VARIATION IN FIBRE MORPHOLOGY AND POROSITY OF RUBBERWOOD (*HEVEA BRASILIENSIS*)

Suhaimi Muhammed
Faculty of Applied Science, Universiti Teknology MARA
26400 Jengka Pahang Darul Makmur

Mohd. Hamami Sahri
Faculty of Forestry, Universiti Putra Malaysia
43400 Serdang Selangor Darul Ehsan

Abstract

Fibre morphology and porosity were determined in rubberwood from two clones and two age groups. Fibre diameter increased from pith to bark but no significant difference between the two clones for the same age group. Similarly, lumen diameter increased from pith to bark. Clone RRIM 600 showed bigger lumen diameter than RRIM 623. Cell wall thickness also increased with increasing distance from the pith. Between age group, the cell wall thickness was significant for clone RRIM 623 but not significant for RRIM 600. Pore diameter increased from pith to bark but pore frequency exhibited a decreasing pattern. Between clone and within clone at both age groups, pore diameter and frequency showed no significant difference. The variation of such properties could serve as a guide in predicting specific end purposes.

Key Words: fibre diameter, cell wall thickness, lumen diameter, pore diameter, pore frequency

INTRODUCTION

The behaviour of wood when applied for specific purposes can be predicted through the measurement of certain wood characteristics collectively known as quality indicators. Such indicators include fibre morphology and porosity which are of prime importance in determining end use characteristics of timber.

Fibre length, an important aspect of fibre morphology, is related to the mechanical strength and longitudinal shrinkage and is known to affect strength properties of paper (Dinwoodie, 1961). It has been pointed out that "a minimum length is required sufficient bonding surface to spread the stresses over the entire area of the sheet" (Panshin and de Zeeuw, 1980). However, variation in fibre length does not reflect the actual changes in the size of initials at the cambium (Goggans, 1962). With respect to tree height, fibre length increases to a maximum below the crown, then decreases towards the top of the tree to the minimum length typical of juvenile wood.

Fibre cross-sectional dimensions such as fibre diameter, lumen diameter and wall thickness affect properties such as strength, shrinkage and swelling, permeability, gluing and pulping and machining characteristics (Van Buijtenen, 1969). There is an increasing

evidence that cell cross-sectional exert a greater influence on paper properties than fibre length (Dinwoodie, 1965). Most fibre cross-sectional dimensions exhibited systematic pattern of change with increasing age or distance from the pith. Fibre diameter, lumen diameter, and cell wall thickness in the earlywood and in the latewood vary in the radial direction in a manner similar to that exhibited by fibre length (Lantican, 1972).

Porosity, represented by the size and distribution of pores, are of prime importance in wood preservation since this would determine the penetrability of wood to some extent. They are also important in pulp and paper making because they affect the printability of paper. Pore in hardwoods has been reported to decrease in diameter, or volume, or both from earlywood to latewood. The changes in radial pore diameter has been related to the physiology of growth (Larson, 1963).

Specifically, the objectives of this study were; firstly, to determine the variation of wood quality indicators such as fibre dimensions and porosity according to clones and age groups, and secondly, to determine the variation of such features according to the distance from pith to bark.

MATERIALS AND METHODS

Rubberwood (*Heavea brasiliensis*), selected from the rubber plantation area of Universiti Putra Malaysia (UPM), Serdang Selangor were obtained from two clones namely RRIM 600 and RRIM 623 at the age of 22 year and 35 years old. Data on rubberwood from UPM rubber plantation is shown in Table 1. Discs measuring 5cm thick were taken at breast height (DBH) of the tree. Each disc was then wrapped in a plastic back and labelled accordingly. The wood samples were stored in a freezer room to prevent from moisture loss and fungal attack.

Table 1: Data on rubberwood from the Rubber Plantation at UPM Serdang

CLONE	AGE	TREE NO.	DIAMETER	HEIGHT OF BOLE (m)	
			(cm)	100 %	DBH
RRIM 623	35	1	30.05	5.33	0.9
		2	34.65	8.63	0.9
		3	37.30	6.65	0.9
		Average	(34.00)	(6.87)	(0.9)
	22	1	30.60	5.52	0.9
		2	34.55	4.55	0.9
		3	33.00	7.67	0.9
		Average	(32.72)	(5.91)	(0.9)
RRIM 600	35	1	34.50	5.05	0.9
		2	41.51	11.7	0.9
		3	35.50	7.35	0.9
		Average	(37.17)	(8.03)	(0.9)
	22	1	36.20	7.35	0.9
		2	28.50	6.12	0.9
		3	43.40	9.90	0.9
		Average	(36.03)	(7.79)	(0.9)

Determination of Fibre Morphology

The wood specimens with dimensions of 1.5cm by 1.5cm by 2cm from outer and inner part of the wood strip were taken using circular saw. The samples were splitted into pieces of matchstick size and later macerated into a 50-50 mixture 15% nitric acid and 10% chromic acid. The fibres were stained and mounted onto glass slide. The slides were examined under transmission light microscope connected to an image analyzer. Measurements were then made on fibre diameter, lumen diameter and cell wall thickness.

Determination of Porosity

Thin sections were obtained from the transverse section of wood specimens of dimension 1.5cm x 1.5cm x 2cm for the outer and inner part of the wood strip by using a sliding microtome. The sections (about 20 micron in thickness) were stained and mounted on glass slides with Canada Balsam. Pore frequency and pore diameter were then measured using an image analyzer which was attached to a transmission microscope.

RESULTS AND DISCUSSION

The mean of fibre dimensions between clones and age groups are shown in Table 2. The average fibre length was noted as 1.31mm, within the average value of most tropical timbers. Bhat *et al.* (1984) found the average fibre length was 1.19mm. Ashaari (1986) showed that the average fibre length from two clones was 1.10mm. Tavita *et al.* (1974) found that the fibre length of 40 tropical hardwoods ranged from 0.80mm to 1.55mm. Peel and Peh (1961) found that the mean fibre length was 1.50mm. Table 3 showed that fibre length was highly significant between clones at age 35-year-old but not significant at age 22-year-old. Radial portions showed significant differences between clones for both age groups, with longer fibres near the bark compared to that near the pith. Significant different was noted within clone RRIM 600 at age groups 22 and 35 years but no significance for clone RRIM 623.

The average fibre length was noted as 1.31mm, within the average value of most tropical timbers. Bhat *et al.* (1984) found the average fibre length was 1.19mm. Ashaari (1986) showed that the average fibre length from two clones was 1.10mm. Tavita *et al.* (1974) found that the fibre length of 40 tropical hardwoods ranged from 0.80 mm to 1.55 mm. Peel and Peh (1961) found that the mean fibre length was 1.50 mm.

TABLE 2: Mean fibre morphological characteristics of rubberwood

Parameter	Age Group (years)	RRIM 623		RRIM 600	
		Near Bark	Near Pith	Near Bark	Near Pith
Fibre Length (centimetre)	22	**1.47**	**1.14**	**1.21**	**1.12**
		[72.73]	[75.17]	[100.73]	[77.74]
	35	**1.53**	**1.17**	**1.64**	**1.43**
		[125.20]	[47.82]	[76.69]	[75.17]
Fibre Diameter (micron)	22	**24.87**	**22.32**	**24.21**	**23.04**
		[1.70]	[4.45]	[2.75]	[1.48]
	35	**26.88**	**23.56**	**26.54**	**25.22**
		[2.37]	[2.49]	[3.06]	[2.53]
Lumen Diameter (micron)	22	**11.39**	**10.49**	**11.07**	**10.43**
		[3.08]	[1.84]	[2.52]	[1.68]
	35	**11.32**	**10.49**	**11.79**	**10.46**
		[2.31]	[1.52]	[2.03]	[2.41]
Cell Wall Thickness (micron)	22	**6.74**	**6.48**	**6.73**	**6.30**
		[1.74]	[0.91]	[0.89]	[0.49]
	35	**8.67**	**6.54**	**7.39**	**7.38**
		[0.99]	[1.34]	[1.00]	[1.67]

Legend: [ ] – Standard Deviation

TABLE 3: Significant of difference in mean fibre morphology of rubberwood

Parameter	Duncan Group	Mean	Duncan Group	Mean	Clone
	22-year-old		35-year-old		
Fibre length (cm)	B	1.30	B	1.35	RRIM 623
	B	1.17	A	1.54	RRIM 600
Fibre diameter(μ m)	A	24.00	A	25.84	RRIM 623
	A	23.97	A	25.77	RRIM 600
Lumen diameter(μ m)	A	10.94	A	10.90	RRIM 623
	A	10.75	A	11.13	RRIM 600
Cell wall thickness(μ m)	B	6.65	A	7.60	RRIM 623
	A	6.52	B	7.38	RRIM 600

Legend: Means with the same letter are not significantly different at alpha = 0.05

Fibre diameter was bigger for clone RRIM 623 than that of RRIM 600 and there was no significant different between clones at similar age groups. Similarly, no difference was observed for each clone at different age groups. Peel and Peh (1961) and Sekhar (1989) found that the mean fibre diameter of rubberwood was about 22 microns. Fibre diameter increases significantly from pith to the bark (Table 2).

Lumen diameter showed no significant difference between clones for the similar age groups and within clone at both age groups (Table 3). There was an increasing trend in lumen diameter from pith to bark as shown in Table 2.

Cell wall thickness (CWT) between age groups was significant for both clone RRIM 623 and clone RRIM 600. CWT was also significant between radial portions. Ashaari (1986) indicated that CWT was not significantly different with neither radial nor height positions. The variability along the radius may be attributed to the responses of tress to tapping.

Porosity as indicated by pore diameter (PD) and pore frequency (PF) was summarised in Table 4. Mean PD for rubberwood was 151.63 microns and mean PF was between 3 to 5 per sq. mm. According to Sekhar (1989) pores were up to 200 micron in tangential diameter and where solitary there were between 3 to 4 pores per sq. mm. PD exhibited higher value from sample of 35 years compared to age 22 years. PF was higher near the pith than near the bark and no significant different existed between clone and within clone at both age groups and height levels (Table 5). Pore frequency was significant only between radial portions with increasing trend from bark to pith (Table 4).

TABLE 4: Mean values for pore diameter and frequency of rubberwood

Parameter	Age Group (years)	RRIM 623		RRIM 600	
		Near Bark	Near Pith	Near Bark	Near Pith
Pore Diameter (micron)	22	**146.60**	**127.44**	**200.78**	**112.96**
		[12.32]	[28.41]	[31.79]	[21.53]
	35	**195.31**	**142.41**	**166.22**	**128.00**
		[42.27]	[28.29]	[19.94]	[9.00]
Pore Frequency (no./sq. mm)	22	**4.30**	**6.10**	**2.60**	**6.20**
		[1.01]	[0.92]	[0.91]	[1.93]
	35	**3.20**	**4.90**	**3.20**	**4.30**
		[1.05]	[1.47]	[1.39]	[0.06]

Legend: [ ] – Standard Deviation

TABLE 5: Significant of difference in mean values of pore diameter and frequency

Parameter	Duncan Group	Mean	Duncan Group	Mean	Clone
	22-year-old		35-year-old		
Pore diameter(μ m)	A	137.02	A	168.76	RRIM 623
	A	159.87	A	147.11	RRIM 600
Pore frequency	A	5.20	A	4.07	RRIM 623
	B	4.40	A	3.77	RRIM 600

Legend: Means with the same letter are not significantly different at alpha = 0.05

CONCLUSION

Longer fibre was observed for the clone RRIM 600, the 35-year-old tree and at position near the bark. Bigger fibre diameter was shown for the clone RRIM 623 and at position near the bark. Lumen diameter exhibited higher value for the clone RRIM 623, with increasing distance from the pith. The fibre cell was thicker for the clone RRIM 600 and at location nearer to the bark. Meanwhile, both pore diameter and frequency exhibited higher values for the clone RRIM 623. Larger diameter pores but smaller in number was shown with increasing distance from the pith to the bark.

REFERENCES

Ashaari Mohd. Amin. 1986. The Fibre Length of Two Clones of Rubberwood. *Malaysian Forester* 49(1): 48-55.

Bhat, K.M., K.V., Damodaran, T.K. and Rugmani. 1984. Some Wood and Bark Properties of *Hevea brasiliensis. Journal Tree Science* 3(1&2), p. 40-46.

Dinwoodie, J.M. 1961. Tracheid and Fibre Length in Timber: A Review of Literature. *Forestry* 34: 125-144.

Dinwoodie, J.M. 1965. *The Relationship between Fibre morphology and paper properties: A Review of Literature*. TAPPI 48: 447-448.

Goggans, J.F. 1962. *The Correlation, Variation and Inheritance of Wood Properties in Pine*, North Carolina State College, School of Forestry Technical Report. No. 14:155pp.

Lantican, C.B. 1972. *Variations in Some Structural Features and Wood Properties of Pinus Caribeae Morelat from British Hondurus*. Unpublished Ph.D. Dissertation, Oxford University, England.

Larson, P.R. 1963. *Microscopic Wood Characteristics and their Variations with Tree Growth*, Proc. Inst. Union Forest Research. Organ Section 41, Madison, Wisconsin.

Panshin, A.J. and de Zeeuw, C. 1980. *Textbook of Wood Technology. 3rd Edition.* McGraw Hill Book Co. New York. 705p.

Peel, J.D. and Peh, T.B. 1961. Para Rubberwood for Pulp and Paper Manufacture – An Account of Laboratory Experiments. *Malayan Forester*. 16: 217-219.

Sekhar, A.C. 1989. *Rubberwood Production and Utilisation*, Rubber Research Institute of India, Kottayam. 219p.

Tavita, Y., Polisco, J. and Villavalez, L. 1974. Fibre Dimension of Some Philippines Woods. *FORPRIDE Digest*. 3(3&4): 87-99.

Van Buijtenen,J.P. 1969. *Controlling Wood Properties by Forest Management*. TAPPI 52(2): 257-259.