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WOOD CHEMICAL COMPONENTS OF THREE SPECIES FROM A MEDIUM DECIDUOUS FOREST

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ABSTRACT

Here, we determined the chemical composition of three plant species, *Prunus hintonii* (C. K. Allen) Kostern, *Pseudobombax ellipticum* (Kunth) Dugand, and *Thouinia villosa* DC. We assessed the pH, ash content, ash composition, extractives, holocellulose, and lignin contents. We determined the following ranges: pH 4.6 to 8.7, ash 0.61- to 6.2- % (calcium, potassium and magnesium in major concentrations), total extractives 5.6- to 13.2- %, holocellulose 50.0- to 68.9- %, and lignin 21.5- to 30.1- %. A variance analysis of the results indicated that the values for the chemical components were statistically different ($p < 0.01$) among species, except for the hot water extractives.

KEYWORDS: Wood chemical analysis, *Prunus hintonii, Pseudobombax ellipticum, Thouinia villosa*.

INTRODUCTION

Forests can be classified as high (trees over 30 m high), medium (trees 15 to 30 m high), or low (trees shorter than 15 m in height). According to leaf longevity, they are considered ever green forests (less than 25 % of the species lose their leaves), semi-deciduous forests (25 to 50 % of the species lose their leaves), or deciduous forests (more than 75 % of the species lose their leaves). In Mexico, medium deciduous forests cover 4193 km^2 of the country, which corresponds to 0.21 % of the total area of Mexico (CONABIO, 2014). In the municipality of Morelia, Michoacán, medium deciduous forests are found in the Balsas River basin, located southeast of the municipality. Specifically, these forests occupy moist ravines and canyons, some with abundant water flow during the rainy season. Although species richness in this area is low compared to other villages along the coast of Michoacán, 14 tree species have been registered, including *Prunus hintonii* (C.K.Allen) Kostern, of the *Rosaceae* family; *Pseudobombax ellipticum* (Kunth) Dugand, of the *Bombaceae* family; and *Thouinia villosa* DC, of the *Sapindaceae* family (Madrigal and Guridi 2002).

The *Prunus hintonii* species (known by the local names, "ucaz" or "aguacatillo") grows to be quite large, and its leaves are toxic to livestock. Its botanical characteristics, anatomical features (Allen 1945), pulp quality index (Vega et al. 2003) and wood uses (Madrigal and Guridi 2002, Vega et al. 2003) have been described in the literature. The *Pseudobombax ellipticum* species (local Spanish names: "escobetilla" or "amapola") is typically a small tree, occasionally growing to 30 -m in height, and its diameter can grow to 1.5 m; it has a straight trunk, horizontal or pendant branches, a broad canopy, and light brown sapwood. This species is described in the literature in terms of its botanical characteristics and distribution (Niembro 1990, Fernández et al. 1998, Carranza and Blanco 2000, Pennington and Sarukhán 2005), anatomic characteristics (Rodríguez 1999), acoustic characteristics (Sotomayor et al. 2010), machining properties (Martínez and Martínez 1996, Zavala and Vázquez 1999, 2002), pulp quality index (Vázquez et al. 2010) and wood uses (Madrigal and Guridi 2002, Niembro 1990; Carranza and Blanco 2000). In contrast, very few descriptions of *Thouinia villosa* species have been published; it is primarily only found in plant listings (Madrigal and Guridi 2002, Valiente et al. 1995, Salinas et al. 2013).

There is a dearth of literature on the three species mentioned above, particularly *Thouinia villosa*. No information regarding the chemical characteristics of these tropical wood species is available. Therefore, the objective of this study was to determine the wood chemical composition of *Prunus hintonii*, *Pseudobombax ellipticum* and *Thouinia villosa*, to provide consolidating knowledge of their chemical components.

MATERIAL AND METHODS

Woods

The woody materials of *Prunus hintonii, Pseudobombax ellipticum,* and *Thouinia villosa* were collected at a site called "Paso Tendido" in the locality of Tumbisca, municipality of Morelia, Michoacan. The geographic coordinates of the site are 19° 35' N and 101° 04' W at 1640 m above sea level. That region has a humid semi-warm climate with summer rains [(A)C(w1)(w)], and the estimated annual rainfall is 800 mm (Madrigal and Guridi 2002).

For this study, we obtained 30-cm thick wood samples cut at 1.30 m above the stump of the tree for each of the three species. Wood samples were cut into small fragments that measured 1x6x10 cm; finally, the fragments were chipped and dried outdoors. Wood chips were milled with a Wiley mill, and then, sieved with 40-fraction mesh (425 micron pores) for chemical analysis. Subsequently, moisture content was determined with the dehydration method at 105 ± 3°C, according to the Technical Association for Pulp and Paper Industry (TAPPI) standard procedure, T 264 cm-97 (TAPPI 2000). All determinations were performed in duplicate.

Chemical analysis

Determinations of pH were based on a method described by Sandermann and Rothkamm (1959). Mineral content was calculated gravimetrically in accordance with the TAPPI standard, T 211 om-93 (TAPPI 2000). Microanalysis of the ash was carried out with an X-ray spectrometer fitted to a Jeol-brand scanning electron microscope (Model JSM-6400). Operating conditions for the analysis were 20 kV and 8.5 s (Téllez et al. 2010). To determine the total content of extractives, sequential extractions were performed with Soxhlet equipment in the followings solvents: Cyclohexane, acetone, methanol, and finally, hot water under reflux (6 h in each case). Solvents were recovered in a rotary evaporator and the respective extract was stored in a dessicator until the weight was constant. After sequential extractions, wood meal designated extractive-free wood meal, was used to determine holocellulose and lignin. Holocellulose content was based on an American Society for Testing and Materials (ASTM) standard, D 1104-57 (2009) (ASTM 1981), where chlorine gas was replaced with sodium hypochlorite. Runkel lignin amount was determined according to the method described by Runkel and Wilke (1951).

Statistical analysis

The data were evaluated with an analysis of variance with one factor (species) with Statistica software, ver. 7.0 ($\alpha = 0.01$).

RESULTS AND DISCUSSION

Chemical analysis

The average measurements and standard deviations of the chemical components are presented in Tab. 1. The results from the X-ray microanalysis of ash are shown in Tab. 2. The pH values for the studied species were moderately acid to moderately alkaline; we found a significant difference between the pH of *Pseudobombax ellipticum* (8.7) and the pH values of the other two species (Tab. 1). The pH values were within the range for tropical species, except for *P. ellipticum*, which had a pH higher than 8.2, the maximum pH reported for *Terminalia superba* (Fengel and Wegener 1989).

Much of the variation in wood pH is due to climatic factors, to the amount and type of extractives, and to the presence of acid groups and free acid (Fengel and Wegener 1989). The moderately acid pH in the woods *Prunus hintonii* and *Thouinia villosa* could affect their use. For instance, pH might affect interactions between certain metals and these woods, and this might cause corrosion. It is known that the pH can also contribute to several problems in the following processes: Fixing for preservatives substances; adhesion during the curing process; manufacturing of particleboard and plastic products; and the pulping process (Fengel and Wegener 1989, Poblete et al. 1991, Poblete and Roffael 2004).

Tab. 1: Chemical composition of wood from trees in Mexican forests.

	Prunus hintonii	***Pseudobombax ellipticum***	***Thouinia villosa***
pH	5.2 (± 0.22) a	8.7 (± 0.41) b	4.6 (± 0.02) a
Ash1	0.6 (± 0.00) a	6.2 (± 0.00) c	1.1 (± 0.13) b
Extractives1			
Cyclohexan	0.7 (± 0.06) b	0.5 (± 0.09) b	0.3 (± 0.04) a
Aceton	4.1 (± 0.11) a	1.6 (± 0.25) b	4.2 (± 0.17) a
Methanol	7.1 (± 0.56) b	2.6 (± 0.38) a	2.1 (± 0.04) a
Hot water	1.4 (± 0.43) a	1.0 (± 0.32) a	1.2 (± 0.05) a
Total solubility	13.2 (± 0.93) b	5.6 (± 0.28) a	7.8 (± 0.30) a
Holocellulose[2]	50.0 (± 1.17) a	68.9 (± 1.04) b	52.9 (± 3.73) a
Runkel lignin[2]	21.5 (± 0.16) b	29.0 (± 1.80) a	30.1 (± 0.16) a

Values are percentages, except for pH; all values in parentheses are standard deviations.

Values followed by different lower-case letters are significantly different ($p \leq 0.01$).

[1]Porcentage based on moisture-free wood meal.

[2]Porcentage based on moisture- free and extractive-free wood meal.

A high ash content was found in *Pseudobombax ellipticum* (6.2 %), compared to *Thouinia villosa* (1.1 %) and *Prunus hintonii* (0.6 %) ($P<0.01$). These results were in the range reported for other tropical wood species (0.11 to 6.50- %) (Torelli and Čufar 1995). The X-ray microanalysis of ash (Tab. 2) showed that the major inorganic compounds in ash were calcium, potassium and magnesium. These chemical elements are typical in woods (Fengel and Wegener 1989).

Pseudobombax ellipticum ash had high levels, particularly of calcium and magnesium. This may be related to the presence of rhombohedral crystals, which were observed in the cells of the wood rays (Guridi 1968). Moreover, the presence of magnesium carbonate crystals might explain the alkalinity of this wood (Tab. 2).

Tab. 2: Inorganic elements in the woods of trees from Mexican forests (%).

	Prunus hintonii	***Pseudobombax ellipticum***	***Thouinia villosa***
Magnesium	14.7	30.7	7.8
Phosphorus	1.0	2.1	6.5
Potassium	26.7	16.9	19.6
Calcium	55.6	50.3	64.8
Sodium	1.2	nd	nd
Sulfur	0.7	nd	1.3

nd = not detected

During the extraction sequence, the least amounts of extractives were recovered in extractions with cyclohexane, followed by hot water. Significantly different extractives content were recovered with acetone in *Prunus hintonii* and *Thouinia villosa*, compared to *Pseudobombax ellipticum* (Tab. 1). Furthermore, *P. hintonii* yielded a significantly higher percentage of methanol extractives and total solubility compared to the other two woods. This could be due to the abundant presence of dark brown gums observed in the woody fibers and parenchyma cells of *P. hintonii* (Vega et al. 2003).

We observed a pattern of low solubility in non-polar solvents, higher solubility in medium polarity solvents, and low solubility again in the aqueous extraction (Tab. 1). This pattern was also observed in the successive extractions described in the heartwood of *Andira inermis* (Téllez et al. 2010) and in the heartwood of *Enterolobium cyclocarpum* (Ramos et al. 2011).

The holocellulose contents of *Prunus hintonii* and *Thouinia villosa* were significantly lower than that of *Pseudobombax ellipticum* (Tab. 1). The values determined in this study were in the range reported previously (49.2 - 82.0 %) for tropical wood species (Rowell 1984, Rutiaga et al. 2010).

Prunus hintonii had the lowest lignin content significantly lower than those of the other two woods (Tab. 1). However, the lignin contents obtained in these wood species were within the range reported previously (21.3 - 39.2 %) for other tropical wood species (Fengel and Wegener 1989).

CONCLUSIONS

The chemical composition of wood from the three species studied here are consistent with literature data for Mexican and foreign tropical woods. *Pseudobombax ellipticum* wood was found to have both the highest pH value and ash content. The main mineral substances found in the studied woods were calcium, potassium and magnesium. The highest total solubility was found in *Prunus hintonii* wood. Wood cell wall components comprised 50.0- to 68.9 % for holocellulose and 21.5 to 30.1 % lignin.

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