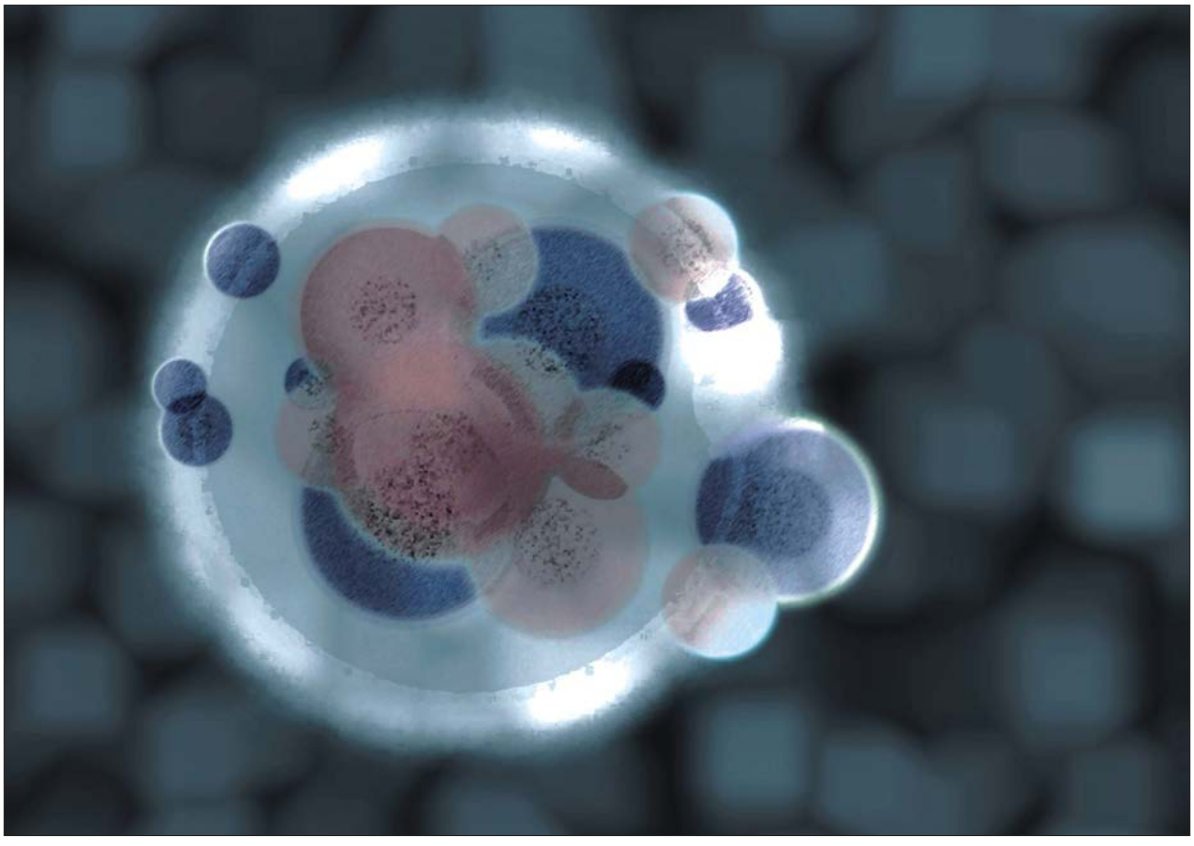

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Physical Characteristics and Anatomical Properties of Cultivated Bamboo (*Bambusa vulgaris* Schrad.) Culms

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Abstract: Two age-groups (2 and 4 years old culms) of cultivated *Bambusa vulgaris* Schrad. were harvested and investigated for their physical characteristics and anatomical properties. The physical characteristics did not show significant differences between both the 2 and 4 year-old bamboo. However, variation in anatomical properties was observed between the two age-group bamboos. The anatomical structure in bamboo has a very strong correlation with the age, location where the samples were taken, moisture content and the basic density. The basic density is higher in the 4 year-old culms than in the 2 year-old by 5 to 8% and increases from lower to upper internodes showing that there is a maturation process going on between the two age-groups relative to the two of tissue types. The frequency of vascular bundles is greater at the bottom and top portion than in the middle portion of both age-groups. There was no difference in vessel diameter between the 2 and 4 year-old culms at the middle of the culms wall thickness. The cell wall thickness of both parenchyma and fibre were greater in the 4 year-old than in the 2 year-old culms.

Key words: *Bambusa vulgaris* cultivated bamboo, 2 age-group culms, physical characteristics and anatomy properties

INTRODUCTION

Bamboo being recognized as one of the fastest growing plants on earth is the best possible alternative to future wood. Unlike timber, bamboo only needs between 3-4 years to mature before they can be harvested and utilized. This has prompted and intensified bamboo research in recent years. The R and D covers all aspects in silviculture, propagation, processing, properties and utilization of bamboo found growing wild in the forest or cultivated. However, study on cultivated bamboo stands has so far mostly confined to enhance growing silviculture and fertilizers application (Azmy *et al*., 2004, 1997). Information on the properties such as morphology, characteristics, physical, mechanical, chemical, etc., at different ages is very limited.

A Razak *et al.* (2007) study on the morphological and anatomical characteristics of managed natural bamboo stands *Gigantochloa scortechinii*. The studies managed to measure and identified some of the important morphological and anatomy properties of 2 and 4 year-old *G. scortechinii* culms. The physical and anatomical properties of bamboo culms have been known to have significant effects on their durability and strength (Razak, 1998; Abdul-Latif, 1992; Abdul-Latif and Mohd Tamizi, 1992; Liese, 1985). Information generated on these properties can be used to determine the possible proper bamboo utilization. Depending on species, bamboo upon maturity (3-4 years after cultivation) is said to possess the best properties for various utilization purposes.

Bambusa vulgaris is mostly cultivated by the rural community because of the high growing rate, thick culms wall, uniform sizes between nodes and the internodes and the high yield of shoots that they produced. Two age-groups (2 and 4 years-old) of cultivated *B. vulgaris* culms were used in this study. They were chosen to represent the young and the mature culms. The 2 year-old culms were chosen in view of their importance to the handicraft and basketry industry. The 4 year-old culms were chosen because this is the right mature age where the culms are normally used for panels, parquets, furniture and construction purposes. *Bambusa vulgaris* is one of the most easily bamboo species to be cultivated.

The physical characteristics and properties such as the culms height, numbers of internodes per culms, internode length, internode diameter, culms wall thickness, girth, moisture content and basic density are considered to be important factors in determining the suitability of bamboo for various application and chemical treatment. Culms of different age-group were studied in

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order to determine at what age influence the bamboo treat ability, dimensional changes and attack by insects and fungi. Basic density is important because it reflects the amount of cell wall material per unit volume of culms and relates directly to strength properties. The anatomical structures were investigated due to their relationship with strength, preservative absorption, distribution and likely pathways for colonization by micro-orgamism (Razak *et al*., 2005a, b, 2002). This study highlights on the physical characteristics and anatomy properties on cultivated *Bambusa vulgaris* culms. The study was conducted from April, 2008 to March, 2009.

MATERIALS AND METHODS

Supply of culms and sampling: Bamboo culms used in this study were taken from the village areas in Kawang, Sabah, Malaysia. Most of the *B. vulgaris* found in the areas were cultivated by the villagers for their own uses.

The bamboo culms of known age were harvested from randomly selected clumps having diameters ranging from 8 to 10 cm. The culms were cut at about 30 cm above the ground level. They were harvested in the month of May, 2008 immediately after the rainy season. Studies indicated that bamboo harvested during this period contained a very minimum amount of starch (Liese, 1985). The top parts of the culms with branches were removed leaving bamboo culms of about 12 m in length. All together 36 bamboo culms consisting of 18 of the 2 year and another 18 of 4 year old were harvested and investigated. These culms were later subdivided into 3 equal lengths consisting of bottom, middle and top portions of 4 m each. Paraffin wax was applied to the cut surfaces of each portion to reduce sap evaporation. Sample blocks for anatomical study were fixed in formalin-acetic acid (90% ethanol of 70% conc., 4% glacial acetic acid, 6% formaldehyde of 37-48% conc.) immediately after felling and kept in closed bottles. Within a week after harvesting, all the culms sample blocks were taken to UMS for processing, sampling and subsequent studies.

Physical characteristics and properties: Measurements for some basic physical characteristics and properties were done on site where the culms were taken. The culms height, internode length, internode diameter, culms wall thickness and girth were measured from the cut base to the tip. The method used in the physical study was based on Razak *et al*. (2007), Sulthoni (1989) and ASTM (1974).

Moisture content (MC): Sample blocks representing the 2 age-group (2 and 4 years), 3 height portions (bottom, middle and top) and 6 replicates, consisting of 36 bamboo samples were used. All sample blocks were cut from fresh culms were 10×10 mm×culms wall thickness. They were weighed and dried in an oven at 105±2°C for 48 h until a constant weight was attained. The sample blocks were then placed 30 min. in a dessicator for cooling-off period before re-weighing.

Basic density: Sample for basic density studies were obtained from the middle portion of each internode at the bottom, middle and top culms portions. Each sample blocks were cut to the size of 10×30 mm×culms wall thickness. Six replicates were used in the study. The sample blocks were oven dried for 48 h at 105±2°C until a constant weight were attained. The sample blocks were then weighed to give the oven dried weight.

The sample blocks were placed in water under vacuum of about 700 mmHg for 24 h until fully saturated to attain green volume condition. The volume of the fully saturated sample blocks was obtained using the water displacement method. The weight displaced is converted to volume of the sample as a green volume.

Anatomical properties: All together 36 sample blocks representing the 2 age-group and 3 height portions with 6 replicates were used in the anatomical study.

Vascular bundle distribution and vessel sizes: Anatomical studies on vascular bundles, vessel sizes, fibres, parenchyma and cell walls thickness were carried out according to methods outlined by Abdual-Latif and Mohd Tamizi (1992) and Jane (1933). Observations for anatomical structure were made using a Leitz microscope. The distributions of vascular bundles were determined by counting the number of vascular bundle on a cross-section per mm^2.

Bamboo sample blocks were cut into sections of 10×10 mm×culms wall thickness, boiled with distilled water for four hours and sliced into 25 μm thick transverse sections by sledge microtome with a 15 degree knife angle. Each section was stained with 4 drops of aqueous safranin-O and 1 drop of alcian blue for 4 min on the slide. They were washed with 50% ethanol then dehydrated through alcohol series of 70, 80, 90 and 95%, 3 changes of absolute ethanol for 1 min. One drop of euparal essence was placed on top of the section before mounting on microscope slides using euparal and covering with a cover slip. The slides were then clamped with clothes pegs and placed on a warm plate set at 60°C oven for the euparal to set over a few days. This method stained the thicker cell walls red and thinner walls light blue.

Fibre length: Bamboo sample blocks of 20×10 mm×culms wall thickness were chipped radially into match stick size splints with a sharp knife. The splints were then put in marked vial. Jeffrey's solution (50:50 mixtures of 15% nitric acid and 10% chromic acid) were used to macerate the fibres. A period of 48 h was allowed to soften the splints (Razak *et al*., 2007; Abdul-Latif and Mohd Tamizi, 1992). At the end of the maceration period, the softened splints were careful washed with distilled water. The vials were then half-filled with distilled water and capped securely. A drop of slurry solution was placed on specially etched glass slide bearing 3 pairs of parallel lines. Drops of safranin-O were introduced to contrast the fibre's images, which were then projected on a screen of a fibre-scope at 71 magnifications. Twenty five complete and reasonably straight fibres in between the parallel lines of the slide were measured. The fibre's measurements were done using a flexible millimeter scale in a systematic manner to avoid duplication (Hart and Swindle, 1967).

Fibre and Parenchyma diameters, lumen diameter and cell wall thickness: The slides prepared earlier were used and the measurement of the fibre and parenchyma diameters, lumen diameters and cell wall thicknesses were made from them.

RESULTS

Physical characteristics: The results on the physical characteristics of the cultivated 2 and 4 year-old *B. vulgaris* (Table 1) shows that there is not much differences between the height, the number of internodes, internodes length and culms wall thickness of the 2 and 4 year-old culm. There are however a slight decreases in the internodes length (31.48 to 30.20 cm), internodes diameter (9.4 to 9.1 cm) and girth (29.2 to 28.9 cm) from the 2 to the 4 year-old bamboo culms.

Table 1: Means physical characteristics of cultivated *B. vulgaris*

	Bamboo culm age	
Characteristics	2 year*	4 year*
Culms height (cm)	1469.00±159	1452.00±148
Number of internodes per culms	36.00±2.8	36.00±2.6
Internode length (cm)		
Bottom	24.53±2.54	22.27±2.32
Middle	34.11±2.89	33.86±3.01
Top	35.81±3.02	33.93±2.97
Mean	31.48±2.82	30.20±2.77
Internode diameter (cm)		
Bottom	9.30±1.21	8.93±1.01
Middle	9.89±1.04	9.75±1.34
Top	9.09±0.09	8.59±0.89
Mean	9.43±0.78	9.09±1.08
Culms wall thickness (cm)		
Bottom	1.46±0.18	1.54±0.14
Middle	0.84±0.07	0.93±0.08
Top	0.55±0.05	0.70±0.08
Mean	2.85±0.10	3.17±0.10
Girth (cm)		
Bottom	29.53±0.20	29.65±0.34
Middle	30.42±0.32	30.31±0.35
Top	27.65±0.24	26.74±0.24
Mean	29.20±0.25	28.90±0.31

*Means of 6 replicates. Data are expressed as Mean±SD

Anatomical properties: The anatomical properties of *B. vulgaris* of the two age-group and at different height of the culms (Table 2) shows slight increases in the parenchyma diameter (23.7 to 24.8 μm), fibre diameter (16.9 to 18.0 μm), fiber length (3.6 to 4.2 mm) and fibre cell wall (7.1 to 7.6 μm). Decreases in diameter occurred in the vessel (123.0 to 122.5 μm), parenchyma lumen (19.7 to 19.5 μm) and fiber lumen (2.5 to 2.4 μm). The result also shows that there is no change in the vascular bundles distribution (2.6 bundles per mm^2) between the 2 year-old and the 4 year-old bamboo culms at bottom, middle and top portions of bamboo.

Physical properties

Moisture content: The means Moisture Contents (MC) in green conditions of the cultivated *B. vulgaris* decreases from 97.3 to 94.4% at bottom portion, 92.1 to 90.3% at middle portion and 86.4 to 82.5% in 2 and 4 year-old

Table 2: Anatomical properties of 2 and 4 years old *B. vulgaris*

Properties	Height	2 year-old*	4 year-old*
Vascular bundle (VB) frequency (VB No. mm^{-2})	Bottom	2.6±0.18	2.6±0.20
	Middle	2.4±0.21	2.5±0.19
	Top	2.8±0.19	2.7±0.17
	Means	2.6±0.19	2.6±0.19
Vessel diameter (μm)	Bottom	117.1±10.45	110.8±10.43
	Middle	133.6±14.21	134.6±11.36
	Top	118.3±11.13	122.2±12.24
	Means	123.0±11.93	122.5±11.34
Parenchyma diameter (μm)	Bottom	22.4±0.18	23.3±0.19
	Middle	25.2±0.23	26.6±0.23
	Top	23.6±0.25	24.4±0.24
	Means	23.7±0.22	24.8±0.22
Parenchyma lumen diameter (μm)	Bottom	19.1±0.16	19.1±0.15
	Middle	20.5±0.21	20.1±0.21
	Top	19.6±0.23	19.3±0.19
	Means	19.7±0.20	19.5±0.18
Fibre diameter (μm)	Bottom	15.8±0.13	16.7±0.17
	Middle	18.6±0.20	19.8±0.16
	Top	16.5±0.15	17.6±0.21
	Means	16.9±0.16	18.0±0.18
Fibre length* (mm)	Bottom	3.7±0.28	4.9±0.33
	Middle	3.6±0.31	4.2±0.30
	Top	3.5±0.25	3.6±0.28
	Means	3.6±0.28	4.2±0.30
Fibre cell wall thickness (μm)	Bottom	6.5±0.62	7.0±0.65
	Middle	7.9±0.69	8.5±0.91
	Top	6.9±0.54	7.4±0.68
	Means	7.1±0.62	7.6±0.75
Fibre lumen diameter (μm)	Bottom	2.4±0.15	2.3±0.21
	Middle	2.5±0.09	2.4±0.18
	Top	2.6±0.11	2.5±0.23
	Means	2.5±0.12	2.4±0.21

*Means of 6 replicates. Data are expressed as Mean±SD

Table 3: Moisture content (%) along the culm length of *B. vulgaris* at green condition

Internode No.	2 year-old*	4 year-old*	Decreases in MC (%)
2	102.3±8.6	97.4±8.2	5.0
4	98.7±8.3	93.2±8.7	5.0
6	95.4±6.9	91.4±7.4	4.4
8	93.3±7.1	89.5±7.0	4.2
10	92.5±6.2	87.9±8.1	5.2
12	91.1±8.3	86.7±7.4	5.1
14	90.5±5.9	85.1±8.2	6.3
16	89.6±6.5	83.9±7.1	6.8
18	86.4±5.7	82.5±5.9	4.7

*Means of 6 replicates. Data are expressed as Mean±SD

Table 4: Moisture content (%) at cross-section along the culm length at green condition

Characteristics	2 year-old*	4 year-old*
Bottom portion		
Outer layer	83.2±7.28	79.0±8.13
Middle layer	97.3±8.46	94.8±8.88
Inner layer	111.4±9.74	109.4±9.55
Means	97.3±8.49	94.4±8.85
Middle portion		
Outer layer	77.0±6.57	76.8±5.84
Middle layer	91.1±8.78	89.0±7.26
Inner layer	108.2±10.24	105.2±9.85
Means	92.1±8.53	90.3±7.65
Top portion		
Outer layer	69.8±5.91	65.4±5.42
Middle layer	88.2±6.88	85.3±9.36
Inner layer	101.2±9.45	96.9±8.73
Means	86.4±7.41	82.5±7.84

*Means of 6 replicates. Data are expressed as Mean±SD

Table 5: Basic density along the culms height and age

	Basic density (kg m^{-3})		
Internode No.	2 year-old	4 year-old	Increases in basic density (%)
2	472.6±52.41	504.3±45.44	6.7
4	507.1±56.12	545.1±52.17	7.5
6	521.9±61.25	557.7±47.45	6.9
8	530.7±58.14	562.5±51.52	6.0
10	542.4±48.23	565.3±56.72	4.2
12	549.6±50.41	570.0±47.43	3.7
14	553.6±56.48	578.0±52.43	4.4
16	559.0±52.87	585.2±49.32	4.7
18	565.3±55.34	591.8±52.40	4.7

*Based on 2 year-old value. Data are expressed as Mean±SD

Table 6: Analysis of Variance for Basic Densities of 2 and 4 years old bamboo

SOV	Sum of square	df	Means square	F-ratio
Age	9609.626	1	9609.636	17.561*
Internode	62317.58	8	7770.257	14.347*

*Significant at $p<0.01$

culms, respectively (Table 3). The differences in MC for the 2 and 4 year-old culms at various internodes are shown in Table 3. Table 4 shows the means moisture content at cross-section along the culm length of *B. vulgaris* in green condition.

Basic density: The basic density increases from 2 year to 4 year-old bamboo culms (Table 5). The increases ranged from 4.2 to 7.5% (based on 2 year-old culm value). The value of the basic density of 2 and 4 year-old *B. vulgaris* taken from internode 2 to 18 are presented as in Table 4. The basic densities between the 2 and 4 year-old culms show significant values (Table 6).

DISCUSSION

The physical characteristics, anatomical and physical properties of cultivated *B. vulgaris* were found to be slightly lower than those of the managed natural bamboo *G. scortechinii*. However, the differences were very small. This might be due to the soil and natural environment where the bamboos grow.

Physical characteristics: The physical characteristics of *B. vulgaris* show variation depending on the age and height along the culms. The culms generally taper from the middle portion towards the tip with a decrease in diameter, girth and culms wall thickness. As seen from Table 1, the culms diameter decreased by 8.7% from middle to top portion in the 2 year-old culms and 13.5% in the 4 year-old culms. The same also goes for the culms wall thickness where there is a decreased in thickness by 62.5.0% from bottom to middle portion and 34.5.7% from middle to top portion in the 2 year-old culms. In the 4 year-old culms the decreased in the culms wall thickness from bottom to middle portion is by 39.6% and from middle to top portion by 24.7%. Similar observations were made by Razak *et al.* (2007) in the study of the *G. scortechinii*.

The total number of internodes per culms and the length of the internodes also vary. The length of the internodes increases from the basal region to the middle portion of the culms and decreases towards the top. Unlike timber, bamboo does not show any secondary thickening and thus attains its final diameter during the sprouting stage (Liese, 1985). With age increment, mature tissue starts to develop and continue to change in density, strength properties.

Selection of sample blocks at the right location along the culms height and age plays an important role in determining a consistent quality of raw material for treatment and utilization purposes. This is mainly because basic density and strength properties vary along the culms height.

Anatomy of *Bambusa vulgaris*

Vascular bundles: The vascular bundles in the *B. vulgaris* were larger in the inner parts, becoming smaller and denser towards the periphery of the culms wall. Each of the vascular bundles consists of the xylem with one or two smaller protoxylem element and two large metaxylem vessels and the phloem with thin walled,

unlignified sieve tubes connected to the companion cells. More parenchyma but few fibres and conducting cells were present in the inner part of the culms wall than in the periphery. The frequency of the vascular bundles was greater at both the bottom and top portion of both the 2 and 4 year-old culms than the middle. The 2 year-old culms had slightly a higher frequency of vascular bundles.

Vessels: The vessels were found not to be truly circular but were slightly elliptical in shape with the radial diameter larger than tangential. This was the same for both the 2 and 4 year-old bamboo throughout the culms wall. The diameters of vessels were measured in radial and tangential directions for the vascular bundles across the culms wall.

The vessels progressively increase in diameter from the outer to the inner part. The means diameters were found to be 117.1 μm at the bottom portion, 133.6 μm at middle portion and 118.3 μm at top portion of the 2 year-old culms. For the 4 year-old culms, the means vessel diameter were 110.8 μm at the bottom portion, 134.6 μm at middle portion and 122.2 μm at top portion. The size of the vessels between the 2 and 4 year-old culms were not significantly different indicating that it is not affected during maturation.

Fibres: The fibres constitute the sclerenchymatous tissue and occur in the internodes as caps of vascular bundles or isolated strands. The fibres are grouped in bundles and sheaths around the vessels. They are long and tapered at both ends. The fibre length from 100 fibres range between 3.5-3.7 mm for the 2 year-old culms and 3.6-4.9 mm for the 4 year-old culms. Similar observation was also made by Abdul-Latif and Tamizi (1992) on their studies on variation in anatomical properties of three Malaysian bamboos from natural stands.

The fibre cell wall thickness in the 4 year-old culms was commonly greater than in the 2 year-old culms. This is consistent with work of Alvin and Murphy (1988) and Murphy and Alvin (1997) on *Sinobambusa tootsik* and *G. scortechinii* who found similar thickening of fibre wall during maturation. A similar finding was also observed by Razak *et al.* (2007), Abdul-Latif (1992) in their study on morphological and anatomical characteristics of managed natural bamboo stands *G. scortechinii* and the effect of age and height on three bamboo species on their machining properties.

The outer zone showed the lowest increase in thickness. This is a reflection of the early maturation of this zone compared with the middle and the inner parts of the culms. In the young culms, the tissues of the outer zone are early maturing resulting in the minimal increment of cell wall thickness with further ageing. The middle and inner zones showed much higher increments in fibre wall thickening.

Parenchyma: The ground tissue consisted of parenchyma cells, which were mostly vertically elongated with short, cube-like one's inter-spread in between. The former is characterized by thicker walls with a polylamellate structure. They become lignified in the early stages of shoot growth. The shorter cells have a denser cytoplasm, thinner walls and retain cytoplasmics activity for a long time.

The parenchyma diameter varies from 22.4 μm at the bottom and 23.6 μm at the top portion, having the larger diameter of 25.2 μm at the middle portion of the 2 year-old culms. The diameter increase was slightly smaller in the 4 year-old culms with 23.3 μm at the bottom, 26.6 μm at the middle and 24.4 μm.

The sizes of the lumen in parenchyma also varied from 19.1 μm at the bottom and 19.6 μm at the top portion, having the larger diameter of 20.5 μm at the middle portion of the 2 year-old culms. The lumen decrease was slightly smaller in the 4 year-old culms with 19.1 μm at the bottom, 20.1 μm at the middle and 19.3 μm at the top. These variations in the diameter of the parenchyma cells and lumens sizes shows that there was some maturation occurring, resulting in the cell wall thickening from 2 years to 4-year ages. A similar finding was also noted by Abdul-Latif amd Mohd Tamizi (1992) in their studies on the variation in anatomical properties of three Malaysian bamboos from natural stands.

Some parenchyma cells were observed to contain starch. However, the amount was quite small. Starch in the 4 year-old culms was more frequent than in the 2 year-old culms. Liese and Weiner (1997) also made similar observations to this and according to them very young culms (3 month old) does not contain starch, the parenchyma of older culms was filled with starch grains. The low starch content in most of the culms used in this study could be attributed to the time of the harvesting. The starch content in bamboo has been known to vary with seasons, which are higher in the dry than in the rainy season.

Physical properties

Moisture content: This study shows that in green condition *B. vulgaris* possesses the highest moisture content which is influenced by age, height and position in the culms wall thickness. The moisture content decreases with age, from bottom portion to top portion and from inner to outer layer in the culms wall. The 2 year-

old culms have means moisture content of 97.3, 92.1 and 86.4% at bottom, middle and top portion height, respectively. In the 4 year-old culms, the means moisture content was 94.4% at the bottom, 90.3% at the middle and 82.5% top the portions.

Differences in moisture content might be due to anatomical structure and chemical composition between the culms age and location along the culms. The lowest and highest moisture occurred at the periphery and inner layer, respectively particularly near the bottom portion of the 2 year-old culms. The trend shows that the moisture increases roughly by 30% from periphery to the inner layer and 20% from top to bottom portion. This has a very strong correlation with the anatomical structure, particularly the vascular bundles and parenchyma cell distributed over the culms and also its density.

Considerable differences in the moisture content of freshly felled culms have to be considered when determining the amount of preservative retention possible during treatment process.

Basic density: The basic density of the cultivated *B. vulgaris* were found to varies from 472.6 to 565.3 kg m^{-3} for the 2 year-old bamboo culms and 504.3 to 591.8 kg m^{-3} for the 4 year-old culms. The basic density of the 4-year culms was consistently higher than in the 2 year old culms and increases from the lower to the upper internodes. There was an increase in basic densities between the two-age group based on the 2 year-old culms, which ranged between 3.7 to 7.5%. This shows that there is a maturation process going from the 2 year to the 4 year-old bamboo culms. Fibre and parenchyma cell walls increased in means thickness from 2 to 4 year-old culms. This is due to the starch deposition and the lignification process that occurred in the bamboo culms which increases with ages. This is supported by Razak *et al.* (2007) and Alvin and Murphy (1988), who found that the cell wall increased in thickness along with an increase in lignification between the first and third year of growth in *G. scortechinii* and *S. tootsik*. These processes contribute significantly to increase the density in the older bamboo. The variation in basic density between different internodes was due to the maturation process that starts from the lower internodes to the upper internodes (Itoh, 1990). This was also due to the presence of higher proportion of fibres in the higher internodes. Razak *et al.* (2007) and Liese (1985) also made similar observations that the higher internodes have higher basic density than the lower portion of the bamboo culms.

CONCLUSIONS

The physical characteristics and properties of *B. vulgaris* vary depending on the age and height along the culms. The culms taper from the middle portion towards the tip with a decrease in diameter, girth and culms wall thickness. The age, height and position in the culms wall thickness influence the present of moisture content in *B. vulgaris*. The anatomical structure in bamboo has a very strong correlation with the moisture content. The means fibre and parenchyma cells wall thickness were greater in the 4 year-old than in the 2 year-old culms. The increased in the cells wall thickness in parenchyma and fibres is part of the maturing process in the bamboo culms. There was no difference in vessel diameter between the 2 and 4 year-old culms at the middle of the culms wall thickness. The basic density is higher in the 4 year-old culms than in the 2 year-old and increases from lower to upper internodes showing that there is a maturation process going on between the two age-groups relative to the two of tissue types. There is no significant different in the anatomical properties between cultivated and natural stands *B. vulgaris*.

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