An Investigation into the Potentials of Dactyladenia bacteri; Dialum guineense; and Anthonota macrophylia for Paper Pulp Production.

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Abstract: An assessment of the wood of *Dactyladenia barteri, Anthonota macrophylla* and *Dialium guineense* for paper pulp production was carried out. Indices of assessment comprise (a) constant availability of wood material; (b) fibers yield of the wood material; (c) the Runkel ratio of the fibers; (d) the flexibility co-efficient of the fibers and (e) the relative fibers length. Results reveal that the three species are widely cultivated by every farming communities in Igbo land and beyond. They are maintained and protected as fallow crops and staking materials. After harvest, the stems (now dry) are cut down, sold as firewood and new plantations established. They are fast growing and early maturing (in 3-5 years). They therefore constitute the dominant species on the farmlands. Vast plantations for paper pulp industry can easily be produced. For fibers yield, the frequency of fibers obtained per unit area was 114, 105, and 67 for *Dactyladenia barteri, Anthonota macrophylla* and *Dalium guineense* respectively. The Runkel ratio was 0.86, 0.56 and 0.99 for *Dacyledenia barteri, Anthonota macrophylla* and *Dialium guineense* respectively. Flexibility co-efficient for *Dactyladenia barteri, Anthonota macrophylla* and *Dialium guineense* were 0.16, 0.24 and 0.12 respectively. The relative fibers length was 37.08, 32.63 and 46.37 for *Dactyledenia barteri, Anthonota macrophylla* and *Dalium guineense* respectively. The implications of the above results were discussed. [Report and Opinion. 2009;1(4):18-25]. (ISSN: 1553-9873).

Key words: Potential, *Dactyladenia bacteri, Dialum guineense, Anthonota macrophylia*, paper, pulp,

1. INTRODUCTION

Dactyladenia barteri belongs to the family Rosaceae, while *Anthonota macrophylla and Dialium guineense* are in the family Leguminosae. The two families (Rosaceae and Leguminosae) are grouped in the order Rosales (Benson, 1957; Longman and Jenik, 1974). The Rosales are herbs, shrubs or trees. Leaves are simple or compound and about half of the 15 families comprising the order are stipulate. The fruits are in legumes, follicles, achenes, drupes, capsules, pomes or berries. About 13,000 of the 18,000 species are in the pea family (Leguminosae). The Rosaceae, according to Dutta (1995) are herbs, shrubs or trees or sometimes vines. Leaves are simple, pinnate, practically alternate and stipulate. Flowers are bisexual or rarely symmetrical, perigynous or epigynous. Fruits are indehiscent and in achenes, follicles, druopes or pomes. Seeds are usually without endosperm.

The family is large including more than 100 genera, one of which is *Dactyladenia* and probably 2000 to 3000 species including *D. barteri* which is more prominently distributed in the North Temperate regions than in the tropics.

Dactyladenia barteri has been characterized by Hutchinson and Dalziel (1958) as shrubs or small trees, branches slender or climbing, leaves dark glossy green, reddish brown when dry. Flowers greenish white and fragrant. Fruits long, green, turgid, more or less pea shaped and pointed, sometimes cultivated. *Dactyladenia barteri* and other members of the Rosaceae family are used by the local people for agricultural and domestic purposes and also have immense industrial and commercial and medicinal uses according to Igbokwe, U.M (1993) and Okeke, S.E (2002).

The Leguminosae on the other hand are herbs, vines, shrubs and trees. They are cosmopolitan in distribution and made up of about 18,000 species (Good, R, 1974). Leaves are pinnate to tripinnate, trifoliate or sometimes simple. Flowers are usually bisexual, actinomorphic to zygomorphic. Fruits are usually in legumes, follicles, schizocarps, achenes, drupes and berries. Seeds are non-endospermic and sometimes arilate. *Dalium* species according to Hutchinson and Dalziel (1958) is a forest tree up tom 40 meters high are also often shrubs persisting in Savanna vegetation. The flowers are small, petals whitish or pinkish. Fruits are black and seeds embedded in reddish pulp. Leaflets usually 5 rarely 3 or 7 usually alternate, sometimes sub opposite; stamens 4 to 5 filaments straight, while *Anthonota macrophylla* has been described as petals blue, stiple of ovary 10 to 12mm long; bracteoles 2.5cm or more long. Fruits without transverse ridges and petioles twisted.

Economically, the Leguminosae is of considerable

importance as a source of high protein food e.g. *Phaseolus vulgaris* and *Vigna spp*)Cowpea). Many members are sources of vegetables for human consumption and industrial use. Many members are important in agriculture as cover crops, as forage crops and as source of timber. During the early years of wood pulp industry, only the more suitable temperate species mainly spruce and fir were used. As the demand for pulp increased, more species became admitted into the wood species (including hard woods) accompanied by modifications of pulping techniques to accommodate those species which are more difficult to pulp.

Major breakthrough has been recorded in India in the use of materials other than timber for the manufacture of pulp. Plants like baggasse, bamboo, jute, hemp, straw became very suitable this wise (Britt, 1964, Oliver, 1971).

After many species have been identified as good sources of pulp fibers, the characteristics of suitable fibre became determined. Okeke and Ademiluyi (1977) included the following qualities and characteristics.

- Suitability of fibers for conversion into pulp.
- Fibre yield per unit volume of raw materials.
- Quality of the resulting pulp for paper making.
- Cost of collection, transportation and conversion.
- Degree of deterioration in storages. From the above parameters, it became known that wood which is light coloured, soft and with long fibers and free form extraneous materials is well suited for pulp making. Okeke (1977) reported three methods of quantitative assessment of fibers for suitability in pulp making as follows:
    a) Runkel ratio which is the ratio of a fiber wall divided by the lumen diameter and expressed as 2W/L. Runkel values are grouped as
    i. Fibers with ratio less than 1 are very good for pulp making.
    ii. Fibers with ratios about or equal to 1 are also good for pulp making.
    iii. Fibers with values greater than 1 are poor for pulp making.
    b) Flexibility co-efficient. This is lumen diameter. Results indicate that the higher the flexibility co-efficient of the wood fibers, the higher is the tensile strength of the pulp and paper product of the species.
    c) Realtive fiber length: This expresses the ration of fibers length to its diameter. It also expresses the slenderness of the fiber. The higher the relative fibre length, the higher is the resistance to tear of the paper product.

When Ademiluyi and okeke (1973, 1977) applied the above techniques to *Bambosa vulgaris* and fourteen other savanna species, they came to the conclusion that all the species involved in the study are well suited to pulp production. This method of assessment is now used universally to assess wood fibers for pulp making.

Nigeria had some time ago (1975-1980) intended to establish mills in the country. The plan was that plantations of *Pinus* spp and *Gmelina arborea* would be established in the country as the source of fibers for the project. The plan failed owing partly to the non-establishment of the imported *Pinus* seedlings into seeds.

Attempts are being made recently to revive the same plan. No attempts have however been made to commission a study of the suitability of Nigeria tree species for pulp making. The results obtained by Ademiluyi and okeke, (1973, 1977) have been found encouraging to warrant a follow up study. An investigation into the potential of *Dactyladenia barteri, Dialium guineense* and *Anthonota macrophylla* for paper pulp production is therefore undertaken in this study. This is motivated by the huge amount of foreign exchange gulped by the dependence of the Federal Government on foreign plant species for paper mills.

2. MATERIALS AND METHOD

Stems from mature (flowering and fruiting parts) of *Dactyladenia barteri* and *Anthonota macrophylla* were cut from farmland in Umuokirika (Ahiazu Local Government Area) and Ikenazizi (Obowo L.G.A) respectively, while stems of *Dialium guineensis* were collected from Egbeada in Mbaitoli L.G.A.

The stems were cut into short pieces each 10cm long and sun dried for one month. Each piece was split open into two equal parts by means of a short kitchen knife. Each half stem pieces (silvers), each equal to the size of a match stick, and put into open container according to the species and brought outside for proper sun drying. Two hundred silvers were selected from each species, put in specimen bottles and labeled accordingly.

The equipment (microscope slides, cover slips, 250ml beakers, Petri dishes, forceps and spatula) were thoroughly washed in distilled water and kept in laboratory benches to dry.

Maceration: The maceration techniques of Schuliz as described by Dutta (1995) was used. Silvers of one locality before of the other localities were taken up. Following the process, 5-10 silvers from one species were introduced into a test tube. One gram of Pottasium Chlorate was added and finally concentrated Nitric acid was introduced just enough to cover the silvers by means of a drop-tube. This started a reaction that yielded large quantities of fumes. The experiment was carried out in a fume chamber. After fuming, the contents of the test tube were poured into a 250ml

beaker half full of water. The silvers were washed in two changes of water to stop the reaction and to properly remove traces of Pottasium Chlorate and concentrated Nitric acid. The silvers were then left in a Petri dish and covered with water.

To study the fibres, one silver was brought out at a time using a forceps, placed on a clean slide and gentle taps on the silver by means of a needle. The taps made the component cells of the wood to fall apart. The taps were continued until the cells became completely separated. Even spreading of the cells was carried out using the mounting needle. Thereafter, 2-3 drops of water were made to cover the cells before a cover slip was gently placed on top of the cells.

The slides were mounted on a microscope and the contents examined. Observations regarding the shape of each xylem element (vessels, parenchyma, fibres) were made. The length, width, lumen diameter and wall thickness of each fibre were measured and recorded. From the measurement, the Runkel ratio, flexibility co-efficient and the relative fibre length were calculated. The frequency of each xylem element (vessels, parenchyma and fibres) per unit area was determined from the average of ten different fields. For this purpose, unit area used is the field of the microscope x 10 occular and x10 objective. One hundred cells of each vessel and parenchyma elements were equally measured with regard to the length, lumen diameter and wall thickness including the average of each (Dabs, 1963, Ruthenber, 1980).

All measurements were carried out by means of a micrometer for each calculation. The distance from one caliberation of the micrometer to the next is 14.3µ to get the figure for a particular measurement. The total number of caliberations measured is multiplied by 14.3 µ. All silvers of the same and the different species were subjected to above processes. The results were recorded and averages (where necessary) determined. After all determinations, the accruing data were collated and presented in tables. Photographs of the various cell types were also produced and presented.

Assessment for pulp making:

Figures determined for the Runkel ratio (2xwall thickness divided by lumen diameter), flexibility co-efficient = lumen diameter divided by fibre diameter) and relative fiber length=fibre length divided by fibre diameter were employed in assessing the suitability of the three species for pulp making.

3. RESULTS

The comparative results of this investigation on *D. barteri, A. macrophylla* and *D. guineense* are presented below in tables 1,2,3 and 4 showing values of the various features of fibres, vessels and parenchyma for three species respectively (tables 1,2 and 3) and the fibre dimension and characteristics of the three species (table 4). Only three elements (vessels, fibres and parenchyma) were onserved during the study. No tracheids were observed. The dimensions of the three cell types are presented species by species in tables 1,2,3 and 4. the photographic representation of fibre lengths for the three species are also presented in figures 1(a,b and c,), 2(a, b, and c) and 3 (a,b,and c). also the comparative photographic representation of parenchyma cells of the three species are represented in figure 4 as (a) for *D. barteri* (b) for *A. macrophylla* (c) for *D. guineense*.

Table 1: Values of the various features of fiber, vessels and parenchyma of *D. barteri*

Xylem Cells	Length (µ)	Fiber diameter(µ)	Wall thickness(µ)	Lumen diameter(µ)	Frequency Per unit area*
Fiber	858.0-1043.9 (96.4)	21.43-28.60 (26)	2.63-2.81 (2.72)	3.05-5.03 (4.04)	81-47 (114)
Vessels	42.9-64.35 (53.63)	20.03-27.17 (24)	4.29-7.15 (6)	17.16-28.6 (22.90)	25-53 (29)
Parenchyma	25.74-35.75 (30.75)	7.15-11.44 (9.30)	1.43-2.86 (2.15)	8.58-12.87 (10.78)	16-20 (18)

*Unit area is the field of view of the microscope at x40 objective.

Table 2: Values of the various features of fiber, vessels and parenchyma of *A. macrophylla*

Xylem Cells	Length (µ)	Fiber diameter(µ)	Wall thickness(µ)	Lumen diameter(µ)	Frequency Per unit area*
Fiber	8430.0-1043.9 (881)	21.45-35.75 (27)	1.59-1.99 (1.79)	4.84-8.04 6.44)	75-135 (105)
Vessels	42.9-57.2 (50.10)	14.3-28.6 (21.43)	1.43-4.29 (2.86)	14.3-24.31 19.31)	14-24 (19)
Parenchyma	14.3-35.75 (25.03)	10.10-14.3 12.16)	1.43-2.86 (2.15)	7.15-10.01 (8.58)	10-18 (14)

*Unit area is the field of view of the microscope at x40 objective.

Table 3: Values of the various features of fiber, vessels and parenchyma of *D. guineense*

Xylem Cells	Length (µ)	Fiber diameter(µ)	Wall thickness(µ)	Lumen diameter(µ)	Frequency Per unit area*
Fiber	1101.1-1569.4 (1252)	14.30-35.75 (27)	1.66-1.80 (1.73)	2.20-4.16 3.18)	60-74 (67)
Vessels	42.9-57.2 (50.10)	14.3-28.6 (21.43)	1.43-4.29 (2.86)	14.3-24.31 (19.31)	22-28 (25)
Parenchyma	14.3-35.75 (25.03)	10.01-14.3 (12.16)	1.43-2.86 (2.15)	7.15-10.01 (8.58)	3-17 (15)

*Unit area is the field of view of the microscope at x40 objective.

Table 4: Fiber dimension and characteristics of *Dactyladenia barteri, Dalium guineense and Anthonota macrophylla*

Species	Fiber Length (µ)	Fiber diameter (µ)	Wall thickness(µ)	Lumen diameter(µ)	Ronkel* ratio(µ)	Flexibility** co-efficient	Relative*** fiber length
A.							
Macrophylla	843-943.8	21.43-35.73	1.59-1.99	4.84-8.04	0.56	0.24	32.63
	(88.1)	(27)	(1.79)	(6.44)			
Dactyladenia	858.0-1043.9	21.45-28.60	2.63-2.81	3.05-5.03	0.86	0.16	37.08
Barteri	(964)	(26)	(2.72)	(4.04)			
Dalium	1101.1-1569.4	14.30-35.75	1.66-1.80	2.20-4.16	0.99	0.12	46.37
Guineense	(125.2)	(27)	(1.73)	(3.18)			

* Ronkel Ratio= $\frac{2 \text{ (wall thickness)}}{\text{Lumen diameter}}$

** Flexibility Co-efficient = $\frac{\text{Lumen diameter}}{\text{Fiber diameter}}$

*** Relative fiber length = $\frac{\text{Fiber diameter}}{\text{Fiber diameter}}$

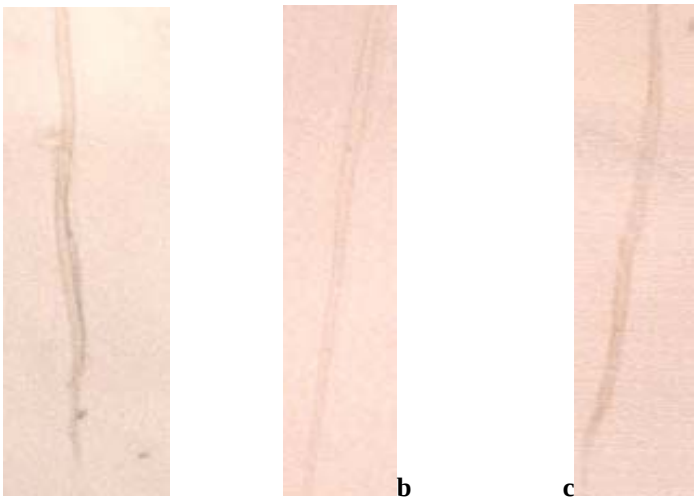
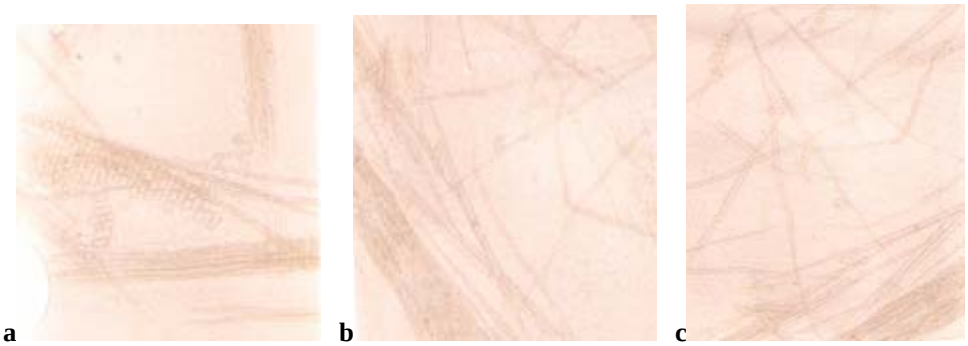
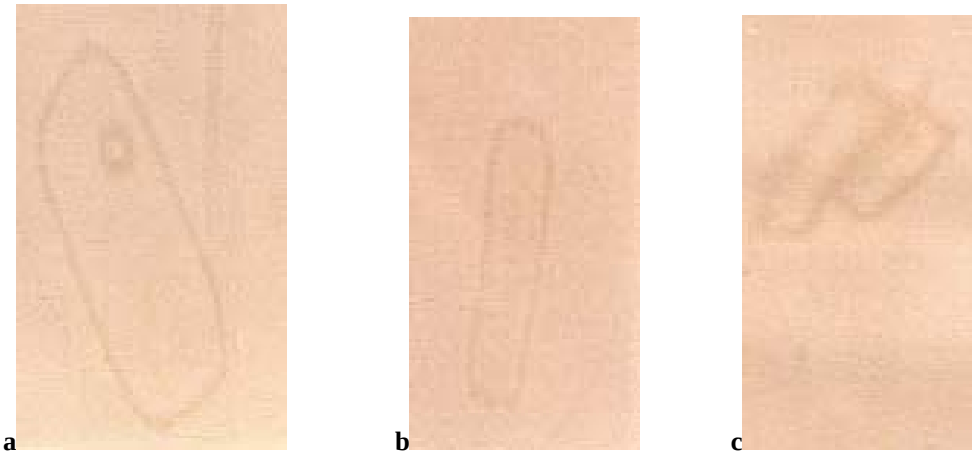


Fig 1: Photographic representation of fiber length of (a) *D. barteri* *(b) Anthonota macrophylla (c) Dalium guineense*



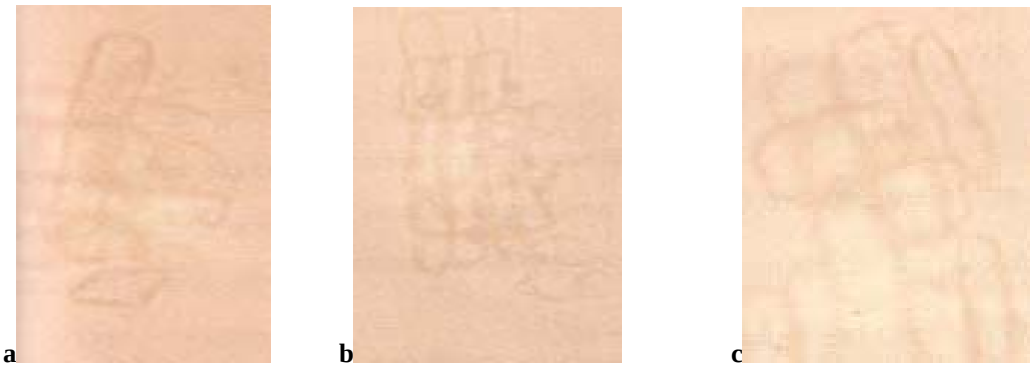
a **b** **c**

Fig 2: Photographic representation of many fiber of (a) *D. barteri (b) Anthonota macrophylla (c) Dalium guineense*



a **b** **c**

Fig 3: Photographic representation of vessels of (a) *D. barteri (b) Anthonota macrophylla (c) Dalium guineense*



a **b** **c**

Fig 4: Photographic representation of parenchyma of (a) *D. barteri (b) Anthonota macrophylla (c) Dalium guineense*

4 DISCUSSION

Wood elements present in the three species *Dactyladenia barteri*, *Anthonota macrophylla* and *Dialium guineense* comprise the three types found in dicotyledons. These include vessels, parenchyma and fibres. Trachieds are usually absent as the four wood elements do not occur in only wood materials.

One interesting result of this study is that fibres are the most abundant vessels element present in each of the three species. This is demonstrated by their highest frequency per unit are recorded (Tables 1,2 and 3; also fig 1). By their abundance, each species satisfies one of the provisions that determine the utility of a given material for pulp making-fibres yield per unit volume (Britt, 1964; Dass, 1963; Ademiluyi and okeke, 1973, 1977; Keay, R.W, 1964 and UNDP, 1995).

The Runkel ratio value is one of the factors considered in the assessments of the three species for pulp making. The values obtained for each species is 0.86µ for *D. barteri*,0.56 µ for *A. macrophylla* and 0.99 µ for *D. guineese*. The stipulation is that when the figures is below 1 or above 1, the fibre are good for pulp making. But when it is above 1, the fibres are not suitable for pulp making. The results of this study show that the Runkel ratio of each species is below 1 in *D. barteri* and *A. macrophylla*, but about 1 in *D. guineense*. The fibres are therefore good for pulp making. When Ademiluyi (1977) assessed fourteen Nigeria savanna tree species for pulp making, they obtained Runkell ratio between 0.6688 and 0.9829, and considered the fibres of each species very good for pulp making.

Calculation of the flexibility co-efficient of the three species under assessment herein yielded 0.16 for *D. barteri*, 0.24 for *A. Macrophylla* and 0.12 for *D. guineense*. Again by the stipulations, these figures indicate the suitability of fibres of the three species for pulp maiking (Dass, 1963, Hutchinson and dalziel, 1954).

Relative fibres length is yet another factor, the values obtained are 37.08 µ for *D. barteri*, 33.63 µ for *A. macrophylla* and 46.37 µ for *Dialium guineense* (table 4). These figures are very high thus meet very well the expectations of fibres for pulp making (Dass, 1963).

Finally, the three species are readily available. They are cultivated/maintained in fallow farmlands in Igbo land (Okeke, 2001). They provide almost all the firewood used in Igbo land. Large scale plantations can therefore be easily raised for commercial pulp making in Nigeria. The above assessment indicates that the three species satisfy all the requirements of species for pulp making. Nigeria should therefore look more inwards while planning to obtain raw materials e.g. pulp for any paper mill industry in the country. `This study suggest that fibres of the species *Dactyladenia barteri*, *Anthonota macrophylla* and *Dialium guineense* are very good for pulp making.

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