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Suitability of *Parkinsonia aculeata* (L.) Wood Grown as an Architectural Landscape tree in North Darfur State for Interior Design and Furniture

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Abstract: Wood samples of *Parkinsonia aculeata* (L.) were collected from Al bohaira Gardens of Al Fashir Town (the capital of North Darfur State, Western Sudan) where they were planted as architectural landscape trees and studied to determine their physical and mechanical properties as potential wood species for structural and furniture purposes. Moisture content, wood density (basic and oven-dry), as well as radial and tangential shrinkage were determined. The mechanical properties included static bending strength, compression strength parallel to the grain, the modulus of elasticity (MOE), the modulus of rupture (MOR) and the maximum crushing strength. The obtained results were compared with those of the well-known dominant small hardwood tree in the same area (*Boscia senegalensis*). The wood of *P. aculeata* has shown medium oven-dry density (534.0 kg m^{-3}) with reasonable bark-to-wood and shrinkage ratio. Due to the acceptable bending and compression strength results, *P. aculeata* wood can be considered as a suitable wood for interior design and decoration work as well as its suitability for indoor furniture.

Key words: *Parkinsonia aculeata* · Architectural Landscape · Basic Density · Staticbending · Compressive Strength

INTRODUCTION

Parkinsonia aculeata L. (Jerusalem – thorn) is a small tree or sometimes a shrub which can reach up to 10 meters high (Figure 1). It belongs to the family Fabaceae and subfamily Caesalpinioideae [1-5]. It is native to tropical and subtropical America in Southern USA and Northern South America [6, 7]. It occurs in nearly all semi-arid tropical countries. It can withstand drought and salinity. This multi-trunked deciduous tree has a green bark, pendulous branch-tips with bipinnate leaves, delicate leaflets and yellow blooms with pleasant fragrance. Those characters made it a popular small landscape tree especially in arid regions [8] where the free landscape design plans developed by professional landscape architects exclusively focuses on trees and shrubs. *P. aculeata* trees are used as street trees or road-side trees (Figure 2) and parking lots (Figure 3) so architects use it in their architectural landscape designs in hot arid regions. They use it as anchors for garden beds and as an architectural accent plant for the corner of the house or panted as a single specimen tree [9]. The tree is also used as windbreak and impenetrable hedges in gardens and parks [3]. The wood is yellowish white in color. It is used as low grade fuel wood. The tree provides fodder for sheep and goats. The leaves, seeds, flowers and bark are used in traditional medicine [10, 11]. Many pharmacological studies and investigations were carried out recently on the different parts of the tree as a medicinal plant [8, 12, 13].

The use of this wood species is restricted to fuel wood and charcoal. In order to make the best utilization and add value to the wood of this landscape tree, this study was carried out aiming at the investigation of the physical and mechanical, properties of this hardwood species and to provide information relating to wood properties which lead to its best utilization as structural and inter design or furniture wood.

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Fig. 1: *Parkinsonia* tree growing at North Darfur State

Fig. 2: *Parkinsonia* tree planted as road-side tree in AlFashir town, North Darfur State, Sudan

Fig. 3: *Parkinsonia* tree planted in Albohaira Park, AlFashir town, North Darfur State, Sudan

MATERIALS AND METHODS

The materials used in this study are wood specimens of *Parkinsonia aculeata* collected from Albohaira Gardens of Al Fashir Town (the capital of North Darfur State, Western Sudan) The trees were planted as architectural landscape trees at the boundaries of the park in the form of life hedge.

Methods: Five logs from five randomly selected trees were collected, debarked and crosscut. Wood samples were prepared and reduced into testing specimens according to the British standards B.S. 373, 1957 [14].

Moisture Content: Moisture content of wood was determined using a sensitive balance and an oven maintained at 105°C. The specimens were dried to constant weight. The moisture content was calculated as follows:

$$M.C\% = \frac{A-B}{B}\% \quad (1)$$

where: A = Air-dry weight of specimen, B = Oven-dry weight of specimen, M.C. = Moisture content.

Wood Density: Wood density was carried out using water displacement system. The basic density was determined as oven-dry weight / green volume, while the oven-dry density was determined as oven-dry weight / oven-dry volume. Both oven-dry density and basic density were calculated by the following equations:

$$Oven-dry\ Density = \frac{oven-dry\ weight}{oven-dry\ volume} kgm^{-3} \quad (2)$$

$$Basic\ Density = \frac{oven-dry\ weight}{oven-dry\ volume} kgm^{-3} \quad (3)$$

Bark-to-wood Ratio: Bark-to-wood ratio was determined as a proportion of the whole tree (including bark) both by volume and by mass. Wood discs (2.5 cm thick) were cut, weighed and dried to constant weight in an oven at 105°C. The bark and wood were weighed separately and from their masses the percentage of bark was calculated based on the oven-dry mass of the original test sample as follows:

$$Bark-to-wood\ ratio = \frac{mass\ of\ oven-dry\ bark}{mass\ of\ oven-dry\ wood} \quad (4)$$

Wood Shrinkage: Wood shrinkage was determined using wood specimens of 2cmx 2cmx 2cm Measured with a Vernier caliper. The specimens were left to dry in an oven until constant weight, then they were measured again and the difference in dimensions was calculated as shrinkage ratio as follows:

$$Shrinkage\ \% = \frac{change\ in\ dimension\ from\ swollen\ size}{swollen\ dimension} \times 100 \quad (5)$$

Bending Strength: Static bending tests were carried out using a universal testing machine Specimens of 2cmx 2cmx 30cm size were supported over a span of 28 cm on the roller bearings. The load was applied to the center of the beam at a speed of 0.01 mm / second. The modulus of elasticity and the modulus of rupture were recorded.

Compression Strength: Compression strength parallel to the grain tests were carried out using specimens of 2cmx 2cmx 6cm size. The tests were carried on a universal testing machine. The load was applied to the piston of the cage at a rate of 0.01mm per second. The maximum crushing strength (P max) was calculated by dividing the load to failure by the cross sectional area of the specimen as shown in the following equation:

$$Comp.sterngth = \frac{P\max}{A} Kpa\ m^{-2}$$

where: P_{max} is the maximum load at break point (kpa), A = the area of the cross section of the specimen.

RESULTS AND DISCUSSION

Physical and Morphological Properties: The mean values of physical properties for *P. aculeata* from North Darfur state are shown in Table 1. The values of moisture content for *P. aculeata* was nearly the same as that of *B. senegalensis* (5.95% and 5.25% respectively). This is because they were from the same dry origin where the surrounding atmosphere has low relative humidity.

Although the average oven-dry density and basic density for *P. aculeata* (534.0 m^{-3} and 448.0 m^{-3}, respectively) were lower than those for *B. senegalensis* but it is considered as a moderate density wood. This is a good property which indicates good or reasonable strength properties.

The average value of bark-to- wood ratio for *P. aculeata* (4.78 %) was found to be lower than that for *B. senegalensis* (10.75 %). This is good in debarking and peeling processes. The basic density and bark-to –wood ratio were considered of the important wood properties in determining the suitability for pulp and paper industry [15-20].

The tangential shrinkage (Table 2) was almost double the radial shrinkage (3.61and 8.46 %) This is very normal as cited by Desch, Elzaki and Khider [21, 22]. The ratio for tangential to radial shrinkage (T/R) was higher for *P. aculeata* (2.68) compared with that for *B. senegalensis* (1.80).

Table 1: Average values for moisture content and bark-to-wood ratio for *Parkinsonia aculeata* wood compared with *Boscia senegalensis* wood

Properties	*P. aculeata*	*B. senegalensis*
Average moisture content. %	5.59	5.25
Average Bark-to-wood ratio by volume %	4.78	10.75

Table 2: Average values of oven-dry density and basic density for *Parkinsonia aculeata* wood compared with *Boscia senegalensis* wood.

Properties	*P. aculeata*	*B. senegalensis*
Average oven-dry density kg m^{-3}	534.0	752.0
Average basic density kg m^{-3}	448.0	646.0

Table 3: Average values for important ratios of physical properties for *Parkinsonia aculeata* wood compared with those for *Boscia senegalensis* wood.

Property ratio	*P. aculeata*	*B. senegalensis*
Average radial shrinkage %	3.61	3.89
Average tangential shrinkage %	8.46	5.98
Average shrinkage ratio T/R	2.68	1.80
Mechanical Properties		

Table 4: Average values for static bending tests for wood specimens of *P. aculeata* compared with B. senegalensis:

Species	P_{max} (kN)	MOR MPa cm^{-2}	MOE kPa cm^{-2}
P. aculeata	1.862	68.786	8180.979
B. senegalensis	2.206	102.159	9131.497

Table 5: Average values for compression strength parallel to the grain tests for wood specimens of P. aculeata compared with B. senegalensis:

Species	P max (KN) minimum	P max (KN) maximum	P max (KN) Average
P. aculeata	25.440	29.900	27.217
B. senegalensis	20.690	33.290	26.002

Table 2 showed the average values of the modulus of elasticity and modulus of rupture due to the static bending tests for *P. aculeata* in comparison with *B. senegalensis*. The values for both modulus of rupture (MOR) and the modulus of elasticity (MOE) for *P. aculeata* (68.786 MPa and 8180.979 kPa) were lower than those for *B. senegalensis* (102.159 MPa and 9131.497 kPa, respectively). This variation may be due to the difference in the anatomical structures and mainly to indicators such as fiber length and cell wall thickness as well as an important physical parameter such as the wood density as cited by Elzaki and Khider [22, 23], Elzaki *et al*. [24-26] and Elsanosi *et al*. [27]. Table 3 shows the results of compression strength parallel to the grain for *P. aculeata* in comparison with *B. senegalensis*. *P. aculeata* has shown a bit higher average P max than that for *B. senegalensis*. This is good for tool handles and other wooden parts which need resistance for compression forces and could be used for a wide range of both indoor and outdoor furniture. This strength of *P. aculeata* wood is considered a real plus-point for furniture designers and give them a wider range of choice in furniture types than in many other wood species.

CONCLUSION

From the physical and morphological results in addition to the highest MOE and MOR as well as the maximum crushing strength and in comparison with the well-known hardwood species, *P. aculeata* wood could be considered as a good timber with good strength properties which are preferred by interior designers and make them consider it as a suitable wood species for inter-design works and indoor furniture.

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