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Properties of Gliricidia Wood (*Gliricidia sepium*) Intercropped with Cocoa (*Theobroma cocoa*) in Malaysia

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ABSTRACT

Trees planted from agroforestry practices can become valuable resources in meeting the wood requirements of many nations. *Gliricidia sepium* is an exotic species introduced to the agricultural sector in Malaysia mainly for providing shade for cocoa and coffee plantations. This study investigates its wood physical properties (specific gravity and moisture content) and fibre morphology (length, lumen diameter and cell wall thickness) of *G.sepium* at three intervals according to age groups (three, five and seven years of ages). Specific gravity (0.72) was significantly higher at seven years of age as compared to five (0.41) and three (0.35) years age group with a mean of 0.43 ($p \leq 0.05$). Mean moisture content was 58.3% with no significant difference existing between the tree age groups. Fibre diameter (22.4 mm) was significantly lower ($p \leq 0.05$) for the trees which were three years of age when compared to five and seven years age groups (26.6 mm and 24.7 mm), respectively. Means of fibre length, lumen diameter and cell wall thickness were 0.83 mm, 18.3 mm, and 6.2 mm, respectively, with no significant differences detected between trees in all age groups. Further calculation on the coefficient of suppleness and runkel ratio suggest that wood from *G.sepium* may have the potential for insulation board manufacturing and paper making. However, future studies should experiment the utilisation of this species for these products to determine its full potential.

Keywords: *Gliricidia sepium, specific gravity, fibre length, fibre diameter, lumen diameter and cell wall thickness*

INTRODUCTION

Gliricidia sepium or locally known as Gliricidia, belongs to the family of Leguminosae or Fabaceae. The Leguminosae are mostly herbs, but also include shrubs and trees found in both temperate and tropical areas. They comprise one of the largest families of flowering plants, numbering some 400 genera and 10,000 species [1]. Gliricidia originated from Central America and it is usually planted along the side of fields as live fencing. The tree is used to provide shade in cacao and coffee plantations. The trunks are used as fence posts. During the dry season, when much of the forage is gone, the tree limbs are cut and the foliage is offered to livestock. Common names for Gliricidia are Gliricidia (English and Malay), Lilac (Mexican), Cocoashade, Quickstick (Nicaraguan), Cacahuanche (Spanish) and Rechesengel (pulauan) [2].

Currently, wood based industry is experiencing a shortage of wood supply from the natural forests. In view of this, there is a need to study the properties and other source of fibres. In this study, wood samples from *Gliricidia sepium* were used to determine the wood properties and fibre morphology at three age groups. It is hoped that this study will provide information about the wood fibre properties of alternative raw materials for wood-based industry.

METHODOLOGY

Wood samples of Gliricidia were collected from the Malaysian Cocoa Board plantation in Jengka 23, Pahang, Malaysia. At the collection site, Gliricidia trees were planted in rows to provide shade for young cocoa plants. Five trees from three different age groups (three, five and seven years old) were sampled. Tree stems were cut at 30cm from the ground level into wood discs. The discs were analysed based on five variables of interests, namely, (moisture content, specific gravity, fibre length, fibre diameter and lumen diameter). A total of 10 and 30 samples from each age group were prepared and their physical properties and fibre morphology were studied, respectively, which brings the total number of samples (n) to 270.

Moisture content and specific gravity determination were based on oven-dried method and in accordance to ASTM D2395-07a, respectively. From the wood discs, the samples were cut into cube size of 2cm × 2cm for each age category. The samples were then split into matchstick size sticks. The sticks were used to produce wood fibre. The chemicals used to determine the fibre length were Natrium chloride ($NaClO_2$), Acetic glacial acid (CH_3CHOOH) and Natrium hydroxide (NaOH). Next, 500ml of CH_3CHOOH was placed in two litre of volumetric flask. Then, distilled water was added for dilution until the two litre of volumetric flask was reached. The samples sticks were placed in the conical flask with NaOH labelled for a day to make the stick softer. After that, NaOH was discharged and CH_3CHOOH 25% was added with 5g of $NaClO_2$.

The conical flask was heated with chemical substance and three wood matchsticks in the water bath. $NaClO_2$ and CH_3CHOOH were added every one-hour until inter-fibre bonding of the broken stick occurred. Then, the soft stick sample and chemical substance were stirred using the glass rod until it became wood fibre. The fibres were then screened and washed with distilled water to reduce acid and alkaline. Finally, ethanol was added to the fibres to ensure they did not dissolve.

Slides of fibres were prepared for morphology study. The fibre properties were observed using Photomicroscopy Microscope. Lens with 40 x magnifications (mm) were used to determine the fibre length. Cell wall thickness is the difference between fibre diameter and lumen diameter. Coefficient of suppleness was calculated based on the percentage of lumen diameter over fibre diameter. Runkel ratio was determined by dividing the cell wall thickness with lumen diameter and multiplies by two.

Statistical Analysis System [3] was used to analyse the data. Summary of statistics (i.e. mean and standard deviation) were produced for each parameter. Analysis of variance procedure was used to test whether the means of all parameters studied are statistically different between the three age groups ($p \leq 0.05$). Multiple comparisons test was performed to identify which pairs of means are significantly different.

RESULTS AND DISCUSSION

Means of moisture content for three age groups of Gliricidia were 57.6%, 58.8%, and 58.5% respectively. No significant difference was found (p=0.7115). In contrast, means specific gravity of Gliricidia wood was significantly different between the three age groups (p=0.0001). Figure 1 shows an incremental value in means of specific gravity from the three, five and seven years old of Gliricidia. Wood from seven years old Gliricidia possess a significantly higher means of specific gravity as compared to five and three years of age. Also, the mean specific gravity for five year old Gliricidia was significantly higher than that of three years of age.

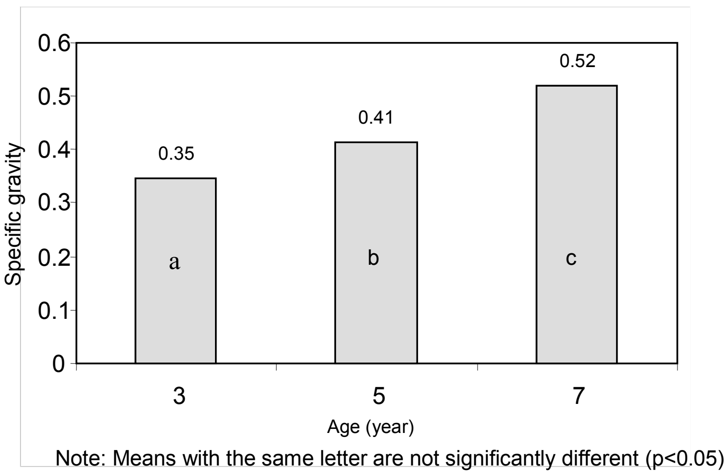
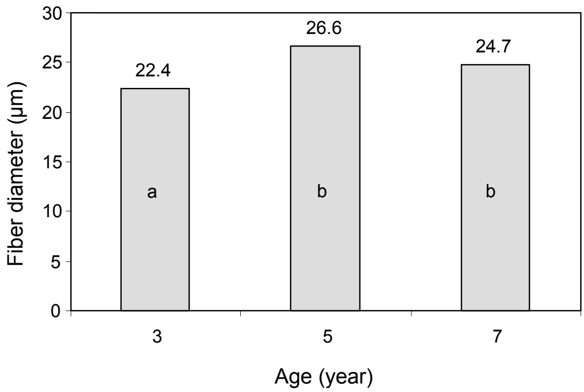


Figure 1: Specific gravity at three different ages

The higher specific gravity found in an older tree could be due to its higher volume of fibres. Hooper and Welch [4] found that the specific gravity was greater at higher volume of fibres. According to Suzuki [5], the presence of extractives and some inorganic materials contributed significantly to the variability observed in the specific gravity. He concluded that the specific gravity is more uniform without the extractives. Site-related factors may have also affected the specific gravity of Gliricidia, such as moisture, availability of sunlight and nutrients, wind and temperature [6]. In this study, wood samples of seven, five, and three years of age were taken from different sites of cocoa plantation. Fiber length and diameter could also be the contributing factors that affect specific gravity of Gliricidia. Wood with longer and broader fibres tends to have higher specific gravity than trees with shorter fibres [7]. Haygreen and Bowyer [6] mentioned that specific gravity of wood ranging from 0.25-0.50 is suitable to produce insulation board. This is due to the efficiency in heat transition and higher stiffness property. Therefore, with the range of specific gravity obtained in this study, Gliricidia wood may have the potential to be used as insulation board.

Study on the fibre length indicates that the means of fibre length between three age groups were 0.78 µm, 0.86 µm, and 0.83 µm, respectively. No significant difference was found in the means of fibre length ($p=0.3407$). From this study, Gliricidia fibres can be considered as having long fibre, which may contribute to good tear strength. The tear strength property is principally dependent upon fibre length; i.e., longer fibre length gives greater tear strength [8]. In the pulp properties, fibre length is a dominant factor besides Runkel ratio (a measure of pulp fibre flexibility) and fibril angle [9].

Higher proportion of hemicelluloses in the fibre contributes to higher quality of paper [6]. From this study, age does not influence the length of fibre, thus fibres produced from Gliricidia wood from all age groups studied may have the potential for pulp and paper making. There is a significant difference in the means of fibre diameter between age groups ($p=0.0113$). Wood from three years old of Gliricidia possesses a significantly lower fibre diameter as compared to five and seven years of age. However, there is no significant difference in fibre diameter between five and seven years of age (Figure 2).



Note: Means with the same letter are not significantly different ($p \leq 0.05$)

Figure 2: Fibre diameter between three different ages

Broader fibre diameter gives the fibre more flexibility and greater fibril angle [10]. This might be due to the amount of hemicellulose presence in the fibre. Usually, broader fibre diameter contains greater amount of hemicellulose [9]. Hemicellulose in large quantity makes the lumen diameter thicker, in which the fibre tends to be more flexible [9]. In addition, cell wall thickness influences fibre properties of the material. Thicker cell wall gives a stronger fibre [11]. Measurement of lumen diameter indicates that there is a significant difference in lumen diameter of Gliricidia at different ages ($p=0.0203$). Wood from three years old of Gliricidia possesses a significantly smaller lumen diameter (16.4 µm) as compared to wood from five and seven years of age (20.3 µm and 18.2 µm, respectively). However, there is no significant difference in lumen diameter between five and seven years of age.

Lumen with wider diameter transports more water compared to lumen with smaller diameter. Fibres from three years of age of Gliricidia may not be flexible enough and have small fibril angle [10]. Wood from five and seven years old may have thinner cell walls and contain more hemicellulose. The thicker the lumen, the greater hemicellulose it contains [9].

As discussed earlier, the fibre and lumen diameters are the dominant factor in determining cell wall thickness. Cell wall thickness influences fibre properties of the material where thicker cell wall will give stronger fibre. In a study on Rubberwood utilisation and processing, Hong and Sim [12] found that fibre diameter of the Rubberwood could range from 20 μm to 30 μm. Range of fibre diameter for Gliricidia obtained in this study is well within the above range. Further research should study the suitability of Gliricidia for making products that are currently using Rubberwood as a raw material. Comparison of product properties from these two materials should be made. Measurements made on cell wall thickness indicate that mean cell wall thickness of 6.2 μm. The means are not statistically different between the three age groups ($p=0.3800$).

Greater degree of fibre-to-fibre is important to produce high quality of pulp and paper [6]. Thicker cell wall thickness results in paper with low burst and tensile strength but with a high degree of resistance to tear. Paper made primarily from thicker cell wall also tends to have high folding endurance. The relationship of burst and tensile strength to cell wall thickness is explained by the fact that these properties are very dependent upon a high degree of fibre-to-fibre bonding [13]. Hong and Sim [12] found that cell wall thickness of the Rubberwood is ranging from 5.1 μm to 7.0 μm. These values are comparable to that of Gliricidia. Therefore, further study on its potential should be carried out.

The means of Coefficient of suppleness and Runkel ratio combined for all tree age groups were calculated at 51.7 and 0.39, respectively. Comparison between the means of these values for all three age groups are not significantly different ($p=0.6791$ and $p=0.4221$, respectively).

Coefficient of suppleness is a ratio between lumen diameter and fibre diameter. Therefore, the size of lumen and fibre diameters affects this coefficient as it is derived from the former. The higher value of the Coefficient of suppleness, the better quality of paper with regards to the relative of fibre bonded. Higher value of coefficient gives greater degree of fibre collapsibility [13]. Hong and Sim [12] found that the Coefficient of suppleness of the Rubberwood ranged from 45% to 55% which are comparable to that of Gliricidia. Runkel ratio is a measure of the suitability of the fibre of the species for paper production [14]. The value of Runkel ratio can affect the strength and quality of paper [8]. Runkel ratio below 0.5 gives fibre more flexibility and has strong conformability. Therefore, it is suggested that further studies should look into the possibility of Gliricidia for paper making based on this encouraging findings.

CONCLUSION

This study revealed that there is a significant difference in specific gravity at three different age group based on the following order: seven years > five years > three years. Means of fibre diameter of Gliricidia are significantly different between the age groups. However, no significant differences were found in the means of moisture content, fibre length, lumen diameter, cell wall thickness, Coefficient of suppleness and Runkel ratio between the three different age groups of Gliricidia. Results from this study suggest that wood from Gliricidia may have the potential for insulation board and paper making. Therefore, based on their properties, future studies should experiment the use of this species in the production of the suggested products.

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