VARIATION IN SPECIFIC GRAVITY AND FIBRE MORPHOLOGY OF BULUH GALAH (BAMBUSA HETEROSTACHYA)

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Abstract

This paper highlights the effects of age and culm height on specific gravity and fibre morphology of Bambusa heterostachya. The specific gravity of B. heterostachya was observed to increase significantly with maturity but not with culm height. Fibre dimensions, on the other hand, varied significantly with age and culm height (except for the fibre length).

INTRODUCTION

Bamboo industries offer a multitude of differently designed end products and has a high potential for development (Aminuddin & Abd. Latif 1991). And Malaysia has the basic resources to support these industries. What is certain, we should exploit these resources to its maximum. Integrated efforts, however, must first be spear-headed towards overcoming immediate problems faced by the industry. At the onset, it should be started with intensive studies on the basic properties of the materials (such as physical and anatomical characteristics) to predetermine its best suited processing and manufacturing qualities. As mentioned by Abd. Latif (1987), the selection of bamboo for industrial use, construction and housing is closely related to its physical and mechanical properties.

The importance of anatomical characteristics and its influence on bamboo and bamboo product should not be over emphasized. Fiber length, for example, influences the physical and mechanical properties which thus often associated with its toughness, workability and durability (Parameswaran & Liese 1976, Espiloy 1987, Abd. Latif et al. 1990).

Malaysian bamboos are normally harvested without due consideration to their characteristics and final uses (Abd. Latif & Abd. Razak 1991). Since the highly variable properties of bamboo presents problems in processing and utilization (Abd. Latif et al 1990), future processing improvement should thus be encompassed on harvesting the material of desired quality, species and suitable age for specific uses. In view of this; we study the effects of age and height on the specific gravity and fiber morphology of buluh galah. Information obtained is therefore hope to be served as a basic guideline for harvesters and users in assessing and utilizing the raw materials for their final intended purposes.

MATERIALS AND METHODS

Samples of buluh galah Bambusa heterostachya (1/4 to three-year-old), the growth of which have been recorded since their sprouting stages, were obtained from an experimental plot established since 1987 at Parit Hj Salleh, Batu Pahat, Johor. Each bamboo culm was divided into three equal portions to represent the base, middle and top.

The method used for the determination of specific gravity (SG) was based on TAPPI standard method (Anon 1979) using bamboo samples of about 2 cm x 3 cm x thickness which were selected from the middle section of the first internode of each portion.

Samples for the determination of fibre morphology were taken from the middle section of each portion. They were then splitted into match-stick size before being macerated, stained with 1% Safranin-O and mounted onto glass slides. Measurements of fibre dimensions (fibre length, fibre and lumen diameter) were then conducted from 25 selected fibres using a Viospan projection microscope.

From the fibre measurements, the Runkle ratio, coefficient of suppleness and Felting Power or L/D factor (Runkle 1952, Anonymous 1955) were calculated as follows:

$$\text{Cell wall thickness} = \frac{D-1}{2}$$

$$\text{Runkle ratio} = \frac{2W}{1}$$

$$\text{Coefficient of suppleness} = \frac{1}{D} \times 100$$

$$\text{Felting Power or L/D ratio} = \frac{L}{D}$$

where,

W = fibre wall thickness (um)

l = lumen diameter (um)

D = fibre width (um)

L = fibre length (mm)

RESULTS AND DISCUSSION

Specific gravity

The specific gravity of buluh galah from the five age groups and at different height levels are given in Table 1. The summary of the analysis of variance (ANOVA) and Multiple Range T-tests (MRT) are presented in Tables 2 and 3, respectively.

Table 1: Specific gravity of buluh galah

Age (yr)	Portion			
	Basal	Middle	Top	Average
1/4	0.23	0.25	0.22	0.23
1/2	0.33	0.30	0.33	0.32
1	0.45	0.40	0.37	0.41
2	0.44	0.38	0.42	0.41
3	0.37	0.42	0.44	0.41

Values are averages of 6 determinations

Specific gravity (SG) measures the amount of solid cell wall materials per unit volume and is the best index for predicting the strength properties of woody materials. The importance of assessing the specific gravity is reflected by the end-use of the woody materials itself. SG is also known to affect pulp and paper yield. Since SG could predetermine fibre properties, it thus serves as a reliable indicator of wood quality (Britt 1970).

The SG of bamboo below two years old showed an indefinite trend relating to their immaturity. The SG of the three-year-old culm, however, increased from basal to the top portion. The lowest and highest SG value were observed in the top portion of the three year old (0.44) and the 1/4-year-old (0.22) culms respectively.

Table 2: Summary of ANOVA on specific gravity

Source of variation	DF	MS	F-ratio
Age (A)	4	0.110	135.28**
Portion (P)	2	0.001	1.416ns
A X P	8	0.006	7.24**

Note: ns and ** denote for insignificant and significant at P< 0.01, respectively.

The specific gravity of bamboo varied significantly with age but insignificantly with culm height. The interaction of both the parameters with specific gravity was also observed to be highly significant.

Effects of age and culm height

In general, the specific gravity of buluh galah increases gradually with age (Table 3) with the highest value observed in the three-year-old culm. This could be attributed to the amount of silica which accumulated during its growth until maturity (Espiloy 1983). Since bamboo matures in about three years, the selection of this material for structural purposes should thus be considered at this age levels. This is particularly important as the strength of bamboo is also at its maximum (Espiloy 1991).

With regards to culm portion from bottom to top, it appears that specific gravity does not vary much with height, but it tends to have a higher value near the top. Abd Latif & Mohd. Zin (1992), Jamaludin et al (1992) and Espiloy (1987) also find similar trends of variation. This is explainable in the sense that the higher frequency of vascular bundles (Liese 1987) and silica content (Espiloy 1983) could attribute for higher SG values at the top portion of the culm.

Table 3: Effects of age and culm portion on specific gravity

Age	SG	Portion	SG
1/4	0.24a	Basal	0.36a
1/2	0.32b	Middle	0.35a
1	0.40c	Top	0.36a
2	0.41c		
3	0.41c		

Means having the same letter down the column differ insignificantly at $P<0.05$

Fibre properties

The results on the fibre morphology are presented in Table 4. The respective ANOVA and MRT are shown in Table 5, 6 and 7.

Table 4: Fibre morphology of buluh galah according to age and vertical portion

Age (y)	Fibre length (mm)	Fibre diameter (um)	Lumen diameter (um)	Cell wall thickness (um)	Runkle ratio	Felting power	Coefficient of suppleness
				Basal			
1/4	2.83	14	4	5	2.67	200.0	28.2
1/2	3.82	14	3	7	4.44	271.9	20.8
1	3.46	17	3	6	4.63	204.8	20.1
2	4.64	17	4	7	3.94	282.2	22.6
3	3.42	16	2	7	6.78	219.9	14.0
				Middle			
1/4	3.48	13	4	5	2.59	264.1	28.9
1/2	3.50	14	3	5	3.29	256.6	23.9
1	3.51	14	4	5	4.23	261.9	25.9
2	4.11	16	4	6	3.40	267.4	23.8
3	3.28	16	4	5	3.56	223.5	23.3
				Top			
1/4	3.38	12	3	4	3.07	285.5	26.5
1/2	3.34	12	4	5	3.19	260.3	25.3
1	3.65	14	4	5	3.11	269.7	26.2
2	3.60	14	4	5	3.01	267.4	26.1
3	3.16	13	4	5	2.70	239.0	28.2

Values are averages of 25 determinations

Table 5: Summary of ANOVA on fibre morphology

F-ratio and statistical significance

Source of variation	Df	Fibre length	Fibre d iameter	Lumen diameter	Cell wall thickness	Runkle ratio	Felting power	Coefficient of suppleness
Age	4	17.00**	8.61**	3.84**	12.62**	7.05**	7.53**	10.04**
Portion	2	2.64ns	26.42**	3.30*	46.94**	20.96**	8.45**	26.43**
Portion x Age	8	4.89**	1.68ns	4.60**	3.07**	5.24**	4.80**	6.29**

Notes: ns and ** denotes that F-ratio are not significant, significant at P<0.05 and P<0.01, respectively.

Table 6: Effect of age on fibre dimensions

Age (y)	Fibre length (mm)	Fibre diameter (um)	Lumen diameter (um)	Cell wall thickness (um)	Runkle ratio	Felting power	Coefficient of suppleness
1/4	3.23b	13.3c	3.71	4.73c	2.81c	250abc	27.8a
1/2	3.55b	13.8bc	3.23b	5.28bc	3.64abc	263ab	23.3b
1	3.54b	14.9ab	3.56ab	5.70ab	3.97ab	245bc	24.1b
2	4.11a	15.5a	3.65ab	5.90a	3.45bc	272a	24.2b
3	3.29b	15.1a	3.23b	5.91a	4.34a	227c	21.8b

Means with the same letter(s) down the column differ insignificantly at P<0.05

Table 7: Effect of culm portion on fibre dimensions

Portion	Fibre length (mm)	Fibre diameter (um)	Lumen diameter (um)	Cell wall thickness (um)	Runkle ratio	Felting power	Coefficient of suppleness
Basal	3.63a	15.9a	3.29a	6.30a	4.51a	236b	21.1b
Middle	3.75a	14.5b	3.63a	5.40b	3.41b	255ab	25.2a
Top	3.42a	13.2c	3.50a	4.82c	3.01b	264a	26.4a

Means having the same letter down the column differ insignificantly at P<0.05

Fibres make up the schlerenchymatous tissue and they occur as caps of vascular bundles or isolated strands. They are long and tapered at both ends.

Fibre length is an important feature in papermaking as it determines the strength properties of the paper produced. Generally, the fibre length, fibre diameter and cell wall thickness decrease with culm height. This is in accordance to the findings of Jamaludin et al. (1993) and Liese (1987). The fibre length of the bamboo being studied, regardless of age and height, falls within the range of 2.83 - 4.64 mm. Generally, the fibre length increases with age up to year two and decreases after that.

All the fibre properties vary significantly with age, height (except for fibre length) and the interaction of age and height (except for fibre diameter).

Effects of age and culm height on the fibre properties

The effects of age and culm height on the fibre properties are shown in Tables 6 and 7, respectively. All the fibre properties vary significantly with age; with a tendency to increase from a quarter- to two-year old culm but decrease (except for fibre thickness) by the age of three. These similar indefinite trends were also reported by Sun & Xie (1985), Abd. Latif & Mohd. Tamizi (1992), Jamaluddin et al. (1993).

With the exception of felting power and coefficient of suppleness, all the other fibre dimensions decrease with culm height. Jalamuddin et al. (1992, 1993) and Abd. Latif & Mohd. Tamizi (1992) also found a similar trend of variation for the fiber length, diameter and cell wall thickness in some other Malaysian bamboos.

CONCLUSION

The specific gravity of buluh galah (1/4 to 3 yrs) was found to be within the range of 0.22 to 0.44, with the highest value of 0.44 in the upper portion of the three years old culm. Fibre properties were significantly influenced by age; and culm height (except for fibre length).

The results obtained in this study further indicate that buluh galah should be harvested and processed at the age of three years old or more. This is particularly important for assuring higher quality products that can be produced from this bamboo.

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