Kenaf as a Source of Paper Pulp

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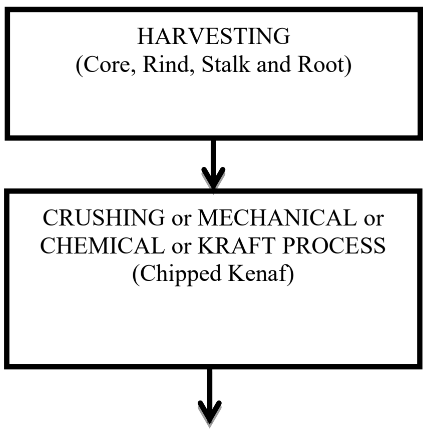
***Abstract*— This paper was an experimental project where it was done to determine whether kenaf plant was actually could be used as a source of paper pulp or not. A few tests had been discovered to know whether kenaf was suitable or not. Characterization of the kenaf had been done by determine the moisture content, ash content and also extractives from the kenaf. From the extractives, the percentage of holocellulose and α-cellulose were obtained. A calculation of kappa number was used to determine the yield quality. The test of the yield strength of the pulp was divided into three tests; burst index, tensile index and tear index.**

Keywords*— Kenaf, Pulping, Kappa number, Tear index, Tensile index, Burst index and Strength properties.

I. INTRODUCTION

Trees have been used as the raw materials to make paper since centuries ago. Many types of trees have been used for the paper industry; for softwoods are spruce, pine, fir, larch and hemlock, for hardwoods are eucalyptus, popular, aspen and birch. All the paper industry's people keep on researching for trees that can be cut down and make it as the source of paper pulp. That is why deforestation keeps on increasing all over the world including Malaysia where in 2006, 76.3% of the land area was under forest but in 2009, only 62% the green in Malaysia [8]. For three years, for about 14% of land area has been cut off and the reforestation process takes years to grow. New alternatives need to be done in order to increase the forest in Malaysia and makes it greener again [7].

For ordinary process of paper making, there are many processes involved in it. It will start with the harvesting of the tree or their own raw materials followed by the chipping and de-barking process where the woodchips can be obtained in order to use for the next process. It will be continued by the chemical pulping and mechanical process. In order to remove the lignin which is bind with the cellulose these are the example of chemicals that has been used; soda and sodium sulfide or sodium hydroxide with slightly high temperature, 70-90°C. The mechanical pulping process is working at the same time with the chemical pulping process where mechanical pulping has differ process but with the same objective as the chemical pulping. The mechanical pulping process is using water lubricated rotating stone to softens the lignin binding fibres and the mechanized forces separate the fibres. The modern technology in the 20th century now, they heat it up to pre-softened the woodchips that is called thermo-mechanical pulp (TMP). After that, the fibre that has been collected will be bleached or cleaned. The bleaching process is a process where the paper that will be produced in a white color. The chemical that actually used in bleaching process is chlorine dioxide, oxygen, ozone and hydrogen peroxide. Then the process is followed by the refining process and the water removal of the fibres. There will be a pressing section where the it will lowered the water content in it and the paper will be done after the drying process in about 100°C [5].



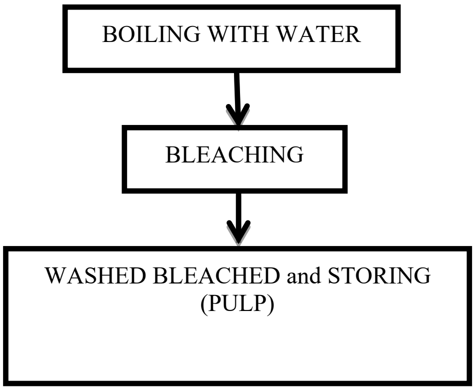


Figure 1: Flowchart the general process of paper [1]

Advantages of Kenaf plants compare to usual trees [2]:

- Kenaf pulping need less use of chemicals.
- Kenaf pulping consumes less energy than wood pulping (Kenaf lignin content is lower).
- Another advantage of Kenaf over wood is its higher rate of production in terms of tons of biomass for land/time units.
- Growing Kenaf in the tropics offers high flexibility to the industry management: while trees growing cycle is 10 – 25 years, Kenaf growing cycle is 4 – 6 months

II. METHODOLOGY

A. Materials

The kenaf plant was undergo the process of grinding and crushing whereas it would be in a solid chipped form. For this project, the kenaf plant sample was already grinding to be used in the laboratory scale procedure. The sample was obtained from UPM where they were the leading in kenaf research. The sample would undergo another two processes that had been identified the major process to synthesis this pulp out.

B. Experimental

The samples would go through screening process, using sieve machine through a slit screen of 400mm. The moisture content (T 264 cm-07) will be determined with the ash content (T 211 om-02) of the kenaf. In determining moisture content, the kenaf would be oven-dried at 105°C ± 3 °C for two hours or more. For the ash content, a 100 g of kenaf was weighed and heated in a furnace at about 100°C then raised the temperature until 525 ± 25 °C where the sample became carbonized without flaming. The sample was weigh until the weight of the sample became constant.

After that, the selected sample would undergo a pulping process with different cooking time and different concentration NaOH (sodium hydroxide) (TAPPI T-207 cm-99 and TAPPI T 212 om-98). The cooking time was start with 90 minutes, followed up by 180 minutes and 300 minutes. There were also three concentrations of NaOH; 16%, 21% and 26%. The pulp was screened through and washed thoroughly by using water. Then, the pulp would be dried inside an oven for 105°C with the time of 1 hour to 2 hours approximately until the pulp dried.

The extractives (T 204 cm-07) process was using the soxhlet apparatus where acetone was the solvent to extract the sample. The extractives process should be more than 24 extractions over a period of four hour. The extractives obtained will show the percentage of holocellulose and α-cellulose (T 203 cm-99). The kappa number (T 236 om-99) was determined by calculation and performed according to TAPPI test methods.

For evaluation of the pulp, the pulp will be tested [3]:

- The burst index (T-494 om-01)
- Tensile index (T-414 om-98)
- Tear index (T-403 om-97)

The tensile testing of the pulp was determined by using the tensile machine inside the strength of properties laboratory at mechanical engineering faculty. The stress is increasing until the point of failure was reached and the pulp would fail and rupture. The machine would determine the tensile index. For the bursting test was to determine the burst index by using the Mullen Test. It was involving to the clamp the pulp between two steel plates where the plates had two circular openings and a rubber diaphragm that would bulging and burst the pulp. The tearing test method was experimented by the Elmendorf method.

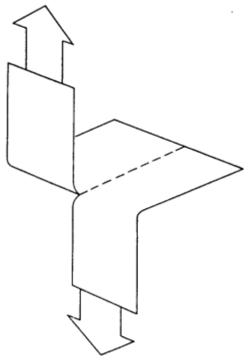


Fig 2: The elmendorf tearing mode

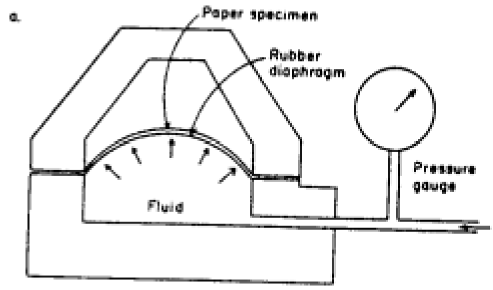


Fig 3: The Schematic bursting test apparatus

III. RESULTS AND DISCUSSION

A. Moisture content

Reading (g)	**1**	**2**	**3**
	67.610 67.240 67.278 67.376 67.632 67.335	68.080 67.795 67.765 67.340 67.388	67.508 67.450 67.499 67.504 45.349
Total Reading	404.471	338.374	315.31
After Dried	38.036	28.514	26.429
Moisture percentage (%)	90.6	91.57	91.62

Fig 4: The moisture percentage loss

From the result of the table, the moisture percentage was the moisture percentage that had loss. So the average moisture percentage that had loss is 91%. The percentage contain inside the kenaf was only 9%.

Fig 5: The oven use to oven-dried the kenaf

B. *Ash Content*

Reading	1	2	3
	34.7610	34.7607	34.7611
	32.7645	34.3433	34.3543
	32.7264	34.3393	34.3442
	32.7043	34.3384	34.3343
	32.7022	34.3245	34.3205

Fig 6: The ash content for every 1 hour after the first 3 hours

The value of the ash content would be obtained until the reading was constant. The first reading was 32.7 g. The second and the third reading had the same value of 34.3 g. The typical percentage value for commercial wood pulp was in a range of 0.3-0.5% carbon contains. For kenaf, the average percentage carbon contains was 2.8%.

Fig 7: The furnace for the ash content of pulp

C. *Holocellulose and α-cellulose contains*

Holocellulose were containing cellulose and hemicellulose where it could be determined by weighing it in after the process. The calculation was done and the holocelluose will be further used to obtain the α-cellulose. The sample would be weigh until it reach constant weight. The table, figure 4 below showed the percentage of holocellulose and α-cellulose obtained.

Holocellulose (%)	α-cellulose (%)
81	43

Fig 8: The percentage of holocellulose and α-cellulose inside kenaf

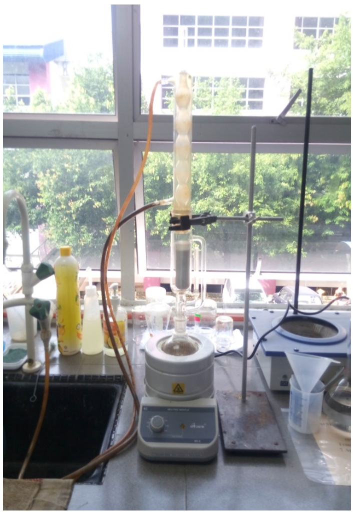


Fig 9: Soxhlet apparatus for the determination of extractives for hemicellulose and α-cellulose

D. *Kappa Number*

Cooking time (mins)	Alkali concentration(%) (NaOH)		
	16	21	26
90	16.9	13.5	9.6
180	20.1	16.7	12.8
300	23.3	19.9	16.0

Fig 10: The kappa number of the pulp with different concentration of alkali concentration or active alkali

From figure 5, the kappa number was different from each pulping with different sodium hydroxide (NaOH) concentration. These were the results obtained that shows that the alkali active and cooking time give a significant impact on the hemicellulose content and lignin content. The pulping with less active alkali would give pulps high kappa number and contained too much uncooked material that was difficult to disintegrate and impossible to make handsheets. So the minimum active alkali chosen for the pulps was 16% where 26% is slightly high and the maximum. 16% NaOH concentration had shown that the lignin within the wall not sufficiently removed as indicated by the high number of Kappa. 21% and 26% active alkali had been chosen in order to determine the decreased in Kappa number and increasing in pulp yield. Pulping by using 21% of active alkali almost eliminates all cellulosic matter and 26% was the maximum because cellulose will disintegrate more. Further addition of active alkali may not be significant because of no more cellulosic matter.

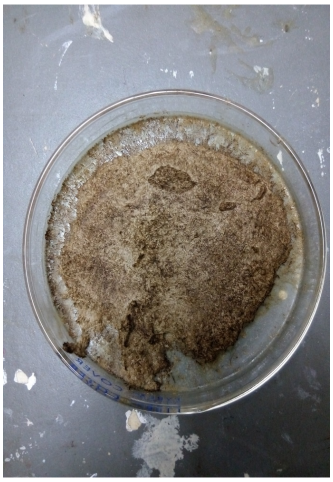


Fig 11: The pulp that produce after the process

E. *Pulp properties and Yield Strength*

Properties	**Active Alkali**		
	16	**21**	**26**
Density (g/cm^2)	0.47	0.51	0.50
Pulp Yield (g)	44.8	48.8	51.4
Tear Index (mN.m^2/g)	29.10	28.80	28.57
Tensile Index (N.m/g)	80.05	78.01	78.00
Burst Index (kPa.m^2/g)	4.90	4.85	4.80
Stretch (%)	2.02	2.00	2.01

Figure 12: The strength properties of kenaf with different active alkali concentration

The pulp with 16% active alkali had the strongest tear index (29.10) followed by 21% and 26% active alkali. This was probably due to the difference in the cooking time.

In overall, the strength properties of kenaf in high percentage active alkali will give a better pulp because of the high bonding ability. It also may be suitable for the blending with the short fibered raw materials in order to improve the physical properties.

IV. CONCLUSION

The pulping process with the high percentage of active alkali will give better yield properties in strength using the most suitable percentage that was 21%. The moisture content gives a promising value of 9% where it is in range of commercial wood pulp (±10%) [4]. The contain of cellulose inside the kenaf is almost equal to the hardwood composition and has lower lignin contain. It was shown that kenaf pulp was suitable for the production of paper because of the good pulping properties and good strength properties equal to the hardwood raw materials [9].

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