Floresta e Ambiente 2010 jan./jun.; 17(1):1-11
doi 10.4322/floram.2011.002
ISSN 1415-0980 (impresso)
ISSN 2179-8087 (online)

Artigo de Pesquisa

Technological Characterization of *Cupressus* spp. Wood

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ABSTRACT

The objectives of the present study were to determine anatomical characteristics, mechanical properties and natural durability to two fungi types [*Gloeophyllum trabeum* (Persoon ex Fries) Murrill and *Trametes versicolor* (Linnaeus ex Fries)Pilat] for cypress wood (*Cupressus* spp.). The wood has straight grain, brown to white color, medium texture, and moderate luster. It also showed medium to low density, low shrinkage, and moderate dimensional stability. Lignin content was relatively high, whereas extractive content was low. *Cupressus* spp. showed static bending properties of 4.1 GPa for modulus of elasticity; 91.0 MPa for modulus of rupture; 1.8 MPa for internal bond; and 6357 and 4039 N for end and side Janka hardness, respectively. All mechanical properties, in air-dry condition, were similar to those described to cypresses and some Amazonian hardwood species. Cypress wood was ranked as highly resistant to the brown-rot fungus *Gloeophyllum trabeum* and to the white-rot fungus *Trametes versicolor*, making it suitable for interior and exterior uses and high humidity environment.

Keywords: mechanical properties, anatomical characteristics, cypress, natural durability.

Caracterização Tecnológica da Madeira de *Cupressus* spp.

RESUMO

Os objetivos deste estudo foram determinar as características anatômicas, propriedades mecânicas e a durabilidade natural da madeira de cipreste (*Cupressus* spp.) exposta ao fungo de podridão-parda, o *Gloeophyllum trabeum* (Persoon ex Fries) Murrill, e ao fungo de podridão-branca, o *Trametes versicolor* (Linnaeus ex Fries) Pilat. A madeira tem grã direita, cor branca a marrom, textura média e brilho moderado. Apresenta de média a baixa densidade, baixa contração e moderada estabilidade dimensional. O teor de lignina foi relativamente alto, enquanto a de extrativos foi baixa. A madeira de *Cupressus* spp. apresentou 4,1 GPa para o módulo de elasticidade; 91,0 MPa para o módulo de ruptura; 1,8 MPa para a ligação interna e 6357; e 4039 N para a dureza Janka de topo e lateral, respectivamente. Todas as propriedades mecânicas, na condição seca, foram semelhantes aos descritos para ciprestes e algumas espécies de madeira da Amazônia. A madeira de cipreste foi classificada como altamente resistente aos fungos de podridão-parda *Gloeophyllum trabeum* e de podridão branca *Trametes versicolor*, tornando-a adequada para uso interior e exterior e meio ambiente de alta umidade.

Palavras-chave: propriedades mecânicas, características anatômicas, cipreste, durabilidade natural.

1. INTRODUCTION

The two most widespread genera of the Cupressaceae family are *Juniperus* and *Cupressus.* At present, there are more than 70 species of *Juniperus*, mostly in North America, Middle East Asia, and Europe. The distribution of the *Cupressus* deserves mention: most species, about ten, grow in the Southern regions of North America, while a few others, about four species, grow in South Asia (Greguss, 1955).

There used to be few articles related to cypress wood, but in the last decade, there have been quite a number of articles reporting the cypress wood properties (Pereira & Higa, 2003; Okino et al., 2006); physical and mechanical properties and decay resistance of particleboards, flakeboards and cement-bonded panels (Okino et al., 2004, 2005), physical and mechanical properties of OSB, natural durability and post-thermal treatment (Okino et al., 2008, 2009, 2007a, 2007b); wood color (Okino et al., 2009); and evaluation of wood chemical constituents using CP/MAS ^{13}C NMR and HPLC techniques (Okino et al., 2008, 2010).

Haslett (1986) published details of the properties and potential uses of *Cupressus macrocarpa, C. lusitanica, Chamaecyparis lawsoniana* and *Cupressocyparis leylandii*. Apart from difficulties with drying, particularly for *C. macrocarpa*, these species are relatively easy to process. The species have similar wood characteristics: attractive grain, medium to low density, low shrinkage, and excellent stability, and most important, high natural durability. Cypress wood is highly suitable for use in exterior joinery, weatherboards, and boat-building. Although it is currently used in furniture, the low surface hardness of cypress wood detracts it for this use. Shukla & Sangal (1986) tested physical and mechanical properties of ten exotic timber species, among them, *Cupressus lusitanica;* they concluded that these exotic species are weak in strength as compared to *Tectona grandis.* Kothiyal et al. (1997), classified *Cupressus goveniana* as a moderately heavy, weak, not tough and soft timber, which should be used for crates and packing. Following the same study, Kothiyal et al. (1998) reported the wood quality of eighteen-year-old *Cupressus lusitanica*, and the timber was found to be quite knotty and also a possessing compression wood. Data shows that the timber is weak in strength properties compared to *Tectona grandis* and *Cedrus deodora.*

Cupressus lusitanica Mill. is a multipurpose tree species with a high potential for wood production in Brazil, in a cool climate with high humidity. The annual increment ranges approximately from 20 to 35 m^3/ha year (Foelkel & Zvinakevicius, 1978).

Clark (1969) established an estimate decay resistance of heartwood of Guatemalan cypress (*Cupressus lusitanica* Mill.) against the brown-rot fungus (*Lenzites trabea*) and the white-rot fungus (*Poria monticola*)*;* 2 and 31% weight loss was found, respectively.

A focused and detailed study is necessary, once cypress wood is well known overseas as a homogeneous plantation with high quality wood yield and a large spectrum of end uses. Moreover, Brazil has little information with reference to genetic and silvicultural improvements, as well as to basic technological data.

The objectives of the present study were to determine the anatomical characteristics, chemical results, mechanical properties and natural durability of cypress wood (*Cupressus* spp.) to two types of fungus [*Gloeophyllum trabeum* (Persoon ex Fries) Murrill and *Trametes versicolor* (Linnaeus ex Fries) Pilat].

2. MATERIAL AND METHODS

Logs of *Cupressus* spp., obtained from 20-30-years-old trees of unknown progeny, were collected in Brasília - DF, Brazil. Cross sectional discs were cut to make anatomical and chemical characterization. The presence of knots and defects was very carefully avoided while preparing small clear specimens for testing. Samples from random heights along the trunk were prepared to evaluate the physical and mechanical properties, as well as the natural durability to two wood-destroying fungi [*Gloeophyllum trabeum* (Persoon ex Fries) Murrill and *Trametes versicolor* (Linnaeus ex Fries)Pilat].

2.1. Anatomical characterization

2.1.1. General characteristics

The general characteristics were based on Coradin & Muñiz (1991). All characteristics analyzed were the average of three observations and the methodology used is described below:

a) Heartwood/Sapwood: Distinction of heartwood and sapwood was verified by means of the difference in color and classified as: distinct and indistinct.
b) Color: It is very subjective and it is one of the main characteristics used to identify and to define end uses of timber, mainly when associated with texture and figures. Color was observed on the longitudinal tangential surface of the 50 x 20 x 150 mm air-dried samples of fresh smoothed surface. Color determination was made by comparison with a standardized scale for soils, the Soil Color Charts (Munsell, 1975), which designate the colors by means of a notation comprising two complementary systems, that is, the name of the so-called color, followed by a code number on the scale corresponding to the color. Another more specific method to find the wood color was based on the CIE La*b* Color System, where measurements were taken on several freshly cut places using a Datacolor Microflash V.4.1 spectrocolorimeter. The illuminant was a D65, with an angle of 10 at 25 °C room temperature and (65 ± 2%) of relative humidity. The measurements were taken in 10 places covering an area of 50 mm^2.
c) Growth rings: The growth rings were observed with the naked eye in sanded discs and classified by their visibility as: distinct, slightly distinct and indistinct.
d) Grain: The grain was verified in 60 x 50 x 200 mm samples, along the radial and tangential longitudinal planes. For the grain observation, the samples were split with a mallet blow on a cutting tool along the radial and tangential direction, as indicated by Jane (1970). The grain was classified as: straight, cross, interlocked, bending, helical and wavy.
e) Texture: A characteristic that refers to the distinction, width, and regularity of growth ring, observed on the transversal section. Texture type: Thin: growth rings slightly distinct to indistinct; Medium: growth rings distinct and narrow; Thick: growth rings well distinct and wide.
f) Figure: It was observed on the sanded surface with dimensions of 50 x 150 mm along the radial and tangential longitudinal sections. The figure of the wood is considered to be the aspects coming from the color differences caused by growth rings, rays with channels, orientation, biological staining agents, knots, and difference in color inside the growth rings.
g) Luster: This characteristic was verified in the sample and was classified as presence or absence of luster as: no luster, medium luster, or high luster.
h) Odor: No specific methodology was used for this characteristic, since it was detected during observations of the general characteristics, and classified as: perceptible or not perceptible.
i) Hardness: Subjective data determined by manual pressure exerted with cutting tools across the fibers, with the wood being classified as: soft, moderately hard and hard.

2.1.2. Macroscopic description

Based on Coradin & Muñiz (1991), wood samples of 20 x 20 mm of transversal section and 30 mm length were taken from disc, polished in microtome and well oriented to transversal, tangential and radial longitudinal sections, for best visibility of the wood elements.

2.2. Chemical characterization

Three discs were randomly chosen and used to determine the lignin content, holocellulose, cellulose and extractives of *Cupressus* spp. Specimens were sampled to determine lignin and extractives according to the "Technical Association of Pulp and Paper Industry" standard (Tappi, 1996). The holocellulose and α-cellulose contents were determined according to Laboratory Instructions, Wood chemistry - WPS 332-L from Research Center of Wood and Paper Department of North Carolina State University (NCSU) (North..., 1989).

2.2.1 Preparation of wood samples for chemical analysis

Wood for chemical analysis was ground in a Thomas-Wiley Model 4 mill to pass a 35 mesh screen. The material to be extracted was inserted into the extraction thimble and placed in the Soxhlet device using a mixture of toluene-ethanol at 2:1 (v/v), followed by ethanol refluxing and later with distilled water, according to TAPPI - T264 om-82 standard (Tappi, 1996a).

2.2.2. Acid-insoluble lignin

The carbohydrates in cypress wood were hydrolyzed with sulfuric acid; the acid-insoluble lignin was filtered off, dried, and weighed according to TAPPI - T222 om-88 standard (Tappi, 1996b).

2.2.3. Quantitative isolation of holocellulose

The holocellulose content was determined through a lignin degradation process in the presence of sodium chlorite and acetic acid. The holocellulose yield was based on the original dry wood.

2.2.4. Quantitative determination of alpha-cellulose and hemicellulose

The alpha-cellulose is the insoluble residue obtained when holocellulose is treated with 17.5% sodium hydroxy; it is considered to represent the undergraded, higher-molecular-weight cellulose in the sample. The soluble portion is reported as hemicellulose and it is obtained from the difference of holocellulose and α-cellulose. The residual weight was reported as the percentage amount of the wood.

2.2.5. Extractive content

The extractive content was determined according to TAPPI T204 om-88 standard (Tappi, 1996c) with some modifications. From the air-dry sample, a specimen equivalent to (2.0 ± 0.1)g of wood was weighed in a tared extraction thimble. The extraction thimble and specimen were placed in position in the Soxhlet device. The extraction flask was filled with 200 mL of ethanol-toluene mixture at 1:2 (v/v) and connected to the extraction device in an adjusted boiling rate and time of extraction. The solvent was then evaporated to near dryness. The flask was dried in an oven for 1 hour at (115 ± 5)°C cooled in a desiccator, and weighed to the nearest 0.1 mg.

2.3. Determination of physical and mechanical properties

Physical and mechanical properties were determined according to ASTM D143-94 (Associação..., 1994) standard, using small clear defect-free specimens. Densities were determined using a water displacement system under the following conditions: basic (oven-dry weight/green volume), air dry (weight/volume both oven-dried), and green density (weight/volume both in green condition). The tangential, radial and volumetric shrinkage was determined based on moisture content change from saturation fiber point to the oven-dry condition. Mechanical properties of air dry specimens were tested in an INSTRON 1127 universal testing machine.

2.4. Decay rating testing

The sound blocks were tested according to ASTM D 2017 (Associação..., 2005) by using pure cultures of decay fungi: a brown-rot fungus, *Gloeophyllum trabeum* (Persoon ex Fries) Murrill and a white-rot fungus, *Trametes versicolor* (Linnaeus ex Fries) Pilat. Tests were carried out in wide-mouth, screw-topped, round bottles, each half filled with soil with a pH of 5.6. Water was added to the soil until a moisture content of 42-45%. Feeding blocks of *Pinus* spp. measuring 3 x 29 mm and 35 mm grainwise were used for brown-rot fungus and blocks of the same dimensions of *Cecropia* spp. were used for white-rot fungus. A feeder block was placed and pressed on the surface of the soil on each bottle and the system was then sterilized (1 hour at 120 °C) and inoculated with the test fungi. The test specimens were previously sterilized in closed bottles for 20 minutes at 120 °C and then placed one in each bottle. A total of twelve replications, blocks measuring 25 x 25 mm and 9 mm grainwise were tested for each tree. The bottles were loosely capped to permit air exchange and then incubated for 12 weeks in a climatized room maintained at (27 ± 1)°C and (70 ± 4)% relative humidity. At the end of the incubation period, the wood specimens were removed, brushed, and dried to constant weight. The weight losses percentage was calculated based on the blocks weights before and after the fungi exposure. This percentage provided a measure of the relative decay susceptibility or, the decay resistance of the wood sample. After testing the blocks were rated according to the Table 1.

Table 1. Decay resistance expressed as either weight loss or residual weight according to ASTM D 2017 standard (Associação..., 2005).
Tabela 1. Resistência à degradação expresso como perda de massa ou massa residual de acordo com a norma ASTM D 2017 (Associação..., 2005).

Average weight loss (%)	Average residual weight (%)	Resistance classes indicated
0 to 10	90 to 100	Highly resistant
11 to 24	76 to 89	Resistant
25 to 44	56 to 75	Moderately resistant
45 or above	55 or less	Slightly resistant or nonresistant

3. RESULTS AND DISCUSSION

3.1. Anatomical characterization

3.1.1. Material description

Common name: cypress

Current botanical name: *Cupressus* spp.

Family: Cupressaceae

Other vernacular names in Brazil: "cipreste-comum", "cipreste-piramidal" (Camargos et al., 2001).

Area of collection: Brasília, DF

3.1.2. General characteristics of the wood

Heartwood/Sapwood: slightly distinct to distinct.

Color: brown moderate pale (10YR 8/3) to white (10YR 8/2), or according to Datacolor Microflash 200d Spectophotometer the values of variables L, a*, and b* were 73.15, 8.19, 22.21 (white), respectively.

Growth rings: distinct and irregular.

Grain: straight.

Texture: medium

Tangential figure: "V" shape and longitudinal strips due to growth rings.

Radial figure: longitudinal strips due to growth rings and dark spots because of knots.

Luster: moderate.

Odor: agreeable characteristic smell.

Hardness: soft.

3.1.3. Macroscopic description

Radial parenchyma (rays): visible trough 10X lens; but difficult in transversal section, and slight visible, even through 10X lens, in tangential section.

Growth rings: distinct to the naked eyes.

Transition between earlywood and latewood: abrupt.

3.2. Chemical characterization

Average values of chemical components of the cypress wood are shown in Table 2. The amount of lignin and extractive contents were homogeneous among the trees. The sum of the chemical compounds of the wood exceeds 100, being difficult to separate these elements of the wood. Results of holocellulose and lignin contents agree with those presented by Foelkel & Zvinakevicius (1978), who evaluated the cypress quality for cellulose kraft production. Extractives were just about the same amount as observed by Guha et al. (1969) to *C. cashmeriana* (4.5% alcohol-benzene), higher than Guha et al. (1971) to *C. lusitanica* (1.8% alcohol-benzene) and lower than Pereira & Higa (2003) to *C. lusitanica* (7.5% total extractives).

3.3. Physical and mechanical properties of cypress wood

Mean values of physical properties of cypress wood are shown in Table 3. The cypress basic density mean value (0.52 g/cm^3) was higher than 0.41 g/cm^3 reported by Okino et al. (2006) and Pereira & Higa (2003). This study corroborated the results reported by Paraskevopoulou (1991), where specific gravity, based on means from three different areas of collection, ranged from 0.447 to 0.510 and individual tree values ranged from 0.396 to 0.594 to *Cupressus sempervirens* var. *horizontalis* Gord. The anisotropy of approximately 1.6 mean value was homogeneous in the three previous studies.

Results of the strength properties, in dry-condition (12% moisture content), are shown in

Table 2. Chemical components of cypress wood average values.
Tabela 2. Valores médios dos componentes químicos da madeira de cipreste.

Material	Components (%)				
	Extractives [a]	Klason lignin [b]	Holocellulose [b]	Hemicellulose [c]	Cellulose [b]
Sample-A	4.0	33.5	72.3	25.0	47.3
Sample-B	4.1	33.7	72.1	25.1	47.0
Sample-C	4.1	33.4	71.1	23.0	48.1
Means [d]	4.1 (0.1) [e]	33.5 (0.1)	71.8 (0.6)	24.4 (1.2)	47.5 (0.6)

[a]Based on oven dry-weight of wood. [b]Based on extractive-free dry-wood. [c]Difference between holocellulose and cellulose. [d]Mean values of three replicates. [e]Number in parentheses are standard deviations.

Table 3. Means for physical properties of *Cupressus* spp. in air dry condition (moisture content of 12%).
Tabela 3. Valores médios de propriedades físicas do *Cupressus* spp., em base seca (teor de umidade de 12%).

Tree	n	Density (g/cm³)						Shrinkage - Green to oven dried (%)						Ratio of shrinkage T/R	
		Dry		Green (Saturated)		Basic		Tangential (T)		Radial (R)		Volumetric (V)			
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A	2	0.54	0.04	0.82	0.04	0.49	0.03	6.2	0.3	4.7	0.4	9.9	0.4	1.3	0.0
B	2	0.60	0.05	0.83	0.04	0.53	0.03	5.9	1.0	3.3	0.7	11.4	2.2	1.8	0.6
C	4	0.57	0.03	0.89	0.04	0.51	0.03	6.5	0.5	3.7	0.3	10.1	0.1	1.8	0.1
D	4	0.62	0.04	0.93	0.07	0.57	0.04	3.7	0.2	2.6	0.2	7.7	0.3	1.4	0.1
E	5	0.63	0.09	0.86	0.07	0.57	0.07	5.6	0.4	4.0	0.5	9.1	0.7	1.4	0.2
F	7	0.60	0.09	0.93	0.08	0.55	0.08	4.8	0.9	3.4	1.1	8.0	1.1	1.4	0.3
G	6	0.44	0.02	0.82	0.07	0.40	0.02	5.2	0.8	3.0	0.4	7.9	0.7	1.7	0.1
H	5	0.55	0.01	0.88	0.09	0.50	0.01	5.8	0.5	4.3	0.5	9.6	0.2	1.3	0.3

n - Number of small clear specimens. M - Mean values. SD - Standard deviation.

Table 4. The variation coefficient of some mechanical properties in this study was higher than the required in the Wood Handbook (United..., 1987), but this deviation can be explained by some not visible internal defects in the small clear specimens. The mean values of stress at proportional limit of elasticity (35.5 MPa) and compression strength parallel to the grain (35.6 MPa) were similar. The mean value of modulus of elasticity - MOE (3122 MPa) was lower than 6965 MPa reported by Okino et al. (2006). On the other hand, end and side Janka Hardness mean values were higher than those reported by Okino et al. (2006).

Table 5 lists physical and mechanical properties of the studied cypress, which showed the lowest and highest basic densities, and were compared to some Amazonian hardwoods, mainly those that have shown basic density in the range of 0.39 to 0.52 g/cm³. The cypress that showed the highest basic density also showed the highest Janka Hardness among all cypress listed on this table. The MOR and compression strength parallel mean values, of the better performance cypress, can be compared to' fava-arara', 'faveira', 'burra-leiteira' and 'açacu', all light color wood species. At first look, cypress wood can be used for paneling, toys, furniture, framework, carpentry work, boats and light construction, the same end-uses applied to this group of woods. According to these groups, the cypress wood is an excellent timber to be introduced as new or replacement species with great potential. The statement of the presence of knots with an average distance of (6.22 ± 2.96)cm between two adjacent knots makes it difficult to obtain timber of proper size for industrial and constructional applications (Kothiyal et al., 1997). It is not applicable to all cypress species because Carvalho (1954) testing *Cupressus lusitanica* observed that, if suitable management is applied and pruning is periodically done since early years, the tree has a strong aptitude for cicatrisation, reducing the knots and other defects in the timber.

Table 4. Means for mechanical properties, in dry-condition (12% moisture content), of *Cupressus* spp. wood.
Tabela 4. Valores médios de propriedades mecânicas, na condição seca (12% de teor de umidade), de *Cupressus* spp.

Static Bending								Compression Strength Parallel to the grain			
Tree	n	MOR (MPa)		MOE (MPa)		SPL (MPa)		Tree	n	(MPa)	
		M	SD	M	SD	M	SD			M	SD
A	1	72	-	3475	-	43	-	A	1	33	-
B	1	47	-	3758	-	37	-	-	-	-	-
C	2	57	12	2340	825	26	5	C	2	31	1
D	1	27	-	2185	-	20	-	D	2	35	8
E	2	91	17	4148	474	42	11	E	2	41	5
F	1	87	-	5431	-	48	-	-	-	-	-
G	2	68	3	2888	411	35	3	-	-	-	-
H	1	80	-	4473	-	33	-	H	2	38	5

Janka Hardness						Tensile strength Perpendicular to the grain			
Tree	n	End (N)		Side (N)		Tree	n	(MPa)	
		M	SD	M	SD			M	SD
A	2	3989	371	3353	598	A	3	2.4	0.8
B	2	7269	1369	6289	2514	B	2	1.9	1.1
C	2	6923	707	5399	354	C	2	2.6	0.3
D	2	5565	1283	4624	1044	D	2	2.1	0.2
E	2	6357	10	4039	359	E	2	1.8	0.4
F	2	6435	884	4398	714	F	2	2.3	0.2
G	2	4631	80	2381	90	G	2	1.7	0.3
H	2	4933	1082	3211	862	H	2	1.7	0.0

n - Number of small clear specimens. M - Mean values, SD - Standard deviations. MOR = modulus of rupture; MOE = modulus of elasticity; SPL = Fiber Stress at elastic limit.

3.4. *Natural durability*

Weight loss percentage after 12 weeks of exposure is shown in Table 6. Both fungi failed to attack the samples. At the end of this period, some bottles resulted in the production of fruiting bodies in the surrounding areas. Cypress wood showed no weight loss after 12 weeks of exposure to *T. versicolor* and it was classed as "highly resistant". Our results for cypress wood are similar to those found for other species of the same family Cupressaceae: *Pilgerodendron uvifera, Fitzroya cupressoides* (French & Tainter, 1973), *Thuja plicata* (Scheffer, 1957), and *Cupressocyparis leylandii* (Building..., 1972). When decaying data between cypress and pine is compared (Eslyn & Highley, 1976; Peterson & Cowling,1964), it is clear that cypress wood naturally has a technological advantage overcoming pine species. As expected, brown-rot caused more degradation than white-rot fungi.

4. CONCLUSION

General anatomical characteristics of cypress (*Cupressus* spp.) wood have shown that heartwood and sapwood is slightly distinct to distinct, and its color is brown moderate pale to white. The wood

Table 5. Small clear strength properties by species.[a]
Tabela 5. Valores médios de algumas propriedades em amostras livres de defeitos.[a]

Vernacular name	Bothanical name	Basic density	Static bending		Compression		Janka Hardness		Tension	Maximum Cleavage Strength	Shear parallel to grain
			MOR	MOE	Parallel	Per-pend.	End	Side	Per-pend.		
		(g/cm³)	(MPa)	(GPa)	(MPa)	(MPa)	(N)	(N)	(MPa)	(N/cm)	(MPa)
Lawson cypress[1]	*Chamaecyparis lawsoniana* (A. Murr.) Parl.	0.43	97.7	12.1	37.3	-	-	2474	-	-	11.2
Mexican cypress[1]	*Cupressus lusitanica* Mill.	0.40	69.6	6.5	38.0	-	-	2622	-	-	8.1
Macrocarpa[1]	*Cupressus macrocarpa* Hartw.	0.54	87.8	5.8	-	-	-	-	-	-	-
Macrocarpa[2]	*C. macrocarpa* Hartw.	0.48	74.3	7.9	40.3	-	-	2500	-	-	-
Leyland cypress[2]	*Cupressocyparis leylandii* (Jacks et Dall.) Dall.	0.50	85.6	6.9	38.0	-	-	-	-	-	-
[3]	*Cupressus goveniana*	0.48	56.9	4.5	25.4	4.9	4625	2518	0.8	-	30.6[c]
[4]	*C. lusitanica*	0.44	53.9	4.3	24.4	5.5	3547	3146	1.0[d]	-	3.8[d]
[5]	*C. lusitanica*	0.43	74.8	8.6	31.3	6.1	2677	2579	-	-	11.1[d]
[b,6]	*C. lusitanica*	0.39	44.6	6.3	21.9	-	3030	2370[d]	-	-	7.0[d]
Yellow-cedar[7]	*Chamaecyparis nootkatensis* (D. Don.) Spach	0.47	91.0	11.7	51.8	6.3	-	3069	-	-	9.5
Western redcedar[7]	*Thuja plicata* Donn ex D. Don	0.32	51.7	7.7	31.4	3.2	-	1559	-	-	6.8
Port-Orford cedar[7]	*Chamaecyparis lawsoniana* (A. Murr.) Parl.	0.43	87.6	11.7	43.1	5.0	-	2805	-	-	9.4
Fava-arara tucupi[8]	*Parkia paraensis* Ducke	0.44	75.0	11.7	39.4	4.7	3990	3370	3.5	570	9.8
Achicha[8]	*Sterculia speciosa* K. Schum.	0.49	92.3	13.9	47.4	4.9	5090	4240	2.4	430	8.9
Quarubarana[8]	*Erisma uncinatum* Warm.	0.46	89.2	11.0	50.7	5.7	5900	3940	3.1	380	8.0
Envira[8]	*Rollinia exsucca* (Dun.) A. DC.	0.52	91.4	12.0	53.3	-	5390	3920	-	300	8.6
Fava-branca[9]	*Stryphnodendrom pulcherrimum* (Willd.) Hochr.	0.48	97.8	12.1	45.8	4.9	7450	5940	3.1	370	12.5
Faveira[9]	*Parkia oppositifolia* Spruce ex Benth.	0.42	83.6	9.7	35.5	5.6	4130	2910	3.2	390	9.6
Burra-leiteira[9]	*Sapium marmieri* Huber	0.39	63.9	9.1	33.2	3.8	2340	1470	2.8	380	6.7
Açacu[9]	*Hura crepitans* L.	0.39	69.0	8.6	33.6	4.8	3920	2830	2.6	340	7.1
Amapá amargoso[9]	*Parahancornia amapa* (Huber) Ducke	0.46	90.8	11.3	46.8	6.1	5400	3580	4.0	520	9.8
Cypress	*Cupressus* spp.	0.40	68.0	2.9	-	-	4631	2381	1.7	-	-
Cypress	*Cupressus* spp.	0.57	91.0	4.1	41.0	-	6357	4039	1.8	-	-

[a]Properties in air dry condition (at 12.0% moisture content). [b]Properties in green condition. [c]Shear parallel to grain in radial. [d]Mean value between radial and tangential directions. [1]Bier (1983). [2]Haslett (1986). [3]Kothiyal et al. (1997).[4]Kothiyal et al. (1998). [5]Shukla & Sangal (1986). [6]Ng'ang'a (1992). [7]McDonald et al. (1997). [8]IBDF (Instituto..., 1988). [9]IBAMA (Instituto..., 1987).

Table 6. Mass loss in a 12-week accelerated decay test of cypress wood exposed to *G. trabeum* (Persoon ex Fries) Murrill and *T. versicolor* (Linnaeus ex Fries) Pilat.
Tabela 6. Perda de massa, em ensaio acelerado de laboratório, de madeira de cipreste exposta aos fungos *G. trabeum* (Persoon ex Fries) *Murrill* e *T. versicolor* (Linnaeus ex Fries) Pilat.

	Average mass loss (%)	
Treatment	*G. trabeum*	*T. versicolor*
Cupressus spp.	1.08 (1.44)[a]	0.00 (0.00)

Mean values of 12 samples. [a] Number in parentheses are standard deviations.

has medium texture, straight grain and showed soft resistance to manual cross-cutting. It has a characteristic odor, very agreeable smell and the natural protective oil gives it an aromatic and durable scent.

Cypress is moderately light with basic density ranging from 0.40 to 0.57 g/cm^3. The ratio of tangential/radial shrinkage ranged from 1.3 to 1.8, classifying the wood as moderately stable to unstable. When being processed, the wood showed very easy workability qualities using hand and machine tools. The wood should be suitable for high value interior joinery, furniture and turnery.

The percentage of extractive content was low and the lignin content was relatively high. These mean values were compatible to the chemical constituents of other softwoods species.

Cypress wood was "highly resistant" to the brown-rot fungus, *G. trabeum,* and white-rot fungus, *T. versicolor*.

Its light color, anatomical characteristics and easy processing, makes it comparable to some common and commercial hardwood and softwood species, mainly *Pinus* spp.

ACKOWLEDGEMENTS

We would like to extend our thanks to the technicians João E. Anacleto, Getúlio F. de Almeida, Luiz D. Santana and Ricardo P. de O. Santos. We are especially grateful to Maria H. M. G. de Figueiredo for her help.

SUBMISSION STATUS

Received: 04/03/2008

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