Global Journal of Science Frontier Research
Agriculture and Veterinary
Volume 13 Issue 9 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

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GJSFR-D Classification : *FOR Code: 070509*

UTILIZATION OF SOME SELECTED WOOD SPECIES IN RELATION TO THEIR ANATOMICAL FEATURES

Strictly as per the compliance and regulations of :

Utilization of Some Selected Wood Species in Relation to their Anatomical Features

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Keywords : fibres, vessels, microscopic, moe, and mor.

I. Introduction

The thickness of the fibre cell wall is the major factor governing density and strength in wood. Species with thin-walled fibers such as cottonwood (Populus deltoides), basswood (*Tilia americana*), *Ceiba pentandra,* and balsa (*Ochroma pyramidale*) have a low density and strength and are therefore preferred for light construction purposes, whereas species with thick-walled fibers such as *Diospyros spp,* hard maple (*Acer saccharum* and *Acer nigrum*), black locust (*Robinia seudoacacia*), Ipe (*Tabebuia serratifolia*), and bullet-wood (*Manilkara bidentata*) have a high density and strength which have made them useful in heavy construction work. The patterns of rays also account for variations in wood processing and wood utilization. For instance, the rays in hardwoods are much more diverse than those found in softwood, and usually more than one cell wide (though in some species, e.g. *Brachystegia kennedyi* and cottonwood, the rays are exclusively uniseriate and are much like the softwood rays). Variation in anatomical properties is not only observed from one species to the other but also within the same species; within a tree, there are differences in wood properties between the core wood of the tree and the outer wood (Albert *et al.*, 2004). This variability reflects in wood utilization. There is a particular pattern of axial parenchyma uniquely present in each wood species, which is more or less consistent from specimen to specimen, and these cell patterns are very important in both wood identification and utilization (Alex and Regis, 2000), yet histological features of wood, the wood chemical components and its mechanical properties vary from pith to bark, from tree base to the top, from the stem to the branches and roots (Rupert, 2002).

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II. Variability of End Uses

Woods of different species from the same genus often have different properties and perform differently under various conditions. Serious problems can develop if species or genera are mixed during the manufacturing process and in use. In order to understand the behaviour of wood in service it is essential to begin with an understanding of the structure and variability of the cells that different wood species are made of. The arrangement, distribution and sizes of wood cells are not the same for every wood. Wood deposits (such as gum and resin), cell wall thickness and pore size are not the same in all wood species. While gum veins is often a natural protective response to injury in most Eucalyptus, gum deposits in some wood species have been found useful in the production of adhesives by the appropriate industries. The dense fibres of *Xylia dolabridormis* are plugged with gum and this makes the wood resistant to wear and thus it is excellent for flooring. The gum resins in *Lignum vitae* is also believed to make the wood self lubricating so that it can be useful for pulley blocks and for pushing the propeller shafts of ships, while gum deposits in the wood of Indian rosewood (*Dalbergia spp*) have been found to pose problems. Kaiser (2003) stated that logs with calcerous deposits are more prone to checking. Wood deposits can shorten the life span of cutting surfaces, and at the finish stage, although coloured deposits in the pores dissolve when solvents containing alcohol are used, and as a result, this can lead to stains. Some wood species glue and finish well but can create

Global Journal of Science Frontier Research (D) Volume XIII Issue IX Version I Year 2013

stain as a result of gum deposits which Balakrisman (2010) mentioned as being promoted by poor soils, drought and other hostile situations. The differences in wood structure and properties allow for the manufacture of wood-based products with many different appearances and uses. For example, a barrel manufacturer tells the difference between red oak, which does not hold liquids, and white oak, which does. Each species has unique cellular structure that creates differences in wood properties and ultimately determines the suitability for a particular use. Therefore, it is necessary to study wood features because specific features in some wood species have suggested them for certain end uses as indicated earlier. Other hardwood species like *Gmelina arborea* was found appropriate for pulp and paper making after investigation into its fibre characteritics.

III. Microscopic Features

The mean tangential diameters (MTDs) of *Ceiba pentandra, Bombax bounopozense, Terminalia superba, Terminalia ivorensis, Milicia excelsa, Tectona grandis, Gmelina arborea, Triplochiton scleroxylon, Ricinodendron heudeolotii, Lophira alata, Afzelia africana* and *Nauclea diderrichii* are over 200 µm, in fact, those of *Ricinodendron heudeolotii*, *Bombax bounopozense* and *Ceiba pentandra* are well over 300 µm. The implication of this is that such wood species have large pores; while the pore sizes of *Nesogordomia papaverifera, Mansonia altissima* and *Diospyros mespiliformis* are small to medium (Table 1). The vessel diameter for *Ceiba pentandra* and *Bombax bounopozense* are 387.75µ and 318.56µ respectively; *Nesogordomia papaverifera* is less than 100µ, while *Diospyros mespiliformis* and *Mansonia altissima* both have 119.04µ and 127.72µ respectively. The mean tangential diameter and cell wall thickness of the wood species are also presented in table 2, while Figures 1-6 show the wood micrographs of some wood species.

Table 1 : Anatomical features and strength properties of selected wood species

Wood Species	MTD (µ)	Fibre diameter (µ)	Cell wall (µ)	Lumen Width (µ)	Runkel ratio	Density at 18% (kg/m^3)	MOR (N/mm^2)	MOE (N/mm^2)	Strength group
Diospyros mespiliformis	119.04	17.41	5.41	6.59	1.64	864	28.00	12,500	N2
Nauclea diderrichii	215.08	29.34	7.29	14.76	0.98	800	35.50	15,000	N1
Tectona grandis	241.24	33.40	8.50	16.40	1.04	640	22.4	10,600	N3
Triplochiton scleroxylon	234.47	18.00	4.00	10.00	0.80	384	11.20	6,300	N6
Terminalia superba	262.00	32.00	8.00	16.00	1.00	464	11.2	6,300	N6
Afzelia Africana	206.20	23.60	5.73	12.30	0.93	864	28.00	12,500	N2
Ceiba pentandra	387.75	37.51	3.54	30.43	0.23	378	11.20	6,300	N6
Mansonia altissima	127.72	28.16	6.24	15.68	0.80	672	22.4	10,600	N3
Gmelina arborea	212.00	38.60	5.10	28.40	0.36	512	14.00	7,500	N5

MTD = mean tangential diameter

Density, MOR and MOE values are dry basic stresses from Nigeria Code of Practice (NCP 2), 1973.

Table 2 : Correlation between Anatomical features and strength properties of timber species

	MTD	*Fibre diameter*	*Cell wall*	*Lumen*	*Rr*	*Density at 18%*	*MOR*	*MOE*	*Strength group*
MTD	1								
Fibre diameter	0.563838	1							
Cell wall	-0.24424	0.169884	1						
Lumen	0.657487	0.904569	-0.26641	1					
Rr	-0.65295	-0.69774	0.451107	-0.87826	1				
Density at 18%	-0.67544	-0.41527	0.352079	-0.55594	0.671688	1			
MOR	-0.54833	-0.3293	0.381926	-0.48565	0.571193	0.932862	1		
MOE	-0.56447	-0.3245	0.388154	-0.48363	0.572581	0.939295	0.999302	1	
Strength group	0.609365	0.320711	-0.39696	0.483606	-0.58132	-0.95581	-0.98889	-0.99369	1

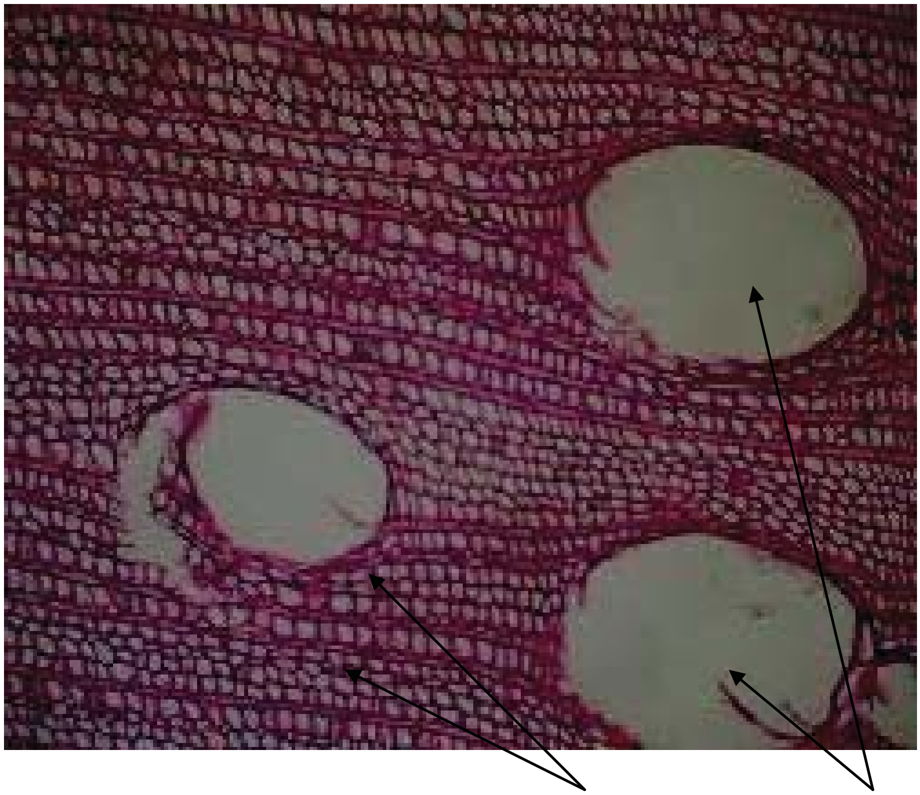

Figure 1 : Ricinodendron heudelotii (Tr. Sec.) Thin fibre wa Large pores

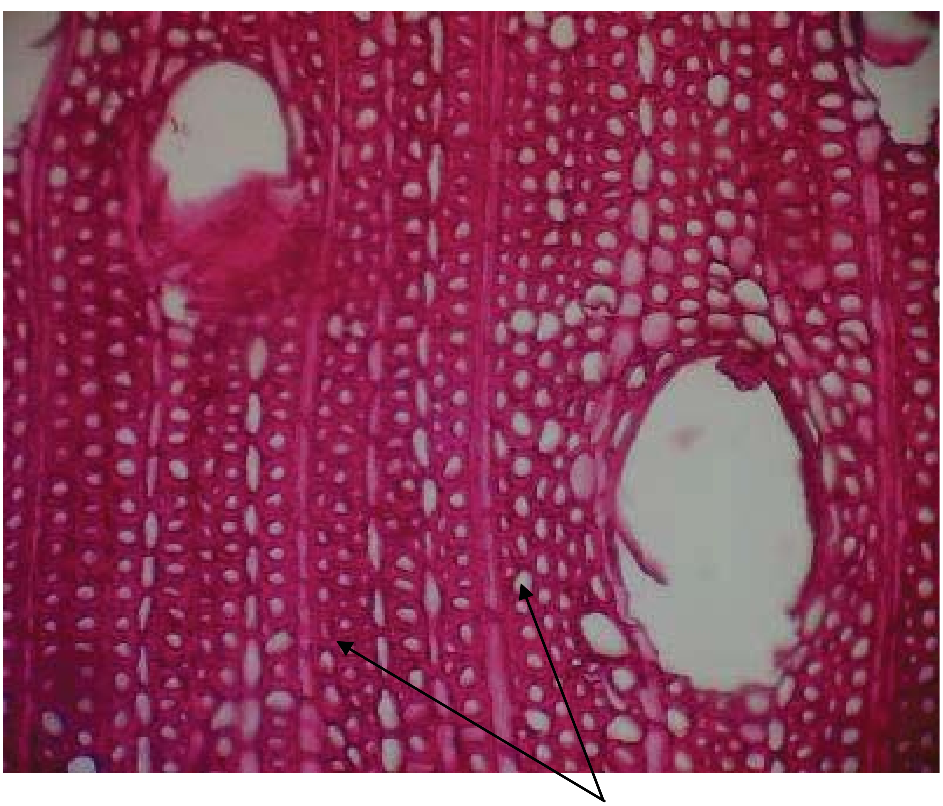

Figure 2 : Nauclea diderrichii (Tr. Sec.) Thicker fibre walls

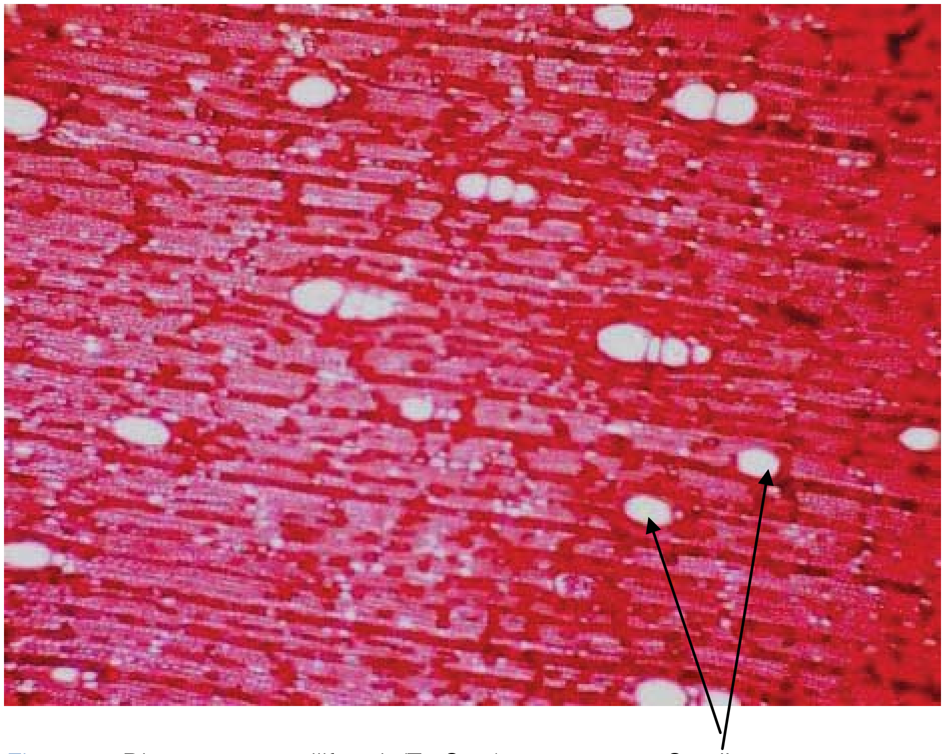

Figure 3 : Diospyros mespiliformis (Tr. Sec.)

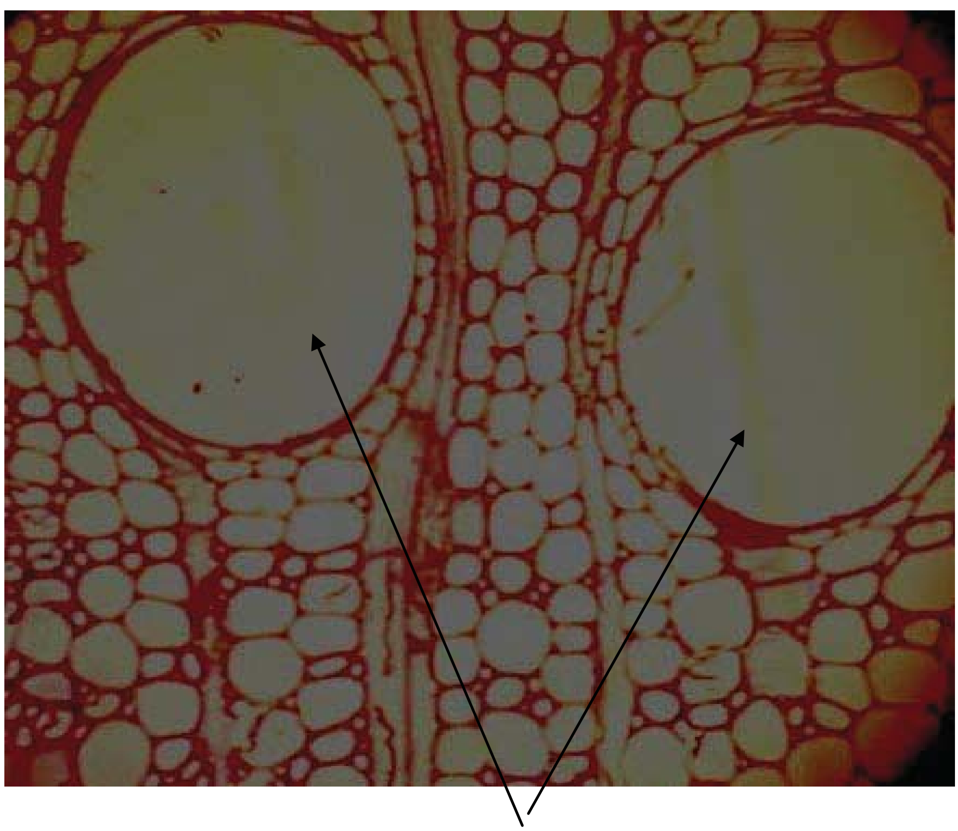

Figure 4 : Ceiba pentandra (Tr. Sec.)

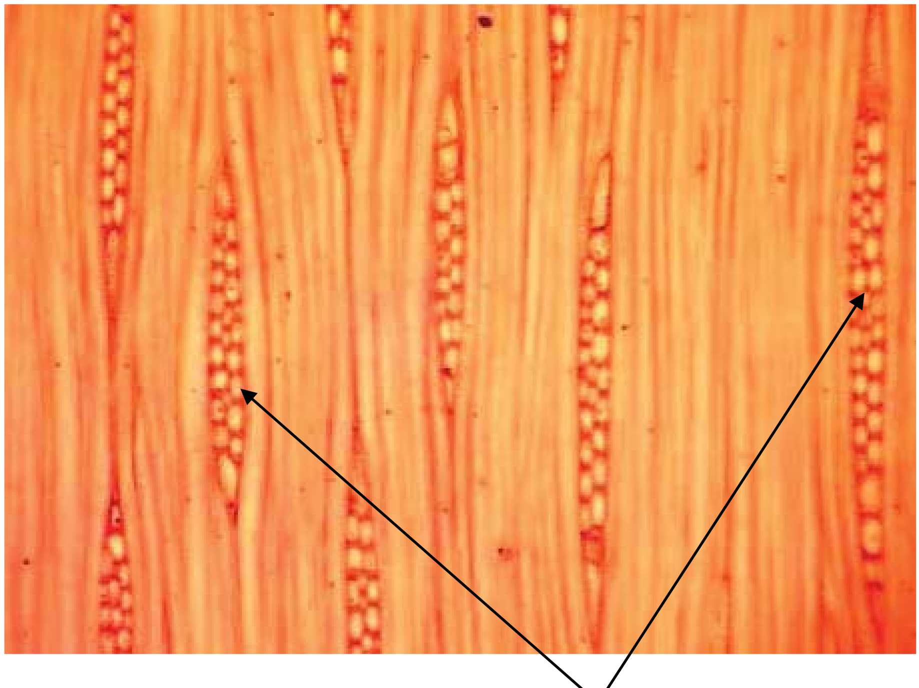

Figure 5 : *Terminalia ivorensis* (TLS) Multi-seriate rays

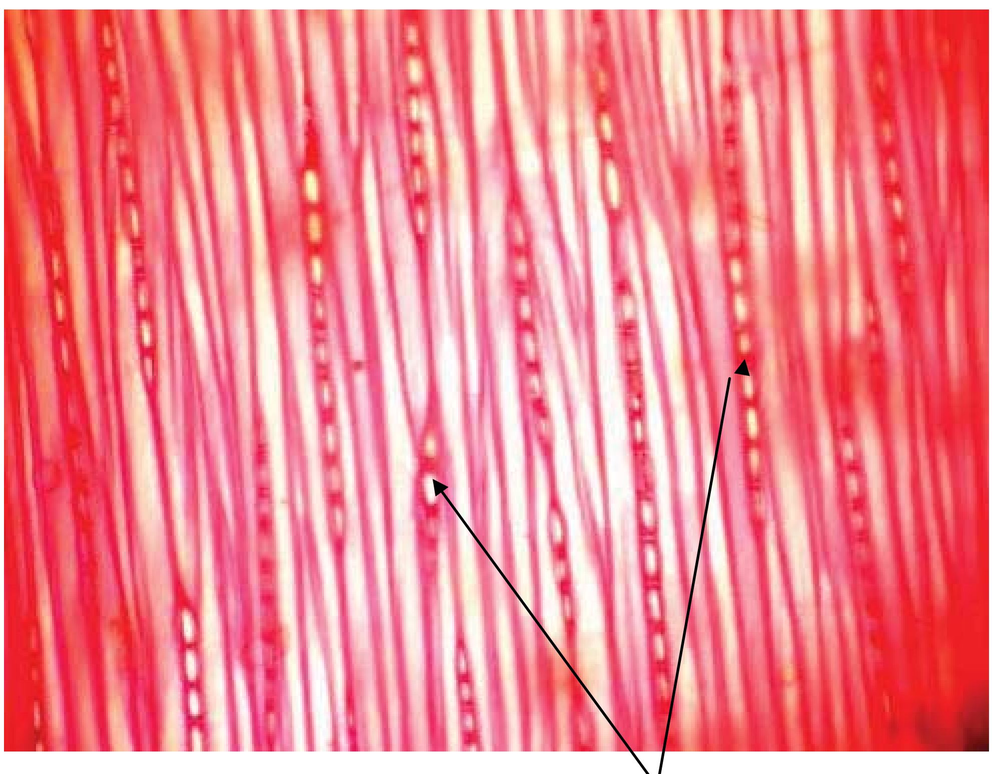

Figure 6 : *Terminalia superba* (TLS) Uniseriate rays

IV. Implications of Wood Features to Wood Utilization

Karl (1984) reported that wood species with large vessels, such as *Ceiba pentandra* and Bombax for instance, may not be good for printing papers. Such wood species with large pores also require some fillers before it is finished to a smooth surface; moreover, species with large pores (e.g. *Ceiba pentandra*) are usually easily attacked by beetles because their eggs are usually laid in the pores after feeding on the starchy contents of the sapwood. Generally, wood with large pores are light, and of coarse texture e.g. *Triplochyton scleroxylon, Ceiba pentandra, Bombax bounopozense* and *Ricinodendron heudelotii.* This could explain the reason why they are used for light construction purposes, lightweight furniture, particle boards, matches, boxes, crates and cabinet making. Small-vessel wood species include *Nesogordomia papaverifera, Diospyros mespiliformis* and *Mansonia altissima*. This characteristic has bestowed fine texture upon the wood species which are often heavy and are often used for flooring, tool handles, sculpture (as in *Diospyros mespiliformis*) and other heavy constructional purposes. *Terminalia superba* can be easily worked but has a tendency to split when nailed or screwed (Lamprecht,1989); this attribute could be explained on the basis of large rays possessed by the wood species. Wood with large rays are not easily nailed at their ends without splitting; in most cases, they are pre-bored before nailing as also witnessed in *Sterculia rhinopetala* (Okeke, 1975), though such wood species often season easily but split along their rays, and if quarter-sawn, they serve as figure and add a lot of beauty to the wood. Some wood species like *Lophira alata*, *Nauclea diderrichii* and *Diospyros mespiliformis* are thick-walled to medium wall. Such timber are very heavy (e.g *Lophira alata*) in weight and often have high specific gravity. Hence, if the cell wall is thick and the fibres have little lumen, the wood species are often used for heavy constructional purposes like *Lophira alata* is being used for railway sleepers and wood flooring. Thick-walled fibres are able to transmit more stress, but are difficult for adhesive to penetrate; the small lumens, thick walls , and narrow pit openings between fibres, all restrict adhesive flow into the wood and usually result in adhesive penetration only one or two fibres deep. Such shallow penetration may be inadequate. High specific gravity may result in poor gluability and low dimensional stability (Choong et al, 2000). On the other hand, wood with very thin fibre wall and wide lumen (e.g. *Ceiba pentandra, Bombax bounopozense* and *Ricinodendron heudeloti*) usually have their specific gravity about 0.25-0.5 and are very light. The wood micrographs showing some features related to wood utilization are presented from figures 1 to 6. Wood with gum deposits include *Afzelia africana, Termilania ivorensis, Nauclea diderrichii* and *Milicia excelsa* that may not be useful in the plywood industry owing to the presence of gum deposit as gum deposits interfere with wood gluability; Dillip (1963) stated that timber for plywood industry should be free from gum. The differences in the anatomical structures of *Terminalia superba* and *Terminalia ivorensis* affect their utilization. *Terminalia superba* had more of uniseriate rays, more abundance of thin-walled axial parenchyma cells that surrounded the vessels than that of *Terminalia ivorensis*. Past work in Forestry Research Institute of Nigeria, Ibadan revealed that these features of *Terminalia superba* accounted partly for the better longitudinal penetration in the wood species (*Terminalia superba*) as copper-chrome-arsenate (CCA) preservative penetrated deeper than in *Terminalia ivorensis* that possessed multiseriate rays, and more of gum deposit in the vessels which blocked the pathway against longitudinal penetration of preservative. Correlation between the anatomical structures (viz pores and cell wall) and strength properties such as density, modulus of rupture (MOR) and modulus of elasticity (MOE) shows that there is a positive correlation between vessel sizes and strength groups (Table 2); which suggests that strong wood species have less size of pores. A positive correlation is also observed between the cell wall thickness and density, MOE and MOR, while a negative correlation is recorded between the cell wall and strength groups.

Among the wood species indicated in table 1, *Triplochiton scleroxylon*, *Ceiba pentandra* and *Bombax* are thin-walled; this feature influences their strength properties (density, MOR and MOE); they also possess large pore size. Table 3 shows that there is a negative correlation between pore size (MTD) and other features like cell wall, density, MOR and MOE. This suggests that the larger the pore size the lower the strength properties of the wood. This negative correlation between MTD and strength properties was in agreement with the findings of Jacobsen et al.(2007) and Hugo et al, (2009) that stated that variation in wood density is mainly driven by variation in fibre lumen diameter which is directly related to cell size and to cell wall thickness.

V. Conclusion

Wood anatomical properties, when studied and put into consideration, are good indices that may guide owners of various wood species for their respective objectives. Vessel diameter, cell wall thickness, density and other indices such as the wood deposits are important areas of consideration before wood utilization. Some hardwood species are thin-walled, some are of medium size, while others are thick-walled, with or without abundance of tyloses, crystals, gum and resins. In any case, different features exhibited by various wood species have made the Nigerian wood species useful in different areas of application.

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