DEVELOPMENT OF HIGH QUALITY PRINTING PAPER USING KENAF (*HIBISCUS CANNABINUS*) FIBERS

By

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DEVELOPMENT OF HIGH QUALITY PRINTING PAPER USING KENAF (*HIBISCUS CANNABINUS*) FIBERS

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Kenaf (*Hibiscus cannabinus*) is an annual non-wood plant which has shown great potential as an alternative source of papermaking fiber. The purpose of this research was to investigate the suitability of Malaysian cultivated kenaf fibers in the production of high quality printing paper.

The first part of the research characterized the chemical, morphological and pulping properties of kenaf fractions. The bast fibers had a lower lignin content, higher cellulose content, and lower hemicellulose content compared to the core fibers. The whole stem kenaf had lower lignin and cellulose content, and hemicellulose and ash content was comparable to softwood. Fiber morphology results showed that kenaf bast fibers were

long and slender, while the core fibers were much shorter and wider. Morphology and chemical analysis indicated that bast and core fibers were significantly different.

In this part, the pulping properties of different fractions of kenaf were also studied. The pulping experiments led to the conclusion that bast fibers are relatively easy to delignify during pulping, followed by the whole stem and the core kenaf fractions. An unbleached whole kenaf pulp with high viscosity, good bleaching characteristics and relatively good yield could be produced with the kraft pulping process.

The second part of the research investigated the production of bleached pulp using environmentally-friendly method, TCF. Conventional Elemental Chlorine Free (ECF) bleaching sequences were also used to compare the results with the TCF sequences. The results indicated that in contrast to unbleached kraft wood pulps, kraft kenaf pulps can be easily bleached to a brightness of 91.4% using a 4-stage TCF [$Q_1(PO)Q_2P$] bleaching sequence. This will be a significant advantage for kenaf over wood.

The third part of the research studied the polymer deposition, surface topography and printability. The utilization of chitosan in sizing improved the paper strength and surface properties significantly, but its effectiveness was strongly dependent on the method of addition and concentration. Spray deposition application gave superior strength properties followed by equilibrium adsorption. It is less effective under alkaline conditions. The effect of chitosan was compared with cationic starch and polyvinyl alcohol (PVA). Sizing quality of cationic starch fairly matched with the sizing quality of chitosan, however, it

was able to reduce the water absorption potential of paper more than chitosan at a same concentration (i.e. 2%).

The final part of study demonstrated that the use of chitosan in optimum dosage could improve the printability and print quality of kenaf paper in terms of surface roughness, water and oil absorption, ink penetration, print density, ink set-off and gloss contrast for offset printing.

The overall conclusion is that whole stem kenaf is an attractive raw material that is suitable for use in the production of high quality printing paper in areas where forest resources are inadequate to supply a kraft mill of economic size. Chitosan is recommended as an additive in conventional surface sizing to enhance strength and surface properties for printing paper.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN KERTAS CETAKAN YANG BERKUALITI TINGGI MENGGUNAKAN GENTIAN KENAF (*HIBISCUS CSNNABINUS*)

Oleh

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Kenaf (*Hibiscus cannabinus*) adalah sejenis pokok tahunan bukan kayu yang berpotensi untuk menjadi sumber pilihan bagi gentian didalam pembuatan kertas. Tujuan kajian ini adalah untuk menyiasat penghasilan kertas cetakan yang berkualiti tinggi dari kenaf (*Hibiscus cannabinus*) dengan.

Bahagian pertama kajian menerangkan sifat-sifat kimia, morfologi dan mempulpa bagi bahagian pokok kenaf. Gentian 'bast' mempunyai kandungan lignin yang rendah, kandungan selulos yang tinggi dan kandungan hemiselulos yang rendah berbanding

dengan gentian teras kenaf. Keseluruhan batang kenaf mengandungi lignin dan selolos yang rendah, dan kandungan hemiselulos dan abu yang lebih kurang sama berbanding kayu conifer.

Hasil gentian morfologi menunujuk bahawa gentian 'bast' bagi kenaf adalah panjang dan pipih, manakala gentian teras pula pendek dan lebar. Analisis morfologi dan kimia menunjukan bahawa gentian 'bast' dan gentian teras adalah berbeza.

Dalam bahagian ini, sifat mempulpa bagi bahagian kenaf yang berlainan juga dikaji. Ujian mempulpa memberi kesimpulan bahawa gentian 'bast' mudah dilignifikasi semasa proses mempulpa diikuti dengan keseluruhan bahagian dan bahagian teras kenaf. Pulpa kenaf tidak diluntur mempunyai sifat viscosity tinggi, sifat pelunturan yang baik dan peratus hasil yang baik melalui proses mempulpa kraft.

Bahagian kedua bagi penyelidikan ini menyiasat tentang penghasilan pulpa yang diluntur dengan mengguna kaedah mesra alam. Peraturan melumtur konvesional Elemental Chlorine Free (ECF) telah digunakan untuk membuat perbandingan hasil dengan kaedah TCF. Hasil menunjukan bahawa keseluruhan gentian kenaf dapat diluntur dengan mencapai kertas yang cerah dengan menggunakan proses TCF dan ECF. Nisbah cerah bagi TCF adalah lebih baik dari kaedah ECF. Keputusan pelunturan menunjukan bahawa pulpa kenaf boleh diluntur mencapai kecerahan 91.4% (ISO) dengan menggunakan 4-peringkat pelunturan TCF [$Q_1(PO)Q_2P$]. Ini merupakan pencapaian baik bagi kenaf berbanding dengan gentian kayu.

Bahagian ketiga bagi kajian ini berkaitan dengan pempolimeran dan sifat percetakan. Kegunaan chitosan, cationic starch dan polyvinyl alcohol (PVA) sebagai aditif untuk menambah baik sifat permukaan kertas tertakluk kepada kepekatan dan kaedah yang digunakan. Hasil kajian menunjukan dengan jelas bahawa penambahan chitosan kepada pulpa daripada gentian yang telah dipukul dapat menambah kekuatan yang baik, berbanding dengan penambahan aditif yang lain. Ini dapat dilihat dengan peningkatan nilai kekuatan koyak, tensil dan pecah. Kesan dari chitosan telah dibandingkan dengan cationic starch dan PVA. Kualiti cationic starch bersamaan dengan kualiti chitosan. Walaubagaimanapun, ia dapat mengurangkan potensi keserapan air oleh kertas berbanding chitosan pada kepekatan yang sama (iaitu 2%).

Bahagian terakhir kajian menunjukan bahawa kegunaan chitosan didalam dos yang berpatutan dapat menambah daya dan kualiti cetakan kertas kenaf dari segi kekasaran permukaan, penyerapan air dan minyak, penyerapan dakwat, kepadatan cetakan dan kelincinan bahan percetakan.

Secara keseluruhannya, kenaf merupakan bahan mentah yang berpotensi untuk menghasilkan kertas cetakan yang berkualiti tinggi. Chitosan juga mempunyai potensi yang baik untuk digunakan sebagai ‘sizing’ permukaan bagi menambah kekuatan dan sifat permukaan kertas cetakan.

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I certify that an Examination Committee met on 30th December 2004 to conduct the final examination of Alireza Ashori on his Doctor of Philosophy thesis entitled "Development of High Quality Printing Paper using Kenaf (*Hibiscus cannabinus*) Fibers" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

_____

ALIREZA ASHORI

Date: 28 January 2005

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LIST OF ABBREVIATIONS

3D	Three-dimensional
a.d.	Air-dried (weight)
pka	Electrostatic potential
ANOVA	Analysis of variations
AOX	Absorbable organic halogens /halides
BDT	Bone-dry tonne
BOD	Biochemical (biological) oxygen demand
CED	Cupri-ethylenediamine
COD	Chemical oxygen demand
Consistency	Ratio of dry weight to wet weight (pulp)
cP	Centipoise
CSF	Canadian standard freeness
D	Chlorine dioxide (bleaching)
DP	Degree of polymerization
DS	Degree of substitution
DTPA	Diethylenetriamine penta-acetic acid
E	Alkaline extraction (bleaching)
ECF	Elemental Chlorine Free (bleaching)
EDTA	Ethylenediamine tetra-acetic acid
gsm	Grammage, g/m^2