

Comparative Analysis of Wood Properties of *Afzelia africana* and *Anogeissus leiocarpus* Growing in Nigeria.

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Abstract
Afzelia africana and *Anogeissus leiocarpus* are two timber species growing in Nigeria. The two species are used in the construction industry. While *A. africana* is regarded as a high grade wood species, *A leiocarpus* is referred to as a medium wood species. This study was carried out to determine the heartwood, sapwood and bark proportions of the two species along with their wood densities and alcohol benzene soluble extractable contents. The ages of the trees used in the study varied from 34 to 52 years in *A. africana* and 35 to 57 years in *A leiocarpus*. The heartwood ratio in *A africana* ranged from 44.6% to 75.9% with a mean of 60.9%. The sapwood proportion also varied from 32.5% to 43.6% ,with a mean of 28.76%. The bark ratio varied from 5.8% to 12.24% with a mean of 10.20%. The heartwood content of *A. leiocarpus* was a paltry 6.12% while the proportions of the sapwood and bark were 87.80% and 10.77% respectively. The mean densities of the two wood species were 716kg/m3 in *A. africana* and 731kg/m3in *A. leiocarpus.* The mean alcohol benzene soluble extractable content was 2.64% in *A. africana* and 1.82% in *A. leiocarpus*. The result obtained indicated that *A. africana* will be more durable and can be use without treatment in most applications while *A. leiocapus* may require adequate preservative treatment in situations where it will be used for outdoor purposes, most especially when it is to have contact with the ground in service.
Keywords: heartwood, sapwood, bark, density, extractives

1.0 Introduction

Afzelia africana is one of the high grade commonly used wood species in tropical Africa. In Sub Saharan Africa, the plant occurs in Senegal, East Africa and Democratic Republic of Congo. The plant is characteristic of the transition zone between wooded savanna and the dense dry forest. *Anogeissus leiocarpa* is a tropical species of transition zone between forest and savanna but grows in savanna wood land of guinea and sudan zones. Its range extends across Africa to Sudan and Ethiopia and downwards to Zaire.

Although, the two wood species are used in the building and construction industries, *A. africana* is preferred as it is regarded as a first grade commercial lumber in Nigeria (Arowosoge, 2010; Beak Consultants, 1999). *A. leiocarp*us on the other hand is a medium grade species (Ogunwusi, 2013; Beak Consultants, 1999). The increasing need to establish plantations of indigenous hardwoods has necessitated that the properties of industrial timbers growing in Nigeria be ascertained to ensure that adequate and appropriate choices are made based on the individual wood characteristics (Ogunwusi, 2010). In this study, the heartwood, sapwood and bark proportions of the two wood species were studied along with their density and alcohol benzene soluble extractive contents. Apart from the fact that there is little or no information in the literature on the heartwood, sapwood and bark ratios of the two species, this study also aimed at providing information for forest managers aiming at establishing plantation of the wood species.

Heartwood, sapwood and bark proportions of timbers define the volume of usable portion of wood and their utilization potentials (Ogunwusi 2013a). The heartwood determines the durability of wood and its presence have been associated as a characteristic for high end products. It has properties that significantly influence the usefulness of wood. Notable among these is its resistance to deterioration by insects, marine borers and microorganisms (Taylor *et al, 2002*). Information on heartwood percentage in wood species promotes its acceptability by end users (Akachukwu, 1979; Ogunwusi, 2013b; 2013c).

Sapwood contains wood that is part of the transpiration stream of the tree and it generally has high moisture content. Its permeability is facilitated by unaspirated and unencrusted pits. It contains few toxic extractives and is generally susceptible to decay (Taylor *et al,* 2002). The primary role of sapwood in a tree is to conduct water from the root to the crown (Bamber and Fukazawa, 1985). It also serves as a storage site for water, energy reserve materials such as starch (Hillis, 1987; Miller, 1999) and as a site for living cells that can respond to injury through production of more tissues or defensive compounds (Boddy, 1992). Sapwood is also responsible for synthesis of bio-chemicals (Wiedenhoeft and Miller, 2005)

Bark content estimation in tropical hardwoods is important in view of its present low economic value. Since tree volumes are normally sold without bark, volume projections usually deduct portions lost on the bark. As a result, the heartwood as well the bark contents are determinant quality characteristics that should be given proper attention by wood scientists and forest managers in order to promote heritability of desirable characteristics in plantation wood species.

In the present study, the proportions of heartwood, sapwood and bark in the two wood species were determined in order to assess the durability of the wood species in service. The role of density and alcohol benzene soluble extractable contents in strength development and durability of the two species were also examined.

2. Materials and methods

2.1 Materials

The hardwood species utilized in the study comprised of *Anogeissus leiocarpus* (D.C.) Guill and Per. and *Afzelia africana* Smith. The materials were collected from tree species growing in the natural forest reserve in the savanna area at Oke Awon, near Jebba, Kwara State (Latitude 9,3^{o}N, Longitude 4.46^{o}E) . The total annual rainfall within the area varied from 1000 to 1250 mm. The tree species were from uneven aged natural forest reserve. Five trees of each species were felled and disc samples, 7.5cm thick, were taken at breast height. The sampled discs were immediately wrapped in plastic bags to prevent loss of moisture during transportation. The discs were stored in a cold room until they are required for analysis.

2.2 Methods

2.2.1. Determination of tree age, heartwood, sapwood and bark proportions

Each disc was sanded with a mechanical sanding machine. The number of rings on each sanded disc was counted with the aid of a 10x magnification hand lens. The result was used to estimate the ages of the trees.

After the above, the volume fractions of heartwood, sapwood and bark were completed on the entire discs of each sampled material using a 120 point circular grid. The test points were constructed by super imposing 15 concentric circles within the other on a tracing paper. The circles were divided into test points by constructing four diagonal lines that ran from one end of the circle to another. The number of points that fell on each feature of interest, divided by total number of test points covered by the sample, gave the volume fraction of each gross feature of interest.

2.2.2 Determination of Alcohol-Benzene Soluble Extractable Contents

Two out of the five test specimens belonging to each species were debarked and 5cm thick strips were removed from the middle of each disc. The strips were pulverized and used for alcohol benzene soluble extractable content determination in accordance with American Standard of Testing Methods (2007)-D-1107. At the end of each extraction process, the samples were oven dried to constant weights and the extractive content calculated based upon initial over dry mass.

2.2.3. Determination of wood density

The remaining three sampled discs were debarked at the laboratory. From the debarked discs, strips 5cm wide were removed from each disc and used for basic density determination. Test blocks obtained from the heartwood, sapwood and transition wood zones were soaked in water and intermittent vacuum applied until the samples became fully saturated. The volume of the saturated specimen were determined by water displacement method and recorded as green volume (Vf). After this, the specimens were oven dried to constant weight at 103 $\pm$ 2^{o}c. The oven dry weight was recorded as $M_{o.}$ The basic density of the sample were then calculated from the formula

$$\text{Basic density} = \frac{Mo}{Vf}$$

3.0 Results and discussions

The average climatic conditions at Oke Awon where the wood species were collected are shown in Table 1. The table indicated that the maximum rainfall in the area reached its peak in August with about 511.2 mm of rainfall. The temperature at this time was about 26^{o}C. Oke Awon forest reserve has distinct dry and wet season periods which are characteristic of most tropical climates.

The ages of the tree species sampled varied from 34 to 52 years in *A. africana* and 35-57 years in *A. leiocarpus* (Table 2). The mean age of the *A. africana* species was 45 years while that of *A. leiocarpus* was 39.8 years. This indicated that the samples came from matured trees.

Table 3 showed the heartwood ratio in *A. africana* to vary from 44.6% to 75.9% with a mean of 60.95%. The sapwood ratio also varied from 32.5% to 43.6% with a mean of 28.76%. The bark ratio varies from 5.8% to 12.24% with a mean of 10.29%. From this result, it can be observed that volume of heartwood in *A. Africana* is very high. As heartwood contains mostly extractives which are toxic chemicals that cannot be attacked by insects, borers and microorganisms, the wood is likely to be very durable in service. Lucas (1965) reported the wood species to be very durable and highly resistant to attack by microorganisms. This may be responsible for its high durability and commercial success in the building and construction industries in Nigeria as stipulated by Beak Consultants (1999).

Table 3 also showed the heartwood, sapwood and bark proportions of *A. leiocarpus* to be 6.12%, 87.80% and 10.77% respectively. The heartwood proportion varied from a paltry 3.08% to 8.64% while the sapwood varied from 82.00% to 90.77%. The bark proportion also varied from 4.94% to 7.07%. This indicated that the species has a very low proportion of heartwood. Although, Lucas (1965) reported the wood species to be moderately durable and resistant to attack, the high proportion of the sapwood it contained may make the wood to be highly susceptible to attack by microorganisms, thereby, making it less durable that *A. africana.*

The densities of the two wood species are high. Table 4 showed the mean density of *A. africana* to be 716kg/m^3 while that of *A. leiocarpus* was 731kg/m^3. The two density values should confer durability on the two species. However, the very low proportion of heartwood in *A. leiocarpus* may limit its application to some uses. It may not be employed for outdoor services where it will be in contact with the ground.

The results of the alcohol benzene soluble extractable contents of the two wood species are also shown in Table 4. From the table, the mean alcohol benzene extractive content of *A. africana* was 2.64% while that of *A. leiocarpus* was 1.82%. The wood extractives are cell wall components which can be removed using solvents such as acetones, ether and water. They have relatively small molecules <C40 and are under genetic control in wood species. In general, they can be grouped into lipid extractive components such as aliphatics, terpenoids and phenolic extractive components which are made up of stilbenes, flavinoids and ligans (Ogunwusi, 2009). In hardwoods, the most predominant extractives are fatty acids which make up 60-90% of total extractive contents (Ogunwusi, 2011). The wood extractives which are the major components of heartwoods, make them toxic and resistant to wood borers, insects and microorganisms (Akachukwu, 1979). Thus, in wood species to be used as structural members in construction, the higher the extractive contents, the better their quality. However in the case of pulp and paper production, the higher the extractive content, the lower the potentials of the wood as raw material for short fibre pulp production (Ogunwusi, 2009; Yew, 2010; Dickens, 1986).

4.0 Conclusion

It is evident from this study that *A. africana* will be a very durable, high quality wood species that can be used in the construction industry as a result of its high heartwood, density and extractive content values. Thus, its classification as a high grade wood raw material is justifiable. Although, *A. leiocarpus* has a high density, the very high content of sapwood and low proportion of alcohol benzene soluble extractable content may militate against its sustainable utilization in applications where it will be used in contact with the ground. This, also may justify its classification as a medium category wood species in Nigeria.

Nevertheless, *A. leiocarpus* may a good raw material for short fibre pulp production as its tendency to deposit pitch will be low. The low volume of wood extractives and low heartwood content may be responsible for the high demand for the wood species for fuel and charcoal production in the guinea, sudan and sahel savannas in the country. In view of the above, forest managers planning to establish plantations of indigenous hardwoods must have a clear objective of end use purpose in mind. In the savanna zone were *A. leiocarpus* is regarded as a very good fuel wood and as an important raw material for charcoal production, any plantation to be established for this purpose may not necessarily have a high percentage of heartwood. However, species to be planted for use in the building construction industry must have adequate proportion of heartwood. Thus, selection of planting materials for plantation establishment must be end use driven.

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Table 1. Average annual climatic conditions of Oke Awon Forest Reserve

Months	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Rainfall (mm)	2.3	15.8	36.0	148.2	181.9	213.8	448.3	511.2	263.2	118.6	6.0	0
Relative Humidity	41.3	46.2	52.7	69.3	75.8	78	81.8	82	78.7	73.2	51.2	41.8
Temperature (^{o}C)	24	28	32	33	32	29	27	26	28	31	29	26

Source: Momodu (1983)

Table 2: Means and ranges of the coefficient of variation of the age and diameter of the two wood species

Species	Statistical parameters	Age (Years)	Diameter (cm)
A, africana			
	Mean	45.0	21.64
	Range	34-52	15.5-29.5
	CV	13.6	23.60
A. leiocarpus			
	Mean	39.8	23
	Range	35-57	20.2-27.5
	CV	21.92	10.6

CV =Coefficient of Variation

Table 3: Means range and coefficient of variation of the heartwood, sapwood and bark proportions of the wood species

Species	Statistical parameters	Heartwood (%)	Sapwood (%)	Bark (%)
A. africana				
	Mean	60.95	28.76	10.29
	Range	44.6-75.9	32.5-43.6	5.8-12.24
	CV	23.73	32.5	19.7
A. leiocarpus				
	Mean	6.12	87.80	10.77
	Range	3.08-8.64	82.00-90.77	4.94-7.07
	CV	29.01	20.53	11.30

CV =Coefficient of Variation

Table 4: Means and ranges of the coefficient of variation of alcohol benzene soluble extractive content and density of the wood species

Parameter		*Afzelia africana*	*Anogeissus leiocarpus*
Alcohol benzene Extractive content (%)	Mean	2.64	1.82
	Range	2.60-2.70	1.74-1.88
	CV	1.60	3.00
Density (Kg/m^3)			
	Mean	716	731
	Range	656-816	696-755
	CV	4.5	2.14

CV =Coefficient of Variation

