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EFFECT OF TREE PORTION AND DISTANCE FROM PITH ON THE BASIC DENSITY, FIBER PROPERTIES AND CHEMICAL COMPOSITION OF *ALBIZIA FALCATARIA*WOOD

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Abstract-Albizia falcataria seems to be the best alternative as it is wood properties offer great usability and multipurpose tree. It is very fast growth and able to grow on variety of soils make it suitable as an alternative tree. Therefore, the basic density, fiber properties and chemical composition of Albizia falcataria were study according the effect of tree portion and distance from pith. The preliminary studies are important in order to make variety of products which nowadays it become insufficient resources according to the increment of human populations in the world.

Keywords *–Albizia falcataria*; Tree portion; Distance from pith; Basic density; Fiber properties; Chemical composition

I. INTRODUCTION

Nowadays, forest products play an important role in the many aspects such as social, economic and environmental for every country. Wood is classified into two categories which is hardwood and softwood. Hardwood terms is designates wood from broad-leaved (mostly deciduous) or angiosperm trees (plants that produce seeds with some sort of covering) sheds their leaves over a period of time. Hardwood employed in a large range of applications, for example construction, furniture, flooring and utensils. The anatomy of hardwood is complex rather than softwood, its contain vessels, fiber and parenchyma [1]. Example of hardwood is Jelutong, oak, mahogany, teak, walnut, birch, poplar and maple. *Albizia falcataria* wood is generally lightweight and soft to moderately soft. *Albizia falcataria*, also known as batai, is one of the most important pioneer multipurpose tree species in Indonesia. It is very fast growth and able to grow on a variety of soils [2]. It does not require fertile soil; it can grow well on dry soils, damp soils and even on salty to acid soils as long as drainage is sufficient. This species has been used for furniture, lightweight packing materials, veneer, pulp and light construction materials [3]. The mean annual increment of *Albizia falcataria* plantation for producing construction wood is up to 45 m^3/ha [4]. Basic density and fiber length are very important factors affecting wood properties [5]. Wood density strongly affects the physical and mechanical properties of wood [6]. Most pulp and paper properties are directly related to wood density [5]. In addition, fiber length directly connects to the strength of inter-fiber bonding and tear strength [7].

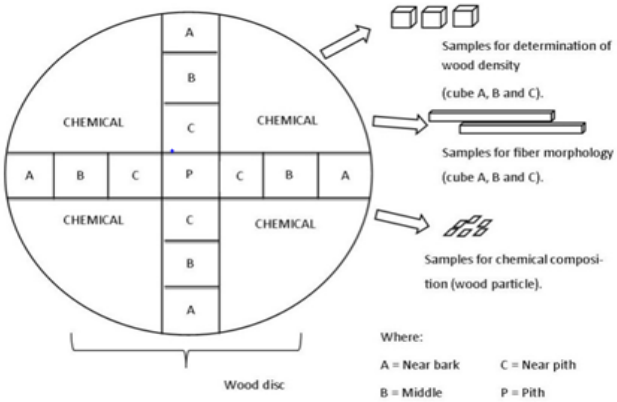

Fig. 1Sample preparation scheme

II. MATERIALS AND METHODS

In this study, matured trees of *Albizia falcataria* (Batai) were collected from Donghwa plantation at Merbok, Kedah Darul Aman. Wood disc (1-inch) was cut from each portion (bottom, middle and top) and samples were then cut as shown in Figure 1 for determination of wood density, fiber morphology and chemical composition. Wood density method was used as in TAPPI Standard T 258-02, fiber morphology was used Franklin method and TAPPI Standard was used to determine chemical composition

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III. WOOD DENSITY

Table 1 shows the wood density of *Albizia falcataria* according portions (bottom, middle and top) and distance from pith (near bark, middle and near pith). The average basic density of *Albizia falcataria* in this study is 0.23-0.32g/mL while the average basic density of *Albizia falcataria* planted in Indonesia is 0.22-0.46g/mL [8].

TABLE 1 WOOD DENSITY OF *ALBIZIA FALCATARIA* ACCORDING TREE PORTION AND DISTANCE FROM PITH

Portion	Distance	Wood Density (g/mL)
Bottom	Near Bark	0.32
	Middle	0.30
	Near Pith	0.29
Middle	Near Bark	0.26
	Middle	0.24
	Near Pith	0.25
Top	Near Bark	0.28
	Middle	0.23
	Near Pith	0.25

IV. THE EFFECT OF TREE PORTION AND DISTANCE FROM PITH ON WOOD DENSITY

According Figure 2 shows the density of wood according tree portions. The density of wood from bottom to top portion of *Albizia falcataria* is decreased with significantly different. Figure 3 shows the density of wood according distance from pith. This also shows that the density of wood from near bark to near pith is decreased with significantly different. Ishiguri et al. [8] found that basic density of *Albizia falcataria* planted in Indonesia showed a constant value up to 10 cm from pith, at which point it began to increase. In this study, wood density is constant and not significant from near pith to middle. Then, the wood density is increase at point near bark.

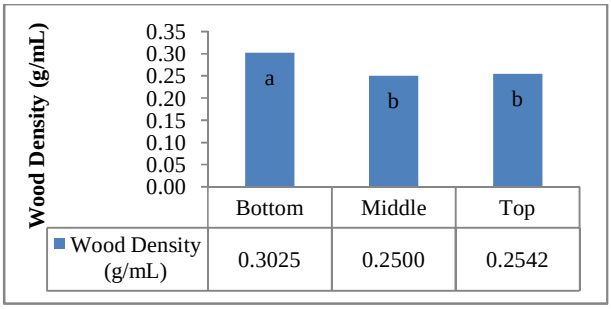


Fig. 2 Density of wood according tree portion

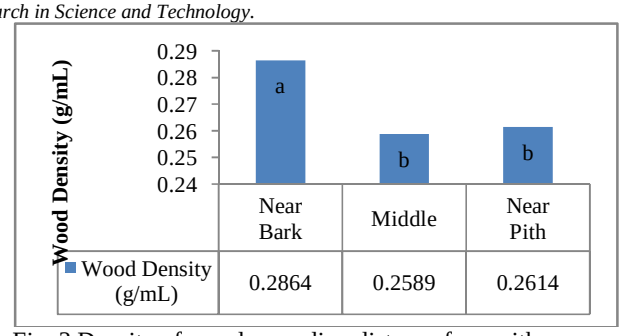


Fig. 3 Density of wood according distance from pith

V. FIBER MORPHOLOGY

Table 2 shows fiber morphology of *Albizia falcataria* according tree portions (bottom, middle and top) and distance from pith (near bark, middle and near pith). The fiber length of *Albizia falcataria* in this study was in the range of tropical hardwoods (0.7-1.5 mm) and considered as short fiber (Hale, 1959). The average lumen diameter (7.53µm-16.36µm) of *Albizia falcataria* is large as compared to OPFB (11.64µm) [9].

Portion	Distance	Fiber Length,*L* (mm)	Fiber Width,*d* (µm)	Lumen Diameter,*l* (µm)	Cell Wall Thickeness,*w* (µm)	Runkel Ratio	Flexibility Ratio (%)	Slenderness Ratio
Bottom	Near Bark	1.05	28.19	7.53	20.31	5.58	25.55	34.74
	Middle	1.25	34.84	10.86	22.43	4.26	35.58	36.89
	Near Pith	0.97	32.65	9.32	23.53	5.24	28.74	29.02
Middle	Near Bark	0.72	35.33	11.34	10.05	1.77	38.81	21.65
	Middle	1.16	33.07	9.92	10.62	2.24	33.25	35.32
	Near Pith	1.10	36.45	9.07	13.00	2.59	26.81	30.23
Top	Near Bark	1.14	29.83	13.07	8.40	1.29	44.46	37.16
	Middle	1.06	34.40	18.72	7.66	0.87	54.39	32.18
	Near Pith	1.11	39.00	16.36	11.19	1.35	42.89	28.76

The values of cell wall thickness do not show large variation as it is ranging from 0.0035 to 0.0031 mm. However, the value of cell wall thickness of *Albizia falcataria* in this study is not in the range and it categorised as bigger. The value of cell wall thickness affects the Runkel ratio and wall fraction [10].Pulp strength properties are usually favorable when value of Runkel ratio is below the standard value which is 1. It is observed that the average of Runkel ratio of *Albizia falcataria* in this study mostly higher than 1. The higher Runkel ratio fibers are stiffer, less flexible and form bulkier paper of lower bonded area than the lower Runkel ratio fibers[10].

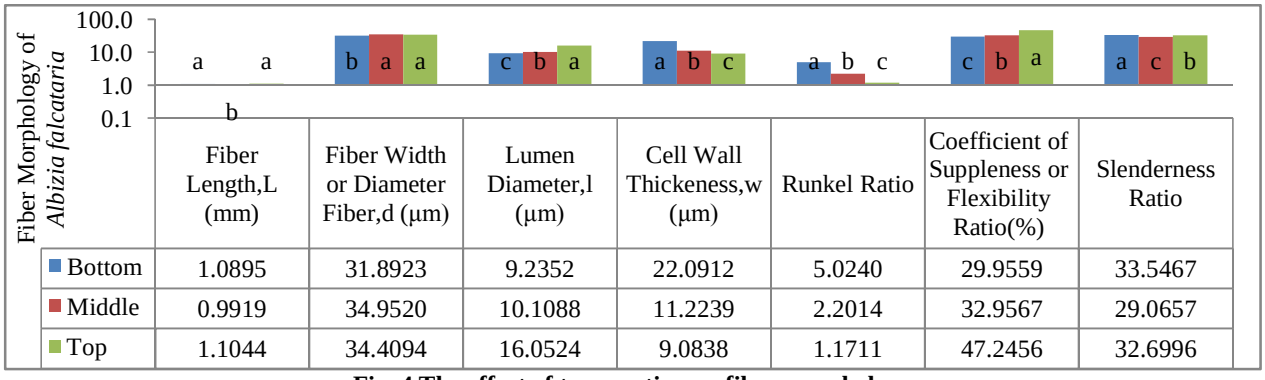
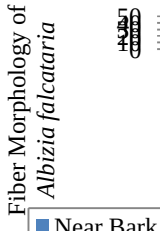


Fig. 4 The effect of tree portion on fiber morphology



	Fiber Length,L (mm)	Fiber Width or Diameter Fiber,d (μm)	Lumen Diameter,l (μm)	Cell Wall Thickeness, w (μm)	Runkel Ratio	Coefficient of Suppleness or Flexibility Ratio(%)	Slenderness Ratio
Near Bark	0.9688	31.1167	10.6491	12.9212	2.8792	36.27	31.1799
Middle	1.1575	34.1056	13.1655	13.5705	2.4567	41.07	34.7945
Near Pith	1.0595	36.0314	11.5817	15.9072	3.0606	32.82	29.3376

Fig. 5 The effect of distance from pith on fiber morphology

However, according to [11], fiber with ratio about or equal to 1 is also good for pulp making. The results indicate that *Albizia falcataria* fiber is suitable for the paper making [11] [12]. However, the results of this study shows that *Albizia falcataria* has low flexibility ratio which is less than values between 50-75 considered for highly elastic and elastic fibers[13]. The average slenderness ratio of the *Albizia falcataria* fiber is 28.76-37.16. This value is lower than cotton stalks (42.35) and aspen (46.15). Generally, the value for slenderness ratio of papermaking is more than 33, respectively[14].

VI. THE EFFECT OF TREE PORTION AND DISTANCE FROM PITH ON FIBER MORPHOLOGY

Figure 4 shows the fiber morphology of *Albizia falcataria* according tree portions and Figure 5 shows the fiber morphology according distance from pith. The fiber length from near bark to near pith is increased with significantly different. Short fibers do not produce good surface contact and fiber-to-fiber bonding [15]. Ishiguri et al. [8] found the fiber length of *Albizia falcataria* increased up to 10cm from the pith and then showed an almost constant value. The diameter fiber is increased with significantly different from bottom to top portion. The diameter fiber from near bark to near pith is increased with significantly different. Fiber lumen width affects the beating of pulp. Fiber diameter and wall thickness influences the fiber flexibility [16]. The value of fiber diameter affects the tear resistance as the ratio of fiber length to the fiber diameter increases the tear resistance [10].The lumen diameter is increased with significantly different from bottom to top portion. The lumen diameter from near bark to near pith is increased with significantly different. However, lumen diameter of middle is the highest. Fibers with large lumen and thin walls tend to flatten to ribbons during papermaking with enhanced inter-finer bonding between fibers and consequently having good strength characteristics [17]. The smaller fiber lumen width results the poorer pulp beating because of liquids into empty spaces of the fibers[18]. Larger the fiber lumen width better will be the beating of pulp, because of penetration of liquid into empty space between the fibers [10].

The cell wall thickness is decreased with significantly different from bottom to top portion. However, the cell wall thickness from near bark to near pith is increased with significant different. Thin walled cells on the other hand, collapse readily to form dense, well-boded paper, low in tear but high in other strength properties [19].The Runkel ratio and flexibility coefficient are important indices derive to determine the suitability of material for pulp and papermaking [20]. The Runkel ratio is decreased with significantly different from bottom to top portion. The Runkel ratio from near bark to near pith is increased with significant different. However, Runkel ratio of middle is the lowest. Low Runkel ratio is expected to have an inevitably positive effect on tensile and bursting strengths as well on folding endurance [15].The flexibility ratio is increased with significantly different from bottom to top portion. The flexibility ratio from near bark to near pith is decreased with significantly different. However, flexibility ratio of middle is the highest. The flexibility ratio is governed by lumen diameter and fiber diameter. It determines the degree of fiber bonding in paper sheet [21].

The slenderness ratio is decreased with significantly different from bottom to top portion. The slenderness ratio from near bark to near pith is decreased with significantly different. However, slenderness ratio of middle is the highest. The top potion seems to be having a great fiber morphology rather than middle and bottom portion in terms of long fiber, high fiber width, high lumen diameter, low cell wall thickness, low Runkel ratio, high flexibility ratio and high slenderness ratio. The middle distance from pith results better fiber morphology.

VII. CHEMICAL COMPOSITION

The main components in wood are cellulose, hemicellulose, lignin and extractives. Holocellulose is a total amount of polysaccharides (cellulose and hemicellulose) and can be explained as the breakdown of carbohydrates that are left after lignin removed. Cellulose and hemicellulose is important to assess the expected quality and pulp yield. Table 3 shows the chemical composition of *Albizia falcataria* according tree portions (bottom, middle and top). Chemical analysis gives an idea about the category to which the wood belongs i.e. softwood, hardwood and agricultural residues [10].

TABLE 3 CHEMICAL COMPOSITION OF *ALBIZIA FALCATARIA* ACCORDING TREE PORTION

Chemical Composition	Portions		
	Bottom	**Middle**	**Top**
Ash Content (%)	0.86	0.96	0.88
Cold-water Solubility (%)	3.80	3.61	3.32
Hot-water Solubility (%)	3.70	3.39	3.73
1%NaOH Solubility (%)	15.15	14.78	15.23
Lignin Content (%)	25.88	26.95	28.55
Alcohol-toluene Solubility (%)	1.36	1.27	1.73
Holocellulose Content (%)	85.22	88.88	88.76

Based on the results, *Albizia falcataria* contain high cellulose content which is almost approaching 90%. Based on the chemical analysis, its indicate that *Albizia falcataria* is hardwood as compared as *Morus nigra* whereas 0.85% ash content, 3.9% cold water solubility, 4.98% hot water solubility, 18% of 1% NaOH solubility, 2.6% alcohol-benzene solubility, 21.42% lignin content and 69.15 % holocellulose content [10]. In this study, holocellulose content of *Albizia falcataria* results higher than *Endospermum diadenum* (75.2%) (Peh et al., 1986) and *Endospermum malaccense*(71.6%) [22].

VIII. THE EFFECT OF TREE PORTION ON CHEMICAL COMPOSITION

Figure 6 shows the chemical composition of *Albizia falcataria* according tree portion. Holocellulose content is high than other chemical composition. However, it is increased with no significant different from bottom to top portion. High cellulose content gives high pulp yield [23]. Lignin content from bottom to top portion is increasing with significantly different. During pulping process, some of the lignin is hydrolysed by chemical materials. High lignin content would complicate the pulping process because high degree of delignification requires more chemical and high cost. Hence, the process will be uneconomical. High lignin content also increase the beating of pulp, weak fiber bonding and low paper strength [24]. 1% NaOH solubility of middle portion is lower than bottom and top portion. The solubility of 1% NaOH from bottom to top portion is increased with significantly different. However, there is no significant different between bottom and top portion. Khoo and Peh[23] found that alkali solubility associated with wood decay and damage caused by pests. Hot-water solubility of middle portion is lower than bottom and top portion. However, the hot-water solubility is increased with no significantly different from bottom to top portion. Cold-water solubility from bottom to top portion is decrease with no significant different.

Ash content of middle portion is higher than bottom and top portion. The ash content is increased with significantly different from bottom to top portion. However, there is no significant different between bottom and top portion. Findlay [25], explained that ash content in wood refers to the mineral content of inorganic materials which is not volatile and flammable.

It is evaluated after combustion of wood is complete. Ash content of *Albizia falcataria* in different portions (bottom, middle and top) is low and less than 1%. The low ash content of the raw materials related to the low silica content [26].

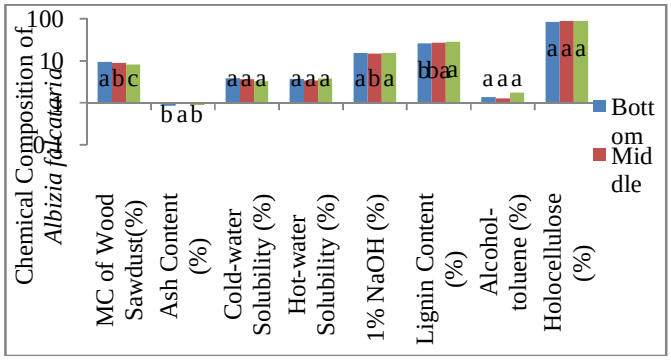


Fig. 6 Chemical composition of *Albizia falcataria* according tree portion

Alcohol-toluene solubility of middle portion is lower while the top portion is higher rather than others. The alcohol-toluene solubility from bottom to top portion is increased with no significant different. Alcohol-toluene is important to know the ingredients that can dissolved in solvent such as wax, fat, resin and glue sticks. The presence of high extractive will reduce yield and efficiency of alkaline pulping. Other than that, extractive will cause pitch problems in papermaking process. It causes the processing and production stopped for a moment [27].

IX. CONCLUSION

The research on *Albizia falcataria* wood on the density, fiber morphology and chemical analysis of wood gave a good indication of the fibers which is becoming alternative raw materials for pulp and paper industry.The average density of bottom portion is 0.29-0.32g/mL, middle portion is 0.24-0.26g/mL and top portion is 0.23-0.28g/mL. The wood density of *Albizia falcataria* is constant and not significant from near pith to middle. Then, the wood density is increase at point near bark. The top potion seems to be having a great fiber morphology rather than middle and bottom portion in terms of long fiber, high fiber width, high lumen diameter, low cell wall thickness, low Runkel ratio, high flexibility ratio and high slenderness ratio. The middle distance from pith results better fiber morphology.The high holocellulose content (85.22% - 88.88%) and low extractives content (1.27% - 1.73%) are capable of producing high pulps.

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