Research Article

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Novel acrylamide-based baits for effective control of subterranean termites (Blattodea: Rhinotermitidae)

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Abstract

BACKGROUND: Acrylamide-based bait has super water absorption making it highly attractive to subterranean termites that are lured by wood with high water content. This study investigated the control efficiency of these baits on subterranean termites. In particular, we evaluated the water-absorption capacity, attractiveness to subterranean termites, and control efficiency of these baits on subterranean termites through wooden blocks (*Populus deltoides* and three types of particleboards).

RESULTS: The results indicated a substantial water absorption capacity of acrylamide (70.6%; control: 14.8%) and a strong attraction for feeding subterranean termites (*P. deltoides*: 198 highest; 81 lowest subterranean termites individuals; combination of neem leaves and walnut shells: 168 highest; 36 lowest subterranean termites individuals). When acrylamide was combined with boric acid at the highest concentration, it resulted in the lowest wood consumption rates (*P. deltoides*: 24.1%; control: 63.8%, combination of neem leaves and walnut shells: 32.5%; control: 62.1%).

CONCLUSIONS: In conclusion, this research supports the commercial viability of employing innovative acrylamide-based toxic baits and particleboards for subterranean termite management.

Keywords: acrylamide; particleboard blocks; subterranean termites; superabsorbent polymer; wood types

1 INTRODUCTION

Pest control has historically relied on approximately 3.6 million tons of pesticides as the principal means of managing pests.[1] Regrettably, only a mere 1% of these insecticides engage directly with their intended insect targets.[2] Hence, controlled-release pesticides have gained widespread adoption in agricultural and forestry sectors over recent decades, contributing to mitigating pesticide concentrations within the environment.[3] Insecticide formulations can be converted into sprays or baits by blending them with superabsorbent polymers to attract pest insects and then increasing their toxicity by adding toxic chemicals to eliminate them.[4] A significant reduction in both the required quantity of pesticides for insect pest management and the subsequent emissions into the atmosphere can be achieved by enticing the target insect pests to consume chemical baits.[5] Even though there were various management strategies for controlling insects,[6,7] superabsorbent polymers remained a major option for controlling termites. Acrylamide, a superabsorbent polymer, is being explored as a bait for insecticide distribution against various pests, however, limited information is available regarding its effectiveness as a bait against subterranean termites.[8,9]

The novel acrylamide represents a superabsorbent polymer compound capable of retaining substantial volumes of water,

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thereby augmenting bait moisture content,[10] and achieving an absorption capacity 400 times its weight.[11] It has been used to distribute different targeted toxicant pesticides as liquid bait.[12] Its water solubility allows easy access to subterranean termites. However, it is also a potent water-absorbing and toxic chemical that causes cellular damage and tumors in Argentine ants (*Linepithema humile*),[13] *Drosophila melanogaster*,[14] rats,[15] and other mammals around 1–6% concentrations.[3,16] Due to its unique physiochemical properties, it can create innovative and effective management methods for subterranean termites, with environmentally friendly results.[8] Adding polyacrylamide to wood-based baits attracts and boosts wood consumption by subterranean termites by around 30% in dry soil.[17] However, wood consumption can be further reduced by enhancing its toxicity with the addition of toxic chemicals to the baits.[17] A study shows that termite baits exhibit high attractiveness and, when combined with synergistic chemicals, result in around 90% mortality rates, significantly improving termite control efficacy.[18]

Boric acid finds extensive application in managing termites, while boron-based compounds serve as treatments for wood preservation, effectively deterring termites and other pests.[19,20] Fiberboards treated with boric acid were presented to *Coptotermes formosanus*, which resulted in delayed mortality among the termites.[21] Mortality occurred after 2–3 weeks, with rates ranging from 20% to 100% across concentrations ranging from 1% to 5%[22,23] and acts effectively as a synergist for termite control.[24]

Walnut (*Juglans regia* L.) and neem (*Azadi rachta indica* A.), renowned for their bioactive compounds, exhibit considerable potential in pest resistance due to their robust resistance, attractive qualities, and toxic properties.[25–32] Walnut shells contain juglone and other substances with insecticidal properties,[33] while neem leaves and seeds contain azadirachtin, a potent natural insect repellent.[34] Utilizing walnut shells powder and neem leaves in particleboard can offer a promising approach for termite-resistant wood-based materials. Studying these particleboards with termite baits enhances resistance and may add further protective properties.

The subterranean termite *C. formosanus* Shiraki (Blattodea: Rhinotermitidae) poses a significant threat to woods in steamy and subtropical areas, causing substantial financial losses worldwide.[35,36] In Pakistan, this species causes damage to a range of 10% to 20% of forest wood, particularly *Populus deltoides*, resulting in substantial global economic losses amounting to forest woods approximately $40 billion.[37] It requires a connection with moist wood to establish and sustain large colonies, enabling them to survive even during transportation across extensive land areas.[38–41] The extensive wood degradation caused by subterranean termites affects a wide range of materials, including particleboards, furniture, paper, textiles, and non-cellulosic substances.[42] Moisture is a critical factor influencing subterranean termites' feeding preferences and wood consumption behaviors.[43–45] Eastern cottonwood (*P. deltoides*) wood protection from subterranean termite damage is essential to protect valuable resources, reduce economic losses, and support sustainable forestry practices.[46] It ensures the longevity of wood products and contributes to environmental conservation and safety.[47] Creating a moisture-based bait to attract subterranean termites and adding toxic chemicals to make it a toxic bait is an effective approach for managing subterranean termites and reducing pesticide use and effort.

Some patents on subterranean termite bait stations suggest using superabsorbent polymers to enhance the moisture content of bait matrices on both dry and wet soil.[48] However, the effectiveness of superabsorbent polymer acrylamide on various types of woods in the context of subterranean termites remains unexplored. Our study aims to address the following hypotheses: (i) Applying superabsorbent polymer acrylamide on various wood types will enhance moisture levels, leading to increased feeding preferences and wood consumption by subterranean termites. (ii) The toxic properties of the properties will act as a toxic bait, resulting in a reduction in wood consumption of subterranean termites. Our specific study objectives are as follows: (i) Determine the water absorption capacity of acrylamide-treated *P. deltoides* wooden blocks. (ii) Assess the feeding preference rate of subterranean termites for acrylamide-treated *P. deltoides* wooden blocks and three types of particleboard blocks. (iii) To determine the wood consumption rate on acrylamide-treated *P. deltoides* wooden blocks and three types of particleboard blocks. Our ultimate goal was to evaluate how the increased attractiveness and toxicity of the bait can enhance the overall effectiveness of subterranean termite control strategies. We will also investigate the preference and consumption of neem and walnut shells particleboard blocks in response to the superabsorbent polymer toxic bait against subterranean termites. These investigations will provide valuable insights into the potential advantages and applications of incorporating superabsorbent polymer into subterranean termite bait stations.

2 MATERIALS AND METHODS

2.1 Wood source

To evaluate the effectiveness of acrylamide and acrylamide–boric acid combined bait on subterranean termites (*C. formosanus*), poplar wood (*P. deltoides*) was selected for the laboratory study conducted in the Social Insects Laboratory, Department of Entomology, University of Agriculture Faisalabad (UAF), Pakistan (1.427837° N: 73.075920° E). A *P. deltoides* log, free from knots and confirmed to be free from both interior and exterior fungal infections by the Department of Microbiology and the Department of Forestry (UAF), was obtained from the Timber Market on Jhang Road, Faisalabad, Pakistan.

2.2 Preparation of *P. deltoides* wooden blocks

Wooden blocks measuring 5 cm × 5 cm were prepared using an electric saw to apply the treatments. Blocks free of cracks and without visible signs of mechanical damage were preferred. The initial weight of all blocks was recorded before applying the treatments.

2.3 Pre-conditioning subterranean termites for analysis of wood consumption

Populus deltoides wooden blocks were strategically placed 14 days before attracting subterranean termite (*C. formosanus*) infestation to initiate wood consumption experiments near the Post Graduate Agricultural Research Station (PARS) in Faisalabad, Pakistan (31.383 °N: 72.989° E). The infestation levels of subterranean termites near *Dalbergia sissoo* trees (highly infected) in the field were considered for the experiments. The choice of conducting field experiments near highly infested *Dalbergia sissoo* trees was facilitated by the prevalence of subterranean termite infestation in the vicinity, simplifying experimental logistics. Following this, a total of 12 pits (one pit per treatment) were dug at different sites, approximately 2–3 ft deep, 10–15 ft apart from each other, ensuring no water connection to prevent any interference with the moisture level of the treated wood and pre-existing colonies. Once the subterranean termites had established their colonies and reached an infestation level of over 80%, the treated woods were introduced to evaluate subterranean termite wood consumption on the toxic baits (Fig. 1).

2.4 Preparation of neem leaves and walnut shells particleboard blocks

Neem leaves were brought from neem trees (*A. indica*) at Horticultural Garden, UAF, and walnut shells (*J. regia*) from a dry fruits shop in Faisalabad, Pakistan. Three types of particleboard blocks were prepared: neem leaves particleboard, walnut shells particleboard, and a composite particleboard comprising both neem leaves and walnut shells. Neem leaves and walnut shells were carefully harvested and thoroughly dried to remove all moisture content. Subsequently, they were finely ground into minuscule particles, forming a powdered mixture. Small-sized particleboard blocks were created by combining this powder with adhesive glue and applying pressure with a heavy pressor for 24 h until complete drying. Three types of particleboard blocks were prepared as follows: (1) neem leaves powder alone, (2) walnut shells powder alone, and (3) a combination of both powders in a 1:1 ratio, with different colored threads (red: treatment 1; green: treatment 2; white: treatment 3) indicating particular treatments (Fig. 2).

2.5 Assessment of water absorption capacity in acrylamide in the laboratory

In the laboratory, we analyzed the water-absorbing capacity of *P. deltoides* wooden blocks treated with acrylamide bait across three treatments (1%, 3%, and 5% per 100 mL solutions, with three replications each) to validate its key property as a superabsorbent polymer. The initial weight of the *P. deltoides* wooden blocks was recorded before immersion, and the final weight after 24, 48, and 72 h was measured to determine the water absorbed by *P. deltoides* wooden blocks due to acrylamide treatments. Water absorbing capacity (%) was measured using Eqn (1).

Figure 1. Pre-conditioning subterranean termites before acrylamide bait application in terms of wood consumption in the field.

$$\text{Water absorption capacity}(\%) = \frac{\text{Wet Weight of Wood} - \text{Dry Weight of Wood}}{\text{Wet Weight of Wood}} \times 100 \quad (1)$$

2.6 Experimental setup for feeding preferences of subterranean termites in the laboratory

To study the feeding preferences of acrylamide-treated *P. deltoides* wooden blocks and three types of particleboard blocks, subterranean termites (*C. formosanus*) were collected from three mounds near PARS in Faisalabad, Pakistan. Workers and soldiers were separated from the royal pair, lower instars, and brood, maintaining their natural ratio. This experiment was conducted in two separate transparent containers for observation. Approximately 450 individuals (900 in total) were placed in a 1 m × 2 m × 1 m transparent container containing a small amount of dry soil and untreated wooden blocks for settling, ensuring no water connection to prevent any interference with the moisture levels. One section of the transparent chamber contained treated *P. deltoides* wooden blocks and three types of particleboard blocks, while the other section housed 450 subterranean termites. These sections were separated by a 1 m distance and connected by a small transparent gallery containing dry soil. A three-day settling-in period allowed the subterranean termites to acclimatize and minimize transportation damage (Fig. 3).

2.7 Determination of subterranean termite feeding preference on acrylamide-treated *P. deltoides* wooden blocks and particleboard blocks

In this study, we investigated the feeding preferences of subterranean termites by introducing 1%, 3%, and 5% per 100 mL acrylamide solutions into transparent containers, each containing three replicates of both *P. deltoides* wooden blocks and three types of particleboard blocks. We employed two separate transparent containers to evaluate subterranean termite feeding preferences. In one container, we assessed their preferences for *P. deltoides* wooden blocks, while in the second container, we examined their preferences among three types of particleboard blocks. Over a 15-day observation period, we quantified the approximate number of subterranean termite individuals attracted to *P. deltoides* wooden blocks and particleboard blocks. This experimental design, with three treatments and replications, allowed us to assess the subterranean termite feeding preferences for *P. deltoides* wooden blocks and particleboard blocks.

2.8 Determination of subterranean termite wood consumption on acrylamide-treated *P. deltoides* wooden blocks and particleboard blocks in the field

In this wood consumption study, *P. deltoides* wooden blocks, and three types of particleboard blocks were separately subjected to three treatments and replications with concentrations of (1%, 3%, and 5% per 100 mL) of acrylamide. The initial weight of the *P. deltoides* wooden blocks and three types of particleboard blocks was recorded before the application of acrylamide. Water was used as a solvent for preparing the acrylamide solutions. These *P. deltoides* wooden blocks and three types of particleboard blocks were then immersed in each acrylamide concentration for 3 days. A control treatment consisting of the solvent without acrylamide was also included. Subsequently, the treated wooden blocks were placed in plastic boxes with entry routes and exposed (buried) to pre-invited subterranean termites under field

Figure 2. Three types of particleboard blocks for assessing subterranean termite feeding preferences and wood consumption.

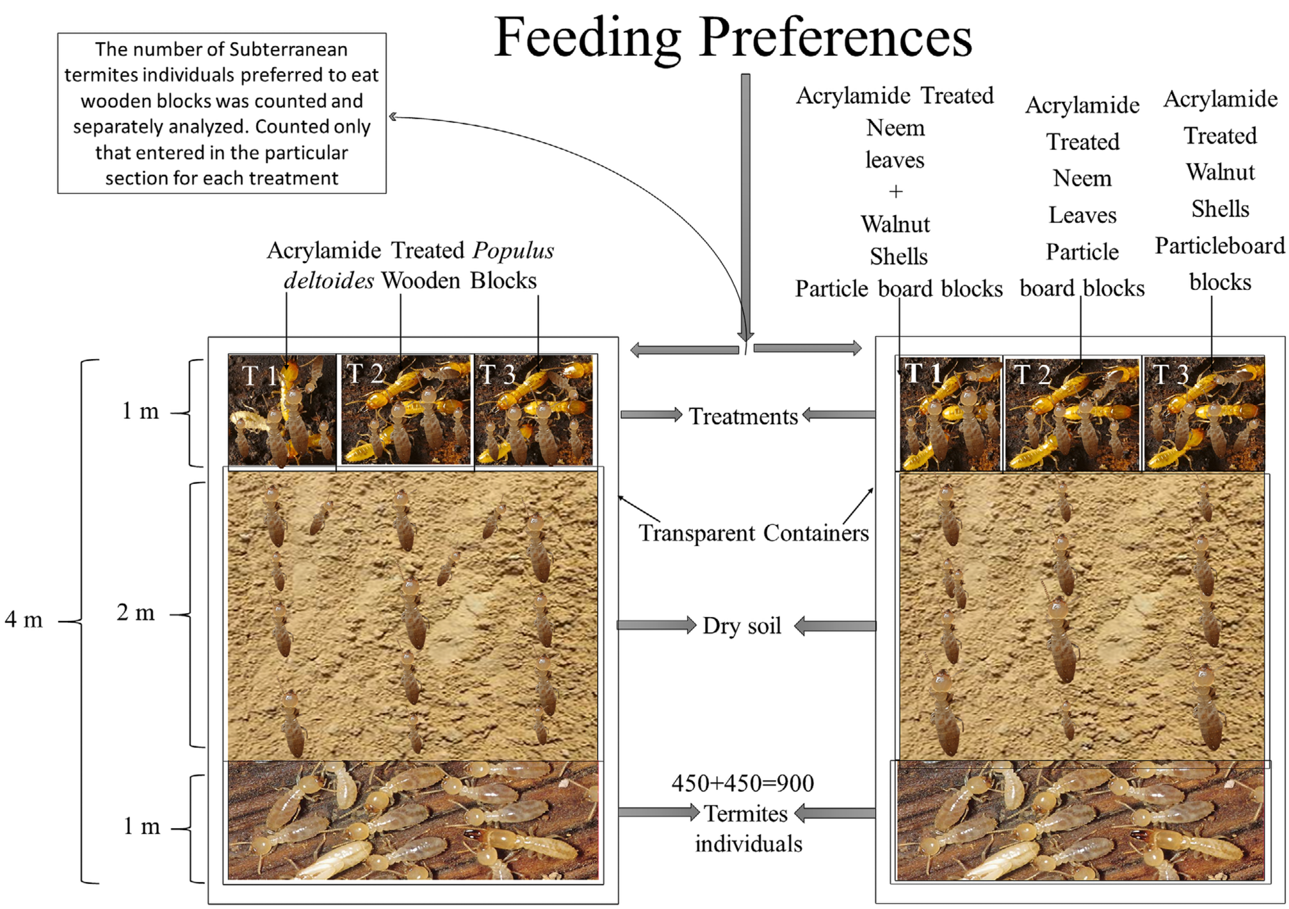

Figure 3. Diagram illustrating the laboratory experimental setup for subterranean termite feeding preferences for *Populus deltoides* wood and three types of particleboards.

Figure 4. Acrylamide–boric acid concentrations for wood consumption analysis of three types of particleboard blocks.

conditions. To assess the bait effectiveness, the wood consumption of *P. deltoides* wooden blocks was determined after 30, 60, and 90 days of exposure.

2.9 Determination of subterranean termite wood consumption on acrylamide–boric acid treated *P. deltoides* wooden blocks in the field

In this experiment, we formulated combinations of acrylamide (1%, 3%, and 5% per 100 mL) with 5% boric acid to enhance the efficacy of acrylamide bait toxicity. The *P. deltoides* wooden blocks were treated using a dipping method and allowed to soak in the solutions for 3 days. Initial weights of the treated *P. deltoides* wooden blocks were recorded before treatment. Following the treatment, the *P. deltoides* wooden blocks were positioned within plastic boxes. The plastic boxes were partitioned into three subsections: the left and right sections contained treated wood, while the middle section remained untreated. The boxes were equipped with entry routes for subterranean termites and were buried in field conditions at the PARS, in Faisalabad. To simulate subterranean termite exposure, the treated *P. deltoides* wooden blocks were exposed (buried) to subterranean termites; wood consumption was measured after 30, 60, and 90 days.

2.10 Determination of subterranean termite wood consumption on acrylamide–boric acid treated particleboard blocks in the field

Particleboard blocks created from neem leaves and walnut shells were subjected to acrylamide–boric acid toxic bait treatments with a combination of acrylamide (1%, 3%, and 5% per 100 mL) and boric acid (5%) to observe its effects on subterranean termite wood consumption in the field. To study subterranean termite wood consumption, three treatments were implemented: (1) neem leaves powder alone, (2) walnut shells powder alone, and (3) a combination of both powders in a 1:1 ratio, and the tied different colored threads (red: treatment 1; green: treatment 2; white: treatment 3) indicated particular treatments (Fig. 4). Three types of particleboard block wood consumption rates were analyzed after 30, 60, and 90 days intervals. The *P. deltoides* wood blocks were considered control samples included for comparison.

2.11 Statistical analysis

The water absorption capacity (%), feeding preferences (number of attracted *C. formosanus* individuals), and wood consumption (%), pertaining to both *P. deltoides* wooden blocks and particleboard blocks treated with acrylamide combined with boric acid toxic baits, underwent two-way analysis of variance (ANOVA) to evaluate the impact of various treatments, and time intervals on subterranean termite behaviors. A three-way ANOVA was employed to evaluate the impact of three types of particleboards, three concentrations of acrylamide-boric acid (5%), and three time intervals on wood consumption. Tukey's test was employed for all multiple comparisons between *P. deltoides* and particleboard blocks, along with standard deviation (SD) representation. The significance level for all tests was established at $\alpha = 0.05$. Statistical software Origin 2023b was utilized for analyzing the data collected from the aforementioned experiments. The wood consumption was calculated using Eqn (2).[49]

$$\text{Wood consumption}\,(\%) = \frac{\text{W1}-\text{W2}}{\text{W1}} \times 100 \tag{2}$$

where W_1 represents the wood initial weight and W_2 the wood final weight.

3 RESULTS

3.1 Water absorption capacity of acrylamide

The water absorption capacity of *P. deltoides* wood blocks showed significant results when subjected to various acrylamide concentrations under different time intervals (df = 3, $F = 19.09313$,

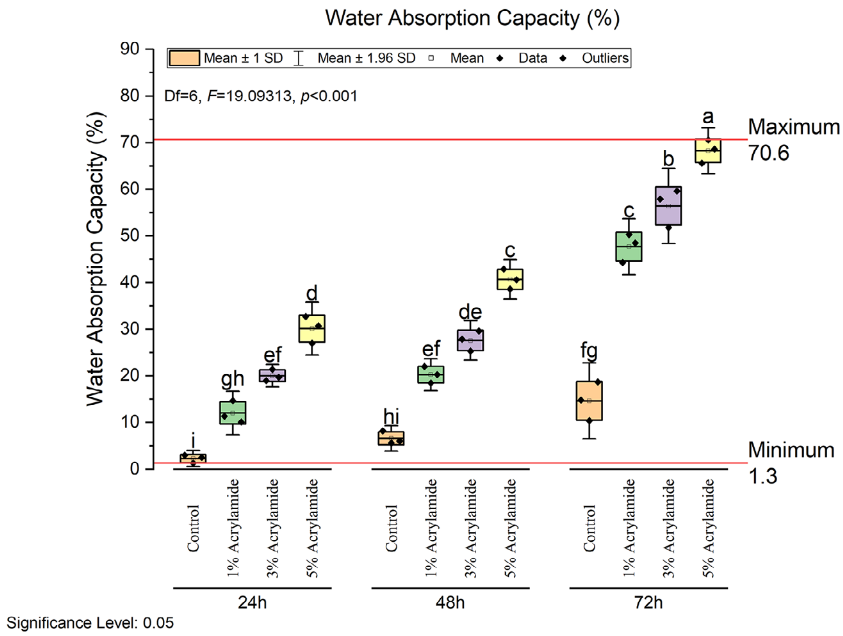

Figure 5. Water absorption capacity of acrylamide in *Populus deltoides* wooden blocks.

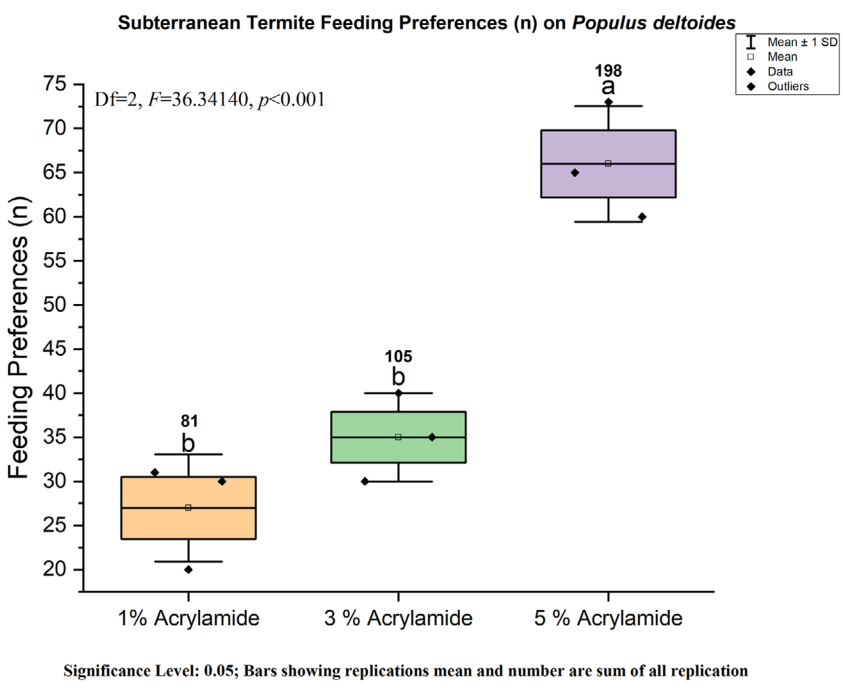

Figure 6. Feeding preference of acrylamide-treated *Populus deltoides* wooden blocks.

$P < 0.001$). The results found that the highest acrylamide concentration significantly increased water absorption capacity, reaching 70.6% after 72 h. In contrast, the control treatment resulted in a 14.9% increase in water absorption capacity (Fig. 5).

3.2 Feeding preference of acrylamide-treated *P. deltoides* and three types of particleboard blocks

Subterranean termites showed a significant feeding preference (df = 2, $F = 36.34140$, $P < 0.001$) across various concentrations and time intervals on acrylamide-treated *P. deltoides* wooden blocks. Specifically, subterranean termites at the highest acrylamide concentration (5%) showed higher feeding preferences (198 subterranean termites individuals) for *P. deltoides* wooden blocks compared to lower concentrations (1% and 3%) of acrylamide after 10 days (Fig. 6). Similarly, subterranean termites showed a significant feeding preference (df = 4, $F = 32.14458$, $P < 0.001$) across various concentrations and time intervals on acrylamide-treated three types of particleboard blocks. Specifically, subterranean termites exhibited a stronger preference (168 subterranean termite individuals) for walnut shells

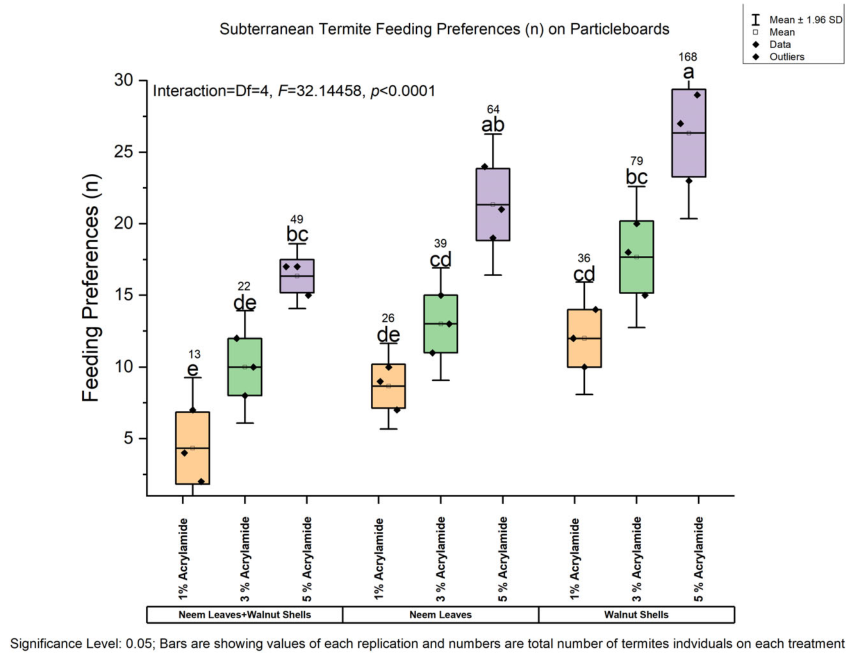

Figure 7. Feeding preference of acrylamide-treated three types of particleboard blocks.

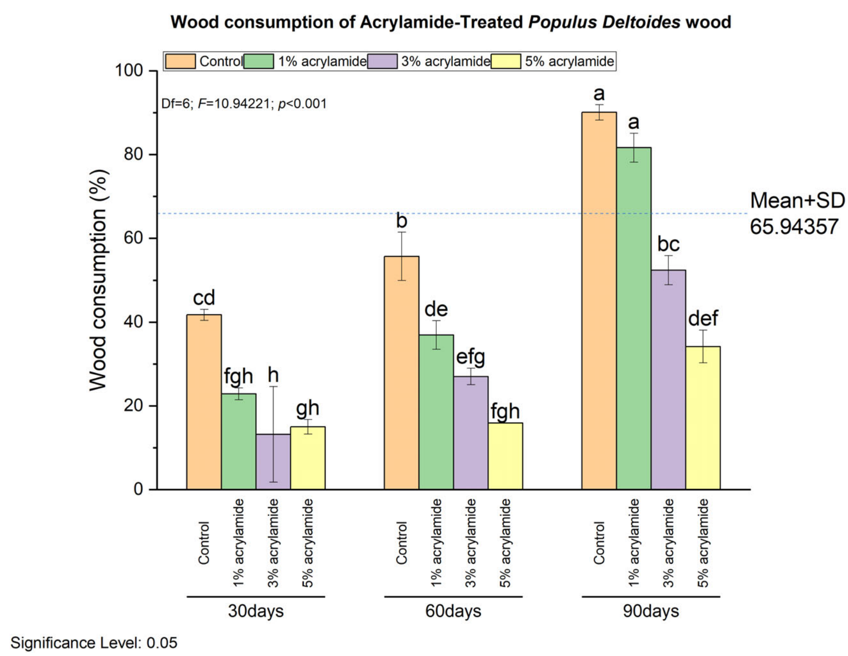

Figure 8. Wood consumption of acrylamide-treated *Populus deltoides* wooden blocks.

particleboard blocks at the highest acrylamide concentration compared to the other two particleboard block types after 10 days (Fig. 7).

3.3 Wood consumption of acrylamide-treated *P. deltoides* and three types of particleboard blocks

Wood blocks of *P. deltoides* treated solely with acrylamide exhibited substantial variations (df = 6, $F = 10.94221$, $P < 0.001$) in wood consumption rate among various concentrations with the time intervals. The highest wood consumption observed was 31.5% at lower acrylamide concentrations after 90 days; while the lowest wood consumption observed was 45.6% at higher concentrations after 90 days, respectively (Fig. 8). Correspondingly, acrylamide alone treated three types of particleboard blocks, which showed highly significant differences (df = 8, $F = 94.31281$, $P < 0.001$) in wood consumption rate among various concentrations with the time intervals. The lowest wood consumption rate was observed in neem leaves and walnut shells combined-particleboard blocks at all acrylamide concentrations after 90 days; the highest wood consumption was observed in

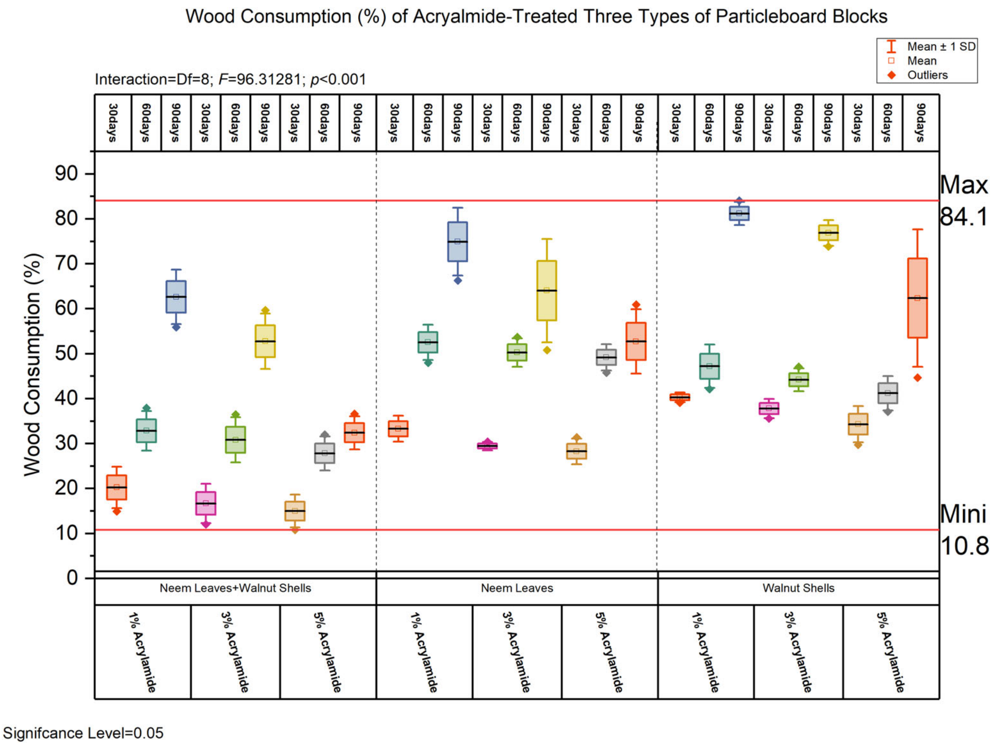

Figure 9. Wood consumption of acrylamide-treated three types of particleboard blocks.

walnut shells combined particleboard blocks at all acrylamide concentrations after 90 days, respectively (Fig. 9).

3.4 Wood consumption of acrylamide–boric acid-treated *P. deltoides* and three types of particleboard blocks

Acrylamide and boric acid combined toxic bait on *P. deltoides* wooden blocks showed highly significant differences (df = 6, $F = 20.977$, $P < 0.001$) with various concentrations and time intervals. The highest wood consumption of *P. deltoides* wooden blocks was observed at lower concentrations of acrylamide combined with boric acid after 90 days, while with the increase of acrylamide combined with boric acid treatments, the wood consumption was reduced (Fig. 10). Similarly, acrylamide and boric acid combined toxic bait on three types of particleboard blocks showed highly significant differences (df = 6, $F = 19.55707$, $P < 0.001$) with various concentrations and time intervals. The highest wood consumption of walnut shells particleboard blocks was observed at lower concentrations of acrylamide combined with boric acid after 90 days, while with the increase of acrylamide and combined boric acid treatments, the wood consumption rate of three types of particleboard blocks was reduced (Fig. 11). Overall, the wood consumption rate of neem leaves and walnut shells combined particleboard blocks treated with acrylamide combined boric acid showed the lowest weight loss compared to neem leaves particleboard blocks and walnut shells particleboard blocks.

4 DISCUSSION AND CONCLUSIONS

Superabsorbent polymers have garnered attention for their potential application in subterranean termite baits. In the present investigation, the combination of acrylamide and boric acid exhibited remarkable efficacy in both attracting and eliminating subterranean termites (*C. formosanus*) across various wood substrates. Once lured to the bait, the termites may ingest it, thereby ingesting toxicants capable of swiftly eradicating them.[50] This indicates that the acrylamide-based bait successfully attracted subterranean termites, resulting in increased feeding activity in the treated areas. Furthermore, the toxicity potential associated with acrylamide played a significant role in enhancing the bait's effectiveness, ultimately preventing wood consumption. Previous studies validate our findings, suggesting that superabsorbent polymers can control subterranean termite populations by attracting them to bait stations and increasing bait consumption.[17,51] When superabsorbent polymers are applied to wood, they can absorb a significant amount of water[52] creating a water-saturated environment inside the baiting containers that may attract subterranean termites.[17] A prior study showed that acrylamide possesses high water-absorption and toxic properties, supporting our results.[53] Research on the toxic effects of superabsorbent polymer acrylamide on various insects and animals (rats and drosophila) has revealed its neurotoxic effects.[54] Superabsorbent polymers can enhance bait consumption by subterranean termites in drought conditions,[55] potentially increasing the effectiveness of the bait.[56] Our experiment proved superabsorbent polymer acrylamide to have water retaining and toxicity properties, making them suitable for various subterranean termite baits. However, it is crucial to acknowledge that acrylamide alone lacks the toxicity necessary for termite eradication. Nevertheless, integrating it with synergistic agents (boric acid), such as termiticides, can effectively control termite infestations.

It was also discovered that subterranean termites encountered difficulties tunnelling through highly absorbent polymer acrylamide, hindering their access to food sources.[57] These subterranean termites excel at transforming empty spaces into tunnel regions

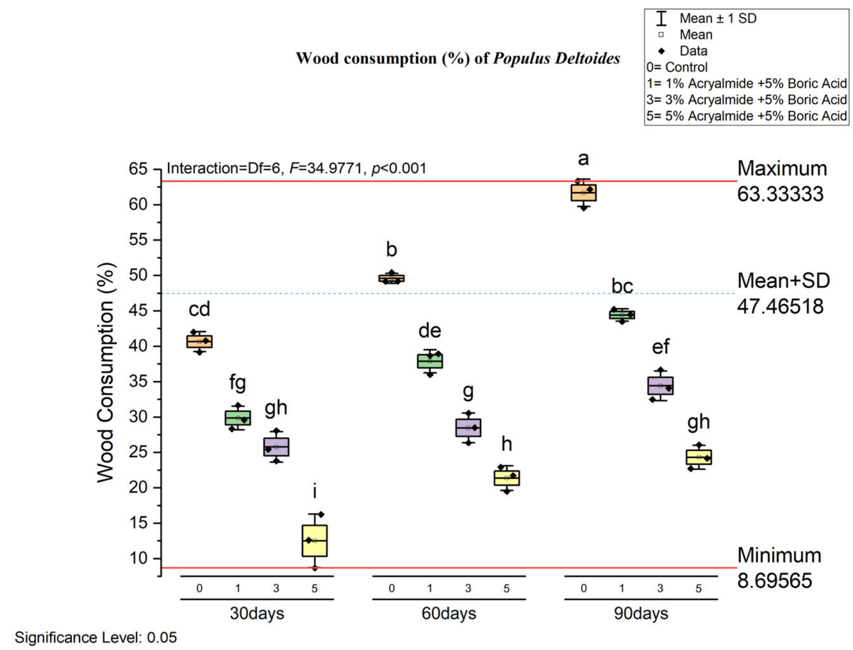

Figure 10. Wood consumption of acrylamide–boric acid treated *Populus deltoides* wooden blocks.

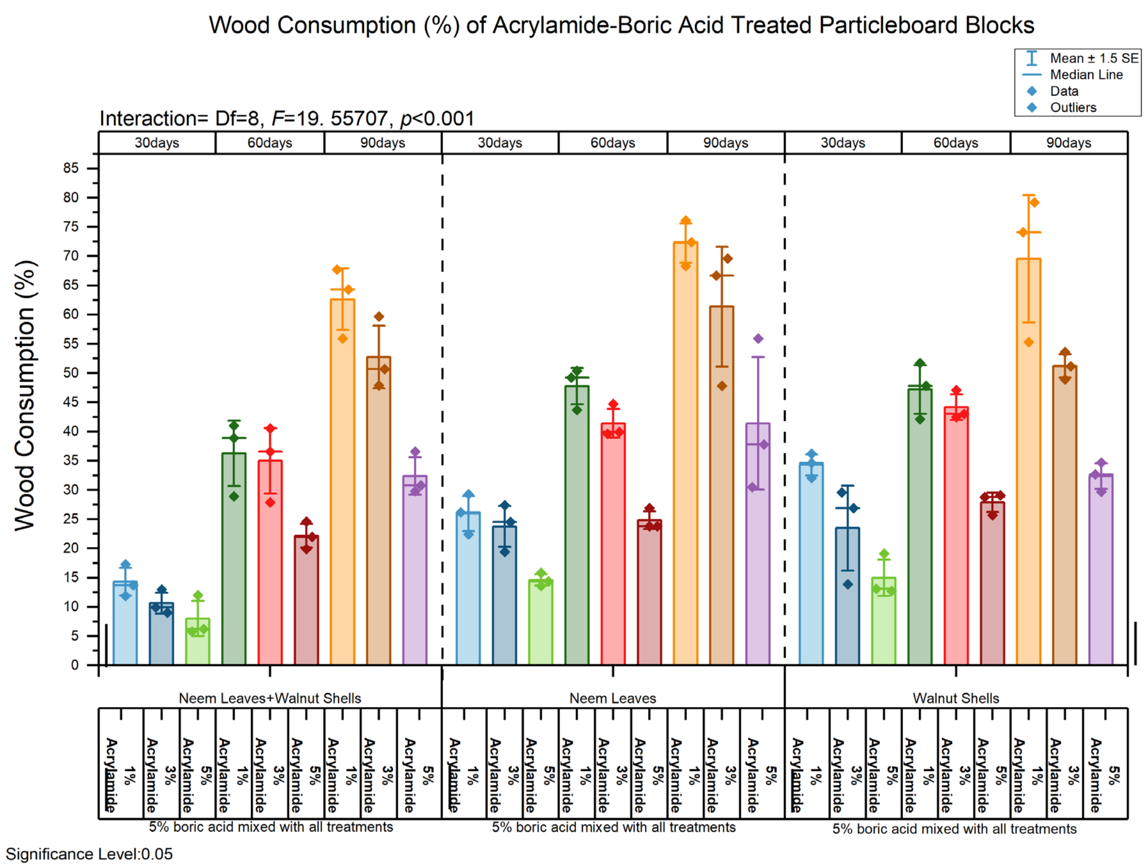

Figure 11. Wood consumption of acrylamide–boric acid treated three types of particleboard blocks.

through soil movement.[58] Increasing acrylamide concentration led to higher moisture levels in *P. deltoides* wood, reducing wood consumption but promoting subterranean termite feeding preferences.[21] While acrylamide is a potent bait with toxic properties, it may not be sufficient to control subterranean termites unless combined with targeted insecticides.

The investigation with three types of particleboard blocks showed strong resistance but were attractive to subterranean termite attacks when treated with acrylamide alone and in boric acid combination but toxicity properties of the bait have proven to be highly effective in combating termite infestations. Previous studies also support walnut wood's resistance and attractiveness as particleboard to subterranean termites.[32,59] Additionally, it was observed that walnut shells have an absorbent capacity which enhanced the acrylamide effect as an attractant.[30,31] Neem leaves possess not only toxic properties but also repellent properties which act strongly when used as attractive and toxic bait. When subterranean termites were exposed to powdered particleboard blocks composed of neem and walnut, synergistic effects were observed, resulting in a significant reduction in subterranean termite feeding preferences. Additionally, wood consumption decreased considerably when treated with a combination of toxic bait comprising acrylamide and boric acid. Subterranean termites exhibit different feeding responses to various types of woods, with walnut shells proving highly resistant to subterranean termite attacks.[60] Furthermore, it was found that walnut possesses toxic, antibiotic, and allelopathic properties, contributing to their strong resistance against subterranean termites and fungal wood decaying factors.[61] Studies have shown that neem's potent anti-termite activity is attributed to its toxicity and repellent properties.[62–64] Neem leaves and walnut shells exhibit termiticidal properties, further emphasizing their effectiveness as subterranean termite repellents. A study aimed to improve the resistance and durability of particleboard blocks by utilizing different parts of various trees. Their findings revealed that the incorporation of neem wood had a significant and noteworthy impact on enhancing the particleboard blocks' resistance to subterranean termite attacks.[65] In conclusion, our investigations have demonstrated the robust resistance, attractant, and toxic properties of neem leaves and walnut shells powdered particleboard blocks against subterranean termite activity, and the application of superabsorbent polymer treatments combined prevented its consumption.

Boric acid has been discovered to harbor termiticidal properties, functioning as a stomach poison that disrupts the subterranean termite's nutrient absorption and inflicts damage upon its nervous system, ultimately leading to the demise of these pests.[50] Once ingested, boric acid disrupts the subterranean termite's digestive system, resulting in dehydration and eventual death.[66] However, the effects of boric acid on subterranean termites may not manifest immediately, and it can take up to a week for the subterranean termite to deteriorate.[67] While boric acid can be effective against subterranean termites, its efficacy depends on subterranean termites ingesting it. Our results align with a study where boric acid was employed against various wood types to control subterranean termites.[68] Our study explores that the application of acrylamide superabsorbent polymer holds promise for termite control due to its exceptional water-absorption and retention capabilities, coupled with its strong attraction for subterranean termites but acrylamide alone lacks toxicity to control termites completely. Therefore, boric acid enhanced acrylamide's toxicity and efficacy, proving synergistic in toxic bait against subterranean termites on *P. deltoides* wooden blocks. The allure of ASP lies in its ability to draw termites by mimicking their preferred damp conditions, concentrating termite populations for targeted control efforts.

In conclusion, our research indicates that superabsorbent polymer acrylamide can attract subterranean termites to baits and increase bait consumption. While their toxic effect may not be highly lethal initially, enhancing their toxicity results in a more novel toxic bait, ultimately contributing to effectively controlling subterranean termite populations in various blocks of wood. Our study revealed an intriguing finding: subterranean termites displayed reduced preference and consumption of *P. deltoides* and three varieties of particleboard blocks treated with neem leaves and walnut shells powder, alongside the absorbent polymer acrylamide. This underscores the necessity for vigilant monitoring and management of subterranean termite infestations in regions utilizing highly absorbent polymer acrylamide treatments. However, the precise mechanism by which novel acrylamide interacts with the digestive system of subterranean termites remains incomplete. Therefore, further research is necessary to gain comprehensive insights into this interaction, potentially leading to more targeted and effective subterranean termite control strategies. Moreover, exploring the synergistic effects of acrylamide alongside target-specific chemicals presents a promising avenue for bolstering subterranean termite control measures. Further investigation in this realm has the potential to unveil the comprehensive efficacy of acrylamide as a formidable asset in subterranean termite management and broader pest control strategies.

AUTHOR CONTRIBUTIONS

Sohail Abbas: Conceptualisation, formal analysis, investigation, writing-original draft, methodology, data analysis and curation, writing-review and editing. Aleena Alam: Writing-review and editing, software and data curation. Muneer Abbas: Writing-review and editing, software and validation. Feng Xiao: Writing-review and editing. Liu Jiali: Writing-review and editing. Umar Daood: Resouces, data collection and investigation. Faisal Hafeez: Writing-review and editing. Muhammad Shakeel: Writing-review and editing. Jamin Ali: Writing-review and editing. Khalid Ali Khan and Hamed A. Ghramh: Critically revised manuscript, writing-review and editing. Donato Romano: validation, visualization, data curation, writing-review and editing. Chen Ri Zhao: Supervision, conceptualization, methodolgy, funding, resources and writing-review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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