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Sound damping and sound absorption of *Acacia mangium* from various diameter

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Abstract. Previous studies recommend acacia wood to be used as an acoustic component of the panel (sound dampening). This study wanted to obtain optimal diameter information in the use of *Acacia mangium* as raw material for acoustic panels. Given the diameter of the wood related with the development of cells that occur in trees that affect the other basic properties of the wood. The research tree of the acacia wood with diameter of 17 cm, 25 cm and 35 cm. The basic properties of the wood being tested are vessel diameter, density and MOE. While the acoustic properties are sound damping and sound absorption. The results showed the acoustic properties of acacia wood were not influenced by diameter, but related to the basic properties of wood such as vessel diameter, density and MOE.

1. Introduction

One coefficient of sound absorption shown by the proportion (percentage) of sound absorbed in the form of sound waves of the uses of wood is the main material of musical instruments because wood has acoustic properties [1]. Wood acoustics is a source of sound and has the ability to absorb sound well that measured by the coefficient of sound absorption shown by the proportion (percentage) of sound absorbed in the form of sound waves.

Imported wood trade for musical instruments has limited, so that the price of imported wood is increasingly expensive, musical instrument makers are looking for alternative types of wood in the country as substitute material. Research on the basic nature of acoustic wood originating from Indonesia (local) is limited by the quality of products of ready-made musical instruments, especially guitars made from local wood, without information that supports the acoustic [2-4]. Meanwhile, there are some types of local wood that have been known has a good acoustic properties and can be used as raw material for musical instruments such as mahogany wood (*Swietenia mahagoni*), pine (*Pinus merkusii*), sonokeling (*Dalbergia latifolia*), merah meranti (*Shorea pinanga*), sungkai (*Peronema canescens*), and acacia (*Acacia mangium*) [5,6]. Specially for acacia's wood, the result of the research showed that acacia's wood with a diameter of 30 cm had a high sound absorption value of 0.476 ns, sound speed of 0.672 ns, with a density of 0.58 kg/cm³ than the other types of wood like mahogany, sonokeling and manii. So, the acacia's wood is recommended for acoustic panel components (dampening sound).

This study wanted to find out the acoustic's properties of wood which from small diameter acacia wood, with assuming differences of the tree's diameter can be expected has differ in age so that it can affect the acoustic properties of wood. The cells formation in a tree affects the basic properties of wood



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including the density and elasticity of wood, where these properties affect the acoustic properties of wood.

2. Materials and Methods

2.1. Materials

The acacia trees are diameter with 17 cm, 25 cm and 35 cm. Each diameters of acacia tree are felled and cut short log 50 cm from a base. See the Picture 1 for more details.

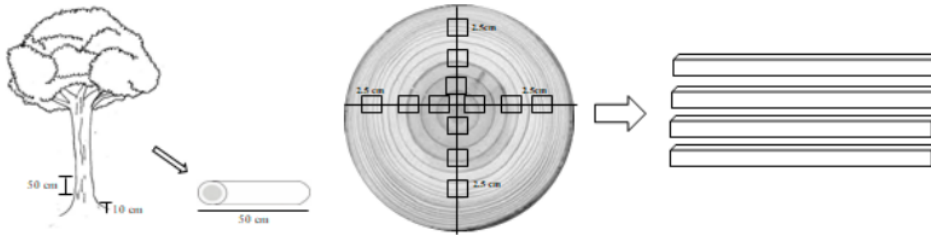


Figure 1. Cutting log tree's scheme and cutting sample's scheme

2.2. Methods

2.2.1. Observation of anatomical structure

Wood anatomic structure observed sum and diameter of vessel at incision prepare from each sample test. For procedure of incision prepare make based on Purnawati *et al.* [7] and Sulistyobudi *et al.* [8] for vessel measurement results.

2.2.2. Test of physical and mechanical properties

Testing of mechanical properties are MOE based on ASTM D-143 [9] with a test sample measuring 2.5 x 2.5 x 41 cm. The loading speed used is 1.3 mm/second with a buffer distance (L) 36 cm. The physical properties of the wood calculated are moisture content, density and specific gravity of the wood. The sample of physical properties research comes from the mechanical properties test sample. The undamaged test sample section is used to measure moisture content, specific gravity and wood density based on [10]. The tools used for this test is Universal Testing Machine (UTM).

2.2.3. Test of acoustic properties

Testing of acoustic properties is carried out before other tests, namely mechanical properties, physical properties and anatomical structure of wood. Testing acoustic properties using sonic waves with a test sample measuring 2.5 x 2.5 x 41 cm refers to ASTM D-143 [9]. The test sample used was 32 units (3 wood diameters with different number of replications each diameter). The tools used for this test is digital oscilloscope Sonic wave testing is done by placing the test sample on a table. At the first side attached sound detector that has been connected with a digital oscilloscope. While the other side is tapped using a pendulum with the same distance that is as far as 12 cm from the test sample (Figure 2). Sonic waveform readings are seen on a digital oscilloscope screen connected to the sound detector using a variable frequency in the range of 1-8 kHz.

2.2.3.1. Sound damping

Sound damping (logarithmic decrement) can be calculated using the formula:

$$\tan \delta = \ln \frac{A_1}{A_2} \quad \text{with } \zeta = \frac{\tan \delta}{2\pi} \quad (1)$$

where, $\tan \delta$: logarithmic decrement, A_1 : wave height on the first period (V), A_2 : wave height on the second period (V), ζ : damping ratio/sound damping, π : 3.14.



Figure 2. Testing of acoustic properties with oscilloscope screen

2.2.3.2. Sound Absorption

Sound absorption can be calculated using the formula:

$$SA = \frac{A_1 - A_2}{A_1} \times 100\% \quad (2)$$

where, SA : Sound absorption (%), A1 : wave height on the first period (V), A2 : wave height on the second period (V)

2.3. Data Analysis

Data analysis was performed with a simple descriptive analysis of the parameters of anatomical structure, physical properties and mechanical properties. Values displayed are average values, minimum values, maximum values and standard deviations. The results of wood acoustic properties were analyzed in oneway analysis using SPSS version 22 on all diameters.

3. Result and Discussion

3.1. Characteristics of acacia wood

The anatomical structure of wood observed was the number of vessel and vessel diameters. Based on Sulistyobudi *et al.* [8] the number of vessel of acacia wood in this study was classified as very rare to infrequently with a large vessel diameter. The number of vessel and vessel diameters of acacia wood at various diameters is presented in Table 1. The greater the vessel diameter, the fewer the number of vessel per mm².

Physical properties calculated in this study are moisture content, density and specific gravity of wood, while the mechanical properties are MOE. As the diameter increases, physical and mechanical properties also increase.

MOE values increase with increasing wood diameter. This is in line with research conducted by Tabet and Fauziah [11] and Susanti [12] which states that as the diameter of the tree increases, the MOE value increases.

MOE test results and specific gravity showed acacia wood in this study included in the strong class III [10]. Table 1 shows the number of vessel, vessel diameters, density and specific gravity of wood and acacia wood MOE at several diameters.

Table 1. Research data on the number of vessel, vessel diameter, moisture content, specific gravity, density, and MOE of acacia wood at several diameters

Characteristics of acacia wood	d 17	d 25	d 35
Anatomi Structre			
Number of Pores (per mm ²)	5	7	4,6
Min	3	5	4
Maks	7	9	6
Sd	0.93	1.08	0.71
Vessel Diameter (µm)	139	127	150
Min	80	98	106
Max	213	206	263
SD	27	27	31
Physical Properties			
Moisture Content (%)	13.84	15.35	16.86
Min	13.27	12.27	9.94
Max	14.63	18.12	37.84
SD	0.45	1.52	7.48
Specific Gravity	0.56	0.65	0.65
Min	0.50	0.60	0.57
Max	0.63	0.68	0.73
SD	0.05	0.03	0.04
Density (g/cm ³)	0.63	0.75	0.78
Min	0.57	0.69	0.65
Max	0.72	0.78	0.90
SD	0.05	0.03	0.06
Mechanical Properties			
MOE (kg/cm ²)	48,533	62,186	79,330
Min	20,244	53,021	46,717
Max	64,219	70,875	102,778
SD	15,535	5564	12,556

3.2. Acoustic properties

Acoustic materials can be divided into three basic categories, namely absorbing materials, barrier materials, damping materials [13]. In this study, the acoustic properties studied were sound damping and sound absorption with a frequency range of 1-8 kHz.

3.2.1. Sound damping

The results of the sound damping test on the diameters of 17, 25 and 35 cm of acacia wood are presented in Figure 3. Although there are differences in the value of damping sound from diameter 17-35 cm, but the value is relatively the same. The results of the analysis of variance showed that the difference in diameter of the wood did not have a real effect on the sound damping where the Sig. (0.281>0.05). Meanwhile for physical and mechanical properties do not have a significant correlation it is suspected that the difference in diameter, especially the density is not enough to give effect to the acoustic properties of sound damping. Trend of the number and diameter of vessel is not in line with the physical and mechanical properties of wood, this illustrates that the number and diameter of vessel does not greatly affect the density of wood the possibility of cell wall thickness being more influential but in this

study were not analyzed. According to Baihaqi [14], the material used in the need for sound dampening is to have a low MOE value, while the value of density, sound damping, and sound absorption is high. In this study, a diameter of 17 cm is enough to be recommended as an acoustic raw material.

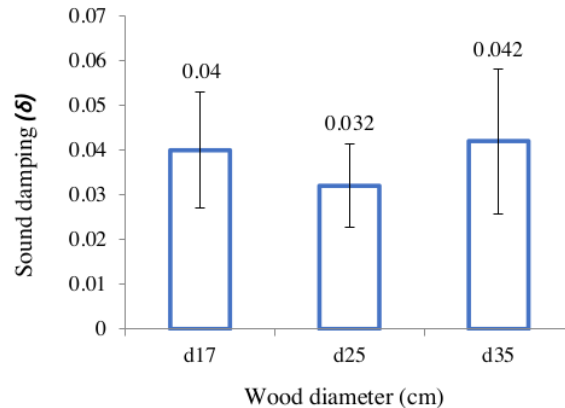


Figure 3. Sound damping seen from various diameters

3.2.2 Sound absorption

Part of the acoustic energy that affects wood partially or wholly can be absorbed, refracted and reflected. This acoustic energy will certainly cause molecular friction and cause energy changes from acoustic energy to thermal energy [15].

The ability of wood to absorb sound with the coefficient of sound absorption as indicated by the percentage of sound absorption. Sound absorption coefficient is influenced by density and other factors such as elasticity (MOE), moisture content, temperature, intensity, sound frequency and wood surface conditions. Wood with low density and elasticity at high temperature and moisture content absorbs more noise, greater absorption of sound with low frequency and lower on wood that is given a coat of varnish [1].

The results of sound absorption testing at diameters of 17, 25 and 35 cm are presented in Figure 4. The low sound absorption value at a diameter of 25 cm is suspected because at that diameter the pore diameter size is smaller than the other pore diameters, where one of the criteria for sound absorbing material is porous which functions as a cavity resonator. Through these pores, sound waves enter and vibrate the air molecules in the vessel [16]. The amount of sound absorption in the absorbent material is expressed by the absorption coefficient (α). Absorption coefficient (α) is expressed in numbers between 0 and 1. The absorption coefficient value 0 states that no sound energy is absorbed and the absorption coefficient value 1 expresses perfect absorption [17]. The results of the analysis of variance showed that the difference in diameter of the wood did not have a real effect on the sound damping where the Sig. (0.281 > 0.05) shows that differences in wood diameter do not have a significant effect on sound absorption.

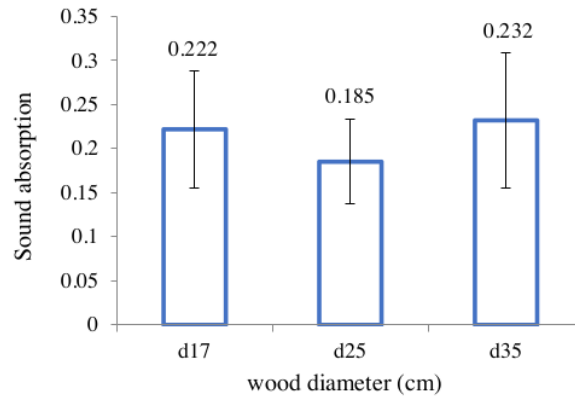


Figure 4. Sound absorption seen from various diameters

12 Conclusion

Based on the results of this study, the acoustic properties of acacia wood are not influenced by diameter, so the use of acacia wood between 17 cm to 35 cm in diameter can be recommended as a good acoustic raw material.

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