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Developing A Solid Termite Bait Matrix and Conducting Efficacy Trials Under Lab and Semi Field Conditions

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Abstract

The study on development of solid termite bait matrix and its efficacy against the *Heterotermes indicola* was performed in Peshawar, during 2023. The study was performed with completely randomized design (CRD) with different treatments i.e., developed bait, patent bait, popular wood and blotting paper. Each treatment was replicated three times. The laboratory experiment consisted of no-choice, free choice and aggregation test. While the semi-field experiment consisted of free choice test. During the no-choice test of the laboratory experiment, *H. indicola* showed a consumption rate of 6.29% for the popular wood and developed bait. However, in the blotting paper treatment, the termites consumed only 2.81%. In terms of choice test conducted in the lab, the popular wood exhibited the highest weight consumption percentage of 2.87%, while the patent bait displayed the lowest weight consumption percentage of 2.25%. Under the choice test maximum number of termites were attracted towards popular wood (77.00 Number of termites) while minimum number of termites were attracted towards patent bait (54.66 Number of termites). Whereas, in aggregation test, of the lab experiment, maximum number of termites were also aggregated

towards popular wood (37.77 Number of termites) while minimum termites were aggregated for patent bait (25.22 Number of termites). In the case of free choice under semi-field conditions, the highest number of termites were observed on popular wood i.e., 380.00 followed by the developed bait, which recorded 293.50 termites. On the other hand, the lowest number of termites were recorded on the patent bait i.e., 231.50. Similarly, when considering the maximum consumed weight in percentage, popular wood exhibited the highest value at 16.24%, closely followed by the developed bait at 15.67% while the patent bait displayed minimum consumed weight percentage of 12.89%. In overall experiments it is concluded that among all the tested treatments, termites mostly consumed popular wood and developed bait. Since the developed bait showed promising results in attracting termites, it is recommended to continue refining its formulation. Conduct additional research to identify the key components or additives that enhance its attractiveness and consumption by termites. This optimization process can help maximize the effectiveness of the bait as a termite control strategy. Adding more popular wood saw dust in the bait may achieve more significant and desired results and can also prove to be cost efficient rather than adding more cellulosic material.

Introduction:

Termites, belonging to the Order Isoptera, have a global distribution and can be found in tropical, subtropical, and warm temperate regions. There are also rarer species that inhabit extremely high altitudes. Some species have the ability to extend their habitat range to relatively cooler regions. The termite family is known for its remarkable diversity and exhibits a variety of social characteristics (Inward et al. in 2007). On a worldwide basis, termites have outperformed other insects in terms of ecological success due to their astounding numbers with approximately 3000 species, 281 genera, and some 8 families. (Krishna et al., 2013). Depending on the presence or lack of intestinal flagellates, broadly classified into lower and higher termites (Bourguignon *et al*., 2017).

Termites are harmful pest insects. Each year, it results in billions in losses and damages. Based on pesticide sales in 1999, a global estimate of this cost of US$22 billion has been made (Su, 2002). Using sales data from 2010, the projected cost of termites climbed to US$40 billion on a global scale, with subterranean termites bearing 80% of the burden (Rust and Su, 2012).

Termites in Pakistan cause significant financial damage to timber structures, including furniture and other wooden items. Out of the 53 termite species found in the country, 11 are particularly harmful to wood, while others are destructive to crops, plants, and organic matter. Preventive termite control measures are crucial to minimize damage and prolong the life of wooden structures. The termite problem is also linked to building materials and construction techniques. Adequate treatment requires a thorough understanding of building materials and structures. Following treatment, annual inspections of building materials for pesticide effectiveness are necessary, and inspectors should be knowledgeable about termites and building material ecology. (Manzoor and Mir, 2010).

In Pakistan, *Heterotermes indicola* (Isoptera: Heterotermitidae) is a widespread termite species in his genus *Heterotermes* (Sheikh *et al.,* 2008). All 15 species of termites found in Khyber Pakhtunkhwa parasitize crops and wood products. Building invasions by two species, *Coptotermes heimi* and *Heterotermes indicola*, have been discovered in Peshawar region (Salihah *et al*., 1994). Damages result in losses of 90–100% for sugarcane, 46–12% for maize, 85–89% for fruit orchards, and 12% for wheat (Zubair *et al*., 2007). Odontotermes obesus is one of the most economically significant agricultural and structural pests in the subcontinent. (Akbar *et al*., 2019).

There are many methods and techniques to prevent and control termite infestations, including physical, chemical, and biological controls. Liquid pesticides including bifenthrin, cypermethrin, deltamethrin, chlorpyrifos, and fipronil are used to treat the majority of termite infestations (Akbar *et al*., 2019). However, employing these liquid formulations has a number of disadvantages, including the fact that they are very prone to evaporative loss, leaching, or shedding from the treatment site (Pérez, 2007). Second, when used on soil, these liquid formulations are readily degraded by soil microbes as well as climate extremes including temperature, light, and humidity. (Singh, 2016 and Huang *et al*., 2018).

Physical barriers, chemical pesticide barriers in soil and building materials, dusting with insecticide toxicants, and baiting are a few techniques used to prevent and control termite assault. Each method, from free-standing wooden cottages in low-density suburbs to tall concrete apartment buildings in heavily populated core cities, has a varied set of advantages depending on the building design and density. Every technique has a different goal, such as avoiding termites from causing damage or minimizing unfavorable side effects, like detrimental environmental repercussions. In order to more effectively destroy all the termites present in a colony and to be more environmentally friendly, baiting was created. By providing termites with pesticides in a cellulose food matrix, the colony was destroyed, and this method had positive environmental effects because it used less insecticide and contained it inside a bait station. (Iqbal *et al*., 2016).

It is difficult to eradicate and manage this pest using conventional techniques like digging and soil injection of pesticides and sometimes ineffective (Habibpour *et al*., 2008). Because of these problems, one of the most effective control methods is the use of bait systems. This has recently become an important technique (tactic) for protecting structures and wood from termites (Dhang, 2011). Bait is an environmentally friendly alternative control method to reduce subterranean termite populations and eliminate colonies entirely (Habibpour *et al*., 2011).

Lee *et al*., (2014) noted that bait systems have become a popular option for subterranean termite control, and baiting is he one of the major strategies for controlling subterranean termites. This method puts small amounts of active ingredients (hexaflumuron, noviflumuron, etc.) into the bait matrix for termites to seek out and consume, eradicating entire colonies. Different methods have been employed to evaluate the prey matrix and deliver venom to the nest. These methods included adding additives, attractants and feeding stimulants to the bait matrix. Although baits have been shown to be successful against termites over the past two decades, baits can become less effective under certain environmental conditions (Evans *et al*., 2015).

Termites discover food in the environment by smelling and chemically sensing their prey. Adding food stimulants (feeding stimulants) including nitrogen compounds, carbohydrates, vegetable oils, and pheromones is one technique to make the diet, which mostly consists of water and cellulose, appealing and acceptable to termites (Castillo *et al.,* 2013). In numerous regions of the world, feeding stimulants play a significant part in the feeding systems that control subterranean termites. Feeding stimulants like amino acids (Chen & Henderson, 1996), carbohydrates (Saran & Rust, 2008) and urea (Waller, 1996), which make diets more palatable, have also been investigated as a means of increasing consumption (Ekhtelat *et al*., 2018).

Several approaches were used to assess the prey matrix and return venom to the nest. These methods included adding additives, attractants and feeding stimulants to the bait matrix. *Reticulitermes flavipes* (Kollar) and *Reticulitermes virginicus* were observed to consume more filter paper that had been treated with Glucose, sucrose, and xylose solutions, according to Waller and Curtis' research (Banks). *R. hesperus* consumes, utilizes, and exchanges sucrose effectively with other sugars such ribose, fructose, and xylose (Saran and Rust, 2005). In order to draw termites to the bait station in a field experiment, solutions of sucrose, yeast, and urea were soaked into the soil. (Waller *et al*., 1999).

Keeping in view the importance of termites in urban areas, current study was initiated with an aim to collect termites from various location of Hayatabad, District Peshawar and develop a Solid Termite Bait matrix using different cellulosic material, different powders, and multiple vitamins. The study was also planned to evaluate the Efficacy of bait matrix under laboratory and semi field conditions against *Heterotermes indicola.*

Materials and Methods

The current study was carried out in 2022 in Peshawar. To Develop a Solid Termite Bait matrix and to conduct Efficacy trials of the Bait Matrix in Lab and Semi Field Condition against *Heterotermes indicola*.

Materials Used

Popular Wood, Spade, Mini hand shovel, Trowel, Sterilized Soil, Petri Dishes, Digital Balance, Plastic Bags, Blotting Paper, Sieve (Size 20), Flask Scissor, Forceps, Marker, Protective Gloves, Desiccators, Steel Tray, Trigger Spray Bottle, Graduated Cylinder, Plastic Cups, Plastic Straws (5 cm), Glue Gun, Knife, Plastic Pipes (2.5 inch in diameter, 1 foot long), Oven, Camel Hairbrushes, Small Tubs/Buckets

Soil Collection

Soil was collected in a tray from a field and was brought to the lab for experiment. The tray composed of soil was placed in the oven for 60 minutes at 127°C. The soil was then taken out. Soil was sterilized because if it contains any unwanted pathogens etc., they were killed and the soil was sieved (size 20). The conditions of the lab were kept consistent throughout the trial to avoid any biases in the results. The baits were weighed in the same conditions (e.g., at the same time of day and with the same scale) and stored in a controlled environment to prevent any changes in weight due to factors such as moisture or temperature.

Termite Collection

Using a technique, termites were gathered from a Peshawar region that was infested for experimental purposes. Wooden pegs constructed of popular wood that were 1.5 feet long and 2.5 inches wide were buried 25 cm deep in the ground. Weekly termite inspections were performed on these pegs. After 15 days, active foraging places were identified, and TERMAPS were planted in lieu of infected popular pegs. Termites were collected in a plastic bag with enough aeration so that they don't suffocate. The termites were put into a plastic bag with enough air in it to keep them from suffocating. By gently caressing the contaminated wooden bundles inside tubs, termites were extracted from the bundles in the laboratory. The tubs were filled with tiny pieces of damp blotting paper, which quickly drew thousands of termites. In order to gather more termites, this technique was repeatedly repeated. A relative humidity of 65±5% and a temperature of 25±2°C were maintained in the lab. Each experiment made use of worker and soldier termites. Worker termites and Soldier termites were used for each experiment.

Bait Preparation

A total of 1kg bait was prepared using the following ingredients. 500 ml of distilled water, 250 gm of various powders (including Popular Wood Saw Dust, Sugar Cane Powder, and Corn Powder), 250 gm of cellulose material, and various vitamins were used to make a 1 kg bait. The components were added to spherical pipes that had been cut to 2.5 inches in diameter and 0.5 inches in height after being fully hand-mixed. A presser was used to press the bait into a neat, rounded form, letting excess water to drain out. To create a spherical form, some bait was also placed in tiny round petri dishes. The application of pressure resulted in the formation of solid round bait, which was used for feeding purposes.

Experiments

Experiment 1. Tests under lab conditions

1. Weight consumption test (no choice)
2. Weight consumption test (free choice)
3. Aggregation test

Weight consumption test (No Choice)

Preparation of the Experimental Setup

Twelve medium-sized sterilized petri dishes with the following labels: T1, T2, T3, T4, and control were duplicated three times (R1, R2, R3) for the no-choice or force-feeding test. Developed bait, Patent Bait, Popular wood, and Blotting Paper were the treatments. The treatments were weighed and put between the petri plates separately before feeding. A graduated cylinder and a trigger spray bottle were used to provide 20 ml of water to each petri dish, which also contained 80 gm of sterilized soil. In each petri dish, 100 *Heterotermes indicola* termite soldiers and workers were released after 24 hours. The dishes were placed within a desiccator in a dark place. The initial weight of the baits was noted. Termites were monitored daily with intermittent moisture application. The final weight of each bait was noted after 30 days in order to determine weight reduction and assess effectiveness.

Percent Weight Consumed

Consumed Weight = Pre feeding weight of treatment – Post feeding weight of treatment

$$\text{Percent Consumed Weight} = \frac{\text{Consumed Weight}}{\text{Pre feeding weight of treatment.}} \times 100$$

Weight consumption test (Free Choice)

Preparation of the Experimental Setup

Three medium-sized petri dishes were utilized as the feeding arena for the free-choice test, and they were labelled with the three treatments (T1, T2, and T3) and replicated three times (R1, R2, and R3). The treatments were Developed bait, Patent Bait and Popular wood. 3 sterilized petri dishes of medium size were placed in sequence. The petri dishes were labelled as T_1R_1, T_1R_2 and T_1R_3. All the treatments (T_1, T_2 and T_3) were weighed before feeding. The treatments (T_1, T_2 and T_3) were all placed all together in each petri dish. Rest of the preparation of the experimental setup was same. Termites were monitored daily with intermittent moisture application. The final weight of each bait was noted after 30 days in order to determine weight reduction and assess effectiveness.

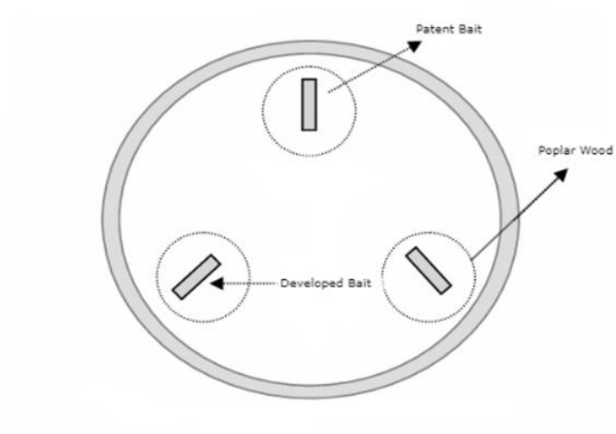

Fig. 1**.** Free choice test in a petri dish. Termites released in the center of petri dish and petri dish containing different treatments. Popular wood, developed bait and Patent Bait.

Percent Weight Consumed

Same Formula as No Choice Test.

The number of termites were also counted on each bait to see the feeding preference of termites.

Aggregation Test (Choice)

Preparation of the Experimental Setup

Twelve pairs of disposable plastic cups were connected by plastic straws (5 cm) in order to evaluate the food preferences of termites using developed bait, patent bait, and popular wood. A hot steel rod was used to poke tiny holes towards the bottom of each cup. Three of the cups contained the baits, while the middle cup functioned as the released plot and was connected to the other three through straws. This setup was replicated three times (R1, R2, R3). As a survival medium, oven-dried dirt (50 gm) was put in each of the cup, making sure that the holes in the cups remained unblocked. A trigger spray bottle was used to deliver moisture (10 ml) each day, and the moisture levels were tracked. The middle cup which was without any bait, 100 *Heterotermes indicola* termite workers and soldiers (95:5) were placed in it. To prevent evaporation, the cup pairs were placed on a laboratory tray in a dark corner and covered with another tray. 48 hours, 96 hours, and 192 hours were chosen as the time periods at which termite activity data were recorded. For each data collection, the termites were taken out of the petri dish and counted with a brush. For the purpose of gathering further data, the procedure was repeated.

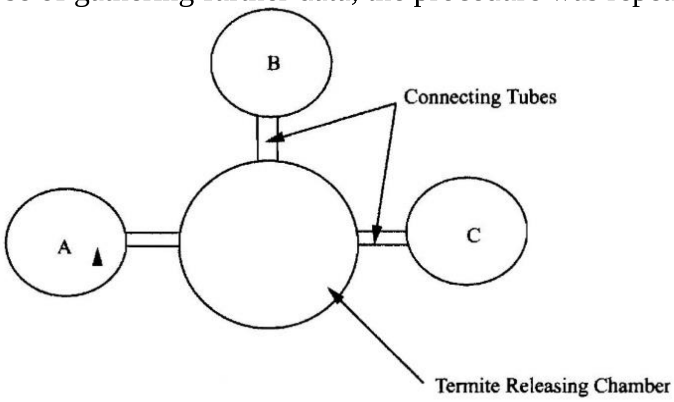

Fig. 2**.** Termites released in the center and varied treatments in side chambers A, B, and C, multiple choice feeding dishes used. A containing popular wood, B containing Developed bait and C containing Patent Bait

Test under semi field conditions

Weight consumption test (Free Choice)

Weight consumption test (Free Choice)

Preparation of the Experimental Setup

Three labelled buckets (T1, T2, T3) replicated as R1, R2, and R3 were prepared with 3 kg of sterilized soil each for a free-choice test. The pipes were put into the buckets with the corresponding baits (T1, T2, and T3). Each pipe had openings at the sides for termite access and measured 2 inches in diameter by 6 inches in length. The pipes were placed 2 inches above the ground and 4 inches below it. The pipes' small bottom holes could allow extra moisture to escape. Each bucket received 200ml of moisture before the termites were placed, and the moisture was left to absorb for 24 hours. Each bucket contained 1000 *Heterotermes indicola* termite workers and soldiers (950:50), which were left there for 15 and 30 days to be observed. To maintain ideal conditions, the termites were observed daily, and moisture was given every two to three days. The pipes were carefully examined after 15 and 30 days, and the number of termites found inside each pipe were counted. To evaluate the effectiveness of the baits and determine the termite's preferred meal, the obtained data was analyzed. It is important to emphasize that because the experiment was carried out under semi-field condition, so environmental variables like moisture and temperature were not under control and could have affected the results.

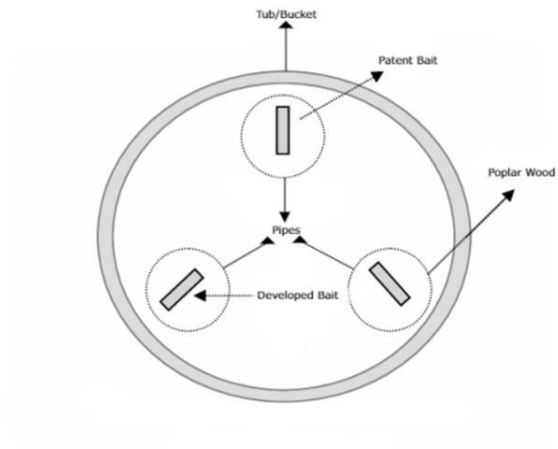

Fig. 3. Free choice test in a bucket/tub in semi field condition. Termites released in the center of the tub and tub containing three pipes which contain different treatments. Popular wood, developed bait and Patent Bait.

Percent Weight Consumed

Same Formula as No Choice Test.

The number of termites were also counted on each bait to see the feeding preference of termites.

Results

Experiment 1. Weight consumption by termites in no choice test under lab condition

Table 1 shows the efficacy of several treatments for termite weight consumption in the no-choice test. In terms of Pre-feeding weight (gm), there were significant variations detected between all of the treatments. Developed bait (5.80 gm) devoured the most post-feeding weight (gm) of all the treatments, followed by popular wood (5.76 gm) and blotting paper (5.64 gm), which was not treated with either bait or diet while patent bait (5.59 gm), consumed the least. Similar to this, the developed bait had the largest weight difference (0.39 gm), followed by popular wood (0.38 mg), patent bait (0.33 gm), and blotting paper (0.16 gm). Maximum weight consumed (%) was recorded on developed bait and popular wood (6.29%), followed by patent bait (5.56%), while smallest weight consumed (2.81%) was noted when termites were given blotting paper under a no-choice test. The results of the statistical analysis revealed no significant differences among any of the tested treatments.

Table 1: Efficacy of different treatments for weight consumption by termites in no choice test under lab condition

Treatments	Pre-feeding weight (gm)	Post-feeding weight (gm)	Difference in weight (gm)	Consumed weight (%)
Developed bait	6.19 a	5.80 a	0.39 a	6.29 a
Patent bait	5.80 b	5.59 b	0.33 a	5.56 a
Popular wood	6.14 a	5.76 ab	0.38 a	6.29 a
Blotting paper	5.80 b	5.64 a	0.16 b	2.81 b
LSD $_{(0.05)}$	0.07	0.22	0.15	2.57

Means in columns followed by same letters are non-significant at 5% probability level.

Experiment 2. Termites attraction in free choice test under lab condition

Table 2 shows the efficacy of several treatments for termites' attraction under the no-choice test. There were no statistically significant differences between any of the analyzed treatments. The most termites were drawn to popular wood (77.00 Number of termites), followed by developed bait (68.33 Number of termites), and the least number of termites were attracted to patent bait (54.66 Number of termites)

Table 2: Efficacy of different treatments for termites attraction in free choice test under lab condition

Treatments	Number of Termites
Developed bait	68.33
Patent bait	54.66
Popular wood	77.00
LSD $_{(0.05)}$	Ns

Means in columns followed by same letters are non-significant at 5% probability level.
Ns. Non-significant

Experiment 3. Weight consumption by termites in free choice test under lab condition

Table 3 shows the efficacy of several treatments for the weight consumption by termites in a free-choice test. Pre-feeding weight (gm) was not significantly different between any of the treatments. Popular wood and developed bait recorded the highest post-feeding weight (gm) among all treatments (2.25 gm), while the lowest consumed patent weight (2.43 gm). Similar to this, the largest weight difference was found with developed bait and popular wood bait (0.06 gm), while the smallest weight differences were found with patent bait (0.05 gm). However, popular wood (2.87%) had the highest percentage of consumed weight, followed by developed weight (2.73%), while patent bait (2.25%) had the lowest percentage of consumed weight.

Table 3: Efficacy of different treatments for weight consumption by termites in free choice test under lab condition

Treatments	Pre-feeding weight (gm)	Post-feeding weight (gm)	Difference in weight (gm)	Consumed weight (%)
Developed bait	2.31	2.25	0.06	2.73
Patent bait	2.49	2.43	0.05	2.25
Popular wood	2.32	2.25	0.06	2.87
LSD $_{(0.05)}$	Ns	Ns	Ns	Ns

Means in columns followed by same letters are non-significant at 5% probability level.
Ns. Non-significant

Experiment 4: Aggregation of termites against the different treatments under lab condition

Table 4 shows the aggregation of termites in relation to the various treatments at the various time intervals. All of the studied therapies were shown to significantly differ from one another. The most termites were found overall across all tested treatments after two days on popular wood (33.33 Number of termites), followed by developed bait (32.33 Number of termites), and the least number of termites were found using treatment patent bait (29.00 No. of termites). Similar to this, after a 4-day interval, the highest number of termites were found in popular wood (38.00 Number of termites), followed by developed bait (35.66 Number of termites), and the lowest number were found on patent bait (23.66 Number of termites). After 8 days, the most termites were found in popular wood (42.00 Number of termites), followed by developed bait (31.33 Number of termites), and the least number of termites were found on patent bait (23.00 Number of termites). The mean number of termites were also shown in the table. Among all the treatments that were tested, the most termites were found in popular wood (37.77 Number of termites), followed by developed bait (33.11 Number of termites), and the least number of termites were found on patent bait (25.22 Number of termites).

Table 4: Aggregation of termites against the different treatments under lab condition

Treatments	Number of Termites			
	Days			Mean
	2	4	8	
Developed Bait	32.33	35.66 ab	31.33 ab	33.11 ab
Patent Bait	29.00	23.66 b	23.00 b	25.22 b
Popular Wood	33.33	38.00 a	42.00 a	37.77 a
LSD $_{(0.05)}$	Ns	12.70	15.05	9.41

Means in columns followed by same letters are non-significant at 5% probability level.

Ns. Non-significant

Experiment 5. Termites attraction in free choice test under semi field condition

Table 5 shows the efficacy of different treatments for termites' attraction under free choice test in semi field condition. After 15 days, maximum termites were recorded on popular wood (378.33 Number of termites) as followed by developed bait (292.67 Number of termites), while minimum termites were recorded on patent bait (230.67 Number of termites). After 30 days of interval, maximum termites were recorded on popular wood (381.67 Number of termites) as followed by developed bait (294.33 Number of termites), while minimum termites were recorded on patent bait (232.33 Number of termites). Maximum mean number of termites were recorded on popular wood (380.00 Number of termites) as followed by developed bait (293.50 Number of termites), while minimum termites were recorded on patent bait (231.50 Number of termites).

Table 5: Efficacy of different treatments for termites attraction in free choice test under semi field condition

Treatments	**Number of Termites**		
	Days		**Mean**
	15	**30**	
Developed Bait	292.67 b	294.33 b	293.50 b
Patent Bait	230.67 c	232.33 c	231.50 c
Popular Wood	378.33 a	381.67 a	380.00 a
LSD $_{(0.05)}$	49.96	52.95	51.39

Means in columns followed by same letters are non-significant at 5% probability level.

Experiment 6: Weight consumption by termites under in free choice test under semi field condition

Table 6 shows the efficacy of multiple treatments for the weight consumption by the termites under free choice test in semi field condition. Before 15 days of interval, maximum pre-feeding weight (gm) was recorded on popular wood (4.16 gm) as followed by patent bait (3.79 gm) while minimum weight was recorded on developed bait (3.16 gm). Similarly, maximum post-feeding weight (gm) was recorded on popular wood (4.86 gm) as followed by patent bait (3.35 gm) while minimum weight was recorded by developed bait (3.09 gm). Maximum difference in weight was recorded on popular wood (0.64 gm) as followed developed bait (0.52 gm) while minimum patent bait (0.44 gm). In term of consumed weight (%), maximum consumed weight after 15 days was recorded on popular wood (15.39%) as followed by developed bait (14.67%) while minimum consumed weight was recorded by patent bait (11.69%). Before 30 days of interval, maximum pre-feeding weight (gm) was recorded on popular wood (4.86 gm) as followed by patent bait (4.49 gm) while minimum weight was recorded on developed bait (4.31 gm). Similarly, maximum post-feeding weight (gm) was recorded on popular wood (4.03 gm) as followed by patent bait (3.86 gm) while minimum weight was recorded by developed bait (3.60 gm). Maximum difference in weight was recorded on popular wood (0.83 gm) as followed developed bait (0.71 gm) while minimum patent bait (0.63 gm). In term of consumed weight (%), maximum consumed weight after 30 days was recorded on popular wood (17.09%) as followed by developed bait (16.68%) while minimum consumed weight was recorded by patent bait (14.09%). Maximum mean consumed weight (%) was recorded on popular wood (16.24%) as followed by developed bait (15.67%) while minimum consumed weight was recorded by patent bait (12.89%).

Table 6: Efficacy of different treatments for weight consumption by termites in free choice test under semi field condition

Treatments	Pre-feeding weight (gm)		Post-feeding weight (gm)		Difference in weight (gm)		Consumed weight (%)		Mean
	Days								
	15	30	15	30	15	30	15	30	
Developed bait	3.16 a	4.31 b	3.09 b	3.60 b	0.52	0.71	14.67	16.68	15.67
Patent bait	3.79 b	4.49 b	3.35 ab	3.86 ab	0.44	0.63	11.69	14.09	12.89
Popular wood	4.16 a	4.86 a	3.52 a	4.03 a	0.64	0.83	15.39	17.09	16.24
LSD $_{(0.05)}$	0.27	0.27	0.42	0.42	Ns	Ns	Ns	Ns	Ns

Means in columns followed by same letters are non-significant at 5% probability level.
Ns. Non-significant

Discussion

Termites are harmful insect pest. Each year, it results in billions in losses and damages. Subterranean termites are seriously compromising structures all over the world in tropical and subtropical areas. Termite infestations are thought to cause a $40 billion annual economic damage worldwide. Damage from termites ranges from 90 to 100% for sugar cane, 46% for maize, 12% for wheat, and 85-89% for orchards. Bait is an environmentally friendly alternative control method to reduce subterranean termite populations and eliminate colonies entirely. Because of the importance of this pest, this study was carried out to develop a solid termite bait matrix. Also, to conduct efficacy trials of bait matrix in lab and semi field condition against *Heterotermes indicola.*

In 2023, various treatments against termites were used in a non-choice test. Where, maximum consumed weight (%) was recorded on popular wood and developed bait as followed by patent bait while minimum consumed weight was recorded when provided blotting paper to the termites. Similarly, maximum number of termites were attracted towards popular wood followed by developed bait while minimum number of termites were attracted towards patent bait. However, in case choice test, maximum consumed weight (%) was recorded by popular wood as followed by developed weight while minimum consumed weight was recorded by patent bait. The parallel study was also done according to Waller and Curtis (2003) research, *R. virginicus* consumed more filter paper that had been treated with 1% glucose, sucrose, and xylose than with water. Similarly, Reinhard and Kaib (2001) reported that termites were show preference towards sugar treated blotting paper as compared with other treatments. Under laboratory conditions, Wang and Henderson (2012) investigated the effectiveness of two commercially used termite bait materials—cardboard and southern yellow pine wood, and a potential bait material that is maize (Zea mays) cob—against the Formosan subterranean termite, *Coptotermes formosanus* (Isoptera: Rhino-termitidae). The consumption of cob and wood was similar in the no-choice test and significantly higher than that of cardboard. In the two-choice test, the consumption was cob > wood, wood > cardboard, and cob = cardboard. In the three-choice test, no discernible difference in consumption was found.

During the present study termites were mostly aggregated towards popular wood as followed by developed bait while minimum termites were aggregated towards patent bait. It is difficult to compare present and previous findings due to the least data availability.

In term of no choice semi field condition, after 15 and 30 days of interval, maximum number of termites' wand consumed weight (%) were recorded on popular wood as followed by developed bait, while minimum termites were recorded on patent bait. These chemicals are only active at very high concentrations, as seen in our tests and earlier research (Waller and Curtis, 2003), and termites are unlikely to come across such high quantities of freely available carbohydrates in their natural habitat. Bartlet *et al*., (1994) observed that many insects, especially those that ingest plants, use sugar as phagostimulants. When R. Hesperus was exposed to solutions containing 5% ribose, 3% xylose, 2% maltose, 2% fructose, 2% arabinose, and 2% glucose, it ate noticeably more brown paper towel discs. *Reticulitermes flavipes* and *R. virginicus* were drawn to yeast and sucrose solution, according to Waller *et al*. 1999. Our findings are in line with those of other researchers, such as Waller *et al*. (1999), he proved through research that *Reticulitermes flavipes* Kollar and *Reticulitermes virginicus* Banks favor and occupy baits with yeast or sugar over those without these elements. *Reticulitermes* spp. have been shown by Swoboda (2004) to preferentially eat paper baits that contain fructose, galactose, glucose, or sucrose.

Summary

In 2023, the research was carried out in Peshawar. The temperature in the lab was held at 25± 2^{o}C, while the relative humidity was kept at 65± 5%. For each experiment, soldier and worker termites were used. Complete randomization (CRD) was used in the study's execution, and each treatment was triplicated.

The study was conducted to develop a solid termite bait matrix and also conduct the efficacy trials of bait matrix in lab and semi field condition against the *Heterotermes indicola*.

Results revealed that mean maximum consumed weight was recorded on popular wood and developed bait (6.29%) while minimum consumed weight was recorded when given blotting paper (2.81%) to the termites under no choice test. Similarly, maximum number of termites were attracted towards popular wood (77.00 Number of termites) while minimum number of termites were attracted towards patent bait (54.66 Number of termites) under no choice test.

Furthermore, in term of choice test, maximum consumed weight (%) was recorded by popular wood (2.87%) while minimum consumed weight was recorded by patent bait (2.255). Whereas, maximum number of termites were also aggregated towards popular wood (37.77 Number of termites) while minimum termites were aggregated for patent bait (25.22 Number of termites).

However, in case of no choice semi field condition, after 15 and 30 days interval, maximum termites were recorded on treatment popular wood (378.33 and 381.67) while minimum termites were recorded on patent bait (230.67 and 232.33), whereas in the release plot recorded '98.33' and '91.66' termites. Maximum mean termites were recorded on popular wood (380.00) followed by developed bait (293.50) while minimum termites were recorded on patent bait (231.50), whereas in the release plot recorded '95.00' termites.

Similarly, maximum consumed weight (%) was observed after 15 and 30 days interval on polar wood (15.39 and 17.09%) while minimum consumed weight was recorded by patent bait (11.69 and 14.09%). Maximum mean consumed weight (%) was observed on popular wood (16.24%) as followed by (15.67%) while minimum consumed weight was recorded by patent bait (12.89%).

Thus, as a result, it may be concluded that in all the experiments, all tested treatments, termites mostly consumed popular wood and developed bait and also attracted towards popular wood.

Conclusions

Among all the treatments, maximum consumed weight (%) was recorded on popular wood and developed bait, similarly, maximum number of termites were attracted towards popular wood followed by developed bait under no choice test. Maximum consumed weight (%) was recorded by popular wood followed by developed bait under choice test. In term of aggregation, among all the tested treatments, maximum number of termites were attracted towards popular wood followed by developed bait.

The popular wood achieved the highest weight consumption (%) in the choice test conducted under semi-field conditions, followed by the developed bait. Similarly, the popular wood attracted the maximum number of termites, with the developed bait closely following suit, during the choice test in the semi-field environment.

Recommendations

Since the developed bait showed promising results in attracting termites, it is recommended to continue refining its formulation. Conduct additional research to identify the key components or additives that enhance its attractiveness and consumption by termites. This optimization process can help maximize the effectiveness of the bait as a termite control strategy.

Adding more popular wood saw dust in the bait may achieve more significant and desired results and can also prove to be cost efficient rather than adding more cellulosic material.

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