EFFECTS OF AGE AND HEIGHT PORTION ON THE CHEMICAL PROPERTIES OF BULUH SEMANTAN (*Gigantochloa scortechinii*)

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ABSTRACT

Cold water, hot water and alkali solubles content were significantly affected by age and height portion. Highest cold water (8.02%) and hot water (10.19%) content were observed in the top portion of two-year-old culm. They were found to have positive correlation with age and height portion. The top portion of three-year-old culm had the highest alkali solubles (25.52%) content and was shown to increased significantly with age and height portion. The alcohol benzenes solubles, ash and lignin content were not significantly affected by age and height portion. Holocellulose content increased significantly with age but remained almost constant with height portion.

INTRODUCTION

Information on the basic properties of many Malaysian Bamboos and their relationship towards industrial applications are lacking. The few published literature available are based on the works of Abd. Latif et al. (1990; 1993a,b: 1994a,b) and Abd. Latif and Mohd. Tamizi (1992). Since only 14 species out of the total 59 species are commercially utilised, research is indeed required to determine the properties of such species and to develop the appropriate utilization methods. The proper selection of bamboo suitable for the machine intensive industry is also very important and is usually dictated by its anatomical, physical, mechanical and chemical propertries.

Bamboo, similar to wood, is a natural composite material formed from a chemical complex of cellulose, hemicellulose, lignin and extractives. These polymeric substances are not uniformly distributed within the cellwall and their concentration change from one morphological region to another. In order to use bamboo effectively as a material, basic knowledge of its anatomical, physical and chemical composition is indeed essential to be ascertained. Therefore this paper highlights the effect of bamboo age and height portion on the chemical properties of buluh semantan (*Gigantochloa scortechinii*).

MATERIALS AND METHODS

Ten bamboo culms from the age group of one, two and three-year-old bamboo were randomly selected and divided into three equal portion namely; basal, middle and top portion. A one inch width specimen was taken from the first internode of each portion of every age group. The specimen was then coverted into matchstick sizes and milled into bamboo meal using a Wiley's mill. Those bamboo meal that were retained on the sieve size of BS 60 were used for the study. The proximate chemical analysis were conducted on air-dried milled bamboo samples according to the following standard procedures;

1. Cold and Hot water solubles : TAPPI T 207 (Anonymous, 1978)
2. Alcohol benzene solubles : TAPPI T 204
3. One percent alkali solubles : TAPPI T 212
4. Ash content : TAPPI T 15
5. Lignin content : TAPPI T 202
6. Holocellulose content : Wise et al. (1946)

RESULTS AND DISCUSSIONS

The approximate chemical properties of *Gigantochloa scortechinii* accordding to age and bamboo portion is indicated in Table 1. The summaries of the Analysis of Variance (ANOVA), Duncan Multiple Range Test (DMRT) and correlation coefficients are given in Tables 2, 3 and 4, respectively. The chemical compositions discussed are the cold (CW) and hot water (HW) solubles, alkali (NaOH) solubles, alcohol benzenes (AB) solubles, ash content, lignin and holocellulose contents.

Cold and Hot Water Solubles

The CW and HW solubles are important in the evaluation of water solubles extractives such as tannin, starch, sugar, pectin and phenolic compounds within any lignocellulosic materials (Janes, 1969). The CW and HW solubles of *G. scortechinii* given in Table 1 were observed to increase from one-year-old to two-y-old and then decrease in three-year-old bamboo. The higher CW (1.11 - 8.02%) and HW (2.40 - 10.19%) solubles contents *of G. scortechinii* may reduces the natural durability of the bamboo as suggested by Plank (1951) and Purusotham et al. (1953). The highest CW solubles was observed in the top portion (8.02%) of the two-y-old and the lowest in basal portion (1.11%) of one-y-old. The highest HW was observed in the top portion (10.19%) of two-y-old culm while the lowest value is found in the basal portion (2.40%) of the one-y-old bamboo. The CW and HW solubles content of *G. scortechinii* are, however fall within the range of those reported for Malaysian hardwoods (Khoo and Peh 1982).

The ANOVA (Table 2) and DMRT (Table 3) indicates that the CW and HW solubles are significantly different between the age group and the culm portion. Table 4 further revealed that cold water solubles have a positive correlation with age (r = 0.64) and culm portion (r = 0.47). Similarly, the hot water solubles was also significantly affected by age (r = 0.58) and culm portion (r = 0.49). In general, the portion with lower CW and HW solubles contains higher lignin and holocellulose contents, and vice versa. This kind of trend was also reported by Abd. Latif (1994a; 1996).

Alcohol Benzenes Solubles

High alcohol-benzene solubles of wood is commonly associated with relatively high degree of durability (Takakashi and Kishima, 1973 ; Yatagai and Takahasi, 1980). However, their relationships towards bamboo is not fully understood due to lack of relevant details. Table 1 showed that the AB solubles was observed to increase with age but not with height portion. Middle and bottom portion of one-year-old bamboo had the highest (3.69%) and lowest (2.49%) AB content, respectively. Table 3 showed that the AB content differed insignificantly with age and culm portion. The correlation analysis (Table 4) further revealed that the AB content increased insignificantly with age (r = 0.28) and culm portion (r = 0.43). This implies for the AB which remains almost constant with increasing bamboo age and culm height. This findings is similar to those reported by Abd. Latif (1996) but contradicts to that of Chen et al. (1987) According to Liese (1985) this discrepancies is due to the inherent characteristics of the individual bamboo itself.

Table 1: Chemical Properties of *G. scortechinii* According to Age and Bamboo Portion

Age (yrs)	Bamboo Portion	CW (%)	HW (%)	NaOH (%)	AB (%)	Ash (%)	Lignin (%)	Holo (%)
1	Basal	1.11	2.40	11.23	2.49	1.12	26.05	66.15
	Middle	3.66	5.60	15.21	3.69	1.10	25.35	65.61
	Top	3.02	4.23	18.45	3.30	1.32	23.80	65.83
	Average	2.60	4.08	14.96	3.16	1.18	25.06	65.86
2	Basal	5.57	6.48	17.90	3.10	1.10	24.90	67.93
	Middle	6.80	7.82	20.15	3.02	1.39	24.50	67.00
	Top	8.02	10.19	21.93	3.45	1.38	26.00	66.62
	Average	6.80	8.16	19.99	3.19	1.29	25.13	67.18
3	Basal	4.46	5.98	18.30	3.41	1.05	26.00	67.61
	Middle	5.86	7.25	22.81	3.32	1.33	25.75	65.84
	Top	7.65	8.38	25.52	3.65	1.18	25.10	69.39
	Average	6.00	7.20	22.21	3.46	1.19	25.62	67.61

Note: Values are averages of three determinations
CW: Cold Water Solubles, HW: Hot Water Solubles, AB: Alcohol Benzene Solubles, Holo: Holocellulose, NaOH: Alkali solubles

Abd. Latif (1996) reported that strength of bamboo are positively correlated with the alcohol benzene solubles. This is due to the fact that the extractives could stiffen and harden individual cells within woody materials and thus increases its strength properties (Panshin and De Zeuuw,1970). High alcohol-benzene solubles are also said to be associated to the lower pulping yield and poor gluing properties (Gardner and Hillis, 1962). However, the AB content (2.49-3.69%) of *G. scortechinii* as observed in the study is within the range of Malaysian Hardwoods (0.6-11.6%) (Khoo and Peh, 1982).

Table 2: Summaries of the Analysis of Variance on the Chemical Composition

Source of Variance	Df	CW	HW	AB	NaOH	Ash	Lignin	Holocellulose
Age	2	29.80**	27.58**	0.17ns	82.72**	0.02ns	0.54ns	4.97*
Portion	2	9.95**	11.31**	0.35ns	57.33**	0.07ns	0.72ns	2.43ns
Age X Portion	4	0.84*	1.89**	0.27ns	1.78**	0.02ns	1.78ns	1.78ns

Notes: ns - not significant at $p< 0.05$, * - significant at $p< 0.05$,
**- highly significant at $p< 0.01$

Ash Content

The ash content of *G. scortechinii* as shown in Table 1 ranges from 1.05 to 1.39%. They do not indicate any definite trends and are within the ranges reported for Malaysian hardwoods (0.1-2.5%) (Khoo and Peh, 1982) and those of Indian, Japanese, Burmese, Indonesian and Philippines bamboos (0.8-9.7%) (Semana et al., 1967). The highest ash content are found in the middle portion (1.39%) of the two-y-old culm while the lowest are recorded from the basal portion (1.05%) of the three-y-old culm, respectively. The ash content was shown in Table 4 to increase insignificantly with age and culm portion. Abd. Latif (1996) also reported a similar pattern for the effects of age and culm portion in his study on the same species. The higher ash content at the top portion could probably be attributed to the bigger amount of vascular bundles within this region. Espiloy (1983) and Chen et al. (1987) concluded this as due to the decreasing ability of the bamboo to absorbs nutrients elements. Since the ash content is commonly related with the amount of silica the selection of bamboo of suitable age with low ash content for specific products is very important towards optimum utilisation.

Alkali Solubles

The alkali solubles of *G. scortechinii* (Table 1) ranges from 11.23 to 25.52%. The highest and lowest alkali solubles were observed at the top portion (25.52%) of the three-y-old bamboo and the basal portion (11.23%) of one-y-old. The results further indicated that the alkali solubles tended to have a higher value in older bamboo and near the top portion of the culm. According to Chen et al. (1987) and Abd. Latif (1996) this could be due to the natural ageing of the bamboo.

The alkali solubles are shown to be significantly affected by age and culm portion (Table 3). In general, it increases with age (r = 0.73) and culm height (r = 0.62) (Table 4). According to Tadena and Villaneuva (1971) the high alkali solubles are said to be associated with high degradation of cellulose and low polyphenol content. The alkali solubles of *G. scortechinii* (11.23-25.52%) as observed in the studies are within the range of Malaysian hardwoods of 3.3 to 24.0% (Khoo and Peh, 1982). Chinese bamboos (Chen et al., 1987) and those of Philippines bamboos (Semana et al., 1967), however, exhibit much higher alkali solubles of 29.00 to 34.30% and 23.00 to 39.50%, respectively.

Table 3: Effects of Age and Portion on the Chemical Properties

Age	CW	HW	AB	NaOH	Ash	Lignin	Holocellulose
1	2.60c	4.08c	3.16a	14.97c	1.18a	25.07a	65.87b
2	6.80a	8.18a	3.19a	19.99b	1.29a	25.13a	67.18a
3	5.99b	7.21b	3.46a	22.21a	1.19a	25.62a	67.61a
Portion	**CW**	**HW**	**AB**	**NaOH**	**Ash**	**Lignin**	**Holocellulose**
Bottom	3.72b	4.95c	3.00a	15.81c	1.09a	25.65a	67.23a
Middle	5.44a	6.91b	3.34a	19.39b	1.27a	25.20a	66.15a
Top	6.23a	7.60a	3.46a	21.97a	1.29a	24..97a	67.28a

Note: Different letters down the column indicates significance at $p < 0.05$

Table 4: Correlation Coefficients of Chemical Properties with Age and Portion

Properties	Age	Portion
Cold water solubles	0.64*	0.47*
Hot water solubles	0.58*	0.49*
1 % NaOH solubles	0.73**	0.62**
Alcohol-benzene solubles	0.28ns	0.43ns
Ash content	0.01ns	0.37ns
Lignin content	0.16ns	- 0.20ns
Holocellulose content	0.52*	0.02ns

Note : ns: means are not significant at $p < 0.05$,
*: means are significant at $p < 0.05$
**: means are highly significant at $p < 0.01$

Lignin Content

The role of lignin in woody materials is to provide rigidity to the plant thus making the upright growth possible. It also adds to the plants toxicity making the plant more durable (Kollman and Cote, 1984). The lignin content of *G.scortechinii* does not exhibits any definite trend with changing age and culm portion. It varies from 23.80 to 26.05%, regardless of age and bamboo portion (Table 1). The lignin content however, falls within the range of Malaysian hardwoods (17.3-34.2%) (Khoo and Peh,1982) and those of Indian bamboos (22.0-32.2%) (Singh et al.,1988). The results also conforms the findings of Abd. Latif (1996) on the same species.

The lignin content shown in the analysis of variance (Table 2) is insignificantly affected by either age or culm portion. This reflect the stability of this chemical component which does not change once bamboo attains its maximum height (less than six months time). Similiar findings were also reported by Chen et al. (1987), Subash and Sathapathy (1990) and Abd. Latif (1996).

Holocellulose Content

The holocellulose content of *G. scortechinii* irrespective of age and culm portion as shown in Table 1 varied from 65.61 to 69.39%. The highest value was observed in the top portion (69.39%) of the three-y-old culm while the lowest value in the middle portion (65.61%) of the one-y-old culm. The results observed in Table 3 indicate a clear increasing trend on the effect of age on the holocellulose content but no definite trend exists for the culm portion. This is further strengthened by the correlation anaylsis (Table 4) which revealed that the holocellulose content increased significantly with age ($r = 0.52$) but remains almost stable with culm portion ($r = 0.02$). As reported by Abd. Latif (1996), the lower holocellulose content in younger culm than that of the older ones could probably be due to the thicker fibre wall in the older culm.

CONCLUSIONS

The cold and hot water solubles increased significantly with age and height portion. The effect of bamboo age and height portion on the alcohol benzenes, ash and lignin content were not significant. As bamboo mature, the increase in alkali solubles was observed to be positively correlated with bamboo age and height portion. However, the holocellulose and lignin content of *Gigantochloa scortechinii* are within the reported range for Malaysian hardwoods and other bamboo species. In this study the holocellulose content varied significantly with age but not with height portion. The high holocellulose content (> 65%) would be a promising source of lignocelulosic material for the bamboo composite industries.

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