

# Differences of Wood Elements of *Prosopis laevigata* from Two Areas of Northeast Mexico

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## ABSTRACT

Anatomical features of wood have a great variation among species as a result of genetic and environmental factors. The anatomical heartwood characteristics of *Prosopis laevigata* species from two areas with differences on temperature and rain precipitation on northeast Mexico were compared. Fibers length ( $\mu\text{m}$ ), diameter of vessels ( $\mu\text{m}$ ), and the area of the vessels ( $\mu\text{m}^2$ ) were measured using light microscopy coupled with a digitized-image analysis system. The differences were statistically analyzed with analysis of variance. Statistical differences between fibers length ( $p < 0.0001$ ) and diameter of the vessels ( $p < 0.001$ ) from the two localities were found. The locality Linares, Nuevo León, Mexico, with higher precipitation and lower temperature, showed higher fiber length and higher diameter of the vessels than China, Nuevo León. Hard environmental conditions, where low precipitation values and high temperatures prevail, condition *P. laevigata* trees do reduce the risk of losing water.

**Keywords:** Wood Anatomy; *Prosopis laevigata*; Vessels; Fiber

## 1. Introduction

Physical, chemical, mechanical, and anatomical features of wood have a great variation among species, trees, and even between samples from the same tree as result of genetic and environmental factors such as temperature, light intensity, wind, frost, photoperiod, soil fertility, and water availability [1,2]. Studies on the relationship between environmental conditions to wood characteristics are mainly focused on wood density, pore distribution, vessel diameter, vessel lumen, and pits [3-5]. Light-demanding species grow faster than shade-tolerant species producing low-density wood. A fast development of stem produced thinner cell wall and wider lumen that slow growing species. Ring-porous species tolerate lower degrees of drought stress than diffuse-porous species [6].

The vessels characteristics as the number of vessels, diameter, length, density, distribution and thickness are affected by some climatic factors such as temperature, water availability as well as latitude, altitude, and differ-

ences in habitats [7-9]. Vessels also show forming groups in dry environment conditions. On the other hand, in humid environments they are only solitary and rarely grouped [10].

Few reports showing the relation between cell length and climate have been developed. Reference [11] did not find relationship between climatic conditions and tracheid length. According to [12] temperature plays the major role in regulating cambial activity and phenologic events in most plants, while the availability of water in dry conditions is the limiting factor.

The study of *Prosopis* wood anatomy and its relationship with environmental conditions is a good opportunity to increase the knowledge on effect of weather condition to wood because it comprises about 44 species of trees and shrubs grown naturally in arid and semi-arid zones of the world [13-16]. Wood anatomical characteristics of *Prosopis* species have been described by [16-23] and some differences in pore distribution, fiber length, vessel diameter, and lumber area have been found because of multiple environmental conditions where the species

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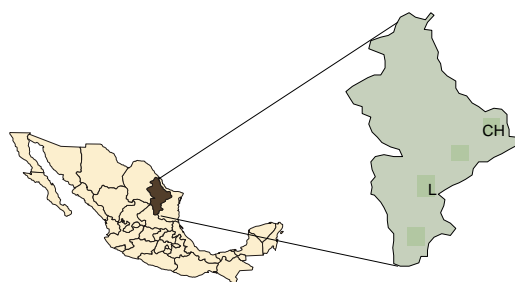
grow. The main objective of the present study is to determine the anatomical characteristics of wood from *P. laevigata* that grow in two different environmental conditions in Northeast Mexico.

## 2. Materials and Methods

### 2.1. Description of the Study Area

The study was developed in Northeast Mexico, the climate is classified as semi-dry to moderate warm, the average annual temperature from the whole area ranges from 14.7°C to 22.0°C, the average annual precipitation is from 400 to 812 mm and potential evapotranspiration is estimated on 1150 mm, the rain season is in the summer, but it is interrupted by a dry period [24,25]. The native vegetation is classified as *Tamaulipan thornscrub* [26]. The origin of rocky type soils are Upper Cretaceous, rich in calcite and dolomite, the dominant soils are deep, dark grey, lime-clay vertisol results from alluvial and colluvial processes, high clay and calcium carbonate content, a pH from 7.0 to 8.0, and low organic matter content.

**Figure 1** shows the two study areas selected. The selection was done according to areas with higher differential in rain precipitation and temperature in the Northeast distribution of *P. laevigata* species. **Table 1** shows the climatic conditions of Rancho Saltilleros municipality of China and La Reforma municipality of Linares, both in Nuevo León, Mexico.



**Figure 1.** Localization of sampling areas of *P. laevigata* wood in northeast Mexico. CH, local area Rancho Saltilleros municipality of China. L, local area Ejido la Reforma municipality of Linares.

**Table 1.** Climatic condition of the two localities selected in Northeast Mexico.

Municipality	Linares	China
Locality	Reforma	Saltilleros
Latitude	24°42'05"	25°24'23"
Longitude	99°32'10"	99°10'22"
Temperature (°C)	20 - 22	22 - 24
Precipitation (mm)	759	512

### 2.2. Sampling Trees for Anatomical Description

Three trees, free of knots, cracks, gum, visually damaged by insects with a diameter at breast height (DBH) from 0.3 to 0.4 m, were selected from natural forest stand in each locality. One disk of 0.1 m thick at the height of DBH was sawn from each tree. In order to use mature wood from each tree, the outer section of heartwood in each disk was used to prepare wooden samples of 2 × 2 × 2 cm for anatomical study.

The samples were softened during one hour in boiling water. Twenty μm thickness sections were obtained from cross, radial, and tangential directions. The length of the fiber was determined using wooden parts from the same heartwood section with toothpicks characteristics then, they were macerated with the solution of nitric acid and chromic acid diluted. They were placed for 10 minutes at 60°C. The measurements for anatomic structures were developed with a Nikon Eclipse E600 microscope equipped with the Dxm 1200 digital camera and computer Lucia (Lucia image version 4.82). The data generated by the program were exported to a Microsoft Excel spreadsheet.

The characterization of wood was carried out based on the list of the International Association of Wood Anatomists (IAWA), which determines the anatomical characteristics for the hardwood species. Average and standard deviation of the length of the fiber, diameter of the vessel (μm), vessel area (μm<sup>-2</sup>) as well as the number of vessels per square mm was calculated. Differences between wood anatomical characteristics were determined using analysis of variance regarding to locality (2) and sample tree (3).

## 3. Results and Discussions

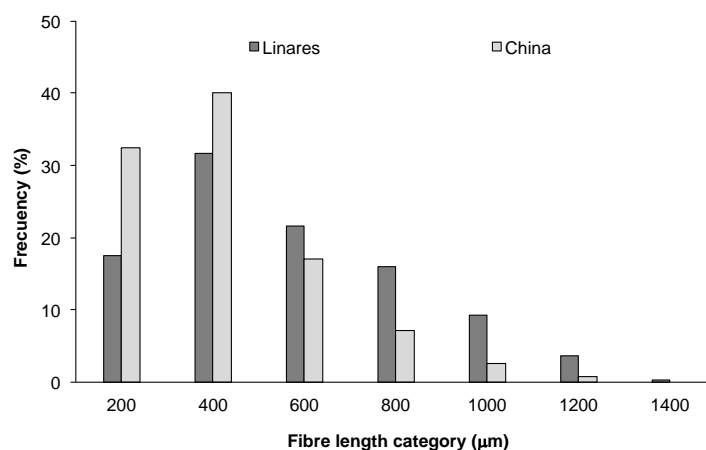
### 3.1. Length of the Fiber

The average length of *P. laevigata* fibers from both localities was 382 μm (1312 - 49 μm maximum, minimum). The average fiber length from Linares locality was 462 μm (1312 - 49 μm maximum, minimum); the length was higher than China's samples that showed an average of 232 μm (1144 - 52 μm maximum, minimum). According to **Table 2**, there were highly significant statistical differences ( $p < 0.0001$ ) on fiber length between localities, trees, as well as the interaction between localities and trees.

The fiber length of both localities was distributed in seven length classes from 200 to 1400 μm (**Figure 2**). China locality with low precipitation values and high temperature, presented high frequency values for the smallest length classes (200 and 400 μm). In contrast, Linares locality with high precipitation values and low temperature presented the highest frequencies values on the higher length classes (600 up to 1400 μm).

**Table 2.** Analysis of variance of fiber length, vessel diameter and number of vessel per square millimeter of *P. laevigata* wood from two localities of Northeast Mexico.

Source of variation	Fiber length			Vessel diameter			Vessel mm <sup>-2</sup>		
	MS	Value		MS	Value		MS	Value	
		F	p		F	p		F	p
Locality (L)	13,004,734	267.55	<0.0001	36,699	11.70	0.0007	14.0833	7.34	0.0352
Tree (T)	4,048,667	83.29	<0.0001	2630	0.84	0.4332	0.5770	0.30	0.7509
Interactions (L * T)	750,570	15.44	<0.0001	21,087	6.72	0.0014	0.5770	0.30	0.7509
Error	48,608			3136			1.9192		

**Figure 2.** Fiber length distribution of *P. laevigata* wood from two localities of Northeast Mexico.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

### 3.2. Vessels

*Prosopis laevigata* is semi-porous or diffuse-porous species; the vessels distribution does not present any characteristic pattern. Most of the vessels are mainly in groups of two, three and four vessels. The average vessels diameter of *P. laevigata* from both localities was 92 µm (420 - 8 µm maximum, minimum). Linares samples presented 103 µm (420 - 8 µm maximum, minimum); the value was higher than China vessels with an average of 81 µm (241 - 7 µm maximum, minimum). According to **Table 2**, there were significant statistical differences ( $p < 0.001$ ) on fiber length between localities, there were no statistical differences between trees ( $p > 0.1$ ). Interactions between localities \* trees showed statistical differences ( $p < 0.01$ ).

Vessel, diameter of *P. laevigata* from both localities was distributed in 14 length classes from 20 to 300 µm

(**Figure 3**). Vessels are adaptive elements developed to enhance water transport especially in species that grow on water stress. China locality with low precipitation values and high temperature presented 81% of the vessels in the smallestest length classes (20, 40 and 60 µm). Linares locality with high precipitation values and low temperature presented 77% of the vessels on higher length classes (40 up to 140 µm).

Vessel area for Linares was 11,435 µm<sup>-2</sup> and 7168 µm<sup>-2</sup> for China vessels, [27] found a positive correlation between the number and total area of vessels with the precipitation on *Prosopis flexuosa*. A positive influence of precipitation was also found for vessel density on *Quercus ilex* [28].

### 3.3. Number of Vessels

The The average number of vessels of *P. laevigata* from both localities was 9.3 vessels mm<sup>-2</sup> (12.4 - 7.2 vessels mm<sup>-2</sup>, maximum, minimum). The average number of vessels from Linares locality was 9.3 vessels mm<sup>-2</sup> (12.5 - 7.5 vessels mm<sup>-2</sup>, maximum, minimum); the number of vessels was higher than China's samples that showed an average of 8.0 vessels mm<sup>-2</sup> (10.2 - 6.8 vessels mm<sup>-2</sup> maximum, minimum).

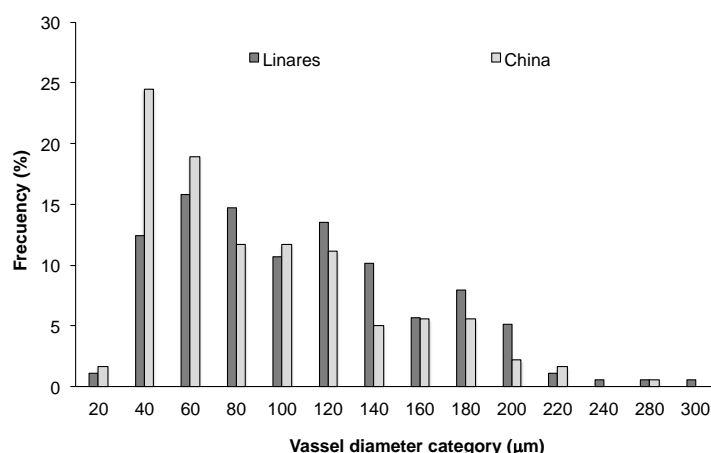


Figure 3. Vessel diameter classes of *P. laevigata* wood form two localities of Northeast Mexico.

#### 4. Conclusion

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