

Investigation on Fibre Characteristics of *Dendrocalmus Strictus* and *Bambusa Bamboos*

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Abstract – The fiber characteristics of the two bamboo species were studied and the results were recorded. From the results fiber characteristics ranged from 3.34 mm to 3.43 mm in fiber length, 24.49 μ m to 24.96 μ m in fiber width and 14.35 μ m to 15.46 μ m in fiber lumen diameter for *Dendrocalmus strictus*, while in *Bambusa bamboos* ranged from 3.60 mm to 3.65 mm in fibre length, 15.58 μ m to 15.95 μ m in fiber width and 12.67 μ m to 13.37 μ m in fiber lumen diameter respectively. Based on the result of ANOVA carried out on the fiber characteristics, it was found that there is no significant differences at ($P < 0.05$) level of probability. The result of DMRT carried out showed that not much variation occurred in fiber length, whereas in fiber width *Dendrocalmus strictus* appears $>$ *Bambusa bamboos* and in lumen diameter, the value was higher in case of *Dendrocalmus strictus* $>$ *Bambusa bamboos*

Keywords – *Bambusa Bamboo*, *Dendrocalmus Strictus*, Fiber, Width, Lumen.

I. INTRODUCTION

In the present scenario of development of the global economy and constant increase in population, the alternative raw materials such as bamboo in place of wood have come into focus and existence. Plant such as bamboo species are suitable raw material, inexpensive, fast-growing, easily available having comparable physical and mechanical properties to the wood species, and also it is compatible and simple to the existing processing technologies. Bamboo fiber which is a three dimensional, biopolymer composite composed mainly of cellulose, hemicelluloses, and lignin with minor amounts of free sugars, starch, protein, extractives, and inorganics. (Xiaobo Li 2004) The performance of a given fiber used in a given application depends on several factors including chemical composition, physical properties, anatomical properties, the interaction of a fiber within the composite matrix, and how that fiber or fiber/matrix performs under a given set of environmental conditions. Many research scientists have worked on different properties of bamboo species, while some works had been done on utilization potentials of the plant. Some of these researcher revealed that fiber length is positive and strongly correlated with fiber diameter, cell wall thickness and internodes diameter, but not with lumen diameter and internodes length. The fiber diameter varies between 11 and 19 μ m, the lumen diameter between 2 - 4 μ m and the cell wall thickness between 4 -- 6 μ m. (Liese W 1985). The anatomical characteristics in relation to the mechanical properties of bamboo have been

studied by Latif Abd *et al.*, (1990). They concluded that fiber length correlated positively with modulus of elasticity (MOE) and stress at proportional limit and an increase in the size (mature stage), and fiber length could be accompanied by an increase in strength properties. They mentioned that bamboo that possesses a longer fiber might be stiffer, if it has a greater vascular bundle size (Latif Abd *et al.*, 1990). The correlation between fiber length and shear strength properties were negative. The fiber wall thickness correlates positively with compression strength and MOE, but negatively with modulus of rupture (MOR). There was also a correlation between lumen diameter and mechanical properties, except compression strength. The effects of the anatomical characteristics of the physical and mechanical properties were determined by (Latif *et al.*, 1991 and 1993). The fiber length of the species of bamboo studied did not significantly differ with age and culm height. The fiber wall thickness is not significant by age or height of the column. They observed that there is a decrease of lumen diameter with the increase of age and height of the culm. Chew *et al.*, (1992) analyzed macerated fiber of bamboo stained with safranin-C and mounted on slides. Their study shows that the fiber is long and slender, with a narrow lumen. The average fiber length and width was found to be 2.8 mm and 0.013mm, whilst the lumen width and cell-wall thickness was 0.003mm and 0.005mm respectively. Latif and Tarmizi (1993) studied the anatomical properties of three Malaysian bamboo species, and fiber length between species to species was significantly different. Age does not significantly affect fiber length. It was revealed that the main bamboo species commonly used in India is *Dendrocalamus strictus* (Singh *et al.*, 1991). This species occupy 53 percent of the total bamboo area in India.

Bambusa bamboos are also known as Giant Thorny Bamboo or Indian Thorny Bamboo, is a species of tropical dense clumping bamboo native to Southeast Asia. This bamboo species was previously named *Bambusa arundinacea* and is often used for construction purposes. In India this species occupies 15% of all bamboo forests. Information about the bamboo species are still limited, so therefore there is need to investigate properties such as anatomical properties in relation to utilization. The main objective of this study is to determine the anatomical properties of two bamboo species (*Dendrocalamus strictus* and *Bambusa bamboos*) at two different stem portions (*Bottom to Middle* and *Middle to Top*).

II. MATERIALS AND METHODS

Dendrocalmus strictus and *Bambusa bambos* species were selected based on the length of nearly 50 to 60 ft and converted into two portions i.e. “Bottom to middle” and “Middle to top” respectively for this study. Bamboo strips were made and oven dried with temperature of 105⁰ C to attain moisture content of 30% strips were further converted into chips using disc chipper through soaking in water for 24 hours and moisture content was determined. The chips were later converted into fiber using thermo mechanical refiner at 180⁰ C with 9 pressure bar. The fiber samples were collected from the refiner separately in accordance to the selected portions (Bottom to Middle and Middle to Top). Fiber characteristics, values were measured while microscopic slides were prepared to study the fiber length, fiber width, and lumen diameter of each bamboo species studied. Slides were prepared with 5g of fiber sample material dispersed in distilled water and drops of fiber suspension was placed on one end of the slide. 0.01% saffronine stain was added to the fiber sample to stain the fiber as presented in (Plate 1 and 2). From the slides measured characteristic such as fiber length, fiber width, and lumen diameter using the progression c3 software system was used

Preparation of slides: Three slides were prepared from fiber suspension as presented in Plate 1 Through progressive dilution with distilled water, fiber distribution. Three test tubes of 6 inches long and 0.75 inches in diameter were filled with fiber suspension and shaken properly.

Title 1: Bamboo fibre separation



Plate 1: Preparation of slides

Title 2: Fibre slides prepared



Plate 2: Prepared slide

Measurement of fiber: The slides with the fiber suspension were placed on the stage of the binocular .The microscope and enlarged image with 40 X (PLATE 5), 10X (P 4) and 4X(P 3) were projected on the computer

screen(Plate 1). The fibers were analyzed for length, width and lumen diameter under Olympus research (4x, 10x, 40 x) microscope).

Title 3: Fibre length measurement

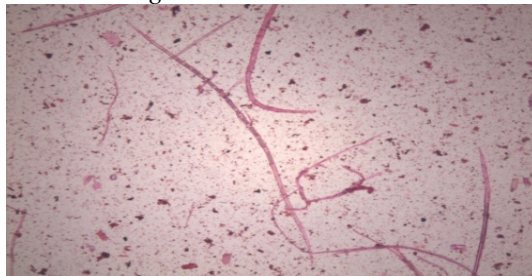


Plate 3: Fibre length measurement

Title 4: Fibre length

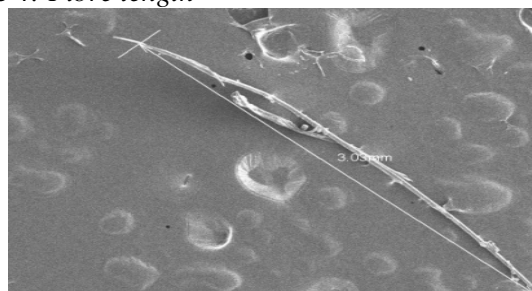


Plate 3: Bamboo Fibre under microscope

Title 4: Fibre width measurement

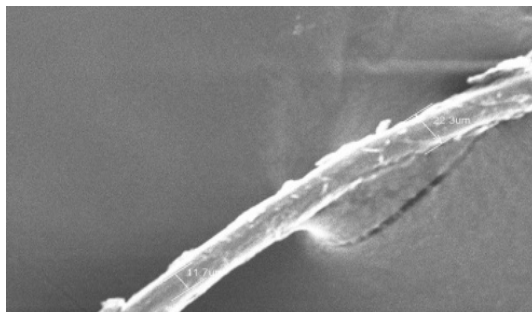


Plate 4: Fibre width under microscope

Title 5: Fibre lumen diameter measurement

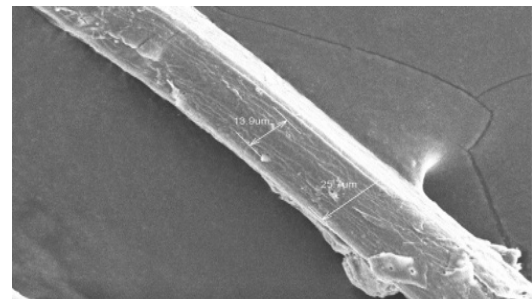


Plate 5: Lumen diameter under microscope

Anatomical Properties of Bamboo Fibre:

30 fibres were measured for fibre length ,width and lumen diameter in which 5 values were randomly selected for statistical analyses,the value was analyzed in 2x2 factorial experiment in CRD using SPSS version 20.0 at the 5 % level of probability.

III. RESULTS

Table I: The result of descriptive statistic carried out on anatomical properties of Bamboo species assessed

Species	Fibre length (mm)		Fibre width (µm)		Fibre lumen diameter (µm)	
	Middle to Top(MT)	Bottom to Middle (BM)	Middle to Top(MT)	Bottom To Middle (BM)	Middle to Top(MT)	Bottom to Middle (BM)
<i>Dendrocalamus strictus</i>	1.2	1.54	23.82	33.19	17.35	17.59
	2.63	2.36	19.97	20.40	16.40	16.48
	3.07	3.49	20.48	27.56	11.98	13.33
	5.40	4.10	27.62	19.15	13.48	12.68
	4.87	5.22	30.55	24.50	12.56	17.24
<i>Bambusa bamboos</i>	1.76	1.48	16.79	14.59	11.69	13.86
	2.43	2.76	18.40	15.06	9.86	14.08
	3.57	3.59	15.53	11.92	11.48	11.66
	4.89	4.66	14.79	14.58	13.76	12.59
	5.62	5.50	12.40	13.67	16.54	14.64

Table 2: Shows mean value of fibre length,width and lumen diameter of two bamboo species

Bamboo Portions	<i>Dendrocalamus strictus</i> (Fibre)			<i>Bambusa bamboos</i> (Fibre)		
	length (mm)	width (µm)	lumen diameter (µm)	length (mm)	width (µm)	lumen diameter (µm)
BM	3.34 ± 1.44	24.96 ± 5.68	15.46 ± 2.29	3.60 ± 1.57	15.96 ± 1.25	13.37 ± 1.21
MT	3.43 ± 1.71	24.49 ± 4.57	14.35 ± 2.39	3.65 ± 1.62	15.58 ± 2.24	12.67 ± 2.57

Note: BM represent Bottom to middle while MT represent Middle to top
Each value represents the mean of 5 replicates with standard deviation

Fiber Characteristics:

The result of a descriptive analysis of the fiber length of *Dendrocalamus strictus* and *Bambusa bamboos* were presented in Table 1. The values ranged from 3.34 mm to 3.65 mm respectively, in *Dendrocalamus strictus* fibre length for BM is 3.34 mm and MT fibre length is 3.43 mm and the fibre length of *Bambusa bamboos* is BM 3.60 mm and high in MT 3.65 mm respectively. Fibre length of this species is high in middle to top and low in bottom to middle. This same observation is shown in *Bambusa bamboos*. The fibre width values ranged from 13.96 µm to 24.96 µm respectively. Fibre widths are higher in *Dendrocalamus strictus* than *Bambusa bamboos*, ie from the BM fibre width is 24.96 µm and MT is 24.49 µm in *Dendrocalamus strictus* while in *Bambusa bamboo*, BM fibre width is 15.96 µm and 15.58 µm for MT respectively. The fibre width values were higher in *Dendrocalamus strictus* than the *Bambusa bamboos*.

Finally, values for the fibre lumen diameter of the two bamboos were also presented in Table 1 above, these values ranged from 12.67 µm to 15.46 µm respectively; it varies accordingly in each bamboo specie. In *Dendrocalamus strictus*, BM had the value of 14.35 µm and 15.46 µm for MT while in *Bambusa bamboos*, BM had the value of 13.37 µm and 12.67 µm for MT, the observation in the fibre characteristic of the each of the bamboo shows that both fibre width and fibre lumen diameter had the higher values in BM than MT, which shows that the width and lumen diameter are larger and bigger in bottom to middle, these are illustrated in Plate 3, 4 and 5 above. In respect to the fibre length of the two bamboo species, *Bambusa*

bamboos values were slightly higher than *Dendrocalamus strictus* while in fibre width and fibre lumen diameter, *Dendrocalamus strictus* values were higher than the *Bambusa bamboos*.

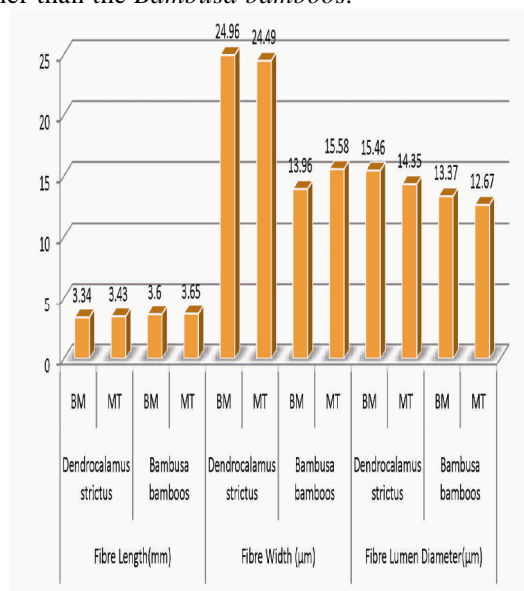


Fig.1. The Mean values of Fibre length,width and Lumen diameter of bamboo.

The result of ANOVA carried out on the fibre properties are presented, the tables show that there are no significant different in fibre length and fibre lumen diameter except fibre width at 5 % level of probability. This shows that there is no significantly difference between the fibre length and lumen diameter of the two bamboo species used in this study. Furthermore, in main factor of bamboo

portion (BM and MT) and two factors interaction between bamboo and portions are not significantly different at 5 % level of probability. This analysis shows that there are no significant in the fibre characteristic of the two bamboo species.

IV. DISCUSSION

Two bamboo samples were taken for analysis of bamboo fiber characteristics of species *Dendrocalamus strictus*, and *Bambusa bamboos*. Initially the two species viz. *B. bamboo* and *D. strictus* were processed separately with two portions – bottom to middle and middle to top taken separately. Moisture content and length of bamboo were respectively determined before processing. These selected sections were further converted into chips (dimension approx. 1”x 1”) by disc chipper. The chips were soaked in water for 24 hours before defibration in refiner in order to convert into its suitable conversion in the refiner. Fibre preparation was carried out using Defibrator (refiner) machine through thermo mechanical pulping process. Variable factors such the temperature which ranged 180°C and pressure at ranged from 9 bar was considered. Furthermore, pre heating time/ retention time which was kept fixed for 8 min for every charge taken for fibre preparation was also noted, From the studies, fibre length, width and lumen diameter ranged from 3.34 mm to 3.65 mm, 13.96 µm to 24.96 µm and 12.67 µm to 15.46 µm respectively. The results of fibre characteristics ranged from 3.34 mm to 3.43 mm in fibre length, 24.49 µm to 24.96 µm in fibre width and 14.35 µm to 15.46 µm in fiber lumen diameter for *Dendrocalamus strictus*, while in *Bambusa bamboos* ranged from 3.60 mm to 3.65 mm in fibre length, 15.58 µm to 15.95 µm in fibre width and 12.67 µm to 13.37 µm in fiber lumen diameter respectively.

The mean average for fiber length in genera *Gigantochloa* reported by Mohd Tamizi Mustafa et al., 2011 was 1.6 mm–2.0 mm. The result obtained by Hisham (2006) studies on *G. scotechinii* was between 2.35-2.63mm. While Ireana 2009, study on *B. blumeana* found the length of fiber was around 2.9mm. *B. vulgaris* fiber length was 3.6mm-4.7mm (Razak, 2010), 1.94 mm-2.43mm (Latif, 1995). Walter lise 1992, Study on *Dendrocalamus giganteus* and *D.membranaceus* found the length of fiber were around 3.2mm and 4.3 respectively. Lessard & Chouinard 1980, reported fibre length 2.65mm, 2.33mm, 2.02mm in Ghana *Bambus vulgaris*, Philippine *bambusa vulgaris*, India *bambus vulgaris*. Omobowale, M.O. and Ogedengbe, K.2008, reported fibre length 2.8-3.7mm base to top in *Nigerian Bambusa vulgaris*.

The mean average for fiber width in genera *Gigantochloa* reported by Mohd Tamizi Mustafa et al., 2011 was 17.26 µm – 22.75 µm. The result obtained by Hisham (2006) studies on *G. scotechinii* was between 26 µm. While Ireana 2009, study on *B. blumeana* found the width of fiber was around 12 µm. *B. vulgaris* fiber width was 16.9 µm -18 µm (Razak, 2010), 23 µm - 37 µm (Latif,

1995). Lessard & Chouinard 1980, reported fibre width 14 µm, 17 µm, 15 µm in Ghana *Bambus vulgaris*, Philippine *Bambusa vulgaris*, India *Bambus vulgaris*. Omobowale, M.O. and Ogedengbe, K.2008, reported fibre width 33 µm -13 µm base to top in *Nigerian Bambusa vulgaris*.

The mean average for lumen diameter in genera *Gigantochloa* reported by Mohd Tamizi Mustafa et al., 2011 was 4.75 µm – 8.60 µm. The result obtained by Hisham (2006) studies on *G. scotechinii* was same value. While Ireana 2009, study on *B. blumeana* found the lumen diameter of fiber was around 1.6 µm. *B. vulgaris* fiber lumen diameter was 2.3 µm -2.6 µm (Razak, 2010), Lessard & Chouinard 1980, reported fibre lumen diameter 9.65 µm, 4.0 µm, 3.98 µm in Ghana *Bambus vulgaris*, Philippine *bambusa vulgaris*, India *bambus vulgaris*.

V. CONCLUSION

From the investigation carried out on the fibre characteristics of *Dendrocalamus strictus* and *Bambusa bamboos* shows that there is not variation in the fibre characteristics of both the species. Though there is variation in the density of *Dendrocalamus strictus* and *Bambusa bamboos*, the fibre characteristics remain almost similar, hence it can be concluded that two species can be used for manufacture of panel product like MDF either individually or admixed with each other without variation in physical and mechanical properties of the final product. Based on the finding that these anatomical properties could be good for MDF production.

APPENDIX

(FIBRE SIZE) Univariate Analysis of Variance
[DataSet0]

Tests of Between-Subjects Effects

Dependent Variable: fibre length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.312 ^a	3	.104	.041	.988
Intercept	245.981	1	245.981	97.296	.000
bamboo	.283	1	.283	.112	.742
portions	.027	1	.027	.011	.918
bamboo * portions	.002	1	.002	.001	.980
Error	40.451	16	2.528		
Total	286.744	20			
Corrected Total	40.763	19			

a. R Squared = .008 (Adjusted R Squared = -.178)

Tests of Between-Subjects Effects

Dependent Variable: fibre width

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	502.214 ^a	3	167.405	11.201	.000

Intercept	7800.065	1	7800.065	521.904	.000
bamboo	495.112	1	495.112	33.128	.000
portions	1.642	1	1.642	.110	.745
bamboo * portions	5.460	1	5.460	.365	.554
Error	239.126	16	14.945		
Total	8541.405	20			
Corrected Total	741.340	19			

a. R Squared = .677 (Adjusted R Squared = .617)

Dependent Variable: lumen diameter

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	22.222 ^a	3	7.407	1.557	.239
Intercept	3899.028	1	3899.028	819.573	.000
bamboo	17.917	1	17.917	3.766	.070
portions	4.095	1	4.095	.861	.367
bamboo * portions	.210	1	.210	.044	.836
Error	76.118	16	4.757		
Total	3997.369	20			
Corrected Total	98.341	19			

a. R Squared = .226 (Adjusted R Squared = .081)

ACKNOWLEDGMENT

The author wish to thank the Director IPIRTI for giving full support to complete the work and permission to publish this paper.

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