POTENTIAL OF BAMBOO (*BAMBUSA VULGARIS*) AS A SOURCE OF RAW MATERIAL FOR PULP AND PAPER IN GHANA

Daniel Sekyere

Forestry Research Institute of Ghana
UST P. O. Box 63, Kumasi, Ghana

ABSTRACT - Laboratory studies were carried out to determine the pulping characteristics of a local variety of *Bambusa vulgaris*. The fibre length of 2.65mm and Runkel Ratio of 1.03 suggest that bamboo fibres might be suitable for pulp and paper-making. The bamboo with a lignin content of 26.8% and cellulose of 61.2% was cooked with 18% active alkali for 90mins to obtain a yield of 54.2% and kappa number of 48.2%. The pulp evaluations showed that it is not necessary to separate the node from the internode during pulping. The physical and strength properties of the pulp produced also showed that the bamboo can make good papers.

Keywords - *Bambusa vulgaris*, **alkali pulping, fibre dimensions, chemical composition**

INTRODUCTION

Bamboo belongs to the family of graminaceae. In Ghana, the most common species is the *Bambusa vulgaris* (Irvine, 1961). The structure of bamboo differs from wood, having solid nodes and hollow internodes at regular intervals. The solid node has a high density and a high silica content which causes considerable difficulties and expenses in chipping. Despite this, bamboo has been used successfully for various paper grades (FAO, 1973).

Suitability of bamboo species with different pulping processes for various grades of paper has been evaluated in different parts of the world. (Guha, 1961; Guha et al, 1975).

In many respects bamboo offers advantages over wood as a raw material for paper making. It grows rapidly and is ready for use within a few years and also coppices easily. It is estimated that 6-7 times as much cellulosic material can be obtained per hectare from a bamboo forest as can be obtained from a coniferous or other broad leaved forest (Lessard and Chouinard 1980). It is reported that bamboo plantations will be ready for harvesting from the tenth year, and that the annual yield will then be three tons green weight per hectare (FAO, 1973). For pulping of bamboo, the acid sulfite process is considered to be unsuitable (Ukil, 1961). Bamboo, however, is readily pulped by the sulphate process to a bleachable pulp.

Because plant development and growth characteristics are affected by enviromental factors, it is important to study the characteristics of bamboos in Ghana to ascertain their suitability for papermaking.

This paper presents the results of pulping of bamboo from Pakyi in the Ashanti Region of Ghana.

MATERIALS AND METHODS

Fibrous raw material preparation

The internode was separated from the solid node and were cut separately by hand to chip size of about 8 x 10 x 30mm by hand.
The nodes and internodes were weighed; moisture contents were determined, and the respective percentage oven-dry weights were calculated.

Fibre Dimension

Portions of the internode (90%) and node (10%) were treated with equal volumes of glacial acetic acid and hydrogen peroxide (20% volume) in a beaker. The beaker was suspended in water at 60°C for 48 hours. The fibre dimensions were measured with a microscope equipped with a micrometer eye piece.

Chemical Analysis

Portions of the internode and node were milled a Willey-Mill and sieved through a BS 40 mesh (42um) but retained on a BS 60 mesh (250um). The following analyses were carried out using one per cent (1%) caustic soda solubility (T4os-59) and alcohol-benzene solubility (T 6os - 59). Also holocellulose (Wise et al), and acid insoluble lignin (T.13os - 54) were determined.

Pulping Method

The chips prepared for pulping were put into a 15-litre stainless steel electrically heated rotating digester. The cooking conditions adopted were the following:-

Oven-dry weight of chips(g) - 150 & 600

Bamboo chips to liquor ratio - 1:5

Active alkali (%) - 17,18,19 & 20

Sulphidity (%) - 25

Rise to temperature (Mins.) - 90

Maximum temperature (°C) -170

Cooking time (Mins.) - 90

Cooling time (Mins.) - 15

The sodium hydroxide and sodium sulphide used were analytical grade chemicals. The cooked chips were washed free of black liquor and broken up in a disc refiner with a clearance of 0.508mm. The yield of pulp was determined by the dilution method. In this method a known volume of water was added to the wet pulp to a specific volume. After thoroughly mixing the suspension of this pulp and water, a litre of the suspension was dished out, sieved and dried in air and then oven dried at 105°C. This was repeated 5 times and the average used to calculate the yield of pulp. The Kappa Number was determined by TAPPI STANDARD Method T236m-60. For comparative purposes, the nodes, internodes and mixture of them were pulped separately.

Pulp Evaluation

Beating was carried out in a Lampen Ball-Mill. Hand sheets were prepared according to Tappi T205 Os-71. The sheets were tested after conditioning at 25°C and 65% relative humidity. The physical characteristics of the pulp were determined Tappi T220 Os-71.

RESULTS AND DISCUSSION

Fibre dimensions and derived values for Bamboo

Table 1 shows the fibre dimensions and derived values for *Bambusa vulgaris* from Ghana, Philippines and India. Generally the fibres of bamboo are longer than those of the hardwoods (Tamolang et al, 1957; Tamolang, et al, 1960). Generally, the suitability of a material for pulp and paper is largely determined by its runkel ratio. The lower the ratio, the better the material for paper making (Lessard and Chouinard 1980). Ghana's bamboo, with a relatively lower runkel ratio compared to those of the Philippines and India will therefore produce pulp of higher strength.

Chemical composition of bamboo

The results in table 2 show that the holocellulose content of bamboo from Ghana is high compared to that from Philipine. Also the cellulose content of bamboo from Ghana is higher than that of *Bambusa arundinacea* (FAO, 1973), a species used currently for production of pulp and paper commercially. The high cellulose content of bamboo from Ghana suggests that high yields of pulp could be obtained from the material. There was no significant difference between the lignin contents of the bamboo from Ghana and that of the Philippines. *B. arundinacea* has higher content of lignin than *B. vulgaris* from

Table 1: Fibre dimensions and derived values for bamboo from Ghana, Philippines and India.

	Ghana *Bambusa vulgaris*	Philippine* *Bambusa vulgaris*	India** *Bambusa vulgaris*
Fibre length, L (mm)	2.65	2.33	2.02
Fibre diameter, D, (μm)	14.60	17.00	15.06
Fibre wall thickness W (μm)	4.95	7.00	5.52
Lumen width, l, (μm)	9.65	4.00	3.98
Slenderness ratio, L/D	182.00	137.00	134.00
Flexibility ratio, l/D x 100	66.10	23.00	26.42
Runkel ratio, 2 W/l	1.03	3.50	2.77

* Lessard & Chouinard 1980
** Varmah & Bahadur 1980

Table 2: Chemical composition of bamboo

	Bambusa vulgaris from Ghana	*Bambusa** *vulgaris* from Phillippine	*Bambusa*** *arundinaceae*
Holocellulose (%)	70.8	66.5	-
Cellulose (%)	61.2	-	57.6
Lignin (%)	26.8	26.9	30.1
Solubility in (%)			
alcohol/benzene	2.1	4.1	-
1% sodium hydroxide	14.65	27.9	-

\- Data unavailable
* Lessard G. and Chouinard A. 1980
** FAO, 1973

Ghana and Philippines. (table 2) Comparison of the solubility in alcohol/benzene and 1% sodium hydroxide for *Bambusa vulgaris* from Ghana and Philippine show lower values for that from Ghana.

Sulphate pulping: Influence of active alkali on yield and Kappa Number

The yield and kappa number of pulp is influenced by the chemical composition of the fibrous material. Table 3 shows that as the amount of active alkali increases

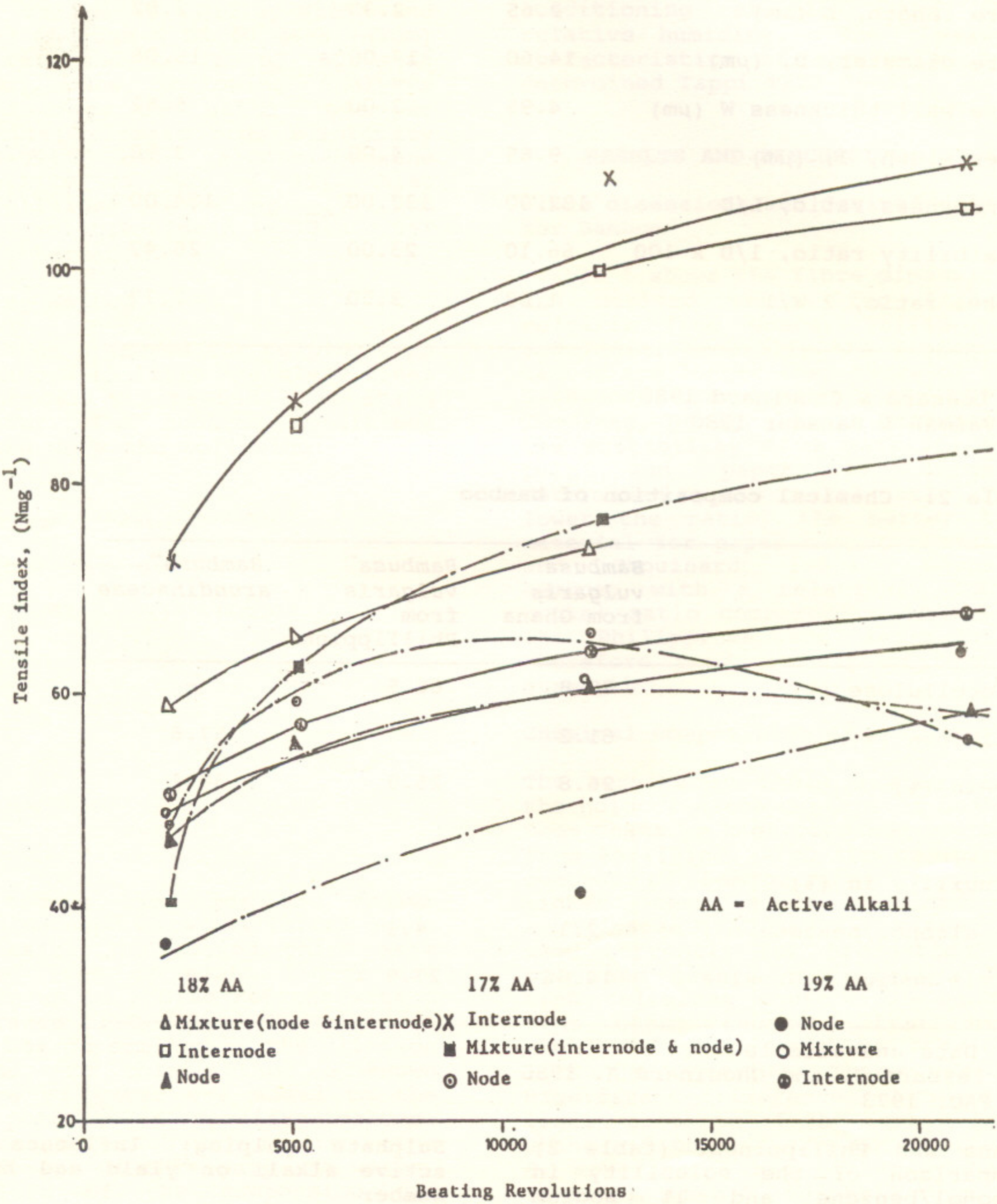

Fig. 1 : Sulphate pulping of internode, node and mixture of node and Internode of Bamboo: Pulp evaluation: Tensile index vrs Beating revolutions.

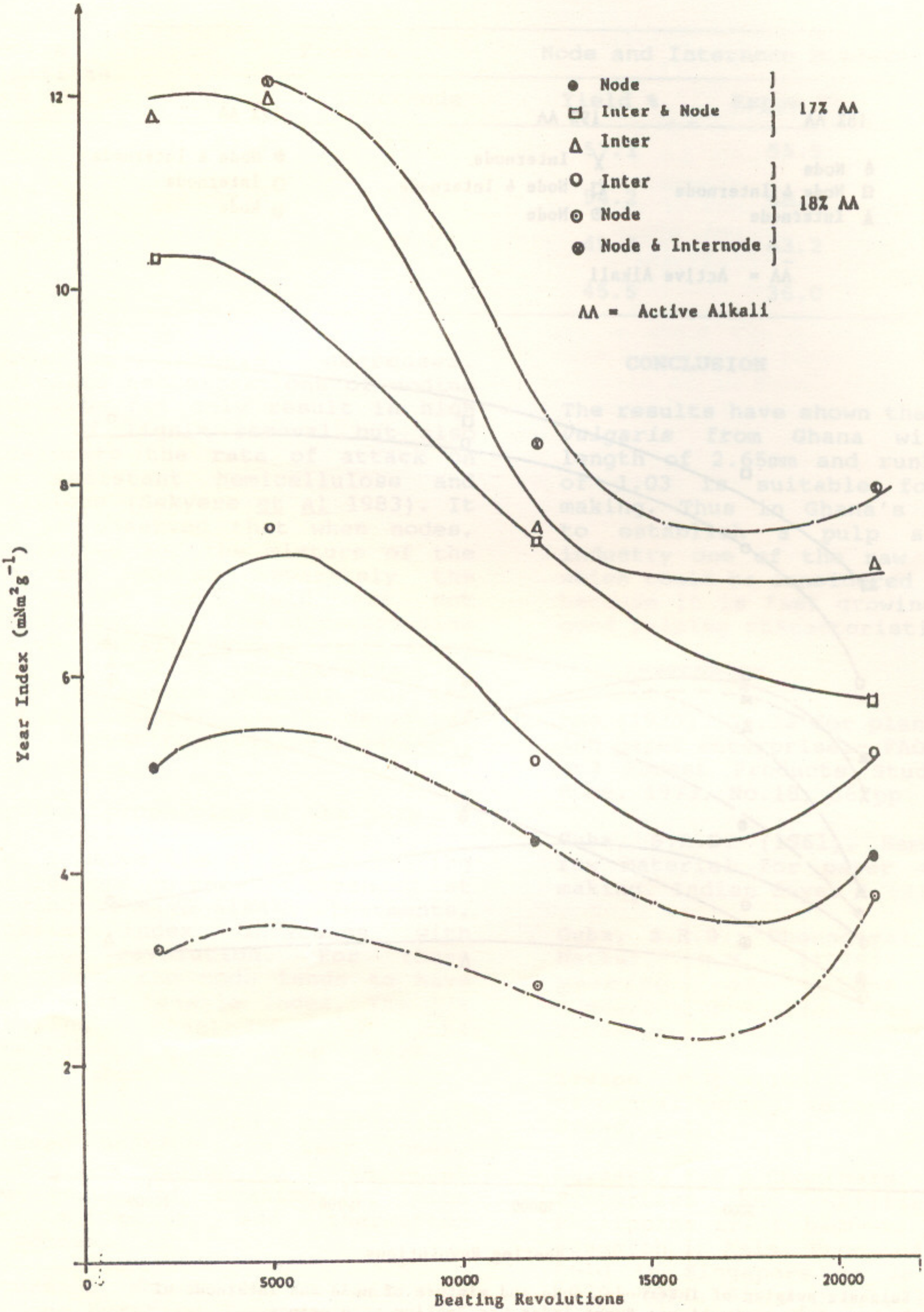

Fig.2: Sulphate pulping of internode, node and mixture of node and internode of Bamboo: Pulp evaluation: Tear index vrs. beating revolutions.

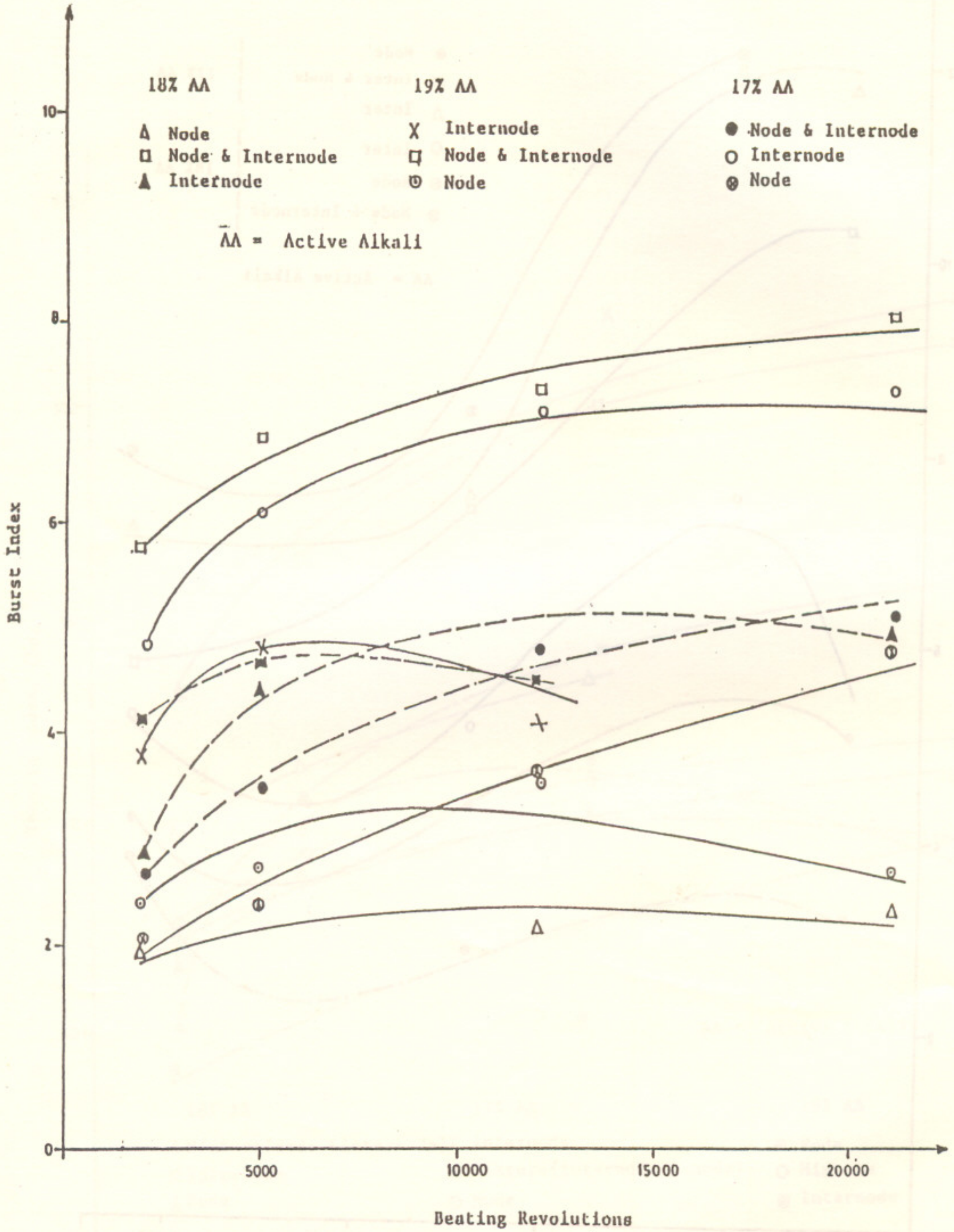

Fig. 3: Sulphate pulping of internode, node and mixture of node and internode of Bamboo: Pulp evaluations: Burst index vrs Beating revolutions.

Table 3: Sulphate pulping: Influence of active alkali on yield and Kappa Number.

Active alkali as Na_2O (%)	Yield %		Node and Internode Mixture	
	Node	Internode	Yield %	Kappa No.
17	57.4	57.0	57.1	55.5
18	54.0	54.6	54.2	48.2
19	49.0	49.2	49.3	43.2
20	-	-	45.5	36.0

percentage yield decreases. Increased concentrations of sodium hydroxide not only result in high rates of lignin removal but also accelerate the rate of attack on the resistant hemicellulose and cellulose (Sekyere et al 1983). It can be observed that when nodes, internodes and the mixture of the two are cooked separately the differences in yield are not significant for the corresponding active alkali cooks, indicating that node has no adverse effect on yield in bamboo pulping. For the mixture, kappa number decreases with increasing alkaline treatment.

Physical properties of the pulp

Fig. 1 shows the effect of beating revolutions on tensile strength at varying active alkali treatments. Tensile index increases with beating revolution. For these treatments the node tends to have the lowest tensile index. The 17% alkaline treatment of the internodes gives the highest tensile index.

Fig 2 shows the relationship between beating and tear index. Tear index begins to increase at the onset of beating to some maximum point and thereafter decreases.

Figure 3 shows the relationship between bursting index and beating revolution. Bursting strength increases with beating. The results show that nodes have the lowest burst strength while 18% alkali treatment of node and internode mixture gives the highest bursting strength.

CONCLUSION

The results have shown that *Bambusa vulgaris* from Ghana with fibre length of 2.65mm and runkel ratio of 1.03 is suitable for paper-making. Thus in Ghana's endeavour to establish a pulp and paper industry one of the raw materials which could be considered is bamboo because it is fast growing and has good pulping characteristics.

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