Technical report

Project 433/06 R3 (I)

"Sustainable Model for the Brazilian Wood Flooring Production Chain"

Specific Gravity and Janka Hardness of the Amazon Wood Species

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Summary

The present study aimed to characterize the physical and mechanical properties of 14 Amazonian species, in order to identify alternative raw materials that may be used in the domestic industry of floors. For this purpose were used 6 samples per species in the dimensions of 5 x 5 x 15cm, for testing of hardness in the direction perpendicular to the fibers (tangential and radial) and parallel fibers (axial) and specific gravity. Based on the results obtained we conclude that all the species studied are alternative raw material for the chain of wood flooring.

1 Introduction

The large expansion of building construction in recent years and the excellent prospects of continuity will require the availability of a considerable amount of wood with high specific density to produce floors for different types of buildings (ROCCO LAHAR et al., 2010).

The solid wood flooring is much appreciated in residential and commercial environments. Despite the great diversity of Brazilian tropical woods available on the market, few species are meant for floors (PADILHA et al., 2006).

The fundamental requirement for the indication of a wood species for the manufacture of flooring is the knowledge of the physical and mechanical properties of the material such as density, dimensional stability and hardness.

Additionally, other attributes of the material, for example, color and figure, and fashion trends may be understood as additional elements.

The incorporation of alternative species of wood in building construction activities is important to the preservation and sustainability of the Brazilian forests (ZENID, 2009).

Therefore, the main objective of this work is the physical-mechanical characterization of 14 species of Amazon timber, in order to identify alternative raw materials that may be used in the domestic industry of floors.

2 Applied methodology

2.1 Wooden species and preparation of samples for testing

The wooden species used in this study are listed in Table 1.

Table 1: List of wooden species studied

Common Name	Scientific Name
Angelim Vermelho	*Dinizia excelsa* Ducke
Itaúba Amarela	*Mezilaurus itauba* (Meisn) ex Mez
Cedrinho	*Erisma unicatum* Warm.
Cupiúba	*Goupia glabra* Aubl.
Pequiá	*Caryocar villosum* (Aubl.) Pers.
Angelim da Mata	*Hymenolobium excelsum* Ducke
Maçaramduba	*Manilkara bidentata* (A. DC.) A. Chev
Timborana	*Piptadenia gonoacantha* (Mart.)
Sucupira Preta	*Bowdichia nítida* Spruce ex Benth.
Tachi Preto	*Tachigali myrmecophila Ducke*
Tanibuca	*Terminalia amazonica* (J.F. Gmel)
Mandioqueira	*Qualea paraensis* Ducke
Sapucaia	*Lecythis pisonis* Cambess
Jarana Amarela	*Lecythis poiteaui* O. Berg

Wood beams (3 per species) with dimensions of 8.5 x 8.5 x 250cm remained in natural drying until they reach a moisture content of 18%. Later they were taken to a room Climatized with temperature (22 ± 2 ° C) and humidity controlled (65 ± 5%) in the laboratory of the Department of Forest Sciences - LCF ESALQ / USP, remaining the same until they reached constant weight.

Subsequently, the wooden beams were processed with the aid of a circular saw resulting in 84 samples (six per species) with final dimensions 5 x 5 x 15 cm.

2.2 Assessment of specific gravity and Janka hardness

The specific gravity was evaluated using the following expression:

$$ME = \frac{m}{v}$$

Where:

ME is specific gravity (g/cm³), *m* is mass of timber (g) and *v* is the timber volume (cm³).

The Janka hardness tests were performed based on recommendations from the Brazilian NBR 7190 (1997) using a universal testing machine (Figures 1 and 2) capable of applying force to 30 tons.

Figure 1 - Machine used in the Janka hardness testing

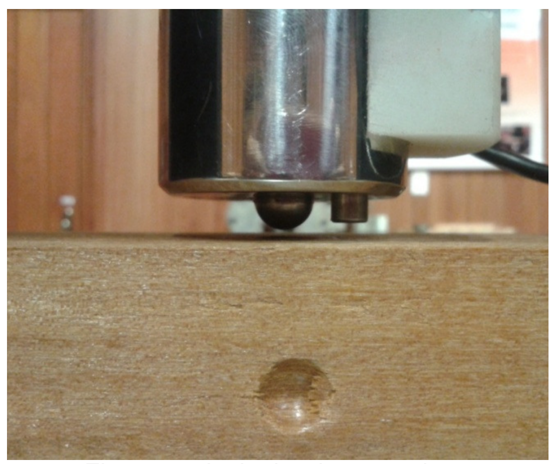

Figure 2 - Janka hardness testing

2.3 Correction of Janka hardness values obtained from tests

Accordance with ISO 7190 (1997), the results should be presented with the corrected values for the standard 12% moisture. Thus, the Janka hardness values were corrected according to the following expression:

$$f_{12\%} = f_{u\%}\left[1 + \frac{3\ (\mathrm{U}\% - 12)}{100}\right]$$

Where:

$f_{12\%}$ is the hardness corrected for moisture content of 12% (kgf/cm²); $f_{u\%}$ is the hardness determined the moisture content of the wood in the trial (kgf/cm²), U% is the moisture content of wood in hardness test (%).

2.4 Statistical Analysis

To obtain this result, an analysis of variance was conducted at a 5% level of probability and subsequently the Scott-Knott testing.

Analyzes of simple linear regression were performed to establish correlations between the density and the hardness axial, radial and tangential.

3 Presentation of the data

3.1 Specific Gravity

The mean values of specific gravity and their standard deviations and coefficients of variation, as well as the average moisture content of 14 wood species studied are shown in Table 2. The same table also presents a classification of timber species by category according to specific gravity, as proposed by Andrade and Jankowsky (2012).

Table 2: Mean values of the specific gravity of the woods studied

Species	Moisture Content (%)	Specific Gravity (g/cm³)	Standard Deviatation	Coefficients of Variation (%)	Classification by Category
Dinizia excelsa	12,9	1,042	0,018	2	Heavier
Mezilaurus itauba	11,7	0,873	0,036	4	Heavy
Erisma uncinatum	15,4	0,687	0,024	4	Medium
Goupia glabra	13,2	0,840	0,068	8	Heavy
Caryocar villosum	12,9	0,891	0,044	5	Heavy
Hymenolobium excelsum	13,2	0,697	0,032	5	Medium
Manilkara bidentata	12,8	0,992	0,040	4	Heavier
Piptadenia gonoacantha	14,0	0,876	0,047	5	Heavy
Bowdichia nítida	13,9	0,977	0,033	3	Heavier
Tachigali myrnecophila	14,1	0,933	0,010	1	Heavier
Terminalia amazonica	14,1	0,933	0,010	1	Heavier
Qualea paraensis	15,1	0,838	0,040	5	Heavy
Lecythis pisonis	13,0	1,023	0,032	3	Heavier
Lecythus poiteaui	12,5	0,994	0,041	4	Heavier

3.2 Janka Hardness

The average values of hardness radial, tangential and axial, and their standard deviations and coefficients of variation are shown in Table 3. Note that these values were duly corrected for moisture standard 12%.

Table 3: Mean values of Janka hardness

Species	N	Janka Hardness (kgf/cm²)		
		Radial	**Tangential**	**Axial**
Dinizia excelsa	6	$_{47}1326^{4}$	$_{72}1322^{5}$	$_{65}1318^{5}$
Mezilaurus itauba	6	$_{102}679^{15}$	$_{98}637^{15}$	$_{86}621^{14}$
Erisma uncinatum	6	$_{13}505^{3}$	$_{16}526^{3}$	$_{46}615^{7}$
Goupia glabra	6	$_{96}769^{13}$	$_{182}842^{22}$	$_{89}847^{10}$
Caryocar villosum	6	$_{97}824^{12}$	$_{99}846^{12}$	$_{156}777^{20}$
Hymenolobium excelsum	6	$_{65}583^{11}$	$_{45}591^{8}$	$_{80}664^{12}$
Manilkara bidentata	6	$_{89}922^{10}$	$_{107}934^{11}$	$_{70}838^{8}$
Piptadenia gonoacantha	6	$_{88}891^{10}$	$_{111}950^{12}$	$_{68}871^{8}$
Bowdichia nítida	6	$_{153}1269^{12}$	$_{212}1188^{18}$	$_{142}1208^{12}$
Tachigali myrmecophila	6	$_{6}718^{1}$	$_{116}798^{15}$	$_{54}792^{7}$
Terminalia amazonica	6	$_{70}1039^{7}$	$_{31}1000^{3}$	$_{55}992^{6}$
Qualea paraensis	6	$_{107}721^{15}$	$_{96}719^{13}$	$_{85}839^{10}$
Lecythis pisonis	6	$_{137}1314^{10}$	$_{66}1186^{6}$	$_{49}1252^{4}$
Lecythis poiteaui	6	$_{181}1169^{15}$	$_{183}1129^{16}$	$_{103}1182^{9}$

3.3 Linear Regression Analysis of the variables Specific Gravity and Janka Hardness

Were held the following linear regression analyzes: specific gravity x radial hardness (Figure 3); specific gravity x tangent hardness (Figure 4) and specific gravity x axial hardness (Figure 5).

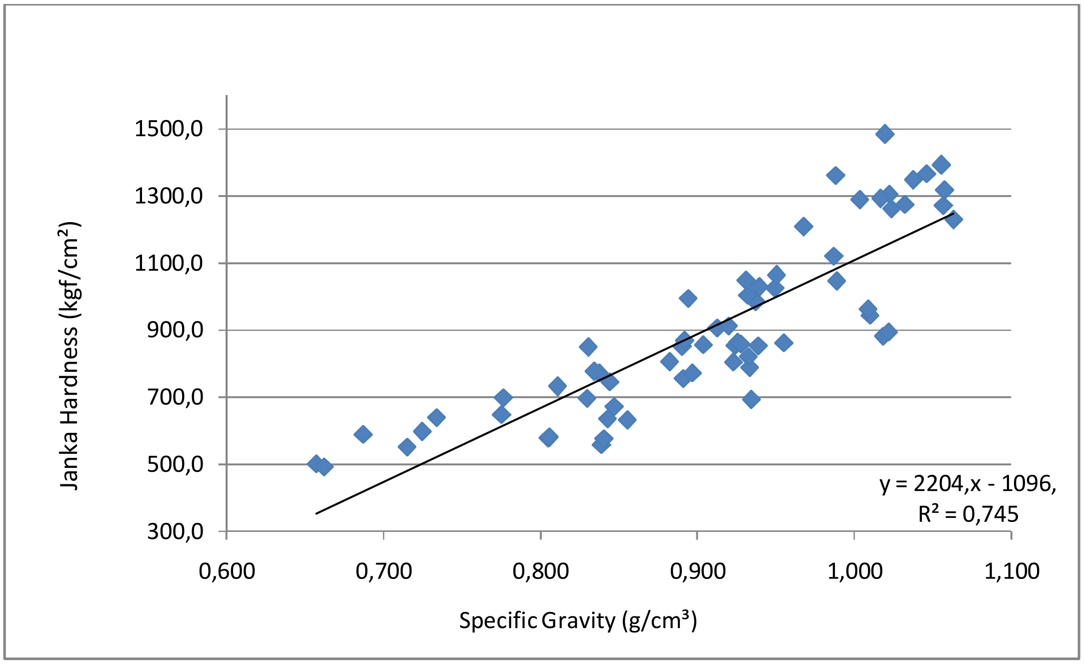

Figure 3: Linear correlation between specific gravity and radial hardness.

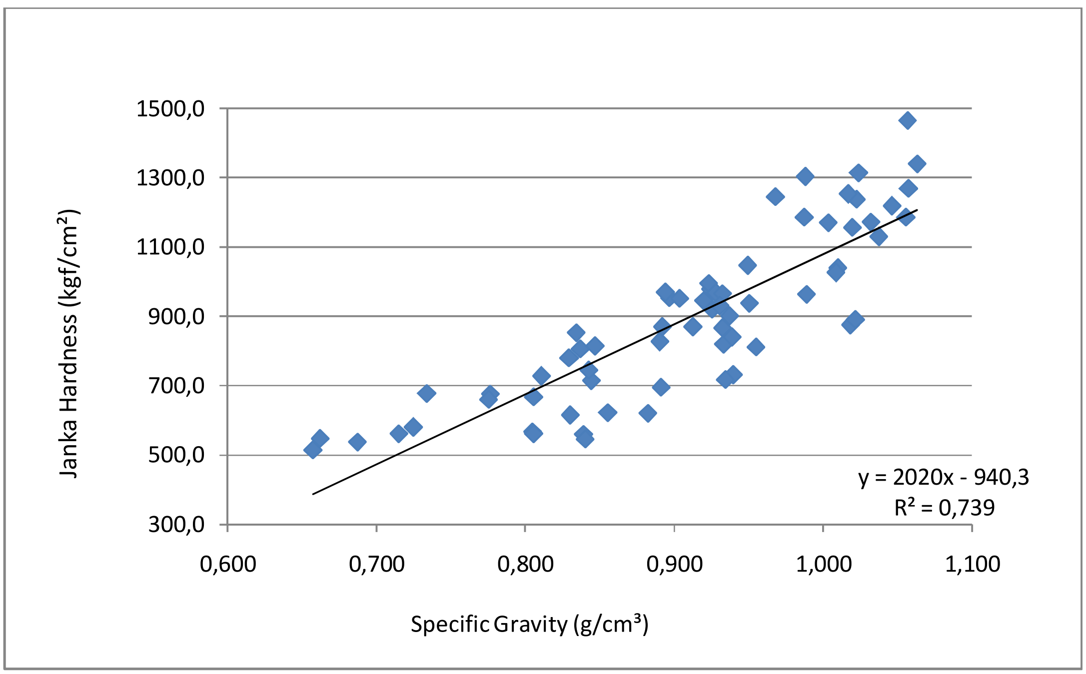

Figure 4: Linear correlation between specific gravity and tangential hardness.

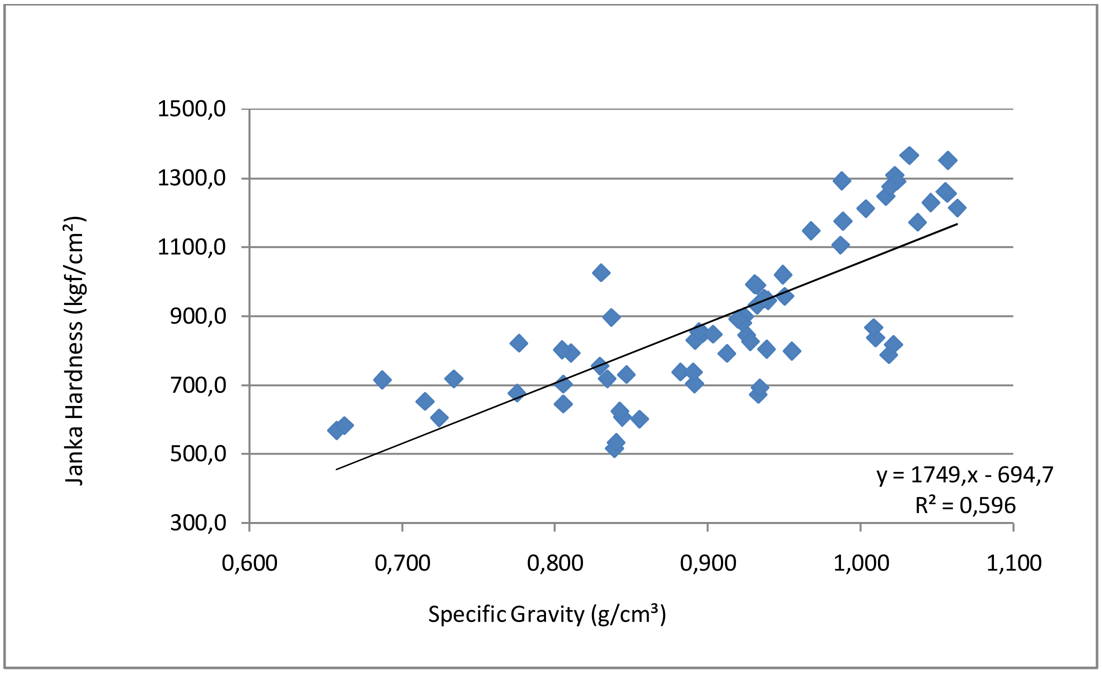

Figure 5: Linear correlation between specific gravity and axial hardness.

3.4 Grouping of species by similarity of hardness

The analysis of variance of transverse hardness indicated statistically significant differences between treatments (species). The Scott-Knott testing allowed the grouping of the species by similarity of transverse hardness, and the result is shown in Table 4.

Table 4: Grouping of the species by similarity of transverse hardness

Espécie	n	Transverse hardness * (kgf/cm²)	Group
Dinizia excelsa	3	1324	A
Lecythis pisonis	3	1250	A
Bowdichia nítida	3	1229	A
Lecythus poiteaui	3	1149	B
Terminalia amazonica	3	1020	B
Manilkara bidentata	3	928	C
Piptadenia gonoacantha	3	920	C
Caryocar villosum	3	835	C
Goupia glabra	3	805	C
Tachigali myrnecophila	3	758	C
Qualea paraensis	3	720	D
Mezilaurus itauba	3	658	D
Hymenolobium excelsum	3	587	D
Erisma uncinatum	3	516	D

4 Analysis and interpretation of the data and results

4.1 Specific Gravity

Analyzing the data in Table 2 it is verified that the average moisture content of wood studied varied between 11.7% and 15.1%. The average values of the specific gravity varied between 0,697g/cm³ and 1,042g/cm³. The respective coefficients of variation showed relatively low and this indicates certain homogeneity of specific gravity the trees sampled.

The timbers studied, in accordance with their average values of specific gravity, were classified as heavier (05 species), heavy (05 other species) and medium (one species).

Based on these results are verified, in most cases, heavy to very heavy timber. According to Andrade and Jankowsky (2012), for wood flooring, heavy timbers are indicated because generally exhibit greater resistance.

4.2 Janka Hardness

It can be observed from Table 3 that the mean values of hardness radial varied from 505 to 1314 kgf/cm² and the coefficients of variation (CV) from 1 to 15%, the hardness tangential 526-1322 kgf/cm² and respective CV from 3 to 22%, and the axial hardness of 615 to 1318 kgf/cm² and the respective CV from 4 to 20%.

As Gonzaga (2006) the wood for floors should be of good strength, with at least average Janka Hardness above 400 kgf/cm². Therefore, it can be inferred that all woods studied (Table 3), according to their average values of hardness, are raw materials of good potential for use in the manufacture of floors. However, a definitive position on such potential should take into account other attributes, especially the dimensional stability of the wood, not addressed in this study.

4.3 Linear Regression Analysis of the variables Specific Gravity and Janka Hardness

The correlations between specific gravity and hardness radial, axial and tangential were analyzed and the results plotted in Figures 3, 4 and 5, respectively. Good correlations were observed in all cases (respectively, R = 0.86, R = 0.86, R = 0.77). The coefficients of determination (respectively, R2 = 0.74, R2 = 0.74, R2 = 0.59), which express the proportion of the variability (the response variable) explained by the linear regression model, revealed a good fit model for the first two cases, in which to the last can be said that the adjustment was reasonable.

4.4 Grouping of species by similarity of hardness

It is observed in Table 4 that the wood species studied were classified into four groups of transverse stiffness (A, B, C, D), where the group A has the highest hardness and the group B has the lowest hardness. In other cases, any species of the same group could be used without distinction between them, considering only the hardness.

5 Conclusions

Conforms to the hardness values, the studied woods appear as alternative raw materials of good potential for use in the manufacture of floors. It was possible to group the species studied by hardness similarity into four distinct groups (A, B, C and D). The timbers belonging to each specific group can be used to replace one another without distinction as to said property.

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