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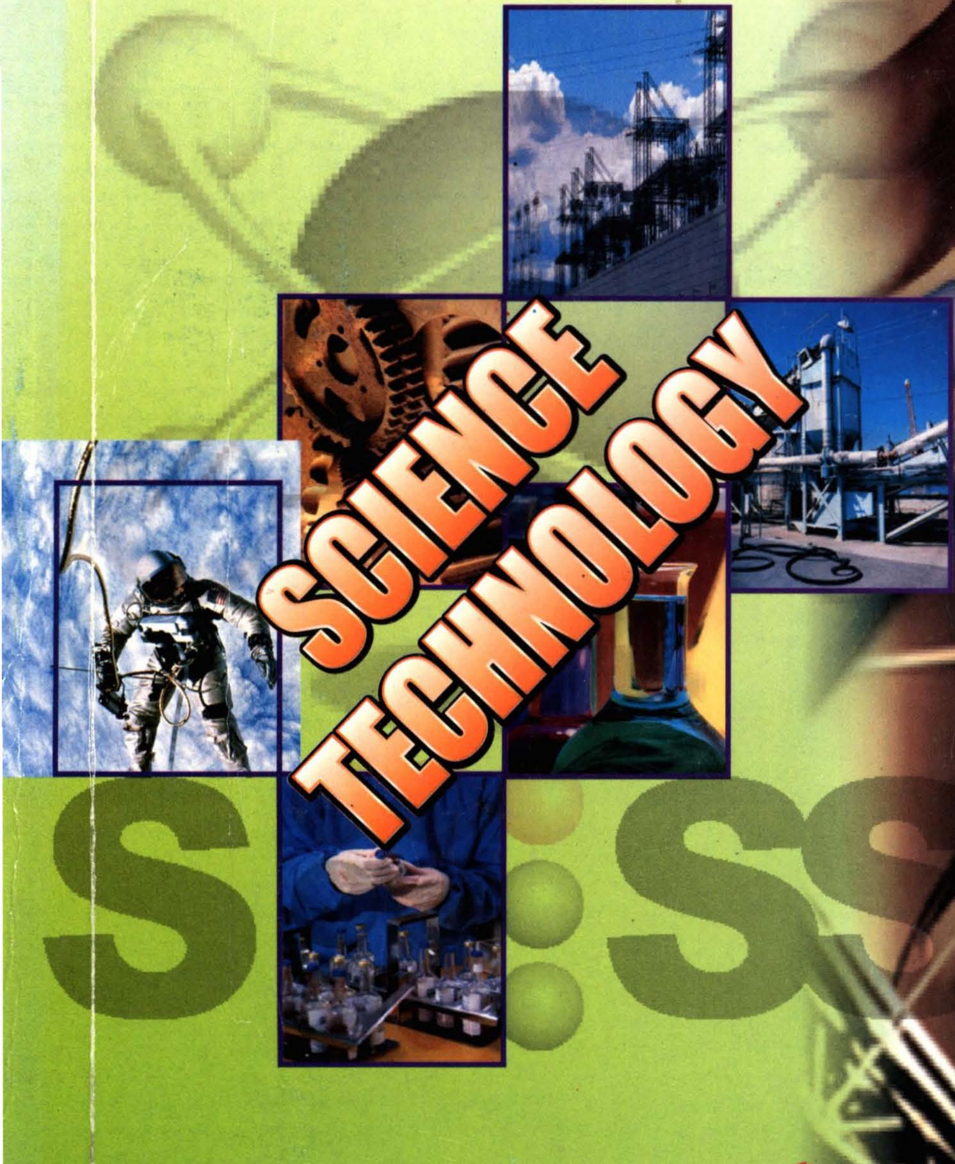

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Variation in Fibre Properties of Wood under Malaysian Dipterocarpaceae

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ABSTRACT

Four wood species belonging to Malaysian dipterocarpaceae namely engkabang, keladan giam kancing and sengkawang air were selected for this study. Wood samples taken from three trees, five segments, two radii and four height levels were used in determining fibre properties such as fibre length, fibre diameter, lumen width and cell wall thickness. The objectives were to determine the extent of among tree, radial and vertical variation of the said properties. Among tree variation was significant for fibre diameter, lumen width and cell wall thickness in keladan and fibre length, fibre diameter and lumen width exhibited significant variation in sengkawang air. Radial variation along the radii and segments were highly significant for almost all the fibre properties in the four wood species but vertical variation along different height levels of the tree was not significant, although slight variation existed for individual cases. The finding revealed that segment number from the pith greatly influences the fibre properties of all the four wood species studied. This implies the possibility of improving the wood quality of these dipterocarp species through the manipulation of rotation age.

Keywords: *Dipterocarpaceae, fibre properties, radial variation, vertical variation, wood quality*

Introduction

The behavior of wood when applied for specific purposes or wood quality can be predicted through the measurement of certain wood characteristics collectively known as wood quality indicators. One of such indicators is fibre morphology which comprises fibre length, fibre diameter, lumen width and cell wall thickness.

Fibre length is considered as one of the more important indicators of wood quality of forest tree (Dinwoodie 1961; Lantican 1975). This property is related to the mechanical strength and longitudinal shrinkage and has been known to affect strength properties of paper (Dadswell & Wardrop 1960; Dinwoodie 1965). Differences in strength between softwood and hardwood pulp are mainly attributed to differences in fibre length (Panshin & de Zeeuw 1970).

Fibre cross-sectional dimensions such as fibre diameter, lumen width and cell wall thickness also affect properties such as strength, shrinkage and swelling, permeability, gluing and pulping and machining characteristics (Goggan 1962; Orman & Maddern Harris 1965; Van Buijtenen 1969). There is an increasing evidence that cell cross-sectional dimensions exert a greater influence on paper properties than fibre length (Dinwoodie 1966). Thus more attention is drawn to the distribution of cell diameters and wall thickness in pulp and paper research (Lantican 1972).

Thus, the objectives of this study are to determine radial variation and vertical variation and also the variation between trees for the fibre properties mentioned above.

Materials and Methods

Four species of Malaysian dipterocarpaceae were studied, namely engkabang (*Shorea macrophylla* Ashton), keladan (*Dryobalanops oblongifolia* Dyer), giam kancing (*Hopea subalata* Sym.) and sengkawang air (*Shorea sumatrana* Sym.). Three trees were randomly selected from even-aged plantations for each wood species. From each tree, four discs were taken to represent four height levels, *viz.* 5%, 25%, 45% and 65% of total height. The discs were divided at the pith region to represent two radii. Each radius was divided into ten equal segments but only the even-numbered (2,4,6,8 and 10) were used for the study.

The samples from each segment were cut into match stick-sized splints and macerated into a 50:50 mixture of 15% nitric acid and 10% chromic acid (Dinwoodie 1961). Several slide specimens were prepared and measurements were carried out for various fibre properties such as fibre length (fl), fibre diameter (fd), lumen width (lw) and cell wall thickness (cwt) using a special equipment known as Image Analyzer attached to a light transmission microscope.

Results and Discussions

The results from the measurement of fibre properties are summarized in Table 1 and the summaries for the analyses of variance for the four wood species studied are shown in Table 2 (engkabang), Table 3 (keladan), Table 4 (giam kancing) and Table 5 (sengkawang air).

Table 1: Mean value of fibre properties examined for the four Malaysian Dipterocarp species.

Fibre Properties	Species			
	Engkabang	Keladan	Giam kancing	Sengkawang air
Fibre length (mm)	1.331	1.676	1.600	1.693
Fibre diameter (μm)	30.641	23.334	16.026	16.559
Lumen width (μm)	14.003	13.407	9.739	9.437
Cell wall thickness (μm)	8.325	4.936	3.184	3.586

Table 2: Summary of the analyses of variance for fibre properties evaluated for engkabang.

Source Of Variance	DF	Computed F-Values			
		Fibre length	Fibre diameter	Lumen width	Cell wall thickness
Trees (T)	2	2.92^{NS}	5.18*	2.84^{NS}	3.29^{NS}
Heights (H)	3	0.53^{NS}	0.97^{NS}	1.20^{NS}	2.67^{NS}
T x H	6	0.75^{NS}	1.22^{NS}	0.69^{NS}	0.46^{NS}
Radii (R) / H /T	12	10.95***	4.38***	6.91***	8.08***
Segments (S)	4	21.37***	30.19***	37.81***	4.01*
T x S	8	3.46***	1.28^{NS}	0.89^{NS}	1.75^{NS}
H x S	12	0.37^{NS}	2.07^{NS}	1.51^{NS}	1.04^{NS}
T x H x S	24	1.65^{NS}	0.74^{NS}	0.73^{NS}	0.84^{NS}

*Significant at 95% level
**Significant at 99% level
***Significant at 99.5% level
^{NS} Not significant at 95% level

Table 3: Summary of the analyses of variance for fibre properties evaluated for keladan.

Source Of Variance	DF	Computed F-Values Fibre length	Fibre diameter	Lumen width	Cell wall thickness
Trees (T)	2	2.82^{NS}	10.10***	22.2***	16.69***
Heights (H)	3	1.20^{NS}	0.59^{NS}	0.13^{NS}	0.83^{NS}
T x H	6	0.87^{NS}	2.38^{NS}	2.89^{NS}	2.00^{NS}
Radii (R) / H /T	12	3.07**	6.48***	5.13***	2.52*
Segments (S)	4	7.84**	32.84***	21.18***	1.89^{NS}
T x S	8	2.45^{NS}	0.90^{NS}	1.83^{NS}	0.91^{NS}
H x S	12	1.37^{NS}	1.23^{NS}	2.27^{NS}	1.50^{NS}
T x H x S	24	1.10^{NS}	0.93^{NS}	1.31^{NS}	0.70^{NS}

*Significant at 95% level
**Significant at 99% level
***Significant at 99.5% level
^{NS} Not significant at 95% level

Table 4: Summary of the analyses of variance for fibre properties evaluated for giam kancing.

Source Of Variance	DF	Computed F-Values Fibre length	Fibre diameter	Lumen	Cell wall thickness
Trees (T)	2	4.22*	1.48^{NS}	2.01^{NS}	1.22^{NS}
Heights (H)	3	2.17^{NS}	1.36^{NS}	1.11^{NS}	2.03^{NS}
T x H	6	1.35^{NS}	1.34^{NS}	1.12^{NS}	0.87^{NS}
Radii (R) / H /T	12	1.29^{NS}	1.95^{NS}	61.22***	32.64***
Segments (S)	4	13.78***	8.61**	28.67***	1.91^{NS}
T x S	8	0.82^{NS}	0.85^{NS}	0.66^{NS}	1.16^{NS}
H x S	12	0.27^{NS}	1.17^{NS}	0.75^{NS}	0.91^{NS}
T x H x S	24	1.00^{NS}	1.03^{NS}	1.62^{NS}	1.17^{NS}

*Significant at 95% level
**Significant at 99% level
***Significant at 99.5% level
^{NS} Not significant at 95% level

Table 5: Summary of the analyses of variance for fibre properties evaluated for sengkawang air.

Source Of Variance	DF	Computed F-Values Fibre length	Fibre diameter	Lumen width	Cell wall thickness
Trees (T)	2	34.02***	9.28***	20.11***	1.29^{NS}
Heights (H)	3	0.68^{NS}	1.54^{NS}	2.08^{NS}	2.00^{NS}
T x H	6	2.23^{NS}	0.88^{NS}	0.89^{NS}	2.23^{NS}
Radii (R) / H /T	12	2.53*	2.54*	9.13***	2.32*
Segments (S)	4	19.23***	3.23^{NS}	47.77***	0.38^{NS}
T x S	8	3.01**	1.31^{NS}	0.79^{NS}	1.42^{NS}
H x S	12	0.19^{NS}	0.61^{NS}	1.29^{NS}	0.75^{NS}
T x H x S	24	1.10^{NS}	0.63^{NS}	0.79^{NS}	0.68^{NS}

*Significant at 95% level
**Significant at 99% level
***Significant at 99.5% level
^{NS} Not significant at 95% level

Fibre length ranges from 1.33 mm for engkabang to 1.69 mm for sengkawang air which is common for most hardwood species (Suhaimi 1980). Other fibre properties such as fibre diameter (fd), lumen width (lw) and cell wall thickness (cwt) were highest for engkabang (fd=30.64μm, lw=14.00μm and cwt=8.33μm) and followed closely by keladan (fd=23.33μm, lw=13.41μm and cwt=4.94μm).

Fibre length varies significantly among different trees for sengkawang air (Table 5) and giam kancing (Table 4) but no significant effect of tree for engkabang (Table 2) and keladan (Table 3). Segment of wood from pith to bark exhibited high significant effect on fibre length for all the wood species. Similarly, the effect of radius portion on fibre length was significant except for giam kancing. This implies that age rotation plays vital role in improving fibre quality of wood species.

Fibre diameter showed highly significant variation for different trees in keladan and sengkawang air but not significant in giam kancing. Significant radial variation was shown for engkabang and keladan where both radii and segment exhibited highly significant variation (99.5% level). Vertical variation as indicated by different height levels was not significant for all wood species. Giam kancing revealed significant difference for segment effect but sengkawang air showed significant difference for the radial effect.

Lumen width of the fibre was highly influenced by different trees for keladan and sengkawang air but no significant effect of tree on lumen width for engkabang and giam kancing. Interestingly, highly significant radial variation (radii and segment) existed for all the four wood species but no significant effect was shown for the vertical direction as revealed by the different height levels of the tree.

Cell wall thickness of the fibre was greatly influenced by different trees of the same species only for keladan (Table 3) and the other three wood species showed no significant differences. Radial variation showed significant difference for radii effect in all cases but not the segment effect although engkabang indicated significant effect (95% level) of segment from pith to bark (Table 2). Again vertical variation was not significant in all the wood species studied.

Conclusion and Recommendation

Radial portion of the tree for almost all cases especially the segment number from the pith greatly influences the fibre properties of the wood species studied *viz.* engkabang, keladan, giam kancing and sengkawang air. This implies the possibility of improving the quality of the fibres through the manipulation of rotation age. The fact that segment number from the pith contributed generally the largest portion of the variance in most fibre properties should not be taken as a restraint to breeding programs for improved wood quality. Selection and breeding may evolve variants that would attain desired wood qualities at an earlier age. The economic implications of this are undeniable.

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