EFFECTS OF AGE AND HEIGHT OF THREE BAMBOO SPECIES ON THEIR MACHINING PROPERTIES

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ABD. LATIF MOHMOD. 1993. Effects of age and height of three bamboo species on their machining properties. The effects of age and height on the machining performance of three Malaysian bamboos, *viz. Bambusa blumeana, B. vulgaris* and *Gigantochloa scortechinii* for toothpicks, satay sticks, skewers and chopsticks were investigated. No significant difference was obtained for the percentage recovery of the three species but processing of immature culms resulted in inferior quality of bamboo products. Results further showed that these bamboos are best harvested at the age of two years or more and the use be limited only to the basal and middle portions to ensure good quality products.

Key words: Malaysian bamboos - age - height - machining properties

ABD. LATIF MOHMOD. 1993. Kesan umur dan ketinggian batang tiga jenis buluh terhadap sifat-sifat pemesinannya. Kesan umur dan ketinggian tiga jenis buluh, iaitu *Bambusa blumeana, B. vulgaris* dan *Gigantochloa scortechinii* terhadap perlakuan pemesinan bagi pembuatan pencungkil gigi, lidi sate, pencucuk daging dan kayu penyepit adalah dikaji. Tiada perbezaan nyata yang dicerap terhadap peratusan kadar pulangan diantara spesis-spesis yang diuji tetapi pemerosesan buluh-buluh muda lazimnya mengakibatkan penghasilan barangan siap yang bermutu rendah. Ujian juga menunjukkan bahawa buluh sebaiknya dituai apabila berumur melebihi dua tahun dengan penggunaan batang yang dihadkan kepada bahagian pangkal dan tengah bagi menjamin mutu hasil akhir barangan yang lebih baik.

Introduction

Information on the basic properties of Malaysian bamboos particularly in relation to their industrial applications is very limited. Since many bamboo species remain unutilized, research is needed to determine the properties of such species and develop their appropriate utilization technology. This is particularly true as many of the problems faced by the processors are closely related to the natural characteristics of the bamboo itself. For example, Malaysian bamboo grows in clumps resulting in bent stems and are therefore under constant stress. The straighter and older culms are commonly found at the centre of the clumps where they are less accessible during felling/harvesting (Abd. Latif & Abd. Razak 1991).

Systematic harvesting of wild bamboos is not yet established. They are normally harvested without due consideration given to their characteristics and final use (Abd. Latif *et al.* 1990). Easy splitting and cracking due to high initial moisture content (Ng 1980) and the uncertain age of the harvested bamboos are some of the problems faced.

The highly variable properties of bamboo present problems in processing and utilization (Abd. Latif *et al.* 1991). Thus, improvement in processing should be focussed on harvesting bamboo of suitable age and knowing the desired quality of the species for their possible end uses. The inter-relationship of the parameters and properties studied may indicate whether silviculture treatment and proper harvesting practices are required to produce natural bamboo stands with improved properties suitable for manufacturing purposes.

The present study aims at examining the effects of age and height on the recovery rate and machining properties of some Malaysian bamboo species for the production of toothpicks, 'satay' sticks, skewers and chopsticks.

Materials and methods

Three species of bamboo, namely, *Bambusa blumeana* (buluh duri), *B. vulgaris* (buluh gading) and *Gigantochloa scortechinii* (buluh semantan) were used in this study. Bamboo samples of known age (1 to 3 *y* old), whose growth has been recorded since the sprouting stage, were obtained from wild clumps growing in the vicinity of the Forest Research Institute of Malaysia (FRIM) at Kepong, Selangor, Malaysia.

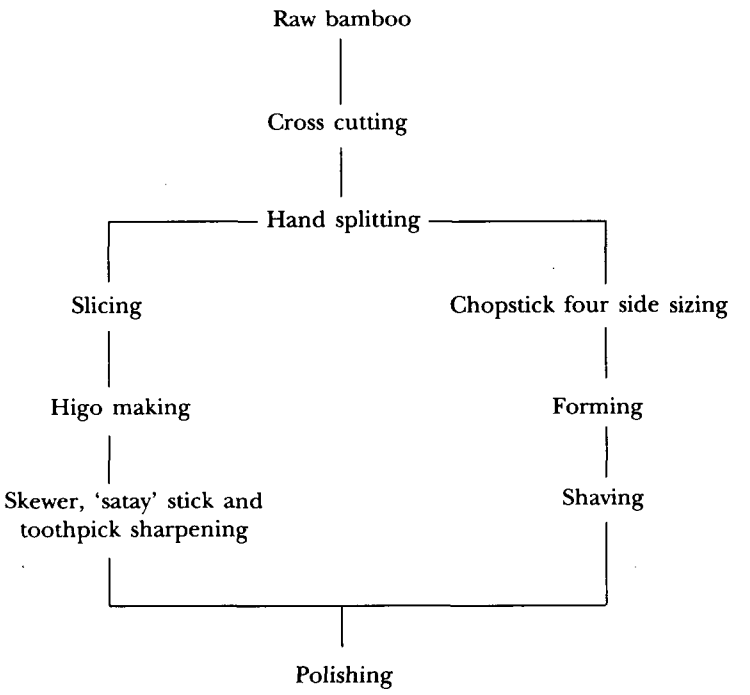

Figure 1. Production flow for toothpick, 'satay' stick, skewer and chopstick manufacture

Fifteen bamboo samples, 1 to 3 *y* old, from each species were cut at about 30 *cm* above ground level and then marked and cut at about 4.0 *m* intervals into basal (B), middle (M) and top (T) portions. They were further cut into internode lengths for each production of toothpicks, 'satay' sticks, skewers and chopsticks. All the bamboo specimens were conditioned in a conditioning chamber at 27.5°*C* and 65% relative humidity to bring the moisture content down to about 12%, and weighed before and after being processed with Taiwan-made machines (Figure 1 and Table 1).

The machining properties of all the three bamboo species studied were then measured according to the methods of Lopez (1974), based on the ease of processing, recovery rate and quality of the products produced.

Table 1. Types of machines used for manufacturing toothpicks, 'satay' sticks, skewers and chopsticks

	Machine	Capacity/*h*
1.	Cross-cut saw (CYM 001)	52 *m*
2.	Splitting (CYM 012)	28 *m*
3.	Slicing (CYM 003)	65 *m*
4.	Knot removing (CYM 013)	65 *m*
5.	Higo making (CYM 005)	2880 pieces
6.	'Satay' stick/skewer sharpening (CYM 0085)	12000 pieces
7.	Toothpick shaving (CYM 0087)	31225 pieces
8.	Toothpick polishing (CYM 0077)	0.03 m^3
9.	'Satay' stick/skewer polishing (CYM 0075)	0.04 m^3
10.	Four side sizing (CYM 040)	1750 pieces
11.	Chopstick forming (CYM 043A)	5400 pieces
12.	Chopstick shaving (CYM 042A)	5400 pieces
13.	Chopstick polishing (CYM 051)	0.06 m^3

Results and discussion

The results on the machining properties of the three bamboo species are given in Table 2. The average recovery rate of the four different bamboo products, mainly toothpicks, 'satay' sticks, skewers and chopsticks, are presented in Table 3.

The machining properties of the bamboos indicate that the cross-cutting, splitting and shaving of all the bamboo species, especially at a younger age, are easy (Table 2). This is probably due to the low shear strength values (Janssen 1981, Abd. Latif *et al.* 1990) and the evenly distributed vascular bundles per square area (Taihui & Wenwei 1987). Finished bamboo products produced from young bamboo culms, however, are observed to be of low quality, fibrous, easily bent and with high shrinkage. The high initial moisture content and low basic density in a young culm, which are basically associated with its low strength (Abd. Latif *et al.* 1991) and poor working properties often lead to lower quality

machine-intensive bamboo products (Chan* personal communication). Furthermore, processing of a young bamboo with high initial moisture content frequently causes the cutter tools to rust (oxidize) resulting in fibrous and low quality end products (Abd. Latif 1987).

Analysis of variance on the recovery rate of bamboo products was conducted and the results are given in Table 4. Regression analysis on the effects of age and

Table 2. Machining properties of the three bamboo species

		1 *y*			2 *y*			3 *y*		
Machining	Bamboo	Butt	Middle	Top	Butt	Middle	Top	Butt	Middle	Top
Cross	a	E,F	E,F	E,F	E	E,F	E,F	E	E	E
cutting	b	E,F	E,F	E,F	E	E	E,F	E	E	E
	c	E,F	E,F	E,F	E	E	E,F	E	E	E
Splitting	a	E	E	E	E	E	E	E	E	E
	b	E	E	E	E	E	E	E	E	E
	c	E	E	E	E	E	E	E	E	E
Knot	a	E	E	E	E	E	E	S	E	E
removal	b	E	E	E	S	E	E	S	E	E
	c	E	E	E	E	E	E	E	E	E
Slicing	a	E	E	E	E	E	E	E	E	E
	b	E	E	E	E	E	E	S	E	E
	c	E	E	E	E	E	E	S	E	E
Higo	a	E,L	E,L	E,L	E,M	E,L	E,L	E,G	E,G	E,L
	b	E,L	E,L	E,L	E,M	E,M	E,L	E,G	E,G	E,L
	c	E,L	E,L	E,L	E,M	E,M	E,L	E,G	E,G	E,L
Four side	a	E,L	E,L	E,L	E,M	E,L	E,L	E,G	E,M	E,M
sizing	b	E,L	E,L	E,L	E,M	E,L	E,L	E,G	E,M	E,M
	c	E,L	E,L	E,L	E,M	E,M	E,L	E,G	E,M	E,M
Forming	a	E,L	E,L	E,L	E,M	E,L	E,L	E,G	E,M	E,L
	b	E,L	E,L	E,L	E,M	E,L	E,L	E,G	E,M	E,L
	c	E,L	E,L	E,L	E,M	E,M	E,L	E,G	E,M	E,L
Shaving	a	F,L	F,L	F,L	E,M	F,L	F,L	E,G	E,M	E,M
	b	F,L	F,L	F,L	E,M	F,L	F,L	E,G	E,M	E,M
	c	F,L	F,L	F,L	E,M	E,M	F,L	E.G	E,M	E,M
Polishing	a	F,L	F,L	F,L	E,M	F,L	F,L	E,G	E,M	F,L
	b	F,L	F,L	F,L	E,M	F,L	F,L	E,G	E,M	F,L
	c	F,L	F,L	F,L	E,M	E,M	F,L	E,G	E,G	F,L

Note:
a : *B. vulgaris;* b: *B. blumeana;* c: *G. scortechinii.*
E : Easy ; F: fibrous; G: Good quality; L: Low quality.
M : Medium quality ; S: Slightly difficult.

* Owner of Jinshi Chopsticks (M) Sdn. Bhd., Sungai Bakau Arang, Rawang, Selangor, Malaysia.

Table 3. Average recovery rate (% weight of bamboo products)

Bamboo	1 y			2 y			3 y		
	Butt	Middle	Top	Butt	Middle	Top	Butt	Middle	Top
	Toothpicks								
a	35.8	28.9	27.8	38.6	41.2	42.7	65.1	63.8	54.3
b	27.3	25.7	23.4	43.7	38.7	35.7	61.1	58.8	45.9
c	33.2	32.1	28.00	45.9	45.1	40.6	4.00	60.4	53.9
	'Satay ' sticks								
a	47.5	44.9	43.1	53.2	51.6	51.7	72.6	69.6	66.0
b	35.2	31.2	27.7	46.2	43.8	41.1	55.7	53.8	51.9
c	21.2	20.9	20.00	45.8	41.1	37.5	51.9	52.4	49.3
	Skewers								
a	39.4	36.9	35.7	5.00	53.2	48.9	71.2	70.1	60.8
b	32.1	31.7	30.9	42.00	42.9	39.8	61.9	62.7	57.5
c	42.1	41.1	37.7	41.2	40.3	50.2	61.6	53.8	44.1
	Chopsticks								
a	34.1	33.1	30.8	44.0	43.4	41.7	74.0	73.8	52.6
b	31.7	32.0	26.9	59.9	56.7	51.2	64.6	62.2	61.6
c	24.0	23.5	33.9	56.3	46.5	45.4	72.3	71.9	66.7

Note:
a: *B. vulgaris;* b: *B. blumeana;* c: *G. scortechinii.*

Table 4. Summary of analysis of variance on recovery rate and average quality of bamboo products

Source of variation	Df	Mean squares and statistical significance				
		Toothpicks	'Satay' stick	Skewers	Chopsticks	Average quality
Species	2	122.29**	1506.47**	309.64**	3.22ns	0.35ns
Age	2	3943.88**	2985.46**	2631.99**	6791.56**	10.35**
Height	2	225.86**	94.13**	93.98*	4.54ns	1.68**
Species × age	4	11.71**	84.40**	150.41**	236.21*	0.35ns
Species × height	4	7.13*	1.26ns	11.12ns	50.80ns	0.2ns
Age × height	4	41.03**	0.84ns	54.21*	8.09ns	0.43*
Species × age × height	8	13.01**	6.80**	27.59ns	26.78ns	0.02ns

Note:
ns : not significant at $p<0.05$; *: significant at $p<0.05$.
** : highly significant at $p<0.01$.

height of the culm on quality and recovery rate of bamboo products is presented in Table 5. The analysis indicates that the quality of bamboo products varies insignificantly with height of the culm (R= - 0.33 at $p<0.05$) but significantly with age (R= 0.80 at $p<0.01$) . This implies that the selection of bamboo for better quality products should mainly rely on the suitable age and, to a lesser extent, the portion of the culm. Bamboo products were observed to correlate significantly ($p<0.01$) with age but decrease insignificantly ($p<0.05$) with the increment of culm height (Table 5). These are further revealed by the Duncan's New Multiple Range tests (Table 6). While the recovery rates of skewers and chopsticks, for example, were about 36 and 30 % respectively for the 1-*y*-old culms, the results indicate higher recovery rates in the 3-*y*-old bamboos (about 69 and 60 %). By taking the same example of bamboo products, the results further show better recovery rates (about 49 -50 % each for skewers and chopsticks) of the basal and middle portions than those in the top

Table 5. Correlation coefficients for the effect of age and height of culms on recovery rate and quality of bamboo products

	Species	Age	Height
Toothpicks	a	0.94 **	–0.15 ns
	b	0.94 **	–0.28 ns
	c	0.96 **	–0.23 ns
	Average	0.93 **	–0.22 ns
'Satay' sticks	a	0.95 **	–0.16 ns
	b	0.97 **	–0.22 ns
	c	0.96 **	–0.13ns
	Average	0.79 **	–0.14 ns
Skewers	a	0.95 **	–0.21 ns
	b	0.97 **	–0.08 ns
	c	0.61 **	–0.20 ns
	Average	0.82 **	–0.15 ns
Chopsticks	a	0.96 **	–0.05 ns
	b	0.92 **	–0.16 ns
	c	0.90 **	0.10 ns
	Average	0.92 **	–0.02 ns
Quality[+]	a	0.80 **	–0.27 ns
	b	0.82 **	0.20 ns
	c	0.80 **	–0.36 ns
	Average	0.80 **	–0.33 ns

Note:
a : *B. vulgaris;* b: *B. blumeana;* c: *G. scortechinii;* ns: not significant at $p<0.05$.
** : highly significant at $p<0.01$.

[+]Note:Analysis of quality was computed by assigning the fibrous, medium and high quality (good appearance) of the polished bamboo products as 1, 2 and 3 respectively.

(about 34 and 45 % respectively). This is probably due to maturity of the older culms and thicker culm walls of the basal and middle portions (Abd. Latif *et al.* 1991) in producing skewers and chopsticks (product thickness of 5.0 *mm*).

In general, the bamboo should be processed at the age of two years or more in order to obtain recovery rate of more than 50%. In addition, the portion used should be limited to the basal and middle portions for the making of skewers and chopsticks but as near as possible to the basal portion for toothpicks and 'satay' sticks (product diameters of 2.0 and 2.5 *mm* respectively). This is important to ensure the production of high quality toothpicks and 'satay' sticks and medium to high quality skewers and chopsticks.

Table 6. Duncan's New Multiple Range test mean values of recovery rate of bamboo products

Products	Mean rate of recovery					
	(Species)		(Age)		(Height)	
1. Toothpick	44.2 a	(A)	58.6a	(3 y)	46.1a	(Butt)
	44.03a	(B)	41.3b	(2 y)	43.8b	(Middle)
	44.82a	(C)	29.1c	(1 y)	39.1c	(Top)
2. 'Satay' sticks	55.6a	(A)	58.2a	(3 y)	47.7a	(Butt)
	42.9b	(B)	45.8b	(2 y)	45.5b	(Middle)
	37.8c	(C)	32.4c	(1 y)	43.1c	(Top)
3. Skewers	52.3a	(A)	60.4a	(3 y)	49.6a	(Butt)
	45.8b	(C)	45.9b	(2 y)	48.1a	(Middle)
	44.6b	(B)	36.4c	(1 y)	45.1b	(Top)
4. Chopsticks	49.7a	(A)	68.9a	(3 y)	50.0a	(Butt)
	49.6a	(B)	49.4b	(2 y)	49.2a	(Middle)
	49.0	(C)	30.0c	(1 y)	34.4b	(Top)

Note:
Means followed by a common letter or letters are not significantly different at $p<0.05$.
A: *B. vulgaris;* B: *B. blumeans;* C: *G. scortechinii.*

Conclusion

Maturity of culm had a major effect on the machining properties of the bamboos. Although no significant difference was observed on the recovery rates between the three bamboo species, processing of the immature culms generally resulted in low grade and fibrous products. The average recovery rates of the one-year-old and three-year-old bamboos were approximately 30 and 60 % respectively. Analysis of the recovery rates further indicated that the bamboo should be harvested and processed at a minimum age of two years old with usage limited only to the basal

and middle portions. This should be emphasized for medium to high quality products that can be produced from these bamboos.

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