PHYSICAL PROPERTIES OF TEN SELECTED INDIGENOUS WOOD SPECIES IN AKURE, ONDO STATE, NIGERIA

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Abstract

The identification of wood can be of critical importance to primary and secondary industrial users of wood, and museums, as well as to scientists in the fields of botany, ecology, forestry, and wood technology. Since wood is a popular and useful material, it is important that professionals be able to distinguish the wood of one species from another. Wood can be identified by using features like mechanical strength, density, hardness, odour, texture and colour. Reliable wood identification usually requires the ability to recognize basic differences in cellular structure and wood anatomy. This study was carried out to determine some physical properties of ten selected indigenous Nigerian wood species. The physical properties of wood species that were studied in this study include; the grain pattern, texture, colour, vessels (pore) distribution and arrangement, rays, density and specific gravity of the wood species. The wood species were collected from different sawmills in Akure, whose major source was Akure forest reserve and its environment. Observations were carried out and the results obtained were compared with information from past records and research made previously on the selected wood species.The result of the study showed variation in all the properties studied. This result and information obtained on the physical properties of the selected wood species were documented and this could be used as baseline information on identification of the wood species, research work and future referencing.

Keywords: Grain pattern, texture, colour, vessels, rays, density, specific gravity.

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Introduction

Wood is one of the oldest, best known structural material, and one of the few renewable natural resources. The ubiquitous nature of wood has made it a valuable material in every stage of human development (Fuwape, 2000). All wood is composed of cellulose, hemicelluloses, lignin, and minor amounts of (5% to 10%) of extraneous materials contained in a cellular structure. Variations in the characteristics and volume of these components and differences in cellular structure make wood heavy or light, stiff or flexible, and hard or soft. However, to use wood to its best advantage and most effectively in engineering applications, specific characteristics or physical properties must be considered. Each wood species has unique cellular structure that creates differences in wood properties and ultimately determines the suitability for a particular use (Brian and Peter, 2002).

Wood identification is a visual exercise based on the characteristic macroscopic and microscopic structural features, which requires the ability to recognize basic differences in wood anatomy and cellular structure (Rocio, *et al*., 2011; Gurau, *et al*., 2010). Wood identification has significant applications to an extensive range of professional fields and academic disciplines. It may assist in forensic science and law; impart invaluable support to quarantine and customs and to antique dealers. It may contribute to biology, archeology, palaeobotany and pharmaceutics (Gurau, *et al*., 2010; Alex, *et al*., 2012; Wheeler and Baas 1998).

Wood is composed of many small cells and its structure is determined by the type, size, shape and arrangement of these cells. The structure and characteristics of wood can vary between species and within the same species. Lumber graders, furniture workers, and those working in the industry often identify wood with their naked eye. Wood of a particular species can be identified by its unique features. These features include strength, density, hardness, odor, texture and color. With experience these features can be used to identify many different woods, but the accuracy of the identification is dependent on the experience of the person and the quality of the unknown wood. If the unknown wood is atypical, decayed, or small, often the identification is incorrect. Examining woods, especially hardwoods, with a 10–20x hand lens greatly improves the accuracy of the identification (Brunner et al. 2001). Reliable wood identification usually requires the ability to recognize basic differences in cellular structure and wood anatomy. Cellular characteristics provide a blueprint for accurate wood identification (Brian and Peter, 2002)

Equally as important as the light microscope in wood identification is the reference collection of correctly identified specimens to which unknown samples can be compared (Wheeler and Baas 1998). If a reference collection is not available, books of photomicrographs or books or journal articles with anatomical descriptions and dichotomous keys can be used (Illic 1991, Miller and Détienne 2001). Wood species identification is a key issue in the scientific conservation of old wooden objects. This is not only because of the need for a replacement or completion with the same type of wooden material as the original, but also due to the importance of a scientific documentation regarding the old objects for taking any conservation action (Maria *et. al* 2012).

Each kind of wood differs as to hardness or softness, fine or coarse texture, open or close grain, light or dark colours. Wood of a particular species can be identified by its unique features. As such there is the need to be able to distinguish the wood of one species from another. This study was therefore carried out to identify the basic physical properties of ten selected indigenous Nigerian wood species in Akure South Local Government Area of Ondo State. Indigenous properties of wood have been recognized by various worker (Desch & Dinwoodie (1996), Hoaldy (1990), and Parsapajouh and Schweingruber (1993)), also Toghraie *et al*., (1999) developed computerized database of wood anatomy to identify the timber species, but the characteristic of indigenous wood cross-section which is visible with lens is very handy and useful tool in timber identification and documentation, have not been much researched into. This study was therefore carried out to identify and describe the basic physical properties of ten selected indigenous Nigerian wood species in Akure South Local Government Area of Ondo State.

Materials and Method

Ten (10) indigenous wood species were obtained from freshly converted logs of wood at a Sawmill in Akure, Ondo State, Nigeria. They include; Abura *(Mitragyna ciliata)*, Afara (*Terminalia superba*), Araba *(Ceiba pentandra)*, Aye *(Sterculia rhinopetala)*, Idigbo (*Terminalia ivorensis*), and Iroko *(Milicia excelsa)*. Others include Obeche (*Triplochiton scleroxylon*), Ofun (*Mansonia altissima*), Omo (*Cordia millenii*) and Opepe (*Nauclea diderrichii*). The wood samples were collected and identified by locals and taxonomist. Other materials used are; Circular sawing machine, Oven, Weigh Balance (Mettler PJ6), Hand lens (2.5x, 5x Magnification), Colour chart, Knife, Water.

The wood samples were prepared in the wood workshop and laboratory sections of the Department of Forestry and Wood Technology, Federal University of Technology, Akure, Ondo State. The macroscopic observations were conducted using facilities at the Forestry Research Institute of Nigeria (FRIN), Jericho, Ibadan, Oyo State, Nigeria.

Determination of physical properties of the wood

The physical properties determined include wood density, specific gravity, colour, texture, grain pattern, pore transition and arrangement, and ray visibility. The density and specific gravity were determined according to ASTM, (2006) procedures. While the macroscopic identification was carried out based on the procedures of Brain and Peter (1998) and David, (2010).

In the determination of the wood density, the wood species were cut into blocks (2cm x 2cm x 10cm) replicated five times and oven-dried at a temperature maintained at 105°C for 24 hours. During the period of oven-drying, the weights and dimensions of the wood samples were taken at regular intervals until constant weights and dimensions were obtained and the wood density was calculated using:

$$D = \left(\frac{W}{V}\right) \text{Kg/m}$$

Where: D = Wood density

W = Weight of the wood

V = Volume of the wood (L x B x W)

(L (longitudinal) x B (Radial) x W (Tangential))

The density determination procedure was also used in obtaining the specific gravity of the wood samples. The specific gravity of the wood samples was calculated using;

$$\text{Specific gravity} = \frac{\text{Density of the wood sample (kg/m}^3\text{)}}{\text{Density of equal volume of water (1000 Kg/m}^3\text{)}}$$

Macroscopic identification (colour, texture, grain pattern, pore transition and arrangement, and ray visibility) of the wood samples involved cutting the wood into blocks (2cm x 2cm x 6cm). A small portion of the wood samples were sliced with a sharp knife in the transverse direction (cross-section i.e. the view exposed by cuts made at right angles to the axis of the tree stem). The surface of the wood sample was neatly sliced and moistened with water so as to enhance observation of the wood surface in order to obtain a good and clean section. Thereafter, the clean surface was observed under a hand lens of magnification 2.5x and 5x, while the pores arrangement and the rays were observed and recorded. The texture and grain pattern were observed from the longitudinal direction (i.e. direction parallel to the grain of the wood). The colour of the wood samples was carried out by visual observation of the wood samples and compared with colours obtained from a colour chart. A descriptive statistical analysis was also carried out to determine the standard error of the wood density. This standard error gives a range of variation and dispersion in the density of the wood species.

Results and Discussion

The result of density for the wood species shown in Table 1 revealed that value was low in species like *Ceiba pentandra, Triplochiton scleroxylon, Cordia millenii.* Their density ranged between 398.47kg/m^3 and 436.51kg/m^3. The wood density of *Mitragyna ciliate, Terminalia superba, Terminalia ivorensis* ranged between 550.80kg/m^3 and 583.63kg/m^3. The closeness in the values for *Terminalia superba* and *T. ivorensis* can be attributed to the fact that they belong to the same family of Combretaceae. But this fact was not true for *Triplochiton scleroxylon, Mansonia altissima and Sterculia rhinopetala* which belong to the same family of Sterculiaceae; as well as *Mitragyna ciliate* and *Nauclea diderrichii* which also belong to the family of Rubiaceae. These wood species belong to the same family but had very wide range of wood density. Thus the fact that wood species belong to the same family does not necessarily mean they will have similar or closely related density. *Milicia excelsa* and *Mansonia altissima* had a close range of wood density of 632.52kg/m^3 and 653.66kg/m^3 respectively. Wood species of *Sterculia rhinopetala* and *Naulea diderrichii* had the highest wood density of 728.27kg/m^3 and 739.45kg/m^3 respectively. Variation in properties of wood as a natural material from the tree is subject to many constantly changing influences (such as moisture, soil conditions, and growing space), wood properties vary considerably, even in clear material (David, 1999). Vahidreza et al., (2008) who worked on identification of Iranian wood suggested that due to wide variance and similar values, wood densities could not be used alone to identify various wood. The result of the density of the various wood samples obtained from this study compared with result obtained from literatures showed little or no differences. The implication of this is that irrespective of location, equipment and method of determination of density, there will be little or no significant variation in the density of indigenous wood species (Table 1 and fig 1). The value range for density and specific gravity followed the same patter because specific gravity is the density of wood relative to the density of water. It is an indication of the quantum of woody tissue per unit volume which will also determine the absorption of preservatives by the wood. This was expressed in the work done by FRIN (1992). A comparison of the study work with those obtained from available literature shown in figure 1 revealed little difference for all the wood species with the exception and *Sterculia rhinopetala and Mansonia altisima*.

The result of macroscopic examination of the ten selected wood species revealing colour, texture and grain pattern is shown in Tables 2, 3, 4, 5, 6 and 7. The colour ranged from reddish pink for *Mitragyna ciliata* (Abura) to golden for *Nauclea diderrichi* (Opepe). Colour is an essential feature of wood identification, and in most wood with distinct heartwood and sapwood, it ranges from dark to light e.g. *Mitragyna ciliata, Mansonia altisima* etc. (Plates 5-14). Familiarity with physical properties is important because they can significantly influence the performance and strength of wood used in structural applications (Jerrold, 1994). A combination of qualities should be considered when selecting a species for flooring: appearance related attributes such as texture, grain and color (NWFA, 2004).

The result of examination for texture (Table 3) showed classification into fine and coarse; the grain pattern for the selected wood species showed that Abura had straight grain, idigbo straight grain and sometimes interlocked, *Araba, Aye, Iroko, Obeche, Ofun, Omo and Opepe* had interlocked grain (Table 4). Pore distribution and arrangement revealed showed transmission from ring porous for Omo, semi-ring porous- Araba to diffuse porous for others (Table 5) and solitary to cluster (Table 6). Rays visibility of the ten selected wood species ranged from visible to not visible (Table 7).

The result of this study showed variation in the properties of these species, this is in consonance with the works of Terry, (2011) and Brian and Peter (2002) that nature has not produced two wood species which are exactly identical. General wood identification can often be made quickly on the basis of readily visible characteristics such as color, odor, density, or grain pattern (Regis, 1999).The knowledge and understanding of the properties of wood is of utmost importance to wood users in selecting appropriate wood for a job design. Engineers, Architects, builders will prefer high density wood with corresponding mechanical properties for structural work in building, while furniture and interior designers will prefer wood with fine texture and good grain patterns.

Table 1: Density and Specific Gravity of the Wood Species

Density Class	Scientific names	Trade names	Density (kg/m^3)	Specific Gravity
High Density	*Naulea diderrichii*	Opepe	739.45±19.35a	0.74
	Sterculia rhinopetala	Aye	728.27±20.53a	0.73
Medium	*Milicia excelsa*	Iroko	653.66± 9.59a	0.63
	Mitragyna ciliata	Abura	632.52±30.19a	0.58
	Terminalia ivorensis	Idigbo	583.63±21.73b	0.56
	Terminalia superba	Afara	555.08±12.91b	0.55
	Mansonia altissima	Ofun	550.80±16.67b	0.65
Low	*Cordia millenii*	Omo	436.51 ±14.39c	0.44
	Triplochiton scleroxylon	Obeche	407.50 ±13.76c	0.41
	Ceiba pentandra	Araba	398.47 ±9.39cc	0.40

***Means with the same superscript are not significantly different**

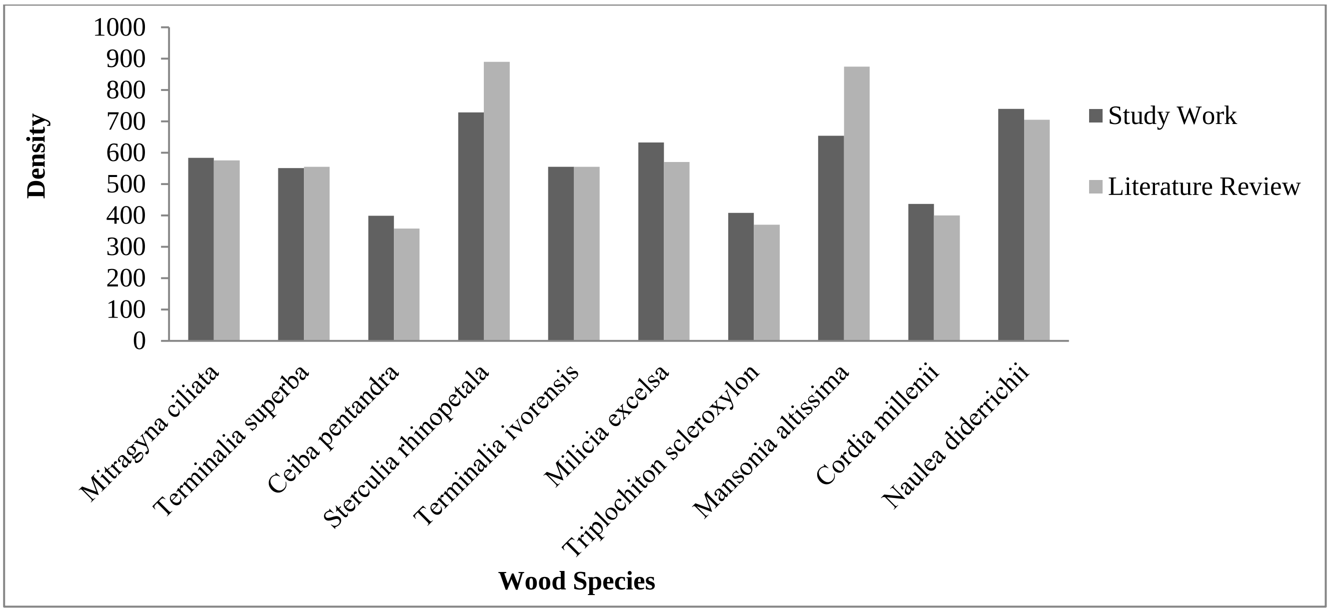

Figure 1: Comparison density values obtained from the study and available literature.

Table 2: Observed colour of the Ten Selected Indigenous Wood Species

	Brown			Yellow						
Wood Species	**Reddish**	**Dark**	**Pink**	**White**	**Pale**	**Golden**	**Greyish**	**Brown**	**Cream White**	**Olive Greenish Grey**
***Mitragyna ciliata* (Abura)**	+		+							
***Terminalia superba* (Afara)**										+
***Ceiba pentandra* (Araba)**				+						
***Sterculia rhinopetela* (Aye)**	+	+								
***Terminalia ivorensis* (idigbo)**					+					
***Milicia excelsa* (Iroko)**							+	+		
***Triplochiton scleroxylon* (Obeche)**									+	
***Mansonia altissima* (Ofun)**							+	+		
***Cordia millenii* (Omo)**	+									
***Nauclea diderrichi* (Opepe)**						+				

Table 3: Texture of the Ten Selected Indigenous Wood Species

S/N	Texture Properties	
	Fine	**Coarse**
1	*Mitragyna Ciliata* (Abura)	
2	*Terminalia superba* (Afara)	
3		*Ceiba pentandra* (Araba)
4		*Sterculia rhinopetala* (Aye)
5		*Terminalia ivorensis* (Idigbo)
6		*Milicia excelsa* (Iroko)
7		*Triplochiton scleroxylon* (Obeche)
8	*Mansonia altissima* (Ofun)	
9		*Cordia millenii* (Omo)
10		*Nauclea diderrichii* (Opepe)

Table 4: Grain Pattern of the Ten Selected Indigenous Wood Species

S/N	Grain Pattern		
	Straight	**Interlocked**	**Irregular**
1	*Mitragyna Ciliata* (Abura)		*Mitragyna Ciliata* (Abura)
2			*Terminalia superba* (Afara)
3		*Ceiba pentandra* (Araba)	
4		*Sterculia rhinopetala* (Aye)	
5	*Terminalia ivorensis* (Idigbo)	*Terminalia ivorensis* (Idigbo)	
6		*Milicia excelsa* (Iroko)	
7		*Triplochiton scleroxylon* (Obeche)	
8		*Mansonia altissima* (Ofun)	
9		*Cordia millenii* (Omo)	
10		*Nauclea diderrichii* (Opepe)	

Table 5: Pore Transition of the Ten Selected Indigenous Wood Species

S/N	Pore Transition from Earlywood to Late wood		
	Ring Porous	**Semi-Ring Porous**	**Diffuse porous**
1			*Mitragyna Ciliata* (Abura)
2			*Terminalia superba* (Afara)
3		*Ceiba pentandra* (Araba)	
4			*Sterculia rhinopetala* (Aye)
5			*Terminalia ivorensis* (Idigbo)
6			*Milicia excelsa* (Iroko)
7			*Triplochiton scleroxylon* (Obeche)
8			*Mansonia altissima* (Ofun)
9	*Cordia millenii* (Omo)		
10			*Nauclea diderrichii* (Opepe)

Table 6: Vessel (Pore) Arrangement of the Ten Selected Indigenous Wood Species

S/N	Vessel (Pore) Arrangement		
	Solitary Pore	**Pore Multiple**	**Nested (Cluster) Pore**
1		*Mitragyna Ciliata* (Abura)	
2	*Terminalia superba* (Afara)		
3		*Ceiba pentandra* (Araba)	
4	*Sterculia rhinopetala* (Aye)		
5	*Terminalia ivorensis* (Idigbo)	*Terminalia ivorensis* (Idigbo)	
6		*Milicia excelsa* (Iroko)	
7	*Triplochiton scleroxylon* (Obeche)		
8	*Mansonia altissima* (Ofun)		*Mansonia altissima* (Ofun)
9	*Cordia millenii* (Omo)		
10	*Nauclea diderrichii* (Opepe)		

Table 7: Rays Visibility of the Ten Selected Indigenous Wood Species

S/N	Rays Visibility	
	Visible	**Not Visible**
1	*Mitragyna Ciliata* (Abura)	
2		*Terminalia superba* (Afara)
3	*Ceiba pentandra* (Araba)	
4		*Sterculia rhinopetala* (Aye)
5	*Terminalia ivorensis* (Idigbo)	
6		*Milicia excelsa* (Iroko)
7	*Triplochiton scleroxylon* (Obeche)	
8		*Mansonia altissima* (Ofun)
9	*Cordia millenii* (Omo)	
10	*Nauclea diderrichii* (Opepe)	

Conclusion

Reliable wood identification usually requires the ability to recognize basic differences in cellular structure and wood anatomy This requires training and can be reinforced through practical exposure. Knowing what to look for and where to look by visual observation in picking up unique wood characteristics and features enables accurate and efficient wood identification.

The result of this study work as revealed by the general principles of wood identification showed that irrespective of geographical location or environment, there will be little or no significant differences in the physical features and properties of indigenous wood species. Each species has unique cellular structure that creates differences in wood properties and ultimately determines the suitability for a particular use. Cellular characteristics provide a blueprint for accurate wood identification. Information on the physical characteristics of the ten selected indigenous wood species presented in the tables above can therefore be used in the identification of unknown wood species that falls within the range of the ten selected indigenous wood species.

Wood preparation and identification

Plate 1: Wood samples at FRIN laboratory

Pore distribution and arrangement

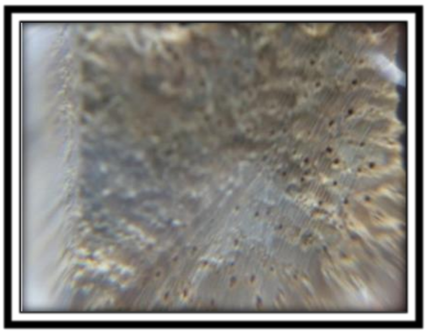

Plate 2:Solitary and diffuse porous

Plate 3: Solitary pores

Wood Colour


Plate 4: *Mitragyna ciliata*)


Plate 5: *Terminalia superba*


Plate 6: *Ceiba pentandra*


Plate 7: *Sterculia rhinopetala*


Plate 8: *Terminalia ivorensis*


Plate 9: *Milicia excelsa*


Plate 10: *Triplochiton sceroxylon*


Plate 11: *Mansonia altissima*


Plate 12: *Cordia millenii*


Plate 13: *Nauclea diderrichi*

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