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Protective property of *Icacina trichantha* against temites (*Macrotermes* spp) attack on the wood *Bombax buonopozense*

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Abstract

The protective property of *Icacina trichantha* against attack was examined using different solvents (water, methanol and petroleum spirit) and extraction methods (hot and cold). The extracts were prepared in different concentrations (0.025, 0.035, 0.045 and 0.055 mg/L) and a control (0.00 mg/L) and applied on the wood (*Bombax buonopozense*). The treated woods were were exposed to termites attack by staking the treated wood into the ground and allowed for six weeks. The woods were removed from the ground on the sixth week and examined for the consumption rate by the termites. The results obtained indicated that the rate of non-consumption of the treated wood (*Bombax buonopozense*) was concentration dependent. The type of extraction (cold or hot) also played an important role in the non-consumption of the wood. Cold solvent extracts were more potent in warding off termites from consuming the wood. This protection may be attributed to higher concentrations of toxic phytochemicals or organic components in them. The protection capacity of the cold solvent extracts of *Icacina trichantha* showed that petroleum spirit offered the highest activity (96.55 ± 3.25 %), followed by methanol (91.89 ± 6.79 %) and water (79.70 ± 4.95%). The protection of the wood by the hot solvent extracts of *Icacina trichantha* were in the order: water (80.98 ± 4.73 %) > methanol (72.83 ±5.43 %) > petroleum spirit (71.68 ± 5.54 %). This work has established that the use of *Icacina trichantha* extracts can be of great importance in the treatment of wood against termite invasion and also a promising and potent antitermitic plant which when explored can prove beneficial to man and the environment.

Keywords: protective property, termites, Icacina trichantha, Bombax buonopozense

Introduction

Buildings made of wooden materials have the capacity to stand for many years. When woods are properly treated they can be used for several years without deterioration (Planet Ark, 2016; Government of Canada, 2016). Wood serves for construction and furniture production because of these properties. One such benefit is its thermal properties, which give it an advantage in terms of its resistance to high temperatures. Unlike steel, which can expand or even collapse in high heat, wood actually dries out and becomes stronger as the heat increases (Government of Canada, 2016). However, wood is still subject to a time disadvantage because it is an organic material and therefore subject to decay, deterioration, attack and infestation from insects (Civelek and Çolak, 2008).

The importance of wood cannot be overemphasized, yet it is under attack by different pests such as insect and fungi. Several methods including use of chemicals and seasoning have been used to control termites attack or invasion of wood. However, the use of chemical method of preservation of wood and prevention of termites' attack is always accompanied with its associated problems. The use of chemicals leads to persistence of toxicants in the environment, toxicity to organisms and the operating personnel, high cost, adverse effect on non-target species, etc.

Due to the attendant problems and risk associated with the application of synthetic wood chemicals and preservatives ((Bozkurt, *et al*., 1993; Ongley, 1996), attention is being shifted to alternative sources of wood preservation, the botanicals. The demand for botanicals or biological plant protectants is on the rise because they are biodegradable and constitute no environmental risks when compared to the widely used synthetic chemicals. Food and agriculture policies favour the use of botanicals to replace fossil oil-based chemicals and have directed policies in that direction (Lee & Neves, 2009) because of the underlying advantages that plant based protectants offer.

Several plants are known to contain bioactive chemicals whose insecticidal properties have not been known or documented or explored for both domestic and agricultural uses (Zhu *et al* 2001).

Icacina trichantha is a member of the family *Icacinacea*. It is a shrub and perennial in nature. It bears simple and alternate broad leaves and bears tubers underground. It grows to a height of 2 metres and grows both in the forest (virgin land) and in fallow lands (Akobundu and Agyakwa, 1998). The tuber is served as different diets in different parts of Southern Nigeria, especially among the Ibos, Binis and the Yorubas and also used in the treatment of several diseases and ailments.

The root was observed to possess some phytochemicals such as alkaloid and benzophenone (Taylor *et al*., 2001), tannins, phenols, glycosides, steroids and flavonoids (Shagal, and Kubmarawa, 2013; Edori and Epkete, 2015; Otun *et al*., 2015). The plant has also been observed to possess anti- termitic properties (Edori and Epkete, 2015).

Termites are social insects which are very destructive. They attack wood and wood products (Manzoor and Mir, 2010). They live in colonies and members have specialized in particular activities. Cellulose is the major food of termites and they find it available in trees and wood. They forage for food by travelling underground though tube channels to long distances in search of wood and wooden materials (Horwood and Eldridge, 2005). Due to the importance of wood in building and construction and the attendant destructions caused by termites on wooden materials, this study was carried out to examine the protective capacity of *Icacina trichantha* on termites invasion of wood *Bombax buonopozense*.

Materials and Methods

Source of Icacina trichantha

Tubers of *Icacina trichantha* were collected from Rumualogu town in Obio - Akpo Local Government Area of Rivers State, Nigeria and transported to the Chemistry Department Laboratory, Rivers State University of Science and Technology, Port Harcourt, Rivers State. They were cut to smaller sizes and air-dried to constant weight for a period of one month. The dry pieces were then powdered with a blender and sieved in a 0.2 mm mesh. The powder was stored in dry clean tightly closed bottle.

Source of Bombax buonopozense

Bombax buonopozense cut to size (2 by 2 inches by 12 feet) were purchased from timber dealers at the Mile 3 Market, Port Harcourt and transported to the Research Laboratory of the Department of Chemistry. The long woods were sawn to one foot lengths, weighed with a beam balance and numbered. The cut woods were marked at the centre (6 inches) with an indelible marker pen. Half of the woods were treated with the extracts using a painting brush.

Solvent Extraction of Icacina trichantha and treatment of the wood (Bombax buonopozense)

Powdered *Icacina trichantha* (100g) was weighed on a compact scale balance 200, Ohause product, made in China, and placed in a 250 ml conical flask. Cold distilled water was added to the 250 ml mark, covered with aluminum foil and the mixture allowed to stand for 48 hours. A hot of the plant was also carried out. The extracts subsequently used for a trial test.

Figure 1: Soxhlet extraction of the plant (Icacina trichantha)

Thereafter, 25g *Icacina trichantha* was soaked in 100 ml of cold water and 100 ml of the cold Petroleum spirit and methanol and allowed to stand for 48 hours in the laboratory. Water was boiled and 25g of the plant was soaked in it and allowed standing for 48 hours. Hot extraction was also carried out on the plant using 25 g of it. The solvents (methanol and petroleum spirit) extraction was done at controlled temperature of 80^{o}C in water bath and was refluxed for 48 hours. The extracts obtained from the cold and hot extractions were serially diluted to obtain the concentrations (0.025, 0.035, 0.045 and 0.055 mg/L) and a control (0.00 mg/L) which were then applied on the wood. The weighed and labeled woods (*Bombax buonopozense*) were treated with the plant extracts from the different solvents (water, petroleum spirit and methanol) and extraction methods (cold and hot) with a brush and allowed to dry for 24 hours. The treated woods were then moved to the experimental site.

The Experimentation

A site behind the Food Science and Technology Department and between the Faculty of Science and Faculty of Engineering of the University was chosen for the experiment. The choice of this position was chosen because of the presence of many anthills within the area. The size of the anthill at the site measured 3.6 metres high, 2.8 metres long and 2.1 metres wide. The treated woods were transferred to the site of the experiment. Eight untreated woods were left in the laboratory to dry completely so that the weight difference between the dry and wet wood can be obtained.

At the experimental site, 2 feet was measured away from the anthill before the treated half of the woods were staked in the ground leaving the half above ground. The woods were arranged in rows and columns one foot apart and were left for a period of six weeks for the termites to attack.

Experimental Design

The experiment was divided into four treatment levels and a control with three replicates. During the experimental period, temperature and humidity readings were taken twice in a week for six weeks.

Mathematical and Statistical Treatment of Data

The woods were removed from the ground at the end of the sixth week (the experimental period), and transferred to the laboratory for further analysis. The infested woods were oven dried to constant weight.

Figure 2: Woods infested by termites

The infested dry woods were then subjected to mathematical processes to determine the percentage wood protection by the different solvent extracts and methods:

a) Wood protection = weight of fresh *Bombax buonopozense* wood – (weight of water + weight loss due to *Macrotermes* specie).

b) Weight loss due to *Macrotermes* specie infestation = weight of fresh wood – (weight of water + weight of wood after infestation)

c) Percentage protection =

$$\frac{\text{wieght of infested wood}}{\text{weight of wood before Macrotermes infestaion}} \times 100$$

Figure 3: Woods removed from ground at the end of experimentation

The results obtained were analyzed using analysis of variance (ANOVA) to determine if differences existed in the infestation of termites on the woods smeared with the different extracts from the solvents and the applied concentrations. Probit analysis (Finney, 1972) was also done on the data to obtain different protection levels of the extracts at 95% confidence intervals.

Results

The internal and external temperature of the termiterium showed that the internal temperature was slightly lower than the temperature of the external environment. The temperature range was between 26.0 – 30.33 ^{o}C internally while the external temperature ranged from 27. 5- 33.33 ^{o}C. The humidity of the internal environment was slightly higher than those of the external environment of the termiterium. The humidity of the internal environment ranged from 64.0 – 76.25, while in the external environment, the humidity ranged from 58.50 -68.75 (Table 1).

Table 1: Temperature and humidity of the termiterium (ant hill) during the six weeks' period.

Week	Temperature		Humidity	
	Inside	Outside	Inside	Outside
1	27.5	29.0	70.0	63.5
2	26.5	28.5	71.0	59.25
3	26.0	27.5	76.25	68.75
4	29.0	30.5	69.0	61.50
5	30.0	32.0	64.0	58.50
6	30.3	33.33	58.67	53.83

The efficacy of cold and hot extracts of *Icacina trichantha* against termites attack on the wood of *Bombax buonopozense* showed a concentration dependent protection. The highest protection for the cold extracts showed cold petroleum spirit offered the highest protection, followed by cold methanol and the least was cold water (Table 2).

Table 2: The efficacy of cold extracts of Icacina trichantha treated Bombax buonopozense wood against Macrotermes specie.

Concentration (mg/L)	Cold Methanol % protection	Cold Petroleum spirit % protection	Cold water % protection
0.00	13.00 ± 0.00	10.20 ± 0.00	7.47 ± 0.00
0.025	28.30 ± 9.35	67.85 ±11.22	79.73 ± 4.90
0.035	45.33 ± 10.11	69.03 ± 9.02	78.78 ± 9.40
0.045	66.90 ± 9.36	94.83 ± 5.50	86.98 ± 4.58
0.055	91.89 ± 6.79	96.55 ± 3.25	79.70 ± 4.95

In the hot extractions, the protection of the wood was of the order hot water > hot methanol > hot petroleum spirit. The concentration dependent protection exhibited by each of the solvent extracts showed more uniformity in the petroleum spirit solvent as against the others (Table 3).

Table 3: The efficacy of hot extracts of Icacina trichantha treated Bombax buonopozense wood against Macrotermes specie.

Concentration (mg/L)	Hot Methanol % protection	Hot Petroleum spirit % protection	Hot water % protection
0.00	2.60 ± 0.00	0.00 ± 0.00	8.40 ± 0.00
0.025	38.60 ± 6.85	26.48 ± 4.40	44.20 ± 10.25
0.035	47.65 ± 5.90	46.93 ± 9.69	43.55 ± 8.98
0.045	59.48 ± 4.40	67.00 ± 9.00	49.13 ± 6.56
0.055	72.83 ±5.43	71.68 ± 5.54	80.98 ± 4.73

The efficacy of the different solvent extracts of *Icacina trichantha* on the wood *(Bombax buonopozense*) protection indicated that water was the best solvent which was followed by petroleum spirit and then methanol (Table 4).
*Table 4: The efficacy of cold and hot extracts of *Icacina trichantha* in various solvents against *Macrotermes* specie on *Bombax buonopozense*

Solvent (Protectant)	Cold extract	Hot extract
Methanol	55.08 ± 8.13	44.23 ± 6.66
Petroleum spirit	71.77 ± 7.07	42.42 ± 8.82
Water	74.75 ± 11.81	45.25± 7.87

**The value obtained in Table 4 is an average value of the values for each solvent from Tables 2 and 3.*

The probit result of the protection of the wood treated with cold extracts showed that for water, 0. 055g/L of the extracts can affect 95 % protection of the wood while petroleum spirit and methanol will utilize 0.053 and 0.1 mg/L respectively to effect 95 % protection of the wood against termite attack (Table 5).

Table 5: Probit protection of Bombax buonopozense wood with cold extract of Icacina trichantha treatment against Macrotermes specie.

Extraction method	Probit protection (%)		
	50	90	95
Cold water	0.016 (0.012 - 0.019) - 0.075)	0.044 (0.04 - 0.05)	0.052 (0.047
Cold petroleum spirit	0.014 (- 0.21 - 0.025) 0.10)	0.045 (0.033 - 0.08)	0.053 (0.04 -
Cold methanol	0.025 (-)	0.081 (-)	0.10 (-)

The probit result of the protection of the wood treated with hot extracts showed that for water, 0. 078g/L of the extracts can affect 95 % protection of the wood while petroleum spirit and methanol will utilize 0.066 and 0.075 mg/L respectively to effect 95 % protection of the wood against termite attack (Table 6).

Table 6: Probit protection of Bombax buonopozense wood with hot extract of Icacina trichantha treatment against Macrotermes specie.

Extraction method	Probit protection (%)		
	50	90	95
Hot water	0.039 (0.025 - 0.062) (0.058 - 0.22)	0.069 (0.052 - 0.18)	0.078
Hot petroleum spirit	0.038 (0.035 - 0.040) (0.059- 0.074)	0.06 (0.056 - 0.066)	0.066
Hot methanol	0.036 (0.034 – 0.039) (0.068 - 0.085)	0.066 (0.060- 0.074)	0.075

The effectiveness of the various extraction solvents as protectants of *Bombax buonopozense* treated with *Icacina trichantha* is shown in Table 7.

Table 7: Summary of efficacy of the solvent extracts of Icacina trichantha.

Extraction method	Solvent used		
	Methanol	Petroleum spirit	Water
Cold	55	72	74
Hot	61	69	70

The Spearman's correlation matrix of temperature, humidity and protection is shown in Table 8.

Table 8: Correlation of temperature and humidity on Icacina trichantha extracts treated against Macrotermes specie on Bombax buonopozense.

	Temperature	Humidity	Protection
Temperature	1.000		
Humidity	- 0.860	1.000	
Protection	0.505	0.549	1.000

Discussion

Termites thrive well at moderate temperatures when compared to extreme weather conditions. In very cold regions such as the Antarctica, there is complete absence of termites. The temperature range observed in this study and this region supports spread of termites. That is why termiterium is a very common sight even on the campus where the study was conducted.

Termites especially the *Macrotermes* specie have been a major wood-destroying pest in Nigeria over the years. Wood dealers and builders have for a long time been using a synthetic wood preservative called solignum mixed with kerosene and used oil (condemned oil) to preserve wood. Though this method is effective, unfortunately it is hazardous to the users especially within the first few weeks of application. These materials also raise significant environmental concerns because of their toxicity to organisms in the environment and persistence (Alshehry *et al*., 2014).

Analysis of the results showed that the resistance of the wood to termites' attack increased with increasing concentration of the extract similar to the findings of Alshehry *et al*., (2014). This is an indication that the active components responsible for the anti-termitic activity offer greater resistance against termites at higher concentrations. This observation is in consonance with the findings of other authors (Emerhi *et al.,* 2015) who worked with *L. breviflora* fruits pulp extract on termites.

Phytochemical and other examinations of *Icacina trichantha* has been carried out by different authors. Shagal and Kubmarawa (2013), observed the presence of alkaloids, tannins, saponins, and phenols in the leaves of *Icacina trichantha* and also found that the extracts (water and ethanol) possess antimicrobial activity. Otun *et al*., (2015) observed the presence of tannins, phenols, glycosides, steroids and flavonoids in the leaves of *Icacina trichantha*. Qualitative and quantitative studies (Gas Chromatography – mass Spectroscopy, GCMS system) showed the presence of different organic acids and ester, with oleic acid being the most predominant one and the plant was further observed to be bioactive against different micro-organisms (Otun *et al*., 2015). Edori and Ekpete, (2015) observed the presence of tannins, saponins, alkaloids and carbohydrates in the tuber of *Icacina trichantha*.

The resistance of the treated wood to attack by termites could be due to the characteristics of some of the extractives or phytochemicals which possess repellent or toxic characteristics (Taylor *et al*., 2006; Syofuna *et al*., 2012). The extracts from different solvents offered varied protection or efficacy to the wood. This is because the solubility of the different chemical components, differ from one solvent to another. However, it was not possible to single out the active chemicals that are toxic to termites which may have necessitated the protection of the wood against termite invasion.

The result obtained showed that the cold extracts from the solvents were more effective in protecting the wood against time attack. This may be based on the assumption that the cold extracts may have retained more volatile organic components than the hot extracts that is the concentrations of the retained components (phytochemicals or other organic constituents) were higher in the cold extracts. The above assumption was also suggested in the work of Hassan *et al*., (1997) who did phytochemical examination of *Rhazya stricta* found in Saudi Arabia.

It has been established that using different extraction methods and extraction solvent makes a difference in the amount (concentration) of components and the type or nature of component that can be extracted (Obomanu *et al*., 2005). The protection result showed that the cold extracts of each solvent offered a better protection than the corresponding hot extracts. The 95 % protection by the various cold solvent extraction showed that cold water extract offered the highest protection to the wood (*Bombax buonopozense*) which was closely followed by cold petroleum spirit and the least protection was offered by the cold extract of methanol. The concentrations of different cold solvent extracts of *Icacina trichantha* were water, 0.052 (0.047-0.075 mg/L), petroleum spirit, 0.053 (0.040- 0.010 mg/L) and methanol 0.10 mg/L. The 95 % probit protection for the hot extractions were water, 0.078 (0.056-0.22 mg/L), petroleum spirit, 0.066 (0.059-0.074 mg/L) and methanol, 0.075 (0.068-0.085 mg/L). The hot solvent extracts of *Icacina trichantha* gave lower protection capacity to the wood *Bombax buonopozense.* The protection capacity of the solvent extracts were of the order petroleum spirit > methanol > water.

The result showed that cold water extract was more potent than petroleum spirit followed by methanol and also the hot extracts followed the same trend. The results obtained is indicative of the fact that in each of the solvents used, the cold extracts of the tuber of *Icacina trichantha* was more protection effective than the hot extracts.

The result showed a negative correlation between temperature and humidity which implies that at low temperature and high humidity, the wood can be protected from being consumed by the termites. However, there was a positive correlation between temperature and protection and between humidity and protection, thus indicating that high temperature is a negative factor in wood protection and also humidity when low confers protection on wood from invasion or attack by termites.

Conclusion

The *Icacina trichantha* tuber used this study could be a potential plant protectant against termite attacks on wood. Toxicity of the extracts depended on the extraction method from which the extracts were obtained and the solvent used for extraction. Moreover, the inherent properties of the plant extracts which is cost effectiveness, environmental safety, can be safely handled without technicalities and availability, if properly utilized can be used as a substitute for synthetic termiticide in particular and as a pesticide in general.

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