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Investigation of Pulping Potentials of Waste from Conversion of *Anogeissus leiocarpus*

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Abstract: *Enormous waste is generated during conversion of wood. This study investigated the pulping potentials of waste from Anogeissus leiocarpus. Fibre dimensions of . shavings, splinters and dust from the wood were determined. Mean fibre length ranged from 1.1mm in splinters to 0.3mm with potentials for bulk smoothness and opacity.. Runkel ratio obtained for splinters, shavings and sawdust was 0.851, 0.785, and 0.686 respectively while flexibility was 54.8%, 52.9% and 60.9% respectively. Both shavings and sawdust had favourable felting power. Waste of Anogeissus leiocarpus proved to be an alternative source of raw material for pulp and paper industries due its appreciable fibre length, readily collapsible fibre with runkel ratio that is below 1. It could be mixed with other pulpwood with high fibre length to produce quality paper grade.*
***Key Words** : Fibre Dimensions, Derived values, Anogeissus leiocarpus, Waste .*

I. Introduction

One of the major wood products now recognized in socio-economic development in Forest-based Industries across the globe is fibre.In Nigeria, one of the problems in pulp and paper industries is inadequate supply of fibre [1,2]. Enormous waste is generated during wood conversion. The problems posed by these wastes are many: they degrade the urban environment, reduce its aesthetic value, produce offensive odours during the rains and pollute the air with smoke when the wastes are burnt uncontrollably. They also constitute health hazards in themselves if they are not timely disposed, they become breeding places for worms and insects [3].

There are several species of wood like *Leucaena leucocephala* [2] and *Gmelina arborea* [4] being processed in sawmill that their waste can be further processed to reduce its negative impact on the environment, increase its ecological importance and at the same time increase its economic value. In Nigeria, *Anogeissus leiocarpus* is being used for building and construction as it is being regarded as a medium grade species [5 and 6]. The process of conversion of the species (i.e. cutting, smoothing, and edging) leads to the wastage of good quantity of the tree species in sawmill which can be further processed to fibre to increase the supply of pulp raw material [5,6].

The increasing demand for papers, cords, ropes, textiles and other fibre derived products which is contributing immensely to over exploitation of some particular species calls for attention. Due to the drastic reduction in the supply of wood species needed in pulp and paper industry resulting from increased demand for wood for various uses, it has become imperative to examine the waste of an indigenous species (*Anogeissus leiocarpus*) for pulping in order to increase the supply of raw material for pulp and paper industries and other fibre derived products on the one hand and reduce the negative effect of sawmills waste by utilizing them on the other hand.

The analysis of fibre length, fibre diameter, fibre lumen width and their derived morphological factors became important in estimating pulp quality of fibre [7],[8].The study therefore investigated the pulping potentials of waste generated from conversion of *Anogeissus leiocarpus.*

II. Methodology

The research was conducted at the Department of Forestry and Wildlife Management, Federal University of Agriculture Abeokuta, Ogun State, Nigeria.The sample (*Anogeissus leiocarpus*) was collected from sawmill in Camp, Odeda local Government in Abeokuta, Ogun State, Nigeria. The wood was converted into three different forms (i.e. shavings, splinters and dust). The dust was obtained through the use of saw to reduce wood into particles and stored in a vial. The shavings was collected with the use of smoothing machine and also stored in a separate vial. The splinters was gotten by using chisel to reduce the wood into splinters, after which hand was used to collect the splinters of the already reduced wood which was also stored in a vial.

2.1Cooking

Acetic acid and hydrogen peroxide were mixed at the ratio of 1:1. 200ml of hydrogen peroxide (which acts as the softening agent) was collected in a 4000ml flat bottom flask containing 200ml of acetic acid (which acts as the bleaching agent). This was replicated three times for the already collected splinters, shavings, and dust of the sample. Each of the converted samples was totally immersed in each of the container containing the mixture and placed on the electric stove which was placed in the fume cupboard. Each container was then observed under regulated temperature at 100^0c for few hours.

2.2Washing and Drying

The cooked materials were later collected from the stove and thoroughly washed with clean water to remove the chemicals that were used in cooking and all other components of the wood leaving only the soft and bleached fiber. The washing was done several times to ensure that all the chemical and other impurities were totally removed. The washed fibers were then dried in a cool dry place after the samples to be examined were collected.

*2.3Laboratory analysi*s

The samples collected were later shaken together with distilled water in a test tube in order to separate the fibres. The separated fibres per sample in each test tube were mounted on microscope and examined. Five fibres each from the materials were randomly selected and traced.

2.4 Determination of Parameters

Fibre length was measured using the micrograph with camera microscope by connecting the microscope with computer which collects the information gotten from the lens of the microscope. Information was collected using the measuring tool of the microscope software. The “curve” tool was selected and dragged along each selected fibre from one end to the other and each drawn lines were given in micrometer.

The fibre diameters were measured using the “line” tool which was drawn at the middle of the fibre while the lumen width was determined by measuring the diameter of the inner cavity by drawing the “line” tool touching the inner cell walls. Fibre wall thickness which is the average difference between fibre diameter and lumen divided by two was also determined.

Mathematically expressed as $\frac{D - Lu}{2}$ (1)

*2.5 Fl*exibility

This gives the tensile and busting strength of the fibre. The higher the flexibility, the greater the tensile strength and corresponding busting strength.

The coefficient of suppleness $= \frac{Lu \times 100}{D}$ (2)

Where Lu = lumen width
D = fibre diameter.

2.6 Derived Values

The fibre quality for pulp and paper making can be determined by Runkel ratio (Runkel, 1952as showed in the formula below.

$$RK = \frac{2 \times \text{wall thickness of fibre}}{\text{Lumen width of fibre}} = \frac{(2w)}{(Lu)} \quad (3)$$

RK is Runkel ratio
Where **RK** is < or = 1, the fibre is good (pulpable)
Where **RK** is < 1, the fibre is very good (highly pulpable)
Where **RK** > 1, the fibre is not good for pulping.
Important criteria in paper making can be determined using the following five equations:

Felting rate $= \frac{\text{fibre length}}{\text{Fibre diameter}}$ (4)

Rigidity coefficient $= \frac{\text{Cell wall thickness} \times 100}{\text{Fibre diameter}}$ (5)

Runkel index $= \frac{\text{wall thickness} \times 100}{\text{Lumen diameter}}$ (6)

III. Results

3.1Mean Value of Fibre Dimensions

The mean value of the fibre length of the splinters was 1.1mm. This was higher than that of the shavings (1.0mm) and sawdust (0.3mm). The average mean of the fibre length of shavings (1.0mm) was higher than for the sawdust (0.3mm). The mean fibre diameter of splinters (0.021mm) was the highest, followed by shavings (0.014), while the mean fibre diameter of sawdust (0.010) was the lowest. The mean lumen width of splinters, shavings and sawdust were 0.012mm, 0.007mm, and 0.007mm respectively. This indicates that the mean lumen width of shavings and sawdust are the same and lower than the mean value of splinters. The wall thickness increases from sawdust to splinters with (0.0027mm) in sawdust, (0.0036mm) in shavings and (0.0048) in splinters.

Table 1: Table showing mean value of fibre dimensions

	SPLINTERS	SHAVINGS	SAWDUST
FIBRE LENGTH	1.1ac	1.0b	0.3bc
FIBRE DIAMETER	0.021a	0.014b	0.010c
LUMEN WIDTH	0.012a	0.007b	0.007bc
WALL THICKNESS	0.0048ac	0.0036ab	0.0027b

Laboratory Practical (2013)

Table 2: Table showing mean of derived values

	SPLINTERS	SHAVINGS	SAWDUST
RUNKEL RATIO	0.851	0.785	0.686
FELTING RATE	100.8	74.9	24.0
FLEXIBILITY (%)	54.8	52.9	60.9

Laboratory Study (2013)

Table 3: Result of Analysis of Variance (ANOVA)

Sources of Variables		Degree of freedom	Sum of square	mean of square	F-cal.	F-tab.
FL	Total1	14	2.17			
	Treatment1	2	2.14	1.07	535	3.89
	Error1	12	0.03	0.002		
FD	Total2	14	328.68			
	Treatment2	2	284.70	142.36	38.95	3.87
	Error2	12	43.98	3.655		
FLW	Total3	14	103.99			
	Treatment3	2	69.50	30.76	12.11	3.89
	Error3	12	34.49	2.87		
WT	Total4	14	145.32			
	Treatment4	2	131.94	65.97	59.17	3.89
	Error4	12	13.38	1.115		
RK	Total5	14	1.62			
	Treatment5	2	0.19	0.0095	0.79	3.89
	Error5	12	1.43	0.12		
FLE	Total6	14	99.16			
	Treatment6	2	244.11	122.05	1.96	3.89
	Error6	12	747.06	62.25		
FR	Total7	14	7255.75			
	Treatment7	2	6483.75	324.88	50.39	3.89
	Error7	12	772	64.33		

Laboratory Study (2013)

IV. Discussion

The mean value for the fibre length of *Anogeissus leiocarpus* in this study ranges from 1.1mm in splinters to 0.3mm in sawdust this may be as a result of conversion. The fibre length of splinters and shavings falls in the same range (0.8mm to 1.65mm) stated by [10]. Therefore the species belongs to the classes of short fibre length with achieving bulk, smoothness, and opacity [11]. Pattern of variation exhibited by the fibre length increases from sawdust (0.3mm) to splinters (1.1mm). This indicates that splinters are the best form for pulping when considering the fibre length. At 5% probability, at least two of the fibre lengths are significantly different (Table 3).

The mean value of fibre diameter in this study was 0.021mm, 0.014mm and 0.010mm for splinters, shavings, and sawdust respectively. Consequently, paper made from *Anogeissus leiocarpus* waste would be expected to exhibit medium contact between fibres since fibre diameter and the cell wall govern the flexibility of paper [11]. Paper manufactured from thick walled fibres will be dense and possess coarse surface whereas paper made from thin walled fibre will be dense and well formed [12]. There was a significant difference in fibre diameter at 5% probability (Table 3).

It has been documented that the fibre characteristics such as lumen width is of great importance in pulp and paper making as this is one of the factors that determines the runkel ratio. The mean of the splinters, shavings and sawdust from this study is 0.012, 0.007and 0.007 respectively while that of [4] on Fiber morphology in fast growth *Gmelina arborea* plantations was 0.0249. Lumen width decreases from splinters (0.012) to (0.007) in shavings and sawdust. Fibre lumen affect the beating of pulp, the larger the fibre lumen width, the better will be the beating and the penetration of liquid to the empty spaces of the fibre [13] and [14].

The proportion of fibre in wood is very crucial to many end properties. It should be noted that fibre proportion is insufficient if its dimensional characteristics are not considered i.e. fibre characteristics in the dimension of strength properties in the material. Some parameters such as fibre length and cell wall are very good indicators. [12] established that fibre cell wall thickness modify the fibre length in exhibition of paper strength. The mean value of splinters, shavings and sawdust of *Anogeissus leiocarpus* from this study was 0.0048, 0.0036 and 0.0027 respectively while that of Roger *et al* 2007 is 0.00402. It increased from sawdust to splinters (0.0027, 0.0036, and 0.0048).

4.1Derived Values

The most important and primary parameter needed to find the suitability of any raw material for pulp and paper is runkel ratio. The standard for this ratio is one (1), favourable pulp strength properties are usually obtained when value is below the standard value. Fibre with high runkel ratio value is stiff, less flexible and form bulkier paper of low bounded area than the lower ratio fibre. The value obtained from splinters, shavings and sawdust of *Anogeissus leiocarpus* from this study was 0.851, 0.785, and 0.686 respectively. This implies that sawdust is more suitable for pulping when considering runkel ratio as it has a relative lower value than splinters and shavings which also falls into the range of desirable runkel ratio.. This makes the fibres a good quality raw material for quality pulp and paper. At 5% probability, there is no significant difference in the runkel ratio of the fibres (Table 3).

The strength properties of paper such as tensile strength, bursting strength and folding endurance are affected mainly by the way in which individual fibres are bonded together in paper sheet. The degree of fibre bonding depends largely on flexibility and compressibility of individual fibre [15]. Other calculated wood properties of importance are flexibility ratio and rigidity coefficient. The higher the value of fibre length to width ratio, the greater will be the fibre flexibility and the chance of forming well bonded paper. Similarly, an increase in the rigidity of fibres results in decrease in fibre bonding. The flexibility of splinters, shavings and sawdust from this study was 54.8%, 52.9% and 60.9% respectively which is in the range with [16] (60%). If the flexibility ratio was between 50 and 70, this kind of fibers easily can be flat and give good paper with high strength properties [16]. It is expected that the pulp made from *Anogeissus leiocarpus* stem will have greater inter-fibre bond and hence greater tensile strength which favour those properties that affects printing. The pattern of variation showed that it increased from shavings to sawdust. The flexibility coefficient is generally on the average indicating the acceptability of its burst and tensile strength [17].

Felting and slenderness significantly influenced the breaking length, bursting, tearing and stretch of the pulp sheets. According to [13] and [14], if the Slenderness ratio is lower than 70, it is invaluable for quality pulp and paper production. But, if the Slenderness ratio is higher than 70, it can be utilized in paper industry. The felting power of *Anogeissus leiocarpus* from this study ranges from 100.8 in splinters, 74.4 in shavings to 24.0 in sawdust. This is closer to 133.0 of [10]. However, the felting power of the fiber of shavings and sawdust was found as 100.8 and 74.4 respectively which are higher than 70 and so they can be utilized in paper industry. Pulp resistance to tear increases with increasing fibre slenderness, paper made from splinters of *Anogeissus leiocarpus* stem is expected to have increased tear strength suitable for wrapping and packaging purposes [18].

V. Conclussion

In this study, the waste of Anogeissus leiocarpus had been proven to be a source of raw material for pulp and paper industries due to the quality of its fibre characteristics. This is due to its medium fibre length, readily collapsible fibre with runkel ratio that is below the standard i.e. one (1) which makes it a desirable wood for pulping. It can also be mixed with other pulpwood with high fibre length to produce quality paper grade. *Anogeissus leiocarpus* as an indigenous tree is a good source of raw material for pulp and paper industries and the waste can therefore be used as raw material for pulping. To utilize this wood to its highest potential, the waste should be included in the raw material in pulp and paper industries.

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