WOOD PROPERTIES OF SELECTED LESSER-USED HONDURAN WOOD SPECIES

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SHUPE, T. F., AGUILAR, F. X., VLOSKY, R. P., BELISLE, M. & CHAVEZ, A. 2005. Wood properties of selected lesser-used Honduran wood species. This paper examines the physical and mechanical properties of seven selected lesser-used species in Honduras for the purpose of promoting broader species utilization and reducing pressure on highly demanded species in the country. Of the seven species tested, *Terminalia amazonia* consistently yielded favourable results for most mechanical property tests. It appears that this species has high potential for further development and market research for many applications, both structural and non-structural. *Ilex tectonica, Calophyllum brasiliense* and *Terminalia amazonia* were then compared against book values for Honduran mahogany using Student's *t*-tests. All were found to be fairly comparable for modulus of rupture, modulus of elasticity and maximum crushing strength.

Key words: Anatomical – mechanical – physical

SHUPE, T. F., AGUILAR, F. X., VLOSKY, R. P., BELISLE, M. & CHAVEZ, A. 2005. Ciri-ciri kayu spesies Honduras terpilih yang kurang diguna. Kajian ini meneliti ciri-ciri fizikal dan mekanik tujuh spesies kayu Honduras terpilih yang kurang diguna. Kajian ini bertujuan untuk menggalakkan penggunaan spesies yang lebih luas di samping mengurangkan kebergantungan kepada spesies kayu yang utama dalam negara. Antara tujuh spesies yang dikaji, *Terminalia amazonia* menunjukkan nilai terbaik bagi kebanyakan ujian mekanik yang dijalankan. Spesies ini nampaknya mempunyai potensi untuk dibangunkan dan dijalankan penyelidikan pasaran bagi aplikasi struktur dan bukan struktur. Nilai-nilai *Ilex tectonica, Calophyllum brasiliense* dan *T. amazonia* kemudiannya dibandingkan dengan nilai-nilai mahogani Honduras yang telah

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diterbitkan menggunakan ujian Student *t*. Nilai-nilai untuk modulus kepecahan, modulus kekenyalan dan kekuatan penghancuran maksimum agak serupa.

Introduction

Due to increasing demand for and dwindling supplies of traditional timber species in many developing countries, there is a need to introduce lesser-used species (LUS) to serve as substitutes. Accordingly, the utilization of LUS is being promoted in many countries to widen the species base of the industry and to lessen the pressure on the forest due to harvesting of the few currently demanded species. As prices of traditional highly sought timber increase, and the quality and quantity of this timber decline, wood products manufacturer begin to explore the possibility of using LUS. Greater use of LUS can contribute towards sustainable forest management and efficient utilization of the tropical forest.

Forest products manufacturers and export customers are generally reluctant to accept substitutes for traditional species for three main reasons: reliability of supply, performance in the manufacturing process and concerns regarding the in-service performance (Poku 1999). However, in a case study of the use of LUS in Ghana, Poku (1999) found that if provided with technical knowledge about LUS and assurances regarding supply, coupled with effective promotional strategies, export buyers are willing to accept LUS wood products.

Research in the area of new species introduction indicates that raw material preferences within the international timber trade are slow to change (Smith & Eastin 1990) and calls for intensified and calculated marketing efforts to reverse this trend. To be able to effectively market LUS, the conservative stance of manufacturers and forest products traders towards these species must be overcome. This requires an effective marketing strategy to introduce LUS as a new industrial material (Eastin 1998). To be able to develop this strategy, knowledge of LUS market potential must be obtained. Market potential is largely based on the suitability or quality of wood for a particular purpose, which in turn is determined by the characteristics, which affect wood structure and physical properties (Panshin & de Zeeuw 1980).

The objectives of this study were to determine fundamental anatomical, mechanical and physical properties of seven lesser-used Honduran timber species. The characterization of basic wood properties will be used as a basis to promote awareness of LUS and to enhance competitiveness of the Honduran forest industry.

Materials and methods

Seven lesser-used Honduran tree species were selected for investigation (Table 1). Trees from three different forest regions were harvested to have a sample representative of the country. One tree per species per site was randomly selected and felled. The north, south, east and west directions were noted on each side of the tree. The mean values reported in this study represent a pooling of data across geographic sites to better represent the country as a whole. From each tree, a

Table 1 Species studied from Honduras

Vernacular name	Species	Altitude (m asl)	Diameter at breast height (cm)	Commercial height (m)
Marapolan	*Guarea grandifolia*	400	61.5	18.0
		180	59.0	24.0
		180	59.0	24.0
San Juan Areno	*Ilex tectonica*	564	80.0	15.0
		475	76.0	12.0
		503	99.0	22.0
		1000	65.0	22.0
Santa Maria	*Calophyllum brasiliense*	440	87.0	20.7
		440	49.5	17.6
		420	72.0	13.9
Sangre	*Virola koschnyi*	430	53.0	25.0
		600	73.0	20.0
		1000	62.0	18.0
Cedrillo	*Huertea cubensis*	605	51.0	20.0
		840	48.0	20.0
		350	65.0	20.0
San Juan Peludo	*Vochysia guatemalensis*	430	82.0	25.0
		100	57.0	14.0
		5	68.0	20.0
Cumbillo	*Terminalia amazonia*	460	74.2	18.0
		130	75.0	15.0
		130	66.2	29.0

defect free 2.4 m log starting above the buttress was removed and cut into samples for determining mechanical, physical and anatomical properties. The boles were sawn using a portable bandsaw into 60 × 60 mm sticks. Each stick was then cross cut into two equal length pieces and then randomly assigned to be used for subsequent mechanical testing in the green or 12% moisture content (MC) condition. Green material was tested immediately for mechanical properties. Samples to be tested at 12% MC were conditioned at 32 °C and 68% relative humidity (RH) until repeated weighing indicated a constant weight. The aqueous sulphuric acid method was used to determine the fibre saturation point (FSP) of each species (ASTM 1985, Shupe & Chow 1996).

Mechanical and physical tests were done in accordance with ASTM D 143-94 (ASTM 1993). A total of 40 samples per tree were tested for each individual mechanical and physical property. Due to financial constraints, not all species could be tested for mechanical properties. Therefore, three species (*Ilex tectonica, Calophyllum brasiliense* and *Terminalia amazonia)* were tested for mechanical properties

at 12%. Five species (*I. tectonica, C. brasiliense, T. amazonia, Vochysia guatemalensis* and *Huertea cubensis)* were tested for mechanical properties in green condition. Specific physical properties tested were specific gravity (SG) at 12% MC, tangential, radial and volumetric shrinkages as well as FSP. All mechanical properties were assessed at 12% MC and green condition. Static bending testing was performed to determine modulus of rupture (MOR) and modulus of elasticity (MOE). Other mechanical properties determined include compression parallel and perpendicular to the grain, Janka hardness, nail holding strength and cleavage strength.

A Least Square Differences (LSD) analysis was performed to denote significant mean differences between species for each mechanical and physical test. Student's *t*-tests were conducted to compare MOR, MOE and maximum crushing of Honduran mahogany (*Swietenia macrophylla*) with those of the four species tested for mechanical properties at 12% MC in this study. The values for Honduran mahogany were from Chudnoff's (1984) report.

Results and discussion

Physical properties

Considerable variation in SG values was observed (Table 2). The values ranged from a high of 0.73 for *T. amazonia* to a low of 0.46 for *H. cubensis.* Volumetric shrinkage also varied widely from 6.0% (*V. guatemalensis*) to 9.6% (*C. brasiliense*).

The FSP values were found to be higher than most tropical wood species. *Huertea cubensis* yielded the highest value of 33.1% in addition to two other species which had mean values of over 30%. Species having high extractive contents typically have a comparatively lower FSP (Choong & Achmadi 1991).

Ramos and Lagos (1998) found that *C. brasiliense* had a mean SG of 0.49 and a range 0.45–0.50 on an oven-dry weight and green volume basis. Their findings

Table 2 Wood physical properties of seven native Honduran tree species

Species	Specific gravity[a]	Tangential shrinkage (%)	Radial shrinkage (%)	Volumetric shrinkage (%)	Fibre saturation point (%)
Guarea grandifolia	0.67 c	6.3 a	2.6 cd	8.8 b	28.3 c
Ilex tectonica	0.55 d	5.9 ab	2.5 d	8.4 bc	28.1 d
Calophyllum brasiliense	0.69 bc	5.7 b	3.9 b	9.6 a	32.2 ab
Virola koschnyi	0.50 e	6.2 ab	2.6 cd	8.8 b	30.7 b
Huertea cubensis	0.46 f	6.2 ab	2.9 c	9.1 ab	33.1 a
Vochysia guatemalensis	0.47 ef	4.4 c	1.6 e	6.0 e	22.0 e
Terminalia amazonia	0.73 a	5.1 c	2.8 bc	7.9 c	24.8 d

[a] Calculated at 12% MC

Values with the same letter are not significantly different at the 0.05 probability level.

contrasted with the density of *C. brasiliense* reported in this study (0.69 at 12% MC). This study found the mean radial, tangential and volumetric shrinkage values of *C. brasiliense* to be 3.9, 5.7 and 9.6% respectively. However, Ramos and Lagos (1998) reported values of 5.3, 8.7 and 13.4% for radial, tangential, and volumetric shrinkages respectively. Chudnoff (1984) reported values that more closely agree with those of Ramos and Lagos (1998) than those of this study. The radial, tangential and volumetric shrinkage values for the Chundnoff (1984) study were 4.6, 8.0 and 13.6% respectively.

A similar situation was found for *Guarea grandifolia.* Our study found the density at 12% MC to be 0.67. However, Ramos and Lagos (1998) found the SG to have a mean of 0.46 with a range of 0.46–0.57. Ramos and Lagos (1998) and Chudnoff (1984) reported the radial, tangential and volumetric shrinkage values as 3.4, 7.0 and 11.2 % respectively, which were greater than the values found in this study (Table 2).

Three other species showed mixed result for SG compared with previous work. The mean SG for *H. cubensis* for this study was 0.46 at 12% MC compared with SG of 0.38 as reported by Ramos and Lagos (1998). The density of *I. tectonica* was 0.55 for this study and was close to the 0.57 as reported by Ramos and Lagos (1998). *Terminalia amazonia* had an SG of 0.73 in this study, which was inconsistent with the mean of 0.52 reported by Ramos and Lagos (1998).

Mechanical properties

Terminalia amazonia consistently yielded high mean values for most tests (Tables 3 and 4). It did not show the highest values for all properties, but overall it appeared that this species had the most potential for high load bearing applications. The mechanical properties of *V. guatemalensis* and *H. cubensis* were the lowest (Table 4). However, they were found to be sufficiently high for many low strength value-added applications. *Vochysia* sp. is used for carpentry, utility plywood, furniture components, interior trim and millwork (Chudnoff 1984). *Huertea cubensis* is recommended for making furniture (Ramos & Lagos 1998).

The MOR, MOE and maximum crushing strength values at 12% MC for *C. brasiliense* in this study were lower than those reported by other researchers. Waangaard *et al.* (1955) found the MOR, MOE and maximum crushing strength at 12% MC for *C. brasiliense* to be 100, 12 617 and 48 MPa respectively. Slightly higher values for MOR and maximum crushing strength at both MC conditions were reported by Farmer (1972).

The mechanical properties at 12% MC for *T. amazonia* in this study were also lower than those of other researchers. Wangaard and Muschler (1952) reported MOR, MOE and maximum crushing strength at 12% MC to be 122, 15 858 and 66 MPa respectively. Their corresponding values in the green condition were 84, 13 859 and 38 MPa. Again, the values were higher than those found in this study (Table 4). Higher values in both MC conditions were reported by Lavers (1969).

Table 3 Wood mechanical properties of three native Honduran tree species at 12% moisture content

Species	Static bending		Compression parallel to grain	Compression perpendicular to grain	Janka Hardness		Nail holding strength	
	MOR	MOE	Max. crushing strength	Fibre stress at proportional limit	Lateral resistance	Side resistance	Lateral resistance	Side resistance
	(MPa)	(MPa)	(MPa)	(MPa)	(kg)	(kg)	(kg)	(kg)
Ilex tectonica	83 bc	8 921 c	34 b	16 b	380.86 b	358.27 a	105.88 a	67.65 b
Calophyllum brasiliense	77 c	9 637 ab	29 b	35 a	522.59 a	243.85 a	109.92 a	51.90 b
Terminalia amazonia	111 a	11 235 a	47 a	23 b	373.09 b	365.57 a	101.38 a	118.57 a

Values with the same letter are not significantly different at the 0.05 probability level.

Table 4 Wood mechanical properties of five native Honduran tree species at green moisture content

Species	Static bending		Compression parallel to grain	Compression perpendicular to grain	Janka Hardness		Nail holding strength	
	MOR	MOE	Max. crushing strength	Fibre stress at proportional limit	Lateral resistance	Side resistance	Lateral resistance	Side resistance
	(MPa)	(MPa)	(MPa)	(MPa)	(kg)	(kg)	(kg)	(kg)
Ilex tectonica	47 c	7 888 c	24 c	4 ab	275.73 d	314.33 d	84.967 d	46.54 d
Calophyllum brasiliense	62 b	9 280 ab	30 b	3 b	422.13 c	498.85 c	117.354 c	67.491 c
Terminalia amazonia	74 a	10 536 a	38 a	6 a	605.36 b	640.37 b	166.577 a	116.923 a
Vochysia guatemalensis	38 d	5 446 e	19 d	3 b	194.72 f	239.40 e	55.089 f	31.89 e
Huertea cubensis	49 c	6 927 d	25 c	2 b	241.62 e	298.85 d	74.043 e	33.60 e

Values with the same letter are not significantly different at the 0.05 probability level.

Table 5 *T*-tests comparing results for modulus of rupture, modulus of elasticity and maximum crushing strength of four Honduran species against Honduran mahogany at 12% moisture content

Species	MOR	MOE	Maximum crushing strength
	t-value	*t*-value	*t*-value
Ilex tectonica	6.39 **	- 0.98	- 1.20
Calophyllum brasiliense	2.64 **	0.70	- 2.81 **
Terminalia amazonia	10.78 **	2.57 *	3.01 **
T critical value $\alpha = 0.05$	1.98	1.98	1.98
T critical value $\alpha = 0.01$	2.63	2.63	2.63

Honduran mahogany control values: MOR = 722.44 kg cm^{-2}; MOE = 94 918 kg cm^{-2}; Maximum crushing strength = 380.03 kg cm^{-2} (Chudnoff 1984).
* Significant ($p < 0.05$), ** significant ($p < 0.01$)

When compared with Honduran mahogany all three species were found to have significantly greater values than Honduran mahogany for MOR (Table 5). For maximum crushing strength, *I. tectonica* was statistically similar to mahogany, whereas *T. amazonia* was significantly higher and *C. brasiliense* was significantly lower. *Terminalia amazonia* was the only species that was significantly greater than mahogany for MOE.

Conclusions

The study indicates that many lesser-used species in Honduras possess properties that may make them an acceptable alternative to Honduran mahogany. *Terminalia amazonia* consistently yielded fairly high values for mechanical properties, indicating that it is a potential timber for structural applications. Additional research work on the physical, mechanical, anatomical and chemical properties are necessary so that the optimal end-uses can be identified. The marketing potential of these species will also be dependent on consumer's attitudes and preferences regarding appearance (colour, grain pattern).

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