BIODIVERSITAS
Volume 24, Number 7, July 2023
Pages: 4193-4201

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d240764

Characteristics of Simalambuo (*Lophopetalum* sp.) wood from Nias Island, North Sumatra Province, Indonesia

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Manuscript received: 25 June 2023. Revision accepted: 31 July 2023.

Abstract. *Iswanto AH, Amanda DW, Gea S, Susilowati A, Fatriasari W, Darwis A, Lubis MAR, Sucipto T, Syahidah, Subekti N, Hartono R, Sutiawan J, Hidayat W, Kim NH. 2023. Characteristics of Simalambuo* (Lophopetalum sp.) *wood from Nias Island, North Sumatra Province, Indonesia. Biodiversitas 24: 4193-4201.* Simalambuo (*Lophopetalum* sp.) wood is commonly used for construction materials in Nias Island, North Sumatra Province especially in the aftermath of the devastating earthquake that affected the region. However, information regarding the fundamental characteristics of this wood has not been available. Therefore, this research aimed to evaluate the basic properties of Simalambuo wood, such as its physical, mechanical, chemical, and natural durability. The destructive method was used to determine the physical and mechanical parameters (i.e., specific gravity, moisture content, shrinkage, MOE, MOR, and hardness) using a small clear specimen sample under the BS 373 standard (1957). The chemical components of wood (i.e., holocellulose, cellulose, lignin, extractives) were analyzed using a variety of methods, including CRC Press methods, LAP NREL 003 standard, and TAPPI. Meanwhile, the SNI 7207-2014 standard was utilized to evaluate its resistance against subterranean termites. The results showed that Simalambuo wood has an average specific gravity of 0.42 and a T/R ratio of 1.78. Based on its specific gravity, the wood is classified within the strength class III-IV. It also exhibits a reduced cellulose and extractive content, along with a higher proportion of lignin. In terms of durability, it is classified as class IV, implying non-resistance to termites' attack and necessitating wood preservation treatment for its practical application. The findings of this study suggest the application of this wood is recommended for light construction, furniture, and other functions, but not for heavy construction.

Keywords: Chemical, durability, Nias, physical-mechanical, Simalambuo

INTRODUCTION

The availability of wood sourced from forests for uses such as building materials, furniture, crafts, and industrial purposes is increasingly constrained. To meet the rising demand for wood, it is imperative to establish an equilibrium between supply and demand. Consequently, it becomes essential to explore alternative options for wood sources, one of which is by looking at the potential of lesser-known wood species. Several wood species, including the lesser-known ones, are used locally as a mainstay of local communities for their construction and furniture materials. Such local utilization is useful to serve as initial information for a wider use, yet there is a need for a deeper understanding on the specific properties of such wood species.

The utilization of lesser-known and locally reliable wood species can increase the diversification of commercial species, minimize the overexploitation of certain wood species (e.g. dipterocarps) and provide sufficient wood supplies in the market for users. However, the value of wood utilization of these species is not widely recognized due to the limited knowledge regarding its fundamental characteristics. Several research have been carried out to investigate local plant species. For example, Iswanto et al. (2016), Iswanto et al. (2019), Iswanto et al. (2021a), and Pasaribu et al. (2013) focused on examining the physical, mechanical, chemical, and durability properties of *Styrax sumatrana* wood used in North Sumatra. Additionally, Iswanto et al. (2021b) conducted a research on the fundamental characteristics of three types of *Cotylelobium melanoxylon* wood from North Sumatra. Hidayat et al. (2018) also explored the characteristics of resin derived from the *Styrax sumatrana* plant and its potential application as an antioxidant material. Susilowati et al. (2017a), Susilowati et al. (2017b), and Rahmat et al. (2017) conducted investigations on the phylogenetics, macrocytic techniques as a potential propagation method, and genetic research of *Styrax sumatrana* plants.

In Nias Island, North Sumatra Province, Indonesia one of the local and potential mainstays of wood for construction materials is Simalambuo wood. Simalambuo (*Lophopetalum* sp.) is endemic plant species in Nias island, and this species has not been explored for its basic characteristics such as physical, mechanical, chemical, and durability. It has been widely used by local communities in Nias as building materials, specifically since the earthquake in Nias Island in 2004, which claimed many lives due to the collapse of buildings made of cement and concrete. Simalambuo wood is known for its slightly lighter weight and has been subjected to initial research, indicating a specific gravity within the low to medium range. This suggests that it belongs to strength class III-IV, which is suitable for light construction purposes. Similar findings were reported by Iswanto et al. (2016) regarding Toba incense wood (*Styrax sumatrana*), which shared a visual resemblance with Sengon (*Paraserianthes falcataria*) wood. Considering the lighter color and lower extractive content, it is expected to possess properties akin to Sengon wood. However, Sengon wood is not resistant to termite attacks, placing it in class V for durability (Hadi et al. 2020a; 2020b).

To ensure the safety and efficiency of wood as a building material, it is crucial to have a comprehensive understanding of its fundamental characteristics, and this includes knowledge about the physical, mechanical, and durability properties. Research conducted by Almeida et al. (2013), Araujo et al. (2016), and de Oliveira et al. (2022) emphasized the importance of investigating these aspects. Therefore, research activities were carried out to analyze the physical, mechanical, chemical, and natural durability of Simalambuo wood concerning its resistance against subterranean termite attacks. We expected the results of this study might inform related to the properties of Simalambuo wood, which can be used as a consideration in the use of wood as a building material, especially for residents in Nias island.

MATERIALS AND METHODS

Materials

The material used was Simalambuo (*Lophopetalum* sp.) wood obtained from Lahewa, North Nias, North Sumatra Province, Indonesia. The logs with a diameter of about 20 cm were converted into smaller logs, each measuring 1 meter long for the bottom, middle, and tip (Figures 1 and 2). The determination of the sample size for testing the physical and mechanical properties of wood is based on the standard BS 373 (1957). To assess the physical properties, it is recommended to use a sample size of 2 cm x 2 cm x 2 cm. The Modulus of elasticity/Modulus of rupture test requires a sample with dimensions of 2 cm in length, 2 cm in width, and 30 cm in thickness. Similarly, for hardness measurements, an appropriate sample size would be 2 cm in length, 2 cm in width, and 5 cm in thickness. When analyzing chemical components, the sample is prepared in powder form, specifically measuring 40 mesh. Sample preparation was carried out based on the standards of the Technical Association of the Pulp and Paper Industry (TAPPI) T 257 cm-02 and TAPPI T 264 cm-97. For determining the sample size for testing the resistance of wood to subterranean termite attack, it referred to SNI 7207-2014, where the test sample had a length of 2.5 cm x width of 2.5 cm x thickness of 0.5 cm.

Physical and mechanical tests

The physical and mechanical properties tested included specific gravity (SG), moisture content (MC), shrinkage (longitudinal, radial, and tangential), modulus of elasticity (MOE), modulus of rupture (MOR), and hardness. This test was carried out regarding the BS 373 (1957) standard.

Analysis of wood chemical components

Chemical component analysis of Simalambuo wood including holocellulose, α-cellulose, lignin (Acid Lignin Insoluble/AIL) and Acid Soluble Lignin/ASL), and extractive content referred to LAP NREL 003 standard, and TAPPI T 204 cm-97 as detailed in Iswanto et al. (2022). The research results were classified according to Table 1.

Figure 1. Simalambuo wooden beams from the bottom (P), middle (T) and Tip (U)

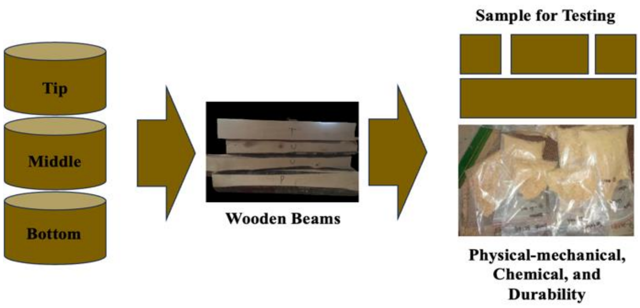

Figure 2. Sample cutting pattern

Natural durability test

The test was conducted under the guidelines outlined in SNI 7207-2014. A total of 200 subterranean termites (*Coptotermes curvignathus*) from the worker caste (Figure 3) were introduced into a test bottle that contained the sample. Termite testing was carried out at Wood Chemistry Laboratory at IPB University. The test bottle was covered with aluminum foil and placed in a dark place for five weeks. Every week, the number of dead termites was calculated, and the parameter observed was the percent weight loss of the sample. The classification of the durability of wood was grouped based on the value of its weight loss (Table 2).

Table 1. Chemical component of hardwood (Anonymous 2020)

Chemical component	Classification		
	High (%)	Medium (%)	Low (%)
Cellulose	>45	40-44	<40
Lignin	>33	18-32	<18
Pentosan	>24	21-24	<21
Extractive content	>3	2-3	<2
Ash content	>6	0.22-6	<0.22

Table 2. The classification of wood resistance from the attack of subterranean termites (SNI 7207-2014.)

Class	Level of durability	Weight loss (%)
I	High durable	<3.5
II	Durable	3.5-7.4
III	Moderate	7.5-10.8
IV	Low durable	10.9-18.9
V	Vulnerable	>18.9

Figure 3. Appearance of subterranean termite species (*Coptotermes curvignathus*) for testing wood durability

Data analysis

This research used a non-factorial Completely Randomized Design and an analysis of variance (ANOVA) was conducted to test significant differences followed by the Duncan Multiple Range Test (DMRT) to identify the difference among stem positions (bottom, middle, and tip). The number of repetitions for testing the parameters of physical and mechanical properties was five, chemical components were two, and natural durability was five.

RESULTS AND DISCUSSION

Physical properties of Simalambuo wood

Specific gravity

The average value of the specific gravity of Simalambuo wood is presented in Figure 4. The wet and dry specific gravity values ranged from 0.38-0.42 and 0.41-0.45, where the highest and lowest values for both are at the base and tip. Mahmud et al. (2017) stated that the greater density at the bottom of the stem is caused by the presence of heartwood. The density at the top of the stem is lower because it is influenced by the presence of juvenile wood around the pith in a vertical variation. The cell wall thickness plays a role in determining specific gravity. Bowyer et al. (2003) stated that the higher the specific gravity, the more wood substance it contains, meaning the cell walls are thicker. Wood at the bottom of a stem is considered mature, where the mass is dominated by latewood with constituent cells having thicker cell walls and smaller cavities. In the apical area of the stem, which consists of young tissue, the cell walls are relatively thinner compared to mature cell tissue. Specific gravity plays a significant role in influencing the strength of wood. An increase in specific gravity leads to an enhancement in the strength of the wood (Kotlarewsky et al. 2016; Herawati et al. 2017; Knapic et al. 2022). Several tropical species with a specific gravity range of 0.30-0.50 as a comparison with the SG values of Simalambuo wood are presented in Table 3.

Analysis of variance showed that stem position significantly affected the 95% confidence interval for the wet (F_{value}: 15.418 and Sig. 0.000) and dry wood-specific gravity (F_{value}: 15.578 and Sig. 0.000) values. The Duncan Multiple Range Test (DMRT) values at a 95% confidence interval on wet and dry specific gravity showed that the stem tip differed significantly from the bottom and middle, and the bottom was not significantly different from the middle.

Moisture content

The average value of the moisture content of Simalambo wood is presented in Figure 5. The moisture content produced ranged from 37.70%-46.66%, where the highest and lowest moisture content value was found at the bottom and middle.

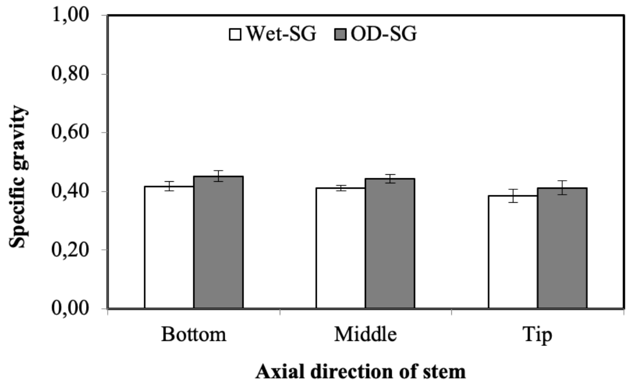

Figure 4. The specific gravity of Simalambuo wood

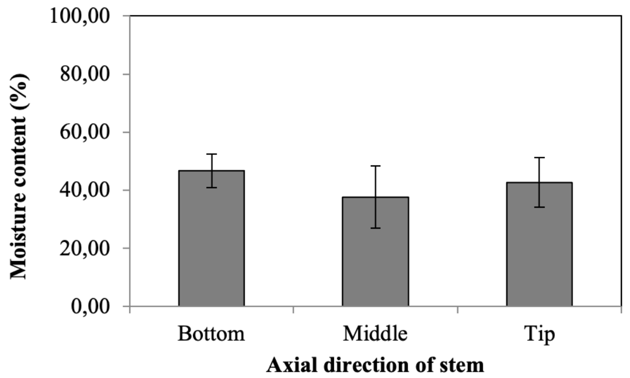

Figure 5. The moisture content of Simalambuo wood

Table 3. Specific gravity (SG) values of several tropical wood species

Wood species	SG	Source
Lophopetalum sp.	0.42	*This study*
Paraserianthes moluccana	0.29	Hamdan et al. (2020)
Sapium baccatum	0.44	
Macaranga gigantea	0.49	
Endospermum malaccense	0.51	
Hevea brasiliensis	0.52	
Eucaliptus grandis	0.52	
Paraserianthes falcataria	0.45	Isighuri et al. (2007)
Hibiscus macrophyllus	0.33	Basri and Rulliaty
Macaranga hypoleuca	0.31	(2008)

Wood contains numerous vessels subject to being filled with free water, resulting in a high moisture content. It is influenced by hygroscopic properties, as stated by Bowyer et al. (2003), where water constitutes more than half of the total weight in the xylem region. Consequently, the weight of water in wood is equal to or greater than dry wood. The wood's capacity to retain water can be influenced by the presence or absence of hydrophobic extractives found in the cell wall or lumen. Water in wood can exist in the form of vapor or liquid, occupying the cell cavities and being bound to the cell walls. The amount of water present in wood has a significant impact on various properties, including strength, shrinkage, density, and resistance to attacks by termites or fungi (Latib et al. 2014). The analysis of variance showed that the position of the stems had no significant effect on the moisture content of the wood at the 95% confidence interval (F_{value}: 2.214 and Sig. 0.125).

Shrinkage

The average value of Simalambuo wood shrinkage is in the form of longitudinal, radial, and tangential shrinkage, as presented in Figure 6. Based on the figure, longitudinal, radial, and tangential shrinkage values range from 0.46% - 0.65%, 2.1% - 2.5%, and 3.67% - 4.77%, respectively.

Generally, wood shrinkage in the tangential direction is greater than in radial. In some species, the tangential and radial shrinkage ratio reaches 2:1. In this research, the base has the greatest depreciation value, and shrinkage is affected by the specific gravity of wood (Mahmud et al. 2017). Many variables influence shrinkage, and the most important is density (Lima et al. 2014). The T/R ratio of Simalambuo wood depreciation is 1.78. According to Basri et al. (2009), wood with a T/R-ratio above 2 has more drying defects (specifically deformities) than a T/R-ratio of 1 or <2. Several tropical species with a specific gravity range of 0.30-0.50 as a comparison with the shrinkage values of Simalambuo wood are presented in Table 4.

The analysis of variance showed that stem position did not have a significant effect on the 95% confidence interval of longitudinal (F_{value}: 0.691 and Sig. 0.513) and radial shrinkage of wood (F_{value}: 0.326 and Sig. 0.726), while the tangential shrinkage was significantly different (F_{value}: 9.197 and Sig. 0.001). The Duncan Multiple Range Test (DMRT) values at the 95% confidence interval for tangential shrinkage showed that the stem bottom was significantly different from the tip and middle, while the tip was not significantly different from the middle.

Mechanical properties of Simalambuo wood

Modulus of elasticity and modulus of rupture

The average MOE and MOR values of Simalambuo wood are presented in Figure 7. The MOE and MOR produced in this research ranged from 69,033-84,177 kg/cm² and 732-810 kg/cm², where the highest and lowest values were found at the bottom and tip of the stem. MOE is an important parameter, specifically for timber construction. According to Augustina et al. (2021), a high wood density in the wood indicated a high α-cellulose content, thereby producing high MOE and MOR values. Knapic et al. (2022) stated that wood density plays an important role in determining strength and has a stronger relationship with MOR than with MOE. In addition to cellulose, lignin also plays a role in determining strength. In this research, the wood at the bottom had a higher lignin content, which positively affected the MOE and MOR values. The base of the stem exhibited the highest lignin content, which contributed to the elevated values of MOE and MOR. Lignin enhances the rigidity of cell walls and provided structural resistance (Fagerstedt et al. 2015). Baharoğlu et al. (2013) suggested that lignin acts as a binder in the cell wall, influencing the stiffness and strength of wood. In terms of MOE value, Simalambuo wood was classified within the strong categories III to IV. Therefore, the wood was suitable for applications such as light construction, furniture, crafts, and other purposes which not require high strength. The high MOR at the base of the stem was attributed to the specific gravity. According to Getahun et al. (2014), the presence of heartwood and the predominance of mature wood structure contributes to the increased specific gravity at the base of the stem. Several tropical wood species with a specific gravity range of 0.30-0.50 as a comparison with the MOE and MOR values of Simalambuo wood are presented in Table 5. Analysis of variance showed that stem position had a significant effect on the MOE of wood at the 95% confidence interval (F_{value}: 20.038 and Sig. 0.000), while MOR did not have a significant effect (F_{value}: 1.441 and Sig. 0.275). The DMRT values at the 95% confidence interval at the MOE showed that the bottom, middle, and tip of each were significantly different from one another.

Hardness

The average hardness value of Simalambuo wood is presented in Figure 8. The hardness value of wood ranged from 189.33-277.61 kg/cm^2, where the highest and lowest values were found at the base and tip.

Similar to the MOE and MOR values, the tendency for hardness values also decreased from the base towards the tip as stated by Getahun et al. (2014). The bottom of the stem had a higher specific gravity and the results showed a decrease in the specific gravity towards the tip of the stem. According to Peng et al. (2016), there is a positive correlation between specific gravity and hardness values. Analysis of variance showed that stem position had a significant effect on the hardness of wood at the 95% confidence interval (F_{value}: 8.836 and Sig. 0.012). The DMRT values at a 95% confidence interval on hardness showed that the stem tip differed significantly from the bottom and middle, and the bottom was not significantly different from the middle.

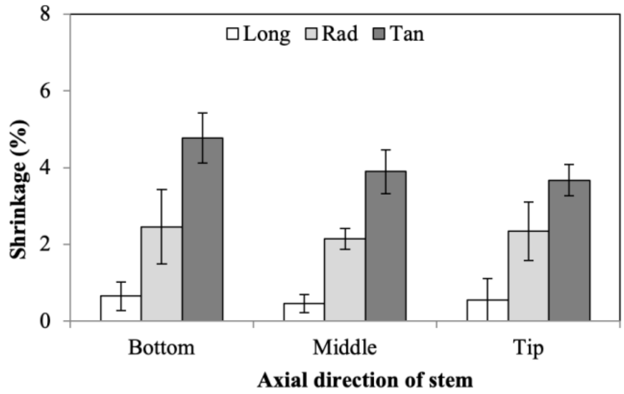

Figure 6. The shrinkage of Simalambuo wood

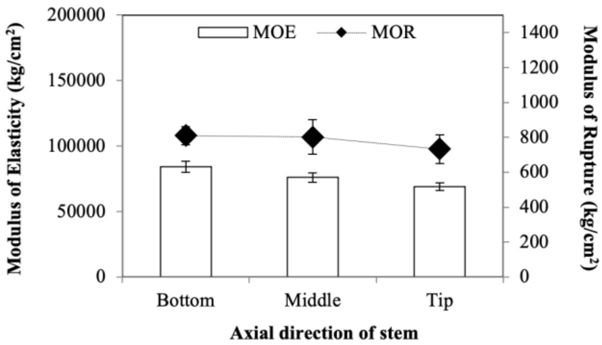

Figure 7. Modulus of elasticity and modulus of rupture Simalambuo wood

Table 4. Shrinkage values of several tropical wood species

Wood species	Shrinkage (%)			T/R ratio	Source
	Long	Rad	Tan		
Lophopetalum sp.	0.6	2.3	4.1	1.78	*This study*
Paraserianthes moluccana	0.8	2.4	3.0	1.25	Hamdan et al. (2020)
Sapium baccatum	0.3	1.1	2.4	2.1	
Macaranga gigantea	0.5	1.5	2.4	1.6	
Endospermum malaccense	0.8	1.7	2.7	1.5	

Table 5. MOE and MOR values of several tropical wood species

Wood species	MOE (kg/cm^2)	MOR (kg/cm^2)	Source
Lophopetalum sp.	76,000	781	*This study*
Paraserianthes falcataria	77,000	-	Isighuri et al. (2007)
Paraserianthes moluccana	51,000	369	Hamdan et al. (2020)
Sapium baccatum	75,000	659	
Macaranga gigantea	80,000	740	
Endospermum malaccense	92,000	795	
Hevea brasiliensis	85,000	813	
Eucalyptus grandis	84,000	840	

Chemical properties of Simalambuo wood

Wood extractives

Wood extractives played a role in determining several properties such as color, odor, flammability, and natural durability (Latib et al. 2014; Fernandes et al. 2017). The results of the extractive content in ethanol benzene of the Simalambuo wood research are presented in Figure 9. The highest and lowest levels of extractive substances in the ethanol-benzene solvent were found at the tip (2.33%) and middle (1.83%) of the wood. According to Anonymous (2020), the value of the resulting extractive content of Simalambuo wood can be classified into the middle category.

The presence of ethanol-benzene-dissolved extractives influences the color of the wood. A higher level of extractive substances dissolved in ethanol-benzene increases the likelihood of the wood being darker. This is because the extractives dissolved in ethanol-benzene comprise terpenoid to phenolic compounds, and dark-colored wood indicated a high concentration of phenolic compounds (Lukmandaru 2016). Kirker et al. (2013) mentioned that extractive substances in wood are non-structural components predominantly found in the heartwood. These substances typically consist of compounds that protect the wood against environmental stressors. The extractive substances in heartwood are toxic and are known as the most important part of determining the natural durability of wood. Some types of wood contain sugar in the cells which turns into highly toxic extractives. The variance analysis showed that the wood's position had no significant effect on the extractives with a 95% confidence interval. Several tropical wood species with a specific gravity range of 0.30-0.50 as a comparison with the extractive values of Simalambuo wood are presented in Table 6.

Holocellulose, α-cellulose, and hemicellulose

The holocellulose, α-cellulose, and hemicellulose of Simalambuo wood can be seen in Figure 10. The holocellulose content exhibited the highest value among hemicellulose and α-cellulose. It represents the total polysaccharide content, which is the combined sum of α-cellulose and hemicellulose in wood (Rahman et al. 2018). According to Rahman et al. (2018), higher levels of holocellulose correspond to increased levels of α-cellulose and hemicellulose. The elevated holocellulose content in wood elucidates its ability to produce pulp.

The highest holocellulose value was found in the middle part of the wood (43.79%). According to Maulida et al. (2020) and Putra et al. (2018), this is attributed to the influence of collenchyma tissue, which is characterized by cell walls containing pectin and holocellulose. The collenchyma cell wall is also subjected to thickening on the tangential side, leading to an increased holocellulose content. The variance analysis showed that the wood's position had a significant effect on holocellulose with a 95% confidence interval. The DMRT values at the 95% confidence interval showed that the tip of the stem was significantly different from the bottom and middle. However, the bottom was not significantly different from the middle of the stem.

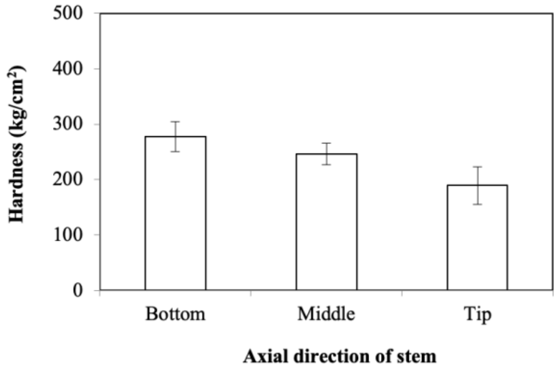

Figure 8. The hardness of Simalambuo wood

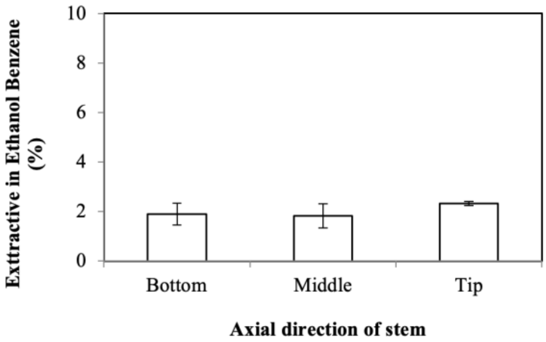

Figure 9. Extractive content of Simalambuo wood

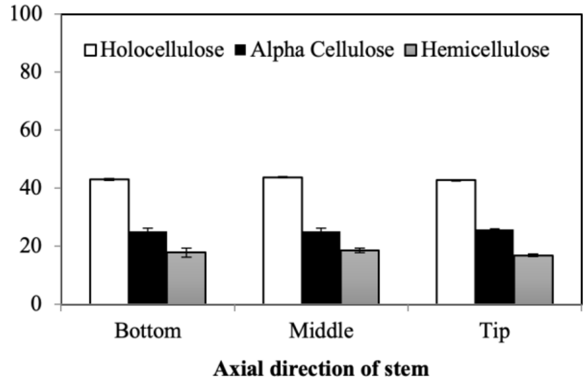

Figure 10. Holocellulose, α-cellulose, and hemicellulose of Simalambuo wood

Table 6. Extractive content of several tropical wood species

Wood species	Extractive content (%)	Source
Lophopetalum sp.	2.02	*This study*
Albizia lebbeck	4.39	Wibisono et al. (2018)
Anthocephalus cinensis	4.27	
Litsea roxburghii	1.54	
Michelia champaca	4.02	
Nauclea orientalis	2.65	

Table 7. Holocellulose content of several tropical wood species

Wood species	Holocellulose content (%)	Source
Lophopetalum sp.	43.2	*This study*
Albizia lebbeck	70.84	Wibisono et al. (2018)
Anthocephalus cinensis	70.94	
Litsea roxburghii	75.15	
Michelia champaca	75.64	
Nauclea orientalis	70.62	

The highest α-cellulose content is found at the tip of the stem, which is 25.85%. Furthermore, α-cellulose is cellulose with a polymerization degree of 600-15,000 and materials with high content indicated high-quality raw materials. Augustina et al. (2021) stated that a narrower vessel diameter shows a portion of the cell wall, and the amount of cellulose is greater. The density is higher, causing the wood to be denser by producing strength. According to Anonymous (2020), the value of the resulting α-cellulose content of Simalambuo wood can be classified into the low category. The variance analysis showed that the wood's position had no significant effect on α-cellulose with a 95% confidence interval.

The highest hemicellulose value was found in the middle part of the wood (18.53%) in association with cellulose and lignin. The ratio of carbon and oxygen in wood was associated with the degradation and lignin regeneration during the heat process. According to (Wang et al. 2014), hemicellulose consists of polysaccharides, namely arabinoxylan, with a significant proportion of galactose and uronic acid without acetyl groups (Costa et al. 2019). The analysis of variance showed that wood position had no significant effect on hemicellulose with a 95% confidence interval. Several tropical species with a specific gravity range of 0.30-0.50 as a comparison with the holocellulose values of Simalambuo wood are presented in Table 7.

Lignin (acid soluble and acid insoluble)

The results of the lignin content in the Simalambuo wood research are presented in Figure 11. Acid soluble lignin (ASL) values ranged from 1.88-1.96%, with the lowest and highest value at the tip and middle of the stem. Meanwhile, the acid-insoluble lignin (AIL) value ranged from 27.16-28.04%, where the lowest and highest value was in the middle and base of the stem.

According to Fernandes et al. (2017), lignin acts as an aggregator between cellulose microfibrils and neighboring cell walls, giving wood rigidity and robustness to shock and compression. Cell lignin, specifically the phenolic compounds, could bind fiber cells and act as a rigidity agent in the cellulose molecules between the cell walls. Furthermore, it increases the stiffness and strongly affects the mechanical properties of wood. Lignin is also vital in the structural assembly of the cell wall. Baharoğlu et al. (2013) stated that the addition of high cellulose and lignin content improves mechanical properties, specifically MOE and MOR in wood panels. The higher the cellulose content, the greater the food source for wood-destroying organisms. According to Anonymous (2020), the value of the resulting lignin content of Simalambuo wood can be classified into the medium category. The variance analysis showed that the wood's position had no significant effect on the ASL with a 95% confidence interval. For AIL, the variance analysis showed that the position had a significant effect. The DMRT values at the 95% confidence interval at the AIL reported that the bottom of the stem was significantly different from the middle and tip, but the middle was not significantly different from the tip. Several tropical species with a specific gravity range of 0.30-0.50 as a comparison with the lignin values of Simalambuo wood are presented in Table 8.

Natural durability of Simalambuo wood

Weight loss and mortality

Based on Figure 12, the value of the weight loss of Simalambuo wood ranged from 14.90-15.62%, where the highest and lowest values were found at the tip and middle. For mortality, the value ranged from 45.7-47.5%, where the highest and lowest values were found at the middle and bottom of the stem. Hadi et al. (2020a; 2020b) reported that *Acacia mangium* wood resulted in lower weight loss values compared to *Paraserianthes moluccana* when testing its resistance to subterranean termite attacks. The termite mortality rate averaged less than 50%, meaning that more than half of the remaining termites were alive. Therefore, the role of extractives, which was a natural preservative, did not provide a lethal toxic effect on termites. According to SNI 7207-2014, the durability of Simalambuo wood from termite attack can be included in the low-durable category because the percentage of weight loss ranged from 10.9-18.9%. Termites that attacked the position of the stem at the end were higher than those in the middle. The number of termites attacking wood greatly affects the damage and loss of the mass. The research on cellulose shows that the content of the stem has the highest value, and acts as the primary source of food for termites. In addition, termites are the biggest threat among wood-destroying organisms because these organisms eat the cellulose in wood. According to Shanbhag and Sundararaj (2013), cellulose has a positive correlation to durability, while lignin and total phenolic compounds have a negative correlation. The high cellulose content indicates more food sources for wood-destroying organisms with increased damage. Meanwhile, lignin and phenolic compounds are barrier agents against attacks by wood-destroying organisms. The natural durability of Simalambuo wood against subterranean termite attacks can be classified as class IV with indications of a heavy attack in the form of deep and wide channels. The variance analysis showed that the position had no significant effect on weight loss with a 95% confidence interval. Several tropical species as a comparison with the weight loss values of Simalambuo wood are presented in Table 9.

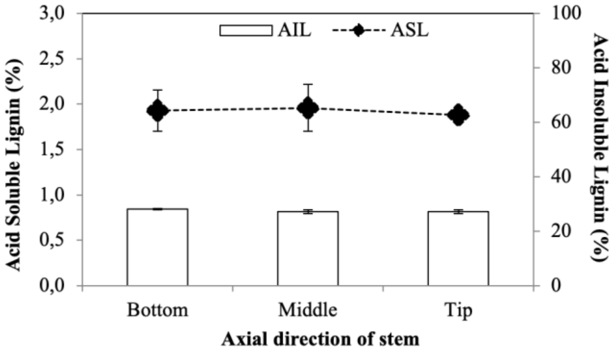

Figure 11. Lignin of Simalambuo wood

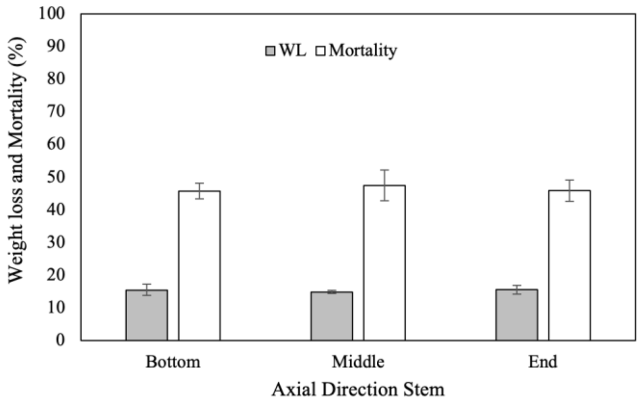

Figure 12. Weight loss and mortality of Simalambuo wood

Table 8. Lignin content of several tropical wood species

Wood species	Lignin content (%)	Source
Lophopetalum sp.	29.38	*This study*
Albizia lebbeck	27.59	Wibisono et al. (2018)
Anthocephalus cinensis	26.24	
Litsea roxburghii	30	
Michelia champaca	25.64	
Nauclea orientalis	26.31	

Table 9. Weight loss values of several tropical wood species

Wood species	Weight loss (%)	Source
Lophopetalum sp.		*This study*
Anthocephalus cadamba	21.1	Hadi et al. (2020a)
Falcataria moluccana	21.7	
Acacia mangium	13.5	
Pinus merkusii	14.6	
Styrax sumatrana	23.2	Iswanto et al. (2021a)
Cotylelobium melanoxylon	1.93	Iswanto et al. (2020)

In conclusion, Simalambuo wood is included in the III-IV strength class based on its physical and mechanical properties. Therefore, the application of this wood is recommended for light construction, furniture, and other functions outside the category of heavy construction. The wood has poor dimensional stabilization compared to several tropical species with the same specific gravity range, and is quite good at minimizing defects due to drying because of its T/R ratio value below 2. Furthermore, it belongs to durable class IV, meaning the wood has low resistance to subterranean termite attack and requires preservative treatment before applying as a building material.

ACKNOWLEDGEMENTS

The authors are grateful to Universitas Sumatera Utara for supporting the research by funding through to Talenta Research Grant (International Collaboration Research Scheme) of 2020 (No: 402/UN5.2.3.1/PPM/SPPTALENTA USU/2020. Date: 28 April 2020).

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