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Wood Properties of Detarium senegalense, a lesser used tropical timber growing in Nigeria.

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Abstract

The wood products sector in Nigeria is currently performing below optimal capacity as a result of increasing scarcity of economic wood species. In order to adequately cater for products requirement of Nigerians locally, the sector has incorporated lesser used wood species into its stream of raw materials requirement. One of these species commonly found in sawmills and plank depots in the country is Detarium senegalense. As the properties of wood determine its utilization potentials, this study was carried out to determine the wood properties of D. senegalense. The basic density is 610kg/m3. This is within the range of the economic species currently used in the wood products sector. However, the heartwood constitutes only 9.02% of the total volume fraction. The sapwood constitutes 75.98%, and the bark 15%. The low percentage of heartwood in contrast with the high volume of sapwood indicated that the wood may not be durable in service. The mean age is 47 years while the mean diameter is 21cm indicating that it is a small diameter hardwood. The vessels elements, fibres, axial and ray parenchyma cells constitute 9.28, 31.4, 30.6 and 28.72% respectively. The number of vessel per mm3 is 13.62 while those of fibres are 3301 per mm3. The relative high proportions of the fibres may have contributed to its high density.

1.0 Introduction

The wood and wood products sector of the national economy is currently facing wood shortage problems. According to RMRDC (2010) the total volume of useable wood down to 30cm cutting diameter in the reserved forest areas is 239,775,500 m^3. This by comparison is not significantly different from 473, 509,205.943 m^3 reported by Akindele *et al* (2001). Considering the ten years difference between the reporting periods, when there figures are juxtaposed with total wood requirement projected at 59,955, room per 2010 (FMAWRRD, 1988; Bourgione,1991), extreme wood shortages are expected within the next 10-15 years. Many of the forest reserves are presently depleted to such a level that the traditional valuable economic large–size logs are becoming increasingly difficult to come by.

In order to adequately meet the demand for wood products, some new indigenous woods are being introduced into the timber market as substitutes to those traditional economic hardwoods that are fast disappearing. *Detarium senegalense* is one of the lesser-known tree species that is presently finding its way to our timber market as a potential valuable wood for various end uses. These lesser used timber were once neglected in the forest reserves in favour of the economic tree species, which were then readily available.

A survey of available literature revealed the paucity of documented information on the wood properties of the *Detarium senegalese*. In particular, no information could be found on its anatomical properties vis-à-vis its wood cellular composition. As a biological material, the properties of wood determine its industrial application. It therefore becomes imperative that a thorough knowledge of its anatomical properties should precede the selection or choice of the wood species for end use. The present study was embarked upon in this regard, to evaluate the cellular the wood properties of the plant species. Emphasis is placed on the wood density, fiber characteristics and wood cellular structure to ascertain its usefulness in the wood products sector of the national economy.

2.0 Materials and Methods

2.1 Field Sampling

The materials used for the study were obtained from the natural forest in the savanna area Okeawon, near Jebba in Kwara State (Latitude 9.30^{0}N. Longitude 4.46^{0}E.

The sampling procedure employed by Onilude *et al* (1988) was used for the study. The sampled trees were selected at random, felled, sample discs about 7.5cm thick were taken at the breast height. The sampled discs were immediately wrapped in plastic bags to prevent loss of moisture during transportation.

2.2. Laboratory procedure

2.2.1 Determination of Wood Microscopic Constituents

Laboratory study was carried out on the entire discs to determine the tree age and volume fractions of heartwood, sapwood and bark of the discs. Tree age was determined using sand paper to brush the discs and a hand lens was used to count the rings. The grid point method using a 120-point circular grid (Ifju, 1981, Onilude et al, 1988, Ogunwusi, 1991), was employed for the determination of volume fractions of heartwood, sapwood and bark of the wood. After this, the sampled discs were debarked for other subsequent analysis.

From the debarked discs, strips 5cm wide were removed and each strip was further sawn in half through the pith. One half was used for fibre length and density determination, while the other was employed for alcohol benzene soluble extractable content tests.

2.2.2 Basic Density Determination

Test blocks for density determination were partitioned into three zones representing the heartwood (taken at four rings from the pitch) transition wood (between heartwood and sapwood zones) and the sapwood zones (taken at four rings from the bark).

The basic density of samples was obtained as the oven weight (103$\pm$ 2^{0}C) to green volume ratios.

2.2.3 Fibre Length Determination

Samples for fibre length determination were obtained as thin slivers taken from sides of the wood blocks used for density determination. The samples were macerated in 1:1 solution of glacial acetic acid and hydrogen peroxide as described by Franklin (1946). The mixture was autoclaved at constant temperature and pressure of 120 ^{0}C and 1.00kgf/cm^2 for 45 minutes. The macerated samples were later rinsed thoroughly in water and a total of 15 projected whole fibre images measured from each sampling zone.

2.2.4 Alcohol/Benzene Solubility Determination

Extractive contents of sampled trees were determined on the entire second half of the diameter strip. Samples used for extraction were debarked and prepared in accordance with ASTM Standard - D1107 – Standard Method for Alcohol/Benzene Solubility of Wood. At the end of each successive extraction process, the samples were oven dried to constant weight. The extractive contents were then determined based upon initial oven dry mass.

3. Results and discussion

Table 1 present the results of the wood properties evaluation. The density decreased from 640kg/m^3 in the heartwood to 635km^3 in the transition wood and to 556 kg/m^3 in the sapwood zone. Radial decrease in density from the pith to the bark as exhibited by this species has been reported in *Butyrospermum paradoxium* and *Albizia zygia* by Ogunwusi (1991) and in *Prospsis africana* by Onilude *et al.* (1988). The mean basic density is 610 kg/m^3. This is within the range of reported for economic wood species that are currently utilized in the wood and wood products industry. For instance the wood density of *Terminalia superba* is reported as 465kg/m^3, *Terminalia ivorensis*, 576kg/m^3, *Mansonia altissima*,672kg/m^3 and *Tectona grandis* 640kg/m^3 (Aribisala,1993). On density basis, the wood can be used where the aforementioned commercial species are deployed.

The fibre length increased from 0.95 mm in the heartwood to 0.96 in the transition wood, and then increased to 1.19 mm in the sapwood zone. The mean fibre length is 0.91 mm. This is within the range of fibre lengths of most hardwood species, indicating, that apart from its use in the wood industry, the plant species can also be used as a source of short fibre raw material in the nation's pulp and paper sector (Ogunwusi,1991). The alcohol benzene soluble extractive content of the wood species ranged from 2.60-2.70% with a mean of 2.67 %. This is within the range of 2 to 4 % reported as suitable for pulp and paper production in hardwood (Panshin and Zeeuw, 1980). As wood extractives are the major cases of pitch deposition in pulp and paper mills, the higher the extractive content of hardwoods, the greater the pitch deposition potentials during pulping (Allen,1988).

The mean volume functions of heartwood, sapwood and bark of the tree species are also presented in Table 1. Heartwood constitutes only 9.02% of the total volume fraction; the sapwood, 75.98%, and the bark, 15%. The low percentage volume of heartwood in contrast to the high volume of sapwood indicated that the wood may not be durable in service. The lifespan may be shorter than those of species with higher volumes of heartwood percentages. Heartwoods contain dead cells with deposited wood extractives which are toxic to wood destroying agents such as insects and fungi attacks. Sapwoods on the other hand contain fluid that are easily attacked by wood destroying agent (Ogbogu,1990). As a result, sustainable utilization of *Detarium senegalense* in the wood industry will require pressure treatment to prolong the lifespan of the wood in service. The age range of the wood species utilized in this study varied from 29-67 years (Table 1). The mean age is 49 years. When this is juxtaposed with the mean diameter of 21cm and a diameter range from 14.3cm to 27.0cm, it showed that the wood species is a small diameter wood species. More recently, it has recommended that saw millers and other practitioners in the nation's wood industry re-strategize to handle small diameter wood species. This is imperative as the large diameter wood species have become scarce in the nation's forest reserves (RMRDC, 2010).

Table 2 shows the result of the quantitative characterization of the wood elements of the plant species. The presence of vessels in hardwood differentiates them from softwoods. The proportion and distribution of anatomical elements are of importance in determining the structural characteristics and quality of wood for a particular purpose. Increase in the proportion of vessel elements may lead to decrease in wood density and an increase in the number of weak points along the surface of the wood. These may serve as pathway for bacteria, fungi and virus infections in the wood leading to increase in wood deterioration (Akachukwu,1979). Vessel elements, fibres, axial and ray parenchyma tissues constitute 9.2, 31.4, 30.6 and 28.72% of the volume fractions of the wood elements respectively. The number of vessels per mm^2 of wood is 13.62 while those of fibre are 3301 per mm^3. The relative proportions of fibres play an important role in the determination of wood for various end uses. The high proportion of fibres may be responsible for the high density of the wood species.

4. Conclusion

The decreasing availability of preferred wood species in the nation's forests have necessitated introduction of new wood species into the mainstream of raw materials utilized in the wood product industries. This development has however led to production of lesser quality products. While substitution or complementary utilization of lesser utilized wood species has become a necessity, it is imperative that any material to be sued as substitutes should at least possess minimum criteria that will make it durable when deployed in the industry. From the findings of this study, *Detarium senegalense* is a good substitute to traditional raw materials use in the sawmill and furniture industries due to its density. However the high proportion of sapwood it contains necessitated that adequate preservative treatment is applied before its deployment for service to increase its lifespan. The presence of vessels and parenchyma's cells will assist in promoting wood preservatives penetration into the wood during treatment.

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Table 1. Means Ranges and Coefficient of variation (CV) for wood properties of *Detarium senegalense*

Parameter	Heartwood	Transition wood	Sapwood
Basic Density (Kg/m^3)			
Average	640	635	556
Range	583-701	591-690	534-590
C.V%	7.5	6.4	4.3
Mean		610	
Fibre length (mm)			
Average	0.95	0.96	1.19
Range	0.61-1.39	0.69-1.24	0.70-1.94
C.V	18.79	13.72	23.64
Mean		0.91	
Heartwood Vol(%)			
Mean	9.02		
Range	16.97-12.12		
V.V%	21		
Sapwood volume(%)			
Mean	75.98		
Range	69.69-79.69		
CV(%)	5%		
Bark volume(%)			
Mean	15		
Range	13.95-18.18		
CV	10.00		
Extractive content			
Mean	2.67		
Range	2.60-2.70		
CV(%)	18		
Diameter (cm)			
Mean	21.66		
Range	14.3-27.0		
CV	21.90		
Age (years)			
Mean	49		
Range	29-67		
CV	25		

Table 2: Mean and Standard deviation of point count for cell types of *Detarium senegalense*

Cell types	Point counts Lumen%	Wall	Total
Vessels			
Mean	0.0.8	9.2	9.28
SD	0.01	0.02	0.05
Axial parenchyma			
Mean	24.3	6.3	30.6
SD	0.03	0.03	0.09
Fibre			
Mean	25.1	6.3	31.4
SD	0.0.4	0.0.2	0.09
Ray parenchyma			
Mean	22.10	6.26	28.72
SD	0.08	0.05	28.7
No of vessels/ mm^2			
Mean	13.62		
SD	0.28		
No of fibre/mm			
Mean	33.01		
SD	105.18		

*Each value was calculated from a total of 4 stereological