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Anatomical Profiles of Indigenous Species of *Bridelia Micrantha*, *Anogeissus Leiocarpus*, And *Albizia Zygia* Grown in A Tertiary Institution, Abeokuta, Nigeria

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ABSTRACT: The objective of this paper was to investigate the anatomical profiles of indigenous species of *Bridelia micrantha*, *Anogeissus leiocarpus*, and *Albizia zygia* grown in a Tertiary Institution in Abeokuta, Ogun State, Nigeria, to ascertain their suitable wood utilization and potential in sustainable forestry using appropriate standard methods. Data were analyzed using descriptive statistics and one-way Analysis of Variance in a completely randomized design. Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$. *Albizia zygia* exhibited the highest fibre length (1.27 ± 0.17 mm), flexibility coefficient ($22.09 \pm 6.17\%$), and moderate cell wall thickness (3.43 ± 1.20 μ m) at the top section, while *Bridelia micrantha* recorded the highest fibre diameter (21.21 ± 3.64 μ m), lumen width (14.35 ± 3.54 μ m), and the lowest Runkel ratio (0.51 ± 0.18) at the middle section. *Anogeissus leiocarpus* had the smallest lumen width (7.47 ± 1.97 μ m), longest rays (2.80 ± 7.98 mm), and highest vessel frequency (8.40 ± 2.55 mm²). It is concluded that fibre parameters from *Bridelia micrantha* at the top section exhibit properties suitable for pulp and paper applications, and *Albizia zygia* for panel products and furniture, and *Anogeissus leiocarpus* for structural purposes. These species provide viable alternatives to over-exploited timbers, supporting sustainable forestry.

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Forests cover about one-third of the Earth's land area and provide essential ecosystem services such as carbon sequestration, climate regulation, soil fertility, and biodiversity conservation (FAO, 2020; Bonan, 2008). Beyond these functions, forests sustain livelihoods by supplying timber, fuelwood, medicinal products, and other resources (Chazdon, 2003). Among these, wood remains the most valuable and versatile raw material, widely used in construction, furniture, pulp and paper production, and energy generation. Wood anatomy plays a critical role in forestry and industrial utilization, as fibre, vessel, and

ray characteristics determine strength, durability, and processing behavior. Fibre dimensions (Length, diameter, lumen width, and wall thickness) affect pulp quality and paper strength, while vessel size and frequency influence drying, permeability, and mechanical performance (Oluwadare and Sotannde, 2007). Derived indices such as Runkel ratio, flexibility coefficient, and slenderness ratio are also widely applied to predict fibre suitability for pulp, paper, and composite board production (Ververis *et al.*, 2004). Despite their importance, anatomical studies in Nigeria have focused mainly on exotic and a few

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commercial hardwoods, leaving many indigenous species underexplored (Arowosoge and Akinyemi, 2010). This knowledge gap limits their inclusion in industrial processes and sustainable forest management strategies. Indigenous trees, often adapted to local conditions and ecologically significant, remain underutilized, leading to overexploitation of a narrow range of commercial species and biodiversity loss (Lamb, 2011). Consequently, the objective of this paper was to investigate the anatomical profiles of indigenous species of *Bridelia micrantha*, *Anogeissus leiocarpus*, and *Albizia zygia* grown in a Tertiary Institution in Abeokuta, Ogun State, Nigeria

MATERIALS AND METHODS

Description of the study area: This study was carried out in the natural forest area of the Federal University of Agriculture, Abeokuta, Nigeria. The University lies within the derived savanna vegetation zone of south-western Nigeria, between Latitude 7°13'N and 7°18'N and Longitude 3°26'E and 3°30'E. The region experiences a tropical wet-and-dry climate with annual rainfall of 900–1,200 mm, temperatures between 24–34 °C, and relative humidity ranging from 60–90% during the rainy season (NIMET, 2020; Ogundipe *et al.*, 2024).

Experimentation and data analysis: The experimental materials used were 60% concentrated Glacial Acetic acid solution (CH₃COOH), Hydrogen peroxide (H₂O₂), Olympus CH Series light microscope with Stage micrometer. Three mature trees were collected from the natural forest of the Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria. The tree species collected are: *Bridelia micrantha*, *Anogeissus leiocarpus*, and *Albizia zygia*. Each of the tree species collected was divided into three vertical sections: base, middle, and top. Samples were processed into small blocks of approximately 1 cm × 1 cm × 2 cm for anatomical studies. Fibre maceration was carried out using a 1:1 mixture of Glacial acetic acid and Hydrogen peroxide at 100–105 °C for 3 hours (Yimlamai *et al.*, 2024). This treatment dissolved lignin and hemicellulose, leaving individual cellulose fibres, which were rinsed, separated, and mounted on slides. Fibre measurements (fibre length (FL), fibre diameter (FD), lumen width (LW), and cell wall thickness (CWT)) were taken using an Olympus CH Series light microscope fitted with a digital camera and calibrated with a stage micrometer. For each sample, 20 fibres were measured in line with the procedures of Yimlamai (2024) to maintain accuracy within a 95% confidence level. Sectioning for microstructural analysis was performed using a sliding microtome to produce transverse, radial, and

tangential sections approximately 20 µm thick. Sections were stained with 1% safranin, dehydrated in ethanol series, cleared in clove oil, and mounted in Canada balsam (Adeniyi *et al.*, 2016). Microscopic observations of vessels and rays were carried out using a photo-micrographic light microscope following IAWA (1989) guidelines.

Fibre length: This was determined using a microscope for fibre examination, where fibres were measured directly and do not have a specific calculation formula, and it is usually expressed in millimeters (mm) (Sharma *et al.*, 2013).

Fibre diameter: Fibre diameter is also measured directly rather than calculated; it is usually expressed in micrometers (µm) and can be measured using microscopy techniques, often with the aid of image analysis software (Sharma *et al.*, 2013).

Lumen width: Lumen width was determined by subtracting twice the cell wall thickness from the fibre diameter, and it is usually expressed in micrometers (µm) using the formula 1:

$$LW = \text{Fibre diameter} - (2 \times \text{Cell wall thickness}) \quad (1)$$

Where LW = Lumen Width = *Cell wall thickness*: Cell wall thickness is usually expressed in micrometers (µm). It was measured directly through microscopic examination and calculated using the formula 2:

$$CWT = \frac{\text{Fibre diameter} - \text{Lumen width}}{2} \quad (2)$$

Where CWT = Cell Wall Thickness. Derived fibre parameters were calculated using standard formulas using the measured fibre length, fibre diameter, and lumen width, some derived fibre parameters (Slenderness ratio, Runkel ratio, and flexibility ratio) were calculated based on fibre quality indices as in equation 3 (Page *et al.*, 1985; Emerhi, 2012):

$$\text{Slenderness Ratio: } SR = \frac{\text{Fibre length}}{\text{Fibre diameter}} * 100 \quad (3)$$

Where SR = Slenderness Ratio,

$$FC = \frac{\text{Lumen Width}}{\text{Fibre diameter}} * 100 \quad (4)$$

Where FC = Flexibility Coefficient

$$\text{Runkel Ratio: } RR = \frac{2 \times \text{Cell Wall Thickness}}{\text{Lumen Width}} \quad (5)$$

Where RR = Runkel Ratio, Quantitative data were analyzed using descriptive statistics and one-way ANOVA in a completely randomized design. Means were separated with Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$. All statistical analyses were performed using SPSS v26.

RESULTS AND CONCLUSION

Fibre morphological Parameters: The mean fibre lengths of *Anogeissus leiocarpus*, *Bridelia micrantha*, and *Albizia zygia* across the tree portions were within the range of $(0.83 \pm 0.15^e$ to 1.27 ± 0.17^a mm) according to Table 1. *Albizia zygia* had the longest significant fibre lengths (1.27 ± 0.17^a mm) at the top portion, while *Bridelia micrantha* had the shortest (0.83 ± 0.15^e mm). However, fibre diameters and lumen widths varied significantly among the species ($p < 0.05$), while wall thickness was highest (3.43 ± 1.20^b) in *Albizia*

zygia. These differences indicated anatomical variations that influence end-use suitability. The longest fibre lengths (1.27 ± 0.17^a mm) observed in *Albizia zygia* indicate potential for improved tearing resistance and strength in pulp and paper production. This aligns with previous findings that fibre length is positively associated with the mechanical properties of paper (Oluwadare and Sotannde, 2007). Conversely, the shortest fibre lengths (0.83 ± 0.15^e mm) obtained in *Bridelia micrantha* may limit its application in paper making but enhance bonding properties useful in composite materials. Meanwhile, the thicker cell walls observed in *Albizia zygia* suggest higher strength and stiffness, which are desirable in structural applications according to (Bello and Jimoh, 2018). Overall, the fibre parameters highlight species-specific advantages that can guide their industrial utilization for pulp and paper production as well as construction applications.

Table 1: fibre morphological parameters of the tree species examined

Tree Species	Tree Parts	Fibre length (mm)	Fibre diameter (μ m)	Lumen width (μ m)	Fibre cell wall (μ m)
<i>Anogeissus leiocarpus</i>	Top	0.94 ± 0.17^{cde}	16.64 ± 2.11^c	11.56 ± 1.94^{abcd}	2.54 ± 1.20^b
	Middle	0.99 ± 0.19^{cd}	14.86 ± 1.59^c	9.27 ± 1.80^{cde}	2.79 ± 0.54^b
	Base	1.08 ± 0.18^{bc}	14.10 ± 2.11^c	7.47 ± 1.97^e	2.86 ± 0.26^b
<i>Albizia zygia</i>	Top	1.27 ± 0.17^a	15.49 ± 3.32^{bc}	8.64 ± 2.53^{de}	3.43 ± 1.20^b
	Middle	1.07 ± 0.19^c	14.99 ± 2.66^c	8.84 ± 0.97^{de}	3.07 ± 1.09^b
	Base	1.22 ± 0.07^{ab}	15.51 ± 3.66^{bc}	9.42 ± 2.39^{bcde}	3.05 ± 0.89^b
<i>Bridelia micrantha</i>	Top	0.85 ± 0.12^{de}	18.42 ± 5.02^{ab}	12.07 ± 4.87^{abc}	3.18 ± 1.08^b
	Middle	0.83 ± 0.15^e	21.21 ± 3.64^a	14.35 ± 3.54^a	3.43 ± 0.86^b
	Base	0.96 ± 0.17^{cde}	18.67 ± 4.83^{ab}	12.55 ± 4.39^{ab}	3.06 ± 1.36^b

Means with the same alphabet are not significantly different ($P \leq 0.05$), means with different alphabets are significantly different ($P \leq 0.05$).

Derived Fibre Parameters: The derived fibre parameters showed marked similarities across and within the three species, as presented in Table 2. *Bridelia micrantha* had the lowest Runkel ratio (0.051 ± 0.18^b), indicating thin-walled fibres relative to lumen size, while *Anogeissus leiocarpus* at the base recorded slightly higher values, but still within acceptable limits for papermaking. Flexibility coefficients were highest in *Albizia zygia* (22.09 ± 6.17^a), suggesting superior fibre bonding capacity. Slenderness ratios also varied significantly ($p < 0.05$), with *Anogeissus leiocarpus* exceeding the minimum threshold for good pulp quality, whereas *Bridelia micrantha* showed comparatively lower values. The low Runkel ratio observed in *Anogeissus leiocarpus* is desirable for high-quality pulp and paper because it is less than 1. Hence, enhances fibre collapsibility and inter-fibre bonding, a finding consistent with Oluwadare and Sotannde (2007). However, the higher runkel ratio value observed at the butt section of *Anogeissus leiocarpus* suggests that the fibres are stiffer, less flexible, and form bulkier paper of lower bonded area than the lower runkel ratio (Olorunfemi *et al.*, 2014). The higher flexibility coefficient in *Albizia*

zygia further strengthens its suitability for papermaking, as flexible fibres yield stronger, more durable sheets.

Although *Anogeissus leiocarpus* recorded slightly higher Runkel ratios, their values still fall within the acceptable range, implying potential for paper production but with slightly lower bonding quality. The moderate slenderness ratio observed in *Anogeissus leiocarpus* and *Albizia zygia* suggests better tensile strength in pulp sheets compared to *Bridelia micrantha*, thus corroborating earlier reports that species with higher slenderness ratios are preferable for pulp production (Bello and Jimoh, 2018). Overall, *Albizia zygia* emerged as the most promising species for pulp and paper applications, while *Bridelia micrantha* and *Anogeissus leiocarpus* may be more suitable for composite or structural uses where fibre length and strength are less critical.

Vessel Parameters: Vessel diameter, frequency, and distribution varied considerably among the species (Table 4). *Bridelia micrantha* exhibited the widest vessel elements (336.80 ± 27.93^a), while *Anogeissus leiocarpus* had the narrowest vessels (125.86 ± 27.02^e),

but the highest vessel frequency (8.30 ± 3.02^a). *Albizia zygia* showed intermediate values for both diameter and frequency. Photomicrographs further confirmed these differences, showing distinct vessel arrangements across the species. The wide vessel elements in *Bridelia micrantha* suggest efficient water conduction but may reduce wood density and mechanical strength, which may make the species less durable in structural applications (Plavcova *et al.*, 2024). In contrast, the narrow and more frequent vessels observed in *Anogeissus leiocarpus* are typically associated with higher density and improved resistance to shrinkage and collapsibility, which

suggests its use in heavy construction and durable wood products (Oluwadare and Sotande, 2007). *Albizia zygia*, with its intermediate vessel traits, represents a balance between water conduction and mechanical performance, making it suitable for general carpentry and light construction. These findings align with previous studies showing that vessel dimensions strongly influence wood density, permeability, and end-use performance (Bello and Jimoh, 2018). Overall, vessel parameters reinforce the superior structural potential of *Anogeissus leiocarpus*, the fast-growth adaptability of *Albizia zygia*, and the limited but specific uses of *Bridelia micrantha*.

Table 2: derived fibre parameters of the three tree species examined

Tree Species	Tree Parts	Runkel ratio	Flexibility	Slenderness
<i>Anogeissus leiocarpus</i>	Top	0.56 ± 0.34^b	16.51 ± 7.44^b	0.06 ± 0.02^b
	Middle	0.63 ± 0.21^b	18.94 ± 3.67^{ab}	0.07 ± 0.02^b
	Base	2.72 ± 6.08^a	19.23 ± 8.39^{ab}	0.17 ± 0.29^a
<i>Albizia zygia</i>	Top	0.92 ± 0.65^b	22.09 ± 6.17^a	0.08 ± 0.02^{ab}
	Middle	0.70 ± 0.23^b	20.01 ± 4.22^a	0.07 ± 0.02^b
	Base	0.66 ± 0.19^b	19.63 ± 3.16^{ab}	0.08 ± 0.01^b
<i>Bridelia micrantha</i>	Top	0.59 ± 0.23^b	17.92 ± 5.30^{ab}	0.05 ± 0.01^b
	Middle	0.51 ± 0.18^b	16.40 ± 4.00^b	0.04 ± 0.01^b
	Base	0.53 ± 0.21^b	16.66 ± 5.10^b	0.06 ± 0.02^b

Means with the same alphabet are not significantly different ($P \leq 0.05$), means with different alphabets are significantly different ($P \leq 0.05$)

Table 3: vessel parameters of the tree species examined

Tree	Part	mtd (μm)	Vessel freq.
<i>Anogeissus leiocarpus</i>	Top	163.89 ± 29.59^d	8.30 ± 3.02^a
	Middle	125.86 ± 27.02^e	8.40 ± 2.55^a
	Base	200.96 ± 75.99^c	1.42 ± 0.81^b
<i>Albizia zygia</i>	Top	184.85 ± 35.99^{cd}	2.40 ± 3.06^b
	Middle	273.28 ± 26.78^b	1.60 ± 0.52^b
	Base	253.11 ± 36.96^b	2.70 ± 1.16^b
<i>Bridelia micrantha</i>	Top	128.27 ± 21.12^e	1.70 ± 0.68^b
	Middle	336.80 ± 27.93^a	1.40 ± 0.52^b
	Base	260.83 ± 47.36^b	2.40 ± 1.27^b

Means with the same alphabet are not significantly different ($P \leq 0.05$), means with different alphabets are significantly different ($P \leq 0.05$).

Table 4: ray parameters of the three tree species examined

Tree species	Part	Ray height (mm)	Ray width (μm)
<i>Anogeissus leiocarpus</i>	Top	0.28 ± 0.07^b	28.26 ± 11.76^d
	Middle	0.45 ± 0.17^{ab}	0.03 ± 0.01^e
	Base	2.80 ± 7.98^a	40.87 ± 15.48^{bc}
<i>Albizia zygia</i>	Top	0.32 ± 0.06^b	37.27 ± 4.92^{dc}
	Middle	0.34 ± 0.08^b	39.11 ± 5.49^{bc}
	Base	0.28 ± 0.06^b	30.70 ± 4.92^{cd}
<i>Bridelia micrantha</i>	Top	0.32 ± 0.10^b	63.75 ± 22.49^a
	Middle	0.31 ± 0.03^b	63.50 ± 9.65^a
	Base	0.28 ± 0.07^b	48.76 ± 14.09^b

Means with the same alphabet are not significantly different ($P \leq 0.05$), means with different alphabets are significantly different ($P \leq 0.05$).

Ray Parameters: Ray characteristics were significantly different among the species as indicated in (Table 3). *Anogeissus leiocarpus* had the highest ray height (2.80 ± 7.98^a) at the base, followed by *Albizia zygia* (0.34 ± 0.08^b) at the middle, while *Bridelia micrantha* showed the lowest (0.32 ± 0.10^b) at the top section. Ray height and width also varied with *Bridelia micrantha* recording the widest rays (63.75 ± 22.49^a) and *Anogeissus leiocarpus* having relatively shorter and narrower rays. These anatomical variations reflect

species-specific adaptations in radial transport and storage functions. The higher ray height obtained in *Anogeissus leiocarpus* suggests efficient radial transport of nutrients and water, which has been linked to fast growth and adaptability (von Arx *et al.*, 2015). In contrast, the lower ray width of *Anogeissus leiocarpus* may contribute to its higher wood density, making it suitable for structural applications where strength is prioritized over fast transport. The wider rays in *Bridelia micrantha* (63.75 ± 22.49^a) indicate

higher storage capacity, a trait that can enhance its role in mechanical support but may also increase susceptibility to shrinkage during drying. These observations align with previous anatomical studies demonstrating that ray spacing and volume are positively correlated with radial compression strength and specific gravity in wood (Bastin *et al.*, 2015). Overall, ray parameters among the studied species highlight trade-offs between growth efficiency and wood strength, which have direct implications for their utilization.

Anogeissus leiocarpus explains its suitability for heavy structural applications. The wider vessels and rays in *Bridelia micrantha* are consistent with its lower density and tendency toward dimensional instability. The balanced anatomical traits in *Albizia zygia* reflect its adaptability and usefulness for light carpentry and agroforestry purposes. These visual confirmations strengthen the interpretation that anatomical variation among the three species underpins their differential suitability for industrial utilization, as earlier reported in comparable studies (Anoop *et al.*, 2012)

Conclusion: The anatomical properties of the three indigenous tree species revealed significant inter-species variations with direct implications for their potential utility in sustainable forest and resources utilization. *Albizia zygia* showed favourable long fibre characteristics for pulp, paper, and light furniture. *Bridelia micrantha*, is best suited for absorbent papers, veneer, and fuelwood, while *Anogeissus leiocarpus* is ideal for structural applications and engineered wood products. Promoting these species for industrial use reduces pressure on a few commercial timbers and enhance sustainable forestry.

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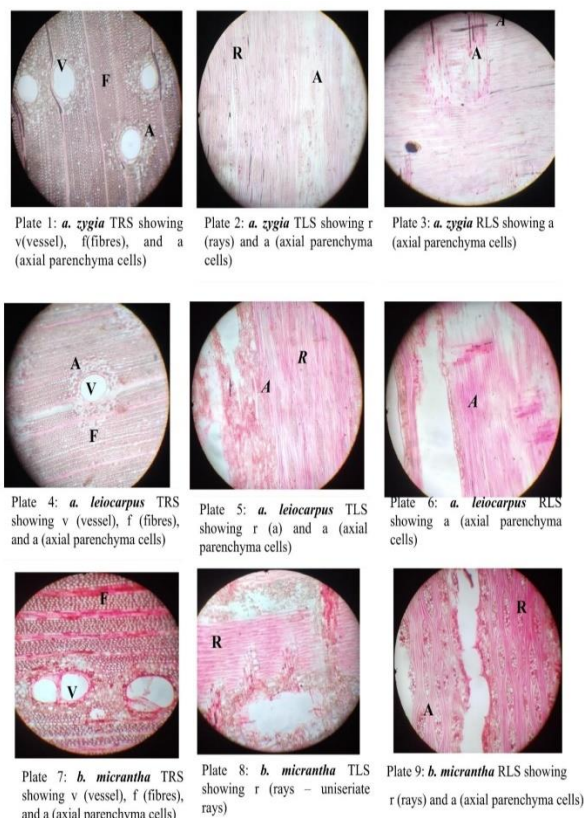


Fig 1: plates 1-9 showing the photomicrographs of the three tree species

RLS= Radial Longitudinal Section; TRS= Transverse Section; TLS= Tangential Longitudinal Section; a= axial parenchyma cells; f= fibres; r= rays; v= vessels

Photomicrographs of the Three Tree Species: The transverse and longitudinal sections of the three species revealed distinct anatomical features (Plates 1–9). *Anogeissus leiocarpus* showed narrow, thick-walled fibres and closely packed vessels, confirming its high-density wood structure. *Bridelia micrantha* exhibited wider vessels and broader rays, while *Albizia zygia* displayed intermediate vessel sizes with relatively frequent rays. The anatomical features observed in the photomicrographs complement the quantitative results presented in Tables 1–4. The compact vessel distribution and thick-walled fibres in

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