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DETERMINATION OF FIBRE CHARACTERISTICS OF *Polyalthialongifolia* (sonn) Thwaites

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Abstract:

The research was carried out to determine the fibre characteristic of Polyalthialongifolia (sonn) thwaites. Two stands were sampled at the base, middle and top and partition into core wood, middle wood and outer wood and then macerated in Hydrogen peroxide (H_2O_2) and Acetic acid (CH_3COOH) solution in ratio 1:1 to soften the fibre. The experiment was designed in 2x3x3 Completely Randomized Design. The soften fibre viewed under microscope assessing the following parameters; fibre length, fibre diameter, lumen width, cell wall thickness, Runkel ratio. Coefficient of flexibility and felting power while descriptive analysis was used to analyze the data obtained. Result obtained shows fibre length pooled mean ranges from 0.92±0.03-1.06±0.11, fibre diameter pooled mean ranging from 17.67±0.81-22.22±3.71, lumen width pooled mean ranging from 9.03±0.46-12.21±2.42, cell wall thickness pooled mean ranging from 4.32±0.22-5.00±0.66, Runkel ratio pooled mean ranging from 0.68±0.03-0.93±0.12, Coefficient of flexibility pooled mean ranging from 53.73±2.82-56.30±3.47 and the felting power pooled mean ranging from 55.33±8.09-58.44±2.73.These values authenticate the use of Polyalthialongifolia for pulp and paper production despite its non- wood quality because of its Runkel ratio which is less than one.

Key words*: Runkel ratio; fibre length; Polyalthialongifolia; Lumen width.*

INTRODUCTION

Wood is one of the renewable forest resources, It has a vast array of application for construction of buildings, erosion control, furniture, cooking utensils, manufacture of pulp and paper and cellulose derivatives (Greek 1995). Paper in its various forms has been become indispensable to the civilized man such as printing, writing and remains the most important medium of recording and presentation of history which will continue to have much impact on the development of the future (Noah 2009).

In Nigeria, *Gmelina arborea* is the only outstanding exotic tropical species that has been widely planted for pulp and paper. Researched have shown that there are potential Nigerian hardwoods that are equally suitable for paper making, such species like *Polyaithialongifolia* should be given trial cultivation and evaluated for their pulping properties (Onilude 2001, RMRDC 2003).

Generally, fiber length, cell wall thickness and some extent fiber width affect the paper properties of the wood (Kauppiene 1998). Oluwadare (1998), reports that fiber length is a critical factor in the selecting of any lignocellulose material for pulp and paper making. Fiber length in wood varies from one species to another and it also varies within the same species and it an important fiber characteristic controlling the strength properties of paper. Thus, the fiber characteristics have a preferential influence on the pulp and

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paper production (Anon 1980). Therefore a critical look at *Polyalthia longifolia (*masquerade tree) will be of great significant in knowing the uses to which the species could be utilized.

Although, consumption of paper product and demand of higher quality is on the increase per year all over the world, but the supply is low due to inadequate raw material that could give quality paper production. However, this problem has created a search for raw material in order for the need to be met (Awe 2005).

The fiber length determine the quality of paper due to the problem of supply of wood resources with long fiber for pulp and paper industry; therefore, there is a need to examine the suitability of lesser known wood species such as *Polyalthialongifolia.*

MATERIALS AND METHODS

Collection of Materials

Samples of 20x20x20mm were collected from two felled trees of *Polyalthia longifolia* wood at various points starting with base (10%), middle (50%) and top (90%) along the merchantable height. Thereafter, the discs were partitioned into three zones which are core, middle and outer, based on the relatives distance from the pith to the bark.

Fiber characteristics

The fibre measurements were conducted at Anatomy Laboratory in Forestry Research Institute of Nigeria, in accordance following ASTM D-1030-95 (2007) and ASTM D-1413-61 (2007). Small slivers having radial and tangential dimensions of 2 and 5mm from each of the wood species were macerated with acetic acid and hydrogen peroxide (1:1) and boiled in a water bath at a temperature of 100°C for 10 minutes following a procedure adopted by Ogbonnaya *et al.* (1997). Some macerated fibres were randomly selected and mounted on slides and then examined under a Reichet Microscope. The fibre length, fibre diameter and lumen width of unbroken fibres were measured using an eye piece micrometer after calibrating with stage micrometer.

Derived Morphological Indices

Some derived values were computed from the measured fibre dimensions (Eq. 1-4) following the method of Saikia *et al*. (1997), Ogbonnaya *et al*. (1997), Ohshima *et al*. (2005) and Sadiku *et al.* (2016). Twenty five fibres were measured from each representative sample slide.

$$Cell\ Wall\ Thickness = \frac{Fibre\ Diameter - Lumen\ Width}{2}\ (\mu m) \quad (1)$$

$$Slenderness\ Ratio\ or\ Felting\ Power = \frac{Fibre\ Length}{Fibre\ Doameter} \quad (2)$$

$$Flexibility\ Coefficient = \frac{Lumen\ Diameter}{Fibre\ Doameter} \quad (3)$$

$$Runkel\ Ratio = 2\ X\ \frac{Cell\ Wall\ Thickness}{Fibre\ Doameter} \quad (4)$$

Statistical analysis

Data obtained were analyzed statistically. Analysis of variance (ANOVA) was used for to test significant difference in the 3 treatments (Top, Middle and Base). When the ANOVA indicated a significant difference, a comparison of means was conducted, employing Duncan Multiple Range Test (DMRT) to identify which groups were significantly different at $\alpha_{0.05.}$

RESULTS AND DISCUSSION

Fiber characteristics

The variation in fibre length of *Polyalthia longifolia* along the sampling height, the radial position and the interaction between the sampling height and radial position are inconsistence, this is in line with findings of Osadare (1995) on his work on variations and fiber dimensions of three tropical hard wood species. One of the fibre property related to strength properties was fibre length, several investigators found that extensibility of the bonding strength site is a function of fibre length. Generally, increase fibre length improves paper tensile strength an influences the tearing strength of a paper. There is no significant difference between the radial position, along the sampling height, and interaction between the sampling height and radial position (Table 1). This results corroborate with the of Oluwadare 2006 who evaluated the fibre and chemical properties of some selected Nigeria wood and non-wood species.

The average fibre diameter for the species is 17.67±0.81-22.22±3.71, the pattern of variation exhibit by *Polyalthia longifolia* along sampling height and radial position is inconsistence. This may be due to molecular and physiological changes in vascular cambium as well as increase in the cell wall thickness during the tree grow. This pattern of variation exhibited by this *Polyalthia longifolia* hence this conform with Zobeland and Buijtenen (1999). There is no significant difference in fibre diameter of the bole at the levels, sampling height, radial position and interaction between sampling height an radial position at 5% level of significant, this result is in accordance with findings of Ogunsile and Uwajeh (2009) on *BambusaVulganis*.

The fibre lumen width plays a large effect or role on the beating property of a paper and the penetration of the liquid into the empty space of the fibre. Lumen width is one of the factors in determining Runkel Ratio, the pattern of variation observed from Table 4. 3 indicate that the fibre lumen width is inconsistence according Ojo (2009) on evaluation of selected fibre characteristics of the wood of *Leucaena luecocephala*. It is shown that there is no significant in fibre lumen width of the bole at the levels, sampling height, radial position and the interaction between the sampling height and radial position at 5% level of significant. This result is in accordance with findings of Wahab *et al.* (2009) and Ogunsile *et al.* (2009) on *Bambusa vulgaris*.

Table 1

Analysis of variance for fibre dimension of the Polyalthia longifolia

Source of Variation		Fibre Length		Fibre Diameter		Lumen Width	
	df	Ms	F-Values	Ms	F-Values	Ms	F-Values
Axial Position (AP)	2	0.032	3.876^{ns}	33.607	4.164^{ns}	15.903	4.164^{ns}
Radial Position (RP)	2	0.002	0.290^{ns}	0.274	0.034^{ns}	0.427	0.117^{ns}
AP*RP	4	0.002	0.269^{ns}	5.693	0.705^{ns}	0.789	0.217^{ns}

ns-no significant difference (P>0.05)

Table 2

Mean value of fibre dimension Polyalthia longifolia

Fier Characteristics	Sampling Height	Radial Position			Pooled Mean
		Core	Middle	Outer	
Fiber Length	Base	1.03± 0.20	1.04±0.01	1.10± 0.14	**1.06± 0.11**
	Middle	0.94±0.00	0.89± 0.23	0.92±0.30	**0.92±0.03**
	Top	0.99± 0.57	0.92± 0.34	0.92± 0.10	**0.95± 0.06**
	Pooled Mean	**0.99± 0.10**	**0.95± 0.07**	**0.98±0.12**	**0.97± 0.10**
Fiber Diameter	Base	20.27± 0.69	22.25±3.48	24.12±6.42	**22.22±3.71**
	Middle	18.08±0.61	17.30±0.27	17.62±1.47	**17.67±0.81**
	Top	19.61± 3.93	19.62±0.56	19.62±0.56	**18.81±2.19**
	Pooled Mean	**19.32±2.07**	**19.73±2.72**	**19.64±4.57**	**19.56±3.10**
Lumen Width	Base	11.27±1.15	12.26±2.70	13.19±4.45	**12.21±2.42**
	Middle	9.13±0.22	8.73±0.09	9.23±0.87	**9.03±0.46**
	Top	10.02±1.62	10.31±0.52	9.69±0.72	**10.01±0.87**
	Pooled Mean	**10.14±1.31**	**10.44±2.00**	**10.67±2.79**	**10.42±2.01**

Derived Morphological Indices

The Values of cell wall thickness ranges 4.32±0.22-5.00±0.66 along the sampling height. It is observe that there is inconsistence variation pattern along the length of the radial. It is shown in the Table 3, there is no significant at sampling height, radial position and interaction between the sampling height and radial position. This result is in accordance with Ojo*et et al.* (2009) on *Leucaena leucocephola*.

Average mean value of fibre Runkel Ratio ranges from 0.68±0.03-0.93±0.12 showing its consistence pattern of variation (Table 4). The most important and primary observation of any raw material for pulp and paper manufacturing is the Runkel Ratio and it is govern by the lumen width an cell wall thickness. According to Yusuf (2007), a fibre with Runkel Ratio less than one has a potential for pulp and paper production. In the

same vein, the species has pulp and paper potential since the Runkel Ratio is lesser than one. However, at 5% of level of probability is observed that, there is no significant different in the Runkel Ratio of sampling height, radial position and the interaction between the sampling height an radial position.

The average mean value of coefficient of flexibility follows inconsistence pattern of variation and it ranges from 53.73±2.82-56.30±3.47 (Table 4). This findings is in accordance with that of Ojo *et al.* (2009) on *Leucaena luecophala*. At 5% level of significance, Table 3 shows that, there is no significant difference in the coefficient flexibility in the sampling height, radial position and interaction between the sampling height and radial position.

Felting power follows inconsistence pattern of variation and it ranges from 55.33±8.09-58.44±2.73 (Table 4). This findings is in accordance with that of Ojo *et al.* (2009) on *Leucaena luecophala.* At 5% level of significance, the Table 3 shows that, there is no significant difference in the coefficient flexibility in the sampling height, radial position and interaction between the sampling height and radial position.

Table 3

Analysis of variance for derived morphological Indices of the Polyalthia longifolia

Source of Variation		Cell Wall Thickness		Runkel Ratio		Flexibility Coefficient		Felting Power	
	df	Ms	F-Values	Ms	F-Values	Ms	F-Values	Ms	F-Values
Axial Position (AP)	2	10.838	2.825^{ns}	0.2	2.627^{ns}	10.334	1.010^{ns}	15.873	0.207^{ns}
Radial Position (RP)	2	0.038	0.130^{ns}	0.1	1.300^{ns}	21.438	2.096^{ns}	14.902	0.194^{ns}
AP*RP	4	0.577	1.946^{ns}	0.005	0.710^{ns}	10.998	1.075^{ns}	19.934	0.259^{ns}

ns-no significant difference (P>0.05)

Table 4

Mean value of derived morphological indices Polyalthia longifolia

Fier Characteristics	Sampling Height	Radial Position			Pooled Mean
		Core	Middle	Outer	
Cell Wall Thickness	Base	4.50±0.23	4.99±0.39	5.51±0.98	**5.00±0.66**
	Middle	4.48±0.20	4.28±0.18	4.19±0.30	**4.32±0.22**
	Top	4.79±1.15	4.66±0.02	3.75±0.03	**4.40±0.72**
	Pooled Mean	**4.59±0.56**	**4.64±0.37**	**4.49±0.94**	**4.57±0.63**
Runkel Ratio	Base	0.91±0.14	0.90±0.10	0.91±0.10	**0.91±0.09**
	Middle	0.03±0.04	1.03±0.02	0.98±0.01	**0.68±0.03**
	Top	1.02±0.96	0.95±0.05	0.83±0.14	**0.93±0.12**
	Pooled Mean	**0.99±0.98**	**0.96±0.08**	**0.91±0.10**	**0.95±0.09**
Coefficient of Flexibility	Base	57.25±4.71	55.83±4.99	55.83±3.24	**56.30±3.47**
	Middle	52.29±0.51	52.25±1.70	56.63±3.40	**53.73±2.82**
	Top	51.84±1.67	54.94±1.70	59.48±3.66	**55.44±3.97**
	Pooled Mean	**53.80±3.50**	**54.36±3.01**	**57.31±3.16**	**55.16±3.43**
Felting Power	Base	58.48±12.58	55.06±9.13	52.47±7.02	**55.33±8.09**
	Middle	57.05±0.48	57.59±3.24	60.68±3.33	**58.44±2.73**
	Top	57.34±17.88	51.78±3.33	59.06±6.94	**56.06±7.35**
	Pooled Mean	**57.62±9.80**	**54.79±5.27**	**57.41±6.06**	**56.61±6.99**

Table 5

Mean Fibre Characteristics and derived indices Value of Polyalthia longifolia in comparison with Pinus caribeae and Gmelina arborea

Fibre Morphology	*Polyalthialongifolia**	*Pinuscaribeae***	*Gmelinaarborea****
Fibre characteristics			
Fibre length (mm)	0.89-1.10	2.32-3.53	3.865
Fibre diameter (mm)	17.19-24.12	24.0-28.0	10.8
Lumen width(um)	8.73-13.19	13.0-14.0	28
Derived Indices			
Cell wall thickness	3.75-5.51	6.00-7.60	31
Runkel ratio	0.03-1.03	0.79-1.00	1.209
Flexibility Coefficient	51.84-57.48	50.00-58.00	35.79

* Current study
** Previous study (Ajala, 1997)
*** Previous study (Yusuf, 2007)

The table above shows the comparative values of the fibre dimension obtained from *Polyalthialongifolia*. The values from *Polyalthialongifolia* compared fairly well with those of *Pinuscaribeae* and *Gmelinaarborea*. However, the Runkel ratio is favoured by Yusuff (2007) that fibre with runkel ratio ≤ is good for pulping.

CONCLUSION

From the result of the study, finding and analysis *polyalthia longifolia* can be introduced to our paper mills for the production of good pulp for paper making also can be used for certain paper grade.

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