VOL. 12, NO. 8, APRIL 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CHEMICAL COMPOSITION OF SMALL DIAMETER WILD ACACIA MANGIUM SPECIES

Mohd Hazim Mohamad Amini[1], Mohd Sukhairi Mat Rasat[1], Mazlan Mohamed[1], Razak Wahab[1], Nur Hafizah Ramle[2], Izyan Khalid[1] and Ag Ahmad Mohd Yunus[3]
[1]Faculty of Earth Science, Universiti Malaysia Kelantan, Jeli, Kelantan, Malaysia
[2]Faculty of Creative Technology and Heritage, Universiti Malaysia Kelantan, Bachok, Kelantan, Malaysia
[3]Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia
E-Mail: sukhairi@umk.edu.my

ABSTRACT

Acacia mangium is an exotic species grows wildly and widely planted in Malaysia, as an effort for reforestation and also known to be used in pulp and paper industries. The objectives of this study is to determine 5 chemical composition (extractives, holocellulose, α-cellulose, hemicellulose and lignin) in 2 different parts (wood and bark) from 3 different portions (bottom, middle and top) of small diameter wild Acacia mangium. Samples were collected from Jeli, approximately 10 kilometers from Universiti Malaysia Kelantan (UMK), Jeli Campus, Kelantan with diameter around 5-8 cm. Samples were then grounded using laboratory grade mill into powder form for chemical composition analysis. All analyses were done according to Technical Association of the Pulp and Paper Industry (TAPPI) standard method, except for hemicellulose which is the data collected through equation. All the data and results were statistically analyzed using two-way ANOVA and Tukey's Post Hoc test. Results acquired reveals that extractives content was highest in bark part from bottom portion (15.03%). Highest holocellulose percentage can be found in wood part of top portion (85.99%) and the highest of α-cellulose content is in wood partfrom top portion (49.84%), meanwhile the highest of hemicellulose content can be found in wood part from top portion (36.15%). Lignin percentage is the highest in bark part of bottom portion (31.18%). This study has determined small diameter wild Acacia mangium as a useful alternative resource in pulp and paper industries.

Keywords: acacia mangium, small diameter, wild, chemical composition.

INTRODUCTION

Acacia mangium is a species of flowering tree in the pea family, Fabaceae. Although it was brought from Australia to be made as a reforestation species, it is now very common in Malaysia and Indonesia due to high resistance and survivability [1].

Acacia mangium has many uses such its glossy and smooth surface finish after polishing leads to be a potential for making export orientated parquet flooring tiles and artifacts [2]. Since these trees crack easily and temperamental for use in furniture, this is mainly used for the pulp and paper industries and currently is look forward for biomass fuel industries [3-5].

The bark of Acacia mangium also shows phenolic content with antioxidative activities [6]. According to database provided by [7], several known uses are made off Acacia mangium domestically and commercially including as animal fodder, fibre and tannin/dyestuffs. The objective of this study is to determine the chemical composition of small diameter wild Acacia mangium and to compare the results between 2 different parts (wood and bark) from 3 different portions (bottom, middle and top).

MATERIALS AND METHODS

Materials

Small diameter of wild Acacia mangium species were selected randomly with approximate same age, based on the diameter of the stem (5-8 cm). Trees were harvested at Jeli, Kelantan, Malaysia which approximately 10 km from Universiti Malaysia Kelantan, Jeli Campus.

Methods

Sample stem were collected from the wild and divided into 3 different portions (bottom, middle and top) and each of the portions divided into 2 different parts (bark and wood). All samples reduced into chips using chipper. Samples then were dried at 103±2 °C for 24 hours to reduce the moisture content. The chips then reduced into coarse particle by using laboratory type mill. Finally, the entire coarse particle reduced into fine particles of less than 1 mm using laboratory grade mill.

Chemical test were conducted to determine the content of Alcohol-Toluene extractives or solubles, α-cellulose and lignin was according to TAPPI standard T204 cm-97 [8],T203 cm-99 [9] and T 222 om-02 [10] respectively. For holocellulose, in [11] method was used. Hemicellulose content determined using equation by [12].

RESULTS AND DISCUSSIONS

Chemical compositions of small diameter wild Acacia mangium were summarized in Table-1 according to the portions and parts. According to the chemical compositions that had been carried out, the results showed that small diameter wild Acacia mangium species has the highest value of holocellulose in top portion of wood. While based on different height, the bottom portion gave the higher value except for the lignin content.

VOL. 12, NO. 8, APRIL 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-1. Chemical compositions of small diameter wild Acacia mangium according to the portions and parts.

Portion	Part	AT (%)	Holocellulose (%)	α-Celllulose (%)	Hemicellulose (%)	Lignin(%)
Bottom	Wood	1.40	82.23	47.00	35.22	21.07
	Bark	14.98	57.36	46.09	11.27	31.18
Middle	Wood	1.86	83.95	48.16	35.79	21.06
	Bark	9.93	61.78	47..24	15.53	28.80
Top	Wood	2.05	85.99	49.84	36.14	17.23
	Bark	5.14	68.89	48.25	20.63	22.68

Note: Values are the average of three replications; AT = Alcohol-Toluene solubles

Table-2. Summary of ANOVA on the chemical composition of small diameter wild Acacia mangium.

Source	Df	AT	Holocellulose	α-Cellulose	Hemicellulose	Lignin
Portions	2	29.672^{**}	135.476^{**}	24.602^{**}	32.370^{**}	55.842^{**}
Parts	1	286.436^{**}	3139.121^{**}	15.287^{*}	1472.980^{**}	235.933^{**}

Note: **significant at $p\leq0.01$; *significant at $p\leq0.05$; Df = degree of freedom;
AT = Alcohol-Toluene solubles

Table-3. Summary of Tukey's post hoc test on the chemical composition in portions of small diameter wild Acacia mangium.

Source (Portion)	Dependent variables				
	AT	Holocellulose	α-Cellulose	Hemicellulose	Lignin
	$F=29.672^{**}$	**$F=135.476^{**}$**	**$F=24.602^{**}$**	**$F=32.370^{**}$**	**$F=55.842^{**}$**
Bottom	8.195^{a}	69.795^{a}	46.548^{a}	23.248^{a}	26.128^{a}
Middle	5.898^{b}	72.868^{b}	47.702^{b}	25.165^{b}	24.933^{a}
Top	3.598^{c}	77.440^{c}	49.048^{c}	28.390^{c}	19.958^{b}

Note: Values here are the average for all values in a portion; **significant at $p\leq0.01$;
AT = Alcohol-Toluene solubles

Alcohol-toluene solubles content

Extractives present in plants may be extracted using alcohol-organic solvent. They are found in higher concentrations in the bark of most woods and are generally considered to be biosynthesized in order to slow or prevent pathogen invasion [13-16]. In [17] stated that bark extractives can be divided into the lipophilic and hydrophilic fractions with the hydrophilic fraction generally three to five times more abundant compared to lipophilic. Ethanol-benzene extraction solution as stated by [6] has the highest level of extractives yield due to the additional dissolution of low molecular weight carbohydrates and polyphenols. Based on statistical analysis in Table-2, there are high statistically significant differences for alcohol-toluene solubles content between portions ($F=29.672^{**}$) and parts ($F=286.436^{**}$). There is a decreasing trend from bottom to top portion for both parts (Figure-1). According to Table-3, all groups within portions are statistically significant compared to each other.

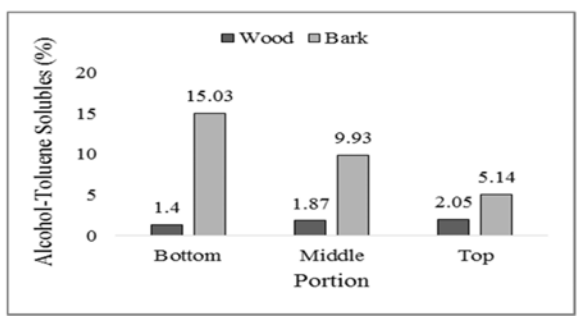

Figure-1. Content of Alcohol-Toluene solubles in portions and parts of small diameter wild Acacia mangium.

Holocellulosecontent

Main components of holocellulose are α-cellulose and hemicellulose. In [18] conducted chemical analysis on Acacia mangium wood and recorded 70.9% holocellulose content with 46.5% of Kurschner-Hoffer cellulose. In this study, holocellulose yielded was up to 85.99% for wood and up to 68.89% for bark. Based on Figure-2, observable

VOL. 12, NO. 8, APRIL 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

trend of increasing holocellulose content can be seen within bark group with bottom bark as the lowest (57.36%) and bark top as the highest (68.89%) although not very distinguished. Same goes for wood group, which increasing trend from bottom to top portion with top portion has the highest holocellulose percentage (85.99%). For statistical analysis, for both groups, there are high statistical differences according to Table-2, with portions ($F=135.476^{**}$) and parts ($F=3139.121^{**}$). Table-3 shows that all portions are statistically significant to each other. In [19] further stated that wood with high cellulose content can be a promising resource for pulp and paper industries, as higher cellulose content means higher pulp yield.

Figure-2. Content of holocellulose in portions and parts of small diameter wild Acacia mangium.

α-cellulose content

α-cellulose is the major component of wood. It was separated from the other components by soaking the pulp in a 17.5% solution of sodium hydroxide. Cellulose may be used in saccharification and ethanol fermentation research [20]. Based on Figure-3, α-cellulose content of small diameter wild Acacia mangium is the highest in top portion of wood (49.84%), followed by top bark (48.26%). From bottom to top portion, there is an increasing trend of α-cellulose content for both parts, although very slightly. According to Table-2, statistical analysis has revealed that statistical differences between portions for α-cellulose is highly significant ($F=24.602^{**}$). Meanwhile, for parts, there is also a statistical significance ($F=15.287^{*}$). Tukey'sPost Hoc test shows that α-cellulose content in all portions are statistically significant compared to each other, as written in Table-3.

Figure-3. Content of α-cellulose in portions and parts of small diameter wild Acacia mangium.

Hemicellulose content

Hemicellulose found in hardwood trees is predominantly xylan with some glucomannan, while in softwoods it is mainly rich in galactoglucomannan and contains only a small amount of xylan. Unlike cellulose, hemicellulose (also a polysaccharide) consists of shorter chains 500-3,000 sugar units as opposed to 7,000-15,000 glucose molecules per polymer seen in cellulose [21]. Based on Figure-4, it can be observed that hemicellulose content ofsmall diameter wild Acacia mangium resides mainly in the wood part. Highest hemicellulose content is in top wood (36.15%). For both parts (wood and bark), there is an increasing trend of hemicellulose content, from bottom to top portion. Statistical analysis in Table-2 shows that there are statistical differences for portion ($F=32.37^{**}$) and part ($F=1472.98^{**}$), both highly significant. Tukey's Post Hoc test in Table-3 also reveals those hemicelluloses content between all portions are statistically significant compared to each other.

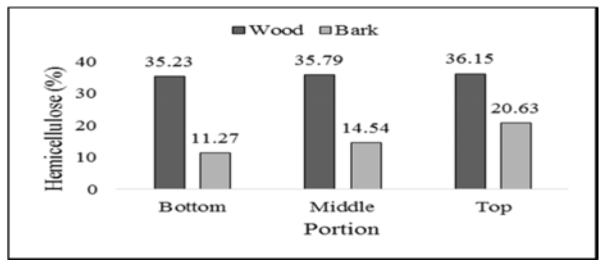

Figure-4. Content of hemicellulose in portions and parts of small diameter wild Acacia mangium.

Lignin content

Lignins are particularly important in the formation of cell walls, especially in wood and bark because they lend rigidity and do not rot easily. Chemically lignins are cross-linked phenol polymers and are cross-linked phenol polymers [22]. The conventional method for lignin quantitation in the pulp industry is the Klason lignin and acid-soluble lignin test, which is standardized. Figure-5 shows that bark bottom has the highest lignin content (31.18%). Lignin predominantly exists in bark due to its function to combat pathogens. From bottom to top portion, lignin content shows a decreasing trend. During pulping process, some of the lignin is hydrolysed by chemical materials. High lignin content also increase the beating required to pulp, produces weak fiber bonding and low paper strength [23]. Based on Table-2, statistical analysis shows that there are statistical differences, which is highly significant for portion ($F=55.842^{**}$) and part ($F=235.933^{**}$). From Table-3, Tukey's Post Hoc test confirmed that lignin content for bottom and middle portion are not statistically significant although both of them compared to top portion are statistically significant.

Figure-5. Content of lignin in portions and parts of small diameter wild Acacia mangium.

CONCLUSIONS

In this study, chemical composition of small diameter wild Acacia mangium was determined. Wood has the most chemical compositions except for alcohol-toluene solubles and lignin. All chemical compositions were found to be statistically significant. For portion, most of chemical composition resides in top portion except for alcohol-toluene solubles and lignin. Tukey's Post Hoc test shows that all portions are statistically significant from each other, except for lignin bottom and middle portion. This research hopefully may give and insight for small diameter wild Acacia mangium as a resource for paper and pulp industries.

ACKNOWLEDGMENT

The authors gratefully acknowledge the Ministry of Higher Education, Malaysia in support of this study through the Fundamental Research Grant Scheme phase 1/2013 (R / FRGS / A08.00 / A00800A / 001 / 2013 / 00114).

REFERENCES

[1] Parrotta J. A. 1993. Secondary forest regeneration on degraded tropical lands. In: Restoration of Tropical Forest Ecosystems. pp. 63-73.

[2] S. K. Sharma, P. Kumar, R. V. Rao, M. Sujatha and S. R. Shukla. 2011. Rational utilization of plantation grown Acacia mangium wild. Journal of the Indian Academy of Wood Science. 8(2): 97-99.

[3] M. S. M. Rasat, R. Wahab, M. Mohamed, M. I. Ahmad, M. H. M. Amini, W. M. N. W. A. Rahman, M. K. A. A. Razab and A. A. M. Yunus. 2016. Preliminary study on properties of small diameter wild Leucaenaleucocephala species as potential biomass energy sources. ARPN Journal of Engineering and Applied Sciences. 11(9): 6128-6137.

[4] M. S. Sirrajudin, M. S. M. Rasat, R. Wahab, M. H. M. Amini, M. Mohamed, M. I. Ahmad, J. Moktar and M. A. Ibrahim.2016. Enhancing the energy properties of fuel pellets from oil palm fronds of agricultural residues by mixing with glycerin. ARPN Journal of Engineering and Applied Sciences. 11(9):6122-6127.

[5] M. I. Ahmad, Z. A. Z. Alauddin, S. N. M. Soid, M. Mohamed, Z. I. Rizman, M. S. M. Rasat, M. K. A. A. Razab and M. H. M. Amini. 2015. Performance and carbon efficiency analysis of biomass via stratified gasifier. ARPN Journal of Engineering and Applied Sciences. 10(20): 9533-9537.

[6] L. Zhang, J. Chen, Y. Wang, D. Wu and M. Xu. 2010. Phenolic extracts from Acacia mangium bark and their antioxidant activities. Molecules. 15(5): 3567-3577.

[7] Orwa C., Mutua A., Kindt R., Jamnadass R. and Anthony S. 2009. Agroforestree database: A tree reference and selection guide version 4.0. World Agroforestry Centre.

[8] Technical Association of the Pulp and Paper Industry (TAPPI). 1997. Solvent extractives of wood and pulp. (T 204 cm-97). Technical Association of the Pulp and Paper Industry.

[9] Technical Association of the Pulp and Paper Industry (TAPPI). 2002. Alpha-, beta- and gamma-cellulose in pulp (T 203 cm-99). Technical Association of the Pulp and Paper Industry.

[10] Technical Association of the Pulp and Paper Industry (TAPPI). 2002. Acid-insoluble lignin in wood and pulp (T 222 om-02). Technical Association of the Pulp and Paper Industry.

[11] L. E. Wise, M. Murphy and A. A. D`Addieco. 1946. A chlorite holocellulose, its fractionation and bearing on summative wood analysis and studies on the hemicelluloses. Paper Trade Journal. 122(2): 35-43.

[12] M. J. Boonstra and B. Tjeerdsma. 2006. Chemical analysis of heat treated softwoods. Holzals Roh-und Werkstoff. 64(3): 204-211.

[13] R. Wahab, M. A. Salam, A. Mohamed, H. W. Samsi, S. Rahman, M. S. M. Rasat and I. Khalid. 2015. Evaluation on strength of chemically reacted 2 and 4 year-old bamboo Bambusa vulgaris through pressurized treatment. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 6(1): 1282-1288.

[14] R. Wahab, O. Sulaiman, A. Mohamed, M. A. Salam, S. Rahman, M. S. M. Rasat and H. W. Samsi. 2014.

Mappings of chemicals distribution in preservatives treated tropical bamboo Gigantochloascortechinii. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 5(3): 1505-1513.

[15] R. Wahab, M. T. Mustafa, M. Sudin, M. S. M. Rasat, A. Mohamed and N. A. A. N. Yusuf. 2014. Analysis on thermal degradation and chemical contents of bamboo Gigantochloabrang. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 5(5): 500-506.

[16] R. Wahab, M. T. Mustafa, A. Mohamed, H. W. Samsi and M. S. M. Rasat. 2013. Extractives, holocellulose, α-cellulose, lignin, and ash contents in 3 year-old bamboo culms Gigantochloabrang, G. Levis, G. Scortechinii and G. Wrayi. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 4(3): 1235-1247.

[17] Sjostrom E. 2013. Wood chemistry: Fundamentals and applications. 2nd Ed. Academic Press, California, USA.

[18] P. C. Pinto, D. V. Evtuguin and C. P. Neto. 2005. Chemical composition and structural features of the macromolecular components of plantation Acacia mangium wood. Journal of agricultural and food chemistry. 53(20): 7856-7862.

[19] Lim S. C., Gan K. S. and Tan Y. E. 2011. Properties of Acacia mangium planted in Peninsular Malaysia. ITTO Project on Improving Utilization and Value Adding of Plantation Timbers from Sustainable Sources in Malaysia.

[20] J. Lu, X. Li, J. Zhao and Y. Qu. 2012. Enzymatic saccharification and ethanol fermentation of reed pretreated with liquid hot water. Journal of Biomedicine and Biotechnology. 2012: 1-9.

[21] L. J. Gibson. 2012. The hierarchical structure and mechanics of plant materials. Journal of the Royal Society Interface. 9(76): 2749-2766.

[22] Lebo S. E., Gargulak J. D. and McNally T. J. 2001. Lignin Kirk-Othmerencyclopedia of chemical technology. John Wiley & Sons, New York, USA.

[23] Robinson J. V. 1980. Fiber bonding. In: Pulp and Paper, Chemistry and Chemical Technology. J. P. Casey (Ed.). pp. 915-963.