	40.00 ± 2.27^{b}	32.50 ± 2.55^{b}	57.50 ± 2.67^{c}	42.50 ± 2.55^{c}	62.50 ± 2.55^{c}	57.50 ± 2.67^{c}
	Chlorpyrifos	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	n-hexane	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
5.0	*J. curcas*	70.00 ± 3.37^{c}	62.50 ± 3.55^{c}	82.50 ± 3.55^{de}	75.00 ± 3.29^{de}	90.00 ± 3.37^{e}	82.50 ± 3.55^{d}
	J. gossypiifolia	62.50 ± 2.55^{c}	57.50 ± 2.67^{c}	72.50 ± 3.55^{cd}	62.50 ± 2.55^{d}	82.50 ± 3.55^{de}	75.00 ± 3.29^{d}
	Chlorpyrifos	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	n-hexane	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
7.5	*J. curcas*	87.50 ± 3.67^{d}	77.50 ± 3.67^{c}	92.50 ± 3.55^{ef}	87.50 ± 3.67^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	J. gossypiifolia	75.00 ± 3.29^{c}	65.00 ± 3.29^{c}	87.50 ± 3.67^{de}	80.00 ± 3.27^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	Chlorpyrifos	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	n-hexane	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
10	*J. curcas*	97.50 ± 2.50^{d}	90.00 ± 3.27^{de}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	J. gossypiifolia	90.00 ± 3.27^{d}	85.00 ± 3.29^{d}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	Chlorpyrifos	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	n-hexane	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
12.5	*J. curcas*	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	J. gossypiifolia	100.00 ± 0.00^{d}	97.50 ± 2.50^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	Chlorpyrifos	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	n-hexane	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
15.0	*J. curcas*	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	J. gossypiifolia	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	Chlorpyrifos	100.00 ± 0.00^{d}	100.00 ± 0.00^{e}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{f}	100.00 ± 0.00^{e}
	n-hexane	00.00 ± 0.00^{a}	00.00 ± 0.00^{a}	25.00 ± 2.29^{b}	20.00 ± 2.27^{b}	30.00 ± 2.27^{b}	27.50 ± 2.67^{b}
0.0	Untreated	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}

Each value is a mean ±standard error of four replicates. Means within the same column followed by the same letter(s) are not significantly different at $p>0.05$ using New Duncan Multiple Range Test.

Phytochemicals Screening of J. curcas and J. gossypiifolia Seed

Table 3 presents the result of the phytochemical screening of the n-hexane and aqueous extracts of *J. curcas* and *J. gossypiifolia* seeds. The phytochemicals present in the n-hexane and aqueous extracts of *J. curcas* and *J. gossypiifolia* were identical.

Table 3. Phytochemicals in different extracts of *J. curcas* and *J. gossypiifolia* seeds

Phytochemicals	n-hexane *J. curcas* extract	Aqueous *J. curcas* extract	n-hexane *J. gossyp iifolia* extract	Aqueous *J. gossyp iifolia* extract
Alkaloids	+	+	+	+
Saponins	+	+	+	+
Tannins	+	+	+	+
Phlobatannins	-	-	-	-
Anthraquinones	-	-	-	-
Flavonoids	+	+	+	+
Cardiac glycosides	+	+	+	+

Legend: -Absent; +Present

DISCUSSION

There have been various assertions about the effectiveness of botanical ashes, powders, oils, latex, and extracts in termite control (Abdulrahaman, 1990; Tadele et al., 2014; Ileke & Adesina, 2018). Although using plants like *Jatropha* species can be an essential part of integrated pest management, there isn't much research on how effective these plants are at keeping termites under control in Nigeria. *J. curcas* and *J. gossypiifolia* have been shown to have insecticidal properties against a variety of insect pests, including cowpea bruchid, *Callosobruchus maculatus*, maize weevil, and *Sitophilus zeamais* (Ogunleye et al., 2010; Sabbour & Abd-El-Raheem, 2013; Suleiman et al., 2014; Ileke & Ariyo, 2015; Sharma, 2017; Opuba et al., 2018). All the tested Jatropha species powders caused high levels (100%) of termite mortality at application rates of 12.5g after 72h compared to extracts that evoked above 50% mortality at the lowest concentration and 100% mortality with 7.5% concentration at 72h after exposure. Powders from the *Jatropha* species had less of an effect on soldier termites than worker termites, while extracts exerted high toxicity on both forms of the insects. The results of this investigation demonstrated that *J. curcas* and *J. gossypiifolia* seed powders and extracts have insecticidal properties that affect *M. subhyalinus* workers and soldiers. This conclusion is consistent with the findings of Ileke and Ariyo's (2015), which showed that *Jatropha* species wood ash and latex used as contact insecticides were highly effective against *C. maculatus*, resulting in a high mortality rate of adult *C. maculatus* within 4 days after application at a rate of 2g/20g of cowpea seeds. They also totally prevented adult emergence and decreased oviposition. This indicates that the *Jatropha* species most likely possesses adulticidal properties. *Jatropha* has demonstrated efficacy against a variety of insect pests through its insecticidal and anti-feedant properties. According to Ogunleye et al. (2010), the *Jatropha* species is excellent at controlling *S. zeamais*, the maize weevil. These effects can be similar to those of insecticides made of synthetic chemicals. There have been reports of *J. curcas* plant parts having anthelmintic, larvicidal, and insecticidal properties. *Jatropha curcas* seeds and pericarps negatively affect insect pests of stored grains (*S. zeamais* and *Rhyzopertha dominica*) (Silva et al., 2012). According to Juliet et al. (2012), an ethanol extract of *J. curcas* leaves may be equally helpful in creating a safe and environmentally friendly medicinal agent to address the issues associated with tick-borne infections and *Rhipicephalus (Boophilus) annulatus* ticks. One possible source of an herbal insect repellent is *J. curcas*. Larvicidal properties of *J. curcas* 100% pure toxin, Jc-SCRIP, from the seed coat, crude protein extract, and leaf methanol extract have the ability to effectively kill *Aedes aegypti*, *Anopheles arabiensis*, and *Culex quinquefasciatus* larvae. (Cantrell et al., 2011; Tomass et al., 2011; Kovendan et al., 2011; Nuchsuk et al., 2012). According to Ahirrao et al. (2008) and Ahirrao et al. (2011), an aqueous extract of *J. curcas* leaves has anthelmintic efficacy against *Pheretima posthuma*. While King et al. (2009), reported that the seeds of *J. curcas* contain some highly toxic compounds that may be the cause of their strong termicidal activity. These substances include the protein curcin and phorbol-esters diterpenoids. *J. curcas* powder/extract are more effective against workers and the soldiers. The findings from this research indicate that the adult population of termites (workers and soldiers) was significantly reduced by the powders and extracts of Jatropha species. This reduction may have been caused by the bioactive chemical constituents of the powders and extracts of *J. curcas* and *J. gossypiifolia* that were investigated. Similar to the findings of Zhang et al. (2009) and Oyetayo and Temenu, (2023), the secondary metabolites produced by plants in this study include alkaloids, tannins, anthraquinones, saponins, and glycosides. These metabolites are known to exert significant insecticidal activities through various mechanisms (Babarinde et al., 2019; Ubulom et al., 2021; Josue & Alexis, 2022). In this study, contact toxicity and stomach poison as reported by Jembere et al. (2005) is suspected as the plant's mode of action. The toxicity of *J. curcas* compared to *J. gossypiifolia* could also be attributed to the presence of phorbol esters, sterols, terpene alcohols, Jatropherol, and jatrophine found in the seeds (Makkar et al., 1998; Devappa et al., 2010; Devappa et al., 2011; Neha, 2017). Alkaloids with anti-cancerous potential found in jatropha include jatrophine, jatropham, curcacycline A, curcain, tannins, glycosides, flavonoids, and sapogenins (Debnath & Bisen, 2008). However, according to King et al. (2009), the seeds of *J. curcas* contain several toxic substances, including the protein curcin and phorbol-esters diterpenoids.

Generally, the efficacy of the insecticidal potentials of botanicals depends on its bioactive components. The active constituent present in the plant is reported to act as insecticidal, larvicidal, ovicidal, feeding deterrent, insect-growth regulator, repellent, sterilant and it may also inhibit the oviposition of insect pests (Figueroa-Brito et al., 2021; Valdez-Ramirez et al., 2023). Mao and Henderson (2007). Makkar et al. (2007) attributed the toxicity of *J. curcas* seeds to the presence of some bioactive components, including saponins, lectins (curcin), phytates, protease inhibitors, curcalonic acid and phorbol esters. Addisu et al. (2014) and Cynthia et al. (2016) reported that the constituents present in the plant might get into the body system of the insect and interfere with the nervous system and normal development causing mortality of the termite. These account for its effectiveness compared to *J. gossypiifolia* products as obtained in this study. The outcome of this study validates the findings of Abdulrahaman et al. (2018) who reported that the pesticidal properties of *J. curcas* seed oil extract was more effective in efficacy than *J. gossypiifolia* as a natural wood preservative against termite infestation.

CONCLUSION

The findings of this study indicate that *J. curcas* and *J. gossypiifolia* seed powders and extracts may be used as potential termicides to control *M. subhyalinus*, a wood and wood product threat. However, *J. curcas* proved to be more successful in termite control than *J. gossypiifolia*. Therefore, *Jatropha* species may be recommended as a potential alternative termicide to manage termites. It is advised that *J. curcas* and *J. gossypiifolia* powders and extracts, which showed insecticidal qualities, be used in the management of *M. subhyalinus* workers and soldiers in light of the study's findings. According to numerous researchers in African nations, the plant is easily accessible, biodegradable, ecologically friendly, and medicinal in nature. In addition to characterizing and isolating the chemical ingredients with the intention of formulating them into herbal termicides as an alternative to synthetic termicides, it is recommended that more research needs to be done to determine the plant's mechanism of action.

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AUTHOR CONTRIBUTIONS

AJM conceived and conceptualized the idea of the research and wrote the draft the manuscript. IKD interpreted the analyzed data and prepared the final manuscript. MTE sourced termites, performed data collection and processing. AOR perform literature searches and sourced plant materials. All authors read and approved the final manuscript.

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AVAILABILITY OF DATA AND MATERIALS

Upon reasonable request, supporting data for the study are obtainable from the corresponding authors

ETHICAL CONSIDERATIONS

The study does not involve the use of animals or human.

COMPETING INTEREST

The authors do not have any conflict of interest to declare.

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