OIL PALM TRUNK (OPT) AS AN ALTERNATIVE CELLULOSIC MATERIAL FOR BROWN PAPER PRODUCTION

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ABSTRACT

The total estimated amount of available biomass from 1997 to 2000 for oil palm trunks (OPT), fronds (OPF) and empty fruit bunches (EFB) respectively are 4.34, 2.99, and 3.08 million tonnes per annum dry weight. The demand for pulp and paper products within Malaysia continues to grow at a considerable rate around 4 per cent per annum, and the trend expected to continue into the next decade. The research has indicated that the chemical composition of OPT fibers lie between that of hardwoods and that of softwoods material. Chemical pulping was used for pulping process because it produced pulp and paper of better properties than mechanical pulping. In this study, the beating effect of Soda-AQ pulp in term of fiber morphology, and mechanical properties such tensile, burst and tear indices was investigated. The pulp was beaten by using PFI Mill at five degree of beating; 15, 30, 45, 60 and 90 minutes. Hand-sheets were made from pulp samples taken at different times during the beating process and standard physical test were carried out. The fiber length decrease and fines were produced with the increasing of degree of beating. The soda pulp also gives the effect on drainage time which is increasing with the degree of beating. The content stock freeness (CSF) is decrease with the degree of beating cause of increasing the surface area to absorb water of fine fiber. The high degrees of beating give the strength paper which showed in tear, burst and tensile indices. The study showed that OPT pulp has a long fiber that can be used as a reinforcement component in paper production and become value-added products.

ABSTRAK

Jumlah anggaran biojisim yang sedia ada dari tahun 1997 hingga 2000 untuk batang kelapa sawit , pelepah dan buah tandan kosong masing-masing adalah 4.34, 2.99, dan 3.08 juta tan berat kering setahun. Permintaan untuk produk pulpa dan kertas di Malaysia terus meningkat pada tahap yang memberansangkan sekitar 4 peratus setahun, dan dijangka meningkat pada abad yang berikutnya. Kajian menunjukkan bahawa komposisi kimia daripada serat batang kelapa sawit terletak di antara kayu keras dan kayu lembut. Proses pembuatan pulpa secara kimia digunakan kerana ia menghasilkan pulpa dan kertas yang mempunyai sifat yang lebih baik berbanding pembuatan pulpa secara mekanik. Kajian ini menekankan kesan pemampatan pulpa Soda-AQ terhadap struktur serat, dan sifat mekanik seperti nilai ketegangan, kepecahan dan koyakan dikaji. Pulpa dipukul dengan menggunakan PFI Mill menggunakan lima waktu pemampatan yang berbeza; 15, 30, 45, 60 dan 90 minit. Helaian kertas yang dibuat daripada sampel pulpa diambil pada masa yang berbeza semasa proses pemampatan dan ujian piawaian fizikal dilakukan. Panjang serat berkurang dan serat halus terhasil dengan peningkatan tahap pemukulan. Pulpa Soda juga memberi kesan terhadap masa air melalui serat dengan berkadar langsung iaitu meningkat dengan perbezaan masa proses pemampatan. Isipadu air yang ditampung oleh serat menurun terhadap perbezaan masa proses pemukulan pulpa, disebabkan oleh peningkatan luas permukaan penyerapan air oleh serat halus. Semakin lama proses pemukulan, akan memberikan kekuatan kertas yang menunjukkan nilai koyakan, kepecahan dan regangan. Kajian ini menunjukkan bahawa pulpa daripada batang kelapa sawit mempunyai serat yang panjang dan boleh digunakan sebagai bahan pengganti dalam proses penghasilan kertas serta menjadi produk yang bernilai.

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LIST OF SYMBOLS

AQ	-	Anthraquinone
CSF	-	Canadian Standard Freeness Method
OPT	-	Oil Palm Trunk
OPF	-	Oil Palm Frond
EFB	-	Empty Fruit Bunch
NaOH	-	Sodium Hydroxide
TAPPI	-	Test & Analysis of Pulp and Paper Institute
POME	-	Palm Oil Mill Effluent
LKPP	-	Lembaga Kemajuan
g	-	gram
rpm	-	Revolution per minutes
FKKSA	-	Fakulti Kejuruteraan Kimia dan Sumber Asli
A.D	-	Air dry
O.D	-	Oven dry
mL	-	millilitre

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Malaysian oil palm industry started way back in 1917 and grew slowly until the late 1950s, when the agricultural diversification policy resulted in switch over rubber to oil palm. Then, the industry grows up rapidly and presently, very little room remains for any significant increase in oil palm plantations in Peninsular Malaysia. As such, all future growth is expected to be in Sabah and Sarawak. Nowadays, Malaysia is one of the largest palm-oil produce and currently produces around 6.5 million metric tons of world palm oil production (Law & Jiang., 2001). At present, the total area under oil palm cultivation is about 3.5 million hectares, while the statistic of oil palm production for the year 2001 was 11.8 million tonnes (Hussin, Mokhtar, Wan, Ropandi.,2002). Despite the huge production, the oil consist only a minor fraction of the total biomass produced in the plantation. The remaining consists of a huge amount of lignocellulosic materials such as fronds, trunk and empty fruit bunches. Therefore, huge amount of waste generated and largely unutilized. World paper consumption was about 300 million tons in 1996/1997 by the year 2010(MPOB 2006). Besides that, the wood sources from the forest decrease every year, so that; the source for pulp and paper production has been decreased. In view of the shortage of conventional raw material for pulping and the increasing of demand of paper products worldwide, non-wood plants and agricultural residues attracted renewed interest. Then, the oil palm industry must be prepared to take advantage of the situation and utilize the available biomass in the possible manner.

1.2 Problem Statement

Malaysia is the largest producer of palm oil in the world and through this activity, it produces huge production of biomass such as trunk, frond and empty fruit bunches. Therefore, huge quantities of these residues are generated and largely unutilized and cause problem to the environment. Thus, in order to manage the waste involved demand special attention from various segments of society. Currently, in Malaysia, we have about 7 million tons of oil palm trunks per year for replanting and burned, creating massive pollutions and economical problems. Malaysia has to change its objective of being a world producer of palm oil to amongst others a leader in converting biomass waste into value-added products. The utilization of the biomass reduces the disposal costs, and at the same time can provide additional income to the plantation. Paper consumption is continuously increasing across the world and world paper consumption was about to rise every year. The availability of soft wood supply cannot meet the growing demand. . In recent years, production of timber from natural forest Malaysia is decreasing, especially in Sabah which is the largest forest area in Malaysia. So, to maintain the growth of paper industry, the biomass of the oil palm has been used as an alternative of non fiber wood source for pulp and paper production.

1.2 Objectives

1. To utilize oil palm trunk as an alternative source of cellulose based material to produce brown pulp and paper.

2. To determine the effect of beating on the properties of Oil Palm Trunk pulp.

3. To study the obstacle that will affect the quality of pulp and paper.

1.3 Research of Scopes

In order to achieve the objectives stated above, the following scopes of study have been drawn.

i. The effect of beating on fiber morphology

ii. The effect of beating on drainage time

iii. The effect of beating on content stock freeness (CSF)

iv. The effect of beating on paper strength

v. The optimum condition of beating in paper production

1.4 Rationale and Significance

Based on the research scopes mentioned above, the following rationale and significance that we could get have been outlined.

i. It shall reduce the huge production of biomass residue.

ii. It shall reduce deforestation and environmental problem.

iii. Alternative way to produce valuable product from oil palm biomass residue.

iv. New substitute of raw material for pulp and paper production.

v. It shall reduce factory's waste disposal costs.

vi. It shall reduce termites' problem in plantation because of Zero Burning Policy.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

The history of Malaysian oil palm industry started in 1917 and grows slowly in the late 1950`s, when the agricultural diversification policy in switch over from rubber to oil palm. Originally, oil palm (*Elaeis guineensis)* come from the tropical forest of West Africa and it is one of the most perennial oil crops. The first commercial cultivation of the oil palm in Malaysia took place in 1917, almost 40 years after it was first introduced to the country as an ornamental tree. The seeds were initially sowed on a tract of land in Kuala Selangor and the seedlings were later planted on a large commercial scale in Tennamaram Estate by M. H. Fauconnier, an associate of M. Hallet. This paved the way for the prolific expansion of oil palm cultivation in Malaysia. Nowadays, Malaysia is one of the largest palm-oil produce and currently produces around 6.5 million metric tons of world palm oil production (Law, Jiang., 2001). At present, the total area under oil palm cultivation is about 3.5 million hectares, while the statistic of oil palm production for the year 2001 was 11.8 million tonnes (Hussin, Mokhtar, Wan, Ropandi.,2002). Oil palm is produced in 42 countries worldwide on about 27 million acres. Average yields are 10,000 lbs/acre, and per acre yield of oil from African oil palm is more than 4-fold that of any other oil crop, which has contributed to the vast expansion of the industry over the last few decades.

. Malaysia is the world's second producer of palm oil with 4.3 million hectares of the crop producing 15.9 million tonnes of the oil. The oil palm trunk has a number of potential uses - lumber, pulp and paper, reconstituted boards, bio-composites, animal feed and fuel. The palm trunk fibre gave sulphate pulp with moderate yield and strength. It has very light structure and can absorb lot of water without congealing. So, it has the potential to be an alternative raw material for pulp and paper production. The soda-anthraquinone pulping process was chosen on the grounds of its usually providing quality using no sulphur which avoids the release of pollutants and causing bad odors. It requires only modest amounts of raw material to be profitable which is compatible with the low non-wood production of some regions in the world – in contrast with the kraft process that is suitable for high productions (Jimenez, Serano, Rodriguez & Sanchez, 2009).

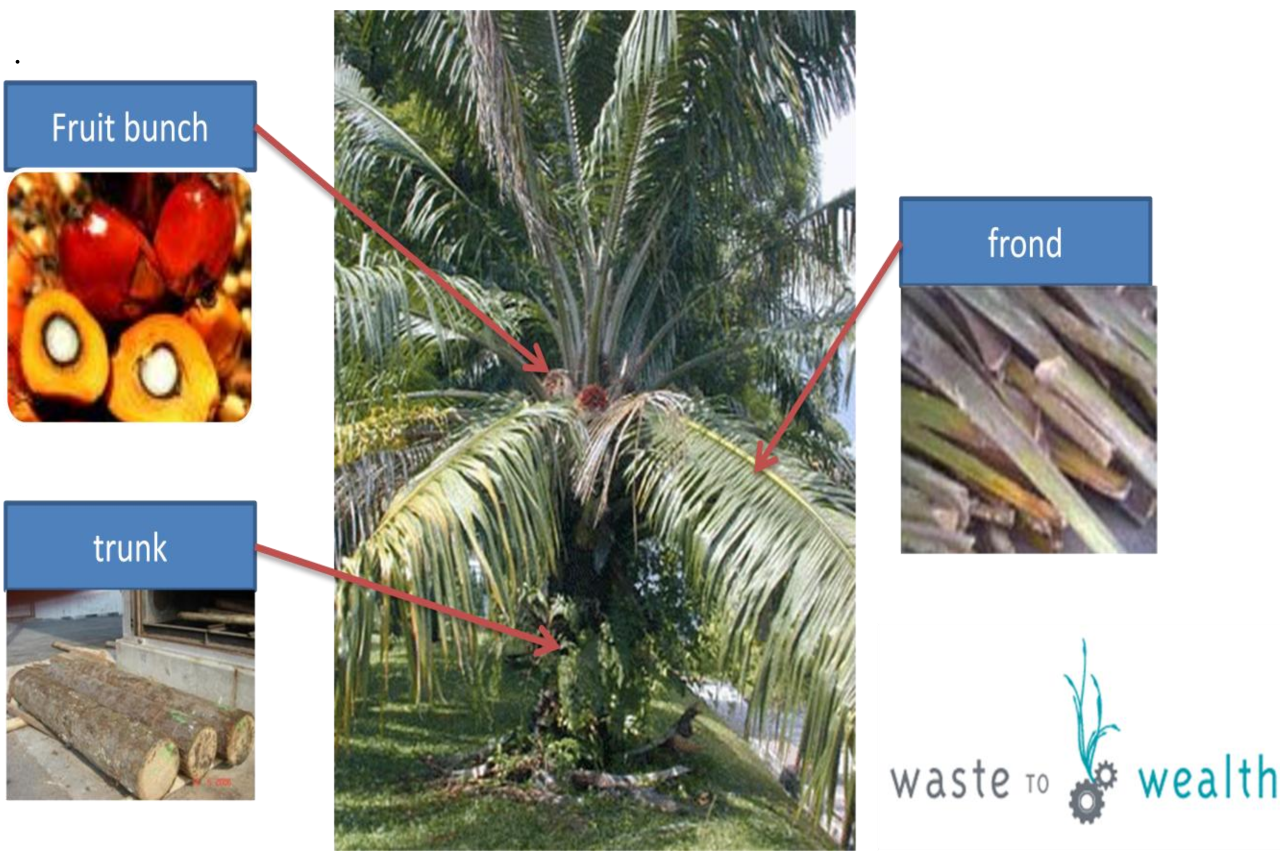

Figure 2.1: Oil Palm Tree

Table 2.1: Oil Palm Planted Area: 1997-2007 (Hectares)

Year	P. Malaysia	Sabah	Sarawak	Total
1990	1,698,498	276,171	54,795	2,029,464
1991	1,744,615	289,054	60,359	2,094,028
1992	1,775,633	344,885	77,142	2,197,660
1993	1,831,776	387,122	87,027	2,305,925
1994	1,857,626	452,485	101,888	2,411,999
1995	1,903,171	518,133	118,783	2,540,087
1996	1,926,378	626,008	139,900	2,692,286
1997	1,959,377	758,587	175,125	2,893,089
1998	1,987,190	842,496	248,430	3,078,116
1999	2,051,595	941,322	320,476	3,313,393
2000	2,045,500	1,000,777	330,387	3,376,664
2001	2,096,856	1,027,328	374,828	3,499,012
2002	2,187,010	1,068,973	414,260	3,670,243
2003	2,202,166	1,135,100	464,774	3,802,040
2004	2,201,606	1,165,412	508,309	3,875,327
2005	2,298,608	1,209,368	543,398	4,051,374
2006	2,334,247	1,239,497	591,471	4,165,215
2007	2,362,057	1,278,244	664,612	4,304,913

Source: Department of Statistics, Malaysia: 1975-1984

MPOB: 1985-2007

2.2 Biomass

It is reported that Malaysia produces 30 million tons annually of oil palm biomass, including trunks, fronds, and empty fruit bunch (MPOB, 2001). Biomass is an important contributor to the world economy. Malaysia is the largest producer and exporter of palm oil in the world with market share of about 50 and 58 percent, respectively (Nasir,2003). In 1997, Malaysia produced about 13.2 million tons of oil palm biomass including trunk, fronds, and empty fruit bunches (Kamaruddin et.al., 1997). Despite the huge production of oil palm production, oil consists of only a minor fraction of the total biomass produced in the plantation. The remainder consist huge amount of lignocellulosic materials in the form of fronds, trunks and empty fruit bunches. Therefore, a lot of waste from oil –palm biomass produce make it cannot be handle properly and give a lot of side effect to the environment and the country. The burn method has been replaced by the no-burn technique, which is both environmentally friendly but cause a lot of problem to the plantation (Noor, 2003).

Biomass is an important contributor to the world economy. Today, various forms of biomass energy are consumed all over the world. Biomass provides a clean, renewable energy source that could dramatically improve the environment, economy and energy security. In developing countries, the use of biomass is of high interest, since these countries have economy largely based on agriculture and forestry. The use of these materials will depend on the state of the art of safe economic technologies which are able to transform them into manageable products (Sensoz et al., 2006). At present the palm oil industry generates the most biomass from the oil extraction process such as the mesocarp fiber, shell, empty fruit bunch (EFB) and palm oil mill effluent (POME). About 9.9 million tons of palm oil wastes are generated every year in Malaysian alone, and this keep increasing at 5% annually (Yang et al., 2006).

Biomass may vary in its physical and chemical properties due to its diverse origin and species. However, biomass is structurally composed of cellulose, hemicellulose, lignin, extractives and inorganic (Husin, Ridzuan, 2002).

2.2.1 Properties and Composition of Biomass

The chemical composition of biomass is very different from that of coal oil, oil shales, etc. The presence of large amounts of oxygen in plant carbohydrate polymers means the pyrolytic chemistry differs sharply from these other fossil feeds. Plant biomass is essentially a composite material constructed from oxygen-containing organic polymers. The major structural chemical components with high molar masses are carbohydrate polymers and oligomers and lignin. Minor low-molar-mass extraneous materials mostly organic extractives and inorganic minerals are also present in biomass. The major constituents consist of cellulose (a polymer glucosan), hemicelluloses (also called polyose), lignin, organic extractives, and inorganic minerals. The high silica content causes difficulties in cutting and chipping of the biomass into desired shapes and sizes (Husin et al., 2000). The outline of general components in plant biomass is given in Figure 2.2 below.

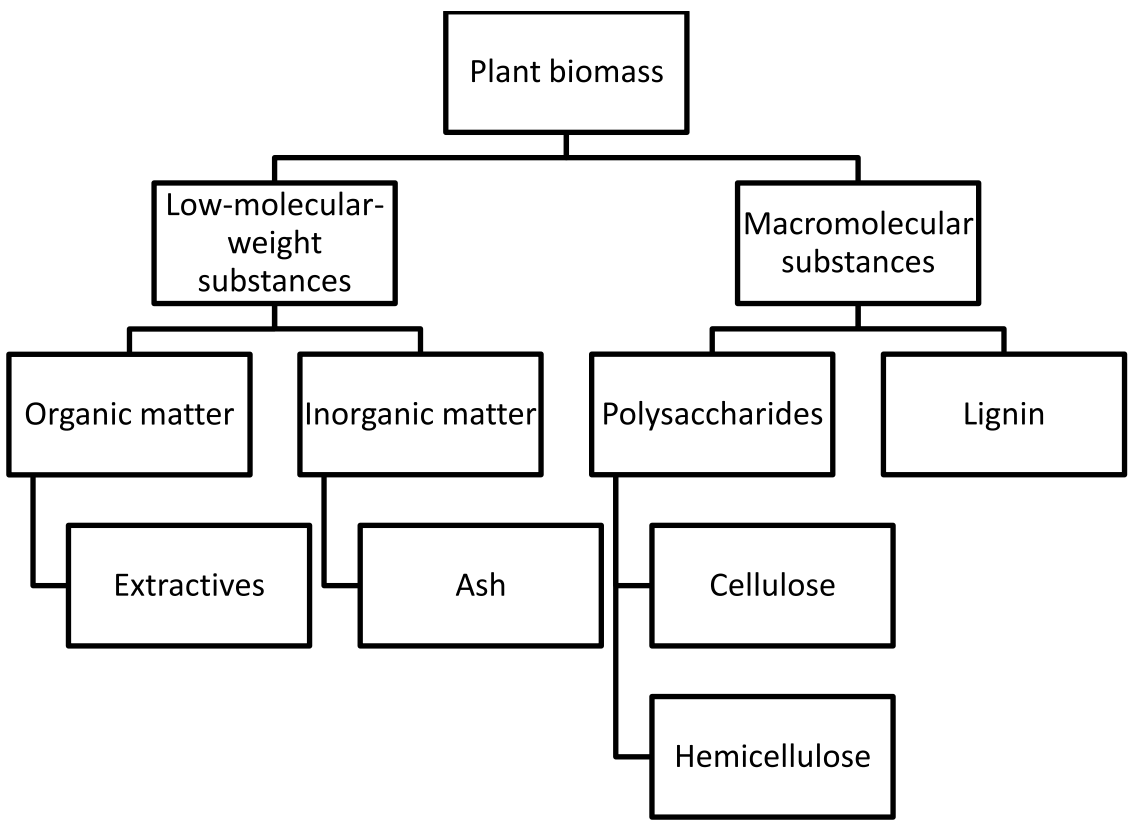

Figure 2.2: General components in plant biomass

2.2.2 Characteristics of Oil Palm Biomass

Oil palm biomass contains quite significant amount of organic nutrient, which contributes to its fertilizer values such as the data below.

Oil Palm Biomass	Dry matters (tonne / hectare)	Nutrient (kg / hectare)			
		N	P	K	Mg
Trunk	75.5	368.2	35.5	527.4	88.3
Fronds (replanting)	14.4	150.1	13.9	193.9	24.0
Fronds (pruning)	10.4	5.4	10.0	139.4	17.2
Empty fruit bunches	1.6	107.9	0.4	35.3	2.7

Table 2.2: Nutrient composition of oil palm biomass

Basically, the oil palm biomass contains about 18 – 21% of lignin, and 65-80% of holocellulose (a-cellulose and hemicellulose), which are more or less comparable with that of other wood or lignocellulosic materials (Table 2.3). This makes the oil palm biomass is also suitable as a raw material for the production of pulp and paper, composites, carbon products and chemicals extraction. The thin-walled parenchyma cells must collapse that aided in fiber bonding and contributing to the tensile strength (Sarwar et al., 2007).

	Oil palm trunk	Oil palm frond	Empty fruit bunch
Lignin	18.1	18.3	21.2
Hemicellulose	25.3	33.9	24.0
α-cellulose	45.9	46.6	41.0
Hollocellulose	76.3	80.5	65.5
Ash	1.1	2.5	3.5
Alcohol Benzene solubility	1.8	5.0	4.1

Table 2.3: Proximate analysis of biomass of oil palm biomass (%, dry weight)

The cell walls of all plants contain fibers of cellulose, an organic material known to chemical as a linear polysaccharide (Desch, 1981). The fiber length of both OPT and OPF is intermediate between hardwood and softwood, this characteristic is affected by high fines (parenchyma) content: parenchyma contents in trunk and frond are about 50 % and 30% respectively, versus about 5% in the EFB.

	EFB	FROND	TRUNK	HARDWOOD	SOFTWOOD
Length weighted avg. fiber length (mm)	0.67	1.03	1.37	0.83	2.39
Width of fiber (µm)	12.5	15.1	20.5	14.7	26.8
Width of lumen (µm)	7.9	8.2	17.6	10.7	19.8
Runkel ratio	0.59	0.84	0.26	0.37	0.35
Area of fiber (µm)	75.6	126.2	86.7	79.0	256.1

Table 2.4: Morphological properties of fibers from oil palm, hardwood and softwood.

2.3 Wood Pulp and Paper History

Paper consumption is continuously increasing across the world. World paper consumption was about 300 million tonnes in 1996–1997 and is expected to rise above 400 million tonnes by the year 2010 (Hurter and Riccio, 1998). Malaysia has a total capacity pulp and paper production around 1 million T/year and is a net importer of pulp, paper, and paper board, and progressively tends to decrease its dependency. However, the self-sufficiency is growing at a slow rate. All the paper mills of the country are small by the world industry standards, none producing more than 300 000 T/Year. The Malaysian pulp and paper industry is heavily dependent on imported fiber, particularly virgin pulp, and is also facing the need to find a new source of fiber to strengthen and retain the quality of secondary fibers as the use of recycled paper is growing in Malaysia. As for the other wood-based Malaysian industries, further development of integration of downstream activities is highly promoted. Malaysia has a rather weak pulp and paper industry, which production does not fulfill the domestic consumption. There are 67 paper mills producing more than 50 T/day (any kind of traditional, recycled, and special papers), out of which 19 small paper manufacturing companies using wood fiber, which includes one integrated pulp and paper mill located in Sipitang, Sabah (Sabah Forest Industries) (Roda and Santosh, 2006). Forest of the world contains great number of species, which is divided into two groups: coniferous trees, usually called softwoods and deciduous trees or hardwoods (Casey, 1981). Cellulose pulp for papermaking purposes is obtained largely from wood (55%), non-wood plants (9%) and recovered paper (36%) (Jimenez et al., 2009).

Malaysia Pulp Production & Consumption

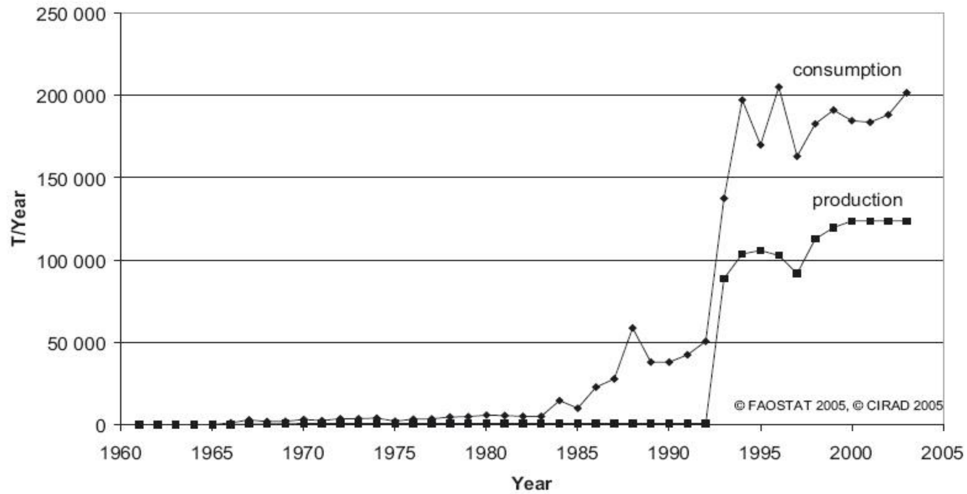

Figure 2.3: Malaysia pulp production and consumption

Malaysia Paper Production & Consumption

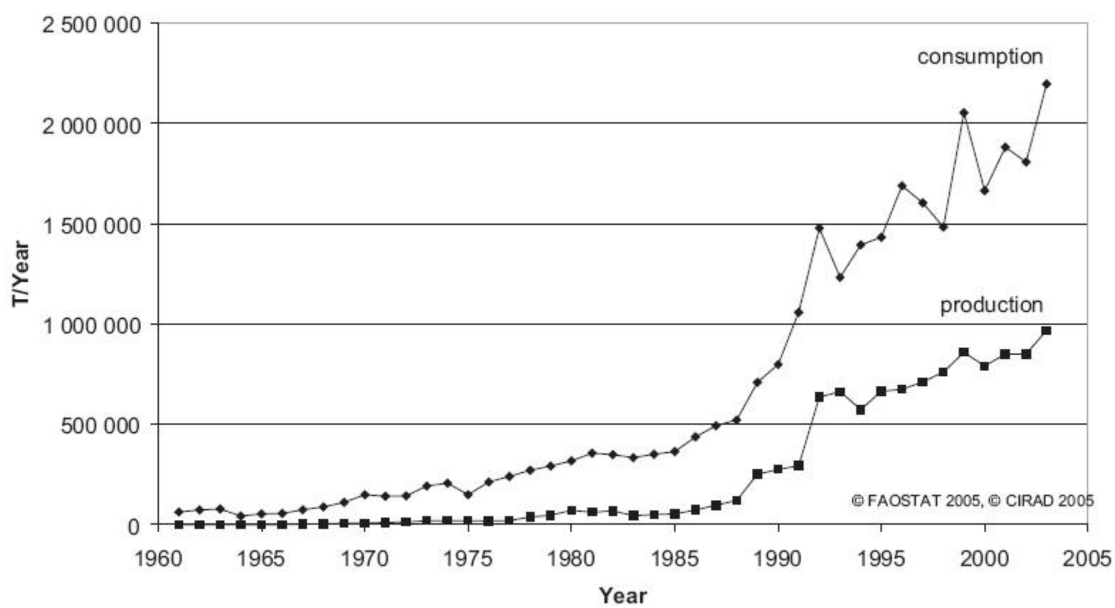

Figure 2.4: Malaysia paper production and consumption

2.4 Effect of Beating Process

Beating is the most important physical treatment carried out on pulp before papermaking; it highly affects the physical properties of the prepared paper sheets. Beating is used to modify the surface of the fiber so that it can increase the inter-fiber bonding between single fibers more tenaciously. Beating makes the fiber soft, flexible through fibrillation and increase the surface area of the fiber to absorb water and make bonding between fibers (Ibrahem et al., 1989).

Many factors affect beating such as pH of pulp slurry, electrolyte concentration, consistency, beater design, beating load, beating speed and time of beating. Also the component of pulp plays an important role during beating. The presence of hemicellulose during beating improves beating characteristics and increases fiber adhesion (Ibrahem et al., 1989). Beating of the pulp is interesting because it influences on various pulp properties such as freeness, specific surface area, specific volume, surface charge, total charge and elastic modulus, that they really improve the stretch properties of paper sheets (Jimenez, 2009).

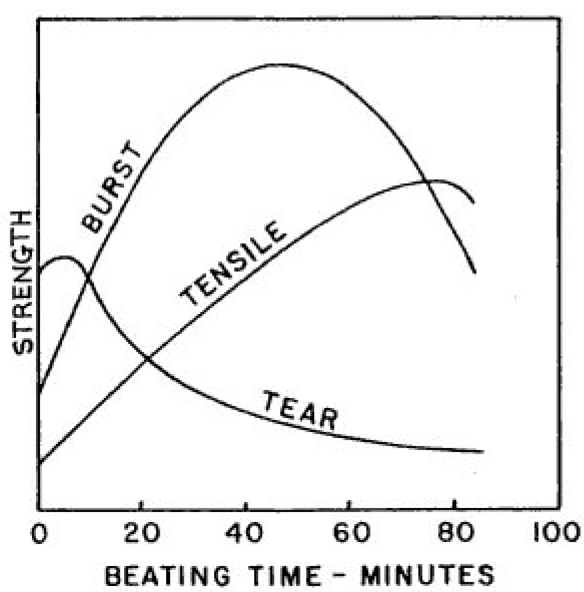

Figure 2.5: Effect of beating time