ISSN impresa 0717-3644
ISSN online 0718-221X
Maderas. Ciencia y tecnología 19(3): 293 - 308, 2017
DOI: 10.4067/S0718-221X2017005000025

XILOTECNIA OF THE WOOD OF *Acacia Schaffneri* FROM THE STATE OF HIDALGO, MEXICO

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ABSTRACT

The genus *Acacia* spp belongs to the family Leguminosae, with more than 1300 species distributed naturally in all continents except Europe. In Mexico there are 85 species, of which 46 are endemic, most located in arid and semiarid regions, being *Acacia coulteri* and *Acacia farnesiana* the most widely distributed. The aim of this study was to determine the technological characteristics of the wood of *Acacia schaffneri*. To determine the anatomical characteristics, the methodology of Autonomous Chapingo University's wood anatomy laboratory was used; for the physical properties, standards NOM EE-117-1981 and NMX-EE-167-1983 were used, and in calculating the mechanical properties the mathematical formulas were employed. The wood is reddish brown and has interlocked grain with diffuse porosity, aliform confluent parenchyma and in confluent bands, and crystals and gums. The proportion of cells was 11,87% vessel elements, 50,65% fibers 27,76% axial parenchyma and 9,81% ray parenchyma. Basic density was 880 kg/m^3, tangential, radial, axial and volumetric shrinkage values were 10,57%; 4,97%; 0,10% and 15,82 % respectively, and fiber saturation point was 19,97%. The mechanical properties were very high, so it can be used in the manufacture of floors and in building constructions.

Keywords: Fiber saturation point, mechanical properties, physical properties, pulp quality indices, wood anatomy.

INTRODUCTION

The genus Acacia spp belongs to the family Leguminosae, subfamily Mimosoideae with more than 1300 species, which are distributed naturally in all continents except Europe. More than 900 species are native to Australia and the rest to dry tropical and warm temperate regions of Africa, southern Asia and the Americas.

With regard to the species found in the Americas, there is little information. Probably the best known are: *Acacia coulteri* in northern Mexico; *Acacia caven* in Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay; *Acacia aroma* in Argentina, Bolivia, Ecuador, Paraguay and Peru; *Acacia adstringens* in areas of Argentina, Paraguay and Peru; and *Acacia farnesiana* in Mexico and Central America (Barros 2007).

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Received: 05.05.2016 Accepted: 20.03.2017

In Mexico there are 85 species, of which 46 are endemic, most located in arid and semi-arid regions, which shows the ecological tolerance of the genus; for example, *Acacia farnesiana* is present throughout the country, covering a wide variety of climates and ecosystems (altitudes of 0-2600 m, temperatures of 5-30 °C and rainfall of 100-900 mm annually on average). *A. schaffneri* is located mainly in the northern and eastern region of the country, and it is commonly associated with *A. farnesiana*.

The genera *Prosopis* and *Acacia* are part of the thorn forest, constitute the main woody cover in the dry tropics and subtropics, tolerate extreme drought and have the ability to fix atmospheric nitrogen, so they play an important role in soil conservation, making them key genera in Mexico's arid and semiarid ecosystems (Gómez and Tapia 2003). Specifically, the fruit of *Acacia schaffneri* has active anti-cancer and anti-inflammatory ingredients (Manríquez 2013).

Concerning the wood, studies of different species have been conducted. These include: the Australian blackwood (*Acacia melanoxylon*), which has a basic density of 430 kg/m^3, and tangential and radial shrinkage at 12% MC of 4,2% and 3,6% respectively; silver wattle (*Acacia dealbata*), with a basic density of 470 kg/m^3 and tangential and radial shrinkage at 12% MC of 5,0% and 4,4% respectively (Ananías *et al.* 2008). In Argentina, *Acacia melanoxylon* had radial shrinkage of 3,82% and 7,38% in the tangential direction. The fiber saturation point value was 24,7% and the average normal density was 604 kg/m^3 (moisture content range of 10-18%) (Igartúa *et al*. 2009).

On the other hand, Correa (2011) mentions that *Acacia melanoxylum* wood has gained wide acceptance in the market because it is easy to saw, having a basic density of 540 to 750 kg/m^3, suitably supports tensile and compression stresses, is resistant to shock and vibration, and has a fine finish. It is used in the manufacture of furniture, interior linings, joinery, turnery, parquet flooring, musical instruments, and ship structures.

Huicochea-Santana and Barajas-Morales (2002) mention some characteristics of the wood of *Acacia farnesiana*, such as its yellowish creamy-colored sapwood with conspicuous and coalescent bands of paratracheal parenchyma, and its use in flooring (parquet). In Mexico its use is restricted to forage and logging for fence posts. The above-mentioned authors also report that *Acacia cochliacantha* has small, reddish brown heartwood with violet tones. It is tasteless, smells like *guaje*, and has no luster, and it is also characterized by medium texture, irregular grain, slightly pronounced figure, diffuse porosity, aliform parenchyma, multiseriate homogeneous rays, libriform fibers, a thick cell wall and specific gravity of 940 kg/m^3.

Finally, *Acacia bilimecki* has greyish heartwood with reddish tones, low luster, medium to fine texture, diffuse porosity, and very abundant confluent-aliform paratracheal axial parenchyma, with chains of prismatic crystals. The rays are moderately numerous, homogeneous and mainly triseriate. Fibers are 1168 mm in length and 12 mm in diameter, cell wall thickness is 4 mm, and specific gravity ranges from 880 to 970 kg/m^3; it is used for wooden posts in rural housing construction.

Regarding the wood of *Acacia schaffneri*, it has a basic density ranging from 880 to 970 kg/m^3, a modulus of elasticity of 15,13 GPa, and a modulus of rupture of 207 MPa; it is used for fuel (firewood), fences, construction and tools. It is also regarded as a melliferous, medicinal species, and as food for goats and sheep (Foroughbakhch *et al.* 2012, Carrillo *et al*. 2011, Conafor 2008, González 2007, Rico 2001).

Therefore, it is necessary to know the anatomical characteristics and the physical and mechanical properties of *Acacia schaffneri* wood, obtained from a plantation, in order to properly use it and to suggest new uses.

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MATERIALS AND METHODS

Study area location

The municipality is located between 19° 57´ north latitude and 98° 55´ west longitude, at an altitude of 2360 meters. It is bordered to the north by San Agustín Tlaxiaca and Zapotlán, to the south by Tizayuca and the State of Mexico, to the east by Tezontepec and Zapotlán, and to the west by the State of Mexico (Figure1).

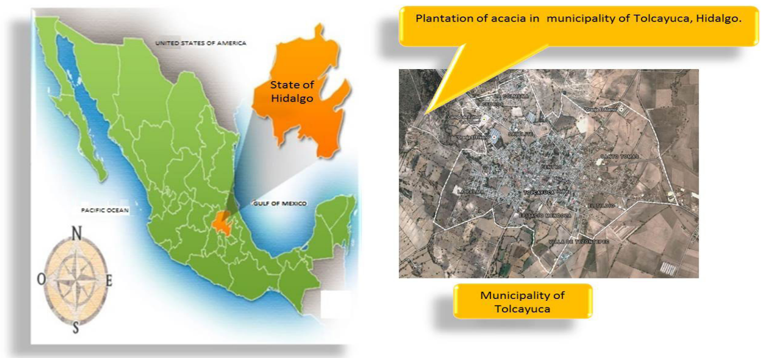

Figure 1. Study area location.

Physical aspects

The area's climate has an average annual temperature of 16,2 °C and 557 mm rainfall. The soil type is semi-desert. The municipality is traversed by the Panuco and Moctezuma rivers. The vegetation consists of unarmed and thorny bushes such as *Agave spp. (*maguey), *Pachycereus pringlei* (S. Watson) Britton & Roseel (cardón), *Opuntia spp*. (prickly pear*), Schinus molle* L. (Peruvian peppertree) and *Yucca spp*. (yucca).

The fauna consists of *Canis latrans* Say (coyote), *Canis lupus* L. (wolf), *Mephitis macroura* Lichtenstein **(**skunk), *Oryctolagus cuniculus* (rabbit), and *Sciurus sp.* (squirrel), along with reptiles, insects and a wide variety of arachnids, plus *Carduelis carduelis* L. (finches)*, Colibríes spp* (hummingbirds), *Passer domesticus* L. (sparrows) and *Serinus canaria* L (canaries).

Description of the species

Acacia schaffneri (S. Watson) F.J. Herm. belongs to the family Mimosaceae (J. Wash. Acad. Sci. 38: 236, 1948). It is commonly called twisted acacia or Schaffner's acacia in the United States, and huizache chino in Mexico. Synonyms include *Pithecellobium schaffneri* (S. Watson 1882), *Samanea schaffneri* (J.F. Macbr. 1919), and *Vachellia schaffneri* (S. Watson, Seigler & Ebinger 2006).

The species is distributed in Texas, United States, and in the following states of Mexico: Aguascalientes, Baja California, Chihuahua, Coahuila, Durango, State of Mexico, Guanajuato, Jalisco, Michoacán, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, Sonora, Tamaulipas, Veracruz and Zacatecas, plus Mexico City.

Acacia schaffneri is part of the thornscrub. It is associated with *Prosopis laevigata* (mesquite), grows on stony slopes or flat terrain, from 1400-2500 masl, in shallow, chalky, sandy, stony, well-drained soils, with pH 5 to 8, and tolerates drought and frost. The trees have short, slender boles, branched from the base, with numerous stems.

The trees have alternate, bipinnate-compound leaves, ranging from 2,5 to 5 centimeters long. The flower is a group of inflorescences arranged in spherical heads, from 6 to 9 mm in diameter, solitary or in groups of two to five; the fruit is a linear, slightly-flattened, but turgid pod, straight or slightly curved (legume), from 7 to 15 cm long and 5 to 8 mm wide.

Material collection

The material was collected in an area with a 15% slope. It is located at 2459 masl, at coordinates 19°56,964 N; 98° 57ˈ12,74″ W; 14 50°47ˈ 86″ E and 220°56ˈ81″ N (PGS NAD 27 UTM).

The species is associated with huizcolote (*Mimosa sp),* prickly pear (*Opuntia* spp.), Mexican kidneywood (*Eysenhardtia polystachya* (Ort.) Sarg. 9), Peruvian peppertree (*Schinus molle* L.), pitaya (*Stenocereus queretaroensis* (F.A.C. Weber) Buxb.) and Texas mimosa (*Mimosa biuncifera* Benth).

Field procedures

From one of the 9 trees collected, two botanical samples, from which total height and diameter at breast height (DBH) (Table 1) were determined, and a log section of approximately 1,20 m (Figure 2) were obtained.

Table 1. Dendrometric characteristics of the trees of *Acacia schaffneri* from Tolcayuca Hidalgo.

No. of tree	Diameter (cm)	Height (m)	Slope (%)
1	26,5	2,50	13
2	29,00	3,0	15
3	19,00	3,0	15
4	34,0	3,5	0,0
5	22,5	3,40	10
6	23,0	2,80	10
7	28,0	27,0	10
8	22,0	3,50	10
9	23	3,0	10

Figure 2. *Acacia schaffneri* from Tolcayuca, Hidalgo: (a). plantation, (b). tree, (c). flower, (d). selected tree, (e). felling the tree, (f). log section showing the cross-section.

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Laboratory procedure

Two 5-cm slices were obtained from the first log section of each tree to determine the microscopic anatomical characteristics and the basic density; also, three 10-cm slices were obtained to determine the radial, tangential and axial shrinkages, and two 20-cm ones were obtained to evaluate the macroscopic characteristics.

Macroscopic anatomical study

Small boards measuring 1 x 7 x 15 cm of the three typical sections (longitudinal-radial, longitudinal-tangential and crosswise) were used to describe the color, smell, taste, luster, grain, texture, figure, and porosity. The color of the wood was classified according to the Munsell (1975) table, the smell and taste using the senses of smell and taste, the luster according to Ortega *et al*. (1992), and the texture and grain according to Tortorelli (1956).

Microscopic anatomical study

Specimens of 2 x 2 x 2 cm^3 were obtained from the first slice to make typical sections. They were placed in a digester at a pressure of 1½ kg/cm^2 for 30 minutes to be softened. Subsequently, the typical sections were made with a Leica microtome at a thickness of 15μ; chips were cut from the same specimens to make the dissociated material, according to Navarro *et al*. (2005).

With the length, lumen diameter, total diameter of the fibers and wall thickness data, the rigidity coefficient (RC), flexibility coefficient (FC), Peteri coefficient or slenderness index (SI) and Runkel's ratio (RR) were calculated (Tamarit 1996). The proportion of fibers, vessel elements, medullary rays and axial parenchyma were determined according to Machuca (1999), and the classification was based on Kollmann (1959). All measurements were performed with an image analyzer using LAS 3.1 software.

Physical properties

Saturated moisture content (SMC) and equilibrium moisture content (EMC) were determined according to Navarro *et al.* (2005). Fiber saturation point (FSP) denotes the moisture state of wood when it no longer contains free water, but its cell walls are saturated with hygroscopic water; to determine this property, the formula reported by Fuentes (2000) was used.

Wood density is influenced by its moisture content (MC); for this reason the following densities were determined: basic density, anhydrous density, equilibrium density, normal density and saturated density. These were evaluated according to standard NOM EE-117-1981 (Dirección General de Normas 1981) and were classified according to Vignote and Jiménez (1996).

Wood shrinkage refers to changes in its dimensions and volume, as a result of changes in moisture content below FSP, i.e. within the hygroscopic water. To determine partial and total volumetric shrinkage, and total radial, tangential and axial shrinkages, Mexican standard NMX-EE-167-1983 was used.

The volumetric shrinkage coefficient (Vβv) is the shrinkage experienced by the wood for every 1% moisture decrease within the hygroscopic water range from the FSP, and reflects part of the degree of dimensional stability that characterizes the wood, calculated according to Fuentes (1998).

The anisotropy ratio (A) is a value that allows inferring the degree of dimensional stability of wood, showing the ratio between the magnitudes of total tangential shrinkage (%βRt) and total radial shrinkage (%βRt); it was calculated according to Fuentes (1998).

Mechanical properties

Mechanical properties refer to the ability of wood to withstand external forces, such as tensile strength, elasticity and/or rigidity and hardness. These were estimated with mathematical formulas for broadleaf trees described by Brown and Panshin (1980).

RESULTS

Anatomical characteristics

Macroscopic characteristics

Table 2 and Figure 3 show the macroscopic characteristics of *Acacia schaffneri* wood.

Table 2. Macroscopic characteristics of wood of *Acacia schaffneri*.

Characteristic		Description
Color	Sapwood	HUE 2.5Y(8/4) Very pale yellow
	Heartwood	HUE 2.5YR(3/4) dark reddish brown
Smell		Presents
Taste		Presents
Grain		Interlocked
Texture		Fine to medium
Figure		Pronounced (presents dark lines)
Luster		High
Ray visibility		Rays visible with a magnifying glass

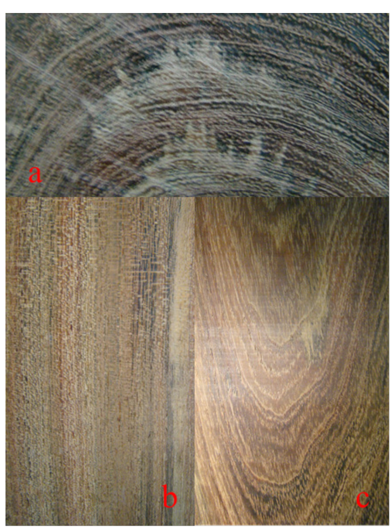

Figure 3. Typical macroscopic sections of the wood of *Acacia schaffneri*.
(a): cross-section, (b): radial section, (c): tangential section

The wood of *Acacia schaffneri* is similar in color, grain and texture to *A. melanoxylum*, *A. acuminata*, *A. arabica*, *A. koa*, *A. cambagei, A. catechu*, A. *aneura* (Kribs 1968, Monteoliva and Igartúa 2010), *A. articulata*, *A. macracantha*, *A. polyphylla* (Williams 2008) and *Acacia gaumeri* (Rebollar and Quintanar 1998). The wood of *Acacia schaffneri*, by having a pronounced figure, can be used for fine cutlery, flooring, and sliced panels for later veneering boards, which coincides with the findings reported by Huicochea-Santana and Barajas-Morales in 2002 for the species *Acacia farnesiana*; in Portugal the wood of genus Acacia was used in ecclesiastical furniture because of its durability (Bernal *et al.* 2011).

Microscopic characteristics

In Table 3 and Figures 4 and 5 it can be seen that the microscopic characteristics of *Acacia schaffneri*, in terms of porosity, fibers, vessel element pits, parenchyma and rays, are similar to those of *Acacia acuminata*, *A. arabica, A. koa, A. melanoxylum, A. cambagie,* and *A. catechu*r (Kribs 1968). The number of vessels per mm^2, tangential diameter, fiber diameter and ray height are similar to *A. cynophylla* but differ numerically from *A. mangium* (Van der Graaff and Baas 1974) and *A. macracantha* (Silva *et al.* 1989). The concentric parenchyma can be considered as denoting growth rings, as in other African Acacias (Gourlay 1995 a,b). Compared with other Acacia species that grow in Mexico, such as *Acacia cochliacantha*, which is distributed on the Pacific slope, *Acacia bilimecki* in Guerrero, Morelos, Oaxaca and Puebla and *Acacia gaumeri* in Quintana Roo, *Acacia schaffneri* is similar to all of them in type of porosity, tangential diameter, simple plate, alternate pits, type of parenchyma, rays, fiber, and cell contents, (Rebollar and Quintanar 1998, Huicochea-Santana and Barajas-Morales 2002), such as the crystals that in developed species in very arid areas may have a reserve of calcium (Gourlay and Grime 1994).

However, it is different in relation to the type of porosity, which is semicircular in *Acacia angustissima* (Aguilar-Alcantara *et al*. 2014).

Table 3. Microscopic characteristics of the wood of *Acacia schaffneri*.

VESSEL ELEMENTS							
Values	Length (µ)	Diameter (µ)	N/mm^2	Arrangement	Distribution	Pits	Perforation plate
Maximum	202,79	212	28	Diffuse	Solitary, multiple (2,3 4 in radial lines).	Alternate	Simple
Average	128,94	124	21				
Minimum	45,06	68	15				
S.D.	33,09	34	3.4				
Classification	Ext, Cuts*	Very small**	Numerous				

FIBERS				
Values	Length (µ)	Lumen diameter (µ)	Total diameter (µ)	Cell wall thickness (µ)
Maximum	1056,14	11,84	25,19	9,61
Average	788,29	4,34	15,03	5,35
Minimum	517,83	1,12	8,03	2,65
S.D.	106,82	1,68	3,51	1,44
Classification	Cuts***	Moderately fine**	Fine***	Very thick**

PARENCHYMA					
Axial: Aliform confluent, confluent bands and concentric parenchyma					
Ray					
Values	Height	Width	N°/mm	Type	Class
Maximum	106,9	13,84	2	Homogeneous	Uniseriate
Average	46,97	7,56	1,35		
Minimum	19,09	3,58	0		
S.D.	25,87	2,90	0,63		
Classification	Very low***	Ext. fine*	Scarce ***		
Maximum	255,07	98,72	4	Homogeneous	Triseriate
Average	134,79	50,70	1,6		
Minimum	99,43	38,48	0		
S.D.	37,89	13,62	1,3		
Classification	Very low***	Mod. fine*	Scarce***		
Maximum	1255,14	72,13	9	Homogeneous	Multiseriate
Average	6 00	48,2	6,55		
Minimum	284,46	34,91	4		
S.D.	248,83	9,64	1,37		
Classification	Medium***	Mod. fine*	Few in number***		

CELL CONTENTS			
Vessels	Axial parenchyma	Ray parenchyma	Fibers
Gums, oils	Crystals		

S.D: Standard deviation Jane (1970)*, Terrazas (1984)**,Tortorelli (1956)***. Ext. Extremely, Mod. Moderately.

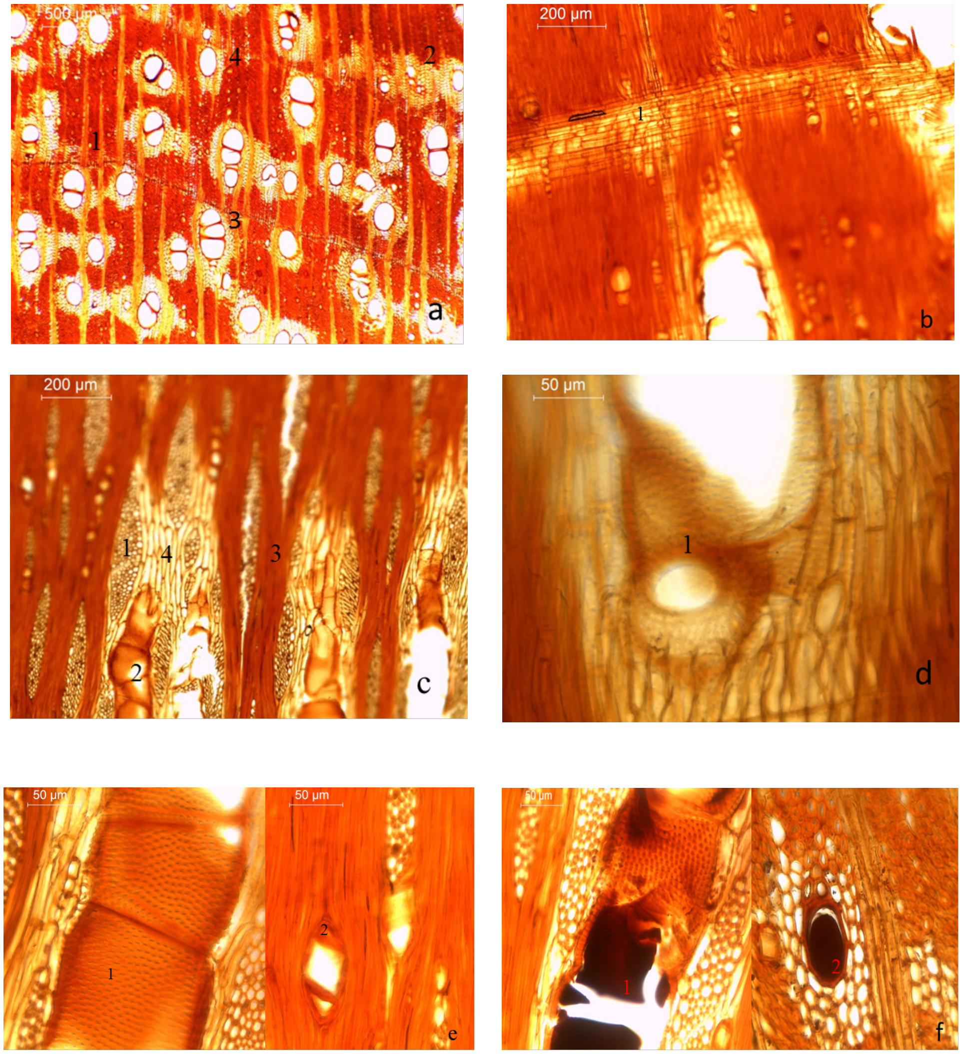

Figure 4. Anatomical characteristics of the wood of *Acacia schaffneri*.
(a): cross section (1. concentric parenchyma, 2. parenchyma in confluent bands, 3. multiple vessels, 4. solitary vessel),
(b): radial section (1. ray),
(c): tangential section (1. multiseriate ray, 2. vessel element, 3. fibers, 4. axial parenchyma),
(d): radial section (1. simple plate),
(e): tangential section (1. alternate pits, 2. rhomboid crystal),
(f): tangential section (1 gum in vessel element);. cross section (2 gums in vessel)

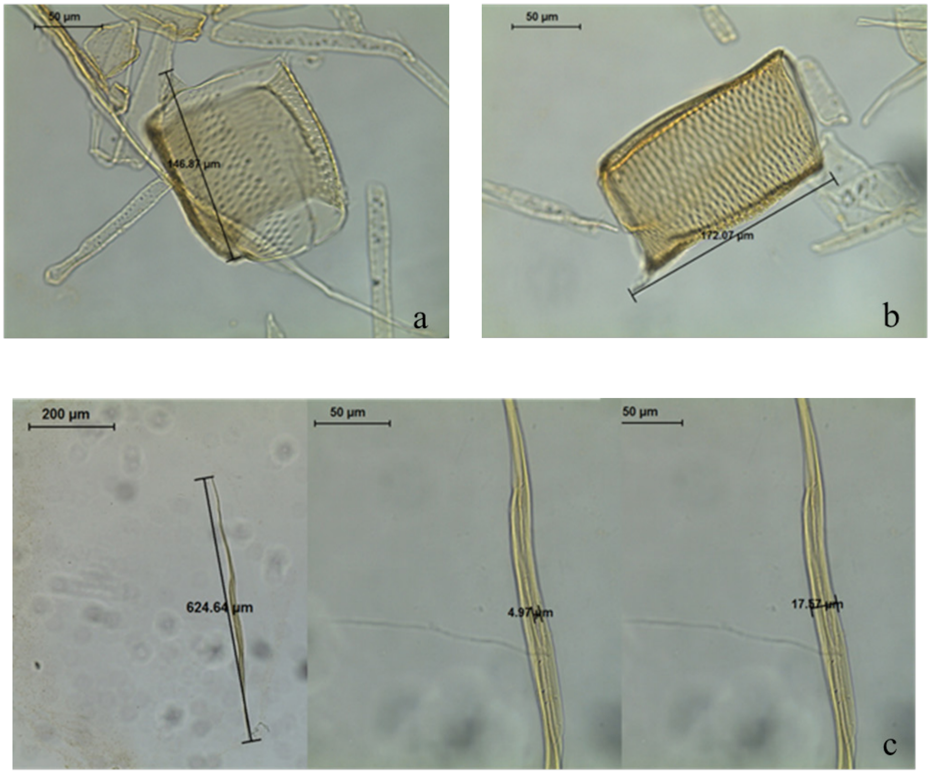

Figure 5. Individualized cells of the wood of *Acacia schaffneri*.
(a): vessel element, parenchymal cell and fiber. (b): vessel element. (c): fiber

Proportion of constituent elements

Table 4 shows the results of the proportion of constituent elements in the wood.

By comparing the proportion of constituent elements reported by Bravo *et al.* 2006, in *Acacia aroma*, which has 10,4% vessels 36,2% fibers 32,2% axial parenchyma and 21,2% ray parenchyma, and in *Acacia furcatispina*, which has 21,8% vessels 42,0% fibers 28,4% axial parenchyma and 7,8% ray parenchyma, it can be seen that the values obtained in this study are between those of the two species.

Table 4. Proportion of constituent elements in the wood of *Acacia schaffneri*.

Value	Cell percentage			
	Vessel element	Fibers	Axial parenchyma	Ray parenchyma
Maximum	20,4	55,2	32,2	14,2
Average	11,78	50,65	27,76	9,81
Minimum	6,7	43,2	21	7
S.D.	5,47	4,93	4,59	2,93
Classification Kollmann (1959)	Average	Average	Average	Lower

Pulp quality indices

The wood fibers of *Acacia schaffneri* have a very thick wall so that they do not collapse and the contact surface is small, so the fiber-to-fiber bonding is poor; consequently, paper made from this type of fiber has low tensile strength. Moreover, Runkel's ratio of *Acacia schaffneri* was classified as bad for paper (Table 5), which is very different from that of *Acacia melanoxylum*, which is classified as good, despite both being of the same family (Tamarit 1996). Other species such as *Acacia mearnsii* and *A. dealbata* planted in Chile provide high-performance wood pulps (Pinilla *et al*. 2006).

Table 5. Pulp quality indices of the wood of *Acacia schaffneri.*

Values	Pulp quality indices			
	R.C.: 2W/D	**F.C.: l/D**	**S.I.: L/D**	**R.R: 2W/l**
Maximum	0,90	0,59	91,05	8,68
Average	0,71	0,29	54,92	2,73
Minimum	0,41	0,10	28,39	0,69
S.D.	0,09	0,09	13,77	1,25
Classification	Thick	Very thick	Not found	Bad for paper

R.C. Rigidity coefficient. 2WD Fiber wall thickness/Fiber diameter. F.C. Flexibility coefficient. I/D Lumen diameter/Fiber diameter.
S.I. Slenderness index. L/D Fiber length/Fiber diameter. R.R. Runkel's ratio. 2W/I Fiber wall thickness/lumen diameter.

Physical properties

Wood density

Density is one of the most important technological properties of wood and constitutes an excellent evaluation criterion, given its close relationship with other characteristics of this material (Díazvaz and Ojeda 1980). Table 6 shows that the wood, based on its basic and normal density, is classified as very heavy (Vignote and Jiménez 1996).

Basic density was 880 kg/m^3, which is different from the value reported by Carrillo *et al*. (2011) and Foroughbakhch *et al*. (2012), which was 790 kg/m^3. However, Morales (2002) reported for *Acacia bilimecki* a range of 880 to 970 kg/m^3; this density is similar to that of *A. schaffneri*, but different than that of *Acacia cochliacantha*, 940 kg/m^3, reported by the same author. Similar data were reported by Bravo *et al.* (2006): 890 kg/m^3 for *A. aroma* and 990 kg/m^3 for *A. furcatispina*. It is also similar to *Acacia acuminata* (960 kg/m^3), *A. arabica* (800 kg/m^3), *A. koa* (830 kg/m^3), *A. melanoxylum* (720 kg/m^3), *A. cambagie* (750 kg/m^3), but different than *A. catechu* (980 kg/m^3), *A. aneura* (1200 kg/m^3) (Kribs 1968) and *Acacia mangium* (450 kg/m^3) (Muñoz and Moreno 2013).

Table 6. Wood density of *Acacia schaffneri*.

	Types of density kg/m^3				
Values	**Green density**	**Moisture content density h**	**Normal density**	**Basic density**	**Anhydrous density**
Maximum	1290	1150	1180	1000	1120
Average	1180	1010	1002	880	980
Minimum	1110	740	720	590	670
S.D.	50	140	140	130	140
Classification			Very heavy, (Díaz 1960)	Very heavy, (Vignote and Jiménez 1996)	

Shrinkage

Shrinkage refers to changes in dimensions that wood experiences as a result of water loss (moisture content) below the FSP. Changes in dimensions due to shrinkage are related to the cell structure, and are manifested according to the structural axis of the wood where the measurement of the wood samples is performed. Table 7 shows the values of the different types of shrinkages found in this study.

Acacia schaffneri presented tangential and radial shrinkage values lower than those of *Acacia melanoxylon* and *Acacia dealbata*, although the shrinkages of these species are at 12% MC (Ananías *et al.* 2008, Igartúa *et al*. 2009).

Table 7. Total shrinkages of the wood of *Acacia schaffneri*.

	Types of shrinkage (%)			
Values	**Tangential**	**Radial**	**Axial**	**Volumetric**
Maximum	13,14	7,39	0,010	18,59
Average	10,17	4,97	0,010	15,82
Minimum	7,51	3,07	0,010	14,16
S.D.	1,37	1,06	0,005	1,32
Classification	Very high (Fuentes *et al*. 2002)	High (Fuentes *et al*. 2002)		High (Vignote and Jiménez 1996)

S.D. Standard deviation

Other physical properties

Table 8 shows the fiber saturation point, volumetric shrinkage coefficient and anisotropy ratio results.

Table 8. Fiber saturation point, volumetric shrinkage coefficient and anisotropy ratio of the wood of *Acacia schaffneri.*

Values	FSP	VSC	A.R.
Maximum	23,48	0,79	3,66
Average	19,97	0,79	2,12
Minimum	17,88	0,79	1,36
S.D.	1,67	1,33432E-16	0,54
Classification	Lower (Kollmann; 1959)	High, (Vignote and Jiménez; 1996)	High (Fuentes; 1998).

FSP: Fiber saturation point, VSC: Volumetric shrinkage coefficient, A.R. Anisotropy ratio

The fiber saturation point of the fibers was lower than that of *Acacia melanoxylon* at 24.7% moisture content (Igartúa *et al*. 2009).

Considering the results shown in Tables 8 and 9, *Acacia schaffneri* wood has high shrinkage values, both linear and volumetric, as well as for the volumetric shrinkage coefficient, indicating that the drying process for this wood should be initiated with a soft schedule, but it showed higher values compared to *Acacia mangium* (Muñoz and Moreno 2013), which may be due to this species having a low density.

Mechanical properties

Table 9 shows that all the mechanical properties are classified as very high. The data reported by Carrillo *et al.* (2011) and Foroughbakhch *et al*. (2012) are similar to those reported in this study, so this species can be used in structural applications in construction. The mechanical properties can be compared with those of *Acacia polyphylla*. D.C., which has a basic density of 520 kg/m^3; this is less than that of *Acacia schaffneri* and, therefore, its mechanical properties are lower. For example, *A. polyphylla* has 38,5 MPa in stress at proportional limit, modulus of rupture of 71,1 MPa and modulus of elasticity of 1,2 GPa in the bending test, along with transversal and side hardness values of 596,3 kg and 426,9 kg respectively (Aróstegui and Sato 1970); it is the same situation for *A. melanoxylon*, which has the following values: basic density of 560 kg/m^3; in the bending test, stress at proportional limit of 37,7 MPa, modulus of rupture of 89,9 MPa and modulus of elasticity of 10,9 GPa; transversal and side hardness of 546,72 kg and 416 kg, respectively (Igartúa *et al*. 2015). The results in this research are compared to studies of the genus Acacia, because there is little information available on the wood of *Acacia schaffneri.*

Table 9. Mechanical properties calculated from mathematical formulas of the wood of *Acacia schaffneri*.

Test	Green condition	Classification	12% Condition	Classification
Static bending				
Stress at proportional limit (MPa)	59,1	Average	118,0	Very high*
Modulus of rupture (MPa)	103,4	Average	181,6	Very high*
Modulus of elasticity (GPa)	14,3	Average	19,7	Very high*
Impact				
Impact (cm)	231,52	Very high	248,76	Very high*
Compression parallel to fiber				
Stress at proportional limit (MPa)	31,9	Low	61,6	Very high**
Maximum stress (MPa)	40,8	______	85,8	Very high***
Modulus of elasticity (GPa)	180,0	Average	23,8	Very high
Compression perpendicular to fiber				
Stress at proportional limit (MPa)	15,5	Average	33,4	Very high*
Hardness				
Side (kg)	1272,40	High	2276,44	Very high***
Extreme (kg)	1163,53	Very high	1787,96	Very high***

(Echenique and Plumptre 1994)*, (Fuentes 1998)**, (Dávalos and Bárcenas 1999)***

CONCLUSIONS

The wood of *Acacia schaffneri* can be used for making fine pieces for various items such as furniture and flooring, among others, but it is not good for making pulp for paper.

Due to the wood density of *Acacia schaffneri*, it is defined as a heavy wood that can be used for the manufacture of heavily-trafficked floors.

The wood of *Acacia schaffneri* is classified as high strength, so it can be used in constructing buildings, heavy platforms, marine structures and posts.

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