Study on the existence and characteristics of Sonokeling (Dalbergia latifolia Roxb) as an Appendix II CITES Wood

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Abstract. Sonokeling (Dalbergia latifolia Roxb) stands are widely lost throughout the world. Sonokeling is currently classified as an Appendix II CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) wood. Therefore, a study on the existence and characteristics of Sonokeling were expected to contribute in providing population data and basic properties of the wood. Exploration was conducted in Plot No. 25, KPH (Forest Management Unit) Gundih, Perum Perhutani Cepu, Central Java. Sonokeling stands have been planted since 1975 (more than 40 years-old) in an area of 54.20 ha, which was not productive for Teak and mixed with Mahogany. Sample was taken from upper part of stem with around 30 cm in diameter and 30 cm in length. The sample was further cutted into 2 x 2 x 2 cm for physical, 30 x 2 x 2 cm for Modulus of Elasticity (MOE) and Modulus of Rupture (MOR), and 4 x 2 x 2 cm for Compression Strength Parallel to the Grain (CSPG) tests. The results showed that specific gravity of sapwood dan heartwood were 0.79 and 0.82, respectively. The average values of MOE, MOR, and CSPG were 117,722, 1122.19, and 1022.93 kgf/cm², respectively. Therefore, Sonokeling can be classified into Strength Class II.

1. Introduction

Sonokeling (Dalbergia latifolia Roxb) is a high-quality wood in trade, known as Rosewood [1]. In Indonesia, Sonokeling is only found growing wild in the forests of Central and East Java at altitudes below 600 m above sea level, especially in rocky, infertile, and dry soils at regular intervals. It grows in groups, but not too much, in the seasonal forests that abort the leaves in the dry season [2].

Sonokeling is mainly used by the wood, which has beautiful, purple, black or purplish black patterns with reddish brown. This wood is commonly used to make furniture, cabinets, and various high-class home furnishings. Its decorative veneer is used to coat expensive plywood surfaces. Because of its good nature, Sonokeling wood is often used to make carvings and sculptures, lathe goods, musical instruments, and sports, as well as bent wood furniture such as umbrella handles, walking sticks, and others [1]. This wood is also strong and durable, so it is not in frequently used in construction such as for sills, doors, and windows, for making railroad cars, and for equipment such as hammers, plows, rakes, and grinding machines [1]. In addition to that, Sonokeling is also used to make parquet floors.

Sonokeling belongs to medium to heavy hardwoods. The specific gravity is between 0.77 – 0.86 at a moisture content of around 15%. The texture is quite smooth, with straight fiber direction and sometimes wavy. This wood is also durable, resistant to be attacked by dry wood termites and very resistant to wood rot fungi [1]. The heartwood is brown and dark purple, with very dark brown smudges.
to black. Sapwood is whitish to yellowish, 3 – 5 cm thick, clearly distinguished from heartwood [1]. Sonokeling wood is rather difficult to do by hand, but it is very easy with a machine. This wood can be shaved so that the surface is slippery, and can be peeled and sliced to make decorative veneers. This wood can also be turned, screwed, and polished with excellent results. However, this wood is difficult to be given preservatives [1].

Sonokeling is one of the most popular agroforestry plants in Indonesia. This tree is planted in an intercropping system, interspersed with various food crops. Sonokeling also becomes an agroforestry tree. Sonokeling leaves are used for animal feed and green manure [3]. Sonokeling roots are nitrogen binding and thus can improve soil fertility [4].

Sonokeling prices are comparable to Teak, even higher. Its high value has encouraged excessive harvesting so that the natural population of this tree faces extinction. Therefore, since 1998 the IUCN World Conservation Agency has included *Dalbergia latifolia* in the category Vulnerable [5,6].

Genetic resources stands of Dalbergia trees have depleted considerably all over the world. The decorative wood has been imported in Europe for several countries for furniture and interior finishing. In many areas, large Dalbergia trees become rare. In Java, for instance, it is now difficult to find an old and large Sonokeling tree. However, Sonokeling is planted on a considerable scale in agroforestry systems in India, and, on a much smaller scale, in Java [1].

Sonokeling is currently classified as an Appendix II CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) wood, besides Agarwood (generas of *Gyrinops* and *Aquilaria*), Ramin (*Gonystylus bancanus*), and Angsana (*Pterocarpus indi*). Therefore, a study on the existence and characteristics of Sonokeling were expected to contribute in providing population data and basic properties (physical and mechanical) of the wood for classification and standardization.

2. Materials and methods
Exploration or field study was conducted in Plot No. 25, KPH (Forest Management Unit) Gundih, Perum Perhutani Cepu, Central Java on July 11, 2018, along with logging activities (figure 1). Sonokeling stands have been planted since 1975 (more than 40 years-old) in an area of 54.20 Ha, which is not productive for Teak and mixed with Mahogany.

The sample was taken from the upper part of the stem with around 30 cm in and 30 cm in length (figure 1). The sample was further cut into 2 x 2 x 2 cm for physical, 30 x 2 x 2 cm for Modulus of Elasticity (MOE) and Modulus of Rupture (MOR), and 4 x 2 x 2 cm for Compression Strength Parallel to Grain (CSPG) tests.

![Figure 1. Logging activities (left) and cutting a wood sample (right).](image)

2.1. Physical properties
Moisture content and specific gravity of wood samples were measured according to British Standard BS 373-1957 [7]. After weighing and measuring in length, width and thickness to get the initial weight ($W_o$) and volume ($V_o$) in fresh condition, the samples were dried at 103 ± 2°C for 24 hours to get oven-dry
weight (Wod). Moisture content was obtained by \[ ((Wo - Wod) / Wod) \times 100\% \], and specific gravity was calculated by \( (Wod / Vo) \).

2.2. Mechanical properties
Modulus of elasticity (MOE), Modulus of rupture (MOR), and Compression strength parallel to the grain (CSPG) were tested according to British Standard BS 373-1957 [7], as well. For bending tests (MOE and MOR), the wood sample was installed, and the load was given in the middle of the span. The maximum load was recorded until it was broken. For the CSPG test, the wood sample was given a compressive load parallel to the grain until it was damaged. MOE, MOR and CSPG values were calculated using the formula:

\[
\text{MOE (kgf/cm}^2\text{)} = \left[ \frac{(\Delta PL^3)}{(4 \Delta ybh^3)} \right] \tag{1}
\]

\[
\text{MOR (kgf/cm}^2\text{)} = \left[ \frac{(3PL)}{2bh^2} \right] \tag{2}
\]

\[
\text{CSPG (kgf/cm}^2\text{)} = \left[ \frac{P}{lb} \right] \tag{3}
\]

where \( P \) = load (kgf), \( \Delta P \) = load difference (kgf), \( L \) = span distance (cm), \( \Delta y \) = deflection (cm), \( b \) = sample width (cm), \( h \) = sample thickness (cm), \( l \) = sample length (cm).

3. Results and discussions
3.1. Study on the existence of Sonokeling stands
Study of primary data on the existence of Sonokeling stands was conducted on July 9 – 13, 2018 through visiting several authorized and related agencies in Central Java Province, such as Ministry of Environment and Forestry, Conservation and Natural Resources Agency (BKSDA), and Perum Perhutani (Regional Division Office, Research and Development Center Cepu, and Forest Management Unit Gundih).

The results of study showed that the existence of this wood species was very difficult to find. According to Annual Report of Conservation and Natural Resources Agency [8], Sonokeling stands grow in Pagerwuning Darupodo Nature Preserve Area (33.20 ha), Wildlife Reserve Area of Mount Tunggangan (102.475 ha), Natural Tourist Park of Mount Selok (116.166 ha). Around 20 Sonokeling trees at Gunung Tunggangan have a diameter ranging between 90 and more than 300 cm. However, some of them fell due to natural disasters.

There is no export quota for nature Sonokeling wood in Central Java unless cultivation harvesting can be utilized according to its production capacity. KPH (Forest Management Unit) Gundih, BKPH Juwono, RPH Kalang got a clear cutting target for fiscal year 2018 with a planned harvesting area of 25 ha in 8 separate blocks, consisting of 2453 Sonokeling trees (1191.603 m³), 114 Mahogany trees (73.193 m³) and 147 Johar trees (54.458 m³). Buyers will come to the log yard (figure 2) and use the wood for various products.
Recently, the selling price of Sonokeling wood is around IDR 17,000,000/m³. For comparison, the selling price of Teak wood is IDR 6,000,000/m³, and for Mahogany wood is IDR 4,000,000/m³. The high selling price of Sonokeling wood is mostly due to its limited stock, but the demand is quite high. There was no intensive cultivation effort which has an impact on Sonokeling wood supply. Therefore, serious attention is necessary to develop cultivation, because Sonokeling wood is very potential and prospective.

In general, Rosewood is one of the most expensive woods. Natural stands of Dalbergia, however, need urgent protection. Loggers should take full account of the fact that the trees are usually slow growers; therefore, the cutting cycles should be very long. Sonokeling is suitable for incorporation in agroforestry systems, but to obtain straight stem, close spacing is desirable, and this means establishing monoculture plantations. Sonokeling can offer good prospects for timber production in plantations in Java, but more research is needed on silvicultural aspects.

3.2. Physical and mechanical properties

Table 1 and 2 show the moisture content and specific gravity of heartwood (table 1) and the sapwood (table 2) of Sonokeling wood samples. The results showed that the average moisture content and a specific gravity of heartwood were 49.59% and 0.82 respectively, while for the sapwood was 25.02% and 0.79 respectively. The moisture content of sapwood was lower than heartwood because the tree had been cut for a few days and left in the field before the wood sample was taken. Therefore, the moisture content values do not represent the fresh condition of the wood.

| Samples | Moisture content (%) | Specific gravity |
|---------|----------------------|-----------------|
| 1       | 43.30                | 0.84            |
| 2       | 51.77                | 0.77            |
| 3       | 62.34                | 0.74            |
| 4       | 49.66                | 0.84            |
| 5       | 47.04                | 0.84            |
| 6       | 48.22                | 0.84            |
| 7       | 48.34                | 0.84            |
| 8       | 45.99                | 0.82            |
| 9       | 49.65                | 0.85            |
| Average | 49.59                | 0.82            |
Table 2. Moisture content and a specific gravity of sapwood.

| Samples | Moisture content (%) | Specific gravity |
|---------|----------------------|-----------------|
| 1       | 21.62                | 0.75            |
| 2       | 27.64                | 0.76            |
| 3       | 22.18                | 0.84            |
| 4       | 27.57                | 0.75            |
| 5       | 26.74                | 0.76            |
| 6       | 26.17                | 0.75            |
| 7       | 24.93                | 0.84            |
| 8       | 24.39                | 0.84            |
| 9       | 23.98                | 0.83            |
| Average | 25.02                | 0.79            |

Table 3. Bending strength.

| Samples | MOR (kgf/cm²) | MOE (kgf/cm²) |
|---------|---------------|---------------|
| 1       | 1,640.79      | 140,909       |
| 2       | 1,259.44      | 129,010       |
| 3       | 994.53        | 102,174       |
| 4       | 1,008.78      | 91,764        |
| 5       | 1,146.95      | 126,224       |
| 6       | 888.66        | 115,860       |
| 7       | 916.18        | 118,115       |
| Average | 1,122.19      | 117,722       |

Table 4. Compression strength parallel to grain (CSPG).

| Samples | CSPG (kgf/cm²) |
|---------|----------------|
| 1       | 1,147.58       |
| 2       | 1,042.21       |
| 3       | 1,166.72       |
| 4       | 1,170.66       |
| 5       | 960.51         |
| 7       | 1,002.49       |
| 6       | 1,116.71       |
| 8       | 872.29         |
| 9       | 727.20         |
| Average | 1,022.93       |

Table 3 and 4 show the average values of MOE, MOR, and CSPG values were 117,722, 1122.19 and 1022.93 kgf/cm², respectively. Therefore, Sonokeling can be classified into Strength Class II, according to table 5.

A test of Sonokeling wood from Java gave the following results for mechanical properties (density at test 790 kg/m³, moisture content 12.5%), MOR 114 N/mm² or around 1,140 kgf/cm², MOE 270 N/mm² or around 2,700 kgf/cm², and compression parallel to grain 61 N/mm² or around 610 kgf/cm² [1]. These results meet the MOR value, but quite higher for MOE and CSPG values.

Furthermore, Soerianegara and Lemmens [1] and Martawijaya et al. [9] reported that the rate of shrinkage from green to oven dry is 2.9% radial and 6.4% tangential, with T/R ratio 2.2%. Sonokeling wood is durable; graveyard tests showed an average life in contact with the ground of 7.3 years long.
under tropical conditions. Laboratory tests indicated that the wood was resistant to dry wood termites and very resistant to wood rot fungi. It is difficult to treat with preservatives using the vacuum-pressure method. Sonokeling wood contained 54% cellulose, 27% lignin, 10% pentosan, 1% ash and 0.6% silica. The solubility was 4.5% in alcohol-benzene, 1.8% in cold water, 5.2% in hot water, and 15.9% in 1% NaOH solution.

Table 5. Strength class of wood [10].

| Strength class | Specific gravity | Absolute bending strength (kg/cm²) | Absolute compression strength (kg/cm²) |
|---------------|-----------------|----------------------------------|-------------------------------------|
| I             | over 0.90       | over 1100                        | over 650                            |
| II            | 0.60 to 0.90    | 725 to 1100                      | 425 to 650                          |
| III           | 0.40 to 0.60    | 500 to 725                       | 300 to 425                          |
| IV            | 0.30 to 0.40    | 360 to 500                       | 215 to 300                          |
| V             | under 0.30      | under 360                        | under 215                           |

4. Conclusions
The existence of this wood species was very difficult to find. There was no intensive cultivation effort which has an impact on Sonokeling wood supply. Therefore, serious attention is necessary to develop cultivation, because Sonokeling wood is very potential and prospective.

The average moisture content and a specific gravity of heartwood of the wood samples were 49.59% and 0.82 respectively, while for the sapwood was 25.02% and 0.79 respectively. The average values of MOE, MOR, and CSPG values were 117,722, 1122.19 and 1022.93 kgf/cm², respectively. Therefore, Sonokeling can be classified into Strength Class II.

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