CHARACTERISATION OF PULP AND PAPER OBTAINED FROM THREE DIFFERENT AGES OF *Acacia mangium* IN SIMILAR HABITAT

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SCHOOL OF INTERNATIONAL TROPICAL FORESTRY
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JUDUL : **CIRI-CIRI PULPA DAN KERTAS DARIPADA TIGA UMUR *Acacia mangium* DIDAPATI PADA HABITAT YANG SAMA**

IJAZAH : SARJANA SAINS

SESI PENGAJIAN : 2004-2006

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DECLARATION

The materials in this thesis are original except for quotations, excerpts, summaries and references, which have been duly acknowledged.

FASIL SAID MANZOOR
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ABSTRACT

Woods samples of *Acacia mangium* tree of three age groups, viz. five, seven and nine years were tested for their alpha cellulose contents, pulp yield and papers quality. The woods were collected from Sabah Forest Industry (SFI) area in Ganui, Sipitang, Sabah. The woods were chipped, grinded into small sizes and turned into powder. The wood chips were treated at 170^0 C, 7-8 MPa for 2.5 hours. The Brendel et al method was used for the extraction of alpha cellulose. The pulp yields of the sample were studied. Later, papers were made using this pulp and the tested for strength qualities. All tests were conducted in accordance to the ISO standards. The results showed that the alpha cellulose contents of the tree increases slightly. The increments were however found not significant. Almost all the age trees gave nearly the same pulp yield with a same cooking condition. The ANOVA analysis was conducted to determine the relation between the age of the tree and alpha cellulose content, pulp yield and paper strength properties. There were no significant changes seen in the paper strength properties with respect to age. It was found that the 5 year old trees showed better characteristics with respect to the older age trees and it's economically suitable for the paper production. These works recommend for the plantation managers (pulp wood) to cut the *Acacia mangium* trees in the age of 5 rather waiting for 7 - 9 years.

ABSTRAK

CIRI-CIRI PULPA DAN KERTAS DARIPADA TIGA UMUR Acacia mangium DIDAPATI PADA HABITAT YANG SAMA

Sampel-sampel kayu Acacia mangium daripada 3 kumpulan umur iaitu 5, 7 dan 9 tahun telah diuji terhadap kandungan alpha sellulosa, penghasilan pulpa dan kualiti kertas yang dihasilkan daripadanya. Kayu-kayu ini diambil daripada kawasan tanaman Acacia di Ganui, Sipitang, Sabah. Kayu-kayu ini dipotong, dikisar kepada saiz kecil dan dijadikan bentuk serbuk. Serbuk-serbuk kayu ini kemudian dikenakan suhu 170^0 C, 7-8MPa untuk selama 2.5 jam. Kaedah Brended et al digunakan bagi mengekstrak alpha sellulosa. Kadar hasil pulpa yang dihasilkan dikaji. Kemudian, kertas-kertas dihasilkan daripada pulpa ini dan diuji bagi menentukan kualiti kekuatannya. Semua ujian dijalankan mengikut piawai ISO. Hasil-hasil kajian menunjukkan bahawa kandungan alpha sellulosa pokok Acacia meningkat sedikit daripada pokok-pokok yang berumur 5 ke 7 dan seterusny 9 tahun. Walaubagaiman pun peningkatan ini adalah tidak signifikan. Kesemua pokok memberikan kadar hasil pulpa yang sama dengan keadaan masakan yang sama. Analisa ANOVA telah dijalankan bagi menentukan hubungan antara umur pokok dan kandungan alpha sellulosa, kadar hasil pulpa dan sifat-sifat kekuatan kertas yang terhasil. Tidak ada perbezaan yang signifikan yang didapati. Kajian juga menunjukkan bahawa pokok yang berumur 5 tahun mempunyai cirri-ciri yang lebih baik daripada pokok yang lebih tua dan secara ekonominya sesuai digunakan bagi menghasilkan kertas. Hasil kajian ini menyarankan bahawa pokok Acacia berumur 5 tahun patut digunakan bagi penghasilan kertas berbanding pokok-pokok yang berumur 7 - 9 tahun yang digunakan sekarang.

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ABBREVIATION

ASEAN	Association of Southeast Asian Nations
$C_6H_{10}O_5$	Cellulose
CD	Cross direction
FAO	Food and Agriculture Oganization
FTIR	Fourier Transform Infrared Spectra
GSM	Grams per square meter
H_2SO_3	Sulphurous acid
HSO_3	Bisulphite ions
ISO	International Organization for Standardization
KCl	Potassium chloride
LSD	least significant difference
MAI	Mean Annual Increment
MC	Moisture content
Max	Maximum
Min	Minimum
MPPMA	Malaysia Pulp and Paper Manufacturers Association
MTC	Malaysian Timber Council
Na_2S	Sodium Sulfide
NaOH	Sodium Hydroxide
RM	Ringgit Malaysia
SCAN	Scandinavian pulp, paper and board testing committee

Sdn. Bhd.	Sendirian Berhad (Company Limited)
SFI	Sabah Forest Industry
SR	Schopper-Riegler
TAPPI	Technical Association of the Pulp and Paper Industry

SYMBOLS

%	Percentage
β	Beta
mL	milliliter
rpm	revolution per minute
m/min	meter per minute
gsm	Gram square meter
N/m^2	Newton per meter square
um	Micro meter
sq.ft.	square feet
lb	pound
kN/m.	Kilo Newton per meter
V	volume
mm	millimeter
mm^3	millimeter cube
m	meter
mg	milligram
m^2	meter square
cm	centimeter
°C	Degree Celsius
kg	kilogram
ha	hectare
N	Newton
mPa	milipascal
kPa	kilopascal

mN	milinewton
°SR	Schopper-Riegle degree

CHAPTER 1

INTRODUCTION

In today's world, paper plays a vital role in our daily life. Paper allows the expression of ideas and thoughts, and it also facilitates communication. The usage of paper is expected to increase with the increasing world population. In 1950, the world population was recorded as 2.5 billions and is expected to reach 9.9 billions by the 2050. According to the statistics (Rymsza, 1999), the world production of pulp and paper in the year of 1961 is recorded as 61,862 million metric ton and this value has increased to 102,840 million ton metric in 1970. In 1980 and 1990, there was an increase of 128,310 million ton metric to 165,873 million ton metric respectively. In 1997, the world pulp and paper production was recorded as 178,550 million ton metric (Rymsza, 1999)

In the context of Malaysia, the paper and paper board industry played an important role in its steady economic growth and development (Kevin, 1994). The country has a total capacity of slightly over 1 million tonnes of paper per annum, with self-sufficiency in the supply of paper and paper board growing at a slow rate. It is predicted that the demand for the paper in the region will grow with an annual average of 6 - 10 % (MTC, 2004). According to the records, Malaysia has 61% area covered with forest and 16% of the total area is under plantation (MTC, 2003) even though it could satisfy the local demands. According to MPPMA, Malaysia imported 1,189,120 metric tonnes of all types of paper and paper products worth RM2.7 billion in 2000 as compared to 1,353,515 metric tonnes valued at RM2.4 billion in 1999. In 2000 the country recorded a 50% self-sufficiency rate in contrast to 43% in 1999, and is striving to achieve the objective of being self-sufficient by the year 2005.

The pulp industry is facing the ever-increasing demands of quality paper and paperboard that is causing search for new and hitherto unexploited sources of cellulosic fibers (Jahan *et al.,* 2005). The awareness of forest conservation has increased in recent years which had led to the decrease in supply of the wood from the natural forest to the industries and this also made the raw materials expensive. To meet the demand of wood, Malaysia is setting up more plantations specially the *Acacia mangium* plantations. Acacias have good biomass production potential and the wood is generally considered to be a good fuel with a high calorific value. Considerable work has been undertaken in recent years to explore this potential in overseas countries, to address pressing issues of fuel shortages, land degradation and pulp production.

This study aim on investigating the suitability of using young *A. mangium* trees for the pulp and paper industry in Malaysia. The outcomes of the study will be rely and pass on to the plantation managers (especially for the chips). If the study can prove that the early age trees can produce good paper with respect to the 9 year age trees it can help to cut down the rotation period of trees and also can help to supply the raw materials to the paper industry continuously with out any problem.

1.1. Distribution and Location of Paper Factory in Malaysia

Malaysia has about 19 paper manufacturing mills (Table 1.1) in operation of which 15 paper mills are the members of Malaysian Paper Manufacturers Association. There are no mills in Negeri Sembilan, Terengganu and Kelantan. The imported pulp or regular paper or mixed together with pulp from tropical hardwood are used by many of the companies. Sabah Forest Industry (SFI) is the only integrated pulp and paper

mill in the country which use wood fibers from various tropical wood species (Kevin, 1994).

Table 1.1: Paper Factories of Malaysia

State	Number of factories
Kedah	2
P.Pinang	3
Perak	2
Selangor	3
Melaka	1
Johor	2
Pahang	3
Sabah	1
Sarawak	2
Total	**19**

Source: MTC, 1999.
The total Production capacity is approximately 1 million tonnes

1.2. Present Status of Pulp and Paper in Malaysia

Total import of paper in Malaysia exceeds 6 million tonnes/year. The Government is very keen interest in sustainable forest management system with replanting and creating forest plantations. Malaysia imports 762,359 tonnes of paper products in 1998 which is worth of RM 1.72 billion. This shows decrement compared to 1997 which total up to 1.05 tonnes worth 1.97 million. This was due to the economic crisis in 1997. During this period Malaysia was not able to export the paper (MTC, 1999).

By 2013 countries in Asia pacific region is estimated to become the largest paper purchaser of the world. This region is estimated to produce 86 million tonnes of paper and paper products that is 30.2% of world production. Factors such as recovery of the economic crisis, increment of population, development in the living standards and development of packaging industry will make the region become the largest buyers (MTC, 1999).

1.3. Pulp and Paper Demand in Developing and Developed Countries

Demand rate for pulp and paper increased from year 1961 to 1991 (Table 1.2), so it is estimated that there will be an increment from year 1991 to 2010. Developing countries has more rate of increment compared with developed country, even though 80 – 90 % of world paper market is controlled by developed country. After 1991 both developing and developed countries showed a decrease in the rate of demand. This is because of economic crisis in 1997 and development in computer technology which decrease the paper usage. The rate of increment for the demand of pulp and paper for developing country is higher compared with developed country because developed country has enough economy and modern technology to do so.

Table 1.2: Rate of Increment of Pulp and Paper

	Year 1961 (Tonnes)	Rate of Increment (%)	Year 1991 (Tonnes)	Rate of Increment (%)	Year 2010 (Tonnes)
Developed Countries	70	3.5	194	2.3	310
Developing Countries	7	6.2	49	2.8	130
Total	77	3.7	243	5.1	440

Source: Malaysia Pulp and Paper Manufacturers Association, 1991.

1.4. Demand of Pulp and Paper in the World

According to Table 1.3, it is forecasted that the world demand for the pulp and paper will increase from year 1991 to 2010. In 1991 the total world demand of paper was 242,939,000 tons. In 1991 the Wood fiber and non wood fibers are respectively 153,939,000 and 14,725,000 tons. In 2010 the paper demand is estimated to reach 443 million ton. For the wood pulp there will be an increment of 257 million ton and for non wood fibers there will an increment of 26 million tons. This shows the rate of pulp and paper demand in the world is always increasing.

Table 1.3: Demand of Pulp and Paper in World ('000 Tons)

Countries	1991			2010		
	Total Paper Products	Wood Pulp	Non Fiber Wood	Total Paper Products	Wood Pulp	Non Fiber Wood
Africa	2,684	1,967	236	4,605	1,683	511
North/Middle America	92,389	73,266	474	155,204	112,983	1,288
South America	8,039	4,947	488	23,699	13,984	1,236
Asia	60,146	22,957	12,880	112,052	39,385	20,908
Europe	67,258	40,689	379	123,351	70,301	1,149
Oceanic	2,833	1,901	13	4,493	3,036	27
USSR	9,590	8,212	255	19,615	16,432	737
Total	**242,939**	**153,939**	**14,725**	**443,019**	**257,804**	**25,856**

Source: Malaysia Pulp and Paper Manufacturers Association, 1991

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