Study on Colour Changes in Appearances based on Two Drying Process of *Gigantochloa scortechinii*

By

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DECLARATION

I declare that this thesis entitled “Study on Colour Changes in Appearances based on Two Drying Process of Gigantochloa scortechinii”is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Kajian Warna Perubahan Penampilan berdasarkan Dua Proses Pengeringan Gigantochloa scortechinii

ABSTRACT

This study investigated the colour changes of 2 and 4 years-old *Gigantochloa scortechinii* culms at different drying techniques. Parameters of drying techniques are open air dried and under shed air dried were taken in account as their influences in enhancing the colour changes of bamboo from outer and inner part of bamboo. The 2 year-old *G.scortechinii* culms were considered as young where the inner part of the culms would normally having lighter colour than at the outer part of the culms. Same goes with the 4 year-old *G.scortechinii* culms which were considered as matured. Turning this bamboo into panel and furniture at this stage will resulted in uneven colour as the results of the mixture between the outer and inner part of the bamboo. This will decrease the value of the products. To compare between both 2 and 4 years-old B. vulgaris culms, the colour at the outer part of 4 year-old culms were pale compared with 2 year-old that were brighter. The colour changes were measured by Minolta Chroma-METER CR-310 and the result presented based on CIE L*a*b* colour co-ordinates system. The result shows that the rising temperature at different drying techniques resulted in enhancing and darkening of bamboo tissues. The results show that the changes of colour are significance at year four. This show that 4 years old are better in making product.

ABSTRAK

Kajian ini mengkaji perubahan warna jelaga Gigantochloa scortechinii berusia 2 dan 4 tahun pada teknik pengeringan yang berbeza. Parameter teknik pengeringan adalah pengeringan secara terbuka dan pengeringan di bawah teduhan telah diambil kira sebagai pengaruh mereka dalam meningkatkan perubahan warna buluh dari luar dan dalam daripada bahagian buluh. Jelaga G.scortechinii berusia 2 tahun dianggap muda di mana bahagian dalam jelaga biasanya mempunyai warna lebih cerah daripada di bahagian luar jelaga. Begitu juga dengan G.scortechinii berusia 4 tahun yang dianggap sebagai matang. Peralihan buluh kepada panel dan perabot pada peringkat ini akan menyebabkan warna tidak sekata akibat daripada hasil campuran antara bahagian luar dan dalam buluh. Ini akan mengurangkan nilai mutu sesebuah produk. Untuk membandingkan antara G.scortechinii berusia 2 dan 4 tahun, warna di bahagian luar jelaga berusia 4 tahun adalah sedikit pucat berbanding dengan jelaga berusia 2 tahun yang lebih cerah. Perubahan warna diukur menggunakan Minolta Chroma-METER CR-310 dan keputusan yang terhasil adalah berdasarkan CIE L*a*b* sistem koordinat warna. Hasil kajian menunjukkan bahawa suhu meningkat pada teknik pengeringan yang berbeza menyebabkan peningkatan dan kemalapan pada tisu buluh. Keputusan menunjukkan bahawa perubahan warna adalah penting di tahun empat. Ini menunjukkan berumur empat tahun adalah lebih baik dalam membuat produk.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
cm	Centimeter
L*	Lightness
a*	Red-greenness
b*	Yellow-blueness
UP	Upper portion of the bamboo
MI	Middle portion of the bamboo
BO	Bottom portion of the bamboo
FRIM	Forest Research Institute Malaysia
VOC	Volatile Organic Compound

LIST OF SYMBOLS

%	Percent
*	Times
L	Lightness
a	red-green axis
b	yellow-blue axis
t	treated sample
s	control sample
tΔ	colour change
cm	centimetres
mm	millimetres
m	metres
°C	degree Celsius

CHAPTER 1:

INTRODUCTION

1.1 Background of the study

The demands for timber are increasing from day to day because of the increased of the world population (Razak, *et al.*,2015). More trees are needed to be harvested to fulfill the demand from the constructional industrial. To overcome this problem, other natural resources that are renewable and have a potential strength can be a potential resource in the market. Since the timber is one of important material to produce a structural product, such as flooring and bamboo house. Bamboo can be found abundantly in all year round. Because of it is a rapidly grow plant, bamboo can be an alternative option to replace timber (Nayak, 2013).

Bamboo is a non-woody and fast growing plant (Yu, 2007). Bamboo also is a versatile raw material. Numerous products can be made and produces by using bamboo. The bamboo can be used from the early stage of bamboo growth, where the shoot can be made as edible food. While for the matured bamboo, the culm can be used to produce furniture, musical instrument and also can be converted to make a charcoal (Lobovikov *et al.,* 2007). Common uses of bamboo in Asia are bridges, scaffolding, and housing (Sharma, 2014). Various parts of bamboo can be extracted from hair and skin ointment, medicine for asthma, eyewash, potions for lovers and poison for rivals. The ashes of the bamboo can be used to polish jewels and manufacture electrical batteries. Bamboo has been used in bicycles, dirigibles, windmills, scales, retaining walls, ropes, cables and filament in the first bulb. Because of that, bamboo has many applications beyond imagination. The uses of bamboo are broad and plentiful(Kumar, 2013).

Bamboo is attractive because of its green appearance which makes people fascinated with it. Bamboo has natural color variation. Different bamboo species have different colors (Meredith, 2001). The green color of bamboo will be fade easily if there is no protective treatment (Shang, 2001).

Since the world now has more advancement of science and technology and the tight supply of the timber, new method is needed to make new things from non-timber sources are need. This is needed to make sure that we can replace timbers which are higher in price and currently depleting because of the increasing of the demand for the timber (Gretchen and Paul, 1992).

Some information of *G. scortechchinii* were documented, but its properties, particularly in relation to the color appearance and the application as the raw material for replacing current VOC paint, is not yet much. *G. scortechchinii* is being exploited in the way that its full potential is not being used.

The aim of this study is to investigate how drying method improved or enhance the bamboo color appearance and the effect of the process. The result of this study will benefit regarding improving the quality of bamboo products.

1.2 Problem statement

Nowadays, timber product is high in demand. The increment of timber demand has caused the forest and other natural resources in depletion. To save our natural resources, we need an alternative and possible material to replace the use of timber.

A plant that can grow rapidly and can replenish itself is an advantage to industry and environment. Bamboo is known as renewable natural resources, and it is also biodegradable. Bamboo also has been seen as efficient material to adopt in decreasing the global warming effects and to save the environment from chemical waste. By exploring and studying the color changes, appearances during the drying process of bamboo as an alternative natural coloring option for finishing material could be replaced. The emission of volatile organic compound (VOC) such as toluene and xylene from paint is a health concern, and they are not environment-friendly (Evuti, 2013).

To be competitive on the market, the color appearance of bamboo needs to be technically homogenized before further processing (Liu, 2016). By studying the drying types, the aesthetic value of bamboo can be explored, where it can be seen from its use on the concept of sustainable technology.

1.3 Objective

1. To evaluate the color changes of *Gigantochloa scortechinii* by drying processes by mean.
2. To determine the significance of color changes of *Gigantochloa scortechinii* at different drying method.

1.4 Expected outcome

The *Gigantochloa scortechinii* will have the different color appearances when using a different type of drying method. The color changes of *Gigantochloa scortechinii* at different culm and site will be verified.

CHAPTER 2:

LITERATURE REVIEW

2.1 Bamboo

Bamboo (Figure 2.0) is one of the available bio-resources in tropical and subtropical. Bamboos have many species such as *Bambusa*, *Chusquea*, *Dendrocalamus*, *Phyllostachys, Gigantochloa, and Schizostachyum*. Bamboo is a type of grass with the class of bambusoideae that have a woody and hollow stem (Yong, *et al.*, 2012). Bamboos are evergreen and rapidly growth because it can grow once a year and stay green year round. There are approximately more than 1600 species that grow naturally on the planet. Bamboo can be used in everything from construction to medicine. Bamboo usually produced in small-scale and labor-intensive. To plant bamboo, there is no need to require special skill because bamboo is easy to be planted. Planting bamboo can increase the land productivity (Zhang and Ma, 2003).

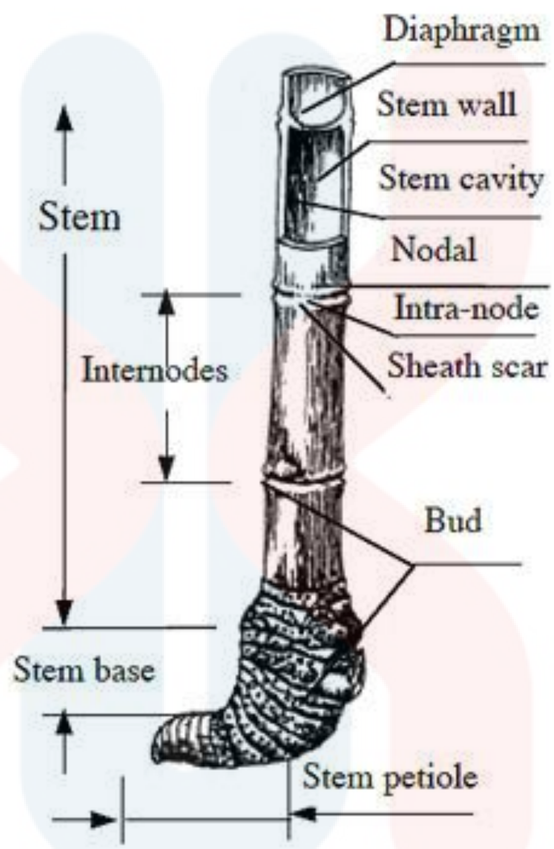


Figure 2.0: A bamboo sketch showing important parts.

2.2 Resources and Habitat of Bamboo

The majority of the bamboos needed a warm climate, abundant moisture, and productive soil, even though some do can also grow in reasonably cold weather which is below -20°C (Wang, *et al.*, 1987). Bamboos grow particularly well in tropics and subtropics, but there are also some thrive in the temperate climate of Japan, China, Chile and the USA (Anon, 1972). The smaller bamboo species are mostly found in higher elevations or temperate latitudes, and the larger bamboos are abundant in tropics and subtropics areas (Lee, *et al.*, 1994).

Bamboo is good in adaptability. Some bamboo species from one country has been introduced to other countries. The exchange of the bamboo proves that bamboo is quite adaptable. Bamboos also can be adaptable to various types of the habitat. Bamboos grow in plains, hilly and high altitude mountainous regions, and also in almost all kind of soil, except alkaline soils, desert, and marsh (Wang, *et al.*, 1987). Bamboo could grow from sea level to as high as 3000 meters (Latif, *et al.*, 1991). Bamboo is suitable on well-drained sandy to clay loom or from underling rocks with pH of 5.0 to 6.5 (Latif, *et al.*, 1991).

2.3 Morphology and growth

There are two major portions, which is rhizomes and the culms. The rhizome is the part of the underground part of the stem and usually sympodial or, to a much lesser degree, monopodial. This dissertation concerned with an upper ground potion of the stem which called culm. This is the portion of the bamboo tree that contain most the woody material. The culm complimented by branching system, sheath, foliage leaves, flowering, fruits and seedlings. It is distinguishable from one to another by the differences of these basic features, along with the growth style of the culm, which either strictly erect, erect with pendulous tips, ascending, arched or clambering. Most of the bamboo culms are cylindrical and hollow. It is without any bark and has a hard, smooth outer skin due to the presence of silica (Tewari , 1992).

There are some of the material extensively described the morphology and structure of the bamboo itself (McClure, 1967). Bamboo is a high-yield of renewable resources and one of the examples of a fast growing species. Bamboo growth is depending on its species, but in general, all bamboo matures quickly. Bamboo might have 40 to 50 stems in one clump, that are adds to 10 to 20 culms yearly (Aminuddin, 1991). The bamboo growth of height can be at its maximum in 4 to 6 month with a daily increment of 15 cm to 18 cm which is 5 inches to 7 inches (Figure 2.1). The culms take two years to 6 years for the maturity, which depends on the species of the bamboo itself (Wong, 1995). It is suggested that by a good management of the bamboo resources, the cutting cycle is normally three years old. Bamboo is mature enough in about 3 to 5 years, which means its growth is rapidly increase than another plant on the planet(Lee, 1994). Some of the species of bamboo have been evaluating to surge skyward as fast as 48 inches in one day (Farelly, 1984). The bamboo itself is the characteristic that is important incentive for the utilization of the bamboo itself. Because of this fact, bamboo is abundant and cheap, bamboo need to be used to its fullest extent (Farelly, 1984).

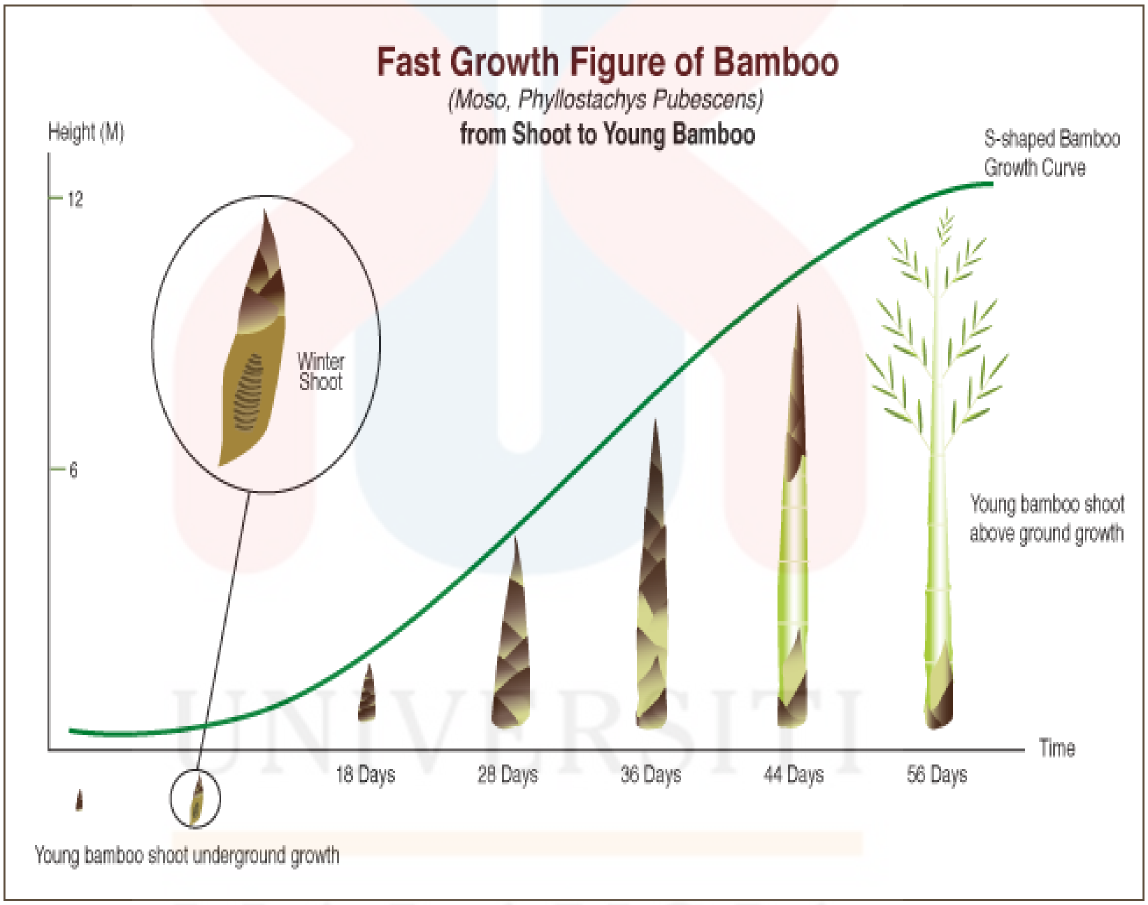


Figure 2.1 : The growth of bamboo with time.

2.4 Harvesting technique

To harvest bamboo, there is the correct way to the basic cultivation and harvesting methods for plantation bamboo (Farelly, 1984). However, a satisfactory and systematic harvesting technique of wild bamboo has not yet been established by any specialist. There is no consideration for its final intended usage when the bamboo can be harvested. The higher initial moisture content of bamboo may easily cause splitting. The uncertainty of age of bamboo that is harvested will create problems in processing and utilization. Different age has different properties of color appearance and the strength of the bamboo itself. Some of the factors that should be taken into consideration for the improvement of the harvesting technique are age, desired quality and the properties of the enduses of bamboo. Various harvesting technique jave been reported (Farelly, 1984). For this research, the technique used are using manually with the energy of human which using chainsaw and handsaw. The bamboo harvested by the aid of Prof Razak to identify the age of the bamboo since he is one of the specialists of bamboo.

2.5 Physical and mechanical properties

The physical and the mechanical properties of bamboo depend on the species, the site or the soil and the climatic condition, silvicultural treatment, the way the bamboo being harvested, the age of the bamboo, the density of the bamboo, the moisture content of the bamboo, the position in the culm, the nodes or internodes and the bio-degradation of the bamboo (Lee, 1994). Many studies had been carried out in order to highlight and evaluate this fundamental characteristic, as well as a way to maximize the bamboo utilization(Lee, 1994).

Abd. Latif and friend (Latif, *et al.*, 1993) have studied the effect of the anatomical characteristic on the physical and mechanical properties of *B. bluemeana*. On this study, age and height do not significantly affect moisture content. There is a range of green moisture content which is 57% to 97%. The younger age of bamboo showed higher moisture content compared to and older age of the bamboo. This means that that increasing in age will make the time for drying of the bamboo will be faster since the moisture content is decreasing. The paper explained that it could be the effect of the thick wall fiber and the higher concentration of vascular bundle of the older bamboo. There is no significant difference in the density along the culm height of 3-year-old culm (Latif, *et al.*, 1993).

The radial and tangential shrinkage of *B. bluemeana*, did not differ significantly through the age and height of the bamboo. The radial and tangential shrinkage range from 5.4% to 9.5% and 6.4% to 20.1% respectively. The older bamboo which is three years old is more dimensionally stabled compared to the younger one which is one year old. The one year old bamboo observed to shrink more at an average of 15% to 22%. Radial and tangential shrinkage at the basal height of 2-year-old *B. bluemeana* culm founded to be 8% to 19% respectively, and the top location approximately 6% to 12% respectively (Latif, *et al.*, 1993).

2.6 *Gigantochloa scortechinii*

In Malaysia, *Gigantochloa scortechinii* (Figure 2.2) is known as Semantan bamboo (Azmy, 2011). The distribution of *G. scortechinii* can be easily found in hill forest. *G. scortechinii* have the physical structure such as the culm size can be of twenty-meter height maximum and with a minimum of fifteen meters and have a diameter of a maximum of twelve centimeters and the minimum of eight centimeters. *G. scortechinii* has a ligule one centimeter, which is narrow strap-shaped part of a plant. In most grasses and sedges, a membranous scale on the inner side of the leaf sheath at its junction with the blade. The leaf blades are up to thirty-five cm times five cm. the leaf has a lower surface that has softly hairy, with a short stalk. A bamboo culm has forty percent fibers, ten percent vessels, and fifty percent parenchyma (Yong, *et al.*, 2012).

Figure 2.2 : *Gigantochloa scortechinii*

2.7 Aesthetic value of bamboo

Bamboo is a versatile type plant that has high economic, environmental and has aesthetic values. This is because bamboo is much known for its strength, flexibility, tenacity, and endurance. In Asia and ancient African Countries like Ethiopia, for century's bamboo is used in religion ceremonies, art, music and daily life (Kassahun, 2015). The examples are paper, brush, and inspiration of poems and painting (Kassahun, 2015).

Bamboo has its value in ancient Chinese culture for its practical value. Bamboo was overflowing in most parts of China. The characteristics of the bamboo itself which are long, hard and having straight stem made it one of the most realistic materials for everyday convenience. In China generally, bamboo was used to build houses, made into chopsticks, baskets, furniture and transporting devices and many other usages of bamboo itself. Bamboo was shaped into slips to record texts before the paper was invented in East Han dynasty. These slips of bamboo originally used to write most of the Chinese classics. Besides, bamboo also used to be made into a musical instruments such as flute and pipes. Music had very high cultural status since Confucius advocated music appreciation as a means to restore the virtue of Western Zhou ritual (Su, 2013).

2.8 Color appearance of bamboos

Green-caned bamboo will produce blue-green and yellowish green tones when the ages are increasing, especially when the bamboo is exposed to strong afternoon sunlight. For example, in a forest of *Phyllostachys vivax*, the older culms on the sunny side are mostly yellowish green while those within the canopy and in the shade will be a darker green. New shoots are the liveliest green. The mix of culm colors, based on age and sun exposure, is healthy and adds more variety to the color scheme (Meredith, 2001). Color changes are the most remarkable when are related to thermal modification (Nguyen, 2012). Different bamboo has different color (Figure 2.3).

Figure 2.3: Variation color of bamboo

2.5 L*a*b* color space

The L*a*b* color space (Figure 2.4) or also known as CIELAB is presently one of the most popular space for measuring object color and is widely used in virtually all fields. L*a*b* color space is one of the uniform color spaces defines by CIE in 1976 in order to reduce one of the major problems of the original Yxy color space that equal distances on the x, y chromaticity diagram did not correspond to equal perceived color differences, in this color space, L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions (Minolta, 1998).

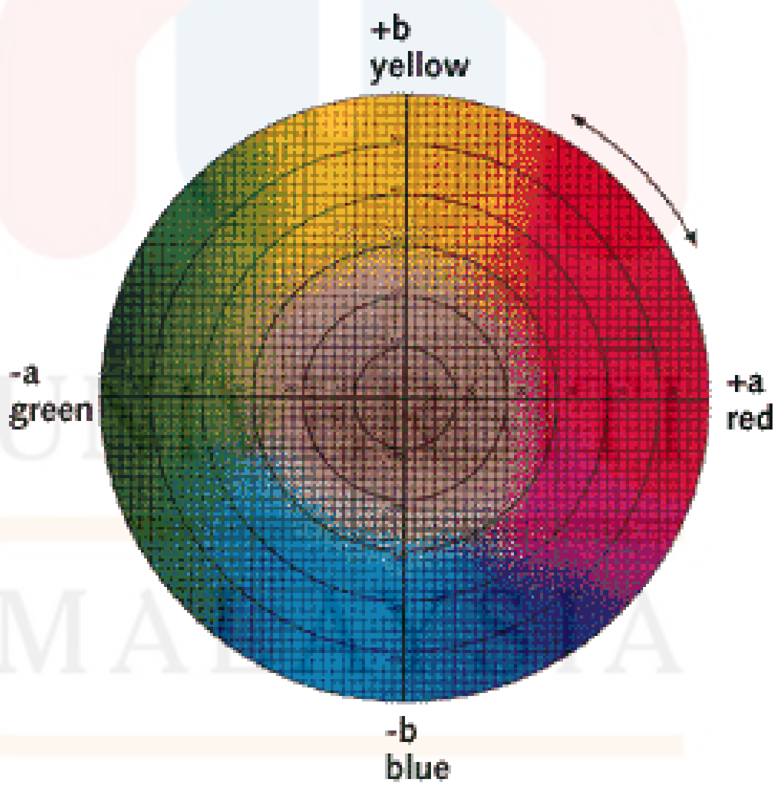


Figure 2.4 : L*a*b* colour space diagram

CHAPTER 3:

MATERIAL AND METHOD

3.1 Material

Two (2) defects free bamboos of 2- and 4-year-old *G. scortechinii* were extracted from the Forest Research Institute Malaysia (FRIM) at Batu Melintang, Jeli, Kelantan, Malaysia (Figure 3.1). The bamboos were selected based on good form, long straight culm, and also decay and insect-free. The equipment that was used to harvest the bamboo is a chainsaw. The bamboos then transported to Universiti Malaysia Kelantan, Jeli Campus for further processing.

Figure 3.1 : A clump of bamboo *G. scortechinii.*

3.2 Method

The selected bamboo culms for both ages (2- and 4-year-old) were cut (see Figure 3.2) at the nodes even numbers of 2 until 26. The culm 2, 4, 6 and 8 were considered as bottom part of the bamboo. The culm 10, 12, 14, 16 and 18 were considered as middle part of the bamboo. The culm of 20, 22, 24 and 26 were considered as the top part of the bamboo. The reason for choosing age 2 and age 4 is that the age 2 represent the young age while the age 4 represent the mature age. Usually, bamboo will be live until year five, and then they will have some culm be old and damaged because of the age. Each culm then was cut into two portions which will be labeled as an inner and outer side. The samples were prepared for two (2) different drying methods. Then the sample will be marked before the drying methods begin so that the result obtained is at the fixed places. This method will be run for thirty days. The results were recorded every single day. The changes might not be significant since it is dried naturally.

Figure 3.2: The bamboo readily being cut

3.3 Drying method

The samples of bamboo were divided into two (2) drying method which is under the shed and air dried. The samples for the drying process were placed at the wood sample preparation workshop at Agro Park, University Malaysia Kelantan, Jeli campus. The samples for under shed were placed on the wood sample preparation workshop. For the air dried samples were placed outside the workshop. To measure the color appearance of the samples, Minolta Chroma Meter CR-10 as in Figure 3.3 was used. The measurement was thirty (30) days. The results then were recorded in the table every day at the same time.

Figure 3.3: Minolta Chroma Meter CR-10

3.4 Color measurement of Drying Process Samples.

Color measurements were done to measure color changes before and after the drying process. The samples were marked using pencil before the drying process start. The mark is needed for the measurement of color changes will be at the consistent place. The mark was made by using pencil, and the marked point will be done by 2 cm × 2 cm at the culm samples.

The measurement of color were determined according to CIE L*a*b* (1986) system for providing more accurate and objective color determination. Three rectangular coordinates will define a solid color. This system was sensitive enough to detect small differences in color parameters to describe between the tree and within species variation. The principal axis is the lightness level L* with a 0-100 scale, where 0 is total blackness and 100 is pure white while intermediate give the values of gray shades. The hue is specified by the other two chromic characters. One (a*) defines the red-green axis. The negative values reflect the dominance of greenness and positive ones reflect redness. The second character (b*) defines the yellow-blue axis. The negative values reflect the dominance of blueness and positive ones reflecting yellowness. (Izyan, *et al.*, 2010)

The sensor head was eight (8) millimeter in diameter. The color reader was used to measure the color differences on the surface of bamboo specimens with two different drying methods which under the shed and air dried. The results will be presented according to the CIE L*a*b* color coordinates system based on D65 light sources with the reflection spectrum was measured in four hundred to seven hundred nanometer regions.

The values were needed to calculate the color change as a function of the drying process according to the Equation 3.1 until Equation 3.3 respectively (Izyan, *et al.*, 2010).

$L^{t*} = L^{t*}-L^{s*}$ Equation 3.1

$a^{t*} = a^{t*}-a^{s*}$ Equation 3.2

$b^{t*} = b^{t*}-b^{s*}$ Equation 3.3

Where, t = treated sample, s = control sample at tΔ = colour change

L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Physical Test Result

Test was run on the *Gigantochloa scortechinii* samples with two parameters. The test was color measurements with parameters of air dried and under shade drying method. The results of the test were taken at the 30th day as the results obtained from days to days were not significant. The result were taken from 8 June 2016 to 8 July 2016.

Some comparisons were also made with samples from internodes of upper, middle, and bottom portions at the age of two and four years old. The results obtained from the tested samples that had undergone vary in drying techniques were compared with each other.

4.2 Data of Color Appearances

The colour measurements of G. *scortechinii* age of two-4 years old was carried out in this research. The data analysis was done and the results were obtained. The average data of L*, a*, b* of 2 and 4 year-old G. *scortechinii* are shown at Tables.

Based on colour measurement of inner and outer layer, the effect on colour through different drying techniques which were open air dried and under shed can be noticed by color of bamboo specimen. In this study, the main involvement in color of the bamboo is the lightness (L*). According to Izyan et al., (2010), the variation in L* is more approachable sign of colour change to the human eye that accompanying change in chromic characters a* and b*. It is also reported that the variability in darkness or lightness is the main cause of wood colour variability.

L* = 0 yields black and L* = 100 indicates diffuse white; specular white may be higher, a*, negative values indicate green while positive values indicate purple and b*, negative values indicate blue and positive values indicate yellow(Minolta, 1998).

Generally, the colour obtained from bottom portion of the bamboo is less lightness than the middle portion and top portion of the bamboo.

TABLE 4.1: Color data of 2 years old *Gigantochloa scortechinii* inner side with different drying methods.

Part	L		a*		b*	
	Air dried	Under shed	Air dried	Under shed	Air dried	Under shed
Bottom	45.7	47.6	4.4	3.6	14.9	22.0
Middle	47.8	52.6	7.6	3.8	22.4	23.7
Top	54.3	48.0	6.9	4.3	23.6	20.1

Note : L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions

From the data obtained the lightness which is data from L are increasing from the portion. From the data obtained from Table 4.1 the lightness from bottom part is 45.7 for and 54.3 for the top part of the bamboo. This shows that the lightness is increasing up the portion. Elongation, however, causes only a few anatomical changes along culm length. The narrowing of the culm wall in the upper part results in a reduction of its inner portion with less parenchyma, and the vascular bundles decrease in size but increase in number (Banik, 1993). Air dried and under shed also have varies result which from the Table 4.10, under shed have more values than air dried which means that under shed have more lightness than air dried. For greenness colour air dried intends to have higher intensity color of green than under shed. For the yellowness color of the bamboo, the air dried are having more color intensity of yellow less than under shed.

TABLE 4.2: Color data of 2 years old *Gigantochloa scortechinii* outer side with different drying methods.

Part	L		a*		b*	
	Air dried	Under shed	Air dried	Under shed	Air dried	Under shed
Bottom	56.9	60.8	3.8	4.7	24.8	24.6
Middle	60.9	63.6	4.9	3.2	30.0	25.3
Top	58.0	62.3	6.4	3.4	30.4	26.6

Note : L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions

From the data obtained the lightness which is data from L are vary from the different portion. From the data obtained from Table 4.2 the lightness from bottom part is the lowest intensity of lightness. Under shed have more value than the value on the air dried. Which mean the lightness of air dried are less than under shed.More sunlight are directed makes the water loss increased (Boiln and Salunkhe. 1982). The reason on why the result show opposite is because of the raining condition on that moment. When there is less water content the lightness should becoming higher logically. The value of a* for bottom for air dried has the lowest value which show it is more toward green than middle and top portion. The value of a* for bottom for under shed has the highest value which show it is more toward purple than middle and top portion. The value of b* bottom portion for air dried has the lowest value which indicate it has less yellow colour intensity than middle and top portion.

TABLE 4.3: Color data of 4 years old *Gigantochloa scortechinii* inner side with different drying methods.

Part	L		a*		b*	
	Air dried	Under shed	Air dried	Under shed	Air dried	Under shed
Bottom	47.1	50.9	6.4	5.3	20.6	25.8
Middle	43.6	47.7	6.0	5.0	16.8	24.3
Top	48.2	46.6	5.9	4.7	20.0	22.8

Note : L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions

From the data obtained the lightness which is data from L are vary from the different portion. From the data obtained from Table 4.3 the lightness from top part in air dried method is the highest intensity of lightness. For the under shed drying method of the bamboo, bottom part has the highest lightness. The value of a* for bottom part for air dried has the lowest value which show it is more toward green than middle and top portion. The value of a* for top portion for under shed has the highest value which show it is more toward purple than middle and top portion. The value of b* bottom portion has the highest value which indicate it has more yellow colour intensity than middle and top portion. Top portion for outer has the highest intensity colour of yellow than middle portion and bottom portion of the bamboo as the value is the highest.

TABLE 4.4 : Color data of 4 years old *Gigantochloa scortechinii* outer side with different drying methods.

Air dried	L		a*		b*	
	Air dried	Under shed	Air dried	Under shed		Under shed
Bottom	55.7	54.3	5.3	6.6	25.8	32.1
Middle	66.7	63.2	4.0	2.9	27.4	23.3
Top	63.6	63.7	4.2	1.4	36.2	22.1

Note : L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions

From the data obtained the lightness which is data from L are vary from the different portion. From the data obtained from Table 4.4 the lightness from middle part for air dried method is the highest intensity of lightness. For the under shed method, top part of the bamboo has the highest lightness. The value of a* for middle part for air dried method has the lowest value which show it is more toward green than middle and top portion. The value of a* for top portion of under shed method has the lowest value which show it is more toward green than middle and top portion. The value of b* top portion for air dried has the highest value which indicate it has more yellow colour intensity than middle and top portion. Bottom portion for under shed has the highest intensity colour of yellow than middle portion and top portion of the bamboo as the value is the highest.

Table 4.5 : T-test analysis for 2 years old *Gigantochloa scortechinii* inner side.

	L		a*		b*	
	Air dried	Undershed	Air dried	Undershed	Air dried	Undershed
Mean	49.26667	49.4	6.3	3.9	20.3	21.93333
Variance	20.10333	7.72	2.83	0.13	22.23	3.243333
P(T<=t) one-tail	0.485823		0.05525		0.323668	
P(T<=t) two-tail	0.971646		0.110501		0.647336	

Table 4.6 : T-test analysis for 2 years old Gigantochloa scortechinii outer side.

	L		a		b	
	Air dried	Undershed	Air dried	Undershed	Air dried	Undershed
Mean	58.6	62.23333	5.033333	3.766667	28.4	25.5
Variance	4.27	1.963333	1.703333	0.663333	9.76	1.03
P(T<=t) one-tail	0.00853*		0.192184		0.084696	
P(T<=t) two-tail	0.01706		0.384368		0.169392	

Note: * indicate significance changes.

Note : L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions.

For two years old *Gigantochloa scortechinii* for inner side,since the value p is 0.486 in L value is greater than 0.05 significance level, it can be concluded that there is no significance difference between the L in undershed and air dried. Since the value p is 0.055 in a* value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the a* in undershed and air dried. Since the value p is 0.324 in b* value is greater than 0.05 in significant level, it can be concluded that there is no significance difference between the b* in undershed and air dried.

For the outer side of two years old *Gigantochloa scortechinii,* since the value p is 0.009 in L value is lower than 0.05 significant level, it can be concluded that there is significance difference between the L in undershed and air dried. Since the value p is 0.192 in a* value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the b* in undershed and air dried. Since the value p is 0.085 in b* value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the b* in undershed and air dried.

The changes of the colour in two years were not significance. This is due to the two years old was still immature. But the lightness for the outer part show the significance changes. The different in sunlight exposure make the results different, besides the outer part was more sensitive to light.

Table 4.7 : T-test analysis for 4 years old *Gigantochloa scortechinii* inner side.

	L		a		b	
	Air dried	Undershed	Air dried	Undershed	Air dried	Undershed
Mean	46.3	48.4	6.1	5	19.13333	24.3
Variance	5.77	4.99	0.07	0.09	4.173333	2.25
P(T<=t) one-tail	0.187228		0.001372*		0.031283*	
P(T<=t) two-tail	0.374457		0.002743		0.062567	

Table 4.8 : T-test analysis for 4 years old *Gigantochloa scortechinii* outer side.

	L		a		b	
	Air dried	Undershed	Air dried	Undershed	Air dried	Undershed
Mean	62	60.4	4.5	3.633333	29.8	
Variance	32.17	27.97	0.49	7.163333	31.36	
P(T<=t) one-tail	0.132548		0.270976		0.285008	
P(T<=t) two-tail	0.265096		0.541952		0.570016	

Note: * indicate significance changes.

Note : L* indicates lightness and a* and b* are the chromaticity coordinates. The* and b* indicate color directions.

For four years old *Gigantochloa scortechinii* for inner side, since the value p is 0.187 in L value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the L in undershed and air dried. Since the value p is 0.001 in a* value is lower than 0.05 significant level, it can be concluded that there is significance difference between the a* in undershed and air dried. Since the value p is 0.031 in b* value is lower than 0.05 significant level, it can be concluded that there is significance difference between the b* in undershed and air dried.

For the outer side of four years old *Gigantochloa scortechinii*, since the value p for one tail is 0.133 in L value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the L in undershed and air dried. Since the value p is 0.271 in a* value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the a* in undershed and air dried. Since the value p is 0.285 in b* value is greater than 0.05 significant level, it can be concluded that there is no significance difference between the b* in undershed and air dried.

The changes of colour for the four years old in inner side have the significance changes than the outer side. Although the changes is not significance at the lightness, but the changes from the value of a* and b* are significance. The four years G. *scortechinii* are already in the mature age and the changes can be seen from the analysis.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the research, colour changes of 2 and 4 year-old *Gigantochloa scortechinii* culms through different drying techniques was carried out and the data was collected and being analyzed to obtain the results.

For color properties, we were able to determine the color changes between outer layer (skin) and inner of G. *scortechinii* culms by using different drying techniques. We had used two parameters for drying techniques which were open air dried and under shed dried naturally. The values of L*, a* and b* are vary depending the drying techniques that were used. Changes in temperatures, parts, portions, ages are also the main factors that effected the values of L*, a* and b*.

From the overall results we can conclude that for open air dried and under shed dried, the value of L*, a* and b* are dependent on the portions, part, days and age. But it is independent on replicates. The colour of the bamboo was changed but not significant in the age of two but the changes is significance on the age of four. At 4 years old, the bamboo can be used to produce more wood product because of maturity and stability.

As a conclusion, the research on the colour changes of 2 and 4 year-old G. *scortechinii* culms through different drying techniques fulfilled the objectives of this thesis.

5.2 Recommendations

Thus as a recommendations, proper precautionary should be done during the experiments and the data taken to avoid the errors from occurring. Besides, further research need to be done in order to know which ages of bamboo are more suitable in making wood product and to replace the current demand of timber as a new alternative for preservation of wood. Heat treatment should also been tested with bamboo in order to compare with the other drying techniques. This is because the skin of the bamboo has a waxy layer, which increased its durability against insect attack. Therefore, a study should be carried out to know the function of bamboo as a skin protective layer and the effect of heat treatment on skinned bamboo as competitive products.

The weather also effect the reading which should be considered as the weather on my research at that moment rainy make the result not so accurate on the air dried.

REFERENCES

Azmy, H., M., Sulaiman, O., Razak, W., Rokiah, H. (2011). Physical Characteristics and Weight Relationship of *Gigantochloa scortechinii* (Buluh Semantan) 1-, 2- and 3-Year Old Natural Stand Bamboos. Pertanika J. Trop. Agric. Sci., 25-32.

Banik, R.L. (1993). Morphological characters for culm age determination of different bamboos of Bangladesh. Bangladesh Journal of Forest Science, 22, 18-22.

Boiln, H. R., and Salunkhe, D. K. (1982) Food Dehydration by Solar Energy, CRC Critical Reviews in Food Science and Nutrition, pp:327-354.

Evuti, A., M. (2013). A Synopsis on Biogenic and Anthropogenic Volatile Organic Compounds Emissions: Hazards and Control. International Journal of Engineering Sciences, 145-153.

Kassahun, T. (2015). Review of Bamboo Value Chain in Ethiopia. International Journal of African Society Culture and Traditions, 52-67.

Izyan, K., Razak, W., Othman, S., Aminuddin, M., Tamer, A., T., Roziela, H., A. **(2010).** Enhancing Colour Appearances of Cultivated 15 Year-old *Acacia Hybrid* through Oil Heat Treatment Process. International Journal of Biology, 199-201.

Liu, X., Gregory, D., S., Jiang, Z., Maximilian, C., D., B., Felix, B., Oliver, F., Ana, G., Liu, K., Helen, M., Kate, E., S., Sharma, B., Michael, R. (2016). Engineered bamboo nomenclature. Bioresouces, 1141-1161.

Lobovikov, M., Paudel, S.,Marco, P., Hong, R,M., Junqi, W. (2007**).** World bamboo resources. Food and Agriculture Organization of The United Nations, 1-31.

Meredith, T., J. (2001). Bamboo for Gardens. Portland : Timber Press.

Minolta, K. (1998). Precise color communication. Seoul: Konica Minolta Sensing.

Nayak, A., Arehant, S., B., Abhishek, J., Apoorv, K., Hirdesh, T. (2013). Replacement of Steel by Bamboo Reinforcement. IOSR Journal of Mechanical and Civil Engineering, 50-61.

Nguyen, C., T., Andr, W., Le, X., P., Vu, H., D., Martina, B., Steffen, F. (2012). Thermally modified bamboo. Bioresources, 5355-5366.

Shang, T., C., Yeh, T., F., Wu, J., H. (2001**).** Mechanisms for the surface colour protection of bamboo treated with chromated phosphate. Polymer Degradation and Stability, 551-557.

Sharma, P., Dhanwanttri, K., Mehta, S. (2014). Bamboo as a Building Material. International Journal of Civil Engineering Research, 249-254.

Razak, W., Othman, S., Madihan, Y., Irshat, U., H., B., Sukhairi, M., R., Izyan, K., Hashim, W., S. (2015). Physical and Strength Properties of bio-composites made from mixture of Oil Palm Frond and Kenaf Bast. International Conference on Biosciences (ICoBio), 1-2.

Yong, A., C., C. (2012). Bamboo! Not just a Nature. Bamboo World. Institute of Tropical Forestry and Forest Product (INTROP). (7), 3-5

Yu, X. (2007). Utilizing bamboo in the industrial context with reference to its structural and cultural dimensions. Bamboo: Structure and Culture, 4-18.

Su, D. Y. (2013). *Chinese Bamboo and the Construction of Moral High Ground by Song Literati*. Toronto: University of Toronto.

Zhang WenYan, M. N. (2003). Transfer of Technology Model . *High Yielding Bamboo Plantation for Paper and Pulp*, 5-7.

Wang, D. and S.J. Shen. (1987). Bamboos of China. Timber Press, Portland, Oregon.

Anon. (1972). The use of bamboo and reeds in building construction. Department of Economic and Social Affairs. United Nations, New York.

Lee, A.W.C., B. Xuesong, and N.P. Perry. (1994). Selected physical and mechanical properties of giant timber bamboo grown in South Carolina. Forest Prod.J. 44(9): 40-46.

Abd.Latif, M., and O. Abd.Razak. (1991). Availability, distribution of bamboo and its industrial status in Peninsular Malaysia. Proceedings 4th International Bamboo Workshop. Bamboo in Asia and the pacific. Chiangmai, Thailand. November 27–30, 60-67.

Tewari, D.N. (1992). A monograph on bamboo. International Book Distribution, Dehra Dun (India).

Aminuddin, M., M. Abd.Latif. (1991). Bamboo in Malaysia: Past, present and future research. Proceeding s 4th International Bamboo Workshop. Bamboo in Asia and the pacific. Chiangmai, Thailand. November 27 – 30. Pp. 349-354.

Wong, K.M. (1995). The bamboos of Peninsular Malaysia. Forest Research Institute Malaysia (FRIM) in collaboration with Forest Research Centre, Forestry Department, Sabah, Malaysia. Malayan Forest Records, No.41.

Lee, A.W.C., B. Xuesong, and N.P. Perry. (1994). Selected physical and mechanical properties of giant timber bamboo grown in South Carolina. Forest Prod.J. 44(9): 40-46.

Abd.Latif, M., A.Ashaari, K. Jamaludin, and J. Mohd. Zin. (1993). Effects of anatomical characteristics on the physical and mechanical properties of Bambusa bluemeana. Journal Tropical Forest Science 6(2): 159-170.

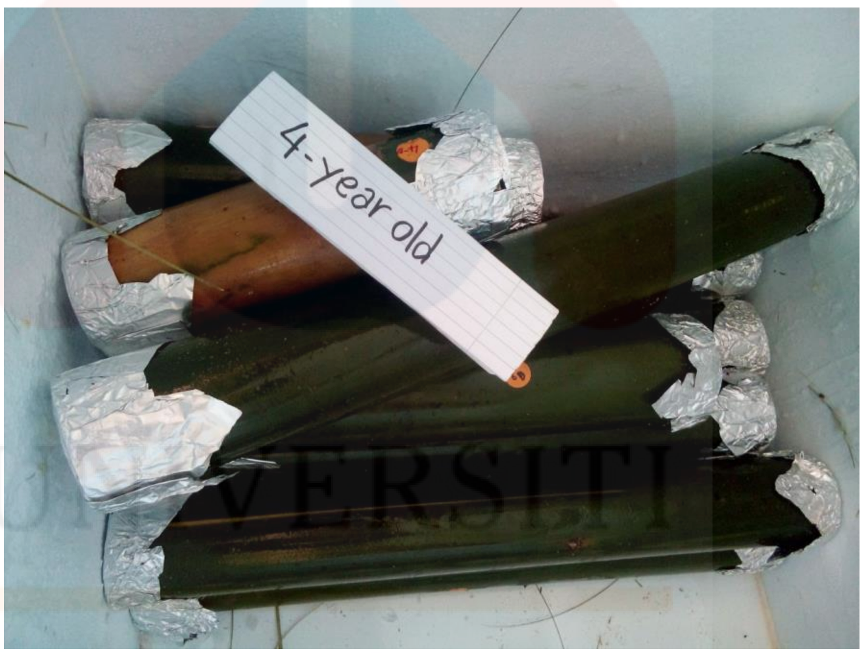
Kumar, A. R., (2013). Bambusa arundinacea (vanshlochan) : An overview. International journal on research in pharmacology & pharmacotherapeutics.

Abd.Latif, M., and M. Mohd. Tamizi. (1993). Variation in anatomical properties of three Malaysian bamboos from natural stands. Journal Tropical Forest Science 5(1): 90-96.

Gretchen, C. D., and Paul, R. E. (1992). Population, sustainability, and earth's carrying capacity: A framework for estimating population sizes and lifestyles that could be sustained without undermining future generations. BioScience McClure, F.A. 1967. The bamboos, A fresh perspective. Harvard University Press. Cambridge, Massachusetts.

APPENDICES

The bamboo after cut into portion



The bamboo of 4 years old

The bamboo that undergo air dried

The bamboo of 2 years old