



Physical and Mechanical Properties of Sabiá Wood (*Mimosa caesalpiniaeefolia* Bentham.)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MFN and FARL designed the study, wrote the protocol and managed the analyses of the study. Author ALC wrote the protocol and statistical analysis. Authors DHA and THA managed the analyses of the study, wrote the first draft of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Wood is a natural material with technological properties that vary between species (genetic factors) and for the same species (edaphoclimatic factors). For the use of wood in civil construction, physical and mechanical properties are of interest. The aim of this research was to determine the physical and mechanical properties of the Sabiá wood (*Mimosa caesalpiniaeefolia* Bentham.) from Caatinga,

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and to evaluate the possibility of its use in civil construction. From a batch obtained from Juazeiro do Norte (CE), Brazil, with moisture content 12%, test specimens were fabricated to determine their physical and mechanical properties, according to ABNT NBR 7190:1997 Brazilian Standard Code. As physical properties were determined: density at 12% moisture (ρ_{12}); radial (RRT), tangential (RTL) and longitudinal (RLT) shrinkages. Mechanical properties considered were: strength in compression parallel (f_{c0}) and perpendicular (f_{c90}) to the grain, tensile strength parallel (f_{t0}) and perpendicular (f_{t90}) to the grain, shear strength (f_{v0}) and cleavage (f_{s0}) parallel to the grain, modulus of elasticity (E_M) and rupture (f_M) in static bending, and modulus of elasticity in compression parallel (E_{c0}) and perpendicular (E_{c90}) to the grain. The characteristic strengths (f_k) were also determined for including the wood batch in the strength classes (ABNT NBR 7190:1997). The results obtained allow to classify the studied species as C40 / dicotyledons ($f_{c0,k} = 48 \text{ MPa}$) with density 1.04 g/cm^3 and small values of shrinkage. These results enable the use of Sabiá wood for structural purposes in civil construction.

Keywords: Caatinga; wood; timber structures; civil construction.

1. INTRODUCTION

Brazil has continental dimensions and, for this reason, presents in its territory different biomes (Amazon, Cerrado, Atlantic Forest, Caatinga, Pampa and Pantanal), each of them with special characteristics, mainly in relation to the flora [1]. It is estimated that, in the Brazilian Amazon region alone, there are approximately 12,000 tree species, most of them still without their known technological properties [2]. Research centers present studies on wood properties from native species of different biomes [3-6].

Brazilian native species Sabiá wood (*Mimosa caesalpiniæfolia* Benth) comes from Caatinga (states of Ceará, Maranhão, Minas Gerais, Paraíba, Pernambuco, Piauí and Rio Grande do Norte). Their trees have height and diameter at breast height (DAP) of up to 10 m and 30 cm, respectively [7,8]. Sabiá wood shows a distinction between sapwood and heartwood (strong pink coloration). In addition, it is considered to be high density (ranging from 0.80 to 1.10 g/cm^3) [9,10].

For the use of wood as a raw material for the construction of structures, it is important to characterize its technological properties, mainly physical and mechanical [11,12]. The Brazilian Association of Technical Standards (ABNT) presents ABNT NBR 7190: 1997 "Timber Structures Design", a reference document for such purpose [13].

In Annex B (Determination of wood properties for structural design) of ABNT NBR 7190:1997, the indications of the necessary tests and their respective methods for the characterization of the wood are presented for their use in structures [14-19].

Among the properties of interest, the strength in compression parallel to the grain (f_{c0}) is highlighted, since, it permits to determine the characteristic strength ($f_{c0,k}$), to frame a batch of wood in one of the resistance classes established by ABNT NBR 7190: 1997 [13] and direct its use as structural material [20-22].

The characterization of the batch of wood of a certain species is important before its use since the wood is a natural material; it presents variabilities in its properties, which may be related by genetic characteristics [23] or even by edaphoclimatic characteristics [24].

The aim of this research is the determination of some physical and mechanical properties of the Sabiá wood (*Mimosa caesalpiniæfolia* Benth) to verify the viability of its use as raw material for the construction of wood structures.

2. MATERIALS AND METHODS

In order to carry out this research, was used batches of Sabiá wood from a certified area of Juazeiro do Norte, state of Ceará, Brazil (geographical coordinates: $07^{\circ}12'47'' \text{ S}$; $39^{\circ}18'55'' \text{ W}$). The batches were obtained from legal reserve trees, which had their first processing still in the Northeast. The drying of air to the moisture content of the order of 12% (as recommended by ABNT NBR 7190:1997 [13]) occurred at Wood and Timber Structures Laboratory (LaMEM), of Structural Engineering Department (SET), School of Engineering of São Carlos (EESC), University of São Paulo (USP), in São Carlos, State of São Paulo, Brazil.

After stabilization of the moisture content (accompanied by portable electric meter), the

Table 1. Estimated physical and mechanical properties of Sabiá wood

Physical properties	Abbreviation
Apparent density with 12% moisture content	ρ_{12}
Total Radial Shrinkage	RRT
Total Tangential Shrinkage	RTT
Total Longitudinal Shrinkage	RLT
Mechanical properties	Abbreviation
Strength in compression parallel to the grain	f_{c0}
Strength in compression perpendicular to the grain	f_{c90}
Modulus of elasticity in compression parallel to the grain	E_{c0}
Modulus of elasticity in compression perpendicular to the grain	E_{c90}
Tensile strength parallel to the grain	f_{t0}
Tensile strength perpendicular to the grain	f_{t90}
Shear strength parallel to the grain	f_{v0}
Cleavage strength parallel to the grain	f_{s0}
Modulus of rupture in static bending	f_M
Modulus of elasticity in static bending	E_M

specimens were prepared to estimate the physical and mechanical properties of Sabiá wood (above Table 1). For each of the estimated properties, 12 specimens were performed according to the recommendations of ABNT NBR 7190:1997 [13].

The classification of the batches of wood of Sabiá wood in the strength classes recommended by the ABNT NBR 7190:1997 [13] was carried out using Equation 1, where f_k means the characteristic strength value, n the number of specimens. For the use of Equation 1, the strength values of each test specimens must be placed in ascending order ($f_1 < f_2 < f_3 \dots < f_n$), discarding the largest value if the number of specimens is odd. The characteristic strength value cannot be less than the lowest strength value or 70% of the average value. Statistical analysis was performed at the Federal University of São Carlos (UFSCar), Brazil, using the software Bioestat 5.3.

$$f_k = \left(2 \cdot \frac{\left(f_1 + f_2 + f_3 + \dots + f_{\frac{n}{2}-1} \right)}{\frac{n}{2} - 1} - f_{\frac{n}{2}} \right) \cdot 1,1 \quad (1)$$

3. RESULTS AND DISCUSSION

Table 2 presents the mean values (x_m), the coefficients of variation (CV), the minimum (Min), maximum (Max) and characteristic values of strength for each studied property of Sabiá wood.

Sabiá wood presented density higher than that estimated for *Vataírea* sp., *Erisma uncinatum*, *Schizolobium amazonicum* and *Anadenanthera colubrina* [15,17-19]. The mean value of density determined for the Sabiá wood ($\rho_{12} = 1.04 \text{ g/cm}^3$) allows comparing it to other species, such as Champagne or Cumaru (*Dipterix odorata*), Cutiúba (*Gouania paraensis*), Ipê (*Tabebuia serratifolia*), Jatobá (*Hymenaea* sp.) and Tatajuba (*Bagassa guianensis*) [23].

Sabiá wood presented mean values of radial and tangential shrinkages lower than *Vataírea* sp., *Erisma uncinatum*, *Schizolobium amazonicum* and *Anadenanthera colubrina* [15,17-19]. In addition, their mean values of shrinkage are also lower than those determined by Dias and Lahr [23] for 40 Brazilian native species.

Analyzing the mean values of the physical properties presented by Sabiá wood, it is possible to recommend this wood specie for use as structural material and, for other purposes, within building construction, among them doors, windows and floors [12,20].

The average value of compressive strength parallel to the fibers (f_{c0}) presented by Sabiá wood was equal to 68.46 MPa, and its characteristic value ($f_{c0,k}$) equal to 48 MPa, which allows to include this batch in strength class C40 (dicotyledons), being able to be used for structural purposes. The result of $f_{c0,k}$ for Sabiá wood allows to compare it with others of the same strength class: Angelim-amargoso (*Vataírea fusca*), Angelim-araroba (*Vataíreopsis araroba*) and Mandioqueira (*Qualea paraensis*) [23].

Table 2. Estimated physical and mechanical properties of Sabiá wood

Properties	ρ_{12} (g/cm ³)	RRT (%)	RTT (%)	RLT (%)	f_{c0} (MPa)
x_m	1.04	2.70	4.70	0.50	68.46
Min	0.94	1.38	3.26	0.50	61.55
Max	1.10	3.96	6.59	0.55	82.41
CV (%)	5.80	13.00	11.00	-	15.89
f_k	-	-	-	-	48
Properties	f_{c90} (MPa)	f_{t0} (MPa)	f_{t90} (MPa)	f_{v0} (MPa)	f_{s0} (MPa)
x_m	19.25	8.74	9.60	18.50	1.35
Min	13.47	5.94	6.99	9.20	0.66
Max	23.55	11.36	16.51	22.35	1.54
CV (%)	18.65	23.43	10.28	29.30	32.76
f_k	12	6.11	6.70	12	0.88
Properties	f_M (MPa)	E_M (MPa)	E_{c0} (MPa)	E_{c90} (MPa)	
x_m	56.35	14800	15400	820	
Min	43.35	12687	12165	575	
Max	74.19	17245	19208	985	
CV (%)	18.55	12.15	23.88	17.89	
f_k	39	-	-	-	

4. CONCLUSIONS

According to the results obtained for the studied properties of the Sabiá wood, it is possible to admit the possibility of its use in the civil construction as raw material for structures. The studied batch presented characteristic value in compression parallel to the grain equal to 48 MPa, which classified it as a C40 wood of dicotyledons. Regarding its physical properties, it had a mean density 1.04 g/cm³ and mean values of radial and tangential shrinkage lower than other Brazilian native species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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