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EVALUATION OF FIBRE CHARACTERISTICS OF *Aningeria robusta* A. CHEV. WOOD FOR ITS PULPING POTENTIALS

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ABSTRACT

The study was carried out to determine the fibre characteristics of *Aningeria robusta* wood with a view to assessing its pulping potentials. Two trees of *Aningeria robusta* were used for the study; they were selected from Gambari Forest Reserve in Oyo State. Samples were collected at base, middle and top portion of the merchantable height. At each sampling height, strips of 2.5cm were removed from the centre of the discs and divided into 3 zones namely: innerwood, middlewood and outerwood based on the relative distance from the pith. Slivers were obtained from each of the zones and macerated in equal volume of glacial acetic acid and 30% hydrogen peroxide at 80^{o}C in an oven. A total of twenty whole fibres were measured in swollen conditions with a calibrated eye piece microscope from each sampling zone for fibre characteristics evaluation viz: fibre length (FL), fibre diameter (FD), lumen width (LW), cell wall thickness (WT), runkel ratio (RR), coefficient of suppleness (CS) and felting power (FP). The results obtained show that *Aningeria robusta* has the following mean value: FL (1.76mm), FD (29.47μ), LW (16.18μ), WT (6.61μ), RR (0.79), CS (55.39) and FP (57.43). The values obtained indicate the suitability of *A. robusta* as a pulping material especially for its runkel ratio of 0.79 which is less than 1 and a favourable coefficient of suppleness of greater than 50. A comparison of the values for the respective variables assessed with similar values from known pulpable wood species like *Pinus caribaea* gives potential results. However, blending of its pulp with fibrous stock from other wood species like pine is recommended. It is therefore observed that *A. robusta* is pulpable and is recommended as a good and suitable fibrous material for the pulp and paper industry

Keywords: *Aningeria robusta*, fibrous material, Runkel ratio, felting power, coefficient of suppleness

Introduction

The pulp and paper industry worldwide is huge and technically diverse. It operates a wide variety of manufacturing processes on a range of fibre types from tropical hardwoods to non-wood materials such as straw and grasses. Traditionally, the industry converts fibrous materials to pulp for paper and paperboard manufacture. The primary raw material for paper-making is cellulosic fibre, which chemically constitutes less than 50 percent cellulose, while lignin and hemicelluloses make up 20 and 30 percent respectively (Smook, 1992 and Sjostrom, 2003).

The annual production of paper from wood-pulp has grown to a multi-billion dollar industry, concentrated mostly in a few industrialized countries. Today, about 90 percent of all pulps are produced from wood. Thus, hardwood and softwood are the major fibre sources for pulp and paper making (FAO, 1991 and Bierman, 1996). The global production of paper and board has increased continuously over the last decades from 125 million tons in 1970 to 365 million tons in 2006 (Onilude, 2011). It is however projected that the global market for paper and paperboard will continue to grow at 2.3 percent per annum (Jalan *et al.*

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2009), largely due to increase in population, literacy rates and quality of life in developing countries. Long fibred woods which are of necessity in paper making are in short supply thereby creating avenue for short fibred tropical species to be mixed with imported long fibre.

Fibre characterization is important in considering the utilization of any fibrous material in pulp and paper making, as Fibre characteristics are the determinants of wood species for pulping (Tiikkaja *et al*. 1998). Therefore in attempting to get quality wood resources, there is compelling need to widen the scope of research into a variety of other wood species with a view to determining their pulp and paper making potentials.

To date, *Gmelina arborea* is one of the few outstanding exotic tropical wood species planted in Nigeria for pulp and paper production (RMRDC, 2003 and Onilude, 2011). This wood species is vastly exploited in the forest for other purposes besides pulp and paper production. It is therefore imperative to start searching for alternative wood species in order to meet up with process needs as insufficient supply of fibrous material on sustainable basis remains the major setback to the pulp and paper sector (Momoh, 1996). Research studies have shown that there are other potential hardwood species that are equally suitable for pulp production (Noah *et al.* 2015). Hence, species like *Aningeria robusta* should be given trial cultivation and be evaluated for its pulping properties (Onilude, 2001 and RMRDC, 2003).

Aningeria robusta, a lesser known tropical hardwood species belonging to the family of Sapotacea. The tree grows up to 36m (120ft) and the bole is clear and straight with buttresses (Dalziel and Hutchinson, 1963 and Keay *et al*., 1964).

It compares well in property with hardwood native to West Africa. In the last decades, this species has been gaining popularity in the timber market, both locally and internationally. The wood of *Aningeria robusta* performs excellently well in the production of joinery and furniture (Chudnoff, 1980 and Ajala, 2006).

According to FAO (2005), it is estimated that there are currently more than 50,000 plant species worldwide, and amazingly,

only about 1000 different tree species are utilised globally. Thus, thousands of tree species are either not utilised, under-utilised or used inappropriately. Therefore, investigating into some lesser-known or lesser-used wood species becomes imperative for researchers in the pulp and paper industry. This research therefore explores the potential of *Aningeria robusta*, a lesser-known species as a suitable pulping material for the pulp and paper industry.

Materials and Method

Two stands of *Aningeria robusta* were used for this study. They were purposively selected from Gambari Forest Reserve in Oyo State latitude $7^{o}25^{1}$ and 25^{1} and $7^{o}55^{1}$ N and longitude $3^{o}53^{1}$ and $3^{o}9^{1}$E. The selection was based on absence of reaction tendencies, bole devoid of crookedness and absence of excessive knots. This practice is typical of sampling for clear wood specimen evaluation as randomisation at this stage may introduce "undesirable" wood specimen. Samples were collected at the base, middle and top positions of the merchantable height. At each sampling height, cross sectional disc of about 2.5cm thick were removed, strips of 2.5cm were also removed from the centre of the discs and divided into 3 zones namely: innerwood, middle wood and outerwood based on the relative distance from the pith. Slivers were obtained from each of the zones and macerated in equal volume of glacial acetic acid and 30% hydrogen peroxide at 80^{o}C and later rinsed thoroughly in water. A total of twenty whole fibres were measured in swollen conditions with a calibrated eye piece microscope from each sampling zone for fibre characteristics evaluation viz: fibre length (FL), fibre diameter (FD), lumen width (LW) and cell wall thickness (WT). A split-plot experimental design was used for the study since 2 trees, 3 radial positions and 3 axial positions were considered.

Analysis of variance (ANOVA) was used to test the effect of different factors treated, while a follow-up Duncan Multiple Range Test (DMRT) was adopted to assess if there was any significant in the parameters treated.

Results and Discussion

The results of the fibre dimensions are presented in Table1. Fibre length had a mean value of 1.76mm. A sinusoidal variation (1.75, 1.73 and 1.81mm) was observed from the base to the top along the axial plane. Adejoba and Onilude (2012) reported a range of 1.5 to 1.6mm with the same trend in *Ficus mucuso*, also a lesser-used species. *Gerdenia ternifolia*, lesser-known timber species had a range of 1.18 to 1.50mm on the same axis (Noah *et al* 2015). Oluwadare and Onilude (2001) reported value of 1.86 to 5.74mm on *Pinus caribaea* while Ajala and Onilude (2007) reported a range of 2.44 to 4.32mm along the same plane for the same species.

The inconsistent axial variation from the base upward disagree with the result of the study of Rulliaty and America (1995), which shows a steady decrease in fibre length from the base upward in big leaf Mahogany, *Swietennia macrophylla* grown in Indonesia. Similarly, it disagrees with Ogunsanwo (2000) and Noah *et al.* (2015) studies on *Triplochiton scleroxylon* and *Gerdenia ternifolia* respectively.

Conversely, an increase in fibre length was observed along the radial plane from the corewood to the outerwood (1.66, 1.75 and 1.87mm). Adejoba and Onilude (2012) also recorded a range of 1.5 to 1.6mm across the wood of *Ficus mucuso* with increasing fibre length from the pith to the bark. Poku *et al* (2001) also recorded an outward increment in fibre length of *Petersianthus macrocarpus*, a lesser –used species. This pattern of variation in the radial axis had earlier been reported by Onilude *et al* (1998) on selected savanna tree species, Pande *et al* (1995), Shupe *et al* (1996) on loblly pine, Ogunsanwo (2000) on *Triplochiton scleroxylon*, Osadare (2001) on *P. Caribaea* and Ajala and Onilude (2007) on *Pinus caribaea* grown in Nigeria.

The observed variations in the findings could be attributed to geographical locations, environmental factors and sampling intensity. Age of trees sampled could also be a factor because older trees have the tendency of having over matured fusiform initials from which the fibres evaluated were derived. The average fibre length for conifers ranges from 1.18 to 7.39mm while that of hardwood ranges from 0.5 to 2.6mm (Panshin and Dezeeuw, 1980). The mean fibre length of 1.76mm recorded in this study can be considered to be good for paper making. The general increase in fibre length as the tree matures with age is due to the cambium aging. The benefit of this is that better paper with higher strength properties will be produced provided there is no concomitant increase in other cell variables especially cell-wall thickness. Table 2 revealed that there is significant difference in radial position, sampling height and the interaction between them. Low but negative correlation co-efficient (r = -0.31) was observed between fibre length and fibre diameter, while lumen width and cell-wall thickness had -0.22 and -0.07 respectively (Figure 1).

The mean fibre diameter was 29.47µm; it ranged from 29.14 to 29.80µm along the radial direction and 29.12 to 31.42µm axially. Fibre diameter decreased from innerwood towards the bark while an inconsistent pattern was observed along the axial direction. Adejoba and Onilude (2012) recorded a range of 28.3 to 28.9µm along the radial axis and 28.1 to 29.0µmin the axial direction of *F. mucoso*. Ajala and Onilude (2007) reported a range of 33.00 to 47.00µm from *P. caribaea* grown in Nigeria while FAO (1975) reported a range of 60.00 to 62.00µm for the same species grown in Malaysia and 45.00 to 47.00µm from Fiji Island. Analysis of variance showed a significant difference at 5% level of probability on the radial position while other sources of variance were not significant. High and positive correlation was observed between fibre diameter and lumen width (0.66) and cell wall thickness (0.74). The decrease in fibre diameter from corewood to outerwood agrees with results of Adejoba and Onilude (2012) on *F. mucoso* and Ogunsanwo (2000) on *Triplochiton scleroxylon* which found a gradual decreasing trend from pith to bark. However, this is at variance with the study conducted by Osadare and Udolitinah (1993) on *Ceiba pentandra* where increase in fibre diameter was from the pith outwardly and *Bombax buonopozense* which had an inconsistent variation along the same axis. The decrease in lumen diameter from pith to bark is due to cell development and maturation. The inconsistency observed in the axial direction disagrees with authors such as Panshin and Dezeeuw (1980), Rulliaty and America (1995) on big-leaf mahogany *Swietennia macrophylla* from Indonesia and Ogunsanwo (2000) on *Triplochiton scleroxylon.*

The mean lumen width was 16.18µm; ranging from 15.98 to 16.43µm radially and 15.07 to 17.76µm axially. Inconsistent pattern of variation was observed along the tree axis while decreasing trend from corewood to outerwood in the radial axis. It disagrees with the results of Adejoba and Onilude (2012) who reported a decrease from the base upward and an increase from corewood to outerwood on *F. mucoso.* The variation in cell-wall thickness may be response ble for the change in lumen width. Radial position is significant at 5% probability level. Weak but positive correlation was observed between lumen width and cell-wall thickness (0.03) while negative correlation co-efficient was recorded between lumen width and fibre length (-0.22), high positive correlation was observed between lumen width and fibre diameter (0.66).

The mean cell-wall thickness was 6.61µm; ranging between 6.43 to 6.78µm radially and 6.03 to 6.98µm axially. A decrease in cell-wall thickness was noticed along the bole while an inconsistent pattern was observed across the bole. The variation pattern along the bole was in agreement with the report of Adejoba and Onilude (2012) on *F. mucoso* and Noah *et al* (2015) on *G. ternifolia* while at variance with the findings of Rulliaty and America (1995), Shupe *etal* (1996) on loblly pine and Ogunsanwo (2000) on *Triplochiton scleroxylon*. Analysis of variance was not significant in all sources of variation. The decrease in cell thickness along the bole is in consonant with the auxin gradient theory that in the apical region of the growing shoot, high production of earlywood near the crown predominates with thin-walled cells at the top (Larson, 1969).

Table 1: Mean Fibre Values of *Aningeria robusta*

Wood Property	Wood Position	Sampling Position Base	Middle	Top	Mean
Fibre Length (mm)	Corewood	1.75	1.65	1.60	1.66
	Middlewood	1.77	1.76	1.73	1.75
	Outerwood	1.90	1.78	1.93	1.87
	Mean	1.80	1.73	1.75	1.76
Fibre Diameter (µm)	Corewood	26.78	32.57	30.07	29.80
	Middlewood	26.42	31.78	29.61	29.27
	Outerwood	28.16	29.91	29.34	29.14
	Mean	27.12	31.42	29.88	29.47
Lumen Width (µm)	Corewood	15.82	17.50	15.97	16.43
	Middlewood	14.88	18.33	15.17	16.13
	Outerwood	14.51	17.47	15.97	15.98
	Mean	15.07	17.76	15.71	16.18
Wall Thickness (µm)	Corewood	6.85	7.50	5.48	6.61
	Middlewood	6.80	6.73	5.77	6.43
	Outerwood	7.28	6.22	6.83	6.78
	Mean	6.98	6.82	6.03	6.61

The results of the ANOVA in Table 2 show that at 0.05 level of probability the effect of tree is not significant in the fibre characteristics evaluated while that of sampling height, radial position and interaction between radial position and sampling height have significant effect on the fibre length. Moreover, radial positions have significant effect on fibre diameter and lumen width. By implication, the effect of tree on fibre characteristics evaluated are the same, hence, trees sampled from the same location will exhibit similar fibre characteristics. In addition, the interaction between sampling height and radial position is not significant in all the fibre dimensions evaluated except for fibre length, implying that the fibre characteristics of *A. robusta* remains the same provided the biotic conditions of climate and soil are the same.

Table 2: Result of analysis (ANOVA) for Fibre Dimensions of *Aningeria robusta*

Source of Variance	Degree of Freedom	Fibre Length	Fibre Diameter	Cell-Wall Thickness	Lumen Width
Tree Number	1	0.00120	0.18	0.03	0.82
Sampling Height (SH)	2	0.07831*	0.42	0.28	0.30
Radial Position(RP)	2	0.01084*	18.33*	2.45	11.21*
SH*RP	4	0.00843*	1.79	1.39	0.70

***Significant @5%probability level

Table 3 shows that there is significant difference in the fibre length obtained from the top, middle and base as well as the corewood, middlewood and the outerwood of the stem of *A. robusta*. This implies that pulp produced from these portions of the trees will be different from one another. For fibre diameter, there is significant difference in the diameter of fibre obtainable from the corewood to the outerwood. For lumen width, no significant difference between the pith area and the periphery of the stem but, clearly different from the middle portion of the stem.

Table 3: Duncan Multiple Range Test on Fibre Characteristics of *Aningeria robusta*

Parameter	Corewood	Middlewood	Outerwood	Top	Middle	Base
Fibre length	1.86	1.73a	1.75	1.66a	1.75b	1.87c
Fibre diameter	27.12c	31.36b	29.80a			
Lumen width	15.07a	17.76b	15.70a			

Means with the same alphabet along the same column are not significantly different from each other.

The runkel ratio of *Aningeria robusta* ranged from 0.76 to 0.82, which is less than 1and in conformity with the standard for good fibre morphology for pulping and paper making (Adejoba and Onilude 2012 and Noah *et al* 2015). It compares favourably well with *Pinus caribaea* and other lesser-known species that have been studied (Table 4).

The coefficient of suppleness recorded for *A. robusta* (55.11 – 55.67) conforms to the assertion of Noah *et al* (2015) that coefficient of suppleness = 50 are necessary for paper making because paper strength tends to improve with increasing coefficient of suppleness. The thinner the cell wall thickness, the more flexible and collapsible the fibres are during web formation (Oluwadare and Sotonnde 2007). From the result in Table 4, *A. robusta*possesses coefficient of suppleness > 50, hence, its fibres are flexible and will produce good surface contact or increased fibre-to-fibre bonding. Thus, the wood of *A. robusta* is suitable for paper making.

Table 4: Mean Fibre Dimension of *Aningeria robusta* in Comparison with values for other Lesser–known species and *Pinus caribaea*

Fibre Characteristics	***Aningeria robusta***	***Ficus mucoso******	***Gerdenia ternifolia*****	**Fiji *Pinuscaribaea****
Fibre Length (**mm**)	1.66 – 1.93	1.5 –1.7	1.18 –1.50	2.4
Fibre Diameter (**μm**)	26.42-32.57	27.4 – 30.1	22.80 –31.00	0.045-0.047
Cell- Thickness(**μm**)	5.48-7.50	1.4 – 5.5	5.21 – 7.45	0.04-0.06
Lumen Width (**μm**)	14.51-18.33	19.0 – 39.4	12.80 – 16.30	0.036-0.037
Runkel Ratio	0.76-0.82	0.25 – 1.05	0.82 – 1.04	0.74-0.81
Coefficient of suppleness (Flexibility)	55.11 – 55.67	76.31 - 80.00	51.9 - 55.6	74.0 - 82.0
Felting power (Slenderness)	55.06-59.79	55.17 – 55.75	47.0 – 55.0	42 - 53

***Adejoba and Onilude (2012)
**Noah *et al* (2015)
*FAO (1975)

	FL	FD	LW	CT
FL	-			
FD	-0.31	-		
LW	-0.22	0.66	-	
CT	-0.07	0.74	0.43	-

Figure 1: Correlation Matrix of Fibre Characteristics of *Aningeria robusta*

Conclusion and Recommendations

Though, a sinusoidal variation was noticed in fibre length from base to the top along the axial direction, yet the fibre characteristics of *Aningeria robusta*evaluated compares favourably well with standard values and known wood species such as *Pinus caribaea* which are used for pulp and paper production. At 0.05 level of probability the effect of tree is not significant in the fibre characteristics evaluated while that of sampling height, radial position and interaction between radial position and sampling height have significant effect on the fibre length. There is significant difference in the fibre length obtained from the top, middle and base as well as the corewood, middlewood and the outerwood of the stem of *A. robusta.* The runkel ratio which is less than 1 and the coefficient of suppleness which is greater than 50 makes the species a satisfactorily pulpable material for pulp and paper production.

Blending of its pulp with fibrous stock from other wood species like pine is recommended. Plantation establishment of *A. robusta* should also be encouraged.

References

Adejoba, O. R. and Onilude, M. A (2012): Evaluation of Fibre Charateristics of *Ficus mucoso*: a lesser used species. *Proceedings of the 3rd Biennial National Conference of the Forests and Forest Products Society*. Pp162-167

Ajala, O. O. (2006): Evaluation of the physical and mechanical properties of the wood of *Aningeria robusta* (A.chev). M.Phil. Thesis, at Dept. of Forest Resources Management, University of Ibadan. Pp137.

Ajala, O. O. and Onilude, M. A. (2007): Effects of Age on Fibre Characteristics of Nigerian grown *Pinus caribaea* (Morelet). *Journal of Tropical Forest Resources*. Vol.23: 10- 17

Bierman, J. C. (1996): Handbook of Pulping and Paper making. 2nd Edition, Academic Press, California, USA.

Chudnoff, M. (1980): Tropical timbers of the world. *USDA Forest Service. Agric. Handbook*No. 607. Forest Products Lab. Madison. Pp 439-442.

Dalziel, J. M. and Hutchinson, J. (1963): *Floral of West Tropical Africa*. Second Edition. Vol. //. Pub. Crown agents Millbank London. Pp. 544

FAO (1975): Pulping and paper Making Properties of Fast –growing Plantation Wood Species. Rome. 466pp

FAO (1991): The Outlook of Pulp and Paper to 1995. Paper Products and Industrial Update. 2nd Proceedings of the Food and Agriculture Organisation of the United Nations, Rome, July 6-10, 1991. Pp131-135

Jalan, M. S., B. G. Ganter and A.F.M. Afaur Rahman(2009): *Subsistuting wood with non-wood fibres in paper-making: A win-win solution for Bangladesh*. Bangladesh Development Research Working Paper Series, BDRWPS No.4

Keay, R. W. J., Onochie, C. F. A. and Stanfield, D. P. (1964): *Nigerian Trees.* Vol.11. Department of Forest Research, Ibadan. Pp495.

Larson, P.R. (1969): Wood Formation and Concept of Wood Technology, New York. McGraw Hill Book Publishing Company, Vol.1, pp79

Momoh, Z. O. (1996): Evolution of the Structure of the Pulp and Paper Industry. *NigerianJournal of Forestry*. Vol. 20, No3.pp3-4

Oluwadare, A. O. and Sotonnde, O. A. (2007): The Relationship between Fibre Characteristics and Pulpsheet Properties of *Leucaena leucocephala. Middle-East Journal of scientific research* 2(2): 65-68

Onilude, M. A. (2001): Sustainable Fibre Sources for Pulp and Paper in Nigeria. Faculty of Technology Lecture, University of Ibadan, Nigeria. Issue No.1 Pp24.

Onilude, M. A. (2011): Pulp and Paper Industry: A neglected goldmine in Nigeria. An Inaugural Lecture at the University of Ibadan. Pp73.

Ogunsanwo, O.Y. (2000): Characterisation of Wood Properties of Plantation Grown Obeche (*Triplochyton scleroxylon* K.Schum) in Omo Forest Reserve, Ogun State, Nigeria. Ph.D. Thesis. Department of Forest Resources Management University of Ibadan.272pp

Osadare, A. O. (2001): Basic wood and pulp properties of Nigerian grown *Pinus caribaea* Morelet and relationship with tree growth indices. Ph.D. Thesis, Department of Forest Resources Management University of Ibadan. 417pp

Osadare, A. O and Udolitinah, J. S. (1993): Fibre characteristics of some Nigerian raw materials for long fibre pulp production. *Proceedings of the 23rd Annual Conference of Forestry Association of Nigeria.* 133-138.

Noah, Akpan S., Mercy B. Ogunleye, Julius K. Abiola and Florence N. Nnate (2015): Fibre Characteristics of *Gerdenia ternifolia* (Linn C.) Schumach for its Pulping Potential. *American Scientific Journal for Engineering, Technology and Sciences*. Pp322-332

Panshin, A. J. and Dezeeuw, C. (1980): Textbook of Wood Technology. Vol. 1 Fourth Edition inc. Graw-Hill Boo Company. 704pp.

Raw Materials Research and Development Council (RMRDC) (2003): Technology Survey Report of the Multi-Disciplinary Task Force on Pulp and Paper Products, Printing and Publishing Sector. 4th Update Version. Abuja, Nigeria.pp95

Ruallity, S. and America, W.A. (1995): Natural variation wood quality indicators of Indonesian big leaf Mahogany *Swietenia macrophylla* King IUFRO World Congress proceeding Tempere, Finland 205pp

Shupe, T. F., Choong, E.T., Stokke, D.D., and Gibson, D. M. (1996): Variation in the dimensions and fibril angle for two fertilized even-aged loblolly pine plantations. *Wood and Fibre Science* 28(2)268-275

Sjostrom, E. (2003): Wood Chemistry Fundamentals and Applications, 3rd Edition, Academic Press, Sandiego USA pp33

Smook, G. A. (1992): Handbook for Pulp and Paper Technology. 2nd Edition, Augus Wilde Publications, Vancover, Canada, pp15

Tiikkaja, E., Kauppiner, M andFerrand, G. (1998): Measuring Fibre Dimensions for Predicting Paper Properties. Rapid Respond No. 56, Paper Equipment and Materials International, Vol. 6 (9)12-15