



UNIVERSITI PUTRA MALAYSIA

**PROPERTIES OF KENAF (*HIBISCUS CANNABINUS* L.) FIBERS AND
HANDSHEETS FOR LINERBOARD PRODUCTION**

AHMAD AZIZI MOSSELLO

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FOR LINERBOARD PRODUCTION**

By

AHMAD AZIZI MOSSELLO

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Fulfilment of the Requirements for the Degree of the Doctor of Philosophy

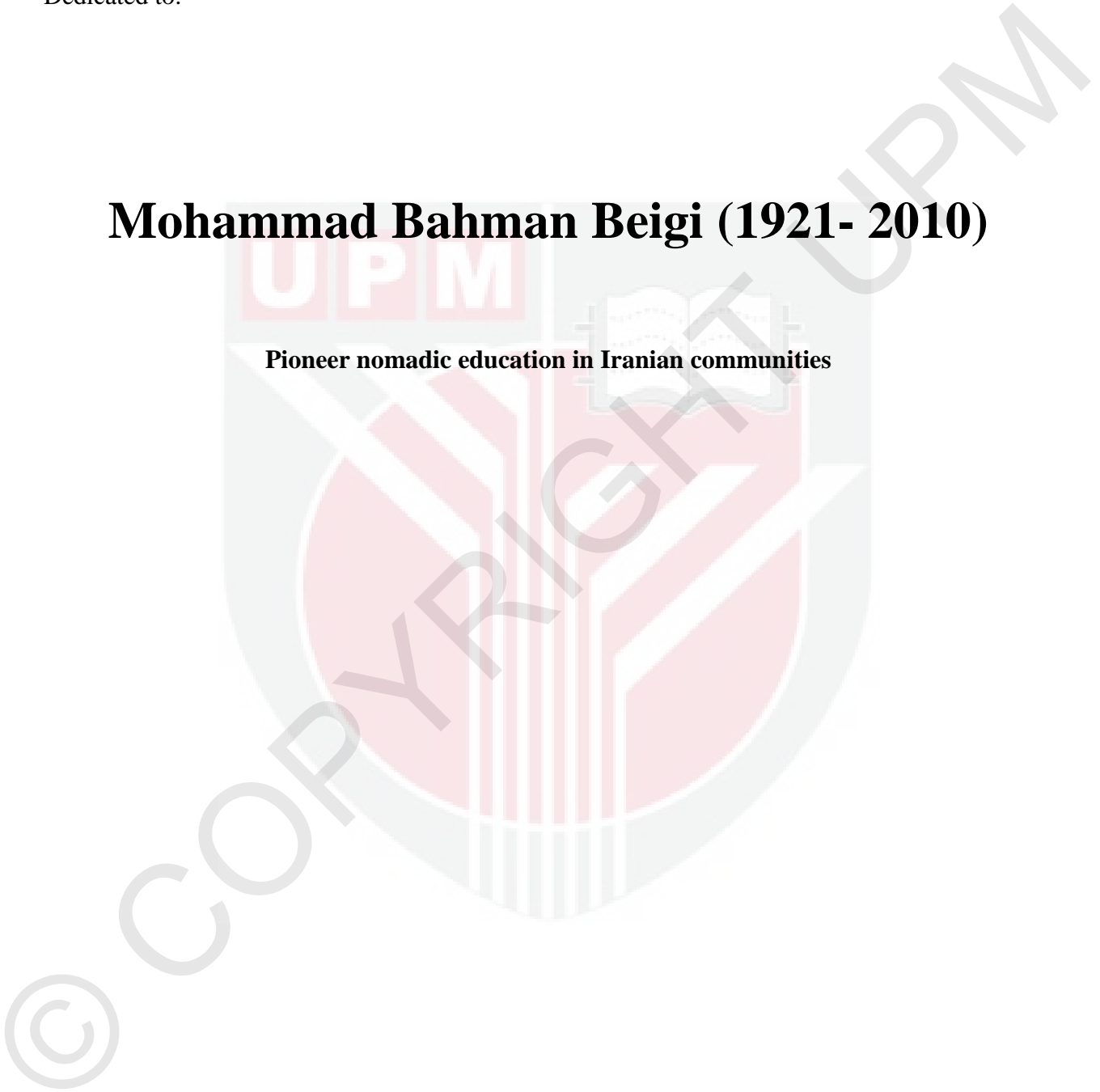
December 2010

DEDICATION

Dedicated to:

Mohammad Bahman Beigi (1921- 2010)

Pioneer nomadic education in Iranian communities



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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December 2010

Chairman: Assoc. Prof. Jalaluddin Harun, PhD

Institute: Institute of Tropical Forestry and Forest Products (INTROP)

In Malaysia, almost 50% of the total paper consumption comes from packaging paper such as kraft liner and medium corrugater. However, there is no local production of kraft pulp in Malaysia and this poses the highest potential for imports. On the other hand, the government of Malaysia has actively encouraged the paper and paperboard industry to enhance self-sufficiency. The insufficiency in the supply of fiber for papermaking has necessitated the paper industry to search for alternative fiber. Kenaf has been identified as one of the potential sources for pulp fibers and some research have been carried out on locally available kenaf in the production of pulp and paper. The study was done in four steps to evaluate the suitability of Malaysian cultivated kenaf for linerboard production. First, the chemical and morphological properties of kenaf fractions were characterized. The chemical and morphological analysis indicated that bast and core fibers were significantly different. The core fraction with short and wide fibers had

higher lignin, hemicelluloses and lower cellulose compared to the long and slender fiber in the bast fractions. In the second step, the pulping properties of different fractions of kenaf (core, bast, and whole stem) were studied. The pulping result showed that kenaf fractions gave high pulp yield (54.2-58.4%) with environment friendly soda-AQ pulping process at mild cooking condition. In comparison to core fibers, bast fibers were relatively easy to delignify and produced paper at higher freeness, lower drainage time and lower strength properties except for tear index. Moreover, due to higher freeness and lower drainage time, bast fibers had the potential to develop strength. Core pulp due to very low freeness and high drainage time was used as unbeaten pulp. Whole stem kenaf showed intermediate properties between core and bast. In the third step, pulp fractionation and sequence selective process was carried out as a new approach to use kenaf whole stem for paper and paperboard production. The result showed that fractionation and sequence selective process made a good opportunity to better beating and fibrillation long fiber at higher level of PFI revolution and remixing with unbeaten short fiber and produced paper with significantly higher strength and better drainability than unfractionated beaten whole stem. In the final part of this study, kenaf whole stem pulps were used to improve old corrugated containers board (OCC). The blending experiments led to the conclusion that fractionated pulp had better effect in the improvement of OCC than unfractionated pulp. In this part, kenaf whole stem pulps were compared to unbleached softwood kraft pulp and mechanical treatment (beating) to improve OCC. The result showed that addition 5-10% fractionated whole stem or unbleached softwood kraft pulp improved OCC properties same as when it was beaten with 2000 PFI revolution. Nonetheless, with better tear index and drainability. The overall conclusion is that, using whole stem, rather than separating the kenaf into bast and core fractions may reduce fiber supply costs for kenaf significantly which would represent a problem for the

commercialization of the raw material. The extra processing steps involved in separation and pulping keeps kenaf from competing effectively with wood. The results discussed above demonstrate that most respects (strength properties and drainability) the whole stems are good for linerboard production or OCC improvement when fractionation and sequence selective process is used to improve strength properties.



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

SIFAT-SIFAT GENTIAN DAN KERTAS DARIPADA KENAF (*HIBISCUS CANNABINUS L.*) UNTUK PENGELUARAN BODLINER

Oleh

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Disember 2010

Pengerusi : Prof. Madya. Jalaluddin Harun, PhD

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Di Malaysia, hampir 50% daripada jumlah penggunaan kertas datangnya daripada kertas pembungkusan seperti liner kraft dan *medium corrugate*. Walaubagaimanapun, ketiadaan pengeluaran tempatan bagi pulpa kraft di Malaysia meningkatkan potensi untuk mengimport bahan ini. Selain daripada itu, kerajaan Malaysia memberi galakan kepada industri kertas dan bodkertas supaya berupaya menghasilkan dan mengurangkan import, dan kekurangan bekalan gentian untuk pembuatan kertas telah merangsang industri kertas untuk mencari gentian alternatif. Kenaf telah dikenalpasti sebagai salah satu sumber berpotensi dan beberapa penyelidikan telah dijalankan berdasarkan keupayaan perolehan kenaf tempatan dalam penghasilan pulpa dan kertas. Kajian ini telah dijalankan dalam empat langkah untuk menilai kesesuaian kenaf Malaysia untuk penghasilan bodliner. Pertama, sifat-sifat kimia dan morfologi bahagian kenaf telah dikaji. Analisis kimia dan morfologi mendapati gentian kulit dan stem adalah berbeza secara signifikan. Pecahan stem dengan gentian pendek dan lebar mempunyai kandungan lignin dan hemiselulosa lebih tinggi, selulosa lebih rendah berbanding gentian kulit yang lebih panjang. Dalam langkah kedua, sifat-sifat pempulpaan daripada bahagian-bahagian

kenaf yang berbeza dikaji. Keputusan pulpulpaan telah menunjukkan kenaf menghasilkan hasil pulpa yang tinggi (54.2–58.4%) menggunakan proses pulpulpaan soda-anthraquinon (soda-AQ) berpersekitaran sihat pada keadaan pemasakan sederhana. Berbanding dengan gentian stem, gentian kulit lebih mudah dinyahlignin dan menghasilkan kertas berkebebasan lebih tinggi, kadar aliran lebih rendah dan sifat-sifat kekuatan lebih rendah kecuali indeks koyakan, tetapi disebabkan oleh kebebasan lebih tinggi dan masa aliran lebih rendah maka ia berpotensi untuk dipukul dan meningkatkan kekuatannya. Disebabkan pulpa stem mempunyai kebebasan yang lebih rendah dan masa aliran lebih tinggi, ia digunakan sebagai pulpa terpukul. Kenaf stem telah menunjukkan sifat-sifat pertengahan di antara batang dan kulit. Dalam langkah ketiga, pemisahan pulpa dan proses pemilihan turutan telah dijalankan sebagai pendekatan baru menggunakan kenaf stem di dalam pengeluaran kertas dan bod kertas. Keputusan telah menunjukkan bahawa pemisahan dan proses pemilihan turutan memberikan peluang lebih baik untuk pemukulan lebih baik dan pemfibrilan gentian panjang pada paras revolusi PFI dan pencampuran semula dengan gentian pendek tak terpukul dan kertas terhasil mempunyai kekuatan yang lebih signifikan dan upaya alir lebih baik berbanding keseluruhan batang kenaf terpukul dan tanpa pemisahan. Di dalam bahagian akhir kajian ini, pulpa keseluruhan kenaf telah digunakan untuk memperbaiki kertas kotak terpakai (OCC). Eksperimen pencampuran (*blending*) membawa kepada kesimpulan bahawa pulpa yang dipisahkan memberikan kesan yang lebih baik untuk membaiki OCC berbanding pulpa tanpa pemisahan. Dalam bahagian ini, pulpa keseluruhan kenaf dibandingkan dengan pulpa kraft kayu lembut tidak terluntur dengan pemukulan untuk membaiki OCC. Keputusan menunjukkan tambahan kurang daripada 5-10% kenaf dengan pemisahan atau pulpa kraft kayu lembut tidak terluntur membaiki sifat-sifat OCC sama seperti pulpa yang dipukul dengan 2000 PFI revolusi, tetapi dengan indeks koyakan dan

kebolehan aliran yang lebih baik. Kesimpulannya, dengan menggunakan keseluruhan stem, daripada memisahkan kenaf kepada pecahan kulit dan stem boleh mengurangkan kos bekalan gentian kenaf secara signifikan yang mana merupakan masalah pengkomersilan bahan mentah ini. Langkah-langkah pemprosesan tambahan, dan kos tambahan dua pulpulpaan meletakkan kenaf berupaya bersaing dengan pemprosesan menggunakan sumber kayu. Sebagaimana data yang telah dibincangkan di atas menunjukkan bahawa dalam kebanyakan segi (sifat-sifat kekuatan dan kebolehan aliran) keseluruhan stem adalah lebih baik untuk pengeluaran bodliner atau pemulihan OCC apabila pemisahan dan proses pemilihan turutan digunakan untuk memperbaiki sifat-sifat kekuatan.

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I certify that a Thesis Examination Committee has met on 22nd December 2010 to conduct the final examination of Ahmad Azizi Mossello on his thesis entitled “ Properties of Linerboard from Kenaf (*Hibiscus cannabinus*) Fibers” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the University [P.U.(A) 106] 15 March 1998. The Committee recommends that that the student is awarded the Doctor of Philosophy.

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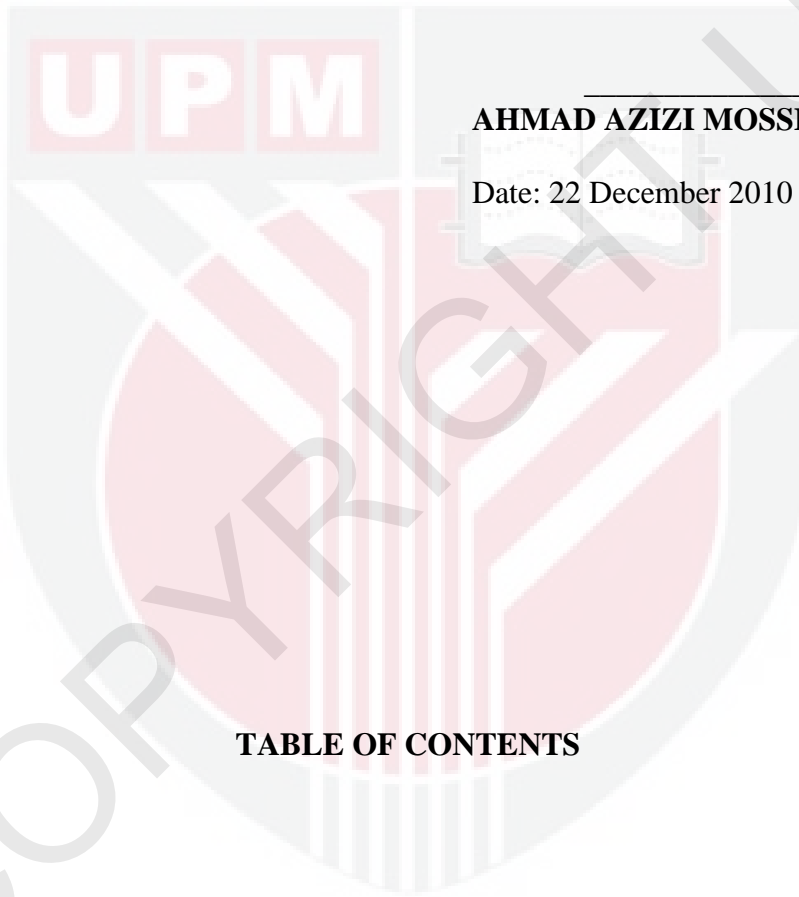
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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also, declare that is it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.





AHMAD AZIZI MOSSELLO

Date: 22 December 2010

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