ISSN 1996-3343

Asian Journal of Applied Sciences

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research
http://knowledgiascientific.com

OPEN ACCESS Asian Journal of Applied Sciences

ISSN 1996-3343
DOI: 10.3923/ajaps.2019.140.148

Research Article
Investigation into Wood Vessels and Rays of *Ficus exasperata* (Vahl) for Industrial Utilization

[1,2]Anguruwa Gloria Titi and [2]Oluwadare Abiodun Oluwafemi

[1]Department of Forest Products Development and Utilization, Forestry Research Institute of Nigeria, P.M.B. 5054, Ibadan, Oyo State, Nigeria
[2]Department of Forest Production and Products, University of Ibadan, Ibadan, Oyo State, Nigeria

Abstract
Background and Objective: Wood properties of a tree determine its utilization potentials. In Nigeria, *Ficus exasperata* is abundant tree species which has been reported to have several medicinal uses from the leaves, stem and roots, but technical information on the use of the wood for industrial purpose is limited. Therefore, determinations of physical and anatomical properties of the wood of *F. exasperata* as a potential wood material were investigated. **Materials and Methods:** Three matured trees of *F. exasperata* were selected from Forestry Research Institute of Nigeria Arboretum and cross-cut into billets at the base, middle and top of the stems. Discs were obtained from each billet and partitioned into corewood, middlewood and outerwood for determination of moisture content (MC), specific gravity (SG), vessel length, vessel diameter, vessel counts, ray length, ray diameter and ray count were all determined. **Results:** Moisture content increased from 70.8% at the corewood to 93.7% at outerwood and from the base (78.1%) to top (86.1%). Similarly, SG increased from 0.48$\pm$0.06 in corewood to 0.52$\pm$0.13 in outerwood and decreased from base to top (0.49$\pm$0.08). Vessels were round in shape and diffusely solitary with the length of 258.01$\pm$86.9 µm. Average vessel diameter, vessel count, ray length, ray diameter and ray count were 146.31 µm, 3.59 mm^2, 517.53, 64.78 µm and 8.86 mm^2, respectively. **Conclusion:** It could be concluded that less amount of preservatives will be absorbed by *F. exasperata* wood during chemical impregnation because of low vessel count and vessel size. Also, narrow vessels of *F. exasperata* wood were advantageous to its utilization for pulp and paper production, because large vessel causes a vessel-picking problem in papermaking.

Key words: Microscopy, vessel, rays, tangential, transverse and moisture content

Citation: Anguruwa Gloria Titi and Oluwadare Abiodun Oluwafemi, 2019. Investigation into wood vessels and rays of *Ficus exasperata* (vahl) for industrial utilization. Asian J. Applied Sci., 12: 140-148.

Corresponding Author: Anguruwa Gloria Titi, Department of Forest Products Development and Utilization, Forestry Research Institute of Nigeria, P.M.B. 5054, Ibadan, Oyo State, Nigeria Tel: +2348069547754

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ficus species are widely known as fig plants with about 800 species in occurrence and more than 45 different species exist in different ecological zones in Nigeria[1,2]. *Ficus exasperata* (Vahl) is one of the species that are terrestrial, fast growing and afro-tropical tree that grows to about 18-20 m tall[3,4]. It is well known as and paper tree because of the rough surface of the leaves. Different parts of the plant have also been reported to have several medicinal and industrial uses. Extract from the leaf of *F. exasperata* was used for the treatment of a hypertensive patient, coughs and hemorrhoids. It serves in lipid-lowering and anti-fungal activities[1,5,6]. Also, fresh leaves are used in treating ringworm and burns, while the dried powdered leaves are applied for treating boils and as a common anti-ulcer remedy. Some of the industrial uses of *F. exasperata* are for vegetable oil stabilization of foamy suspension, as food stocks supplement and for wood polishing[1,7,8].

However, it is necessary to discover more potential and other applications of this wood species in addition to using it for medicinal purpose.

Therefore, the purpose of the study was to investigate some of the physical (moisture content and specific gravity) and anatomical properties (vessels and rays) of *F. exasperata* in order to identifying its potentials for better utilization, thereby reducing overexploitation of other well-known species such as *Gmelina arborea*, *Eucalyptus* spp. and *Tectonagrandis* etc.

MATERIALS AND METHODS

Three stands of trees of *F. exasperata* were felled in the month of May, 2017 from the Arboretum in Forestry Research Institute of Nigeria. The estimated ages of the trees are 18, 20 and 25 years with a merchantable length of 3.78, 3.50 and 3.60 m and diameter at breast height (DBH), 15.8, 18.46 and 20.05 cm for T1, T2 and T3, respectively. The stem was cross-cut into billets at base (10%), middle (50%) and top (90%) of the stems. Discs were obtained from each billet and partitioned into corewood, middlewood and outerwood for determination of moisture content, specific gravity, vessel length, diameter and count and ray length, diameter and count.

Determination of physical properties

Decorative value of wood: The color, odour and physical appearance were carried out by observation while diameter at breast height was measured in centimeter.

Percentage moisture content: Since moisture is one of the main components of a plant material, which also serve as one of the determinant factor in the use of plant fiber for pulp production. Each of the fresh samples was cut from corewood, middlewood and outerwood into approximately 2×2×2 cm and labeled. The labeled samples were dried in the oven at a temperature of 100±2°C until constant weight was obtained. The percentage moisture content (MC) in relation to the fiber component was determined using ASTM designation[9]. The final moisture content was obtained using the Eq. 1:

$$MC = \frac{W_0 - W_1}{W_1} \times \frac{100}{1} \quad (1)$$

Where:
MC = Moisture content (%)
W_0 = Green weight (g)
W_1 = Oven dry weight (g)

Specific gravity determination: The specific gravity of samples was determined using the volume immersion method described in the ASTM designation[10] D2395-02. Since the dried sample cannot sink by itself, a 10 g metallic object was used as a sinker while sealed nylon was used as a container. The volume of water displaced by the sinker and the nylon was first obtained. Each labeled sample used for moisture content determination was put in turn inside the nylon attached to the sinker and immersed in a glass cylinder of a known volume of water. The rise in the level of the water in the cylinder minus the amount of water displaced by the sinker and the nylon give the actual volume of the sample. The specific gravity of each sample was estimated using the Eq. 2:

$$SG = \frac{1}{\frac{W_o - W_s}{W_o} + \frac{1}{1.53}} \quad (2)$$

Where:
SG = Specific gravity
W_s = Saturated weight of wood
W_o = Oven-dry weight of wood
1.53 = A constant which is the actual weight of wood[11]

Determination of anatomical properties (microscopy)

Preparation of wood samples for micrographic analysis (sectioning): To prepare the stem discs for sectioning, samples were cut into blocks of 2×2×2 cm for easy clamping on microtome holders and carefully labeled for easy identification. The wooden blocks were soaked in water for 17-24 h to soften for easy sectioning based on the density of the wood. The wood blocks were oriented to show these dimensional planes or axes: Transverse, tangential and radial sections. The sections were 0.02 mm thick wood in size.

However, the steps taken in slides preparation were:

- Sections were stained with safranin O for 30 min and then rinsed in water. The sections were immersed in 50 and 95% ethanol. The ethanol was used to extract the excess staining on the sections
- Ethanol solvent was cleared by covering the sections with several drops of clove oil for about 5 min
- Sections were transferred into xylene. The process of immersing into xylene solvent is called dehydration and differentiation process
- Sections were mounted on the slides with the use of Canada balsam. The function of the Canada balsam is to help place the cells intact, without shrinking or collapsing for a very long period and to be seen clearly. Descriptive terminology and measurements described by Quilho *et al.*[12]

Lastly, sample representative was selected and examined under the microscope in order to view the cell differentiation of the species along the dimensional plains (transverse, tangential and radial sections) and the photomicrographs for rays and vessels were measured and counted. About 10 rays and vessels were measured (Length and diameter).

Statistical analysis: A one-way analysis of variance (ANOVA) was used. Data were subjected to statistical analysis of $3\times3\times3$ factorial experiment in a completely randomized design (CRD) and Mean$\pm$SEM. However, a follow-up test was carried out using the least significant difference test (LSD) at 5% level of probability.

RESULTS

Physical properties

Decorative value of *F. exasperata* wood: The wood of *F. exasperata* used in the study had the diameter at breast height of 54, 43.05 and 48 cm. This wood does not have distinct sapwood and heartwood. The color of the wood was white to grey which turned cream to yellow on exposure to the atmospheric condition in the laboratory (Fig. 1 and 2).

Fig. 1: Physical appearance of the wood

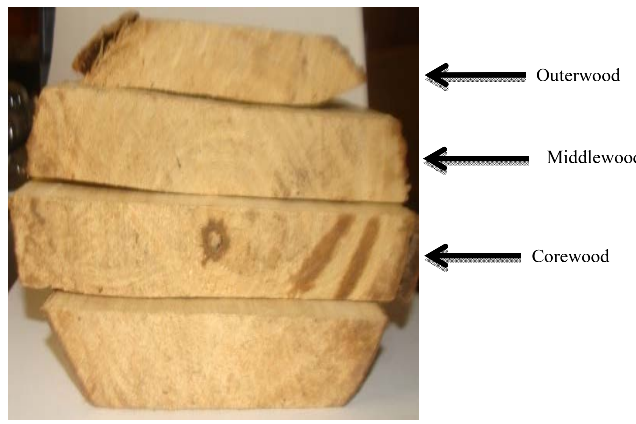

Fig. 2: Partition of the billet to core, middle and outerwood

Percentage moisture content (MC): Mean values in Table 1 shows that sampling height increased in moisture content from 78.10% at the base to 93.49% at the middle and then decreased to 93.49% at the top. On the contrary, moisture content increased from 70.78% at the corewood, 83.57% at the middlewood and 93.67% at the outerwood. However, the average moisture content of *F. exasperata* wood was 82.67%.

The ANOVA presented in Table 2 which shows that radial position significantly influenced moisture content at $p<0.001$. Separation of mean using LSD at 5% level of probability further showed that moisture content of the wood at the corewood, middlewood and outerwood are significantly different from each other along the radial position (Table 3).

Specific gravity (SG): Table 1 shows that mean specific gravity along the sampling height decreased from 0.53 at the base to

Table 1: Individual mean values of moisture content and specific gravity along sampling height and radial position of *F. exasperata*

Parameters	Wood portion	Corewood	Middlewood	Outerwood	Mean
Moisture content (%)	Base	67.45±21.14*	88.18±31.45	86.48±30.88	78.10±26.79
	Middle	75.44±21.14	88.18±17.18	87.88±32.76	98.49±25.04
	Top	69.44±17.31	82.17±7.51	106.67±20.59	93.49±10.01
	Average	70.78±24.61	83.57±20.80	93.67±29.28	82.67±26.62
Specific gravity	Base	0.47±0.04	0.54±0.15	0.56±0.08	0.53±0.11
	Middle	0.49±0.09	0.48±0.07	0.51±0.17	0.49±0.11
	Top	0.48±0.07	0.51±0.04	0.48±0.12	0.49±0.08
	Average	0.48±0.06	0.51±0.10	0.52±0.13	0.50±0.10

*Means±Standard error of mean of 4 replicate samples

Table 2: Significance (p-values) influence of sampling height and radial position on the moisture content and specific gravity of *F. exasperata*

Sources of variations	Degree of freedom	Moisture content (%)	Specific gravity
Tree (T)	2	<0.001*	<0.001*
Sampling height (SH)	2	0.129^{ns}	0.076^{ns}
Radial position (RP)	2	<0.001*	0.076^{ns}
T×SH	4	<0.001*	0.497^{ns}
T×RP	4	0.510^{ns}	0.099^{ns}
SH×RP	4	0.069^{ns}	0.189^{ns}
T×SH×RP	8	0.071^{ns}	<0.001*
Error	81		
Total	107		

p-values>0.05 are not significant. *Significant, ns: Not significant

Table 3: Influence of sampling height and radial position on the moisture content and specific gravity of *F. exasperata*

Sources	Moisture content (%)	Specific gravity
Sampling height		
Base	78.10±32.16^{*a}	0.53±0.11^{a}
Middle	83.83±24.63^{a}	0.49±0.11^{a}
Top	86.10±22.15^{a}	0.49±0.08^{a}
Radial position		
Corewood	70.78±24.61^{c}	0.48±0.06^{b}
Middlewood	83.57±20.80^{b}	0.51±0.10^{ab}
Outerwood	93.67±29.28^{a}	0.52±0.13^{a}

*Means±standard error of mean of 4 replicate samples. $^{a-c}$Mean separation. Values with the same alphabet in each column are not significantly different at α = 0.05 using LSD

0.49 at the middle and top along the sampling height, while it increased marginally from 0.48 at the corewood to 0.51 at the middlewood and 0.52 at the outerwood. The average mean specific gravity of *F. exasperata* was 0.50.

Table 2 presented the analysis of variance which indicated that sampling height and radial position had no significant influence on specific gravity. Least significant difference (LSD) at 5% level of probability confirms that specific gravity of the wood at the corewood was not significantly different from that of the middlewood, but specific gravity at the corewood was significantly different from the outerwood (Table 3).

Photomicrographic description of the *F. exasperata*

Transverse section: The light microscopy of the transverse sections revealed the prevalence of tyloses at the base with distinct growth ring boundary (Fig. 3a). The vessels were observed to be round but partly solitary and appear in some cases 2-3 or very small clusters (Fig. 3b).

Tangential section: In Fig. 4a, septate fibers are present with a thin transverse wall. An observation made on the transverse section also showed that tylosis is sclerotic with a very thick, multi-layered and lignified wall (Fig. 4b). The presence of larger rays of about 4-10 seriate and there were stories of rays and axial elements though not horizontal or vertical, but appeared wavy/oblique. A tile cell which is a special type of apparently empty upright cells was seen occurring in intermediate horizontal series usually interspersed among the procumbent cells (Fig. 4b).

Radial section: Figure 5a showed the presence of tiles cells which is a special type of apparently empty upright ray cells occurring in intermediate horizontal series usually interspersed among the procumbent cells (Durio type). Body ray cells are procumbent with 2-4 rows of upright/square marginal cells (Fig. 5b). Presence of tile cells, body ray cells are heterocellular, the presence of crystals and black streaks among fibers.

Vessel length (μm): The mean values in Table 4 showed no specific pattern of variation in vessel length along the sampling height. The length of vessels rather decreased from the base (261.02 μm) to the middle (242.21 μm) of the wood and then increased with 270.80 μm at the top. However, along the radial position, vessel length increased from 233.64 μm at the corewood to 278.38 μm at the outerwood (Table 4). On average, vessel length was 258.01 μm.

Analysis of variance shows that radial position of the wood significantly influenced vessel length at p = 0.013 (Table 5). The follow-up test conducted using least significant difference at 5% probability level shows that length of vessels at the corewood is not significantly different from middlewood but the length at the middlewood is significantly different from the outerwood (Table 6).

Table 4: Individual mean values of vessels and rays along sampling height and radial position of *F. exasperata*

Parameters	Wood portion	Corewood	Middlewood	Outerwood	Mean
Vessel length (μm)	Base	230.95±58.16*	283.34±102.59	268.77±52.33	261.02±75.71
	Middle	230.74±89.56	209.66±70.60	286.23±146.31	242.21±109.03
	Top	239.22±73.89	293.05±62.08	280.14±70.73	270.80±71.00
	Average	233.64±72.91	262.02±86.67	278.38±95.99	258.01±86.91
Vessel diameter (μm)	Base	118.01±35.30	156.76±31.66	162.44±27.70	145.73±36.73
	Middle	126.07±33.34	127.10±31.55	132.99±44.70	128.72±36.05
	Top	138.36±26.23	173.49±74.85	181.56±55.55	164.47±57.52
	Average	127.48±32.08	152.45±52.60	158.99±47.43	146.31±46.52
Vessel count (mm^2)	Base	4.06±1.52	2.53±1.07	3.20±1.79	3.26±1.58
	Middle	4.61±2.43	3.95±2.12	3.61±2.21	4.06±2.23
	Top	4.03±1.47	3.10±1.19	3.28±1.56	3.47±1.44
	Average	4.23±1.83	3.19±1.83	3.36±1.83	3.59±1.80
Ray length (μm)	Base	488.97±64.67	514.49±172.02	552.01±140.89	518.49±132.42
	Middle	556.76±198.09	437.10±93.61	530.62±248.56	508.16±193.04
	Top	506.23±163.69	532.58±255.89	538.99±146.96	525.93±189.73
	Average	517.31±151.37	494.73±185.37	540.54±180.47	517.53±172.49
Ray diameter (μm)	Base	48.57±11.97	56.42±9.32	83.67±16.12	62.55±19.30
	Middle	73.57±17.65	54.04±25.64	79.56±59.62	69.05±39.29
	Stem-top	49.49±6.39	71.29±20.35	67.37±15.69	62.72±17.69
	Average	57.21±17.14	60.58±20.59	76.53±36.35	64.78±27.18
Ray count (mm^2)	Base	9.31±1.57	9.43±1.60	9.31±4.45	9.35±2.80
	Middle	9.02±2.69	6.78±1.72	7.83±1.56	7.88±2.20
	Top	9.04±2.82	9.23±1.56	9.78±2.69	9.35±2.37
	Average	9.12±2.36	8.48±2.00	8.98±3.16	8.86±2.54

*Means±Standard error of mean of 4 replicate samples, μm: Micrometer, mm^2: Millimetre square

Table 5: Significance (p-values) of vessels and rays along the sampling height and radial position of *F. exasperata*

Sources of variations	Degree of freedom	VL (μm)	VD (μm)	VC (mm^2)	RL (μm)	RD (μm)	RC (mm^2)
Tree (T)	2	<0.001*	<0.001*	<0.001*	<0.001*	0.076^{ns}	<0.001*
Sampling height (SH)	2	0.156^{ns}	<0.001*	0.003*	0.614^{ns}	0.322^{ns}	<0.001*
Radial position (RP)	2	0.013*	<0.001*	<0.001*	0.045*	<0.001*	0.100^{ns}
T×SH	4	0.213^{ns}	0.001*	<0.001*	0.001*	<0.001*	<0.001*
T×RP	4	0.053^{ns}	0.049*	0.051^{ns}	0.152^{ns}	0.005*	<0.001*
SH×RP	4	0.064^{ns}	0.068^{ns}	0.424^{ns}	0.007*	0.003*	0.009*
T×SH×RP	8	0.103^{ns}	<0.001*	0.045*	<0.001*	0.033^{ns}	<0.001*
Error	81						
Total	107						

p-values>0.05 are not significant. *Significant, ns: Not significant, VL: Vessel length, VD: Vessel diameter, VC: Vessel count, RL: Ray length, RD: Ray diameter, RC: Ray count, μm: Micrometre, mm^2: Millimetre square

Table 6: Influence of sampling height and radial position on vessels and rays of *F. exasperata*

Sources	VL (μm)	VD (μm)	VC (mm^2)	RL (μm)	RD (μm)	RC (mm^2)
Sampling height						
Base	261.02 ± 75.71^a	145.73 ± 36.73^b	3.26 ± 1.58^b	518.49 ± 132.42^a	62.55 ± 19.30^a	9.35 ± 2.79^a
Middle	242.21 ± 109.03^a	128.72 ± 36.05^a	4.06 ± 2.23^a	508.16 ± 193.09^a	69.06 ± 39.29^a	7.88 ± 2.19^b
Top	270.80 ± 71.00^a	164.47 ± 57.52^c	3.47 ± 1.44^b	525.93 ± 189.73^a	62.72 ± 17.69^a	9.35 ± 2.37^a
Radial position						
Corewood	233.64 ± 72.91^b	127.48 ± 32.08^b	4.23 ± 1.83^a	517.32 ± 151.37^{ab}	57.21 ± 17.14^b	9.12 ± 2.36^a
Middlewood	262.02 ± 86.67^{ab}	152.45 ± 52.60^a	3.19 ± 1.60^b	494.73 ± 185.47^b	60.58 ± 20.59^b	8.48 ± 2.00^a
Outerwood	278.38 ± 95.99^a	158.99 ± 47.43^a	3.36 ± 1.83^b	540.54 ± 180.47^a	76.53 ± 36.35^a	8.98 ± 3.16^a

VL: Vessel length, VD: Vessel diameter, VC: Vessel count, RL: Ray length, RD: Ray diameter, RC: Ray count, μm: Micrometre, mm^2: Millimetre square. *Means±Standard error of mean of 4 replicate samples. [a-c]Mean separation, values with the same alphabet in each column are not significantly different at $\alpha = 0.05$ using least significant difference

Vessel diameter(μm): As shown in Table 4, just like the vessel length, the mean of vessel diameter did not show any trend of variation, it decreased from 145.72 μm at the base to 128.72 μm at the middle and then increased to 164.47 μm at the top. On the other hand, vessel diameter increased from the corewood 127.48 μm to the outerwood 158.99 μm along the radial position (Table 4). However, average vessel diameter was 146.31 μm.

The ANOVA presented in Table 5 showed that vessel diameter was significantly influenced by sampling

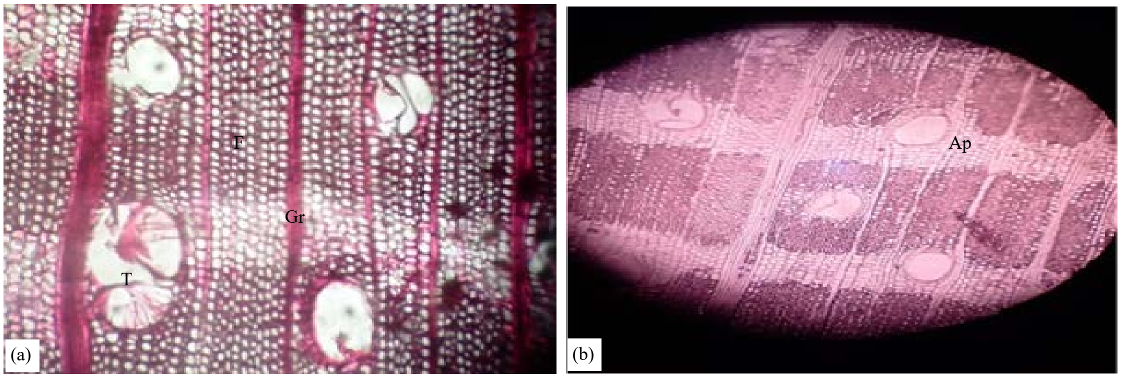

Fig. 3(a-b): (a) Transverse section showing F: Fibre, Gr: Growth ring and T: Tyloses and (b) Transverse section showing Ap: Axial parenchyma, V: Vessel

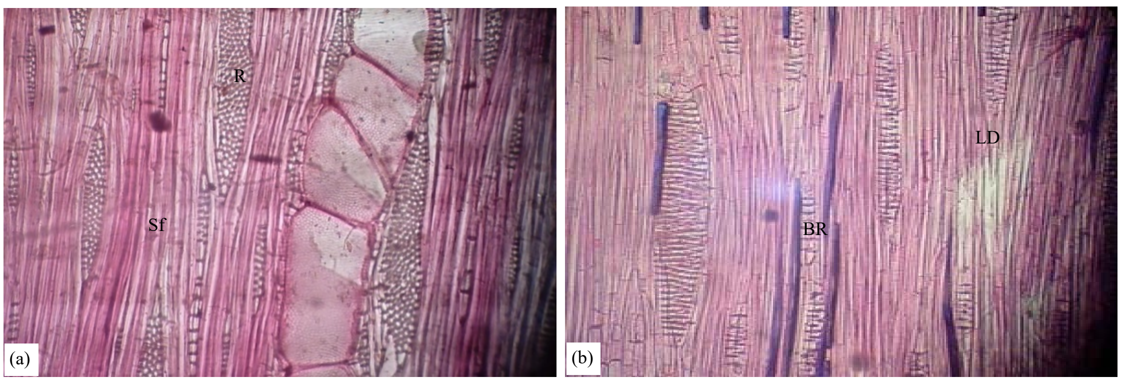

Fig. 4(a-b): (a) Tangential section showing R: Rays, Sf: Septate and (b) Tangential section showing, LD: Latex duct present, BR: Biserate rays (Uniserate or partly)

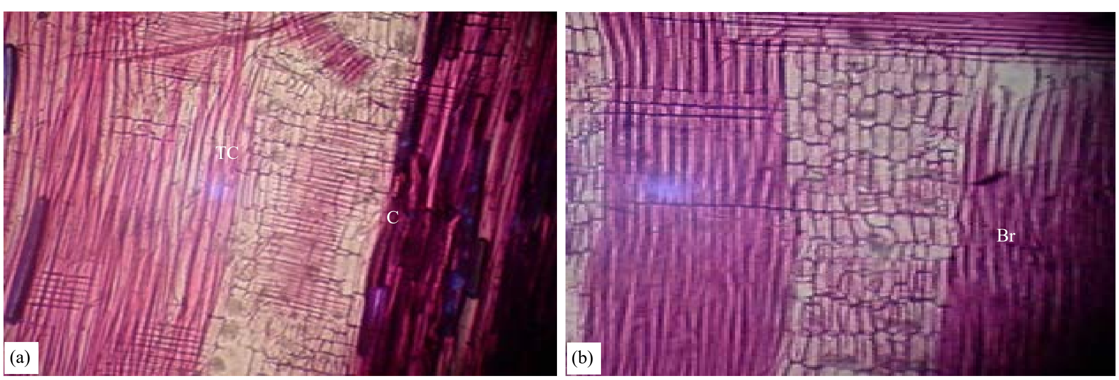

Fig. 5(a-b): (a) Radial section showing the presence of TC: Tile cells, rays are heterocellular consisting of procumbent and upright cells and presence of C: Crystals and (b) Radial section showing the presence of Brc: Black streaks among fibres

height and radial position ($p<0.001$) (Table 5). A further test of significance carried out using least significant difference at 5% probability shows that the diameter of vessels at the base, middle and top are all significantly different from each other along the sampling height. While along the radial position the diameter of vessels at the middlewood and outerwood were not significantly different from each other but they are significantly different from the diameter at the corewood (Table 6).

Vessel count (mm^2): Mean vessel count of *F. exasperata* presented in Table 4 showed no variation in vessel count along both the sampling height and radial position. Thus, the highest count of vessels was obtained at the middle (4.06 mm^2) along sampling height, while the highest vessel count was obtained at the corewood (4.23 mm^2) along the radial position (Table 4). Vessel count of *F. exasperata* averaged 3.59 mm^2.

Analysis of variance carried out at 5% level of significance shows that sampling height at $p = 0.003$ and radial position at $p<0.001$ significantly influenced vessel count (Table 5). The LSD at 5% level of probability further shows that vessel count at the base and top are not significantly different from each other but they are significantly different from the vessel count at the middle along the sampling height. More so, along the radial position, the vessel count at middlewood and outerwood are not significantly different from each other but they are significantly different from vessel count at corewood (Table 6).

Ray length (μm): The result presented in Table 4 is an indication that the mean ray length didn't give a particular trend of variation. The rays decreased from 518.49 μm at the base to 508.16 μm at the middle and then increased to 525.93 μm at the top along the sampling height. Similarly, ray length decreased from 517.32 μm at the corewood to 494.73 μm at the middle and tends to increase to 540.54 μm at the outerwood along the radial position. The average ray length of *F. exasperata* is 517.53 μm.

The results of the analysis of variance presented in Table 5 at 5% level of significance showed that length of rays was significantly influenced by variations along radial position at $p = 0.045$. Follow-up test using LSD shows that ray length at the corewood is not significantly different from the length at the middlewood and outerwood but the ray length at the middlewood is significantly different from the outerwood (Table 6).

Ray diameter (μm): Similar to the vessel, mean ray diameter in Table 4 shows no specific trend of variation along the sampling height; it increased from 62.55 μm at the base to 69.72 μm at the middle and later decreased to 62.72 μm at the top. On the other hand, ray diameter increased from 57.21 μm at corewood to 76.53 μm at the outerwood. However, the average ray diameter was 64.78 μm.

From the ANOVA Table 5, the radial position had a significant influence on the ray diameter at $p<0.001$. Least significant difference test conducted to test at 5% level of probability shows that ray diameter at the corewood and middlewood are not significantly different from one another but they are significantly different from the ray diameter at the outerwood (Table 6).

Ray count (mm^2): The mean ray count in Table 4 shows no pattern of variation along both the sampling height and radial position. Ray count had the same value of 9.35 mm^2 at the base and top and lowest at the middle (7.88 mm^2) along the sampling height. While along the radial position, highest ray count of 9.12 mm^2 was obtained at the corewood and lowest count of 8.48 mm^2 at the middlewood. The average ray count of 8.86 mm^2 was obtained.

The result in Table 5 shows the analysis of variance at 5% level of significance. It was observed that ray count was significantly influenced by sampling height at $p<0.001$. Test of significant using LSD shows that the number of ray at the base and top are not significantly different from each other but they show significant difference from ray count at the middle (Table 6).

DISCUSSION

The moisture content of 82% obtained along the sampling height and radial position was said to be high. This is an indication that moisture is one of the major components of the wood. It was discovered that the moisture content was higher at the outerwood than corewood, also higher at the top of the wood than the base. As the moisture content increased, the overall size of the wood fibers also increased[13]. The high moisture content obtained in this wood suggests that efficient bailer will be required to densify the wood due to its volume for the purpose of handling, transportation and storage. The closeness of the values obtained from base to the top and corewood to the outerwood suggests that the wood can be seasoned together without any sorting.

The specific gravity of wood indicates the amount of dry matter present. Increase in specific gravity of the wood could be attributed to thickening of the cell wall. Meanwhile, like many other hardwood species, *F. exasperata* had an average specific gravity of 0.50 and it compared favorably with 0.50 for *Angeria robusta*[14], 0.51 in *Gmelina arborea* and 0.46 obtained in *F. thonningii* as reported by Ogunkunle and Oladele[15]. The value also falls within the range of 0.45-0.59 for *Dipterocarpus indicus* recorded by Al-Sagheer and Prasad[16]. On the radial view, there is increased from the core wood to the outer wood, this pattern of variation was reported by Veenin *et al.*[17]. The low specific gravity is an indication that the wood can be chipped easily without wearing the chipper knives. The specific gravity obtained implied that consumption of liquor during pulping will be low while the rate of delignification is expected to be high. Also, a large volume of the *F. exasperata* will be needed to achieve full digester due to the bulkiness of the wood. The low density of this wood species can be said to be used in the manufacture of furniture and other materials that do not carry heavy loads[18].

The vessels are composed of single cells; their size and distribution within the growth ring vary with species. In this study, vessel elements are present in the wood but in lower numbers. They are either found singly or in twos but not more than three in the fibro-vascular bundles of the wood. Vessels are circular or oval in outline had diffuse-porous woods with indistinct growth rings.

The vessel length and diameter increased from corewood to the outerwood while the vessel count/frequency decreases from base to the top. The average vessel length, diameter and frequency of 258.01, 146.31 µm and 3.59 mm^2. The vessel diameter in this study is lower than 400 µm obtained in Eucalyptus reported by Paavilainen[19]. However, the values in this study confirm the result of Sharma *et al.*[20]. Large vessel causes a vessel-picking problem in papermaking[21] and large vessels could result in more consumption of preservative. Narrow vessel of *F. exasperata* wood is advantageous to its utilization for pulp and paper production. The number of vessels per mm^2 in this study 3.59 mm^2 compares favorably with vessel count of 3.60 mm^2 obtained in *F. thonningii* but lower than 5.20 mm^2 obtained for *Gmelina arborea* by Ogunkunle and Oladele[15].

Rays were heterocellular and composed of procumbent cells and square cells, crystals and lated ducts were observed. The sampling height and radial position significantly influenced ray diameter but not with ray length and count. Mean ray length, diameter and count 517.53, 64.78 µm and 8.86 mm^2, respectively are in line with the work of Sharma *et al.*[20] on some *Ficus* species. It also revealed the consistency and uniformity in anatomical characters with other *Ficus* species[20]. Ray count of *F. exasperata* of 8.86 mm^2 was obtained in this study and it was observed to be lower than 10.40 mm^2 obtained in the same species by Ogunkunle and Oladele[15].

CONCLUSION AND FUTURE RECOMMENDATION

The study focused on the physical and anatomical morphology of the wood along the sampling height and radial position.

From the results the following conclusions were drawn:

- From the physical appearance, it shows that the wood of *F. exasperata* could be used for wall cladding
- The physical properties: About 82% moisture content and 0.51 specific gravity of the wood is a clear indication that the wood of *F. exasperata* is bulky. For that reason, a large quantity of the wood will be needed to achieve a full digester volume for pulp making
- Anatomical description (vessels and rays) of the wood of *Ficus exasperata* gave indices of its suitability for pulp and papermaking
- Due to size and number of the vessels, it shows that the wood at the base will absorb more preservative during impregnation than the middle and top of the stem

It could be recommended based on the narrow vessels that *Ficus exasperata* could be used for pulp and paper making in Nigeria.

Also, further studies should be carried out to determine the mechanical properties of *F. exasperata wood* to be able to subject it to full utilization as a small diameter timber.

SIGNIFICANCE STATEMENT

This study discovered the physical appearance of wood of *F. exasperata* that can be beneficial as a species for wall cladding. Also, descriptions of the species through sectioning were given which could be used to classify the wood into utilization group. This study will help the researchers to uncover the critical areas of utilization of the wood species that many researchers were not able to explore. Thus a new theory on a lesser used species may be arrived at.

ACKNOWLEDGMENT

Authors appreciate the assistance of the entire staff of Wood Anatomy laboratory of the Department of Forest Products Development and Utilization, Forestry Research Institute of Nigeria.

REFERENCES

1. Odunbaku, O.A., O.A. Ilusanya and K.S. Akasoro, 2008. Antibacterial activity of ethanolic leaf extract of *Ficus exasperata* on *Escherichia coli* and *Staphylococcus albus*. Sci. Res. Essays, 3: 562-564.

2. Keay, R.W.J., 1964. Trees of Nigeria. Clarendon Press, Oxford University, Pages: 476..
3. Berg, C.C., 1989. Classification and distribution of *Ficus*. Experientia, 45: 605-611.
4. Lansky, E.P. and H.M. Paavilainen, 2010. Figs: The Genus Ficus. 1st Edn., CRC Press, Taylor and Francis Group, Boca Raton, ISBN: 978-1-4200-8966-0.
5. Ayinde, B.A., E.K. Omogbai and F.C. Amaechina, 2007. Pharmacognosy and hypotensive evaluation of *Ficus exasperata* Vahl (Moraceae) leaf. Acta Pol. Pharm., 64: 543-546.
6. Sonibare, M.O., A.O. Isiaka, M.W. Taruka, N.S. Williams, M. Soladoye and O. Emmanuel, 2008. Constituents of *Ficus exasperate* leaves. Nat. Prod. Commun.
7. Adebayo, E.A., O.R. Ishola, O.S. Taiwo., O.N. Majolagbe and B.T. Adekeye, 2009. Evaluations of the methanol extract of *Ficus exasperata* stem bark, leaf and root for phytochemical analysis and antimicrobial activities. Afr. J. Plant Sci., 3: 283-287.
8. Cousins, D. and M.A. Huffman, 2002. Medicinal properties in the diet of gorillas: An ethno-pharmacological evaluation. Afr. Study Monographs, 23: 65-89.
9. ASTM., 2008. Standard test methods for moisture in cellulose. ASTM D 1348-94. American Society for Testing and Materials, Philadelphia.
10. ASTM., 2003. Standard test methods for specific gravity of wood and wood-base materials. ASTM D 2395-02. American Society for Testing and Materials, Philadelphia, pp: 15.
11. Stamm, A.J., 1929. The fiber-saturation point of wood as obtained from electrical conductivity measurements. Ind. Eng. Chem. Anal. Ed., 1: 94-97.
12. Quilho, T., J. Gominho and H. Pereira, 2004. Anatomical characterisation and variability of the thistle *Cynara cardunculus* in view of pulping potential. IAWA J., 25: 217-230.
13. Gao, X., Q. Li, W. Cheng, G. Han and L. Xuan, 2017. Effects of moisture content, wood species and form of raw materials on fiber morphology and mechanical properties of wood fiber HDPE composites. Polymer Compos., 39: 3236-3246.
14. Okai, R., K. Frimpong-Mensah and D. Yeboah, 2003. Characterization of moisture content and specific gravity of branchwood and stemwood of *Aningeria robusta* and *Terminalia ivorensis*. Holz Als Roh-und Werkstoff, 61: 155-158.
15. Ogunkunle, A.T.J. and F.A. Oladele, 2008. Structural dimensions and paper making potentials of the wood in some Nigerian species of *Ficus* L. (Moraceae). Adv. Natl. Applied Sci., 2: 103-111.
16. Al-Sagheer, N.A. and A.G.D. Prasad, 2010. Variation in wood specific gravity, density and moisture content of *Dipterocarpus indicus* (Bedd). among different populations in Western Ghats of Karnataka, India. Int. J. Applied Agric. Res, 5: 583-599.
17. Veenin, T., M. Fujita, T. Nobuchi and S. Siripatanadilok, 2005. Radial variations of anatomical characteristics and specific gravity in *Eucalyptus camaldulensis* clones. IAWA J., 26: 353-361.
18. Jamala, G.Y., S.O. Olubunmi, D.A. Mada and P. Abraham, 2013. Physical and mechanical properties of selected wood species in tropical rainforest ecosystem, Ondo State, Nigeria. IOSR J. Agric. Vet. Sci., 5: 29-33.
19. Paavilainen, L., 2002. Fibre Structure. In: Handbook of Physical Testing of Paper. Habeger, M., J. Borch and M. Lyne (Eds.)., CRC Press, USA., ISBN: 0824704983, Pages: 1040.
20. Sharma, M., C.L. Sharma, M. Lalmalsawma, M.K. Singh and B.R. Gogoi, 2014. Wood anatomy of some *Ficus* species of Mizoram, NE India with reference to their identification. Int. J. Bot. Res., 4: 19-30.
21. Panula-Ontto, S., A. Fuhrmann, M. Kariniem and A. Sarkilahti, 2007. Evaluation of vessel picking tendency in printing. Proceedings of the 3rd ICEP International Colloquium on Eucalyptus Pulp, March 4-7, 2007, Belo Horizonte, Brazil.