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Original Research

Evaluation of Some Plant Extracts Effectiveness on the Termites *Reticulitermes* spp. (Isoptera: Rhinotermitidae)

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Abstract

Termites cause important economic losses worldwide and insecticides are largely used to control termites, resulting in significant economic losses around the globe. The development of alternative termite control methods is motivated by concerns for the health of humans and the environment. Such knowledge would greatly help in optimizing termite management methods. However, few studies have documented the various effects that plant extracts may have on termites. Under laboratory conditions, we assessed has examined the numerous ways that plant extracts affect termites, we tried determining the median lethal concentration (LC_{50}) circumstances of five extracts of natural plants including Spike Lavender (Lavandula latifolia Medik.), Clove (*Syzygium aromaticum* (L.), garlic (*Allium sativum* L.), Cinnamon (*Cinnamomum verum*) and Marjoram (*Origanum vulgare* L., Lamiaceae)), on the termites *Reticulitermes* spp. (Isoptera: Rhinotermitidae). When treated with different concentrations (0, 5, 10, and 15 µL/ L) of the five above-mentioned plants, over specific periods (1, 2, 3, 4, 5, 6, and 7 days). The results of the current study showed that the tested Plant Extracts could be discerningly arranged as follows: Garlic, Clove, Lavender, Cinnamon, and marjoram. The corresponding LC_{50} values were 17.274, 17.84, 18.823, 23.706, and 25.483 µL/L. On another hand, the LC_{90} values were 87.47, 90.434, 88.377, 133.321, and 132.296 µL/ L. As well as $\chi 2$ values were 0.0322, 0.4688, 0.5364, 0.7074, and 1.54, respectively. The current findings may aid in improving the management of termites, plant extracts against termites are efficient and offer various potential future sustainable development applications.

Keywords: bioagent pesticide, lethal time 50 (LT_{50}), mortality, plant extracts, sustainable control, termites

Introduction

Termites are a major problem in both urban and rural locations around the world because they cause significant damage to vegetation, crops, and wood structures, and cause financial loss [1]. Termites as social insects comprise a king, queen, workers, and soldiers in the colony. Termites can be found in wood, above the floor, and underground. Currently, 2,500 species of termites are known to the world, out of 300 species are acknowledged as a pest [2]. Nevertheless, termites are a widespread, ancient group

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of social insects that are largely known as economically significant pests for destroying timber constructions and as agricultural pests, social insects that are widely distributed, they are mostly known as economically significant pests for destroying timber constructions and as agricultural pests [1]. Termites that consume wood are a significant pest of plantation crops because they attack plant sections beneath the soil's surface, their attacks are typically difficult to forecast at an early stage, as a result, treating termites using chemical insecticides requires extreme caution [3].

Managing termite colonies successfully requires various specialized expertise, understanding termite ecology and how to identify them can aid in identifying harm and providing solutions [4]. Significant amounts of synthetic insecticide are used to control termites, which results in phytotoxicity, mammalian toxicity, and pesticide resistance in the intended pests and insect outbreaks. Intensive pesticides have long-lasting impacts on living things and irritate helpful insects, they are also associated with environmental risks and have acquired resistance, on the other hand, extracts from plant leaves offer a unique range of biological components with several potential applications, the creation of new biological substances with a broad spectrum of action is necessary for resistance [5]. The use of chemical pesticides to preserve food products is a major concern on a global scale, due to their damaging effects on the environment and human health, the European Union has been working to cut back on their use recently by promoting alternate or complementary strategies based on natural ingredients, plant-borne essential oils (EOs) are suitable alternatives for Integrated Pest Management (IPM) [6].

The current situation has compelled humanity to look for other solutions, pest management, particularly the control of termites and other Phyto-diseases, must be prioritized while keeping in mind the idea of sustainable agriculture, and eco-friendly and economical strategies. Biopesticides are recognized to have anti-termite activity and play a crucial part in the development of organic food products. They are often composed of herbal and microbial compositions. The large field of biological alternatives needs to be investigated to decrease the use of chemicals, as they offer us numerous advantages like sustainability, appropriate application, biodegradable nature, target specificity, etc. [7]. However, rely mainly on chemical treatments, such as spraying liquid chemicals, applying bait, dusting, and grouting because the active ingredients in these chemicals are synthetic organic pesticides, which pose varying degrees of risk to soil, water, and human health, more environmentally friendly termite control methods, such as biological control agents, must be developed [8].

While there is a debate over the current efficacy of synthetic pesticides, it is obvious that there are valid concerns about their use. Examples of such issues include rising levels of pesticide resistance, restrictive laws prohibiting their usage, impacts on pests other than the intended targets, and environmental contamination [9]. Bioagents, chemical insecticides, and natural items are all employed as treatments for this termite, plant extracts are among the natural products being researched for termite management. Chemical pesticides are viewed as being bad for the environment in many parts of the world, particularly the new studies looking at use naturally occurring, less toxic molecules instead [10, 11].

The way that homeowners see pesticides has changed, and there is now more interest in using alternatives like natural treatments. Due to the numerous reports of essential oils' effectiveness, including against insecticide-resistant urban insect pests, they have attracted the attention that they merit [12]. Therefore, it is critical to create chemical control alternatives that not only address the aforementioned issues but are also likely to follow the current trend of creating new insecticides with botanical origins [13]. Different plant extracts were screened against termites, resulting in higher mortality in lab bioassays and a field in different termite species at different formulations [2]. In crops comprising insecticidal features against termites, bioactive chemicals are in the form of metabolites [14].

Numerous plant compounds are toxic against termites, according to reports on plant derivatives published worldwide. For instance, it has been discovered that the essential oils of *Mentha arvensis*, *Cymbopogon citratus*, and *Carum capsicum* have great termiticidal activity due to their potential toxic effects on Termite *Odontotermes obesus* (Rambur). Lantana Camara var. aculeate leaf extract had a poisonous action against O. obesus [15]. A study by Park and Shin[16] indicates that garlic and clove bud oils and their constituents may be effective fumigants for Japanese termites. However, more research is needed to determine whether these substances are safe for humans to consume and to develop formulations that will increase their efficacy, stability, and affordability.

Many of the now-banned insecticides that were previously recommended to control termites had a significant negative impact on agricultural society. So, raised awareness of the use of biocontrol agents as a safe and effective pest alternative becomes necessary at this time. To reduce the use of chemicals, it has become vital to identifying alternative methods of termite control in the various natural habitats and cultivated soil. Thus, the aim of this study is to the evaluation of some plant the effect of extracts from some natural plants, including Spike Lavender (*Lavandula latifolia* Medik.), Clove (*Syzygium aromaticum* (L.), garlic (*Allium sativum* L.), Cinnamon (*Cinnamomum verum*) and marjoram (*Origanum vulgare* L., Lamiaceae)), against growing Termites. When treated with different concentrations (0, 5, 10, and 15 µL/ L) of the five above-mentioned plants, during specified time periods (1, 2, 3, 4, 5, 6, and 7 days).

Materials and Methods

Study Area and Termite Infestation

The field experiment was conducted in December the season 2022, in the western region of the kingdom of Saudi Arabia. An infestation could be observed by Termite *Reticulitermes* spp. (Isoptera: Rhinotermitidae) on the floors of the buildings, causing cracks and separation of mortar, also, the plants are affected through Termite tunnels, as shown in Fig. 1. We used some plant extracts to evaluate their effectiveness on termites to test the efficiency of the control method and learn that has the most effect.

Preparation of Insects for Experiment

The collection of worker's termites was done with cardboard installed from various locations, Termites were discovered inside wood that was suitable for reproduction and eating. These termites were then gathered, along with some remaining pieces of the wood they were found in and sent to the university lab. A plastic container (d = 15 cm, h = 30 cm) used for termite care was covered in gauze to maintain the airflow. The containers were placed in a climatic chamber (25±1ºC, 75±5 % RH). 50 workers' termites were used as test subjects. Dry, deteriorated wood was used as the termite feed.

Plant Extracts

Some plant extracts included: Spike Lavender (*Lavandula latifolia* Medik.) dry flower, Clove (*Syzygium aromaticum* (L.), garlic (*Allium sativum* L.), Cinnamon (*Cinnamomum verum*) and marjoram (*Origanum vulgare* L., Lamiaceae), for their potential effect on termites. The extraction process was carried out at the Entomological Research Laboratory, Department of Biology, College of Science, University of Jeddah. After the leaves were dried and the blades of a blender were used to crush them, the extract was obtained. Samples of 3, 4, and 5 g of the extract were then taken and placed in the blender jar to be processed in 500-mL water by further grinding until the substance extracted from the vegetal tissue was obtained. The extract was then decanted onto a blanket canvas, which allowed the vegetal residue to be separated; the resulting substance was then applied to the termites. Twenty milliliters of the extract were applied to the termites and the wood remnants using a hand atomizer, and the time it took for 100% of the termites to become still or die was then recorded.

Experimental Design

The research was carried out in a completely randomized design (CRD) with treatments of plant extracts having four concentrations each i.e., 15, 10, 5, and 0 µL/ L were considered control concentration. Each concentration consisted of three 3 replications.

The Study of the Mortality, Lethal Concentration 50 (LC_{50})

Following 1, 2, 3, 4, 5, 6, and 7 days after exposure, dead adults were prodded with a brush to induce movement. Each treatment plant extraction treatment and control used a different brush. Every experiment, whether it used Plant Extract or controls, was repeated

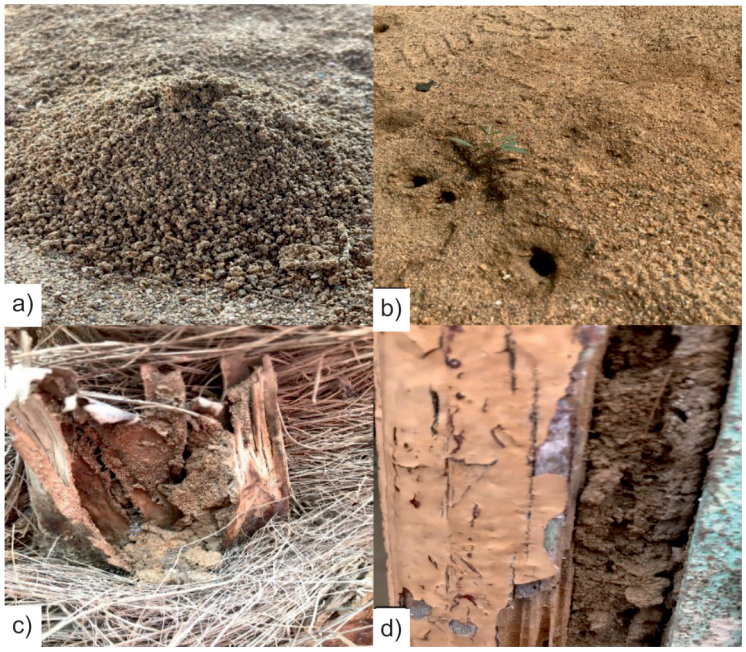

Fig. 1(a-d). show the damage by termites.

thrice. The determination of the LC_{50} was carried out according to the method described previously. According to a previously reported procedure [17], the LC_{50} was determined. The individuals were evaluated after exposure for 7 days, and when they remained following repeated mechanical stimulation with a brush, they were deemed dead.

The Study of the Longevity, Lethal Time 50 (LT_{50})

Determination of the lethal time 50 (LT_{50}), termites were exposed for the concentration LC_{50}, over a period of varying length of time. The study period lasted for recorded through at 1, 2, 3, 4-, 5-, 6- and 7 days, after the termite died, the were removed, and their numbers were recorded [18].

Statistical Analysis

Data were considered acceptable if the mortalities observed in controls were less than 20%. If there were mortalities in the controls, data were adjusted using Abbot's formula [19]. Concentration-mortality regression lines were analyzed using a computer program modified from the method of [20] to estimate the LC_{50}, the confidence limits, and the slopes of Ldp lines. Lethal time 50 (LT_{50}) was estimated for each group at P = 0.05; the Probit analysis Ldp line was also used to calculate LT_{50}. When the 95% confidence limits did not overlap, the values were deemed significantly different [21], the chart made by (https://charts.hohli.com/).

Results

The results of this study showed the effects of plant extracts from some natural sources, including Spike Lavender (*Lavandula latifolia* Medik.), Clove (*Syzygium aromaticum* (L.), garlic (*Allium sativum* L.), Cinnamon (*Cinnamomum verum*) and marjoram (*Origanum vulgare* L., Lamiaceae)) against Termites *Reticulitermes* spp. (Isoptera: Rhinotermitidae). Where treated with different concentrations; (0, 5, 10, and 15 µL/ L), of the five above-mentioned plants, to calculate the throng mortality rates over selected time intervals (1, 2, 3, 4, 5, 6, and 7 days).

Lethal Effect- LC_{50} Estimate

Data in Table 1 and Fig. 2 explain demonstrate the relative toxicity of some plant extracts against developing termites, by spraying the termites and the wood debris. Post-treatment data indicate that the tested Plant Extracts could be discerningly arranged as follows: Garlic, Clove, Lavender, Cinnamon, and marjoram. The corresponding LC_{50} values were 17.274, 17.84, 18.823, 23.706, and 25.483 µL/ L, while the LC_{90} values were 87.47, 90.434, 88.377, 133.321, and 132.296 µL/ L. However, $\chi 2$ values were 0.0322, 0.4688, 0.5364, 0.7074, and 1.54, respectively. As well as, in Table 1 show the effect of some plant extracts against termites after 7 days, it was observed that the toxicity indexes of garlic, clove, lavender, cinnamon, and marjoram were 100, 96.827, 91.771, 72.868, and 67.786 % at the LC_{50} level, respectively. Data in Fig. 3 represented the mortality ratio relative to termites *Reticulitermes* spp. (Isoptera: Rhinotermitidae), after testing by some Plant Extracts when sprinkling it on the termites after 7 days. After treatment, data indicate that the tested Plant Extracts could be descendingly arranged as follows: Garlic, Clove, Lavender, Cinnamon, and marjoram. Termites were highly affected by Garlic at a concentration of 15 µL/L reaching 45 individual deaths after treatment by it, while termites were lowest affected by marjoram at a concentration of 15 µL/L reaching 28 individual deaths after treatment by it, after 7 days. However, Clove, Lavender, and Cinnamon were mildly affected by Termites at a concentration of 15 µL/L after 7 days, reaching 42, 40, and 32 individual deaths, respectively.

Effect Plant Extracts on Termites through Different Times-LT50 Estimate

According to the mortality LT50, the current study's findings indicate post-treatment that the tested Plant Extracts could be descending arranged as follows: clove, garlic, lavender, cinnamon, and marjoram,

Table 1. The mortality ratio on testing some plant extracts against termites under laboratory conditions after 7 days.

Plant Extracts	χ^2	LC_{50}	Confidence limits of LC_{50}		LC_{95}	Slope	Index	Folds
		* µL/ L	Upper	Lower	* µL/ L		(T.I.)	(R.T.)
Garlic	0.0322	17.274	25.031	14.148	87.47	2.335±0.441	100	1
Clove	0.4688	17.84	26.386	14.513	90.434	2.333±0.446	96.827	1.033
Lavender	0.5364	18.823	28.216	15.245	88.377	2.449±0.466	91.771	1.09
Cinnamon	0.7074	23.706	46.232	17.728	133.321	2.193±0.482	72.868	1.372
Marjoram	1.54	25.483	52.494	18.776	132.296	2.3±0.514	67.786	1.475

T.I. - Index compared with Garlic R.T. - No. of folds compared with Garlic $\chi 2$ = Chi-square * = µL/ L based on a:I

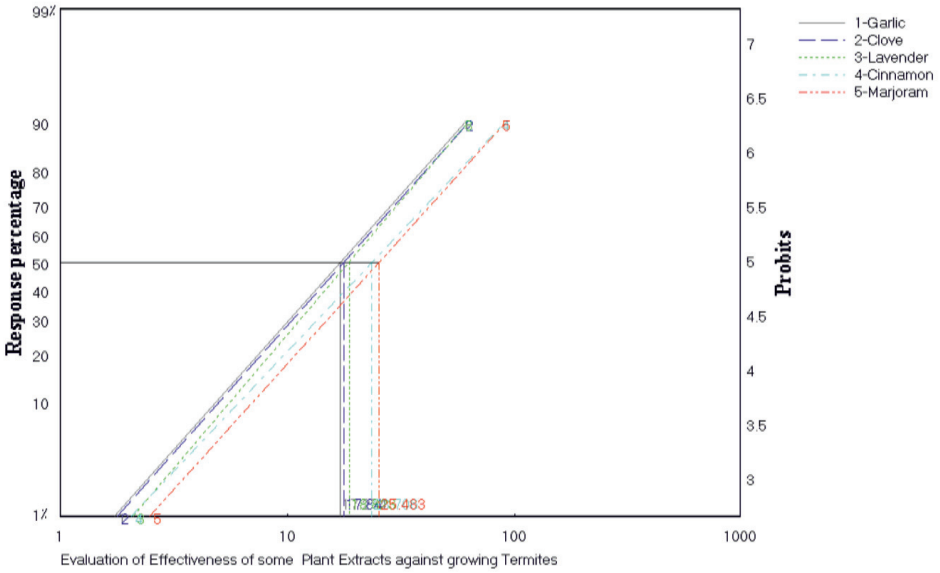

Fig. 2. Lethal concentration (LC_{50}) values are shown when a Termite is exposed after 7 days of exposure to different concentrations of Plant Extracts.

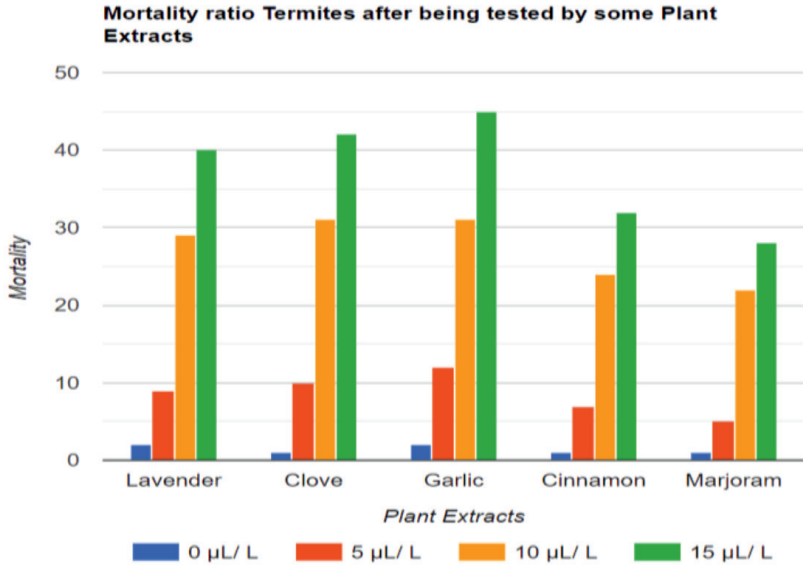

Fig. 3. Mortality ratio Termites after being tested by some Plant Extracts, Link to the chart (https://tinyurl.com/58x85yxt).

and the corresponding LT_{50} values were 8.482, 8.748, 8.906, 10.855, and 11.12 days, respectively, while the LT_{90} values were 28.833, 33.933, 35.853, 43.111, and 45.513 days, respectively, to kill half of the individuals. In comparison to Marjoram, which requires 5.5509 to kill half of the insects, Clove has a higher effect on the death and eradication of termites, with a $\chi 2$ value reaching 13.0427 after 7 days, Table 2, Fig. 4. Data in Fig. 5 represented the Time ratio relative to Termites *Reticulitermes* spp. (Isoptera: Rhinotermitidae), after testing by some Plant Extracts when sprinkling it on the termites after 7 days. After treatment data indicated that the tested Plant Extracts, we found that the Termites were highly affected by Garlic after 7 days and reached 45 individuals killed, while Marjoram was the lowest affected, reaching 28 individuals after 7 days. However, Clove, Lavender, and Cinnamon were mildly affected by Termites at a concentration of 7 days reaching 42, 40, and 32, respectively.

Discussions

The data presented in this work clearly show the effectiveness of some Plant Extracts against termites after 7 days, under laboratory conditions. The results of this study revealed the effect of Extracts of some natural plants, including lavender, clove, garlic, cinnamon,

Table 2. Testing some Plant Extracts against Termites at Treated time different (days).

Plant Extracts	χ^2	LT_{50}	Confidence limitsof LT_{50}		LT_{95}	Slope	Folds	Index
		day	Upper	Lower	day		(R.T.)	(T.I.)
Garlic	13.0427	8.482	14.47	7.471	28.833	3.096±0.383	1	100
Clove	19.1859	8.748	20.847	8.288	33.933	2.794±0.348	1.031	96.959
Lavender	9.1001	8.906	11.335	7.611	35.853	2.719±0.342	1.05	95.239
Cinnamon	6.9531	10.855	15.36	8.857	43.111	2.746±0.4	1.28	78.139
Marjoram	5.5509	11.12	16	9.002	45.513	2.688±0.397	1.311	76.277

T.I. - index compared with Clove R.T. - No. of folds compared with Clove $\chi 2$ = Chi-square

and marjoram against termites. When treated with different concentrations; (0, 5, 10, and 15 µL/L), of the five above-mentioned plants, when calculated the throng mortality rates over selected time intervals (1, 2, 3, 4, 5, 6, and 7 days). The effect of all five plant extracts increased and reached the highest after 7 days. after the bioassay. It is obvious, as shown in Tables 1, 2 and Figs 2, 3, 4, 5. Garlic had the steepest toxicity line, while Marjoram had the flattest. However, Lavender, Clove, and cinnamon were in between, this reflecting the superiority of garlic.

These results were in agreement with those of Park and Shin [16] who showed that clove bud and garlic oils induced 100% mortality at 0.5 µL/L of air, but that after three days of treatment at 0.25 µL/L of air, this fell to 42 and 67%, respectively. Several plant chemicals can cause termites to die rapidly, due to their effects on the insect nervous system [22]. Additionally, plant substances may behave in neurotoxic ways (hyperactivity, seizures, and tremors) [23]. Clove extract demonstrated the least amount of efficacy against *Microcerotermes eugnathus* in a trial by Cornelius, et al., [24] with an LC_{50} value of more than 2000 mg/L, also, it has been demonstrated that eugenol works well as a fumigant and a feeding inhibitor against the termite *Coptotermes formosanus*.

Resulted by Khairan, et al., [25] five different garlic extracts were tested for their effects on termites at concentrations of 10, 25, and 50%, including aqueous garlic extract (AGE), methanol garlic extract (MGE), ethyl acetate garlic extract (EAGE), and n-hexane garlic extract (HGE). The results revealed that HGE has the strongest activity against the termite *Nasutitermes* sp. The insecticidal toxicity of clove and cinnamon essential oils and their main components has been documented in some investigations, that successfully control-stored product pests [26-28] other insects [29]. The bulk of studies have linked the main components of essential oils – eugenol and – caryophyllene – to their insecticidal effects since these substances affect insects› nervous systems [30] and systems and by inhibiting the actions of acetylcholinesterase [31].

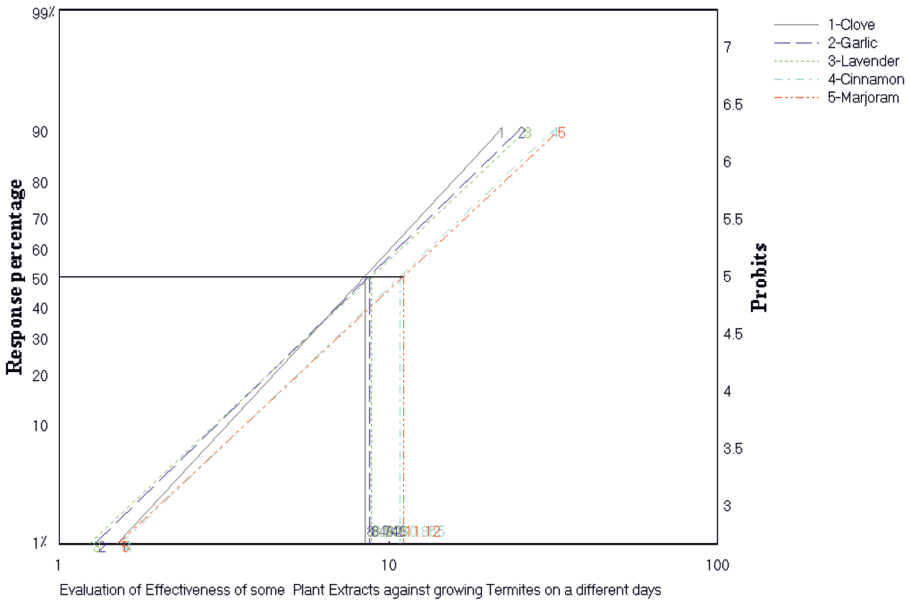

Fig. 4. Shown values of lethal time 50 (LT_{50}) when a Termite is exposed of exposed to different concentrations of Plant Extracts.

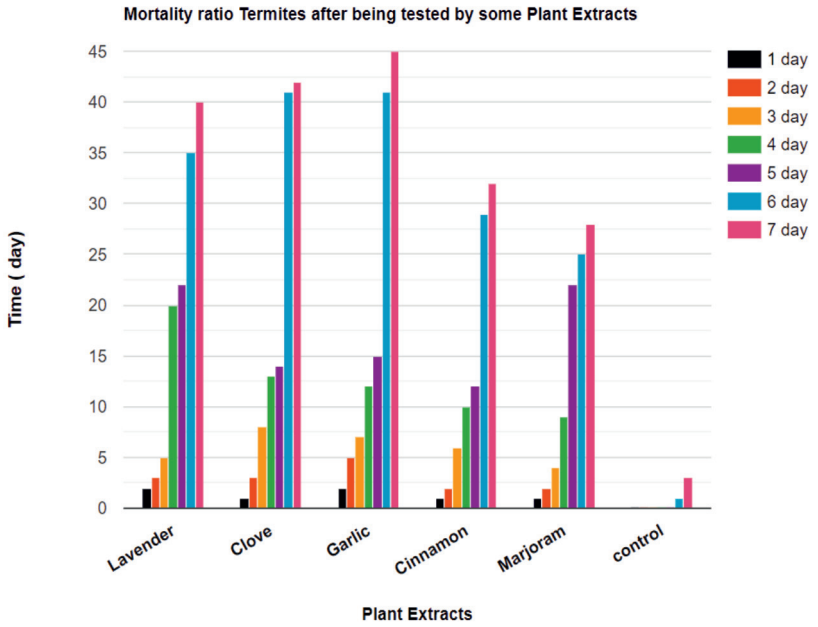

Fig. 5. Mortality ratio of termites after treatment by some Plant Extracts at treated times different (days), Link to the chart (https://tinyurl.com/2tprh57k).

The study by Allam, et al., [32] tested commercially available aqueous extracts of garlic, chili, turmeric, and black pepper on underground termites (Psammotermes). The results revealed that chlorpyrifos was the most toxic substance, while black pepper aqueous extract was the least toxic. However, B. bassiana, K. Z. oil, garlic aqueous extract, chili pepper AgNPs, turmeric aqueous extract, and turme were less toxic. In conclusion, based on those findings, all the chosen chemicals and extracts significantly increased worker mortality for P. *hypostoma* compared with control, and they can be employed as a low-cost option in future IPM programs against P. *hypostoma*. Our study agrees with that found by Anjorin, [33] the crop protection potential and pesticidal efficacy of garlic (*Allium sativum* L.) have been attributed to its production of several biologically active defense compounds. The plant is rich in organo-sulfur content, which has great potential to prevent and treat many diseases of plants and animals. Garlic phytochemical contains alliinase, which is released when it is chopped. Alliance is involved in catalyzing the formation of S-allyl cysteine sulfoxide (allin), which is the main active component of garlic. It is possible that constituents from garlic could be used to develop alternatives to conventional pesticides for managing crop pests and disease-causing pathogens. This chapter describes the biochemical compounds found in garlic bulbs, preparatory procedures of garlic pesticidal products from fresh and aged bulbs, and the discovery process of bioactive phytochemicals from garlic bulbs. It further explains the insecticidal, fungicidal, bactericidal, and nematicidal usage of garlic products and discusses issues on natural pesticide formulation from garlic. The usage of garlic herbal preparations by growers can reduce non-target exposure to hazardous pesticides and curb resistance development in pests, thus enabling sustainable organic crop protection.

The mortality of termites through the plant leaves extract was found to be noteworthy for managing termites. Our results overlap with the results of Indrayani, et al., [34] they discovered that, despite being treated at the same eugenol-based concentration, crude extracts of several plant species have varied effects on subterranean termites. In a study by Jumbo, et al., [35], they assessed the effectiveness of applying the essential oils of clove, *Syzygium aromaticum* L., and cinnamon, *Cinnamomum zeylanicum* L., to control Callosobruchus maculatus, given that the use of plant essential oils effectively controls insect pests of stored beans, significantly reducing the risks associated with synthetic insecticides. The cinnamon and clove essential oils are valuable tools with the potential to be integrated into the management of C. *maculatus* infestations, according to the results of bioassays that showed both essential oils to have insecticidal activities like the synthetic pyrethroid insecticide deltamethrin. The study by Nisar, et al., [5] showed that Conocarpus lancifolius extract with a solution methanol and solution water exhibited higher mortality of subterranean termites, whereas the solution of methanol had higher repellency and mortality than water solution of botanical extract. Chlorfenapyr solutions in methanol and water with various concentrations (15%, 10%, 5%, and 0%) were applied to the soil against termites to determine mortality and repellency. Both the plant extract of C. lancifolius with water and methanol solution and the insecticide chlorfenapyr in methanol solution were found to be effective against termites when used against

subterranean termites; however, the insecticide with the methanol solution revealed 100% mortality. These two treatments can be used as new biological controls.

Under laboratory circumstances, cedar extract killed termites as an insecticide, but of the dosages tested, 5.0-g leaves per 500-mL water was the one that caused the termites to quickly perish [36]. Regarding sustainable and integrated termite management practices (ITM), in a review by Ahmad, [37], they discovered that proponents hold that better control of this threat can be achieved by I enhancing conventional methods to keep termites away from crops, (ii) enhancing agricultural practices to maintain plants with greater vigor and less susceptibility to termite attack, and (iii) integrating all available methods to lessen the termite infestation in crops and surroundings. The greatest alternative for agricultural farmers is to use an efficient blend of established techniques and freshly developed strategies. Additionally, more creative approaches to managing this pest are required. However, The study by Udousung, et al., [38] they evaluated the various methods of termite control and management used by farmers collected primary data using a structured questionnaire and focus group discussions, and selected 120 farmers for the study using a multi-stage sampling technique. Descriptive, inferential statistics (Logit regression analysis), and 4-point Likert scale techniques were used to analyze the data.

The continuous use of pesticides in the ecosystem is of great concern, as some of them are highly stable and impact non-target organisms. Therefore, the effects of various pesticide concentrations (Deltamethrin and Malathion) and natural items were studied, according to the findings of a study by Aljedani, [39] lemongrass oil at a concentration (LC_{50} = 9.7478 mg LG1) causes half of the Fruit Fly (Drosophila melanogaster) to perish. Additionally, lemongrass oil (LT_{50} = 819.745) took 819.745 h to kill half of the test subjects, leading researchers to conclude that the lemon plant and its constituents have excellent potential for use in the management of Drosophila melanogaster, which played a significant role in biological control.

But, no structural insect pest have ever attracted greater attention than termites because they destroy wooden structures for billions of dollars and require significant financial outlays for control and damage restoration [14, 40]. Their communal existence is credited with their ecological success, particularly considering that ants and termites are the most prevalent creatures on Earth. While the bulk of colony members (workers/soldiers) postpone reproduction, at least temporarily, they live in colonies with few reproducing individuals. Despite their clear similarity in social organization, both groups developed social existence separately [41]. Historically, termite prevention has relied on building construction techniques that don't foster termite infestations. However, as product development has also provided previously unheard-of opportunities to study the biology and behavior of cryptobiotic termites, and as social media and communications technology have advanced, consumers and science educators alike face a dilemma [40].

Conclusions

Urban insect pests have a significant impact on public health on a global scale, resulting in losses of lives and billions of dollars. A large amount of pesticide resistance has been documented, and most chemical insecticides no longer give the desired degree of control. As a result, interest in alternatives to traditional pesticides has increased. Natural remedies made from plants have drawn the most interest among them due to numerous reports of their effectiveness and toxicity even against insecticide-resistant urban insects. However, there is no research on the scope and effects of managing urban insects with natural plant extracts. Our results indicate that garlic and some plant extracts and their components could be useful as a control for termites. Whereas found in this study the termites (*Reticulitermes* sp.) were highly affected by Garlic at a concentration of 15 µL/L, reaching 45 individual deaths after treatment by it, while termites were lowest affected by marjoram at a concentration of 15 µL/L, reaching 28 individual deaths after treatment by it, after 7 days. Therefore, the garlic extract had an insecticidal effect on the termites, and of all dosages examined, 15 L/L had a higher effect on the death of the termites after a few days of application in a laboratory setting. Further study is necessary on the safety of these materials to humans and the environment, and on the development of formulations to improve efficacy and stability and reduce cost.

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Conflict of Interest

The authors declare no conflict of interest.

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