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Wood properties of *Abizia zygia* and *Anogeissus leiocarpus*: medium category wood species found in timber markets in Nigeria.

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Abstract
The decreasing availability of commonly used wood species has made wider industrial application of lesser used wood species imperative in Nigeria. The categorization of wood species commonly found in the timber market on the basis of acceptability and extent of usage is expected to foster utilization of the lesser used wood species. In this study, the wood properties of *Albizia zygia* and *Anogeissus leiocarpus*, two medium category wood species were examined. The mean wood density of *A. zygia* was 818kg/m^3. The mean fibre length was 1.22mm. The mean volume fractions of heartwood, sapwood and bark were 49.19%, 40.04% and 10.77% respectively. The result of the quantitative characterization of the anatomical elements of the wood species shows the proportion of fibres, vessels, axial and ray parenchyma cells as 36%, 7.38%, 23.3% and 30.0% respectively. The result shows the wood of *A. zygia* to be durable and may not require extensive preservative treatment before deployment for service. The wood density of *A. leiocarpus* is also high at 731kg/m^3. However, the result of the volume fractions of heartwood, sapwood and bark at 6.12%, 87.80% and 6.08%, coupled with mean volume fractions of fibres, vessels, axial and ray parenchyma cells at 32.2%, 22..3%, 25.1% and 32.2% respectively indicated that the wood may require adequate preservative treatment to endure in service.
Keywords: heartwood, sapwood, bark, vessels, axial and ray parenchyma.

INTRODUCTION

Nigeria's forest resources have served as engine of growth and have propelled economic activities in the country as far back as 1792 when pit sawing operation commenced, followed by the establishment of a power sawmill in Delta area in 1902 (Aribisala, 1993). These led to substantial increase in wood exploitation in the country. Wood export picked up in 1950's with log and sawn wood and subsequently, veneer and plywood. This trend was maintained and sustained in the 1960's and early 1970's. However, by mid 1970's, the toll of intensive exploitation has started showing and volume of wood export which peaked at 700,000m^3 , in 1964, decreased steadily to 290,000m^3, in 1970 (Aribisala, 1993). Among the factors that led to reduction in forest resources availability is intensive exploitation of the resources. As far back as 1899, the perspective planning for economic development was to exploit forest resources (Adeyoju, 1975). The export revenue from forestry grows at 4.1%, 8.0% and 28.8% between 1950-60, 1960-70 and 1970-80 respectively (Aribisala, 1993). The period witnessed the development of a virile forest products industry.

Despite its contribution to economic development, logging in the forests has been complicated by the fact that only a few members of the abundant tree species in the tropical forests are harvested, while others are neglected and destroyed during harvesting (Arowosoge, 2010). The few species that are harvested are generally refereed to Commonly Used Species (CUS). They are harvested by selective methods, which, coupled with the fact that tropical timbers rarely occur in pure stands, lead to high level of damage to remaining trees, depletion of genetic stock of the CUS, early reentry into a forest block within a concession, all resulting in non sustainable forest management practices (Coleman, 1998). The problem is further complicated as out of more than 600 tree species that are available in the tropical forests of Nigeria; only about 60 are of commercial importance. The remaining species are termed Lesser Used Species (LUS).

More recently, the decreasing availability of the Commonly Used Species, coupled with the alarming rate at which natural forests continue to diminish, have necessitated that efforts be directed towards promoting sustainable development of tropical forests. Towards this end, the International Tropical Timber Organization (IITO) has funded many projects in the tropics to ensure a more intensive management regime that fully utilized the diverse mixture of timber species located within concessions (Arowosoge, 2010). However, according to Jayanelti (1998), Eastin *et. al.* (2003) and Barany *et. al.* (2003), where Lesser Used Species are used as replacements to economic species, the products faces problems of acceptance in international markets. Thus, Coleman (1998), Barany *et. al.*

(2003) and Eddowes (1980) considered lesser used species as important element of the forest of the future which deserve special attention in present day management decisions. For this to be achieved, Eddowes (1980) recommended the need for adequate study of the properties of the Lesser Used wood Species. As a way forward, Beak Consultants (1999), assigned grades to some of the wood species found timber markets in Nigeria on the basis of their local acceptability and extent of usage. Table 1 shows the categorization of twenty six of the wood species found in Nigeria timber markets on the basis of the classification. Although, Beak Consultants (1999) assigned *Albizia zygia* and *Anogeissus leiocarpus* as medium category grade species, a survey of literature revealed paucity of documented information on the wood properties of the two species to support this categorisation. This study is designed to provide detailed information on the properties of the two wood species.

Materials and Methods

a) Field Sampling

The materials used for the study were obtained from Oke Awon, a natural forest reserve located in the savanna area 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. Five sample trees of the two species were selected at random, felled and sample discs about 7.5cm thick were taken at the breast height. The sample discs were immediately wrapped in plastic bags to prevent loss of moisture during transportation.

b) Laboratory procedure

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 sample 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.

Basic Density Determination

Test blocks for density determination were partitioned into three zones representing the heartwood (taken at four rings from the pith) 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.

Table 1: Some Common Wood Species found in Nigerian Market and their end Uses
Source: Beak Consultants Limited (1999)
Key ***= High grade species **= Medium grade species *= Low grade species

S/NO	Botanical name	Local name	End uses
1.	Afzelia Africana***	Apa	Carving, building construction and flooring
2.	Anthostema aubryanum***	Odogbo	Furniture construction
3.	Cedrela odorata***	Cida	Furniture, carving, doors and staircases.
4.	Cordia milienii***	Omo	Furniture construction
5.	Guarea cedrata***	Olofun/Obobo	Furniture construction and decoration work.
6.	Khaya grandifoliola***	Benin mahogany	General construction and veneer.
7.	Khaya ivorensis***	Lagos mahogany	Furniture, boat building and general fitting.
8.	Khaya senegalensis***	African mahogany	Furniture, doors, stair cases and roofing
9.	Lophira alata***	Ekki	Railway sleepers, furniture and boat construction
10.	Lovoa trichilioides***	African walnut	Paneling, moulding and cabinet works
11.	Mansonia hecketii***	Makore	Veneer decorations and house fittings
12.	Mansonia altissima***	Ofun	High class furniture and turnery.

13.	Milicia execelsa***	Iroko	Doors, window frames, stair cases, flooring and furniture
14.	Nauclea diderichii***	Opepe	Bridges, railway sleepers, flooring, parquet, window and frames.
15.	Nesogordonia papaverifera***	Danta/Oro	Bench tops, lorry bodies and floor In boat building
16.	Piptadeniastmm africana***	Agoyin	Joinery and construction work where strength and durability are essential.
17.	Pterygota macrocarpus***	Pterygota	Interior fittings and joinery work
18	Tectona grandis***	Teak	High class furniture, laboratory table tops due to its resistance to acids and transmission poles.
19.	Albizia zygia**	Ayure	Ornamental fittings.
20.	Anogeissus leiocarpus**	Kaniran	Roofing and fittings, veneer and roofing.
21.	Brachystegia eurycoma**	Ako	Ornamental fittings, veneer and roofing.
22.	Celtis zenkeri**	Ita	Axe and handles
23	Alstonia boonei*	Ahun	Plywood cores and Match making
24.	Antiaris toxicaria*	Oriro	Packaging case
25.	Pycanthus congolensis*	Akomu	Rotary veneer
26.	Triplochiton scleroxylon*	Arere	Interior fitting, match making and veneer

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.

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 (2007) 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.

Results and discussion

Table 2 present the result of the wood properties evaluation of *A. zygia*. The mean density of *A. zygia* is 761kg/m^3. Density of the species increased from 818kg/m^3 in the heartwood to 878kg/m^3 in the transition wood and then decreased to 684kg/m^3 in the sapwood. This type of radial density pattern had been reported in *Parinarium kerstingii* growing in Nigeria by Onilude *et al* (1988). The mean density of the species compare well with those of very durable wood species such as *Afromosia elata* at 784kg/m^3, *Mansonia altissima* at 672kg/^{3} and *Nuclea didderichii* that are Commonly Used Species in the wood industry (Aribisala, 1993). Thus the categorization of *A. zygia* as a medium grade wood species is well placed as it is likely to be durable and very resistant to attack by wood destroying agents.
The fibre length of the wood species increased from 1.27mm in the heartwood to 1.28mm in the transition wood and decreased to 1.27mm in the sapwood zone. The mean fibre length is 1.22mm. This is within the range of the fibre length reported for hardwood in general by Pashin and De-zeuw (1980). The mean extractive content is 3.87%. This is also within the range of 1-5% reported for hardwoods in general by Yew (2010). The mean volume fractions of heartwood, sapwood and bark are 49.19%, 40.04% and 10.77% respectively. With the high percentage of the heartwood, the wood of *A. zygia* is

likely to be very durable and could be employed in uses where durability is required such as in roofing, outdoor furniture and fence.

Table 2. Means Ranges and Coefficient of variation (CV) for wood properties of *Albizia zygia*

Parameter	Heartwood	Transition wood	Sapwood
Basic Density (Kg/m^3)			
Average	818	878	684
Range	775-848	737-866	589-742
C.V%	3.8	7.1	11.6
Mean		761	
Fibre length (mm)			
Average	1.20	1.28	1.27
Range	0.61-1.52	1.67-1.73	0.85-1.67
C.V	20.5	23	19.15
Mean		1.22	
Heartwood Vol(%)			
Mean	49.19		
Range	33.33-55.55		
CV%	16.53		
Sapwood volume(%)			
Mean	40.04		
Range	30.43-54.17		
CV(%)	20.53		
Bark volume(%)			
Mean	10.77		
Range	8.6-12.5		
CV	15.8		
Extractive content			
Mean	3.87		
Range	3.5-4.55		
CV(%)	12.00		
Diameter (cm)			
Mean	14.28		
Range	13.0-16.30		
CV	4.1		
Age (years)			
Mean	32.6		
Range	31-37		
CV	6.8		

Table 3: Mean and Standard deviation of point count for cell types of *A. zygia*

Cell types	Point counts Lumen%	Wall	Total
Vessels			
Mean	4.7	3.13	7.83
SD	0.01	0.04	0.04
Axial parenchyma			
Mean	14.0	9.2	23.2
SD	0.07	0.02	0.06
Fibre			
Mean	28.2	7.9	36.1
SD	0.02	0.03	0.11
Ray parenchyma			
Mean	15.9	14.1	30.0
SD	0.10	0.01	0.09
No of vessels/ mm^2			
Mean	10.88		
SD	0.50		
No of fibre/mm			
Mean	1709		
SD	20.53		

*Each value was calculated from a total of four stereological counts

Table 4. Means Ranges and Coefficient of variation (CV) for wood properties of *Anogeissus leiocarpus*

Parameter	Heartwood	Transition wood	Sapwood
Basic Density (Kg/m^3)			
Average	755	742	696
Range	745-765	720-756	688-711
C.V%	1.08	2.14	1.50
Mean		731	
Fibre length (mm)			
Average	1.30	1.27	1.22
Range	0.94-1.63	0.87-1.88	0.67-1.60
C.V	14.5	18.7	18.7
Mean		1.26	
Heartwood Vol(%)			
Mean	6.12		
Range	3.08-8.64		
CV%	29.01		
Sapwood volume(%)			
Mean	87.80		

Range	82.00-90.77
CV(%)	3.25
Bark volume(%)	
Mean	6.08
Range	4.94-7.07
CV	11.30
Extractive content	
Mean	1.82
Range	1.74-1.88
CV(%)	23.00
Diameter (cm)	
Mean	21.64
Range	15.5-29.5
CV	23.60
Age (years)	
Mean	39.8
Range	35-57
CV	21.29

Table 5: Mean and Standard deviation of point count for cell types of *Anogeissus leiocarpus*

Cell types	**Point counts Lumen%**	**Wall**	**Total**
Vessels			
Mean	12.3	10.0	22.3
SD	0.03	0.04	0.04
Axial parenchyma			
Mean	22.9	1.6	25.1
SD	0.10	0.02	0.10
Fibre			
Mean	24.4	7.8	32.2
SD	0.05	0.03	0.11
Ray parenchyma			
Mean	15.8	6.8	22.6
SD	0.13	0.07	0.12
No of vessels/ mm^2			
Mean	18.49		
SD	0.25		
No of fibre/mm			
Mean	2482		
SD	118.2		

*Each value was calculated from a total of four stereological counts

The mean diameter of the wood species is 32.6cm. This is a major drawback for industrial utilization of the wood species as sawmilling and veneer production equipment in Nigeria require large diameter wood species. However when the ages of the samples utilized in this study which ranged from 31-37 years are taken into consideration, the samples may be considered as relatively young in age.

Table 3 shows the result of the quantitative characterization of the wood elements of the plant species. The proportion and distribution of anatomical elements are important in determining the structural characteristics and quality of wood for a particular purpose. Table 3 shows the propotion of fibres in the wood species to be 36% while those of vessels, axial and ray parenchyma cells are 7.38%, 23.3%, and 30.0% respectively. The high proportion of fibres may have been responsible for the high density of the wood species.

Table 4 presents the result of the wood properties of *Anogeissus leiocarpus*. The mean density of *A. leiocarpus* is 731kg/m^3. Density of the wood species decreased from 755 kg/m^3 in the heartwood to 742km^3 in the transition wood and to 696 kg/m^3 in the sapwood zone. This type of decrease in radial density from the pith to the bark has been reported in *Butyrospermum paradoxum* by Ogunwusi (1991) in *Prospsis africana* by Onilude *et al.* (1988) and more recently in *Detarium senegalense* by Ogunwusi (2012). The density is within the range reported for economic wood species that are currently being utilized in the wood and wood products industry.

The fibre length decreased from 1.30 mm in the heartwood to 1.27mm in the transition wood, and further to 1.22 mm in the sapwood zone. The mean fibre length is 1.26 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. The alcohol benzene soluble extractive content of the wood species ranged from 1.7-1.88% with a mean of 1.82 %. This is within the range of 2 to 4 % reported as suitable for pulp and paper production in hardwood (Panshin and Zeeuw, 1980).

The mean volume functions of heartwood, sapwood and bark of the tree species are also presented in Table 4. Heartwood constitutes only 6.12% of the total volume fraction; the sapwood, 87.80%, and the bark, 6.08%. 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 as heartwood 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 the wood species would 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 35-57 years (Table 4). The mean age is 39.8 years. When this is juxtaposed with the mean diameter of 21.64cm and a diameter range from 15.5-29.5cm, it showed that the wood species is a small diameter wood species. This may limit its usefulness for certain applications in Nigeria where sawmills and plymills are designed to handle large diameter wood species.

Table 5 shows the result of the quantitative characterization of the wood elements of *Anogeissus leiocarpus*. The mean proportion of fibres is 32.2%. The mean proportions of vessels, axial and ray parenchyma cells are 22.3%, 25.1% and 22.6% respectively. The volume of vessel elements, axial and ray parenchyma cells are high and may necessitate that the wood species undergo pressure treatment to make it durable in service. This is necessary as these points may serve as weak points where bacteria, fungi and virus infections may the wood, leading to wood deterioration (Akachukwu, 1979).

Conclusion

The two wood species studied may be classified as medium grade wood species on the basis of their density values.

In view of its wood properties, most especially, its density, heartwood volume fractions and low contents of vessels, *Albizzia zygia* has all the attributes of wood species classified as Commonly Used Species. The major disadvantage of the wood species is its diameter which may limit its application in the wood industry. The wood species is likely to be durable in service and may not necessarily require extensive preservative treatment for certain applications.

While the density of *Anogeissus leiocarpus* is also high at 731kg/m^3, the high volume fractions of sapwood, vessel elements, axial and ray parenchyma cells may make the wood less durable thereby necessitating pressure treatment prior to deployment.

In summary, while both wood species may be classified as medium grade wood species, there is need for *A. leiocarpus* to be adequately treated if it is to be used in situations where it will be exposed to wood deteriorating agents.

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