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Original Research Paper

Evaluation of the Woody Stem of *Alstonia boonei* for some Physical Properties

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Some of the physical properties of the woody stem of *Alstonia boonei* which includes wood density (g/cm^3) and percentage moisture content (%) were evaluated following recommended standard procedures. Pool means of 572.93 ± 191.25 and 125.18 ± 54.73 were the respective wood density and percentage moisture content of the stem. Evaluation along the axial axis of the stem showed pool means of 539.75 ± 42.49, 541.10 ± 191.54 and 637.95 ± 263.94 as densities at the base, middle and top regions of the stem respectively. In the same vein, the percentage moisture content (%) of the stem at the base, middle and top regions were 121.04 ± 15.38, 139.29 ± 66.71 and 115.20 ± 66.25 respectively. There were no significant variations (P ≤ 0.05) in wood density and moisture content at the base, middle and top regions of the stem. Conversely, significant variations at P ≤ 0.05 existed in the two properties when evaluated along the radial direction of the stem. Reduction of the moisture content of the stem of this species by drying was opined so as to increase the mechanical property thereby rendering the wood useful for construction purposes. It was also opined that drying of the stem might not be necessary if the intended end use is for herbal preparations like concoctions (a process that mostly requires water). Various opinions were corroborated with the previous assertions of authorities in the same context.

Keywords: *Alstonia boonei,* Axial and radial axes, Density, Evaluation, Moisture, Physical properties.

INTRODUCTION

Physical properties are the quantitative characteristics of wood and its behavior to external influences other than applied forces. The physical properties evaluated here are wood density and percentage moisture content. The density of a material is the mass per unit volume at some specific condition. For a hygroscopic material such as wood, density depends on two factors: the weight of the wood structure and moisture retained in the wood. Wood density at various moisture contents can vary significantly and must be given relative to a specific condition to have practical meaning.

The moisture content of wood is defined as the weight of water in wood given as a percentage of oven-dry weight. Water is required for the growth and development of living trees and constitutes a major portion of green wood anatomy. In living trees, moisture content depends on the species and the type of wood, and may range from approximately 25% to more than 250% (two and a half times the weight of the dry wood material). In most species, the moisture content of sapwood is higher than that of heartwood (Panshin and Dezeeuw, 1980 and Winandy, 1994)

According to Zobel and Jett (1995) the durability of wood is often a function of water, but that doesn't mean wood can never get wet. Quite the contrary, wood and water usually live happily together. Wood is a hygroscopic material, which means it naturally takes on and gives off water to balance out with its surrounding environment. Wood can safely absorb large quantities of water before reaching moisture content levels that will be inviting for decay fungi. Two important moisture content numbers to remember are 19% and 28%. A piece of wood could be termed dry if it is at 19% or less moisture content. Fiber saturation averages around 28%.

Fiber saturation is an important benchmark for both shrinkage and for decay. The fibers of wood (the cells that run the length of the tree) are shaped like tapered drinking straws. When fibers absorb water, it is at first held in the cell walls themselves. When the cell walls are full, any additional water absorbed by the wood will now go to fill up the cavities of these tubular cells.

Fiber saturation is the level of moisture content where the cell walls are holding as much water as they can. Water held in the cell walls is called bound water, while water in the cell cavities is called free water. As the name implies, the free water is relatively accessible, and an accessible source of water is one necessity for decay fungi to start growing. Therefore, decay can generally only get started if the moisture content of the wood is above fiber saturation. The fiber saturation point is also the limit for wood shrinkage. Wood shrinks or swells as its moisture content changes, but only

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when water is taken up or given off from the cell walls. Any change in water content in the cell cavity will have no effect on the dimension of the wood. Therefore, wood only shrinks and swells when it changes moisture content below the point of fiber saturation.

Like other hygroscopic materials, wood placed in an environment with stable temperature and relative humidity will eventually reach a moisture content that yields no vapor pressure difference between the wood and the surrounding air. In other words, its moisture content will stabilize at a point called the equilibrium moisture content (EMC). Wood used indoors will eventually stabilize at 8-14% moisture content; outdoors at 12-18%. Hygroscopicity is not necessarily a bad thing – this allows wood to function as a natural humidity controller in our homes. When the indoor air is very dry, wood will release moisture. When the indoor air is too humid, wood will absorb moisture. Wood shrinks/swells when it loses/gains moisture below its fiber saturation point.

This natural behavior of wood is responsible for some of the problems sometimes encountered when wood dries. For example, special cracks called checks can result from stresses induced in a piece of wood that is drying. As the piece dries, it develops a moisture gradient across its section (dry on the outside, wet on the inside). The dry outer shell wants to shrink as it dries below fiber saturation, however, the wetter core constrains the shell. This can cause checks to form on the surface. The shell is now set in its dimension, although the core is still drying and will, in turn, want to shrink. But the fixed shell constrains the core and checks can thus form in the core (TRADA, 2011)

According to Adotey (2012) *Alstonia* comprises about 40 species and has a pantropical distribution. There are about twelve species of the genus *Alstonia. Alstonia boonei* De Wild belongs to the family Apocynaceae. The species are scattered all over the world of which two are indigenous to Africa. Palla (2005) reported that the wood of *Alstonia boonei*, called *Alstonia* in international trade, is used for light construction, light carpentry, open boats, moulding, furniture, interior joinery, implements, boxes, crates, matches, pencils, sculptures, and for veneer and plywood. It is locally popular for the production of household implements because of its good working properties and stability.

In Ghana, it is used for the famous Asante stools, and in Nigeria for sound boxes of musical instruments of the Yoruba people. The wood is also used as firewood. The bark of the bole is important in traditional medicine. In local markets in West and Central Africa it is often amongst the most common plant materials sold as crude drugs. A bark decoction is widely used to treat malaria, typhoid fever, gonorrhoea, yaws, asthma and dysentery, and is also applied to sores, ulcers, snakebites, rheumatic pain and toothache, and as a galactagogue.

A maceration of the bark is taken to treat jaundice, cough and sore throat, and is applied externally to treat skin complaints. The bark is also used as an anthelmintic. The latex is applied to snakebites, skin complaints and swellings caused by filarial infections, and in concoction to treat fever. The leaves are applied topically to reduce oedemas and to treat sores. The latex has been used as birdlime and as an inferior alternative for rubber. *Alstonia boonei* is a useful shade tree for coffee, tea and banana plantations.

Information on the density and percentage moisture of woods in the tropics is scanty and not properly documented. Consequently, Gill and Okoegwale (1990) reported that wood density decreased insignificantly (at P≤0.05) with plant height in their assessment of variations in wood properties of *Entandrophragma angolense* and *Entandrophragma cylindricum* both in Nigeria. In the recent time, the present author and his collaborators have begun work in this direction as reported in Otoide, *et al*,. 2012, Otoide (2013) and Otoide (2016). Otoide, *et. al.*, (2012) evaluated the moisture content and vessel elements in the stem of *Adansonia digitata* and reported average percentage moisture of 78-82% in the stem. In the same vein, Otoide (2016) assessed the variations in wood density and moisture along the axial and radial axes of the trunk of *Afzelia Africana* and reported that the wood density and moisture were high being greater than 540kg/m^3 and 30% respectively.

Alstonia boonei is highly valued in Nigeria because of its medicinal and timber properties. It is, therefore, necessary to evaluate the physical properties (especially the density and percentage moisture content) of the stem which is the most exploited portions of the plant.

MATERIALS AND METHODS

Collection of Materials

A fully grown tree of *Alstonia boonei* was felled at the diameter at chest height (1.3meters above ground level), from former poultry of Ekiti State University, Ado-Ekiti, Nigeria (17^{0}37´16´´N 5^{0}13´17´´E). The log was thereafter taken to the Department of Wood Technology and Utilization (WT&U) of the Forest Research Institute of Nigeria (FRIN), Ibadan, Nigeria for identification and assessment of physical properties (wood density and moisture). The evaluation
of the woody stem was between October, 2015 and May, 2016.

Experimental Procedures

The procedures used in this assessment strictly followed Otoide, *et.al.* (2012). The bole length of the felled tree was measured with the aid of a measuring tape from the level of chest height, to the crown and the value was 1.10meters. Thereafter, a transverse disc of 20cm thick axially was cut from the base, middle and the top of the trunk. A total of three transverse discs was cut out of the entire trunk. Each of the discs was divided longitudinally into two semi-circular hemispheres with the line of division passing through the pith.

One of the two semi-circular hemispheres was tagged as the Northern hemisphere and the other one, the Southern hemisphere. Only the Northern semi-circular hemispheres were used for the whole of the experiments while the Southern semi-circular hemispheres were discarded. The base, middle and the top semi-circular hemispheres were further divided into three regions, with the lines of division parallel to the equator, which passes through the centre of the pith. These three regions were labelled as:

- CORE (C),
- MIDDLE (M) and
- OUTER (O).

Five blocks of the dimension, 2cm x 2cm x 2cm and another five blocks of the dimension, 2cm x 2cm x 6cm cut out of the core, middle and outer blocks earlier extracted from the three semi-circular hemispheres, each of which was cut out from the base, middle and the top of the trunk. On the base disc, five replicate extracts, each from the core, middle and the outer regions of the semi-circular hemisphere were cut out, making a total of 15 blocks of the dimension, 2cm x 2cm x 2cm and also a total of 15 blocks of the dimension, 2cm x 2cm x 6cm. A total of 30 blocks were extracted separately from the Base, Middle and the Top of the log. Ground total of 90 blocks of wood pellets was extracted from the whole of the tree trunk. All the 90 blocks of wood pellets were used for the whole of the experiments involved in the assessment.

Determination of Wood Density

Determination of wood density was according to Okoegwale and Gill (1991). Each of the freshly cut blocks of the dimension 2cm x 2cm x 6cm was initially weighed using sensitive balance and the value was recorded as the wet weight (Ws) The wet weighed blocks were oven dried at the interval of 2 hours with the aid of an electric oven machine and the new weight was measured as the oven-dry weight (Wo). From these measurements, the density of the wood (D) was determined as:

$$D = \frac{1}{\frac{Ws-Wo}{Wo}} + \frac{1}{1.53}$$

Where: D= Wood density
Ws = Wet-weight of specimen
Wo = Oven-dry weight of specimen
1/1.53= Reciprocal of the density of wood substance.

Determination of Percentage Moisture Content

Determination of percentage moisture content was according to Otoide *et.al*. (2012). Each of the freshly cut blocks of dimension, 2cm x 2cm x 2cm was initially weighed, using sensitive balance and the value was recorded as the wet weight (Wu). The wet weighted blocks were then, oven dried at intervals of 2 hours with the aid of an electric oven machine. At the various intervals of this process, the blocks were reweighed to achieve a new type of weight. This was repeated until a constant weight, known as the oven dry weight (Wo), was measured and recorded. The formula:

$$\%Mc = \frac{(Wu-Wo)}{Wu} \times \frac{100\%}{1}$$

Where:
%Mc = Percentage moisture content (%)
Wu = Wet weight of wood (g)
Wo = Oven dry weight (g),
was used to determine the percentage moisture content.

Experimental Design

The Experimental Design adopted for this work is a two Factorial in a Complete Randomized Design (C.R.D) with different replications of the test Samples.

Factor A: The longitudinal direction (Base, Middle and Top) of the trunk.

Factor B: The radial directions, where the sample sticks were collected (The Core, Middle and Outer) region of the trunk.

Statistical Analysis

Analysis of Variance (ANOVA) was conducted to test the relative importance of various sources of variation on the Density (g/cm^3) and percentage moisture of the woody stem. The main effects considered were differences along the longitudinal (i.e. Axial) and Radial Positions. The Follow-up test was conducted, using Duncan Multiple Range Test (D.M.R.T). This was done to know the significant difference between the two Means at $P \le 0.05$. The mathematical Model for the two Factors factorial experiment is given as:

Yij = u + Ai + Bj + (AB)ij + Eij

Where:
μ = General mean of individual observation;
Ai = Effect of Factor A;
Bj = Effect of Factor B;
(AB)ij = Effect of interaction between Factor A and B;
Eij = Effect of interaction Error term.

RESULTS AND DISCUSSION

The physical properties evaluated in the present research were wood density (g/cm^3) and percentage moisture content (%). The results have been summarized in tables 1 and 2 respectively. The overall mean values for wood density and moisture content of the stem were 572.93 ± 191.25 and 125.18 ± 54.73 respectively. These values placed the woody stem of *Alstonia boonei* in the class of average density and light-weight woods. When evaluated from the axial direction pool means of 539.75 ± 42.49, 541.10 ± 191.54 and 637.95 ± 263.94 were the wood density for the base, middle and top positions of the stem respectively (Table 1). Whereas, from the radial direction the pool means of 571.39 ± 238.56, 670.83 ± 182.93 and 476.58 ± 66.05 were the values for wood density at the core-, middle- and outer-woods of the stem respectively (Table 1).

In the case of percentage moisture content (%), pool means of 121.04 ± 15.38, 139.29 ± 66.71 and 115.20 ± 66.25 were the percentage moisture content of the stem at the base, middle and top positions respectively (Table 2). However, when evaluated from the radial directions pool means of 131.34 ± 61.34, 93.68 ± 39.94 and 150.51 ± 47.59 were the percentage moisture content of the stem at the core-, middle- and outer-woods positions of the stem respectively (Table 2).

Results obtained in the present evaluation showed that wood density increased from the base to the top of the stem of this species. Though this was not significant at $P \le 0.05$. On the other hand, there were variations in wood density from core-, to outer-woods of the stem. This variation was significant at $P \le 0.05$ (Table 1). Furthermore, the percentage moisture content varied insignificantly at $P \le 0.05$ from base to top of the stem but from core-, to outer-woods it varied significantly at $P \le 0.05$.

In view of the foregoing, it suffices to point out that the woody stem of *Alstonia boonei* has high moisture in it. In this state, the mechanical property of the stem is very low and will not be suitable for building and construction purposes.

Table 1: Wood Density (g/cm^3) of the woody stem of *Alstonia boonei* (De wild).

AXIAL POSITION	RADIAL POSITION			
	COREWOOD	MIDDLEWOOD	OUTERWOOD	POOLMEAN
BASE	559.25±17.82	574.62±10.29	485.36±14.20	539.75±42.49[a]
MIDDLE	478.16±94.65	722.15±217.73	422.99±93.19	541.10±191.54[a]
TOP	676.74±406.18	715.73±228.54	521.37±13.66	637.95±263.94[a]
POOL MEAN	571.39±238.56[a]	670.83±182.93[b]	476.58±66.05[c]	572.93±191.25

Means with same letters on the column are not significantly different (P ≤ 0.05) from one another but means with different letters on the row are significantly different (P ≤ 0.05) from one another.

Table 2: Percentage Moisture Content (%) of the woody stem of *Alstonia boonei* (De wild).

AXIAL POSITION	RADIAL POSITION			
	COREWOOD	MIDDLEWOOD	OUTERWOOD	POOLMEAN
BASE	113.60±5.76	108.71±3.08	140.81±6.11	121.04±15.38[a]
MIDDLE	149.53±36.75	84.15±46.49	184.18±74.92	139.29±66.71[a]
TOP	130.90±104.77	88.17±54.58	126.55±5.01	115.20±66.25[a]
POOL MEAN	131.34±61.34[b]	93.68±39.94[c]	150.51±47.59[a]	125.18±54.73

Means with same letters on the column are not significantly different (P ≤ 0.05) from one another but means with different letters on the row are significantly different (P ≤ 0.05) from one another.

However, to increase the mechanical property, it would need to be subjected to drying. This notion is in line with the assertion of Winandy (1994) that the mechanical property value of wood increases as wood dries from the fiber saturation point to 10 to 15% moisture content. For clear wood, mechanical property values continue to increase as wood dries below 10 to 15% moisture content.

Furthermore, the high moisture content of the stem of this species could make it to face the risk of infection by wood deterioration agents such as fungi and insects. The earlier reports of Otoide (2016) about the woody trunk of *Afzelia africana* lend credence to this claim. In line with this, TRADA (2011) advised that reduction of the moisture content of wood below 20% will make it resistant to damaging agents that usually take advantage over wet woods. It therefore means that if the moisture in the woody stem of *Alstonia boonei*, which was 125.18 ± 54.73 is reduced to between 18-20% the woody stem would become resistant to infection by wood deteriorating agents and also become useful for construction purposes. On the other hand, if the intended end product is in the context of herbal medicine, reduction of the moisture content of the stem of this species might not be necessary since decoction and other herbal medicine preparations require water.

In view of the average density evaluated for this species, it suffices to deduce that the woody stem of this species be recommended for end use where light-weight wood will not be a disadvantage such like light construction, light carpentry, boxes, crates, matches, pencils, plywood, sound boxes of musical instruments e. t. c.

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