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Investigation of Pulping Potentials of *Jathropha curcas*

Ogunjobi K.M [1], Adetogun A.C [1], Soetan D.O [1], Omole A.O [2], Olorunfemi, O. and J.B. Odebiyi [3]

1 Department of Forestry and Wildlife Management, Federal University of Agriculture, Abeokuta, Nigeria
2 Department of Forest Resources Management, University of Ibadan, Ibadan, Nigeria
3 Bola- Biyi Agroforestry Consultancy, Nigeria.

Abstract

The study investigated the pulping potentials of Jathropha curcas, Samples of sawdust, shaving and splinters were taken at three sampling heights.(20%, 50% and 90%) and *macerated using glacial acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2) in ratio 1:1. Result of fibre characteristics showed that mean fibre length ranged from 0.216mm at top to 0.243mm at middle and 0.244m at the base. Mean fibre diameter of sawdust (0.01053mm) was highest followed by 0.01028mm for splint and shaving had 0.01002mm. Highest lumen width was recorded at base while highest cell thickness was recorded at top. Both sampling height and within sample exhibited Runkel ratio of less than 1 while Flexibility coefficient compared favourably with other species. This study showed that Jatropha stem can be used as an alternative in pulp and paper industry taking advantage of its appreciable short fibre length and Runkel ratio of less than 1.*

Keywords : Fibre Characteristics, Derived values, *Jathropha curcas*, sampling height, Within sample.

1. Introduction.

Most of the tree species used for pulp and paper production are threatened due to high rate of deforestation and increasing demand of their wood for other economic purposes. This trend has increased pressure on *Gmelina arborea* established for the use of paper industries.

The major species used as the raw material for pulp and paper making are the long fibre exotic softwood such as Gmelina, Eucalyptus and Pines. [1] disclosed that high consumption rate of paper has skewed from advanced countries to the developing countries. This is an indication of great challenges to the developing countries in terms of meeting the requirements of paper demand by the end of the 21st century. Hence, the increase in paper demand calls for screening of other species as possible alternatives for pulp and paper production.

In Nigeria, wood is the major source of fibre supply for paper making. The Gmelina plantation which was originally established to serve as a source of material for paper production in has overgrown and utilized for some other purposes such as furniture e.t.c. The fibre properties of the raw materials affect the quality and end use of paper. For fine papers,both long and short fibres areneeded.The long fibres fromsoftwoods with fibre length of about 2.8mm forma strong matrix in the paper sheet. The shorter hardwood fibres from deciduous trees with fibre length ranging from 0.6-1.9mm [2] contribute to the properties of pulp blends, most especially its opacity,printability and stiffness. In fine papers, short fibre length contributes to printability.

The lack of long fibre pulp materials production locally is a problem to the paper making industry in Nigeria. In order to meet the growing demand constituted by increasing population, investigation of pulping potentials of other species has become imperative.

Jatropha curcas is a poisonous, semi-evergreen shrub or small tree, reaching a height of 6m (20ft) [3]. It grows almost everywhere even on gravely, sandy and saline soils. It is resistant to a high degree of aridity, allowing it to be grown in deserts [4]. The objective of the study is to determine the pulping potentials of different categories of the wood.

2. Materials and Methods.

2.1 Study Area.

Jatropha stem was sourced from Ilupeju, Camp,Odeda Local Government Area of Abeokuta, Ogun State, Nigeria which lies on Latitude 7°10'N and Longitude 3° 2' E. The pulping process was carried out at Wood Laboratory of the Department of Forestry and Wildlife Management, Federal University of Agriculture Abeokuta.

2.2 Preparation of Materials.

Samples from Jatropha stem ware taken at three sampling heights i.e. 20%, 50% and 90%. From the samples of the woody materials; sawdust, shaving and splinters were produced.

2.3 Experimental Procedure.

The samples were placed inside different beakers containing glacial acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2) in ratio 1:1[5]. and properly labeled before being placed on electric stove for 3hours at temperature of 100^0C. The hydrogen peroxide acts as an oxidizing agent that bleaches the samples' colour to white, while glacial acetic acid acts as cooking medium, which softens the wood samples. After heating, the samples were removed and rinsed one after the other with water several times and spread on a net for the samples to dry. The pulped fibres were dried and kept in vial. The fibres were placed on the slide and glycerol was added for clear visibility of the fibres. Then safranine was also added to stain the fibres and they were viewed under the microscope. Five fibres each from the samples were randomly selected.

2.4 Determination of Fibre Characteristics.

Fibre length was measured using the micrograph with camera microscope by connecting the microscope with computer. Data 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 diameter was measured using the "line" tool which was drawn at the middle of each of the fibre while lumen width was measured by drawing the "line" tool touching the inner cell walls.

The cell wall thickness is the average difference between fibre diameter and lumen width divided by two.

Mathematically expressed as:

$$\frac{FD-LU}{2}$$

Where FD = Fibre diameter

LU = Lumen width

2.5 Derived Values.

The derived values help in predicting the pulping potentials.

2.6 Runkel Ratio Index.

The fibre quality for pulp and papermaking can be determined by Runkel ratio [6] as shown in the equation below:

$$RK = \frac{2 \text{ X cell wall thickness of the fibre } (2W)}{\text{Lumen width of the fibre} (Lu)}$$

This is the Runkel ratio (RK)

When, RK = 1, the fibre is good (pulpable), RK < 1, the fibre is very good (highly pulpable), RK > 1, the fibre is not good (not pulpable).

2.7 Coefficient of Flexibility.

This gives the tensile and bursting strength of the fibre. The higher the coefficient, the greater the tensile strength and corresponding bursting strength.

The coefficient of flexibility =

$$\frac{\textit{Lumen diameter}}{\textit{fibre diameter}} \text{ X } 100$$

2.8 Felting Rate.

This is the ratio of length to its diameter. It gives the tearing resistance of the paper.

$$\textbf{Felting rate} = \frac{\text{fibre length}}{\text{fibre diameter}}$$

3.0 Results and Discussion

Mean fibre length ranged from 0.216mm at the top to 0.243mm at the middle and 0.244m at the base (Table 1). [7] reported a decrease in fibre length from base to top, which corroborates this study. For within samples, mean fibre length ranged from 0.211mm for sawdust to 0.240mm for splint and 0.252mm for shaving. The fibre length of the species is categorized as short fibre according to [8]. This stipulated that wood with fibre length of greater than 10mm could be regarded to as long fibre as in *Pinus species*, 2-10mm as medium fibre and and less than 2mm as short fibre wood. Values are within the range (0.99-1.33mm) reported by [9] for 12 *Ficus* species. Fibre length and distribution has been reported to play important roles in the processing and mechanical performance of fibre-based products such as paper and fibreboard [10]. For pulp and paper production, species with higher fibre lengths are preferred since a better fibre length will be achieved, resulting in a paper with high resistance. Since the fibre possesses short fibre length, the fibre can therefore be used to augment species of long fibre. The short fibre may be as a result of inherent anatomical and physiological characteristics. There was significant difference between base and top whereas no significant difference between middle and top (Table 2). For within sample, there was significant difference between sawdust and shaving but no significant difference between shaving and splint.

Results of fibre diameter as presented in Table 1 ranged from 0.01137mm to 0.00921mm. However, the highest mean value 0.01137mm was obtained from the base followed by 0.01027mm at the top and least 0.00921mm was from the middle. For within sample, the mean fibre diameter of sawdust (0.01053mm) was the highest followed by 0.01028mm for the splint and shaving 0.01002mm, though there was no significant difference (Table 2). This is agrees with observations of [5]on the fibre and chemical properties of some Nigerian grown *Musa species* . It is also in line with [11] on the Grease proof paper from banana pulp fibre with 0.02359mm.

Mean value of lumen width ranged from 0.0053mm to 0.0072mm. Although there was significant difference in lumen width along sampling height, the highest was found to exist at the base while the least value was at the top. For within sample, lumen width ranged from 0.0058mm to 0.0062mm with splint having the highest value and shaving having the least. Lumen width recorded n this study is greater than the range (2.47-4.94um) with a mean of 3.31um reported for some indigenous hardwood species in the tropical rainforest ecosystem [12].

The thickness of the cell wall of this species ranged from 0.0018mm to 0.0024mm from . Highest thickness of cell wall was observed at the top while the least was recorded at the middle. Average mean value of 0.0021mm recorded for this species is within the range of what was reported for Gmelina (2.82um) and Ficus species (1.94-4.99um) by [12].

Table 1: Showing the mean value of fibre characteristics of the Jatropha stem for sampling height and within sample

Fibre characteristics	
Fibre Length (mm)	**Mean**
Base	0.244
Middle	0.243
Top	0.216
Average mean	**0.234**
Splint	0.240
Sawdust	0.211
Shaving	0.252
Average mean	**0.234**

Table 1 cont'd:

Fibre diameter (mm)	Mean
Base	0.01137
Middle	0.00921
Top	0.01027
Average mean	**0.01028**
Splint	0.01028
Sawdust	0.01053
Shaving	0.01002
Average mean	**0.01028**

Lumen width (mm)	Mean
Base	0.0072
Middle	0.0052
Top	0.0053
Average mean	**0.0060**
Splint	0.0062
Sawdust	0.0060
Shaving	0.0058
Average mean	**0.0060**

Cell wall thickness (mm)	Mean
Base	0.0020
Middle	0.0018
Top	0.0024
Average mean	**0.0021**
Splint	0.0021
Sawdust	0.0022
Shaving	0.0021
Average mean	**0.0021**

Source: Laboratory analysis (2013)

Table 2: Analysis for fibre characteristics

Treatment	Fibre length	Fibre diameter	Lumen width	Cell wall thickness
Sampling height				
Base	0.244 [a]	0.01137[a]	0.0072[a]	0.0020[ab]
Middle	0.243 [ab]	0.00921[b]	0.0054[b]	0.0018[b]
Top	0.216 [b]	0.01027[ab]	0.0053[b]	0.0024[a]
Within sample				
Sawdust	0.211 [b]	0.01053[a]	0.0060[a]	0.0022[a]
Shaving	0.252 [a]	0.01002[a]	0.0058[a]	0.0021[a]
Splint	0.240 [a]	0.01028[a]	0.0062[a]	0.0021[a]

3.1 Derived Values.

The runkel ratio of wood fibre is one of the properties of wood that have been recognized as important traits for pulp and paper properties [13]. It should be less than 1 for a wood with good quality for pulp production [14]. The runkel ratio of this species is less than 1 in sampling height and within sample as shown in Table 3. For sampling height, runkel ratio was between 0.5760-0.9214 with average mean value of 0.7343. For within sample, 0.6860-0.7788 with average mean value of 0.7343. Based on sampling height, the highest runkel ratio of 0.9214 was obtained at the top followed by 0.7054 for middle and the least runkel ratio of 0.5760 at the base. This is within the range of 0.79 reported for tropical Pine species [15] and 0.70 for *Dacryodes edulis* [16]. This species is suitable for pulp and paper production since the runkel ratio value is less than 1.

3.2 Flexibility.

For wood to be eligible for pulping, its fibre must have adequate flexibility [17]. This gives the tensile and bursting strength of the fibre. Flexibility coefficient recorded ranged from 52.150% - 63.354% with base having the highest value and top having the least. For within sample, it ranged from 56.962% - 60.329% with splint is having the highest value and sawdust, the lowest. The mean flexibility value is in the range of 55 – 70% reported for most softwood [18]. It follows that the mean flexibility derived for this species is an advantage for its pulping potentials.

3.3 Felting rate.

Felting rate of wood is the ratio of length to its diameter. It gives a paper its ability to resist tearing. The value for this species is 20.472 for the base, 26.393 for the middle and 21.383 for the top. The felting rate for within sample is 20.179 for sawdust, 25.474 for shaving and 23.602 for splint.

Table 3: Showing the mean value of fibre derived values of the Jatropha stem for sampling height and within sample

Fibre derived values	
Runkel ratio	**Mean**
Base	0.576
Middle	0.7054
Top	0.9214
Average mean	**0.7343**

Table 3 cont'd:

Splint	0.686
Sawdust	0.7788
Shaving	0.7415
Average mean	**0.7343**
Flexibility (%)	**Mean**
Base	63.354
Middle	59.535
Top	52.15
Average mean	**58.346**
Splint	60.329
Sawdust	56.962
Shaving	57.747
Average mean	**58.346**
Felting rate	**Mean**
Base	21.48
Middle	26.393
Top	21.383
Average mean	**23.085**
Splint	23.602
Sawdust	20.179
Shaving	25.474
Average mean	**23.085**

Source: Laboratory analysis (2013).

Table 4: Analysis of derived values

Treatment	Runkel ratio	Felting rate	Flexibility
Sampling height			
Base	0.5760[b]	20.472[b]	63.354[a]
Middle	0.7054[b]	26.393[a]	59.535[ab]
Top	0.9214[a]	21.383[b]	52.150[b]
Within sample			
Sawdust	0.7788[a]	20.179[b]	56.962[a]
Shaving	0.7415[a]	25.474[a]	57.747[a]
Splint	0.6860[a]	23.602[ab]	60.329[a]

4. Conclusion.

The result of the fibre characteristics observed in this study showed that Jatropha stem can be used in pulp and paper industry taking advantage of its appreciable short fibre length and runkel ratio of less than one (1) on average. The short fibre can be blended with long fibre to produce high tensile strength and quality grade papers. It can also be used for toilet paper, since short fibres are easily decomposed in septic tanks and drainage. This species is pulpable and therefore can be used for pulp and paper making.

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