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Phytochemical Profile of Makila (*Litsea angulata*) Wood Extracts and Their Potential for Bio-Based Wood Preservation against Subterranean Termites

(Profil Fitokimia Ekstrak Kayu Makila (Litsea angulata) dan Potensinya sebagai Bahan Pengawet Kayu Hayati terhadap Rayap Tanah)

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ABSTRACT

Subterranean termites pose a substantial threat to wood durability in tropical environments, highlighting the need to investigate sustainable, plant-derived wood-protection agents. This study characterised the qualitative phytochemical profiles of Makila (Litsea angulata) wood extracts obtained from basal, middle and upper stem sections and evaluated treatment-associated responses in meranti and samama wood following field exposure. Methanolic extracts were subjected to qualitative phytochemical screening, while treated and untreated wood specimens underwent a 30-day field graveyard test. Final oven-dry mass was evaluated descriptively and using separate one-way analyses of variance for each wood species. Saponins, tannins, alkaloids, triterpenoids and phenolic compounds were detected in all stem sections. Flavonoids were detected only in basal and middle sections, whereas steroids were not detected. No statistically significant differences in final oven-dry mass were observed among meranti treatments ($p > 0.05$). In contrast, samama exhibited significant between-treatment differences ($p < 0.05$), with the highest mean final mass recorded for specimens treated with upper-stem extract (69.49 g), compared with 51.59 g in untreated controls. These findings demonstrate stem-position-related variation in qualitative phytochemical detection and contrasting treatment-associated responses between the two wood substrates. Nevertheless, differences in final mass cannot independently establish preservative efficacy without accounting for initial specimen mass and potential treatment retention. Further investigations incorporating normalised mass loss, quantitative phytochemical characterisation and direct termite bioassays are therefore required. Makila wood extracts represent promising candidates for further investigation as locally sourced bio-based wood-protection agents.

KEYWORDS*: *Litsea angulata; phytochemical screening; natural wood preservatives; subterranean termites; wood durability

INTISARI

Serangan rayap tanah merupakan salah satu faktor utama yang mengancam keawetan kayu di lingkungan tropis sehingga diperlukan penelitian mengenai bahan perlindungan kayu

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berbasis sumber daya hayati. Penelitian ini bertujuan mengkarakterisasi profil fitokimia kualitatif ekstrak kayu Makila (*Litsea angulata*) berdasarkan posisi batang, yaitu pangkal, tengah, dan atas, serta mengevaluasi respons kayu meranti dan samama terhadap perlakuan ekstrak setelah paparan lapangan. Ekstrak metanol dianalisis melalui skrining fitokimia kualitatif, sedangkan spesimen kayu yang diberi perlakuan dan kontrol tanpa perlakuan diuji menggunakan metode graveyard test selama 30 hari. Massa kering oven akhir dianalisis secara deskriptif dan menggunakan analisis ragam satu arah (ANOVA) secara terpisah untuk setiap jenis kayu. Hasil penelitian menunjukkan bahwa saponin, tanin, alkaloid, triterpenoid, dan senyawa fenolik terdeteksi pada seluruh posisi batang. Flavonoid hanya terdeteksi pada bagian pangkal dan tengah, sedangkan steroid tidak terdeteksi. Kayu meranti tidak menunjukkan perbedaan massa akhir yang signifikan antarperlakuan ($p>0,05$). Sebaliknya, kayu samama menunjukkan perbedaan signifikan antarperlakuan ($p<0,05$), dengan rerata massa akhir tertinggi pada perlakuan ekstrak bagian atas batang sebesar 69,49 g, dibandingkan 51,59 g pada kontrol tanpa perlakuan. Temuan ini mengindikasikan variasi deteksi fitokimia berdasarkan posisi batang serta perbedaan respons terhadap perlakuan antara kedua jenis kayu. Namun, perbedaan massa akhir belum dapat digunakan sebagai bukti langsung efektivitas pengawetan tanpa mempertimbangkan massa awal spesimen dan kemungkinan retensi bahan perlakuan. Penelitian lanjutan diperlukan untuk mengevaluasi persentase kehilangan massa, karakteristik fitokimia kuantitatif, serta aktivitas biologis ekstrak melalui pengujian rayap secara langsung. Ekstrak kayu Makila berpotensi diteliti lebih lanjut sebagai kandidat bahan perlindungan kayu berbasis sumber daya lokal.

KATA KUNCI: *Litsea angulata*; skrining fitokimia; bahan pengawet kayu alami; rayap tanah; keawetan kayu.

INTRODUCTION

Wood is an important forest resource widely used in construction, furniture manufacturing, handicrafts and other biomass-based industries (Nursalam, 2016; Santoso, 2024). Its suitability for these applications depends not only on its mechanical and aesthetic properties but also on its resistance to biological deterioration (Diah & Husni, 2017; Rudiyansyah *et al*., 2025). Subterranean termites are among the principal biological agents responsible for wood degradation in tropical environments, where they consume lignocellulosic materials and can substantially reduce the service life of timber products. Species such as *Coptotermes curvignathus* are recognised as economically important wood-destroying pests, although the termite species responsible for deterioration at individual field sites require direct identification. Termite-associated damage can increase maintenance and replacement costs and may compromise structural integrity in timber-based

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applications (Diba, 2016; Syahril *et al*., 2022). The warm and humid environmental conditions prevalent in Indonesia further favour termite activity, emphasising the importance of developing effective and sustainable wood-protection strategies (Aflah *et al*., 2021; Karlina, 2022).

Conventional wood-preservation approaches commonly involve synthetic preservatives and chemical termiticides (Kheng *et al*., 2019; Rismayadi *et al*., 2019). Although these treatments may provide effective protection against biological deterioration, their environmental and health implications depend on chemical composition, application methods, exposure pathways and disposal practices. Potential concerns include contamination of soil and water and adverse effects on non-target organisms (Arinana *et al*., 2024; Manoppo *et al*., 2024). These considerations have encouraged growing interest in plant-derived compounds as potential alternatives or complementary agents for wood protection. Nevertheless, the natural origin of a preservative does not necessarily guarantee its biological effectiveness, environmental compatibility or practical applicability. These characteristics must be established through systematic chemical characterisation and appropriate biological testing.

Plants synthesise a wide range of secondary metabolites that contribute to defence against herbivores, pathogens and other biological stressors (Jonathan *et al*., 2024; Maliana *et al*., 2013). These metabolites include tannins, phenolic compounds, alkaloids, saponins, flavonoids and terpenoids, several of which have been associated with antifeedant, repellent or insecticidal activities in different biological systems (Diba, 2016; Indria *et al*., 2013). Their potential biological functions provide a scientific rationale for investigating plant extracts as candidate wood-protection agents. However, the qualitative detection of a metabolite class does not establish its concentration, biological activity against a particular termite species or contribution to the effectiveness of a crude extract. Consequently, phytochemical screening should be integrated with experimentally measured wood responses while maintaining a clear distinction between the presence of potentially bioactive constituents and demonstrated preservative efficacy.

Makila (*Litsea angulata*), a member of the Lauraceae family, is a locally important timber resource in Maluku, Indonesia (Dominggus Komul, 2023; Siruru & Riupassa, 2021). Wood-processing activities generate sawdust and other lignocellulosic residues that may provide potential feedstocks for recovering extractable secondary metabolites. Previous investigations involving *Litsea* and other plant taxa have reported diverse phytochemical constituents and biological activities, providing a basis for further investigation of Makila wood. The potential utilisation of Makila processing residues may contribute to value-added forest-resource management and circular bioeconomy approaches. However, the technical feasibility, environmental safety and sustainability of such applications require independent evaluation. In particular, the valorisation of existing processing residues should be distinguished from additional timber harvesting undertaken specifically for extract production.

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The chemical composition of wood extractives may vary according to the position of the sampled material within a tree stem. Differences between basal, middle and upper stem sections may reflect variation in the distribution of extractable constituents, potentially influencing their suitability as sources of bioactive compounds. Nevertheless, information concerning the qualitative phytochemical profiles of Makila wood extracts across stem positions and their association with treated-wood responses under field exposure remains limited. Furthermore, different wood substrates may exhibit contrasting responses to the same extract treatment because of differences in their physical, anatomical and chemical properties. Meranti and samama therefore provide relevant substrates for exploring treatment-associated variation, although the contribution of substrate characteristics cannot be established without direct measurements of wood density, permeability, extract uptake and retention.

These considerations identify two interrelated research gaps: the limited characterisation of stem-position-related phytochemical detection in Makila wood and the insufficient understanding of how Makila extract treatments are associated with post-exposure responses in different wood substrates. Addressing these gaps requires an integrated assessment of extract composition and treated-wood behaviour while distinguishing preliminary treatment responses from definitive evidence of biological protection.

Accordingly, this study aimed to characterise the qualitative phytochemical profiles of methanolic Makila wood extracts obtained from basal, middle and upper stem sections and to compare the final oven-dry masses of untreated and extract-treated meranti and samama specimens following a 30-day field graveyard test. The study further examined whether treatment-associated response patterns differed between the two wood substrates. By integrating qualitative phytochemical screening with field-exposure measurements, the research provides preliminary evidence relevant to selecting extract sources and designing subsequent wood-preservation experiments. Because final post-exposure mass alone cannot quantify termite-induced deterioration independently of initial specimen mass, definitive conclusions concerning improved wood resistance require normalised mass-loss analysis and direct biological validation. The findings are therefore intended to support further investigation of Makila-derived wood-protection agents and the responsible utilisation of locally available forest resources.

MATERIALS AND METHODS

Study Area and Research Period

The study was conducted in July 2025 in Maluku Province, Indonesia. Makila (*Litsea angulata*) wood samples were collected from Kawa Village, West Seram Regency. Sample preparation and sawdust production were undertaken in Poka Village, Ambon City, while extraction and qualitative phytochemical screening were performed at the Basic Chemistry Laboratory, Pattimura University,

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Ambon. The field exposure experiment was conducted at a site with established subterranean termite activity. The geographical location of Makila wood collection is presented in **Figure 1**.

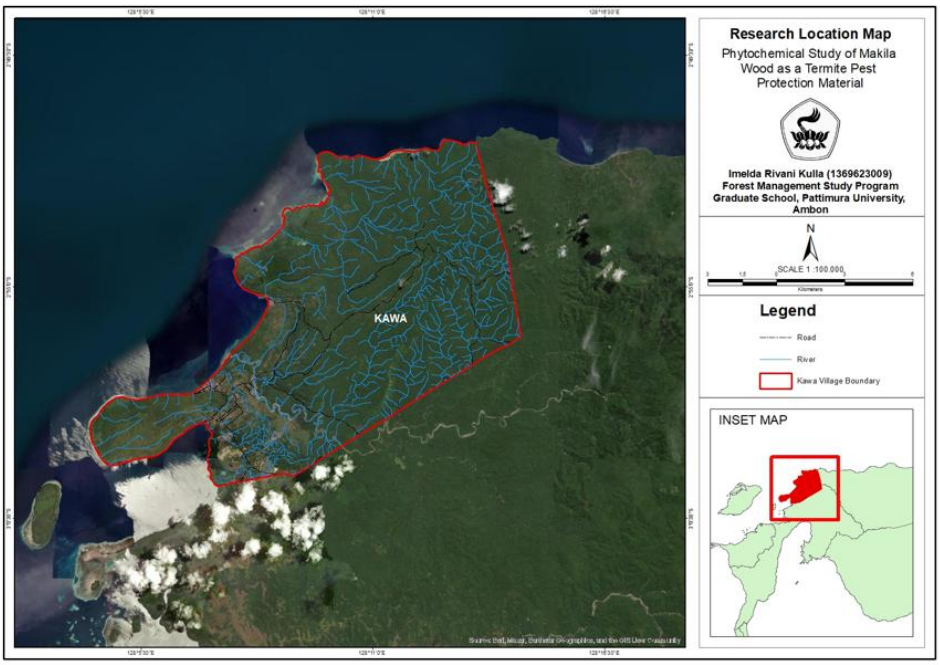


Figure 1. Location of Makila (*Litsea angulata*) wood sample collection in Kawa Village, West Seram Regency, Maluku Province, Indonesia.

Materials and Equipment

The principal experimental material consisted of Makila wood collected from three stem positions: basal, middle and upper sections. Sawdust prepared from these sections was used for extraction, while meranti and samama wood served as substrates for evaluating treatment-associated responses under field exposure. Methanol was employed as the extraction solvent, and appropriate chemical reagents were used for qualitative detection of saponins, tannins, alkaloids, triterpenoids, phenolic compounds, flavonoids and steroids. The principal equipment included a drying oven, grinder, sieve, analytical balance, measuring cylinders, test tubes, filtration apparatus, rotary evaporator and standard laboratory glassware.

Experimental Design

The experiment evaluated three Makila wood-extract treatments and an untreated control in two wood substrates, meranti and samama. The extract treatments corresponded to material obtained from the basal, middle and upper stem sections. Four treatment groups were established for each wood species: untreated control, basal-section extract, middle-section extract and upper-section extract. Each group comprised three replicate wood specimens, resulting in 12 specimens per wood species and 24 specimens in total. Treatment-associated differences were evaluated separately within each wood species to avoid interpreting differences in their inherent wood characteristics as treatment effects.

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Preparation of Makila Wood Samples

Makila wood samples were collected from the basal, middle and upper stem sections and processed separately to maintain their sampling identities. The samples were debarked and converted into sawdust, which was subsequently oven-dried and sieved to obtain a relatively uniform particle fraction. Materials from different stem positions were labelled and stored separately throughout sample preparation, extraction and phytochemical screening to minimise cross-contamination.

Preparation of Makila Wood Extracts

Crude Makila wood extracts were prepared separately from the three stem sections using methanolic maceration. For each stem position, 50 g of dried sawdust was immersed in 1 L of methanol, corresponding to a solid-to-solvent ratio of 1:20 (w/v). Maceration was performed for three days at room temperature with periodic agitation to facilitate the extraction of solvent-soluble constituents. The mixtures were then filtered to separate the liquid extracts from residual wood particles. The filtrates were concentrated using a rotary evaporator to remove the extraction solvent and obtain crude extracts. Extracts from the three stem positions were maintained in separate, labelled containers until phytochemical screening and preparation of the wood-treatment solutions.

Qualitative Phytochemical Screening

Qualitative phytochemical screening was performed separately on Makila wood extracts from the basal, middle and upper stem sections. Seven secondary-metabolite groups were examined: saponins, tannins, flavonoids, alkaloids, steroids, triterpenoids and phenolic compounds. Detection was based on characteristic diagnostic reactions associated with the corresponding qualitative assays. Saponins were assessed through persistent foam formation, tannins and phenolic compounds through characteristic colour reactions, and alkaloids through precipitate formation. Flavonoids, steroids and triterpenoids were assessed using their respective diagnostic colour reactions.

The screening results were classified as positive (+) when the specified diagnostic reaction was observed and negative (−) when no positive reaction was detected. These classifications represented qualitative analytical observations rather than measurements of metabolite concentration. Consequently, variations in colour appearance or reaction intensity were not interpreted as quantitative differences in phytochemical abundance.

Preparation of Wood Test Specimens

Meranti and samama wood specimens were prepared to dimensions of 2 cm × 2 cm × 30 cm. A total of 24 specimens were used, comprising 12 meranti and 12 samama specimens. Within each wood species, nine specimens were assigned to the three Makila extract treatments, with three replicates per treatment, while the remaining three specimens served as untreated controls.

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Before treatment and field exposure, the specimens were oven-dried to constant mass and weighed using an analytical balance to determine their initial oven-dry mass (W_i). The extract-treated specimens were then assigned to their respective treatment groups. The available methodological record does not specify the application concentration, treatment duration or extract retention, and these parameters therefore require verification against the original experimental records.

Field Graveyard Test

The treated and untreated wood specimens were subjected to a 30-day field graveyard test at a site with established subterranean termite activity. Each specimen was installed vertically in the soil to a depth of approximately 20 cm, leaving approximately 10 cm above the soil surface. The specimens were arranged according to the experimental layout and labelled to maintain treatment identity throughout field exposure. After 30 days, the specimens were carefully excavated and cleaned to remove adhering soil and debris while avoiding unnecessary removal of intact wood material. They were subsequently oven-dried at 104 ± 5°C until constant mass was achieved and weighed to determine their final oven-dry mass (Wf). The resulting measurements provided the basis for describing post-exposure responses among treatment groups.

Measurement and Interpretation of Wood Mass

Initial and final oven-dry masses were defined as Wi and Wf, respectively. Where paired measurements are available, percentage mass loss can be calculated using Equation (1):

$$Mass\ Loss\ (\%) = \frac{W_i - W_f}{W_i}\ x\ 100 \qquad (1)$$

Where:

W_i = the initial oven-dry mass of the specimen before field exposure (g);

W_f = the final oven-dry mass after field exposure (g).

The results reported in this study are based on final oven-dry mass rather than specimen-level percentage mass loss. Accordingly, final mass was interpreted as a post-exposure response variable and not as an independent measure of termite-induced deterioration. Evaluation of preservative efficacy requires paired initial and final mass measurements, together with consideration of treatment uptake and retention.

Statistical Analysis

Quantitative observations were summarised using treatment means and standard deviations. Differences in final oven-dry mass among the four treatment groups were evaluated separately for meranti and samama using one-way analysis of variance (ANOVA) at a significance level of α = 0.05. The reported analysis was interpreted as an assessment of between-treatment variation in post-exposure mass rather than a direct test of preservative efficacy.

Statistical significance was evaluated using the reported ANOVA outcomes. Where an overall treatment effect was significant, identification of specific differences between treatment groups would require an appropriate *post-hoc* multiple-comparison procedure. The interpretation of

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statistical findings was restricted to the response variable analysed, the experimental replication and the limitations of the available measurements.

RESULTS AND DISCUSSION

Phytochemical Profile of Makila Wood Extracts

Qualitative phytochemical screening identified six detectable classes of secondary metabolites in Makila (*Litsea angulata*) wood extracts, with differences in detection patterns among the basal, middle and upper stem sections. Saponins, tannins, alkaloids, triterpenoids and phenolic compounds were consistently detected across all three stem positions, whereas flavonoids were detected only in basal and middle sections. Steroids were not detected in any of the examined extracts (**Table 1**). These findings indicate that Makila wood contains a broadly consistent qualitative phytochemical profile, with stem-position-related variation primarily associated with flavonoid detection.

Table 1. Qualitative detection of secondary metabolites in Makila (*Litsea angulata*) wood extracts according to stem position.

Metabolite	Base (B)	Middle (M)	Top (T)	Diagnostic Reaction	Interpretation
Saponins	+	+	+	Stable foam	Detected in all stem sections
Tannins	+	+	+	Dark green to greenish-brown	Detected in all stem sections
Flavonoids	+	+	−	Dark red (B–M); dark brown (T)	Detected in base and middle sections only
Alkaloids	+	+	+	Brown precipitate	Detected in all stem sections
Steroids	−	−	−	No positive reaction	Not detected
Triterpenoids	+	+	+	Red (B–M); yellow (T)	Detected in all stem sections
Phenolic compounds	+	+	+	Dark green to greenish-brown	Detected in all stem sections

Source: *Laboratory analysis, 2025.*
Note: Positive (+) and negative (−) results indicate the presence or absence of the specified diagnostic reaction under the analytical conditions employed. Qualitative colour differences should not be interpreted as quantitative differences in metabolite concentration.

The detection of multiple secondary-metabolite classes provides a relevant chemical basis for investigating Makila extracts as potential bio-based wood-protection agents. Tannins and phenolic compounds have been associated with plant defence mechanisms involving protein interactions and reduced palatability, while saponins, alkaloids and terpenoid compounds encompass constituents with potentially relevant biological activities (Akasia *et al*., 2021; Jonathan *et al*., 2024). Nevertheless, the detection of these compound classes does not establish their concentrations, chemical identities or activity against subterranean termites. Their relevance to wood preservation must therefore be regarded as a rationale for further biological investigation rather than direct evidence of preservative efficacy.

The qualitative diagnostic reactions further supported the classification of the detected metabolites. Persistent foam formation was associated with saponin detection, characteristic colour reactions supported the identification of tannins and phenolic compounds, and precipitate formation

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indicated the presence of alkaloids. Differences in diagnostic colour responses were also observed among stem positions, particularly for triterpenoids. However, these observations cannot be interpreted as evidence of differences in metabolite concentration because the assays were not quantitatively calibrated. Furthermore, the specificity of individual colour reactions depends on the reagents and analytical conditions employed.

The frequency of positive detection is presented in **Table 2**. Saponins, tannins, alkaloids, triterpenoids and phenolic compounds were detected in all 27 analytical observations, corresponding to a positive detection frequency of 100%. Flavonoids were detected in 18 observations (66.7%), while steroids were not detected in any observation. Each stem position comprised three independent samples, with three analytical replicates per sample. Accordingly, the reported frequencies describe the occurrence of positive analytical reactions rather than the abundance of metabolites or the number of independent biological samples.

Table 2. Frequency of positive phytochemical detection across analytical observations of Makila (*Litsea angulata*) wood extracts.

Metabolite	Positive Detection (Base, n = 9)	Positive Detection (Middle, n = 9)	Positive Detection (Top, n = 9)	Total Positive (n = 27)	Positive Frequency (%)
Saponins	9	9	9	27	100.0
Tannins	9	9	9	27	100.0
Flavonoids	9	9	0	18	66.7
Alkaloids	9	9	9	27	100.0
Steroids	0	0	0	0	0.0
Triterpenoids	9	9	9	27	100.0
Phenolic compounds	9	9	9	27	100.0

Source: *Laboratory analysis, 2025.*
Note: *Each stem position comprised three independent samples analysed in triplicate, yielding nine analytical observations per position and 27 observations in total. Detection frequencies describe analytical occurrence and do not represent metabolite concentration or independent biological replication.*

The qualitative detection patterns are illustrated in **Figures 2** and **3**. **Figure 2** presents the binary detection profile across stem positions, while **Figure 3** summarises the overall frequency of positive analytical reactions. Together, these visualisations demonstrate the consistent detection of five metabolite classes and the restricted detection of flavonoids in the basal and middle stem sections. However, these results do not establish statistically significant differences in phytochemical composition among stem positions, nor do they indicate quantitative differences in extract potency.

An important observation is that flavonoids were not detected in the upper-stem extract, although this treatment subsequently yielded the highest mean final oven-dry mass in samama wood. This finding indicates that flavonoid detection alone cannot explain the observed post-exposure mass pattern. Other extract constituents, differences in their concentrations, interactions among metabolite classes or variation in treatment uptake may have contributed to the response. Because these factors were not quantified, their individual or combined contributions remain unresolved.

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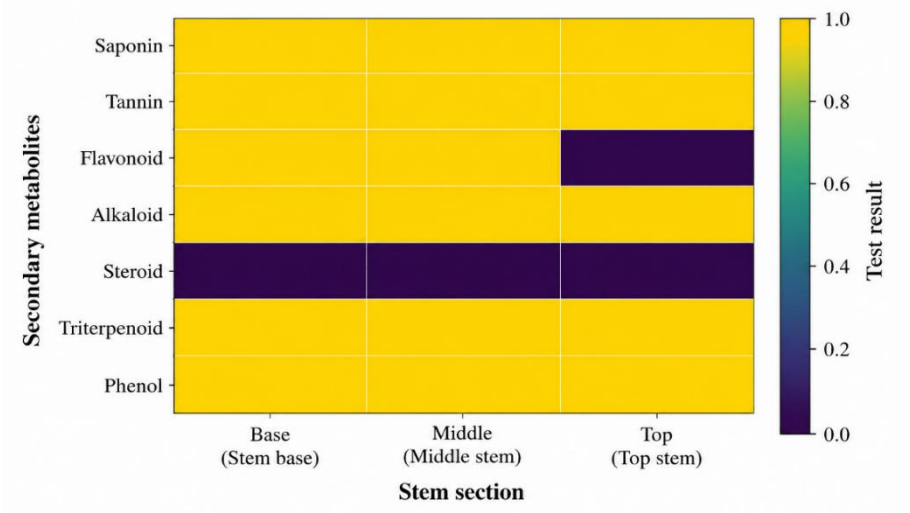


Figure 2. Binary qualitative detection profile of secondary metabolites in Makila (*Litsea angulata*) wood extracts across basal, middle and upper stem sections (1 = detected; 0 = not detected).

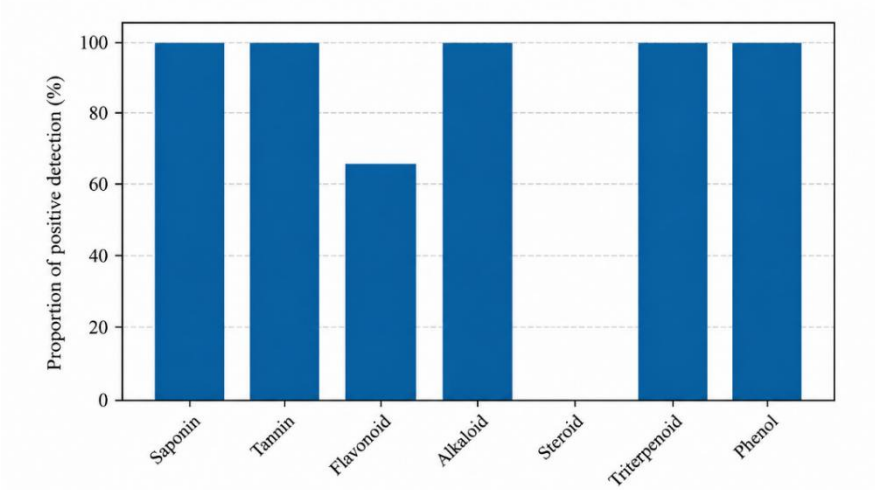


Figure 3. Overall frequency of positive analytical detection of secondary metabolites in Makila (*Litsea angulata*) wood extracts.

Overall, the phytochemical findings identify Makila wood as a source of several detectable secondary-metabolite classes potentially relevant to biological wood protection. The principal contribution of this analysis is the identification of qualitative detection patterns across stem positions, providing a preliminary basis for subsequent quantitative chemical characterisation, targeted compound identification and direct biological evaluation.

Post-Exposure Response of Wood to Subterranean Termite Exposure

The responses of meranti and samama wood to Makila extract treatments were evaluated using final oven-dry mass following a 30-day field graveyard test. Four treatment groups were examined within each wood species: untreated control and specimens treated with extracts obtained from the basal, middle and upper stem sections. Treatment means, standard deviations, relative differences from the untreated controls and 95% confidence intervals are presented in **Table 3**.

Final oven-dry mass provides a descriptive measure of specimen mass after field exposure. However, its interpretation as an indicator of wood preservation requires caution because final mass

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is influenced by the initial mass of each specimen and potentially by the retention of treatment materials. Consequently, the comparisons presented here describe treatment-associated differences in post-exposure mass rather than directly quantified reductions in termite-induced deterioration.

Treatment Response in Meranti Wood

Meranti wood exhibited broadly comparable final oven-dry masses among the three extract treatments and the untreated control. Mean final masses were 34.16 g for the basal-section treatment, 36.09 g for the middle-section treatment and 32.35 g for the upper-section treatment, compared with 36.82 g for the untreated control (**Table 3**). Relative to the control, these values corresponded to approximately 7.23%, 1.98% and 12.14% lower mean final masses, respectively.

Table 3. Final Oven-Dry Mass of Meranti and Samama Wood Following the 30-Day Field Graveyard Test under Different Makila Extract Treatments.

Wood species	Treatment / Stem section	n	Mean (g)	Standard deviation (g)	Relative change from control (%)	95% Confidence interval (Lower–Upper)
Meranti	Base	3	34.16	2.34	−7.23	28.35–39.97
	Middle	3	36.09	5.49	−1.98	22.45–49.73
	Top	3	32.35	1.05	−12.14	29.74–34.96
	Control (untreated)	3	36.82	4.37	0.00	25.97–47.67
Samama	Base	3	61.54	1.47	+19.29	57.89–65.19
	Middle	3	58.47	5.75	+13.34	44.19–72.75
	Top	3	69.49	2.79	+34.69	62.56–76.42
	Control (untreated)	3	51.59	0.99	0.00	49.13–54.05

Note: *Values are expressed as means, standard deviations and 95% confidence intervals (n = 3 per treatment). Relative changes were calculated against the untreated control within each wood species. Positive and negative percentages indicate higher and lower mean final oven-dry masses, respectively, and do not represent changes in termite resistance or percentage mass loss.*
Source: *Basic Chemistry Laboratory, Universitas Pattimura, 2025.*

One-way ANOVA indicated no statistically significant differences in final oven-dry mass among the four meranti treatment groups ($p > 0.05$). Thus, the available data did not provide sufficient statistical evidence of a treatment-associated difference in the measured post-exposure response. Importantly, this result should not be interpreted as proof that Makila extract has no biological activity against subterranean termites, because the experimental replication was limited and the analysis did not directly quantify specimen-level deterioration.

Several factors could potentially influence the observed meranti responses, including variation in initial specimen mass, wood density, anatomical structure, permeability, extract uptake and treatment retention. However, these characteristics were not quantified in the present study and therefore cannot be invoked as established explanations. The findings instead indicate that the evaluated extract treatments did not produce statistically detectable differences in final mass under the experimental conditions. The treatment means and associated 95% confidence intervals are illustrated in **Figure 4**. These results provide a preliminary basis for further investigation of treatment concentration, extract penetration, retention and normalised mass loss in meranti wood.

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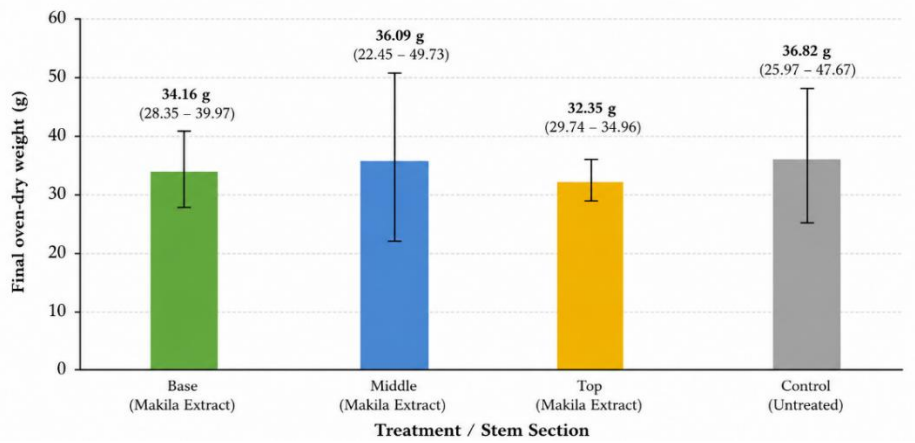


Figure 4. Mean final oven-dry mass of Meranti wood after the 30-day graveyard test under different Makila extract treatments. Error bars represent 95% confidence intervals.

Treatment Response in Samama Wood

Samama exhibited a contrasting pattern of final oven-dry mass following field exposure. All extract-treated groups had higher mean final masses than the untreated control. Mean values were 61.54 g for the basal-section treatment, 58.47 g for the middle-section treatment and 69.49 g for the upper-section treatment, compared with 51.59 g for the untreated control (**Table 3**).

The upper-section treatment yielded the highest mean final oven-dry mass, representing a reported relative difference of approximately 34.69% compared with the untreated control. The corresponding differences for the basal- and middle-section treatments were approximately 19.29% and 13.34%, respectively. These percentages describe relative differences in final specimen mass and should not be interpreted as reductions in wood mass loss or increases in termite resistance.

One-way ANOVA indicated statistically significant differences in final oven-dry mass among the samama treatment groups ($p < 0.05$). This result demonstrates that at least one treatment-group mean differed from another under the reported analysis. However, the overall ANOVA result does not identify which specific treatment pairs differed significantly. Consequently, the upper-section treatment can be described as having the highest observed mean final mass, but its statistical superiority over individual treatments or the control cannot be confirmed without appropriate *post-hoc* comparisons.

The higher final masses observed in treated samama specimens may reflect treatment-associated differences, but their interpretation remains dependent on the initial masses and physical characteristics of the specimens. Without specimen-level normalisation and information on extract retention, it is not possible to determine whether the observed differences resulted from reduced biological deterioration, variation in initial wood mass or other treatment-related factors.

Figure 5 illustrates the treatment means and 95% confidence intervals for samama. The findings provide preliminary evidence of between-treatment variation in post-exposure mass and identify the upper-stem extract as a priority for further evaluation. Nevertheless, confirmation of

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preservative efficacy requires paired initial and final oven-dry mass measurements, standardised treatment procedures and direct assessment of termite-related deterioration.

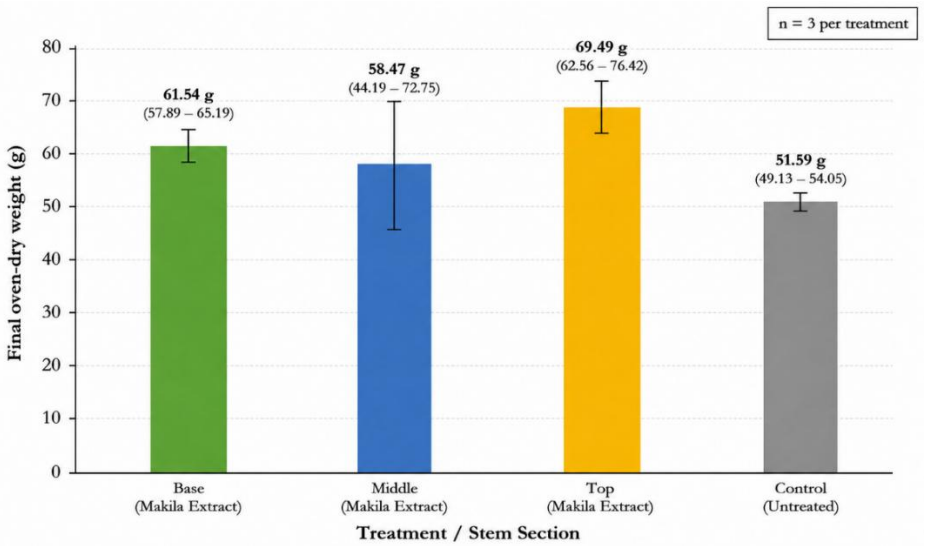


Figure 5. Mean final oven-dry mass of Samama wood after the 30-day graveyard test under different Makila extract treatments. Error bars represent 95% confidence intervals.

Species-Specific Treatment Responses

The two wood substrates exhibited contrasting statistical patterns following treatment with Makila extracts and subsequent field exposure. No statistically significant between-treatment differences in final oven-dry mass were detected in meranti, whereas significant differences were reported among samama treatments. These results indicate that the observed post-exposure mass patterns were not identical across the two wood species.

Differences in wood anatomy, density, porosity, permeability and inherent extractive composition may influence the uptake, distribution and retention of plant-derived treatment materials. Such properties may also affect the exposure of wood constituents to biological deterioration. However, these factors were not directly measured in the present experiment, and their contribution to the observed differences remains hypothetical.

Moreover, the presence of a statistically significant treatment effect in one species and a non-significant effect in another does not, by itself, demonstrate a statistically significant species-by-treatment interaction. Establishing such an interaction would require an appropriate factorial analysis and consideration of initial specimen characteristics. The present findings should therefore be interpreted as contrasting within-species statistical outcomes rather than definitive evidence of different biological treatment efficacy between meranti and samama.

These observations highlight the importance of substrate-specific evaluation when developing bio-based wood-protection agents. Subsequent experiments should incorporate standardised initial specimen properties, extract uptake and retention measurements, normalised percentage mass loss and sufficient replication to evaluate potential interactions between wood species and extract treatments.

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Linking Phytochemical Composition with the Observed Wood Response

The qualitative phytochemical profiles provide a preliminary chemical context for interpreting the treatment-associated responses observed during field exposure. Makila extracts contained detectable saponins, tannins, alkaloids, triterpenoids and phenolic compounds across all stem positions, while flavonoids were detected only in basal and middle sections. Several of these metabolite classes have been associated in previous investigations with biological activities potentially relevant to insect deterrence, feeding inhibition or physiological disruption (Akasia *et al*., 2021; Maliana *et al*., 2013; Jonathan *et al*., 2024).

Tannins and phenolic compounds may interact with proteins and digestive enzymes, potentially influencing the utilisation of lignocellulosic substrates. Saponins have been associated with interactions involving biological membranes, while alkaloids and triterpenoids include compounds exhibiting diverse insect-related biological activities. These reported properties provide plausible hypotheses concerning the potential contribution of Makila extract constituents to wood protection. However, the activities of individual compounds cannot be assumed to occur in the crude extracts at the concentrations applied in this experiment.

The present study did not directly measure termite mortality, feeding intensity, repellency, digestive-enzyme activity, membrane integrity, gut microbial communities or other physiological endpoints. Accordingly, the proposed biological mechanisms remain literature-supported hypotheses rather than experimentally demonstrated causal pathways. The detection of secondary-metabolite classes establishes the chemical rationale for further investigation but does not independently verify their biological effectiveness.

A particularly relevant observation is that the upper-stem extract, in which flavonoids were not detected, yielded the highest mean final oven-dry mass in samama. This pattern indicates that the presence of detectable flavonoids alone cannot account for the observed post-exposure response. Other metabolites, variation in compound concentrations, interactions among constituents or differences in extract uptake may be involved. Nevertheless, these explanations cannot be distinguished using the available qualitative screening and final-mass measurements.

The potential biological activities of the detected metabolite classes are summarised in **Table 4**. These relationships should be interpreted as hypotheses derived from the relevant literature rather than experimentally confirmed mechanisms in Makila-treated wood. Quantitative phytochemical profiling, bioassay-guided fractionation and direct termite-response measurements are required to determine whether specific constituents or combinations of compounds contribute to biological protection. Overall, the integration of phytochemical screening and field-exposure observations identifies promising directions for future research. Its principal contribution is the establishment of preliminary associations between extract-source characteristics and post-exposure wood responses, while recognising that causal relationships between individual metabolites and termite resistance remain unresolved.

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Table 4. Literature-Supported Potential Biological Activities of Secondary Metabolites Detected in Makila (*Litsea angulata*) Wood Extract and Their Relevance to Subterranean Termite Resistance

Metabolite	Detection Pattern	Potential Biological Activity	Potential Effect on Termites	Relevance to Wood Protection
Tannins	Detected in all stem sections	Protein and digestive-enzyme binding	May reduce digestive efficiency and utilisation of lignocellulosic substrates	Potential reduction in wood consumption
Phenolic compounds	Detected in all stem sections	Potential interaction with digestive enzymes and gut-associated microorganisms	May interfere with lignocellulose utilisation and feeding processes	Potential contribution to reduced wood deterioration
Saponins	Detected in all stem sections	Interaction with biological membranes	May alter membrane permeability and physiological processes	Potential contribution to the bioactivity of the extract
Alkaloids	Detected in all stem sections	Diverse insecticidal and physiological activities	May interfere with feeding and physiological functions	Potential suppression of termite-associated wood deterioration
Triterpenoids	Detected in all stem sections	Potential repellent and feeding-deterrent activities	May modify termite feeding or contact behaviour	Potential reduction in wood consumption
Flavonoids	Detected in the base and middle sections only	Potential antifeedant and physiological activities	May contribute to reduced palatability or feeding activity	Potential supplementary contribution to wood protection

Source: Interpretation based on the qualitative phytochemical screening conducted in this study and biological activities reported in the cited literature.
Note: The biological activities and effects presented in this table represent literature-supported hypotheses for interpreting the observed responses. These mechanisms were not directly measured in the present study and should not be interpreted as experimentally demonstrated causal pathways.

Implications for Bio-Based Wood Preservation and Forest-Resource Valorisation

The detection of multiple secondary-metabolite classes in Makila wood and the treatment-associated differences observed in samama indicate that Makila extracts warrant further investigation as potential sources of bio-based wood-protection agents. This prospect is particularly relevant to the utilisation of sawdust and other residues generated during timber processing, which may provide locally available feedstocks for the recovery of potentially valuable extractive compounds.

The conversion of wood-processing residues into value-added products could contribute to more efficient forest-resource utilisation and circular bioeconomy approaches. Nevertheless, the sustainability of such applications depends on responsible biomass sourcing, efficient extraction technologies, environmental compatibility and the avoidance of additional harvesting pressures. The present findings therefore provide a preliminary research rationale rather than evidence of technical or commercial feasibility.

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The contrasting treatment-associated responses observed in meranti and samama further emphasise that the potential performance of plant-derived wood preservatives cannot be inferred solely from the qualitative phytochemical composition of their source material. Practical performance is likely to depend on extract concentration, application method, wood permeability, preservative uptake and retention, resistance to leaching, substrate characteristics and biological exposure conditions. These factors should be explicitly incorporated into subsequent experimental designs.

Future research should prioritise the determination of paired initial and final oven-dry masses to calculate normalised percentage mass loss, together with measurements of extract uptake and retention. Quantitative phytochemical characterisation, including total phenolic and flavonoid contents and chromatographic profiling, would provide a more detailed understanding of chemical variation among stem positions. Direct termite bioassays should evaluate mortality, feeding activity and repellency under controlled conditions, while longer-term field trials should assess durability under environmentally relevant exposure conditions.

Additional investigations should address dose–response relationships, preservative penetration, leaching resistance, effects on non-target organisms and environmental safety. Increased biological replication and appropriate factorial experimental designs would also strengthen the statistical evaluation of potential interactions between extract treatments and wood substrates. Taken together, the findings establish a preliminary basis for exploring Makila-derived wood-protection agents while identifying the methodological requirements for subsequent validation. The results support further investigation of locally sourced forest biomass as a potential feedstock for bio-based preservation research, but do not yet establish preservative efficacy, specific biochemical mechanisms or readiness for practical application.

CONCLUSION

This study characterised the qualitative phytochemical profiles of Makila (*Litsea angulata*) wood extracts obtained from basal, middle and upper stem sections and evaluated the post-exposure responses of meranti and samama wood following a 30-day field graveyard test. Saponins, tannins, alkaloids, triterpenoids and phenolic compounds were consistently detected across all stem positions, whereas flavonoids were detected only in basal and middle sections and steroids were not detected. These findings demonstrate a broadly consistent qualitative phytochemical profile, with stem-position-related variation in flavonoid detection. The field experiment revealed contrasting treatment-associated responses between the two wood substrates. No statistically significant differences in final oven-dry mass were detected among meranti treatments ($p > 0.05$), whereas significant between-treatment differences were observed in samama ($p < 0.05$). The upper-stem extract treatment yielded the highest mean final oven-dry mass in samama (69.49 g), compared with 51.59 g in untreated controls. Nevertheless, these differences cannot be interpreted as definitive

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evidence of improved termite resistance because the reported analysis did not account for paired initial specimen masses. Overall, the findings provide preliminary evidence supporting further investigation of Makila wood extracts as potential locally sourced bio-based wood-protection agents. Future studies should prioritise standardised treatment concentrations, preservative uptake and retention, normalised percentage mass loss, quantitative phytochemical characterisation, direct termite bioassays and longer-term field validation. These investigations are essential for establishing preservative efficacy, identifying active constituents and assessing the feasibility of sustainable wood-protection applications.

REFERENCES

Aaqil Abiyyi, R., Al Rofiq, B., Pramilia Dewi, A., & Widayoko, A. (2024). Bioaktivitas Anti Rayap Minyak Atsiri Dari Citrus Limon Terhadap Rayap Tanah (Macrotermes Sp.). Jurnal Integrasi Sains Dan Qur'an (JISQu), 3(01). https://doi.org/10.64477/301262-267

Aflah, U. N., Subekti, N., & R. Susanti, R. S. (2021). Pengendalian Rayap Tanah Coptotermes curvignathus Holmgren Menggunakan Ekstrak Daun Avicennia marina. Life Science, 10(1). https://doi.org/10.15294/lifesci.v10i1.47164

Akasia, A. I., Nurweda Putra, I. D. N., & Giri Putra, I. N. (2021). Skrining Fitokimia Ekstrak Daun Mangrove Rhizophora mucronata dan Rhizophora apiculata yang Dikoleksi dari Kawasan Mangrove Desa Tuban, Bali. Journal of Marine Research and Technology, 4(1). https://doi.org/10.24843/JMRT.2021.v04.i01.p03

Arinana, A., Dharma, R. A., Sari, R. K., Rahmawati, A. I., Andika, R., & Nandika, D. (2024). Bioactivity of Cajuput Seedling n-Hexane Extract as an Attractant for Subterranean Termite Coptotermes curvignathus Holmgren (Isoptera: Rhinotermitidae). Journal of the Korean Wood Science and Technology, 52(1). https://doi.org/10.5658/WOOD.2024.52.1.31

Ayu, N., Ningsih, N., Pratama, A. O. S., Dwi Apriliana, A., Salsabila, N., Nabilah, S. R., Fransisca, T., Indah, Y., Dewi, P., Raden, N., Lampung, I., Letkol, J., Suratmin, E., & Lampung, B. (2021). Jenis Bioaktivitas Terhadap Rayap Tanah (Coptotermes Sp.) Di Kalimantan Barat. Gunung Djati Conference Series, 6.

Cahyaningrum, S. H. (2020). Analisis Potensi Bioinsektisida Untuk Pengendaliam Hama Alphitobius diaperinus. Skripsi, 4(1).

Diah, R., & Husni, H. (2017). Efektivitas Bioatraktan Dari Bahan Alami Terhadap Rayap Tanah (Coptotermes curvignathus Holmgren). Jurnal Hutan Lestari, 5(3).

Diba, F. (2016). Studi Anatomi, Fisiologi Dan Bioaktifitas Sekresi Pertahanan Diri Rayap Tanah Coptotermes curvignathus Holmgren (Isoptera : Rhinotermitidae). Bogor Agricultural University, 1.

Hafiz Ramadhan, Muhammad Arsyad, & Putri Indah Sayakti. (2020). Skrining Fitokimia Dan Uji Aktivitas Antibakteri Ekstrak Etanol 70% Biji Kalangkala (*Litsea angulata* Bl.) Terhadap Bakteri Penyebab JerawatPropionibacterium acnes. Borneo Journal of Pharmascientech, 4(1). https://doi.org/10.51817/bjp.v4i1.283

Imaniar, R., Latifah, & Sugiyo, W. (2013). Ekstraksi Dan Karakterisasi Senyawa Bioaktif Dalam Daun Kenikir (Cosmos Sulphureus Kuning) Sebagai Bahan Bioinsektisida Alami. Indonesian Journal of Chemical Science, 2(1).

Indria, S. P., Khotimah, S., & Rizalinda. (2013). Jenis-Jenis Jamur Entomopatogen Dalam Usus Rayap Pekerja Coptotermes curvignathus Holmgren. Potobiont, 2(3).

Jonathan, Hairani, R., & Ruga, R. (2024). Skrining Fitokimia Dan Uji Toksisitas Ekstrak Diklorometana Rimpang Temu Kunci (Boesenbergia Rotunda) Phytochemical Screening And Toxicity Assay Of Dichloromethane Extract Of Finger Root (Boesenbergia Rotunda) Rhizome. Jurnal Atomik, 9(2).

e-ISSN : 2746 – 7155
p-ISSN : 1978 – 4996
®2026 Jurusan Kehutanan Universitas Pattimura

Karlina. (2022). Uji Efektivitas Bioinsektisida Ekstrak Daun Sirsak (Annona Muricata L) Terhadap Mortalitas Rayap Tanah (Coptotermes Gestroi). Skripsi, Universitas Islam Negeri Raden Intan Lampung.

Kheng, H. P., Hung, K. J., Patricia, Huat, O. K., Fah, B. C., Joseph, & Mahadi, N. M. (2019). Laccases repertoire of a subterranean termite: Coptotermes curvignathus holmgren (Blattodea: Rhinotermitidae). Serangga, 24(2).

Komul, Y. D. (2023). Estimasi Potensi Tegakan Hutan Hasil Inventarisasi Di Pulau Buano Kabupaten Seram Bagian Barat. Jurnal Sylva Scienteae, 6(2). https://doi.org/10.20527/jss.v6i2.8549

Kuspradini, H., Sinta, Silau, S., & Putri, A. S. (2021). Karakteristik Minyak Atsiri dari Tumbuhan Aromatik Hutan Tropis Jenis Litsea spp dan Potensinya sebagai Antimikroba. In Minyak Atsiri: Produksi dan Aplikasinya untuk Kesehatan.

Maliana, Y., Khotimah, S., & Diba, F. (2013). Aktivitas Antibakteri Kulit Garcinia mangostana Linn. Terhadap Pertumbuhan Flavobacterium dan Enterobacter Dari Coptotermes curvignathus Holmgren. Protobiont, 2(1).

Manoppo, J. S. S., Putra, R. E., Dungani, R., & Ahmad, I. (2024). The diversity and distribution of residential termites in the Minahasa Raya Region, North Sulawesi Province, Indonesia. Biodiversitas, 25(1). https://doi.org/10.13057/biodiv/d250105

Muhlisoh, M., & Hasaini, A. (2023). Efektifitas Biji Kalangkala (*Litsea angulata*) dan Daun Kelakai (Stenochlaena palustris (BURM. F.) BEDD.) terhadap Daya Hambat Bakteri P. Aeruginosa Pada Luka Dekubitus. Dunia Keperawatan: Jurnal Keperawatan Dan Kesehatan, 11(3). https://doi.org/10.20527/jdk.v11i3.548

Muliyani, P., Soemarie, Y. B., & Fauzi, M. (2025). Studi Fitokimia: Identifikasi Senyawa Metabolit Sekunder Dari Ekstrak Daun Mengkrengan (Polygonum barbatum L.) di Kalimantan. Jurnal Farmasi IKIFA, 4(1).

Mustikasari, K., & Ariyani, D. (2010). Skrining Fitokimia Ekstrak Metanol Biji Kalangkala (*Litsea angulata*) The Phytochemistry Screening Of Methanol Extract From Kalangkala (*Litsea angulata*) SEEDS. Sains Dan Terapan Kimia, 4.

Novitasari, Jayuska, A., & Wibowo, M. A. (2014). Bioaktivitas Anti Rayap Minyak Atsiri dari Daun Jeruk Sambal (Citrus microcarpa Bunge) terhadap Rayap Tanah Macrotermes sp. Jurnal Kimia Khatulistiwa (JKK), 3(1), 57-62.

Nursalam, N. (2016). Kebijakan Pelestarian Sumber Daya Hutan Dalam Rangka Pembangunan Berkelanjutan. Jurnal Geografi Gea, 10(1). https://doi.org/10.17509/gea.v10i1.1660

Pratiwa, C., Diba, F., & Wahdina. (2015). Bioaktivitas Ekstrak Etanol Buah Mengkudu (Morinda citrifolia L.) Terhadap Rayap Tanah (Coptotermes curvignathus Holmgren). Jurnal Hutan Lestari, 3(2).

Ramadhan, A. (2021). Toksisitas Ekstrak Kulit Batang Kalangkala (*Litsea angulata*) Terhadap Larva Udang (Artemia salina) dan Identifikasi Senyawa Metabolit Sekundernya. Jurnal Kartika Kimia, 4(2). https://doi.org/10.26874/jkk.v4i2.84

Rismayadi, Y., Hartati, S., & Dewi, M. (2019). Study of Feeding Preference of Subterranean Termites (Coptotermes curvignathus Holmgren) on Wood Decaying Fungi. 3BIO: Journal of Biological Science, Technology and Management, 1(1). https://doi.org/10.5614/3bio.2019.1.1.3

Rudiyansyah, Malinda, E. P., Alimuddin, A. H., Sapar, A., & Indrayani, Y. (2025). Antifeedant Activity of Limonoids from the Seeds of Lansium domesticum Corr. Against Subterranean Termite Coptotermes curvignathus. Journal of Tropical Biodiversity and Biotechnology, 10(1). https://doi.org/10.22146/jtbb.11823

Santoso, W. J. (2024). Perubahan paradigma pembangunan sektor kehutanan di Indonesia: Tantangan dan peluang dalam konteks keberlanjutan. Scientica: Jurnal Ilmiah Sains Dan Teknologi, 3(2 SE-Articles).

Siruru, H.-, & Riupassa, P. (2021). Analisis Bilangan Gelombang Arang Aktif Kayu Makila (*Litsea angulata* B.L). MAKILA, 15(2). https://doi.org/10.30598/makila.v15i2.4560

Syahril, S., Sribudiani, E., & Somadona, S. (2022). Efektivitas Pengawetan Kayu Sengon (Paraserianthes falcataria) Menggunakan Ekstrak Biji Mahoni dengan Metode Rendaman Dingin Terhadap Serangan Rayap Tanah. Journal of Forest Science Avicennia, 5(2). https://doi.org/10.22219/avicennia.v5i1.21662

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p-ISSN : 1978 – 4996
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