Assessment of Suitability of Wood Fibres of Four Nigerian Fruit Trees for Paper–Making

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Abstract

Wood fibres of four fruit trees of Nigeria commonly found in Nsukka metropolis were studied and assessed for their suitability for paper-making. These trees include Mangifera indica, Anacardium occidentale, Persea americana and Dacryodes edulis. The parameters used in the study were the fibre dimensions and derived fibre values. The mean values for fibre length of the species ranged from 0.89 ± 0.34 mm in Persea americana to 1.15 ± 0.38 mm in Dacryodes edulis; mean fibre lumen diameter of 0.009 ± 0.001 mm in Anacardium occidentale to 0.014 ± 0.06 mm in D. edulis; mean fibre diameter of 0.023 ± 0.005 mm in P. americana to 0.026 ± 0.005 mm in M indica; mean fibre cell wall thickness of 0.004 ± 0.002 mm in D. edulis and M. indica to 0.006 ± 0.002 mm in A. occidentale. For the derived fibre values, a mean Runkel ratio of 0.70 ± 0.03 in D. edulis to 1.35 ± .56 in A. occidentale. Coefficient of flexibility of 0.37 ± 0.08 in A. occidentale to 0.57 ± 0.17 in D. edulis and a slenderness ratio of 41.61 ± 20.31 in P. americana to 50.07 ± 14.79 in A. occidentale. Analysis of variance for the derived fibre values showed highly significant difference among the species. In consideration of the parameters – Runkel ratio and coefficient of flexibility, D. edulis seemed to have better paper making potentials than the other three.

Keyword: Nigerian fruit trees, Wood fibre, Paper-making

Introduction

The most current inventory of trees of Nigeria indicates the occurrence of 935 tree species Keay (1989) as against 901 previously reported by Keay *et al.* (1964). This increased number as explained by Keay (1989) was mainly due to the introduction of exotic species.

A general review of literature reveals extensive and intensive studies on the fibre dimension of some timbers of Nigeria for their suitability in paper making. Okereke (1962) measured the fibre dimensions and derived values of *Cassia siamea* and *Eucalyptus ctridora;* Coursey (1963) worked on *Terminalia ivorensis.* Grossley and Ogunle (1965) studied the African grass, *Vossia cuspidate* and found it of good paper-making potentials.

The work done by Chittenden and Rotibi (1962) on *Gmelina arborea* is of special interest. They found out that the derived fibre values of *Gmelina arborea* make if suitable for paper-making than the fibre dimensions. They stated that "…the properties of paper manufactured from the material are somewhat more favorable than would be predicted from the consideration of the fibre dimension". Based on this novel work, the Nigeria government set up a newsprint manufacturing company at Oku-Iboku in Akwa-Ibom State. Other paper mills established by the Federal government of Nigeria in the 1960's basically to expand the industrial base of its economy include Jebba Paper Mill in Kwara State and Iwopin Paper Mill in Ogun State (Ogar.1990). Other fast-growing species of Nigeria have been explored (Palmer, 1986).

Many tree species of Nigeria are yet to be investigated. There is the need to carry out pulping and paper trials on the suitability of Nigeria trees for paper-making before a valid assessment could be made.

This line of research is very important due to the ever increasing demand Nigeria has for wood products, especially pulp and paper. With this in view, the present work is aimed at the pulping and characterization of four fruit-trees commonly grown in the Nsukka area of Enugu State. These include *Mangifera indica* (mango), *Anacardium occidentale* (cashew), *Persea americana* (Avocado pear) and *Dacryodes edulis* (indigenous pear).

Materials and Methods

The tree species used in this work were identified based on the preliminary observations on their morphological and floral characteristics as described by Keay *et al.* (1964). The four samples were collected from mature trees located in Nsukka area of Enugu State (Table 1). The wood were manually debarked and cut to small blocks using a chain saw machine (Sthil brand) and carpenter's saw.

Table 1: Tree species and locations of collection

Tree species	Location of collection
Mangifera indica	Obukpa layout Nsukka
Anacadium occidentale	Obukpa layout Nsukka
Persea americana	Umueko village Nsukka
Dacryodes edulis	Umueko village Nsukka

Some of these blocks were fixed in formalin Acetic Alcohol (F.A.A) in clearly labeled specimen bottles and taken to the laboratory for sectioning, while the rest were oven - dried to eliminate moisture in readiness for maceration process.

Transverse sections (T.S) were cut for each of the tree species, with the aid of a Reichert sledge microtome. Each section was 20 µm thick. These sections were stored in four Petri-dishes, from where temporary preparations were made for preliminary observations.

Table 2: Mean fibre dimensions and derived values

Species	Fibre Length	Fibre Diameter	Fibre Cell Wall Thickness	Fibre Lumen Diameter	RR	CF	SR
Mangifera indica	0.94 ± 0.37	0.026 ± 0.005	0.004 ± 0.002	0.001± 0.002	0.82± 0.21	0.483± 0.11	47.29 22.38
Anacardium occidentale	1.15 ± 0.30	0.024 ± 0.005	0.006 ± 0.002	0.009± 0.001	1.35± 0.08	0.37±s 0.56	50.07± 14.79
Persea americana	0.89 ± 0.34	0.023 ± 0.005	0.005 ± 0.001	0.012± 0.003	0.95± 0.49	0.46± 0.14	41.27± 20.31
Dacryodes edulis	1.15 ± 0.38	0.026 ± 0.004	0.004 ± 0.002	0.014± 0.006	0.70± 0.03	0.57± 0.17	43.27± 22.39

Table 3: Mean separation using Duncan's New Multiple Range Test (DNMRT) for the tree species

Tree species	Runkel ratio		Coefficient of flexibility		Slenderness ratio	
	Mean	DNMRT	Mean	DNMRT	Mean	DNMRT
M. indica	0.815	A	0.438	a	43.28	a
A. occidentale	1.350	B	0.311	a	50.07	a
P. americana	0.901	A	1.837	b	41.61	a
D. edulis	0.701	A	0.459	a	44.68	a

These sections were stained with iodine solution to determine stored starch; Floroglucinol and concentrated HCL to contrast lignified areas of the section. These were mounted with 30% glycerine as mountant on a light microscope.

Permanent slides were prepared as outlined by Sass (1958). The oven-dried blocks of wood were reduced to chips of about half the size of a match stick, and macerated in long test-tubes using Schultz's method as adopted by Kpikpi and Olatunji (1990), using 2% potassium chlorate crystals ($KClO_3$) and concentrated Nitric acid (Conc. HNO_3) as the maceration chemicals.

The fibres were washed with tap-water and stored in well labeled injection bottles and stained with safranin. Samples were drawn from the injection bottles and measurements of fibre dimensions were taken using a calibrated monocular ordinary light microscope (Kyowa, Tokyo Japan). Twenty measurements were made for each species on each of the parameters measured.

The fibre parameters measured were: (a) Fibre length (L), (b) Fibre cell wall thickness (C) and (c) Fibre lumen diameter (l). From these measurements, derived fibre values were calculated as follows: (d) Runkel ration (RR) = 2C/l, (e) Coefficient of flexibility (CF) = 1/D and (f) Slenderness ration (SR) = L/D. Statistical analysis of these values were done using analysis of variance and mean separation by Duncan's New Multiple Range Test (DNMRT).

Results and Discussion

Microscopic observation on the T.S. of each of the species showed the presence of pores (end of vessels). The volume of fibre by the observations was much more than the rest of the wood elements put together in all the species.

Iodine solution stained the parenchyma tissues blue-black, while Floroglucinol and Conc. HCl stained the lignified tissues (fibres and vessels) red. The measurements on the fibre dimensions and the derived fibre values are shown in Table 2.

Table 3 gives the mean separation for Runkel ratio, Coefficient of flexibility and Slenderness ratio for the four tree species.

Means not followed by the same letters are significantly different at 5% level of probability as determined by Duncan's New multiple Range Test (DNMRT).

Fibre length of the tree species studied ranged from 0.89± 0.34 mm in *Persea americana* to 1.15 ± 0.38 mm in *Dacryodes edulis.* According to Metcalfe and Chalk (1983) and Anon (1984), fibres below 1.60 mm were classified as short, while those above 1.60 mm in length were said to be long. Going by this classification, all the four tree species studied having mean fibre lengths of less than 0.60 mm were therefore considered as short. Similar observations were made for some Nigerian hardwood species as reported by Kpikpi and Olatunji (1990), Uju and Ugwoke (1997). Also earlier reports and observations by (Anon, 1951; Cutter, 1971; Hurter, 2001) revealed that the average fibre length in hardwood was only about 1 mm as against 3 mm in softwood species (conifers).

Apart from the fibre length which is the major advantage conifers have over hardwood in paper-making, Ademiluyi and Okeke (1970) pointed out that the derived fibre values provide greater information about fibres and the pulp and paper to be made from them. The Coefficient of flexibility determines the tensile strength property of the fibre; the higher the coefficient, the more flexible and tensile the fibre. The Slenderness ratio or Relative Fibre Length is an expression of the slenderness of this fibre; the higher this value, the more slender and tear-resistant the fibre. Runkel ratio is a measure of the collapsibility of the fibres, which makes for more fibre to fibre bonding surface area. So, a Runkel ratio of 1 or less indicates fibres that are good for paper-making while fibres with Runkel ratio of more than 1 are poor for paper-making.

From the result in table 2, *Anacardium occidentale* had a Runkel ratio of 1.35 ± 0.56 which was considered poor for paper-making when compared to the value, 0.394 ± 0.117, reported for *Gmelina arborea* by Ajuziogu and Uju (2007). Also it had a Coefficient of flexibility of 0.37 ± 0.08 which was equally low when compared to the value, 0.731 ± 0.052 reported for *Gmelina arborea.* It had a good Slenderness ratio of 50.07 ± 14.79 as against 38.95 ± 11. 467 for *Gmelina* arborea. This parameter alone cannot certify it good for paper-making.

In *Mangifera indica,* a Runkel ratio of 0.82 ± 0.21 was recorded, which was well below 1 as against 0.394 ± 0.117 in *Gmelina arborea.* It had a Coefficient of flexibility (CF) of 0.43 ± 0.11 and a Slenderness ratio (SR) of 43.29 ± 22.38 as against 0.73 ± 0.052 and 38.95 ± 11.467 for *Gmelina arborea* respectively.

Persea americana had a Runkel ratio (RR) of 0.95 ± 0.49 which was very close to the value 1, as against 0.394 ± 0.117 reported for *Gmelina arborea.* It had a (C.F) of 0.46 ± 0.14 which was by far lower than that of G. *arborea* (0.73 ± 0.052) and a (SR) of 41.61 ± 20.31.

Dacryodes edulis had a Runkel ratio of 0.70 ± 0.03, which was well below the value 1 as against 0.384 ± 0.117 for *G. arborea;* a fairly high (C.F) value of 0.57 ± 0.17 against 0.731 ± 0.052 in *G. arborea* and a good (SR) of 43.07 ± 22.39.

The values for *M. India* though looking promising were not as good as those of *D. edulis. P. americana* had a better Slenderness ratio (SR) than *G. arborea* but because of the other two values (RR) and (CF) which were poor; it was considered poor for paper-making.

In the four tree species studied, *D. edulis* had the best paper-making qualities. *M. indica* ranked second and *P. americana* third. *A. occidentale* with a relatively high (SR) could not be considered good because the (RR) was above 1 and (CF) very low.

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