Differences in Physical and Mechanical Wood Properties of Mesquite (*Prosopis laevigata*) in Four locations in Northeast Mexico

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Abstract

Mesquite wood (*Prosopis laevigata* (Humb. & Bonpl. ex Willd.) M.C. Johnst) is used for a wide range of purposes, e.g. construction, decoration, and energy. The differences in physical and mechanical wood properties of *P. laevigata* in four locations, northeast Mexico, were investigated. The results showed that densities at 12% Equilibrium Moisture Content (EMC) in the four sites ranged from 0.79-0.91 g cm^{-3} compared to 0.72-0.84 g cm^{-3} under oven dry conditions. Tangential and radial shrinkage varied from 2.2-3.3% and 1.6-1.9%, respectively. Modulus of rupture (MOR) ranged between 97-114 N mm^{-2}, Static and dynamic modulus of elasticity (MOE_{stat}, MOE_{dyn}) varied from 6,580 and 9,669 N mm^{-2} and 6,677 to 9,984 N mm^{-2}, respectively. The correlation between MOE_{stat} and MOE_{dyn} was 0.94. Physical and mechanical wood properties of *P.laevigata* varied depending on latitude, growth conditions and forest sites. Physical wood properties should be considered by foresters when selecting tree site or individual trees for plantation programs.

Keywords: mesquite, density, static and dynamic modulus of elasticity, modulus of rupture.

Introduction

There are 44 *Prosopis* species in arid and semi-arid areas around the world (Burkart, 1976; USDA, 2007). According to Pasiecznic *et al.* (2001) in North America grow 9 species; the largest *Prosopis* species number is found in South America where 31 grow naturally. In Africa and Asia are 4 species (Lopez *et al.* 2005). The name *Prosopis* comes from the ancient Greek word "Prosopis", which means "bark used for tanning sheep skins" (Rodríguez and Maldonado, 1996). In Mexico this particular type of tree is known as "mezquite" which is a modification from the native language Náhuatl "mizquitl" that also means "bark for tanning" (Pennington and Sarukhan, 1968; Rodríguez and Maldonado, 1996).

Prosopis vegetation covers almost 3 million hectares from sea level to 2,200 m, corresponding to 1.51% of Mexico's area (Palacio-Prieto *et al.* 2000). As was mentioned early, 9 *Prosopis* species grow naturally in North America forming the complex named North American or "Mexico-Texano": The species *P. laevigata* is especially prominent in some locations of Guerrero, Queretaro, Estado de Mexico, Michoacan, Morelos, Oaxaca, Puebla, San Luis Potosi, Veracruz, Nuevo Leon, Aguascalientes, Durango, Guanajuato, Hidalgo, Jalisco and Zacatecas, Mexico (INE, 1994).

Although various factors, such as cattle management, excess harvesting and agriculture, have reduced tree numbers, the *Prosopis* species still play a very important role in the economy and the environment. The wood has been used for agricultural tool handles, the hubs for car wheels, poles for mining, in house construction, fence, door and window frames, furniture, parquet flooring, fire wood, and charcoal. Without doubt, these last two products are the ones most often utilized. This results from the fact that these trees have a slow growth pattern, thus producing lumber of small dimension (Felker, 1979; 1981).

The wide genetic adaptations have allowed a widespread distribution of this species (Peacock and McMillan, 1965; Rzedowski, 1988). Individual species exhibit different tree shapes, leaf sizes, bark thicknesses, and colours as a result of ecological conditions (Graham, 1960; Johnston, 1962; Galindo, 1983) and anthropogenic intervention.

It is known that environmental conditions during wood formation as climate, soil, aspect conditions, and management as well as the geographical distribution may affect wood anatomy and physical properties (Hapla and Saborowski, 1984).

The physical and mechanical properties of *Prosopis* species have already been described by a number of researches (Tortorelli, 1956; Berni *et al*. 1979; Universidad Nacional del Nordeste, 1979; Ffolliott and Thames, 1983; Galindo and García, 1986; Perpiñal and Pietrarelli, 1995; Tewari *et al.* 2000; CEN/TS 15083-1, 2004). However, investigations relating some environmental conditions as rainfall, soli type and geographical distribution on *P. laevigata* wood properties from natural areas have not been addressed. The aim of this study is to provide to foresters, wood industrialist and general people interested in wood quality of this species the physical and mechanical wood properties which are related to environmental conditions.

Materials and Methods

The State of Nuevo Leon is located in the Northeast Mexico covering 64,220 km² (INEGI, 2010). The vegetation found in this area has been characterized by eight major vegetation types: Central plateau desert scrub, Eastern coastal plain scrub, Piedmont scrub, Montane low forest, Montane mesic forest, Western montane chaparral, Subalpine humid forest and Alpine meadow and timberline (Muller, 1939). The landforms are characterized as plains and gentle slopes. The soils formed on plains and lower slopes are deep, silty clay vertisols with smectite according to the soil moisture content, they can shrink and swell noticeably. The soil structure has been described as prismatic. On gentle hills and upper slopes, outcrops of Upper Cretaceous mudstone or shale occur, often overlain by silty-clay loams (Reid *et al*. 1990). Potassium, calcium, and magnesium are found notably on soils as result of their low hydraulic conductivity (Woerner, 1991).

There are a strong climatic gradient in the region due to the orographic effect of the mountains and the gradual increase in elevation from east to west. Of the total annual precipitation, 80% falls between May and October. In general, the climate has been classified as subtropical semi-arid, with hot summer and severe frosts occur during the winter season.

Study area

To determine the relationship between some physical and mechanical properties of *Prosopis laevigata s*pecies to environmental conditions, this research was carried out on four different sites along the natural distribution of *Prosopis* were *P. laevigata* species is logged by the land owners according to the management program in order to produce fuelwood, choarcoal and timber. Site characteristics and geographical map distribution is shown in Table 1 and Fig. 1, respectively.

Table 1. Site characteristics of four research sites, northeast Mexico

	Site			
Description Locality	China Rancho Saltilleros	General Teran Rancho San Lorenzo	Linares Ejido La Reforma	Dr. Arroyo Ejido Sta. Gertrudis
Latitude	25°24’23"	25°20’18"	24°42’05"	23°54’48"
Longitude	99°10’22"’	99°31’00’’	99°32’05’’	100°10’14’’
Mean annual temperature (°C)	22 – 24	22 - 24	20 – 22	16 – 20
Mean annual precipitation (mm)	512	631	759	300 – 600

(INEGI, 2000).

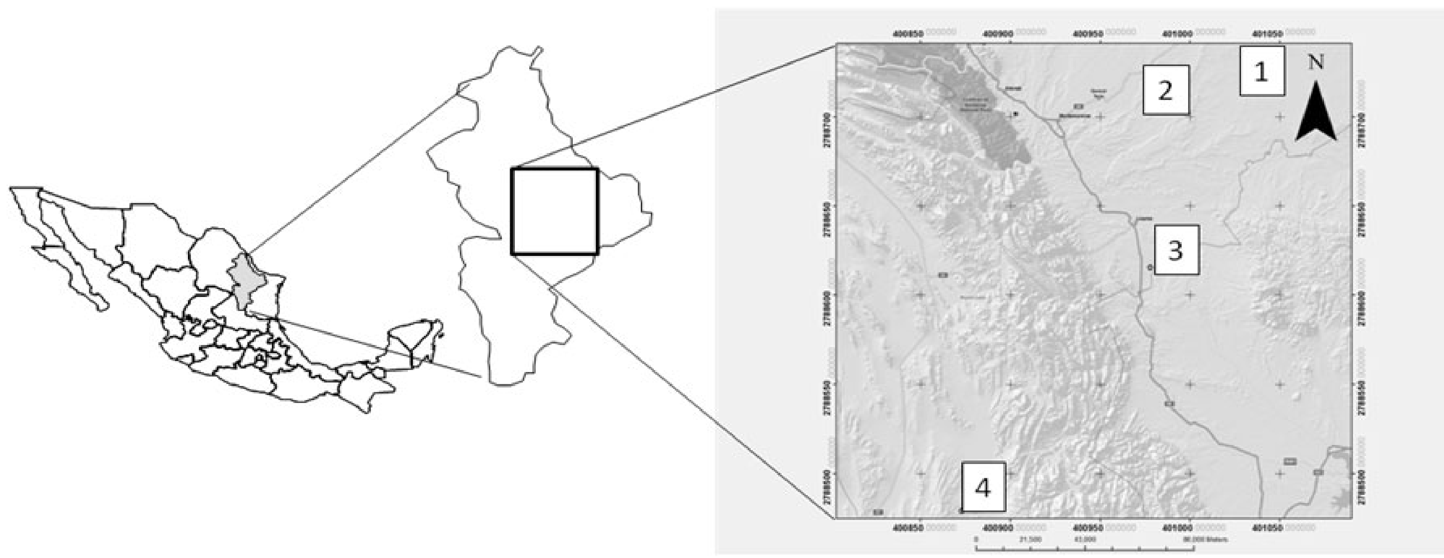

Fig. 1. Research sites were trees were logged to determine the physical and mechanical properties of *P. laevigata*, northeast Mexico

Wood sampling design

Twelve *P. laevigata* trees free of branches and deformations to a height of 3 m were randomly selected from four different harvesting areas. Diameter at breast height (DBH), total height and diameter of crown were measured from each tree; the values are shown on Table 2. The wood samples were obtained along the bole in a zone from 0.3 m to 2.4 m above the base according to Ramos-Alvarez and Diaz-Gomez, (1981). As shown on Fig. 2, the section A was used to prepare samples for mechanical tests and sections B to physical tests. After sawing, all samples were dimensioned according to the different standards; specimens were conditioned at 20°C and 65% relative humidity (RH) before and during the tests. Measured variables were: wood density, swelling and shrinkage, dynamic and static modulus of elasticity and modulus of rupture. The tests performed, standards applied, the number, as well as the specimen dimensions are shown on Table 3. The equations used to determine the wood properties of *P. laevigata* are described on Table 4.

Table 2: Diameter at breast height, total height and diameter of crown in each tree.

No tree	Locality	DBH (cm)	Height (m)	Crown Diameter (m)
1	China	35	6	8.5
2	China	41	6.2	9.5
3	China	32	5	6.30
mean ± std.	36 ± 4.5	5.7 ± 0.6	9 ± 0.7	
4	General Terán	36	8	9.5
5	General Terán	36	8	5
6	General Terán	45	9.5	7.1
mean ± std.	39 ± 5.1	8.5 ± 0.8	7.2 ± 2.2	
7	Linares	40	6.4	10.85
8	Linares	67	8.5	18.25
9	Linares	55	7.6	13.5
mean ± std.	54 ± 13.5	7.5 ± 1.0	14.2 ± 3.7	
10	Dr. Arroyo	56	6.8	9.25
11	Dr. Arroyo	43	6.1	7.85
12	Dr. Arroyo	46	6.8	8.5
mean ± std.		48.3 ± 6.8	6.5 ± 0.4	8.5 ± 0.7

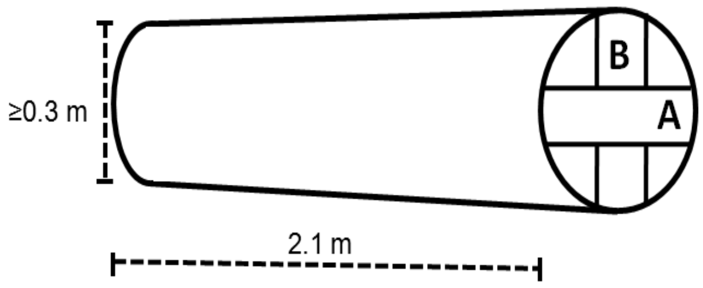

Fig. 2. Geometry of *P. laevigata* log used to obtain wood samples for physical and mechanical properties. Secction A was used to obtain samples for mechanical properties and secction B for physical properties.

Physical properties

Wood density

The value of density depends on many endogenous and exogenous factors including rate of growth as well as cellulose and lignin content. Thus, there is a strong correlation between density and the mechanical properties (Kollmann and Cote, 1968; Forest Products Laboratory, 1999). The density of *P. laevigata* wood was determined using 120 specimens from four different local areas (30 replicates per local area) under two evaluated conditions: Condition 1:"oven-dry": the samples were dryed in a oven for 24 h at 103± 3°C until constant weight. Condition 2: "12% moisture content": in this condition the samples were acconditioned on a climatic chamber at 20±1°C and 65±3% relative humidity (RH) until constant weight.

Swelling and shrinkage

The wood is an hygroscopic material that swell and shrink to a lesser or greater extent depending on in humidity and temperature of the surrounding air. The swelling of *P. laevigata* was determined from 120 specimens (30 replicates per local area, recording the dimension change in percent of a certain anatomical direction of wood from the oven-dry condition to a predetermined moisture condition (20±1°C, 95% RH). Simmilary, the shrinkage was calculated in 80 specimens (20 replicates per local area) according to the change in percent of a certain wood-anatomical direction from a determined moisture condition (20±1°C,

Table 3. Physical and mechanical standards performed, overall number of specimens and specimen dimensions used to determine the physical and mechanical properties of *P. laevigata*.

Test type	Number of samples	Sample dimension[1](mm)	Standard
Density (g cm^{-3})	120	20 X 20 X 20	DIN 52 182, (1977)
Swelling (%)	120	10 X 20 X 20	DIN 52 184, (1979)
Shrinkage (%)	80	10 X 20 X 20	DIN 52 184, (1979)
Static modulus of elasticity (N mm^{-2})	120	100 X 5 X 10	DIN 52 186, (1978)
Dynamic modulus of elasticity (N mm^{-2})	120	100 X 5 X 10	*
Modulus of rupture (N mm^{-2})	120	100 X 5 X 10	DIN 52 186, (1978)

[1]longitudinal x radial x tangential; *According to Machek *et al.* (1998a, b)

Table 4. Equations used to determine the density, swelling and shrinkage, dynamic and static modulus of elasticity, and modulus of rupture of *P. laevigata* wood samples.

TestEquation	Equation	Description	
Densityr = $\rho_N = \dfrac{m_N}{v_N}$		ρ_N =	density under climate condition (g cm^{-3})
		m_N=	mass under climate condition (g)
		v_N =	volume under climate condition (cm^3)
Swelling $\alpha = \dfrac{l_w - l_o}{l_o}\ 100$		α =	maximum swelling (%)
		l_w=	dimension at saturation point
		l_0=	dimension under oven-dry condition
Shrinkage		=	maximum shrinkage in %
		l_w =	dimension under saturation point
		l_0 =	dimension under oven-dry condition
Dynamic modulus of elasticity		MOE_{dyn}=	dynamic modulus of elasticity (N mm^{-2})
		I =	moment of Inertia (mm^4)
		A =	cross section area (mm^2)
		f =	frequency (kHz)
		ρ =	mass density (g mm^{-3})
		l =	length (mm)
		K_1 =	49.48
		m_l=	4.72
Static modulus of elasticity		MOE_{stat}=	static modulus of elasticity (N mm^{-2})
		ÄF =	load (N)
		l =	span length of the specimen (mm)
		Äf=	deflection (mm)
		b =	width of the specimen (mm)
		h =	thickness of the specimen (mm)
Modulus of rupture		MOR =	modulus of rupture (N mm^{-2})
		F =	load (N)
		l =	span length (mm)
		b =	width of the specimen (mm)
		h =	thickness of the specimen (mm)

95% RH) to oven dry condition. The wood swelling, shrinkage and the ratio between tangential/radial (t/r) directions were determined for the tangential and radial directions.

Mechanical Properties

The mechanical properties of *P. laevigata* wood were tested on wood specimens free from defects under controlled climatic conditions (65±3% RH and 20±1°C, DIN 52 180). The tests were focused on the static and dynamic modulus of elasticity and modulus of rupture. The results were evaluated to determine differences between local areas. Results from the different mechanical test are given on result secction.

Modulus of elasticity (MOE)

The elasticity properties, as well as the density, are fundamental to determine wood quality (Ilic, 2003). The Modulus of elasticity of *P. laevigata* was obtained by applying both the dynamic MOE (MOE_{dyn}) and the static MOE (MOE_{stat}) on bending strength tests. The correlation between the MOE_{dyn} and MOE_{stat} was also measured.

The MOE_{dyn} is quick and easy to perform and does not require installed equipment to determine elasticity (Hearmon, 1966; Machek *et al.* 1998b) and is used to determine the mechanical properties of the wood without destroying the samples (Ying *et al.* 1994; Bucur, 2006). It is possible to test the same wood specimens more than once. Moreover, tests can be carried out to establish whether differences occur over time or whether treatments have any effect. The strong relationship between static and dynamic MOE shows, in most cases, a coefficient of correlation greater than 95% (Pellerin, 1964; Görlacher, 1984; Machek *et al.* 1998b; Ilic, 2003; Grinda and Göller, 2005).

The MOE_{dyn} of *P. laevigata* was determined at the fiber saturation point on 120 specimens (30 replicates per local area) with resonant frequencies. Two flexible sponges located at a distance of 2.24 cm from each end supported the specimens; the vibrations were produced by hitting the mid-point on the upper surface of the specimens with a hammer (Machek *et al.* 1997; Machek *et al.* 1998a; Machek *et al.* 1998b; 2001).

The MOE_{stat} is the physical property which describes the deformation caused by a low level stress from which recovery can be complete once the stress is suspended (Kollmann and Cote, 1968). The wood specimen is supported at both ends by rollers and the resistance is measured as a slow load is applied at the centre of the specimen.

Modulus of rupture (MOR)

MOR is defined as the maximum load capacity of a member; it is proportional to the maximum moment borne by the specimen (Kollmann and Cote, 1968). This modulus was computed for 120 specimens.

Statistical Analysis

The results obtained from the physical and mechanical tests of each condition were separately subjected to a variance analysis (ANOVA); the mean of each property from each location was then compared to the corresponding analyses of other origins by applying the Tukey test in order to determine statistical differences between the locations. The coefficient of correlation (r) between MOE_{stat}-MOE_{dyn} was also determined.

Results and discussion

Physical Properties

Density

The oven dried and conditioned densities of *P. laevigata* were ranging from 0.72 to 0.84 g cm^{-3} and 0.79 to 0.91 g cm^{-3} respectively. Fig. 3 shows the average values from the four different localities. Density values of *P. laevigata* found in this research are similar to other *Prosopis* species as *P. alba* from Argentina that is ranging from 0.75 to 0.85 g cm^{-3}, but higher than other Argentineans species as *P. canldenia* that is 0.65 to 0.75 g cm^{-3} and lower than *P. chilensis* (0.80-0.92 g cm^{-3}) and *P. kuntzei* (1.2-1.35 g cm^{-3}) Berni *et al.* (1979) in Alden, (1995). The data is relatively high if comparing the wood density of *P. laevigata* to three well-known and commercially important European species as *Fagus sylvatica, Quercus robur* and *Fraxinus excelsior* which values are 0.72 g cm^{-3}, 0.69 g cm^{-3} and 0.69 g cm^{-3} respectively (Wagenführ, 1996).

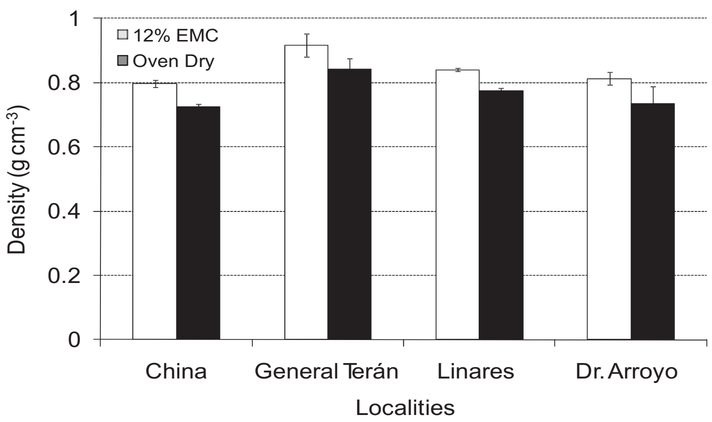

Fig. 3. Wood density of *P. laevigata* wood determined on two conditions: Oven-dry and 12% MC, northeast Mexico.

The high density in all of the areas tested might be a result of the wood structure which is characterised by thick fiber cell walls.

Wood structure and properties characteristics are consequence by genetic, environment and anthropogenic factors influencing during cell and tissue formation (Wodzicki 2001). External factors affecting the changing density values of *P. laevigata* are latitude, temperature, precipitation and growing behaviour interactions. Changing specific densities as North latitude distribution were also determined by Wiemann and Williamson (1989) in tropical dry and montane rain-forest trees. According to Figure 1 and latitude data on Table 1, locality China (the Northeast locality) and Genaral Terán are geographically close, but General Terán presented higher density. Average temperature is the same in both localities, but precipitation is higher on General Terán. Differential wood formation is influenced by environmental conditions. In ring porous tree species, "better" environmental conditions (more precipitation rates) produce more proportion of latewood having smaller vessels diameters (more wood cm^{-2}) than earlywood which has bigger vessel diameter (more porous cm^{-2}), consequently latewood is denser than earlywood (Record 2004). According to Carrillo *et al.* (2009) *P. laevigata* is a semi-ring-porous and diffuse-porous tree; differences of precipitations between both localities (119°C) might produce differences on densities by producing more amount of latewood on sites with more precipitation. On the other hand Linares is geographically located in the middle between China, General Terán localities on North direction and Dr. Arroyo on South direction, its density is higher than Dr. Arroyo because of higher temperatures values and precipitation (20-22 °C and 759 mm respectively). Finally Dr. Arroyo is southeaster than other three localities but its density is higher than China even it has the lowest temperature values. High density presented by China might result of its average precipitation values that can reach 600 mm.

ANOVA tests were performed in order to find statistical differences in density between localities. Results are shown on Tables 5 and 6, the densities on four localities and both conditions (oven dry and 12% EMC) were statistically different (P <0.0001).

Table 5. Analysis of variance for density of *P. laevigata* wood determined at oven dry condition at four locations, northeast Mexico

	Statistic				
Source of variation	DF	Sum of squares	Mean square	F Value	Pr > F
Location	3	0.2541	0.084	78.37	0.0001
Error	116	0.1254	0.0010		
Corrected total	119	0.3796			

As is shown on Table 5, density under oven dry conditions differ between areas, similar results were found on several researches with Eucalyptus in South Africa and Brazil (Lima *et al*. 2000; Malan and Verryn 1996), on both research were significant statistical differences on wood density between sites.

Table 6. Analysis of variance for density of *P. laevigata* wood determined at 12% M.C. at four locations, northeast Mexico.

Source of variation	Statistic				
	DF	Sum of squares	Mean Square	F Value	Pr > F
Location	3	0.2546	0.0848	84.45	0.0001
Error	116	0.0533	0.0004		
Corrected total	119	0.3080			

It was observed that density (12% M.C.) differed significantly between localities. The locality China and Dr. Arroyo are statistically different with respect to the other two (12% EMC).

Swelling and shrinkage

Swelling in the tangential and radial direction were ranging from 2.3% to 3.6% (average = 2.8%), and 1.6 to 1.8% (average =1.8%) respectively (Fig. 4). Shrinkage values in the tangential direction were from 2.2% to 3.3 (average = 2.7%) and 1.6% to 1.9 (average 1.8%) (Fig. 5). The values found on this study were lower than those reported for *P. glandulosa* which had shrinkage values of 2.7% and 4.8% in the radial and tangential directions (Pasiecznik *et al.* 2001) or *P. juliflora*, from Pune, India (2.3% and 4.0%, respectively) while lower shrinkage values were found in *P. juliflora* samples from the driest site (Sekhar and Rawat, 1960). According to Carrillo *et al.* (2008), extractive content on *P. laevigata* ranging from 14.1% to 16.0% of dry mass could explain the high dimensional stability. As has been explained in a number of studies showing that extractives occupy spaces normally used by water and their presence can affect bulk water absorption and desorption (Tortorelli, 1956; Stamm, 1964; Mantanis *et al.* 1994).

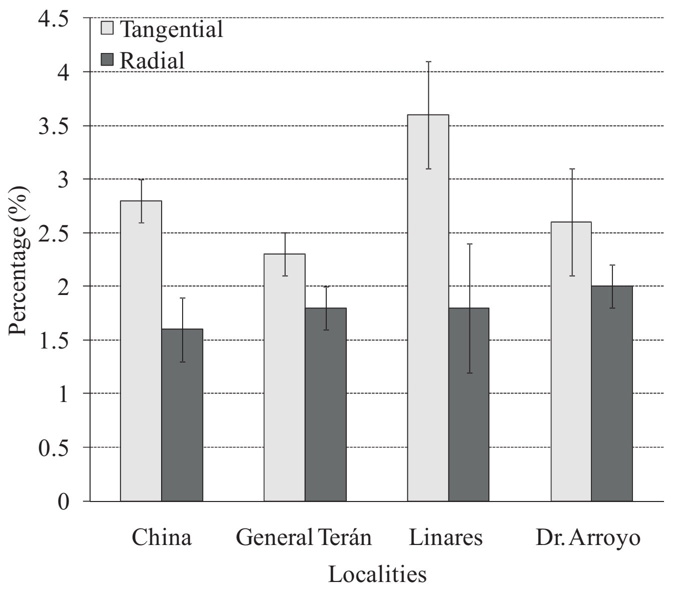

Fig. 4. Swelling values on tangential and radial direction of *P. laevigata* wood determined at four locations, northeast Mexico.

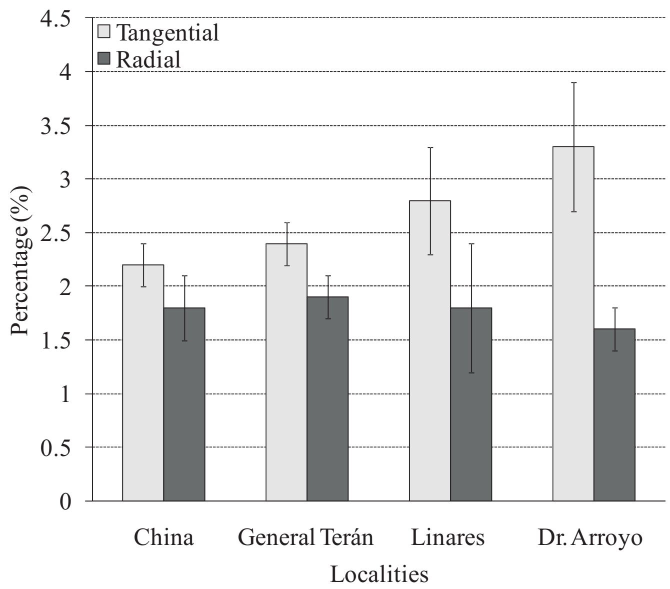

Fig. 5. Shrinkage values on tangential and radial direction of *P. laevigata* wood determined at four locations, northeast Mexico.

ANOVA tests were performed in order to find statistical differences in swelling and shrinkage between localities. Results are shown on Tables 7 and 8.

Table 7. Analysis of variance for radial swelling of *P. laevigata* wood at four locations, northeast Mexico

Source of variation	Statistic				
	DF	Sum of squares	Mean Square	F Value	Pr > F
Location	3	1.3204	0.4401	2.59	0.0593
Error	76	12.9361	0.1702		
Corrected total	79	14.2565			

ANOVA test (Table 7) showed that radial swelling of *P. laevigata* wood did not differed among sites (P d”0.05), this is because radial swelling is less than tangential.

Table 8. Analysis of variance for tangential swelling of *P. laevigata* wood at four locations, northeast Mexico.

Source of variation	Statistic				
	DF	Sum of squares	Mean Square	F Value	Pr > F
Location	3	17.1171	5.7057	31.41	<.0001
Error	76	13.8077	0.1816		
Corrected total	79	30.9248			

ANOVA tests (Table 8) showed that tangential swelling of *P. laevigata* wood did differ significantly between sites (P<0.001). This is because tangential swelling is bigger than radial.

Mechanical properties

The static MOE from different localities are represented on Fig. 6, as density, the values were low in the Northeast locality, increases to the two following localities and reducing at Dr. Arroyo, the Southest locality. Comparing to another *Prosopis* species, the average value (8504 N mm^{-2}), was relatively low compared to *P. juliflora* (12411 Nmm^{-2}). However average MOR values (114 N mm^{-2}) was higher than the same species (73 Nmm^{-2}). MOE was also low if comparing to other commercially utilized timber species as *Fagus sylvatica, Quercus robur* and *Fraxinus excelsior* which MOE values are 16000, 11700 and 13400 respectively (Wagenführ 1996). The low values showed early on MOE and MOR, could be resulting to the growing behaviour of *P. laevigata* with cross and spiral grain, that having a marked effect on bending strength (Carrillo 2007). In another hand, dynamic MOE was found to be a reasonable prediction of strength properties of *P. laevigata* wood. MOE_{stat} and MOE_{dyn} were highly correlated (r= 0.87) as is show on Fig. 8. The coefficient of correlation (r= 0.81) between MOE_{dyn} and MOR. Those results were consistent with report for other species (Pellerin, 1964, Larsson *et al.* 1988 and Ilic 2001, 2003).

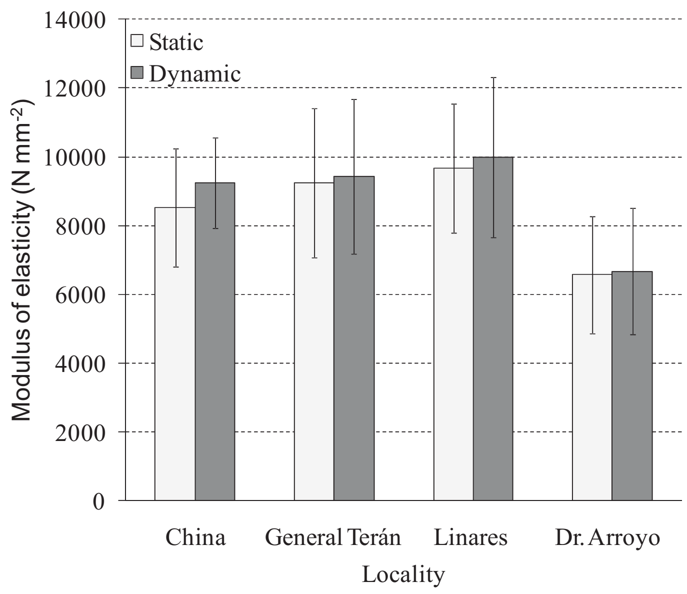

Fig. 6. Static and Dynamic Modulus of elasticity of *P. laevigata* wood determined at four locations, northeast Mexico.

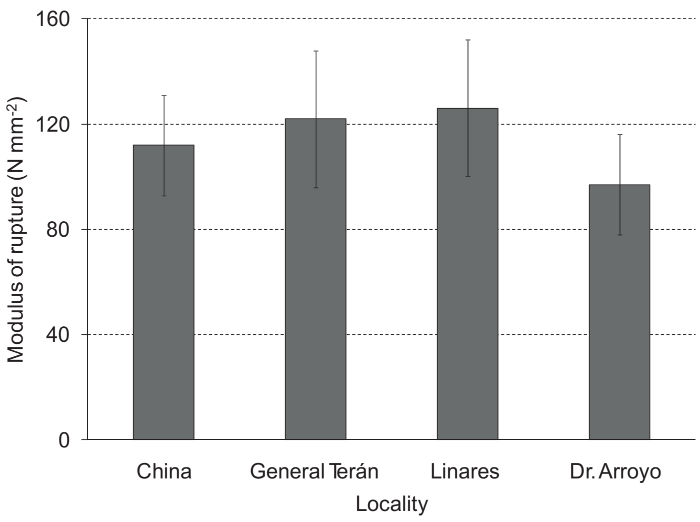

Fig. 7. Modulus of rupture of *P. laevigata* wood at four locations, northeast Mexico.

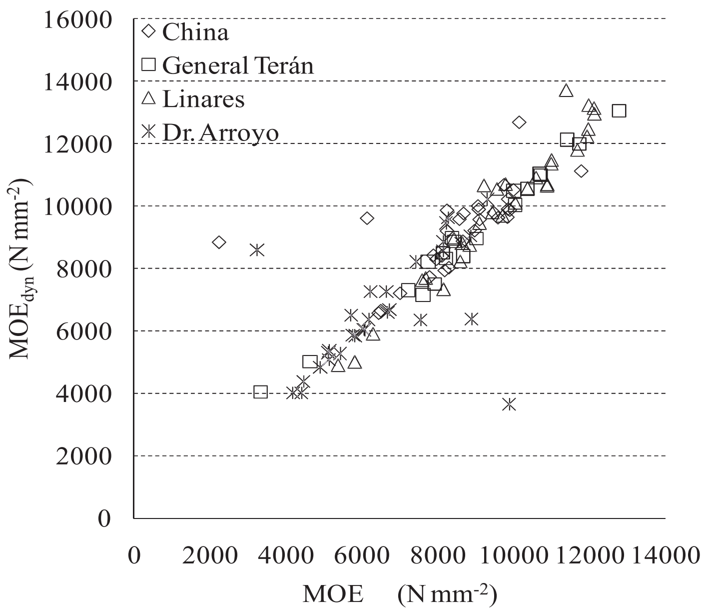

Fig. 8. Relationship between static modulus of elasticity and dynamic modulus of elasticity of *P. laevigata* wood, northeast Mexico.

According to ANOVA test results shown on Table 9. There were statistical differences (P<0.001) between sites when comparing the values of modulus of elasticity in statics test.

Table 9. Analysis of variance for static modulus of elasticity

	Statistic				
Source of variation	DF	Sum of squares	Mean Square	F Value	Pr > F
Location	3	168132917	56044305.7	15.91	<.0001
Error	116	408639627.2	3522756		
Corrected total	119	576772544			

Table 8 present the result of ANOVA for modulus of elasticity in dynamic test, according to this table there were differences between localities.

Table 10. Analysis of variance for dynamic modulus of elasticity on four different localities.

	Statistic				
Source of variation	DF	Sum of squares	Mean Square	F Value	Pr > F
Location	3	195008057.6	65002685.9	16.7	<.0001
Error	116	450810424	3886296		
Corrected total	119	645818481			

Table 11 present ANOVA of modulus of rupture between four different localities, according to this table, there were statistical differences between localities.

Table 11. Analysis of variance for modulus of rupture on four different localities

	Statistic				
Source of variation	DF	Sum of squares	Mean Square	F Value	Pr > F
Location	3	14874	4958	9.3	<.0001
Error	116	61831	533		
Corrected total	119	76706			

Conclusions

Environmental factors present on the different localities as temperature, precipitation and geographical distribution affect some physical and mechanical wood properties of *P. laevigata*. There are statistical different on wood density, both static and dynamic modulus of elasticity and modulus of rupture between localities. Selection for optimal sites where *P. laevigata* had better growth behaviour may help to the foresters on increasing the wood quality.

Differential environmental characteristics influence the wood formation in *P. laevigata* which is a semi-ring-porous and diffuse-porous tree. High precipitation rates and high temperature values on a semi-arid land produce more proportion of latewood than earlywood resulting on high density. The same interactions of latitude, temperature and precipitation are influencing the different growing pattern producing differences on physical and mechanical properties of wood coming from different sites. The physical and mechanical properties showed a very high correspondence to density values. More investigations on all natural distribution of P. *laevigata* are necessary to identify a clear concordance between localities and wood properties.

Finally, *Prosopis laevigata* wood has potential for uses where high compression strength in parallel direction is required, such as railway sleepers and semi-structural uses as decking, parquet flooring and joinery.

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