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Research Article

Termiticidal Activity of *Parkia biglobosa* (Jacq) Benth Seed Extracts on the Termite *Coptotermes intermedius* Silvestri (Isoptera: Rhinotermitidae)

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The chemical and mineral composition of raw and boiled seeds of the African locust bean, *Parkia biglobosa* (Jacq) Benth, was determined while the termiticidal action of the aqueous, alcoholic, and acetone extracts of the bean seeds were investigated. Variations in the proximate and mineral composition of the raw and boiled seeds were obtained while heavy minerals such as cadmium, cobalt, lead, nickel, and copper had been leached out of the seed during the process of boiling. Extracts from the raw seeds exhibited varying degree of termiticidal activity, while extracts from the boiled seed had no effect on the workers of *Coptotermes intermedius* Silvestri. Alcoholic extracts were more active than the aqueous and acetone extracts. Termites die within 30 min, 40 min, and 110 min when exposed to concentration of 4 g mL^{-1} treatments of alcoholic, aqueous, and acetone extracts, respectively.

1. Introduction

Termites cause the most serious damage of all wood-feeding insects. In addition to timber and wood products, they attack growing trees, leather, rubber, and wool as well as agricultural crops [1]. Significant damage is caused by termites to man-made fabrics, polythene, plastics, metal foils, books, furniture, wooden telephone poles, wooden railway sweepers, and insulators of electric cables [2].

Damage caused by termites to wooden structures in the United States of America is estimated to be over 3 billion Dollars annually, with subterranean termites accounting for at least 80% of these damages [3]. Costs attributable to *Coptotermes formosanus* in the Hawaiian Islands alone are greater than 60 million Dollars per annum [4].

Termites are so destructive in that they derive their nutrition from wood and other cellulotic materials. In Africa and elsewhere in the developing countries, there is hardly any data on either the quantum of damage done by termites to agricultural crops, construction timbers, paper, and paper products, or the cost of control or repairing the damage done by these insect pests.

The damage done by various termite species in Nigeria [2] ranged from scavenging on tree barks and dead branches, to eating out grooves in the roots and stems of plants.

Past research efforts had focused more on chemical methods of control, with an obvious lack of attention placed on understanding the behavior and history of these termites.

In view of mounting concerns over the side effect caused by the use of these toxic and environmentally unfriendly chemicals, direction of research is now focusing on alternative nontoxic, biological, and environmentally friendly methods of control. These methods include baiting systems, use of asphyxiant gases, application of extreme temperatures, barriers of various types, as well as biological control organisms [3, 5].

Extractives with insecticidal properties from naturally resistant wood and plant species in form of phenolic, terpenoid, and flavonoid compounds, show great promise for prevention of termite attack [6–9]. Some of these substances may also act as feeding deterrent [10–12].

The termite *Coptotermes formosanus* was found to be attracted and preferentially feed upon the amino acids, glutamic and aspartic acids [13]. These could be used to improve the effectiveness of baiting systems. Many of the chemicals causing attraction and avoidance in several tree species are polar molecules [14]. Investigation has shown that steaming of the heartwood of the Japanese larch, degraded or removed the chemicals responsible for the inhibition of termite attack [15]. A number of tree species such as the Alaska cedar, redwood, and teak [16] are resistant to termite attack. Neem was found to be a strong repellent to *Coptotermes formosanus* and was suggested as a barrier tree to protect more vulnerable plants [17]. The use of high levels of carbon dioxide, for extended period of time has been successfully used to control termites in contained spaces [4]. The application of heated air to kill termites has shown to be successful in laboratory bioassays [18]. Liquid nitrogen has also been shown to be effective in eliminating termites in the laboratory [3]. These temperature-based control methods are showing great promise, but need more field studies on their effectiveness in natural settings. In other studies [19] Inundation with water was shown to cause a decline in foraging worker population. This could indicate possible applications to control, for example, the controlled flooding of the territories of specific termite colonies to reduce damage by foragers. Barriers to foraging termites that are being tested include sand, crushed granite, glass splinters, and metal shields. These methods have had mixed successes, thereby pointing to the need for more research in this area [3].

The African locust bean, *Parkia biglobosa* (Jacq) Benth, is a perennial leguminous tree, found growing wildly in forested and savanna belts in Nigeria. Fermented *Parkia* seeds are locally used in traditional soup seasoning, medicinal preparations and food additives [20]. In addition, boiled water obtained during fermentation process of *P. biglobosa* seeds is used in controlling termite infestation at the local level. In spite of this practice, few reports exist on the termiticidal properties of aqueous solution of *P. biglobosa* seeds.

The effect of various concentration levels of aqueous and acetone extracts of *P. biglobosa* was reported to record total mortality within 40–110 minutes after application [21].

This study is therefore aimed at investigating the effect of aqueous, alcoholic, and acetone extracts of *P. biglobosa* seeds on the rhinotermitid, *Coptotermes intermedius* Silvestri in order to ascertain its efficacy in the control of this termite pest.

2. Materials and Methods

2.1. Parkia biglobosa . *P. biglobosa* seeds were obtained from the open market at the King's market in Akure, Southwest Nigeria.

The raw seeds were washed and sun-dried before grinding to powdered form. 100 mL of deionized water, 70% alcohol, and acetone were added to each of 20 g of the powdered seeds of *P. biglobosa* in covered 250 mL glass beakers, respectively, for 12 h. The extract was filtered, and the filtrate was kept for the bioassay.

20 g of the dried boiled seeds were also grounded to powdered form, and 100 mL of de-ionized water, 70% alcohol and acetone were added to beakers containing the powdered seeds, respectively. The mixtures were left for 12 h, filtered, and the filtrate was kept for subsequent bioassay.

2.2. Termites. Colonies of *Coptotermes intermedius* were collected from a decaying branch of *Cassia sp*. at the Federal University of Technology, Akure, and brought to the Termite Research Laboratory, Akure, Southwest Nigeria. The termite colony with its decaying wood was kept and maintained in a plastic container that was kept moist with the aid of a water-filled cotton wool-capped McCarthy bottle affixed to the side of the container. The termites were maintained in the laboratory for at least one month before use, at a temperature of 27°C ± 3°C and relative humidity of 70% ± 5%.

2.3. Determination of Proximate Composition of P. biglobosa Seeds. The moisture content, ash, crude fiber, and fat contents (raw and boiled seeds) were determined by the methods of the Association of Official Analytical Chemists [22] while the nitrogen component was determined by the micro-Kjeldahl methods [23]. The percentage nitrogen value obtained was converted to crude protein by multiplying with a factor of 6.25 [21]. The carbohydrate constituent was calculated from a difference of all the components from 100.

2.4. Mineral Analysis. The mineral components were determined by dry-ashing 1 g of the seed powder at 550°C in a furnace. The ash obtained was dissolved in 10% hydrochloric acid, filtered, and made up to standard volume with deionized water. The Atomic Absorption Spectrophotometer (Buck Model 200-A) was thereafter used to determine the following minerals in the seed preparation: sodium, potassium, calcium, magnesium, iron, copper, lead, manganese, cadmium, cobalt, nickel and phosphorus.

2.5. Bioassay to Determine Termiticidal Activity of Extracts of the Seeds of P. biglobosa (Raw and Boiled). One milliliter aliquot of the different extract concentrations, ranging from $0.1\,g\,mL^{-1}$ to $0.4\,g\,mL^{-1}$, were each applied unto the surface of a Whatman No. 1 filter paper, allowed to air dry, and placed at the bottom of the covered petri dish arenas, respectively [21, 24]. 50 workers of *Coptotermes intermedius* were placed in each of the arenas containing the different extract concentrations, and they were monitored every 10 min for 3 h to determine the conditions of the termites. The experiments were replicated 5 times.

For the control experiments, one milliliter of deionised water, 70% alcohol, and acetone were each applied on the surface of a Whatman No. 1 filter paper, allowed to dry, and placed at the bottom of the covered petri dish arenas, respectively. A bioassay was carried out as described above, and replicated 5 times.

3. Results

The proximate determination of *P. biglobosa* seeds showed varying values between the raw and boiled seeds. Moisture content, crude fiber, ash, and carbohydrate values are slightly higher in the raw seeds as against the values for boiled seeds (Table 1). Values for crude protein, fat, and nitrogen are higher in the boiled seeds than in the raw seeds.

Table 1: Proximate composition (mean of 5 replicates) of *Parkia biglobosa* seeds.

Chemical components (%) ± SD	Raw (%) ± S D	Boiled
Moisture	13.40 ± 0.01	11.20 ± 0.02
Crude protein	25.44 ± 0.01	30.19 ± 0.01
Crude fat	6.60 ± 0.01	18.20 ± 0.01
Crude fiber	8.81 ± 0.02	7.53 ± 0.01
Ash	4.81 ± 0.01	3.63 ± 0.01
Carbohydrate	40.94 ± 0.01	29.25 ± 0.01
Nitrogen	4.07 ± 0.01	4.83 ± 0.01

Table 2: Mineral composition of *Parkia biglobosa* seeds.

Minerals	Raw (mg · mL^{-1}) ± SD	*Boiled (mg · mL^{-1}) ± SD
Sodium	165.09 ± 0.03	299.50 ± 0.02
Potassium	120.54 ± 0.05	451.00 ± 0.03
Calcium	548.40 ± 0.02	271.05 ± 0.01
Magnesium	62.60 ± 0.01	426.90 ± 0.03
Zinc	16.34 ± 0.01	20.02 ± 0.01
Iron	7.85 ± 0.02	9.00 ± 0.01
Lead	2.45 ± 0.01	ND
Manganese	0.97 ± 0.01	0.66 ± 0.01
Cadmium	0.18 ± 0.10	ND
Cobalt	4.21 ± 0.01	ND
Nickel	4.01 ± 0.01	ND
Phosphorus	4.39 ± 0.01	65.72 ± 0.02
Copper	6.97 ± 0.02	ND

*: Mean of 5 replicates; SD: standard deviation; ND: not detected.

The mineral composition of boiled seeds of *P. biglobosa* such as sodium, potassium, magnesium, zinc, iron and phosphorus, has higher values than in the raw seeds (Table 2). However, calcium and manganese levels were higher in the raw seeds than in the boiled ones. Elements such as lead, cadmium, cobalt, nickel, and phosphorus present in the raw seeds are absent in the boiled seeds (Table 2).

The termiticidal action of the aqueous seed extracts showed that mortality was achieved faster at higher concentrations than at lower concentration levels. At 0.4 g mL^{-1} treatment, all the termites died within 40 minutes while it took 60 minutes for all the termite workers to die when exposed to the 0.1 g mL^{-1} treatment (Figure 1).

For the alcoholic extracts, it took just 30 minutes to eliminate all the termite workers at the 0.4 g mL^{-1} concentration level compared to 0.1 g mL^{-1}, which took 60 minutes to kill all the termites (Figure 2).

The acetone extracts showed termiticidal activity at 0.3 g mL^{-1} and 0.4 g mL^{-1} concentration levels while no significant activity was detected at the 0.1 g mL^{-1} and 0.2 g L^{-1} concentration levels (Figure 3).

Termiticidal activity was not detected in bioassays involving aqueous, alcoholic, and acetone extracts of boiled seeds of *P. biglobosa*, as no death was recorded in all the tests. Similarly, no termite death was obtained in the control experiments.

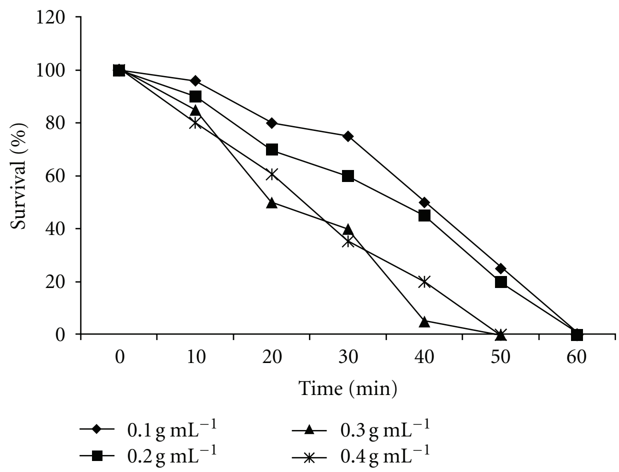

Figure 1: Antitermitic activity of aqueous extracts of *Parkia biglobosa*.

4. Discussion

The variations obtained in the values of proximate and mineral composition of raw and boiled seed powder of *P. biglobosa* may be due to the effect of boiling, which increases, reduces, or totally eliminates some minerals from the boiled

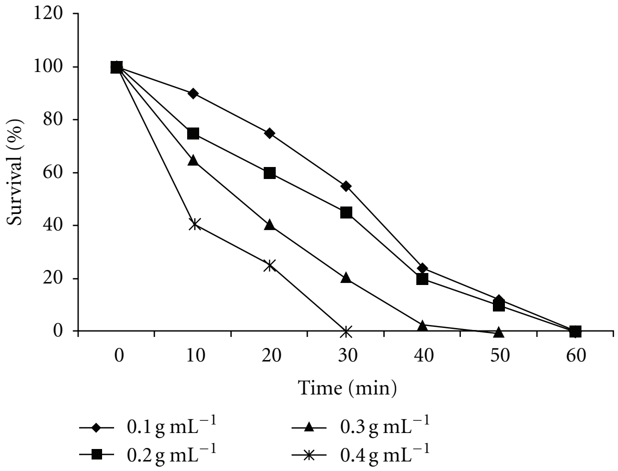

Figure 2: Antitermitic activity of 70% alcoholic extracts of *P. biglobosa*.

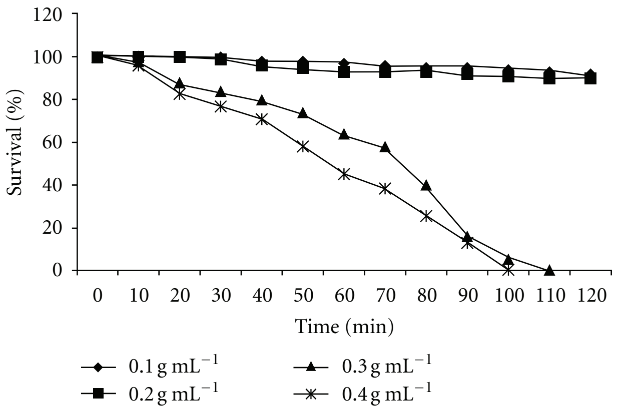

Figure 3: Antitermitic activity of acetone extracts of *P. biglobosa*.

seeds. An earlier study [25] had reported that boiling, soaking in water, and dehulling of African locust bean, led to the reduction in ash, crude fiber, and mineral contents of the seeds. However, the overall increase in crude fat and crude protein contents in the boiled seed extract may be due to reduction in concentration of other chemical components during the boiling process. These differences may account for the termiticidal activity in extracts of the raw seeds when compared with extracts from the boiled seeds.

It was reported [26] that a larger percentage of the mineral constituent in *P. biglobosa* may reside in the hull of the seed, and are therefore leached out during processing. Raw *P. biglobosa* have been found to contain some heavy metals such as cadmium, cobalt, nickel, lead, and copper [27], which are basic natural components of the earth crust and are toxic at low concentrations. Heavy metals such as Cd, Co, Cu, Ni, and Pb were found in extracts of the raw seeds, but absent in extracts of the boiled seeds. These elements might have been lost during the boiling process [25].

The presence of these heavy metals in the raw seeds, in addition to the factor of polar organic compounds arising from the interactions between the mineral constituents and the extracting medium may therefore explain the termiticidal action of these extract on workers of *C. intermedius*.

Termiticidal activity of aqueous and alcoholic extracts of raw seeds of *P. biglobosa* increases as concentration levels increases while significant termiticidal activity for acetone extract was obtained only at higher concentration levels ($0.3\,\mathrm{g\,mL^{-1}}$ and $4\,\mathrm{g\,mL^{-1}}$). At lower concentration levels ($0.1\,\mathrm{g\,mL^{-1}}$ and $0.2\,\mathrm{g\,mL^{-1}}$), acetone extracts of raw *P. biglobosa* did not confer significant activity on the test termites. This result confirmed an earlier observation made in a study on the termiticidal effect of *P. biglobosa* extracts on the termite, *Amitermes evuncifer* [21].

Aqueous, alcoholic, and acetone extracts of boiled seeds did not have termiticidal effect on these termite workers.

This may explain why the boiled water obtained during the fermentation stage of preparation is effective in the traditional control of termite infestation in the rural areas [1, 21].

Extracts from several plants have been reported to have biocidal effects or feeding deterrents to insects such as termites [8, 9, 11, 12, 28]. It has also been well established that certain extractives found in plant materials acted as natural repellent for termites [7, 14, 28, 29].

Extracts from raw seeds of *P. biglobosa*, which appears to be relatively nontoxic to people, have therefore shown to be an effective termiticide candidate for the control of the termite, *Coptotermes intermedius*. Since there has never been any adverse documented toxicological effect on local processors of *P. biglobosa* as well as consumers of the finished product, toxicity of the raw extracts may be unharmful to people.

5. Conclusion

This study has shown that extracts of the African locust beans (*P. biglobosa*) seeds have termiticidal properties, and could be effectively used for the control of termite infestations. The presence of some heavy metals as well as the interacting polar organic compounds in the raw seed extracts could account for this termiticidal property. Further research work is, however; required to determine the contributions of each of these chemical constituents to the overall termiticidal action of raw locust bean seed extracts.

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