

**Wood characteristics of the indigenous tree, *Sindora siamensis* Teijsm .& Miq.
in Thailand**

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ABSTRACT: In recent years, agriculture not only focused on food crops but also the conservation of woody species on farmland for many purposes. Woody trees provide shade, shelter, energy and timber that enables the farmstead to prosper. The focus of this study was to characterize the anatomy and mechanical properties of *Sindora siamensis*, an indigenous tree species for households to plant on their farmlands. *S. siamensis*, collected from Sakaew Province (eastern, Thailand), was examined under light microscope (LM) and scanning electron microscope (SEM). Wood is characterized by interlocking grain. Vessels number are 7.16 ± 2.48 cells/mm² and are arranged in tangential bands, diameter 113 ± 9.7 μ m. Fiber wall thickness varies from thin to thick. Wood density (12% mc) is 0.72 g/cm³ with compressions parallel and perpendicular to grain of 181.42 and 108.88 MPa, respectively. Modulus of elasticity (MOE) is 6,346 MPa and modulus of rupture (MOR) is 84 MPa, suggesting good mechanical properties for commercial and furniture construction as well as interior design. *S. siamensis* deserves consideration as a supplemental agricultural species.

ข้อคิดเห็น[h3]: เขียนเป็น Past tense

Key words: *Sindora siamensis*, wood properties, wood density, indigenous tree

ข้อคิดเห็น[h4]: ใช้คำต้องไม่ซ้ำ กับชื่อเรื่อง

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INTRODUCTION

Thailand has many indigenous tree species, however, agricultural land demands for timber and fuel have greatly diminished their abundance. In paddy landscapes in eastern Thailand, trees are mainly from the family Leguminosae (Pham et al., 2015). One interesting species in northern and eastern regions of Thailand is the *Sindora siamensis* Teijsm & Miq, known locally as “Makha-Tae”, and is associated with a wide range of soils, often those regarded as nutrient poor (Karachi et al. 1997). This 10-12 m deciduous tree is characterized by 3-4 jugate leaves with broadly elliptic leaflets, yellowish-red flowers (inflorescence) and

ข้อคิดเห็น[c5]: ตรวจจลอบ

34 pods armed with stout spines. *Sindora* wood is used in the manufacture of furniture,
35 agriculture implements and heavy construction (Smitinand and Larsen, 1984).

36 Leguminosae can also be used as timber for house construction, charcoal and fuel.
37 Karachi et al. (1997) observed mainly species of 15 Leguminosae in western Tanzania as,
38 *Acacia* spp., *Sesbania sesban* and *Faidherbia albida* used for forage and wood production.
39 While, Mozambique uses *Afzelia*, *Erythrophloeum*, *Milletia* and *Pterocarpus* as major raw
40 material. However, little information is available on the mechanical properties of its wood,
41 potentially limiting its full commercial application.

ข้อคิดเห็น[c6]: หมายถึงอะไร

42 The focus of this study was to characterize the anatomy and mechanical properties of
43 *Sindora* wood including density, compression to grain and bending strength (MOR and
44 MOE), with a view to expand its commercial uses.

46 MATERIALS AND METHODS

47 Fresh stems from ten-year old trees were collected from Sakaew province (eastern,
48 Thailand). Light microscope (LM) study was conducted on wood blocks, 1x1x1.5 cm,
49 from the pith to the bark of the stems. The blocks were softened in boiling water and cut with
50 a sliding microtome (transverse, tangential and radial directions). Sections were stained with
51 safranin and mounted on slides. For scanning electron microscope (SEM) study, wood blocks
52 were dehydrated with graded ethanol series (30, 50, 70 95 and 100 %), dried by the critical
53 point (CPD) and affixed to aluminum stubs. Specimens were sputter-coated with a gold-
54 palladium mixture and examined with a JEOL (JSM-35CF) SEM. Fiber length was measured
55 from wood first macerated in a mixture of 30 % hydrogen peroxide and glacial acetic at a
56 ratio of 1:1 at 70 °C. Macerated fibers were mounted on slides and 30 unbroken fibers were
57 measured (Kermanee, 2005). Wood characteristic description was followed Wheeler and
58 Gasson (1989).

ข้อคิดเห็น[h7]: ไม่เห็นหลักฐานทางวิชาการในเรื่อง
ปัจจัยศึกษามีที่ปัจจัย ใช้หน่วยทดลองเป็นอะไร ใช้
จำนวนซ้ำเท่าไร วิเคราะห์ทางสถิติใช้วิธีใด
-บทความนี้จะไม่เข้าข่ายเป็นงานวิจัยเลย
-เป็นส้อมตัวอย่างมาส่งกล้องเท่านั้น แล้วรายงาน
ผลเท่านั้น

ข้อคิดเห็น[c8]: ลูกบาศก์ มี 3 แกน xxxyz

59 Wood density was determined on 2x2x2 cm blocks, oven-dried at 105 °C to constant
60 weight and calculated by the following formula (Desch and Dinwoodie,1996);

$$61 \quad D = M/V$$

62 Where D = density (g/cm³), M = mass (g), V = volume (cm³).

63 Mechanical properties were followed ISO 3129-1975 standards (International
64 Standard, 1975) and were determined using a universal testing machine (Instron 4466).
65 Measurements were made on specimens conditioned at 12 % relative humidity. Dry materials
66 were cut into small specimens to determine compression strength parallel and perpendicular
67 to grain, modulus of elasticity (MOE) and modulus of rupture (MOR), respectively.

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RESULTS AND DISCUSSIONS

Macroscopic characters:

Growth ring and semi-ring porous present. Heartwood is brownish, while sapwood is light-yellowish. Wood grains are interlocked and moderately coarse texture (**Figure 1**). Wood surface is luster. Vessels filled with deposits. Rays are moderately fine and can be seen with the naked eye.

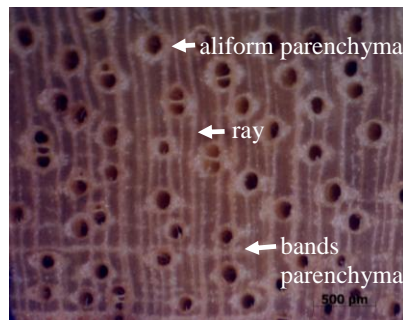


Figure 1 Wood transverse section showing ray and aliform parenchyma.

Microscopic characters:

Vessels are diffuse, 7.16 ± 2.48 cells /mm², solitary and multiples of 2-4, occasionally in clusters (**Figure 2a**), average tangential diameter 113 ± 9.7 μm; perforations simple (**Figure 3a**); pit aperture vestured, intervessel pits alternate (**Figure 3b**). Fibers are abundant, 970 ± 210 μm in length, septate and rather thick wall (**Figure 2b**). Fibers wall thickness are 4.17 ± 0.36 μm. Axial parenchyma rather abundant, paratracheal parenchyma aliform and narrow bands at margins of a growth ring (**Figure 1**). Ray are 1-3 seriates (**Figure 4b**), heterocellular, composed of procumbent parenchyma cells, only 2-4 rows of marginal cells, usually upright. (**Figure 4a**). Prismatic crystals occur in chambered axial parenchyma cells (**Figure 4b**). Deposits present in vessels (**Figure 4a**). Tylose absent. All elements non-storied.

ข้อคิดเห็น[c9]: ,

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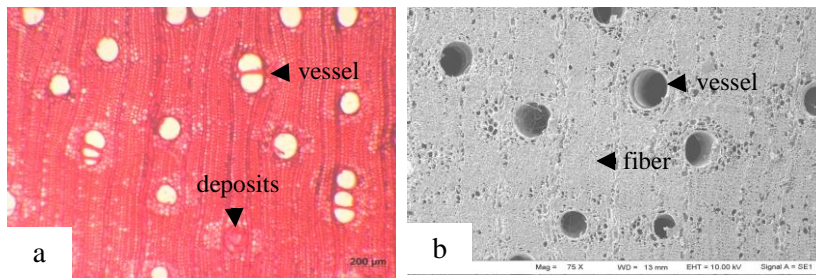


Figure 2 Wood transverse section wood showing (a) deposits presented in vessels.
(b) A SEM micrograph showing dense fibers in wood texture.

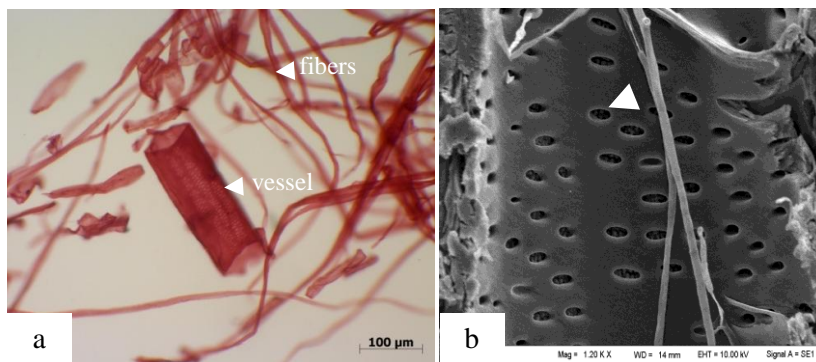


Figure 3 a) Wood maceration showing simple perforate vessel and fibers.
b) A SEM micrograph showing vestured pits on the vessel (arrow).

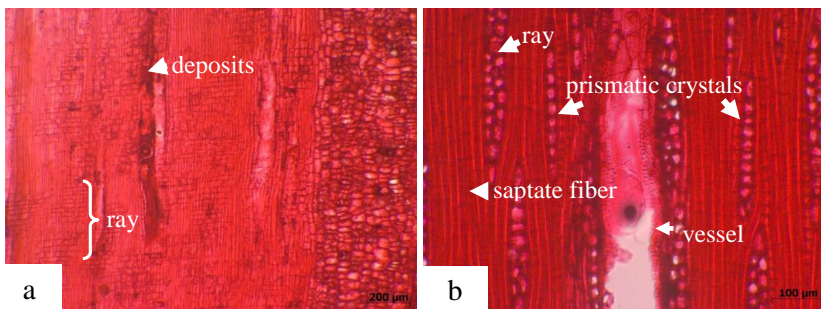


Figure 4 a) Wood in radial section showing ray and deposits in vessel.
b) Wood in tangential section showing ray and fiber.

135 Interlocking grain, however, is one of several tropical wood characteristic that may
 136 influence the utility and causing twisting or shrinkage. Interlocking grain may be desirable, as
 137 interlocking grain can increase stability and contribute to beautiful figure (Thinley et al.,
 138 2005). Therefore, *S. siamensis* wood can apply as both face veneer and fineness furniture.
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140 **Table 1.** Physical and mechanical properties (tested at 12 % moisture content)

Species	Average density g/m ³	Average compressive ⊥ strength (MPa)	Average compressive // strength (MPa)	Average MOR (MPa)	Average MOE (MPa)
<i>S. siamensis</i>	0.72	108.88	181.48	83.51	6,345.9

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142 The Wood and Forest Products Development Division of the Forest research and
 143 Development Bureau, Royal Forestry Department (2010) reported the Thai timbers
 144 characteristics such as, *Pterocarpus* spp. (Pra duu) and *Peltophorum dasyrachis* (Non see)
 145 were classified into high qualities timber group by observed from wood density (0.92 and
 146 0.68 g/m³) and wood bending strength (130 and 92 MPa). To compare with those two
 147 species, *S. siamensis* has a rather high quality. The wood with high density has a strong
 148 defense against the effects of a drought (Crous et al., 2012; Nugroho, 2012). Thus,
 149 *S. siamensis* is a tree for a country with low precipitation. Because drought was such a
 150 problem for Thai farmers in the past, concern about drought tolerance tree is necessary. As,
 151 *S. siamensis* is dominating species in dry deciduous dipterocarp forest and high mechanical
 152 properties that suitable for plant in many part of Thailand.

153 *S. siamensis* trees do not provide a large canopy minimizing distances among plants
 154 and forest or farm density. A recent trend in agroforestry is the deliberate retention of native
 155 trees to increase diversity and sustainable production for increased economic and
 156 environmental benefits. Moreover, indigenous tree species are used to balance the goals of
 157 agricultural development with the conservation of soils, water, local climate and biodiversity.
 158 *S. siamensis* is a multi-purpose tree and suitable for the agroforestry industry.

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ข้อคิดเห็น[c10]: ต้องการบอกอะไรที่แข็งแรง

ข้อคิดเห็น[c11]: ต้องการบอกอะไร

CONCLUSIONS

ข้อคิดเห็น[h12]: เขียนเป็น past tens

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164 Wood characteristics of *S. siamensis* include interlocked grain and moderately coarse
165 texture. Wood surface is luster. Fibers are thin to thick- walled. Wood density (12% mc) is
166 0.72 g/cm³; compression parallel and perpendicular to grain is 181.42 and 108.88 MPa,
167 modulus of elasticity (MOE) and modulus of rupture (MOR) is 6,345.9 and 83. 51 MPa,
168 respectively. Because of rather high density and high mechanical properties, the *S. siamensis*
169 wood is classified to high quality timber. So, *S. siamensis* is suitable for furniture production
170 and for indoor construction that households should to plant on their farmlands.

ข้อคิดเห็น[c13]: ต้องการบอกอะไร

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