ABSTRACTS (PH D THESIS)

Variation of Fiber Properties in Relation to the Distance from Vessels in *Acacia mangium*

(Laboratory of Biomass Morphogenesis and Information, RISH, Kyoto University)

Ridwan Yahya

The *Acacia* plantation in Indonesia requires a tree improvement program to increase the yield of solid wood and its quality to meet market demands. In the plantations operating on Sumatra Island in Indonesia, the plantation program remains primarily in the selection step, and has not yet implemented the breeding step. Another problem of these plantations is that trees are primarily selected based on growth rate and stem form. Hence, the improvement of wood quality to meet end-product requirements is still in progress. For instance, a trial hybrid of *A. mangium* and *A. auriculiformis* are growing. Its stem form and growth rate show that this *Acacia* hybrid is promising, and tends to produce better quality raw material for pulp and papermaking compared to its parents [1]. However, to date, little is known even regarding basic properties, such as density, anatomy, and chemical composition of the hybrid in Indonesia.

The objectives of this study are as follows; (1) evaluating wood properties of the *Acacia* hybrid, in parallel to searching for specific anatomical predictors of pulp yield and paper strength applicable to this species, (2) introducing a facile, quick, and reliable technique to obtain 3D reconstructed data from serial optical micrographs to investigate the above mentioned relationships, and (3) investigating fiber length in tangential direction in relation to the distance of fibers from vessels.

The basic properties of the *Acacia* hybrid were investigated. Compared to both parents, *A. mangium* and *A. auriculiformis*, the *Acacia* hybrid had longer fibers, in addition to a higher slenderness ratio, fiber proportion, and holocellulose content, but smaller proportions of vessels, parenchyma cells, and extractives. In addition, the hybrid tended to have a thinner cell wall, and a lower proportion of ray cells, rigidity, and lignin content, but a higher flexibility coefficient and wood density compared to *A. mangium* (Tables 1,2). Fiber length was positive & negative correlation with α-cellulose and lignin content, respectively. Holocellulose content was all reliably predicted by fiber length. The slenderness ratio was a better predictor of extractive content than fiber length. Both the fiber length and slenderness ratio were better predictors of chemical composition than wood density. Therefore, fiber length and the slenderness ratio could be used as reliable predictors of pulp yield and paper strength for acacias.

Table 1. Fiber dimension and derived values of *Acacia* hybrid and its parents

Species	FL (μm)	FD (μm)	FLD (μm)	FWT (μm)	RR	MR	SR	CR	FC	PF (%)	PR (%)	PP (%)	PV (%)
Acacia hybrid	1068	18.76	13.74	2.51	0.37	46.17	57.4	0.13	0.73	72.65	8.51	9.39	9.45
A. mangium	982**	19.39	14.29	2.55	0.37	45.85	51.29*	0.13	0.73	62.46**	9.77	15.66*	12.11**
A. auriculiformis	879**	16.74*	11.13*	2.81	0.55	55.00	52.65*	0.17	0.67	68.18*	9.07	11.23	11.55**

FL = fiber length, FD = fiber diameter, FLD = fiber lumen diameter, FWT = fiber wall thickness

RR = Runkel ratio, MR = Muhlsteph's ratio, SR = slenderness ratio, CR = coefficient of rigidity, FC = flexibility coefficient

PF, PR, PP, PV = Proportions of fiber, ray cells, parenchyma cells and vessels respectively

** Significantly different at the 0.01 level, * = at 0.05 level

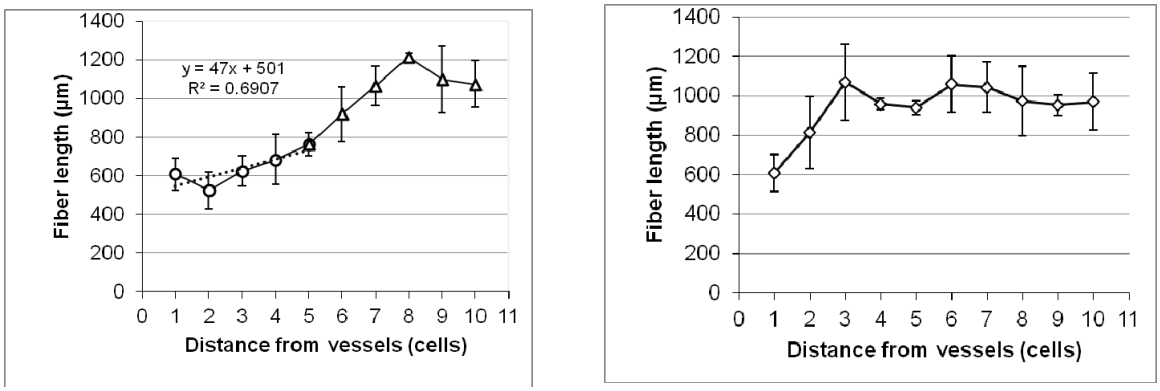
Next, I focused on a more detailed search of the anatomical factors, with special reference to fiber length by exploring *A. mangium*. A newly developed 3D microscopy technique was introduced to create aligned serial images from the cross sectional micrographs. Reconstruction of 200 serial images took just 1 day, and all digital information was compiled in a personal computer. This dataset allowed us to quickly and easily estimate wood fiber length using a public-domain software. It took no more than 2 min to locate the 2 tips of a fiber, by scrolling images on the computer, which contrasts against previous studies of serial cross sections [2]. Given this technical development, fiber length variation in relation to the distance from

vessels was measured in detail. Fibers that were more distant from vessels were found significantly longer, not only in the radial direction, but also in the tangential direction (Figure 1).

Table 2. Chemical compositions and wood density of Acacia hybrid and its parents

Species	Alcohol–benzene extractives (%)	Holocellulose (%)	α-Cellulose (%)	Lignin (%)	Density (g cm-3)
Acacia hybrid	2.9	82.88	45.45	30.91	0.49
A. mangium	5.38**	80.43**	45.71	31.30	0.46
A. auriculiformis	5.96**	71.33**	40.57*	34.10	0.52

** Significantly different from Acacia hybrid at the 0.01 level, * = at the 0.05 level



a **b**

Fig. 1. Fiber length variation in (a) radial and (b) tangential directions.

In search of the superiority of *Acacia* hybrid than its parents as a resource for pulp and papermaking, the microstrucre of *A. mangium* were thouroughly investigated, vessels influence the anatomical features such as length in both the radial and tangential direction, although these influences were more tailed in the radial direction. Therefore, to produce high quality pulp and paper, I suggest that the quantity of vessels in the *A. mangium* tree should be reduced through tree improvement breeding programs.

REFERENCES

[1] Yahya, R., J. Sugiyama., D. Silsia & J. Gril. 2010. J. Trop. For. Sci. 22: 343--351.
[2] Yahya, R., K. Koze & J. Sugiyama. 2011. IAWA J. 32: 341--350