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RESEARCH PAPER

The effect of *Cerbera odollam* leaf and fruit peel extract on subterranean termite *Coptotermes curvignathus*

Ummahatul Mujahidah[1], Auliya Ilmiawati[1,2], Arinana[3], Gustini Syahbirin[1], & Irmanida Batubara[1,2]

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ABSTRACT

Coptotermes curvignathus is a termite pest that attacks buildings, plantations, and forests. Controlling this pest requires environmentally friendly natural materials. The bintaro plant (*Cerbera odollam*) are known in Indonesia as natural insecticides and traditional medicines because of their strong toxic properties, so they have the potential to be used in termite control. This study evaluated the efficacy of *C. odollam* leaf and fruit peel extracts as natural termiticides and their effectiveness against subterranean termite *C. curvignathus*. The extraction process used three solvents with different polarities: *n*-hexane, acetone, and ethanol. Anti-termite bioactivity tests were conducted following the Japanese Industrial Standard (JIS) 1571-2010 method. Ethanol extract from *C. odollam* leaves produced the highest yield (9.52%). Phytochemical analysis showed the presence of alkaloids, flavonoids, phenolics, steroids, and saponins in both leaf and fruit peel extracts. The anti-termite bioactivity test showed that the leaf extract with acetone solvent caused 97.33% mortality, while the fruit peel extract with ethanol solvent caused 100% mortality at a 5% concentration. This study demonstrates that *C. odollam* leaf and fruit peel extracts have strong potential as natural termiticides.

Keywords: Bioactivity, *Cerbera odollam, Coptotermes curvignathus*, natural termiticide, phytochemical

INTRODUCTION

Termites are social insects that feed on organic matter, live in colonies, and depend heavily on other members of the colony (Nandika et al., 2015). Although termites play an important role in ecological processes, their feeding behavior often causes significant losses. Termites are known to damage crops, forests, and wooden structures, and are therefore considered major pests (Nandika et al., 2015). In Indonesia, the subterranean termite *Coptotermes* sp. is one of the most destructive species. According to Puteri et al. (2016) and Meidianto et al. (2019), subterranean termites (*Coptotermes* sp.) damage plantation crops such as coconut, rubber, cocoa, and oil palm. In particular, *Coptotermes curvignathus* Holmgren is a serious pest of rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*), attacking plant tissues rich in cellulose. Nurwansyah & Erniwati (2019) reported that these termites excavate tunnels in the soil and attack the roots and lower parts of the plant, causing structural damage and reducing yield. Such productivity losses can lead to substantial economic impacts, especially in rubber and oil palm plantations, which are major agricultural commodities in tropical regions. The status of *C. curvignathus* as a key plant pest underscores the importance of effective termite management strategies.

Common termite control methods rely on synthetic chemical termiticides such as imidacloprid, aldrin, dieldrin, chlordane, heptachlor, and chlorpyrifos (Nandika et al., 2015). However, many of these compounds have been banned in Indonesia due to their harmful effects, including human toxicity, environmental persistence, and potential contamination of soil and water (Erliana et al., 2022). Other termiticides—such as nitroguanidine, phenylpyrazole, organophosphates, and pyrethroids—are effective even at low concentrations but lack specificity for target organisms, thereby posing risks to aquatic ecosystems (Nandika et al., 2015). These limitations highlight the need for safer, environmentally friendly alternatives to synthetic termiticides.

One promising alternative is the use of plant-based natural termiticides. *Cerbera odollam*, belonging to the Apocynaceae family, is commonly known as

Corresponding author:
Auliya Ilmiawati (aulia_ilmiawati@apps.ipb.ac.id)

[1]Department of Chemistry, Faculty of Mathematic and Natural Sciences, IPB University, Bogor, West Java, Indonesia 16680
[2]Tropical Biopharmaca Research Center, IPB University, Bogor, West Java, Indonesia 16680
[3]Department of of Forest Products Technology, Faculty of Forestry and Environment, IPB University, Bogor, West Java, Indonesia 16680

bintaro (Erliana et al., 2022). *C. odollam* is widely planted for urban greening and landscaping purposes but remains underutilized, and its economic value is still relatively low. Ilmiawati et al. (2024) reported that bintaro possesses anticancer, antioxidant, insecticidal, pesticidal, and antifungal properties that are useful in pharmacology and toxicology. They also found that the plant contains a variety of secondary metabolites, including alkaloids, saponins, tannins, polyphenols, phenolic acids, flavonoids, and terpenoids. According to Adudu et al. (2022), all parts of the *bintaro* plant—including the stems, flowers, seeds, and fruits—contain high levels of toxicity.

Several studies have reported various benefits of *bintaro*, which has the potential as a biopesticide, bioinsecticide, and larvicide (Sholahuddin et al., 2018; Dewi et al., 2018; Meisyara et al., 2020; Handayani et al., 2023). Tarmadi et al. (2018) reported that the methanol extract of bintaro leaves can cause up to 100% termite mortality, as can *n*-hexane and acetone extracts of the bark. The ethanol extract of bintaro seeds is also effective in increasing *Aedes aegypti* mortality (Wulandari & Ahyanti, 2018). Although the potential toxicity of bintaro has been widely studied, to date, no study has comprehensively compared the effectiveness of *C. odollam* leaf extract and fruit peel extract using various solvents as a biotermiticide against *C. curvignathus.* In this study, extraction solvents were varied from non-polar to polar (*n*-hexane, acetone, and ethanol) to obtain a diverse spectrum of secondary metabolites. Therefore, this study evaluated the toxicity of *C. odollam* leaf and fruit peel extracts prepared with various solvents against the subterranean termite *C. curvignathus*.

MATERIALS AND METHODS

Research Site. This research was conducted at the Laboratory of the Organic Chemistry Division, Department of Chemistry, FMIPA, IPB University and the Termite Laboratory, Department of Forest Products, FAHUTAN, IPB University.

Sample Preparation and Extraction. *C. odollam* plant material were identified at the Tropical Biopharmaceutical Research Center (Trop BRC), International Research Institute for Food, Nutrition, and Health, Bogor Agricultural University (IPB), and obtained in powder form. A total of 500 g of *C. odollam* powder was macerated using three different solvents—technical *n*-hexane, technical acetone, and p.a. ethanol—with a sample-to-solvent ratio of 1:5 (w/v). The technical solvents (*n*-hexane and acetone) were first distilled to remove impurities and improve solvent purity before being used for extraction.

The maceration process was carried out separately for each solvent for 3 × 24 hours. Every 24 hours, the mixture was filtered using filter paper, and the resulting filtrate was concentrated using a rotary evaporator (Ilmiawati et al., 2023). Extract yield was calculated using the formula:

$$Y = \frac{Wc}{Wd} \times 100\%$$

Y = Yield (%);
Wc = Weight of concentrated extract;
Wd = Weight of simple drug.

Phytochemical Test. Phytochemical analysis was carried out to detect the presence of alkaloids, flavonoids, phenolics/tannins, terpenoids/steroids, and saponins. The procedure followed Shaikh & Patil, (2020) and Kurniawanti et al. (2021).

Alkaloid Test. A total of 0.3 g of extract was dissolved in 5 mL of 10% ammonia solution, soaked in 10 mL of chloroform, and then concentrated. The residue was dissolved in dilute sulfuric acid and divided into three test tubes. Mayer, Dragendorff, and Wagner reagents were added. The presence of alkaloids was indicated by: white precipitate (Mayer), reddish-brown precipitate (Dragendorff), and brown or pink precipitate (Wagner).

Flavonoid Test. To test for flavonoids, 0.1 g of extract was dissolved in 1 mL of distilled water, followed by the addition of magnesium granules and 1 mL of concentrated HCl. The solution was stirred, then 1 mL of amyl alcohol was added. The appearance of purple, yellow, or orange coloration indicated positive flavonoid content.

Phenolic and Tannin Test. A total of 0.1 g of extract was dissolved in 1 mL of distilled water and chloroform and shaken to form two layers. A few drops of 5% $FeCl_3$ were added to the upper layer. The formation of a dark blue or greenish-black color indicated the presence of phenols and tannins.

Terprenoid and Steroid Test. A total of 0.1 g extract was dissolved in 1 mL of distilled water and 1 mL of chloroform, then shaken until two layers formed. The chloroform (bottom) layer was filtered, and the filtrate was transferred to a drop plate and evaporated to dryness. One drop of Liebermann–Burchard reagent was added. A green/blue color indicated steroids, while a red color indicated terpenoids.

Saponin Test. The extract was diluted with 5 mL of distilled water and shaken vigorously for several min. Stable foam persisting for 10 min indicated the presence of saponins.

Anti-termite Bioactivity Test. The bioactivity test against the subterranean termite *C. curvignathus* followed Adfa et al. (2010) and a modified Japanese Industrial Standard (JIS K 1571:2010). Modifications included changing the bait sample to filter paper and reducing the number of termites per unit from 165 to 55.

Each test unit consisted of 50 worker termites and five active soldier termites. A 50-mm-diameter Whatman No. 1 filter paper disc was used as the test bait. The filter paper was weighed, then soaked in extract solutions at concentrations of 1.25%, 2.5%, and 5% (w/v), with three replications per concentration.

After soaking, the paper discs were air-dried and weighed (initial weight). Controls included: untreated filter paper, filter paper treated with *n*-hexane, filter paper treated with DMSO, filter paper treated with commercial termiticide (OAK) containing imidacloprid.

A forced-feeding method was used. Filter papers were placed inside acrylic test containers (8 cm diameter, 6 cm height) with a 1-cm-thick dental cement layer at the base (Figure 1). Containers were placed on damp tissue in a dark room for 21 days.

After the feeding period, surviving *C. curvignathus* termites were counted, and the filter paper was weighed again (final weight) to calculate termite mortality using the formula:

$$M = \frac{N}{T} \times 100\%$$

M = Mortality (%);
N = Number of dead termites;
T = Total number of termites (50 individuals).

Weight loss was calculated using the following formula:

$$W = \frac{Iw - Fw}{Iw} \times 100\%$$

W = Weight loss (%);
Iw = Initial weight (g);
Fw = Final weight (g).

Data Analysis. Data were analyzed using a completely randomized factorial design to test the effect of: Factor A: solvent (*n*-hexane, acetone, and ethanol); Factor B: extract concentration (1.25%, 2.5%, 5%) on termite mortality and weight loss. If ANOVA indicated significant effects, Duncan's multiple range test was applied at α = 5%. Data were processed using IBM SPSS Statistics version 27.0.1.

The variance analysis model for the completely randomized factorial design followed Adfa et al. (2010) dan Zaki et al. (2014):

$$Yijk = \mu + Ai + Bj + (AB)ij + \epsilon ijk$$

Y_{ijk} = Observed value of factor A at level i, factor B at level j, and repetition k;
μ = Overall mean;
Ai = Effect of factor A at level i;
Bj = Effect of factor B at level j;
ABij = Interaction effect between factor A and B;
ε_{ijk} = Random error for the i^{th} level of A, j^{th} level of B, and k^{th} replication.

RESULTS AND DISCUSSION

***C. odollam* Extract.** Extraction is the process of separating compounds from plant powder using an appropriate solvent. The choice of extraction method is determined by the characteristics of the material or compound, the effectiveness in extracting the maximum amount of compounds, and efficiency in terms of cost and time (Budiarti et al., 2019). Maceration was chosen because it is a simple and safe extraction technique suitable for compounds sensitive to heat (Zulfiah et al., 2020). In addition, solvent selection in the extraction

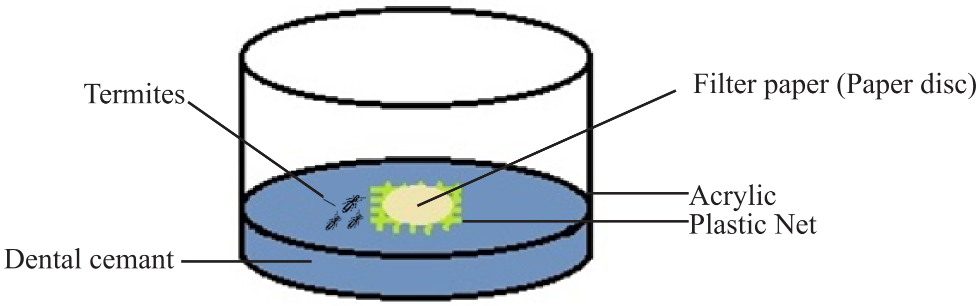

Figure 1. Sketch of the bioactivity test of the extract against the subterranean termite *C. curvignathus.*

process is critical to ensure that the target compounds can be extracted effectively. According to Arsa & Achmad (2020), the ideal solvent for extraction has a high dissolving ability for the compounds being targeted.

In this study, various solvents with different polarity levels were used to obtain optimal yields and active compound contents from the leaves and fruit peels of *C. odollam*. The extract yields of *C. odollam* leaves and fruit peels are presented in Table 1.

Table 1 shows that the leaf extract of *C. odollam* produced the highest yield using ethanol solvent (9.53%), while the lowest yield was obtained with *n*-hexane (3.27%). In contrast, the fruit peel extract produced the highest yield using n-hexane (3.79%) and the lowest yield using ethanol (2.00%). Extract yield reflects the solvent's ability to dissolve extractive substances from the material. The higher the yield, the more effective the solvent.

When comparing the leaf and fruit peel extracts, the leaf extract generally produced a higher yield. This suggests that ethanol is more effective in attracting extractive compounds from leaves. Ethanol is an effective polar solvent because it can dissolve both polar and some non-polar compounds (Arsa & Achmad, 2020). This characteristic makes ethanol more suitable for extracting a richer variety of active compounds from leaves than from fruit peels.

These findings align with the results of Tarmadi et al. (2007), who reported that leaf extraction using methanol produced the highest yield (10.55%) compared to ethyl acetate and acetone. Previous studies (Sahoo & Marar, 2018; Syarif et al., 2022), have also shown a tendency to use polar solvents for extracting various parts of the *C. odollam* plant.

Phytochemical Results. The chemical compounds in the leaves and fruit peels of *C. odollam* were analyzed qualitatively using phytochemical tests with various specific reagents. The results (Table 2) show that the solvent used significantly influenced the type and intensity of extracted bioactive compounds.

In leaf extracts, ethanol produced the greatest variety of bioactive compounds—especially alkaloids, flavonoids, and steroids—demonstrating high effectiveness in extracting polar or semi-polar compounds compared to acetone and *n*-hexane. Acetone extracted alkaloids, steroids, and saponins, while n-hexane extracted only steroids and traces of alkaloids.

A similar pattern was observed in the fruit peel extracts. Ethanol was effective in extracting alkaloids, steroids, phenolics, and saponins. Acetone extracted steroids, phenolics, and limited alkaloids, while *n*-hexane showed the most limited profile, extracting only steroids and traces of alkaloids.

Overall, the phytochemical results indicate that polar solvents such as ethanol are most effective for extracting polar bioactive compounds from *C. odollam* leaves and fruit peels, whereas non-polar solvents

Table 1. Yield of *C. odollam* extract

Sample	Solvent	Extract color	Concentrated extract weight (g)	Yield (%)
Leaf	*n* -hexane	Green-brownish	16.34	3.26
	Acetone	Blackish green	42.05	8.41
	Ethanol	Dark green	47.64	9.52
Fruit peel	*n* -hexane	Chocolate	18.95	3.79
	Acetone	Dark green	11.92	2.38
	Ethanol	Light green	10.04	2.00

Table 2. Phytochemical analysis of *C. odollam* extract

Sample	Solvent	Phytochemical Test					
		Alkaloid	Flavonoid	Phenolic	Steroid	Terpenoid	Saponins
Leaf	*n*-hexane	+	-	-	+	-	-
	Acetone	+	-	-	+	-	+
	Ethanol	+	+	-	+	-	-
Fruit peel	*n*-hexane	+	-	-	+	-	-
	Acetone	+	-	+	+	-	-
	Ethanol	+	-	+	+	-	+

(+) = Contains secondary metabolite compounds; (-) = Does not contain secondary metabolite compounds.

such as *n*-hexane are more effective for lipophilic compounds.

These findings agree with previous studies reporting that ethanol extraction of *Cerbera* leaves and fruit peels can obtain alkaloids, flavonoids, steroids, phenols, tannins, saponins, and glycosides (Nasution et al., 2019; Mahdi et al., 2024). To date, no studies have specifically reported the phytochemical profiles of *C. odollam* leaf or fruit peel extracts using acetone and *n*-hexane, making this research an important preliminary contribution.

Anti-termite Bioactivity. The anti-termite bioactivity test was assessed based on termite mortality and weight loss of the test paper during the 21-day trial. Termite mortality reflects the effectiveness of the extract; higher mortality indicates stronger bioactive potential.

Two controls were used: a positive control (commercial anti-termite product containing imidacloprid/OAK) and negative controls (0% control, paper discs with only *n*-hexane, and paper discs with only DMSO). N-hexane was used because *C. odollam* extracts in this solvent cannot dissolve directly in DMSO. Extract concentrations of 1.25%, 2.5%, and 5% were tested (Figures 2–5).

The results showed that the highest mortality (97.33%) occurred in termites treated with *C. odollam* leaf extract using acetone solvent at 5%, followed by ethanol (94%) and *n*-hexane (90%) (Figure 2). The positive control showed 100% mortality, confirming maximum effectiveness. These findings demonstrate that *C. odollam* leaf extract has high toxic potential and could be developed into a natural termite control agent.

The high mortality in the positive control is due to imidacloprid, a neonicotinoid insecticide known to cause >90% mortality at low doses by binding to nicotinic acetylcholine receptors, causing paralysis and death within 24–48 hours.

Statistical analysis showed that solvent variation had a greater effect than concentration variation. Duncan's test indicated that acetone and ethanol resulted in the highest mortality, particularly at 5%. Increasing extract concentration (1.25% → 5%) increased mortality, indicating higher amounts of dissolved bioactive compounds.

The effectiveness of *C. odollam* leaf extract is linked to the presence of alkaloids, flavonoids, steroids, and saponins—compounds toxic to insects. These compounds disrupt the termite nervous system and kill symbiotic protozoa responsible for cellulose digestion (Maharana et al., 2021; Saxena et al., 2022).

C. odollam also contains cardiac glycosides such as neriifolin, tanghinin, monoacetylneriifolin, and 2'-O-acetyl cerleaside A, which disrupt neurosecretion and ion regulation (Rahman et al., 2017). These compounds inhibit Na^+/K^+-ATPase in insect nerve and heart tissues, leading to dysfunction and death (Sholahuddin et al., 2018; Saxena et al., 2022 and; Ilmiawati et al., 2024).

Bioactivity of Fruit Peel Extract. Mortality patterns differed from the leaf extract. Fruit peel extract with ethanol at 2.5% and 5% concentrations caused 100% mortality, followed by acetone (98%–98.67%) (Figure 3). Negative controls (*n*-hexane and DMSO) showed lower mortality than the 0% control (34%). Mortality

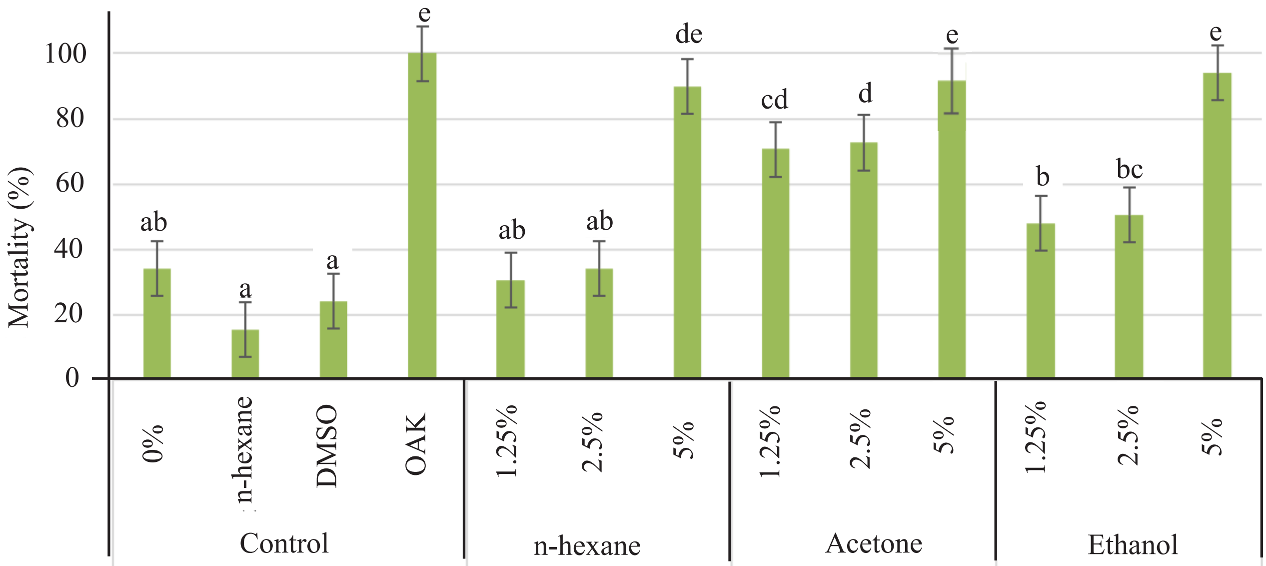

Figure 2. Mortality of *C. curvignathus* termites after treatment with *C. odollam* leaf extract at various concentrations. 0%= Without extract and solvent; DMSO= Dimethyl sulfoxide; OAK= Commercial anti-termite product. Different letters indicate significantly different results ($p < 0.05$) based on the Duncan test.

below 55% in the 0% control is still acceptable (Harsono, 2016).

ANOVA and Duncan's test showed that fruit peel extracts using ethanol (2.5%–5%) and acetone (1.25%–5%) produced significantly higher mortality. Increasing concentration increased mortality. Fruit peel extracts therefore demonstrate strong potential for termite control.

The high toxicity of *C. odollam* fruit peel extract is thought to be due to the presence of secondary metabolites such as alkaloids, phenolics, steroids, and saponins detected in the extract. According to Ilmiawati et al. (2024), these compounds have the potential to act as insecticides or pesticides. Phenolic compounds, for example, are known to inhibit the activity of insect digestive enzymes and damage the symbiotic microflora in the termite digestive tract. When these symbiotic protozoa die due to exposure to toxic compounds from the extract, the termite's digestive system becomes disrupted, preventing it from digesting cellulose optimally and depriving it of the energy needed for survival (Nandika et al., 2015). Furthermore, Chan et al. (2016) reported the presence of active metabolites in *C. odollam,* specifically cardenolide compounds such as cerberin, cerberoside, and odollin. These compounds are classified as highly toxic cardiac glycosides. Exposure to these compounds can disrupt ion balance in cells, ultimately leading to cardiac arrhythmias, cardiac arrest, and even death in organisms exposed to sufficiently high dosess (Dewi et al., 2018).

Weight Loss Analysis. In this study, another parameter used to demonstrate termiticidal activity was the weight loss of the filter paper. Weight loss indicates the extent of termite consumption of the test paper. A higher percentage of weight loss reflects lower anti-termite effectiveness, whereas a lower weight loss percentage indicates higher extract toxicity.

The results showed that *C. odollam* lleaf extract dissolved in acetone at a concentration of 5% resulted in the smallest weight loss percentage, at 7.65%. This value indicates that the extract had the highest toxicity because it caused a decrease in food consumption by termites. In contrast, at the same concentration (5%), the *n*-hexane and ethanol extracts produced weight losses of 8.95% and 10.97%, respectively. The complete weight loss values are presented in Figure 4.

The lower the weight loss percentage of the test paper, the higher the toxicity of the extract. More toxic extracts tend to cause termites to avoid and reduce consumption of the treated food source (Arbaiatusholeha et al., 2016). Compared with the controls, the positive control showed the lowest weight loss among all controls, while the DMSO control exhibited the highest weight loss. This is due to the highly hygroscopic nature of DMSO, which easily attracts and retains water molecules and organic compounds from the surrounding environment into the test paper. As a result, the volume of cellulose fibers increases because more DMSO molecules are adsorbed between the hydrogen bonds in the cellulose fibril structure, even after drying. This condition leads to a higher final weight of the paper compared with the other controls (Cao et al., 2015).

Based on the analysis of variance, the weight

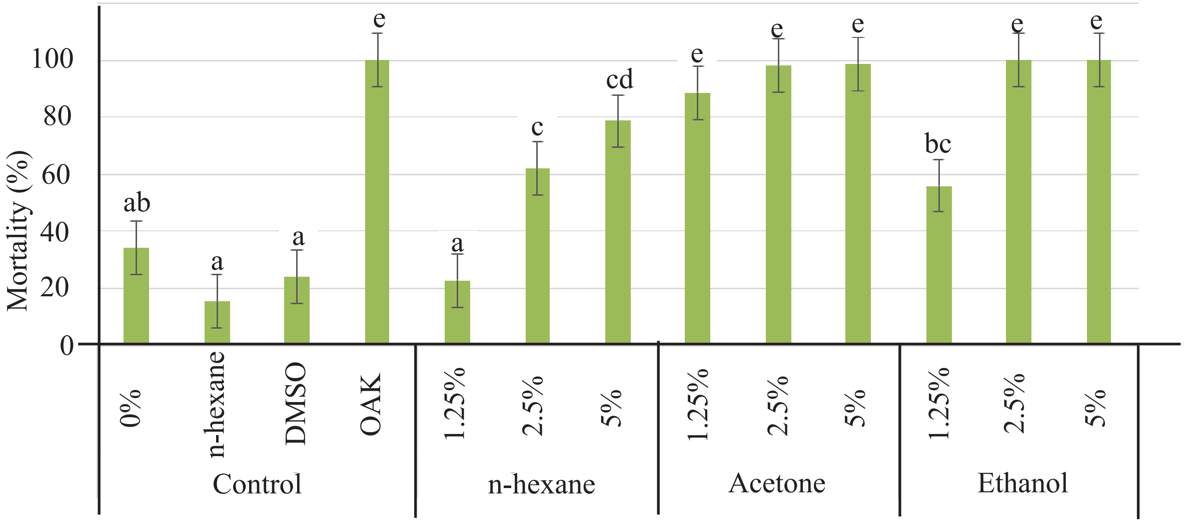

Figure 3. Mortality of *C. curvignathus* termites after treatment with *C. odollam* fruit peel extract at various concentrations. 0%= Without extract and solvent, DMSO= Dimethyl sulfoxide, OAK= Commercial anti-termite product. Different letters indicate statistically significant differences ($p<0.05$) according to Duncan's test.

loss of the test paper treated with *C. odollam* leaf extract using different solvents had a p-value of 0.06, which is close to the significance level ($p < 0.05$). This indicates that solvent variation has a potential influence, although it is not statistically significant at $\alpha = 0.05$. Meanwhile, extract concentration resulted in a p-value of 0.15, which was also not significant ($p > 0.05$). The results of the Duncan test also showed that the percentage of weight loss in test papers treated with *C. odollam* leaf extract using *n*-hexane (2.5% and 5%), acetone, and ethanol at concentrations of 1.25% to 5% did not differ significantly.

Although the differences were not statistically significant, the graphical trend clearly shows that the *C. odollam* leaf extract prepared with acetone at 5% resulted in the lowest paper weight loss. The association between the low percentage of paper weight loss and the high level of termite mortality indicates that the extract's effectiveness remains biologically relevant. This finding suggests that the extract has a substantial toxic effect, causing termite mortality and reducing termite feeding on the test paper.

The weight loss of the test paper treated with *C. odollam* fruit peel extract also showed varying results. Extracts prepared with acetone at concentrations of 2.5% and 5% produced the lowest weight losses—4.55% and 4.22%, respectively. Extracts prepared with ethanol also resulted in relatively low weight loss at 2.5% and 5%, with values of 6.61% and 7.32%. In contrast, extracts dissolved in *n*-hexane showed much higher weight losses, all above 10%. Complete weight loss values are presented in Figure 5.

These results indicate that solvent variation, as well as extract concentration, significantly affects weight loss. Medium-polar acetone (dielectric constant ~21) is effective at extracting medium-polar compounds such as phenolics, flavonoids, and terpenoids, which are known to have antifeedant effects on termites, thereby significantly reducing consumption of the test paper. The condition of the consumed test paper is shown in Figure 6.

Overall, this study provides strong evidence that *C. odollam* extract—particularly those prepared with acetone and ethanol solvents—has the potential to serve as an effective natural alternative for controlling *C. curvignathus*. The use of this extract in pest management may offer a more environmentally friendly and sustainable solution for the agricultural sector, reducing reliance on chemical pesticides that often have negative impacts on ecosystems and human health.

CONCLUSION

Leaf and fruit peel extracts of *Cerbera odollam* demonstrated strong potential as natural anti-termite agents, with their effectiveness influenced by solvent type and extract concentration. The highest extract yield from leaves was obtained using ethanol (9.52%), whereas the highest yield from fruit peel was obtained using *n*-hexane (3.79%). Phytochemical screening revealed the presence of alkaloids, flavonoids,

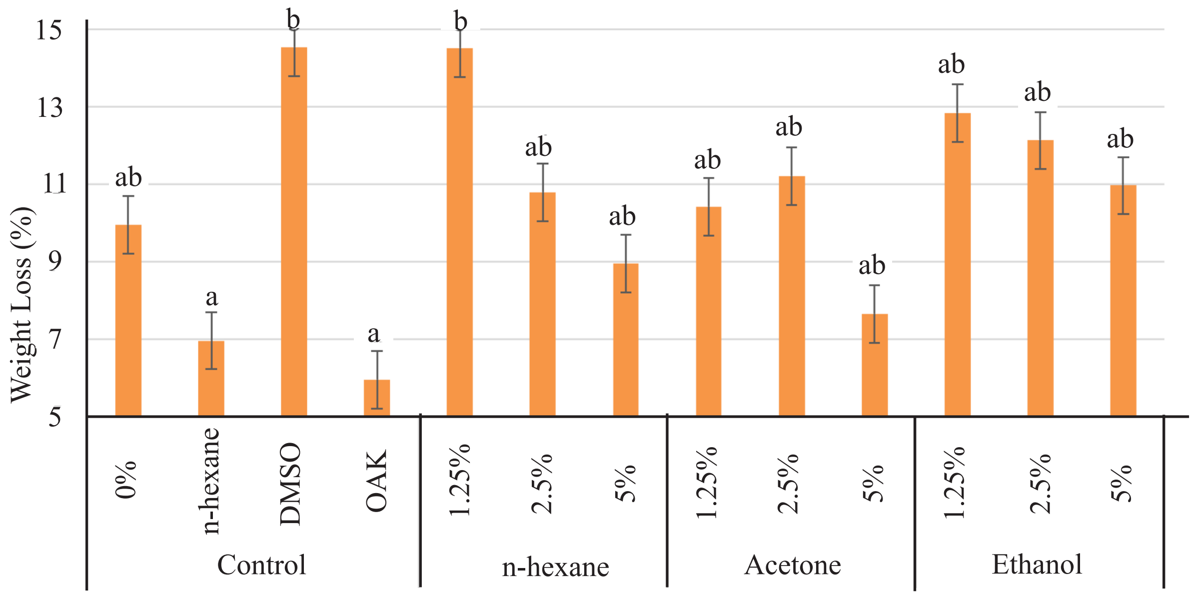

Figure 4. Loss of weight of the test paper after being given *C. odollam* leaf extract with various concentrations. 0%= without extract and solvent; DMSO= Dimethyl sulfoxide; OAK= Commercial anti-termite product. Different letters indicate statistically significant differences ($p<0.05$) according to Duncan's test.

phenolics, steroids, and saponins in both extracts. Bioactivity tests showed the highest termite mortality in leaf extracts prepared with acetone (97.33%) and fruit peel extracts prepared with ethanol (100%) at a concentration of 5%. Weight-loss analysis of filter paper also indicated the highest toxicity in extracts prepared using acetone. These results confirm that *C. odollam* extracts have strong potential as natural termiticides, with acetone and ethanol being the most effective solvents. However, further studies are needed to evaluate the performance of the extracts in the termite gut and to identify specific bioactive compounds responsible for anti-termite activity. Additionally, assessing the potential environmental toxicity and impacts on non-target organisms is essential to ensure the safe future application of these extracts.

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AUTHORS' CONTRIBUTIONS

AI, A, and IB designed and planned the experiment. UM conducted the experiment (extraction and termiticidal activity testing), collected data, analyzed the data, and prepared the manuscript. AI, GS, and IB supervised the extraction and phytochemical analysis. AI and A supervised the termiticidal activity testing and contributed to manuscript editing. All authors provided input on research flow, data analysis, interpretation, and manuscript structure. All authors have read and approved the final manuscript.

COMPETING INTEREST

The authors declare that they have no known competing financial or non-financial interests, and no professional or personal relationships that could influence the work submitted for publication.

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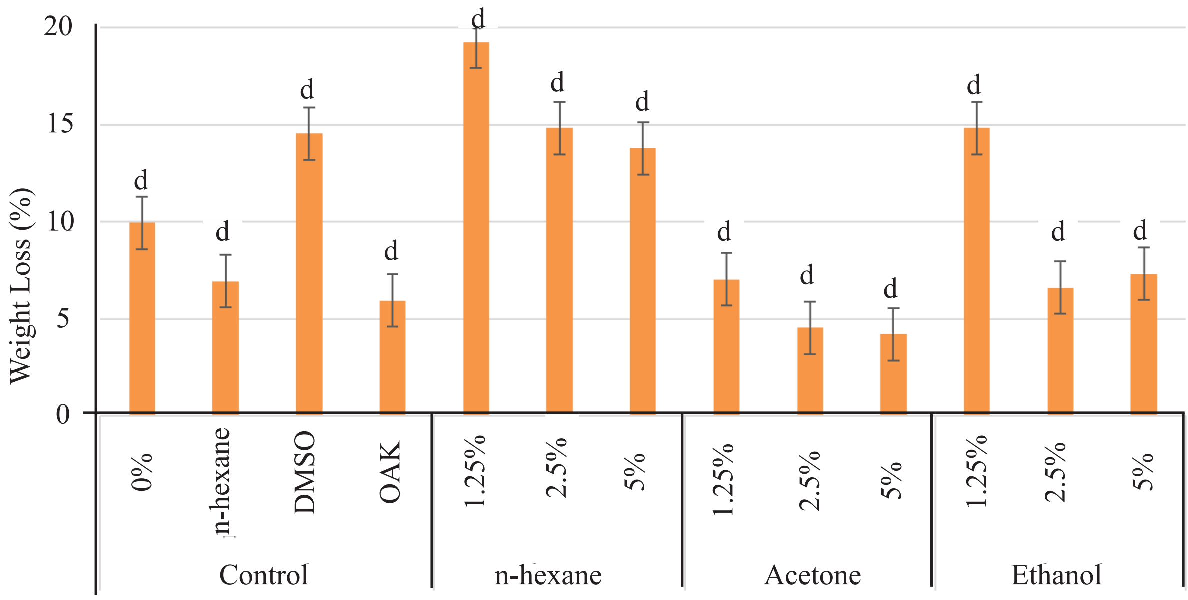

Figure 5. Loss of weight of the test paper after treatment with *C. odollam* fruit peel extract at various concentrations. 0%= Without extract and solvent; DMSO= Dimethyl sulfoxide; OAK= Commercial anti-termite product. Different letters indicate statistically significant differences ($p<0.05$) according to Duncan's test.

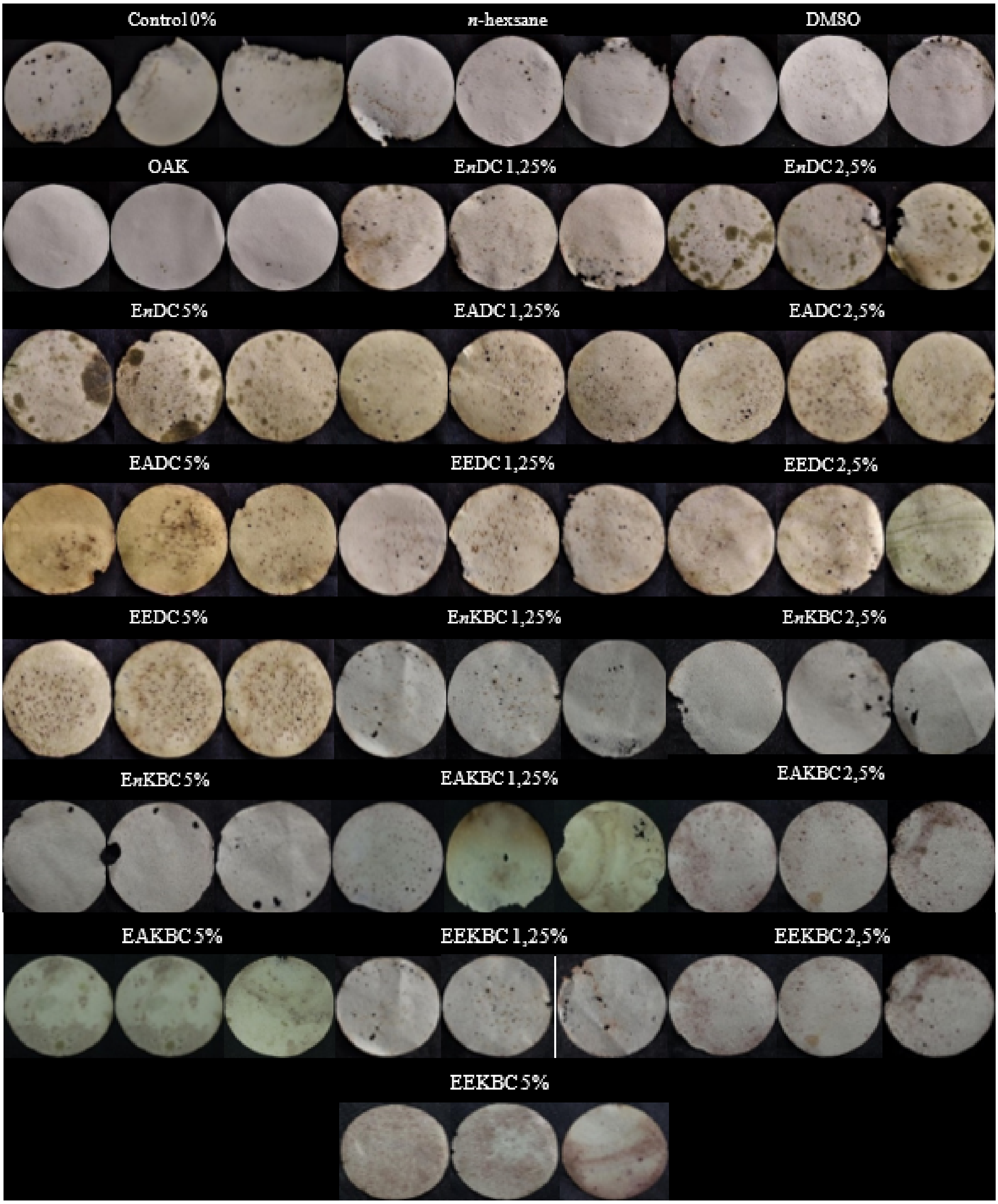

Figure 6. Condition of the test paper after testing. 0%= Without extract and solvent; DMSO=: Dimethyl sulfoxide; OAK= Commercial anti-termite product; EnDC= *n*-hexane extract of *C. odollam* leaves; EADC= Acetone extract of *C. odollam* leaves; EEDC= Ethanol extract of *C. odollam* leaves; EnKBC= *n*-hexane extract of *C. odollam* fruit peel; EAKBC= Acetone extract of *C. odollam* fruit peel; EAKBC= Acetone extract of *C. odollam* fruit peel; EEKBC= Ethanol extract of *C. odollam* fruit peel; Extract concentration= 1.25%, 2.5%, and 5%.

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