



## Original article

Wood anatomy and properties of three species in the genus *Spondias lakonensis* (Anacardiaceae) found in Thailand

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## ABSTRACT

The anatomy and properties of woods in the genus *Spondias* (Anacardiaceae) were investigated. Wood samples were collected from North and Northeast Thailand. Permanent slides of wood sections and tissue maceration were made. The specimens were observed under a light microscope and using scanning electron microscopy. The wood density, specific gravity and hardness were also investigated. It was found that the wood of all three species had indistinct growth rings and fine textured and straight grain. Kribs heterogeneous rays type I were found in *Spondias lakonensis* while Kribs heterogeneous rays type III were found in *Spondias pinnata* and *Spondias cytherea*. Radial canals were present in rays of all studied species. Prismatic crystals were found in the rays of *S. lakonensis* and *S. cytherea* but not in *S. pinnata*. Starch grains were also observed in *S. pinnata* and *S. cytherea*. The wood specific gravity of *S. pinnata*, *S. lakonensis* and *S. cytherea* was 0.45, 0.33 and 0.30; the wood density was 0.44, 0.33 and 0.27 g/cm<sup>3</sup> and the wood hardness was 2795.85, 1329.26 and 1059 N, respectively. The results from this study suggest that *Spondias* woods can be used for agricultural utensils but they are not suitable for heavy construction.

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## Introduction

The family Anacardiaceae comprises more than 70 genera and over 600 species which are mainly trees and shrubs growing in tropical, subtropical and temperate zones (Wannan, 2006). *Spondias* is a small genus consisting of 17 species, seven of which are native to the neotropics and 10 species are native to tropical Asia. Ten species of *Spondias* bear edible fruits (Chayamarit, 2010). Five species are found in Thailand—*Spondias bipinnata*, *Spondias cytherea*, *Spondias lakonensis*, *Spondias laxiflora* and *Spondias pinnata* (Morton, 1987; Hoyos, 1989).

Chayamarit (2010) studied the distribution and physical characteristics of *S. cytherea* Sonn. which is a typical tree native to the Pacific Islands and found in all South American countries. The tree is approximately 5–25 m in height. It is stately in appearance and has pinnate leaves (8–10 cm in length), opposite or sub-opposite, ovate-oblong or oblong leaflets (6–9 cm long) being apex acuminate or acute. The fruit is a fleshy drupe, up to 5 cm in diameter. This species is cultivated as a fruit crop in North and Northeast Brazil and is a very important component in jelly, juice and ice cream.

Fermented fruits are used for making alcoholic beverages. Industrial glue can be made from the sticky resin released to make antiseptic solutions (Villegas et al., 1997). Its roots are commonly used for the treatment of fever, migraine and diarrhea (Abo et al., 1999). *S. pinnata* (L.f.) Kurz is found in India, Sri Lanka and other Southeast Asian countries (Anonymous, 1963). It is deciduous, all leaf parts are glabrous and the bark is gray and smooth. The tree is approximately 5–25 m in height. It is stately in appearance and has pinnate leaves (5–25 cm in length), elliptic or oblong leaflets (4–26 cm in long) with the apex acute or abruptly acuminate. The fruit is a fleshy drupe, up to 4.5 cm in diameter and contains a large stone seed (Chayamarit, 2010). The young leaf, flower and fruit are edible. The green fruit is pickled in brine and is commonly used in culinary preparations such as curries, jams and sherbet in countries where it grows naturally. Its bark contains large amounts of flavonoids, phenolic compounds and is high in antioxidant and free radical scavenging activities (Hazra et al., 2008). The wood is used for making match boxes, toothpicks and boxes (Development of Forest Products, 2005). *S. lakonensis* Pierre originated from Southern China, Lao and Vietnam and is abundant at an altitude of 200–500 m above sea level in North and Northeast Thailand (Chuakul, 1996). The tree is approximately 8–30 m in height. Young branches are pubescent. It is stately in appearance and has pinnate

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leaves (5.5–15 cm in length), opposite or elliptic, ovate or oblong (Chayamarit, 2010). The fruit is sour and astringent. Pricked young leaves are used for cloth staining.

Although the old trees are usually pruned and cut, the use of *Spondias* woods is not clear. Anatomical data of wood are important to evaluate the wood properties and can lead to suitable wood utilization. Furthermore, the anatomical characteristics support wood identification. At present, information on the wood anatomy in this genus is lacking and needs to be investigated.

## Materials and methods

### Specimens collection

Wood samples of *S. pinnata*, *S. lakonensis* and *S. cytherea* were collected from Nakhon Ratchasima, Ranong and Chiang Mai provinces, Thailand. Species identification was performed and examined with type specimens at the Forest Herbarium, Bangkok, Thailand. The wood samples were removed from the tree trunks at 1.3 m height from the ground.

### Macroscopic study

Each wood sample was trimmed into a 1 × 1 × 3 cm block and then was cut into sections of 120 μm thickness using a sliding microtome (SM 2010R; Leica, Wetzlar, Germany). The sections were observed under a light microscope (SZ30; Olympus, Tokyo, Japan).

### Microscopic study

#### Permanent slides preparation of wood sections

Wood samples were cut into sections in three dimensions (cross section, radial long section and tangential long section) using a sliding microtome (SM 2010R; Leica, Wetzlar, Germany) with 20 μm thickness. The sections were stained with safranin T for 2 h and then were dehydrated with an ethyl alcohol series (30, 50, 70, 95 and 100%). The samples were placed in xylene for 6 h before being mounted with permount. The permanent slides were observed under the light microscope.

#### Maceration of wood tissue

Wood samples were cut into small pieces (toothpick size). Each specimen was boiled in a mixture of acetic acid and hydrogen peroxide (1:1) for 3 h, followed by washing three times with water. The macerated samples were stained with safranin T for 2 h and then were dehydrated with an ethyl alcohol series (30%, 50%, 70%, 95% and 100%). The samples were left in xylene for 6 h before mounting with permount.

#### Scanning electron microscopy

Wood sections (120 μm thickness) and macerated cells were dehydrated with an ethyl alcohol series (30%, 50%, 70%, 95% and 100%), dried in a critical point dryer (K850; Emitech; Dubai, United Arab Emirates) and coated with gold particles (Ohtan et al., 1987; Schneider and Carlquist, 2001). The samples were observed under a scanning electron microscope (JSM 5600 LV; JEOL, Tokyo, Japan).

#### Wood property measurement

##### Wood density

Wood samples were trimmed into 2 × 2 × 2 cm blocks. Each wood block was left for 1 wk at room temperature for air drying. The wood density was calculated using the formula in Equation (1):

$$D = \frac{M}{V} \quad (1)$$

where D is the density, M is the mass and V is the volume (Desch and Dinwoodie, 1996).

##### Specific gravity

The specific gravity was calculated using the formula in Equation (2):

$$S = \frac{W_o}{V} \quad (2)$$

where S is the specific gravity, W<sub>o</sub> is the weight of wood (oven dry) and V is the weight of an equivalent volume of water (Brown et al., 1949).

##### Hardness

Wood samples were trimmed into 6 × 6 × 8 cm blocks. Each wood block was subjected to measurement in a hardness tester machine (Janka W-tester Type 5, Ludwigshafen, Germany).

## Results

### *Spondias pinnata* (L.f.) Kurz (Thai name: Ma kok)

#### Macroscopic characters

The wood is fine-textured with a light, fulvous color, no luster and is odorless. Growth rings are indistinct, the grain is straight, vessels are medium sized, visible to the naked eye, with yellow deposits (Fig. 1A).

#### Microscopic characters

The wood is diffuse-porous with more solitary pores and few multiple (2–6) pores. Vessels are round to oval shaped and are arranged in tangential bands and a diagonal pattern. There are 10 pores mm<sup>-2</sup> with 149 (102–206) μm diameter and 408 (209–591) μm length. Tyloses and gummy deposits were found in vessels (Fig. 1B). Vessels cover 14% of the cross section. The perforation plate is simple (Fig. 1C). Intervessel pits are 7 (5–10) μm in length, non-vestured, oval shaped and alternate in arrangement (Fig. 1D). Vessel-ray pits are 9 μm in length, oval shaped with much reduced borders to apparently simple (Fig. 1E). Septate fibers are usually observed (Fig. 1D), with 13 (8–18) μm diameter and 934 (627–1319) μm length. The fiber wall is very thin with 3 μm thickness. Axial parenchyma are vascentric paratracheal or scanty paratracheal (Fig. 1B). Rays are 60 (34–84) μm or 2–4 cells in width and 480 (268–692) μm or 7–24 cells in height. Rays consist of several rows of procumbent cells and two rows of upright cells (Kribs heterogeneous type III). There are 4 rays/mm. Radial canals are present in rays with 44 (20–62) μm diameter (Fig. 1F). Starch grains are commonly observed in ray cells (Fig. 1G).

#### Physical characters

The wood is light weight with 0.45 specific gravity. The wood density is 0.44 g/cm<sup>3</sup> at 12% moisture content and hardness is 2795.85 N.

### *Spondias lakonensis* Pierre (Thai name: Ma ho)

#### Macroscopic characters

The wood is medium textured, with a light, luscious color, no luster and is odorless. Growth rings are indistinct, the grain is straight and vessels are small sized, being visible to the naked eye (Fig. 2A).

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