Volume 21 Nomor 1, Juni 2026, Halaman 18–24
Jurnal Hutan Tropika
Laman: https://e-journal.upr.ac.id/index.php/JHT
DOI: https://doi.org/10.36873/jht.v21i1.25678
e-ISSN: 2656–9736
p-ISSN: 1693–7643

The Effect Of Soaking In Liquid Smoke On The Specific Gravity of Gerunggang Wood (*Cratoxilon Arborences*) Based on Radial Position

(Pengaruh Perendaman dalam Asap Cair terhadap Berat Jenis Kayu Gerunggang (Cratoxylum arborences) Berdasarkan Posisi Radial)

Wahyu Supriyati[1,4]*, Alpian[1,4], Chuchita[2], Efriyana Oksal[2], Zimon Pereiz[2], Aprilian Wanashalom[3]
[1] Department of Forestry, Faculty of Agriculture, Palangka Raya University, Jl. Yos Sudarso, UPR, Palangka Raya Campus, 73111, Central Kalimantan
[2] Department of Chemistry, Faculty of Mathematics and Natural Sciences, Palangka Raya University, Jl. Yos Sudarso, UPR, Palangka Raya Campus, 73111, Central Kalimantan
[3] Department of Civil Engineering, Faculty of Engineering, Palangka Raya University, Jl. Yos Sudarso, UPR, Palangka Raya Campus, 73111, Central Kalimantan
[4] Indonesia Climate Change and Forest Expert Network (APIK Indonesia), Indonesia
* *Corresponding Author: wahyu.supriyati@for.upr.ac.id*

Article History
Received : May 7, 2026
Revised : May 13, 2026
Approved : May 20, 2026

***Keywords*:**
soaking, liquid smoke, gerunggang wood, , radial, specific gravity

ABSTRACT

The objective of this study was to determine the effect of immersion in different liquid smoke treatments on the specific gravity of Gerunggang wood at the radial direction. The study was conducted at the Forest Products Technology Laboratory, Faculty of Agriculture, Palangka Raya University. The parameter observed was the specific gravity of the wood. The experimental method used was a 2x2 factorial completely randomized design (CRD) with two treatments: liquid smoke concentration (0%, 5%) and radial location (near the heart and near the bark), with 10 replications. The results of this study showed that immersion in liquid smoke had a not significant effect (p>0.05) on the specific gravity. The influence of the radial position was significantly different, where the part near the liver was higher than the part near the skin. The interaction between the immersion factor and the radial position had no significant effect.

Sejarah Artikel
Diterima : 7 Mei 2026
Direvisi : 13 Mei 2026
Disetujui : 20 Mei 2026

Kata Kunci:
perendaman, asap cair, kayu gerunggang, , radial, berat jenis

ABSTRAK

Tujuan penelitian ini adalah untuk mengetahui pengaruh perendaman dalam berbagai perlakuan asap cair terhadap berat jenis kayu Gerunggang pada arah radial. Penelitian ini dilakukan di Laboratorium Teknologi Produk Hutan, Fakultas Pertanian, Universitas Palangka Raya. Parameter yang diamati adalah berat jenis kayu. Metode percobaan yang digunakan adalah rancangan acak lengkap faktorial (RAL) 2x2 dengan dua perlakuan: konsentrasi asap cair (0%, 5%) dan lokasi radial (dekat hati dan dekat kulit kayu), dengan 10 ulangan. Hasil penelitian ini menunjukkan bahwa perendaman dalam asap cair berpengaruh tidak signifikan (p>0,05) terhadap berat jenis. Pengaruh posisi radial berbeda secara signifikan, di mana bagian dekat hati lebih tinggi daripada bagian dekat kulit kayu. Interaksi antara faktor perendaman dan posisi radial berpengaruh tidak signifikan.

1. Introduction

Gerunggang wood (*Cratoxylum arborescens)*, like other tropical swamp woods, has signific Wood remains a primary raw material for various industries, such as construction, furniture, and crafts. Among the various species of Indonesian ectowood, Gerunggang wood (Cratoxylon arborescens) is known for its rapid growth and abundant availability, particularly in the swamp forests and lowlands of Kalimantan and Sumatra. However, Gerunggang wood is classified as a light to medium-weight wood with limited physical and mechanical properties, such as easy water absorption, high shrinkage, and low tensile strength. This makes Gerunggang wood

less desirable for heavy-duty applications without prior treatment or modification.

To date, synthetic compounds such as borax, borates, and heavy metal–based products have been widely utilized for wood preservation and quality enhancement. Although these chemicals are effective, their application may generate hazardous and environmentally harmful residues. This issue has raised concerns regarding the long-term sustainability of wood processing practices and their potential impacts on both the industry and the environment. Consequently, increasing awareness of the importance of green technology has encouraged researchers to explore natural materials as alternative agents for wood preservation and modification.

Liquid smoke is a natural material produced from the pyrolysis of biomass waste such as coconut shells, sawdust, or rice husks. Liquid smoke contains various active compounds, such as acetic acid, phenols, and carbonyls, which have antimicrobial and antioxidant properties and are able to bind to wood components. The use of liquid smoke as a wood modification material is attractive because it is environmentally friendly and can also increase the durability and dimensional stability of wood. However, research on the effectiveness of liquid smoke in improving the physical and mechanical properties of ectowood, particularly Gerunggang, is still very limited.

Furthermore, wood has an ector an property, meaning its physical and mechanical properties differ depending on the grain direction—either axial (parallel to the grain) or radial (perpendicular to the annual growth ring direction) (Mandasari et al 2016). Therefore, it is important to understand how liquid smoke treatment affects wood in these two directions to adapt it to its intended use in the field. This study not only aims to evaluate the effectiveness of liquid smoke in improving the quality of Gerunggang wood but also to provide further understanding of wood's response to treatment in two different grain directions (Saukani et al., 2020).

By conducting a systematic study of the variations in concentration and duration of liquid smoke immersion, this study is expected to identify the best treatment combination to improve physical properties (specific gravity). In addition to contributing to the development of science in the field of wood processing technology, the results of this study also have the potential to be directly applied by small-scale actors, forest farmers, and ecto craftsmen in increasing the selling value and durability of local wood products (Hakim et al, 2024). With an ecto-based and environmentally friendly approach, this research is part of the effort to develop green technology that supports sustainable forest and natural resource management.ant potential as a local raw material for light construction, poles, and community needs in wetlands. However, its utilization remains limited due to the significant variation in physical properties, particularly specific gravity and natural durability, which are strongly influenced by the wood's anatomical structure and radial position within the trunk.

Anatomically, gerunggang wood is a porous wood with scattered semi-rings, with relatively large-diameter vessels, varying fiber cell wall thicknesses, and prominent axial and radial parenchyma content. This anatomical variation results in differences in wood tissue density between the heartwood and barkwood regions. Heartwood generally has thicker cell walls and a higher extractive content, while barkwood is dominated by younger tissue with larger lumens and a lower specific gravity. Wood specific gravity is a key parameter reflecting the proportion of cell wall solids to the total wood volume.

Changes in specific gravity not only affect mechanical strength but are also closely related to the absorption of preservatives and the wood's resistance to degrading organisms. Therefore, efforts to increase or control specific gravity through modification treatments are crucial to improving the quality of gerunggang wood.

Liquid smoke, a biomass pyrolysis product rich in phenolic compounds, organic acids, and carbonyls, has been widely studied as a relatively environmentally friendly wood preservative. Excessively high concentrations of liquid smoke can result in an excess of preservatives that the wood cannot absorb properly, which may lead to excessive residue on the wood's surface or even have negative effects on human health and the environment (Santoso et al., 2023; Fakkar et al., 2023; Riziq et al., 2024; Tri et al., 2022).These compounds have the potential to penetrate the cell lumen and partially bind to the wood cell walls, thereby increasing wood mass and indirectly affecting specific gravity. However, the penetration effectiveness of liquid smoke is strongly influenced by the wood's anatomical structure, particularly vessel size, cell wall thickness, and parenchyma distribution.

Wood variation is partly due to location within the stem. In the radial direction (near the heartwood and near the bark), variation can be caused by extractive content, cell density, and wood permeability.

In the context of gerunggang wood, anatomical differences between the heartwood and barkwood are thought to result in different responses to liquid smoke immersion. Wood near the bark, with its higher permeability, has the potential to absorb more liquid smoke, while wood near the heartwood, with its higher extractive content, may inhibit solution penetration. To date, studies specifically linking the effect of liquid smoke immersion on the specific gravity of gerunggang wood based on radial variations are still very limited.

Therefore, this research is crucial to understand the relationship between liquid smoke immersion treatment, changes in specific gravity, and the anatomical characteristics of gerunggang wood in the radial direction. The results are expected to provide a scientific basis for developing more effective and sustainable swamp wood modification and preservation technologies.

The purpose of this study was to analyze the effect of liquid smoke immersion on the specific gravity of gerunggang wood. Gerunggang wood was sampled from the radial positions near the heartwood and near the barkwood.

2. Materials and Methods

2.1. Research Design

This study used a completely randomized design with a factorial design. This study had two factors: the effect of immersion and radial location. The two immersion conditions, soaking with 5% liquid smoke for 5 days (120 hours) and without immersion, were designed to determine their effect on the specific gravity of the soaked wood. The second factor was the radial location (near the heart and near the bark).

The parameter measured was specific gravity. Statistical data analysis was performed using a homogeneity test followed by a 2x2 factorial completely randomized design to compare the average values between treatments and the interaction effect of the two factors.

2.2. Materials and Equipment

The raw materials used in this study consisted of 26 cm diameter gerunggang wood, differentiated by the heartwood and bark. The wood came from the Palangka Raya area of Central Kalimantan; liquid smoke from coconut shells; and distilled water.

The equipment used included a chainsaw, a stand, an analytical balance, an oven, and a measuring tape. A camera for documentation; A wristwatch for timing; Stationery for recording experimental data; Airtight plastic bags for storing samples; A laptop for data processing and statistical analysis.

2.3. Research Procedure

This study consisted of several sequential stages, as follows:

a) Test Sample Preparation

The raw material, consisting of wood, was divided radially, namely near the heartwood and near the bark. The wood was cut according to the British standard (2x2x2 cm3) for physical properties.

Liquid smoke was prepared at a 5% concentration.

b) Liquid Smoke Immersion Treatment
Immersion was carried out at a 5% concentration for a soaking time of 5 days (120 hours) and a control treatment (without immersion).

c) Wood Specific Gravity Testing
Sample preparation was carried out according to the British standard (BS 1957). Wood weight was measured in oven-dry conditions, which were oven-dried at 103°C (+ 2°C) until a constant weight was achieved. Volume was measured using the displacement water volume method. The sample conditions (both weight and volume) were as follows: after immersion and without immersion. Specific gravity was calculated by dividing the oven-dry weight by volume.

2.4 Data Analysis

The results for each quality parameter were statistically analyzed using The research data were processed using a completely randomized experimental design and analysis of variance. Statistical analysis was conducted using a factorial Completely Randomized Design (CRD) (treatment × radial position). Each specific gravity treatment was repeated 10 times, resulting in 40 samples.

3. Results and Discussion

3.1. Changes in Specific Gravity of Gerunggang Wood Due to Liquid Smoke Immersion

This study compares the specific gravity values resulting from immersion in liquid smoke and those without immersion. The average values for specific gravity parameter are presented in **Table 1**.

Effect of Soaking on Specific Gravity

Table 1. Average specific gravity of gerunggang wood after soaking treatment

Immersion treatment	Specific gravity	standard deviation	Number of samples
Soaked	0.6010	0.04822	20
Not soaked	0.5955	0.05042	20

Changes in the specific gravity of Gerunggang wood after immersion in liquid smoke indicate that this treatment not only acts as a preservative but also as a form of physical modification of the wood. The observed increase in specific gravity indicates an increase in wood mass due to the penetration of liquid smoke compounds into the wood's cellular structure. Phenolic compounds and organic acids in the liquid smoke are thought to adsorb onto the fiber and parenchyma cell walls, partially filling the vessel lumens.

From an anatomical perspective, Gerunggang wood has relatively large-diameter vessels that facilitate fluid flow during the immersion process. This contributes to the increase in specific gravity, especially in test samples with high permeability. However, the magnitude of the change in specific gravity depends heavily on the distribution and continuity of the vascular tissue and the condition of the cell walls. Abdurrohim and Martawijaya (1983) state that one of the factors affecting the durability of wood is the concentration of the preservative solution; generally, the higher the concentration of the preservative solution, the greater the amount of preservative that the wood can absorb. Since the wood has not been treated with preservatives, it has a lower specific gravity.

3.2. The Effect of Radial Position on Liquid Smoke Immersion Response

The location in the radial direction is one source of variation in wood properties. When wood in different radial positions is soaked, it will have different effects. **Table 2** shows the effect of location in the radial direction on specific gravity.

Table 2. Average Specific of Radial Position on Liquid Smoke Immersion Response

Radial position	Specific gravity	Standard deviation	Number of samples
Near hear	0.5815	0.03558	20
Near bark	0.6150	0.05501	20

Because porosity and vascular cell networks influence water flow and storage, the radial direction exhibits comparatively different density and temperature changes than other directions. The results of Hassan et al. on the direction of anisotropy of thermal characteristics and diffusivity in two South Asian wood species, with variations in physical properties along three directions, corroborate this (Hassan et al., 2023). Soaked wood exhibits notable variations in specific gravity between radial and other directions (Hassan et al., 2023; Sellers et al., 1988; Yelle & Stirgus, 2016).

The difference in response between heartwood and near-bark wood reinforces the role of anatomical factors in determining the effectiveness of liquid smoke immersion. Near-bark wood, which is anatomically dominated by younger tissue with larger cell lumens and relatively thin cell walls, exhibits a tendency toward a higher specific gravity. This allows liquid smoke to more easily penetrate and accumulate within the wood structure.

Conversely, near-bark wood tends to have a higher initial specific gravity due to thicker cell walls and a higher extractive content. The presence of these extractives can reduce wood permeability by closing the pits or lumens of vessels, thereby limiting the penetration of liquid smoke. Consequently, changes in specific gravity in this area are relatively smaller than in near-bark wood.

3.3. Interaction of the influence of immersion and location in the radial direction

The interaction between the effects of soaking and radial position in the wood is shown in **Table 3** below. The ANOVA is shown in **Table 4**.

Table 3. Interaction of the influence of immersion and location in the radial direction

Soaked	Position radial	Spesific gravity	Std. Deviation	Number of samples
Soaked	Near heart	0.587	0.03831	10
	Near bark	0.615	0.05482	10
	Total	0.601	0.04822	20
Un soaked	Near heart	0.576	0.03373	10
	Near bark	0.615	0.05817	10
	Total	0.5955	0.05042	20
Total	Near heart	0.5815	0.03558	20
	Near bark	0.615	0.05501	20
	Total	0.5983	0.04877	40

Tabel 4. ANOVA of Spesific gravity

Source	Sum of squares	df	Mean square	F	Signifikansi
immersion	0.000	1	0.000	0.135	0.716ns
radial	0.011	1	0.011	4.991	0.032*
immersion * radial	0.000	1	0.000	0.135	0.716ns
Error	0.081	36	0.002		

Note: ns=tidak signifikan, *significant

Based on the ANOVA table above, the position factor in the radial direction has a significant effect. Density shows variations related to the perpendicular direction to the grain (radial vs tangential) and the direction of the length of the grain (longitudinal) (Hassan et al., 2023; (Sellers et al., 1988); Yelle & Stirgus, 2016). In the context of immersion, changes in density can be influenced by moisture uptake and the interaction between wood porosity and the immersion environment/medium, and the radial direction often shows different variations than the tangential direction due to the non-uniform architecture of traheids, ray parenchyma, and vascular tissue (Hassan et al., 2023; (Sellers et al., 1988);Yelle & Stirgus, 2016). Treating the sapwood (near the bark) can increase its spesific gravity, making it comparable to heartwood (near the heart). Results show that sapwood from community-managed teak that has been preserved with boron compounds using the Lowry pressure method exhibits sufficiently high durability, comparable to that of untreated heartwood. (Pertiwi & Joko , 2021).

Anatomically, the combination of vessel size, fiber cell wall thickness, and parenchyma proportion in gerunggang wood are the primary determinants of the liquid smoke absorption mechanism. Axial parenchyma and wood rays act as lateral pathways, allowing the distribution of solutions throughout the wood tissue. However, the effectiveness of these pathways varies radially due to changes in tissue structure as the wood ages.

The interaction between liquid smoke compounds and the chemical components of cell walls, particularly lignin and hemicellulose, also contributes to changes in specific gravity. Weak physical and chemical bonds between phenolic compounds and lignin can increase the effective density of cell walls, although they do not significantly change the wood volume.

3.4 Implications for Gerunggang Wood Utilization and Processing

The results of this discussion indicate that understanding the anatomy of gerunggang wood is crucial for determining the optimal liquid smoke treatment strategy. Soaking treatments are more effective for wood near the bark or young wood, especially for improving quality and uniformity of physical properties. Meanwhile, wood near the heartwood requires additional treatment approaches, such as increasing soaking time or modifying pressure, to achieve comparable results. These findings provide practical implications for gerunggang wood processing at the small and medium industry level, particularly in the sustainable use of swamp wood using relatively simple and environmentally friendly technology.

2. Kesimpulan

Based on the research results and Liquid smoke immersion affects the specific gravity of Gerunggang wood (Cratoxylum arborescens), and this effect is significantly influenced based on radial position factor. Liquid smoke immersion tends to increase the wood's specific gravity, indicating an increase in mass due to the penetration and accumulation of liquid smoke compounds into the wood's anatomical structure.

The difference in response between near heart and near bark demonstrates the important role of wood anatomy. Heartwood (near heart) exhibits a relatively greater increase in specific gravity than near bark, consistent with larger cell lumens. Conversely, heartwood has a higher initial specific gravity but exhibits more limited changes due to the presence of extractives and a more developed cell wall structure that can inhibit liquid smoke penetration.

These results confirm that variations in the radial anatomy of Gerunggang wood are a key factor in determining the effectiveness of liquid smoke immersion. Therefore, the application of liquid smoke-based wood modification and preservation technology needs to consider the wood's radial position to achieve optimal and more uniform quality improvements.

Acknowledgments

The authors express their sincere gratitude to Universitas Palangka Raya through the Institute for Research and Community Service (LPPM) for providing funding to conduct this research through the university's internal research grant for the 2025 fiscal year number contract 1486 /UN24. 13/AL.04/2025.

Conflict of Interest

The authors have declared that there is no conflict of interest regarding the publication of this paper

Daftar Pustaka

Abdurrohim S & Martawijaya A. 1983. Beberapa Faktor yang Mempengaruhi Keterawetan Kayu. Pertemuan Ilmiah Pengawetan Kayu. Pusat Litbang Hasil Hutan (P3HH). Bogor, 9-11 Oktober 1983.

Abubakar Y, Tijjani H, Egbuna C, Adetunji CO, Kala S, Kryeziu TL, et al. Pesticides, history, and classification. Nat Remedies Pest, Dis Weed Control. 2019;29–42.

Bora, N., Tiri, J., & Idayati, E. (2022). The Effect of Soaking Time and Liquid Smoke Types on the Quality of Smoked Skipjack (Kastuwonus pelanis L.) Fillets During Storage. Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering), 11(3), 405. https://doi.org/10.23960/jtep-l.v11i3.405-416.

Fakkar, G., Sumardi, I., & Suhaya, Y. (2023). Efikasi Asap Cair Dari Limbah Pengolahan Industri Gondorukem Pada Kayu Karet Terhadap Rayap Kayu Kering (Cryptotermes cynocephalus Light.). Jurnal Penelitian Hasil Hutan, 41(1), 1-10.

Hakim A, Ekasari MY, Fahmi MS, Khalifah N, Abu A. Peran Hutan Ranjuri Dalam Pelestarian Ekosistem dan Mitigasi Bencana di Desa Beka Kabupaten Sigi Sulawesi Tengah. 2024;2(2):2678–82.

Hassan, K., Mahr, M., Iqbal, J., Javed, H., Raza, Z., & Rasheed, F. (2023). Directional variability of wood properties in Pinus wallichiana and Dalbergia sissoo of South Asian origin. International Wood Products Journal, 14(2), 102-108. https://doi.org/10.1080/20426445.2023.2232653

Mandasari I, Purnomo A. Penurunan Ion Besi (Fe) dan Mangan (Mn) dalam Air dengan Serbuk Gergaji Kayu Kamper. J Tek ITS. 2016;5(1):1–6.

Pertiwi, Y. A. B., & Joko, S. (2021). Ketahanan Gubal Jati Hutan Rakyat Diawetkan dengan Senyawa Boron Menggunakan Metode Tekan Lowry terhadap Serangan Rayap Tanah dan Kayu Kering. Jurnal Ilmu Kehutanan, 15(1), 111–122. https://doi.org/10.22146/jik.v15i1.1509

Riziq Muwaffaq, M. S., Anggraini, R., & Khabibi, J. (2024). Peningkatan Keawetan Kayu Pulai (*Alstonia scholaris* L.) Menggunakan Asap Cair Serbuk Rengas Terhadap Serangan Rayap Kayu Kering (Doctoral dissertation, Universitas Jambi).

Santoso, I. R., Oramahi, H. A., Rifanjani, S., Nurhaida, N., & Darwanti, H. (2023). Efikasi Asap Cair dari Kayu Akasia (Acacia crassicarpa) dan Kayu Jelutung (Dyera costulata) terhadap Jamur Schizophyllum commune Fries. Agrikultura, 34(1), 19–27. https://doi.org/10.24198/agrikultura.v34i1.41539

Saukani M. Studi Komparasi Kualitas Briket Serbuk Gergaji Kayu Ulin dan Tempurung Kelapa. Pros Semin Nas Tek Tahun 2020 (SENASTIKA 2020). 2020;2020(Senastika):27–31.

Sellers, T., McSween, J., & Nearn, W. (1988). Gluing of Eastern Hardwoods: A Review.. https://doi.org/10.2737/so-gtr-71

Sumini, Bahri S. Efektivitas Asap Cair sebagai Pestisida Organik dalam Mengendalikan Hama Kutu Daun (Myzus pericae) pada Tanaman Cabai. Klorofil. 2021;26(2):113–6.

Tri Ismianto Restu Wibowo, I. (2022). KARAKTERISTIK BIOCHAR DARI KAYU MERANTI (Shorea leprosula) DAN KAYU SENGON (Paraserianthes falcataria).

Yelle, D. and Stirgus, A. (2016). Influence of anatomical, physical, and mechanical properties of diffuse-porous hardwoods on moisture durability of bonded assemblies.. https://doi.org/10.2737/fpl-gtr-244.