



UNIVERSITI PUTRA MALAYSIA

**DEVELOPMENT OF MULTI-LAYERED KENAF (*Hibiscus cannabinus* L.)
BOARD USING CORE AND BAST FIBRES**

NOR HAFIZAH HJ. AB. WAHAB

IPTPH 2007 1



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By

NOR HAFIZAH HJ. AB. WAHAB

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
Malaysia, in Fulfilment of the Requirement for the Degree of Master of
Science**

January 2007



DEDICATE TO:

PARENTS

Hj. Ab. Wahab Bin Hassan
Hjh. Asiah Binti Daud

BROTHER

Khairul Anwar Bin Hj. Ab. Wahab

SISTERS

Zuraini Binti Hj. Ab. Wahab
Norlin Binti Hj. Ab. Wahab
Noorul Azura Shida Binti Rosman

NIECE

Sara Khadeeja Binti Khairul Anwar



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in
fulfilment of the requirement for the degree of Master of Science

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Chairman : Paridah Md. Tahir, PhD

Institute : Institute of Tropical Forestry and Forest Products

Kenaf (*Hibiscus cannabinus* L.) is relatively a new crop in Malaysia. This fast growing species has been chosen and introduced in Malaysia to ensure a continuous supply of raw material for the composite industry, and as alternative solution for the shortage in rubberwood supply.

An attempt was made to develop a multi-layered kenaf board (MLKB) utilising different parts of kenaf stem: bast, core and a combination of bast and core fibres. The objectives of this study were: 1) to evaluate methods of retting and separating of kenaf fibres (bast and core fibres) for kenaf board production, 2) to determine the effects of resin content and bast to core proportion on the physical and mechanical properties of MLKB, and 3) to determine the properties of kenaf board with woven-bast mat as core.



The kenaf bast and core were separated manually. The retting process (to separate bast fibres from the pectic materials) was carried out by submerging the bast in either cold water or alkali (NaOH) at certain duration. Three levels of alkali concentration were used: 1, 3, and 5%. The crude bast fibres were then combed and washed several times until straight and silky fibres were produced. The core portion was chipped into ≤ 2 cm size particles. Both bast fibres and core particles were then dried to about 5% moisture content. Multi-layered kenaf boards were fabricated using urea formaldehyde (UF) and melamine urea formaldehyde (MUF) resins as binders. Four types of 0.50 g/cm^3 density MLKB were made with varying bast : core proportions. Homogenous particleboards utilising 100% rubberwood particles were used as control. Since bast fibres have low wettability, a low molecular weight phenol formaldehyde (LPF) resin was used to pretreat the bast fibres prior to normal blending with either UF or MUF resin. An attempt was also made to produce a kenaf board with woven bast fibre mat as core. The properties of boards were tested using MS standards 1737: 2005. Data were subjected to Analysis of Variance (ANOVA) and the effects were further analysed by means separation using Least Significant Difference (LSD) at $p \leq 0.05$.

The study indicates that treatment of kenaf bast with different alkali concentrations significantly affected the properties of kenaf bast fibres such as fibre and lumen diameter, cell wall thickness and chemical components. Kenaf

bast fibres that have been treated with 5% NaOH gave the lowest amount of holocellulose, hemicellulose, α -cellulose, and lignin (48.7%, 29.7%, 19.0%, and 8.5% respectively.) High yield of holocellulose was obtained for treatment with water alone. Both the kenaf core and rubberwood have similar buffering capacity which is more sensitive towards acid. Bast fibre, on the other hand is more sensitive towards alkali. Due to its morphological properties, kenaf core inner surface exhibited higher wettability than outer surface.

Kenaf board comprising bast materials in the middle layer were stiffer than that of homogeneous 100% rubberwood. The incorporation of LPF resin in the fibres of MUF-bonded board comprising 70% kenaf core on the surface and 30% bast in the middle layer produced boards of reasonably good strength and dimensional stability. The modulus of elasticity (MOE) was 873 MPa, modulus of rupture (MOR) 8.9 MPa, internal bonding (IB) 0.32 MPa, thickness swelling (TS) 12.6%, and water absorption (WA) 118.9%. The presence of bast long fibres had improved the linear expansion (LE) length-wise by about 16.2%. All the kenaf board have higher MOR than that of 100% rubberwood.

The woven technique applied to improve the performance of the MLKB was found to be effective, producing 8.2% stronger and 22.3% stiffer board. The IB was also improved by 61.9%. The dimensional stability of these boards was superior to that of MLKB. Boards having 100% kenaf core consistently gave

superior performance in mechanical strength but relatively poor in TS and WA due to the high porosity and absorbent of the core itself. The linear regression between IB and strength showed higher R^2 values were obtained for all boards containing bast fibres compared to those having 100% core particles. The lack of fibre bonding among the bast fibres was found to be the dominant factor affecting the performance of woven-layered kenaf board (WLKB).



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**PENGHASILAN PAPAN KENAF (*Hibiscus cannabinus* L.) PELBAGAI
LAPIS MENGGUNAKAN GENTIAN TERAS DAN KULIT**

Oleh

NOR HAFIZAH HJ. AB. WAHAB

Januari 2007

Pengerusi : Paridah Md. Tahir, PhD

Institut : Institut Perhutanan Tropika dan Produk Hutan

Kenaf (*Hibiscus cannabinus* L.) merupakan tanaman yang agak baru di Malaysia. Spesies yang cepat tumbuh ini dipilih dan diperkenalkan di Malaysia adalah untuk memastikan bekalan bahan mentah yang berterusan bagi industri komposit, dan sebagai penyelesaian alternatif kepada kekurangan bekalan bagi kayu getah.

Percubaan untuk menghasilkan papan kenaf pelbagai lapis (MLKB) menggunakan bahagian batang kenaf yang berbeza: kulit, teras dan kombinasi gentian kulit dan teras telah dibuat. Objektif kajian ini adalah 1) untuk menilai kaedah-kaedah melembutkan dan memisahkan gentian-gentian kenaf (gentian kulit dan teras) untuk menghasilkan papan kenaf, 2) untuk menentukan kesan-kesan kandungan resin dan nisbah gentian kepada teras ke atas sifat-sifat



fizikal dan mekanikal papan kenaf pelbagai lapis (MLKB), dan 3) untuk menentukan sifat papan kenaf dengan tenunan-gentian sebagai teras.

Gentian kulit dan teras kenaf telah dipisahkan secara manual. Proses untuk melembutkan (untuk memisahkan gentian kulit daripada bahan-bahan “pectic”) telah dilakukan dengan merendam gentian di dalam air sejuk atau alkali (NaOH) pada tempoh tertentu. Tiga tahap kepekatan alkali telah digunakan: 1, 3, dan 5%. Gentian kulit mentah telah disikat dan dibersihkan beberapa kali sehingga hasil yang lurus seperti gentian sutera diperolehi. Bahagian teras telah diserpihkan sehingga saiz serpai ≤ 2 cm. Kedua-dua gentian kulit dan serpai teras telah dikeringkan sehingga kandungan lembapan 5%. Papan kenaf pelbagai lapis telah dihasilkan menggunakan resin urea formaldehid (UF) dan melamin urea formaldehid (MUF) sebagai pengikat. Empat jenis papan kenaf pelbagai lapis (MLKB) yang berketumpatan 0.50 g/cm^3 telah dibuat dengan nisbah kulit dan teras yang berbeza-beza. Papan serpai yang sama jenis menggunakan 100% serpai kayu getah telah digunakan sebagai kawalan. Gentian kulit mempunyai nilai pembasahan yang rendah, resin fenol formaldehid yang berjisim molekul rendah (LPF) telah digunakan sebagai pra-rawatan gentian-gentian kulit sebelum campuran sama ada dengan resin urea formaldehid (UF) dan melamin urea formaldehid (MUF). Percubaan menghasilkan papan kenaf dengan tenunan gentian kulit sebagai teras juga telah dibuat. Papan yang dihasilkan diuji menggunakan piawaian Malaysia

1737: 2005. Data kemudiannya dianalisis menggunakan analisis varian (ANOVA) dan kemudian kesan-kesannya dianalisis menggunakan perbezaan minimum yang ketara (LSD) pada $p \leq 0.05$.

Kajian ini menunjukkan rawatan kulit kenaf dengan kepekatan alkali yang berbeza sangat ketara ke atas kesannya terhadap sifat gentian kulit kenaf seperti diameter gentian dan diameter lumen, ketebalan dinding sel dan komponen-komponen kimia. Gentian kulit kenaf yang dirawat dengan 5% NaOH telah memberikan jumlah holoselulosa, hemiselulosa, α -selulosa dan lignin yang paling rendah (48.7%, 29.7%, 19.0%, dan 8.5% masing-masing). Hasil holoselulosa yang tinggi diperolehi bagi rawatan dengan air. Kayu getah dan teras kenaf mempunyai sifat keserupaan keupayaan menampakan yang mana lebih sensitif ke arah asid. Sebaliknya, gentian kulit lebih sensitif ke arah alkali. Dengan sifat morfologinya kenaf teras permukaan dalam mempamerkan nilai pembasahan yang lebih tinggi daripada permukaan luar.

Papan kenaf yang mengandungi bahan gentian di bahagian lapisan tengah adalah lebih teguh daripada 100% papan kayu getah. Penggabungan resin fenol formaldehid yang berjisim molikul rendah (LPF) dalam gentian-gentian papan ikatan-melamin urea formaldehid (MUF) yang mempunyai nisbah teras kenaf 70% dibahagian permukaan dan 30% kulit dibahagian tengah menghasilkan papan yang lebih teguh dan mempunyai kestabilan dimensi yang baik.

Modulus kekenyalan (MOE) adalah 873 MPa, modulus kehancuran (MOR) 8.9 MPa, kekuatan dalaman (IB) 0.32 MPa, pengembangan ketebalan (TS) 12.6%, dan serapan air (WA) 118.9%. Kehadiran gentian kulit kenaf yang panjang telah meningkatkan nilai pengembangan linear sebanyak 16.2%. Kesemua papan kenaf mempunyai nilai modulus kehancuran (MOR) yang lebih tinggi daripada papan 100% kayu getah.

Aplikasi teknik tenun untuk memperbaiki papan kenaf pelbagai lapis (MLKB) telah ditemui berkesan dengan menghasilkan kekuatan papan 8.2%, keanjalan papan 22.3%. Kekuatan dalaman (IB) papan juga telah ditingkatkan sebanyak 61.9%. Kestabilan dimensi papan yang dihasilkan lebih baik daripada papan kenaf pelbagai lapis (MLKB). Papan yang mempunyai 100% teras kenaf memberikan persembahan yang baik secara konsisten dalam kekuatan mekanikal tetapi mempunyai nilai pengembangan ketebalan (TS) dan serapan air (WA) yang tinggi berdasarkan kepada sifat porous dan serapan pada teras itu sendiri. Linear regresi di antara kekuatan dalaman (IB) dan kekuatan menunjukkan nilai R^2 yang tertinggi diperolehi pada papan yang mengandungi gentian kulit berbanding 100% serpai teras. Kelemahan ikatan gentian dikalangan gentian kulit telah ditemui sebagai faktor yang dominan pada persembahan papan tenunan kenaf (WLKB).

ACKNOWLEDGEMENTS

In The Name of Allah, The Most Merciful and The Most Gracious.

First of all, I would like to express my deepest sincere gratitude and appreciation to my supervisor, Associate Professor Dr. Paridah Md. Tahir, and committee members, namely Associate Professor Dr. Jalaludin Harun, Dr. Mohd Nor Mohd Yusoff and Associate Professor Dr. Azmi Ibrahim for their advice, guidance, encouragement, constructive criticisms and suggestion and help rendered throughout the progress of this study.

Special thanks are also due to Associate Professor Zakiah Ahmad for the guidance and great contribution towards the successful completion of this study. Many thanks also to Dr. Nor Yuziah Mohd Yunus and Malayan Adhesive and Chemical Sdn. Bhd. for supplying the resin needed in this study. I would like also to thank Puan Siti Noralakmam Yahya and Mr. Rozainie from Golden Hope MDF Sdn. Bhd who had assisted on the testing of this particleboard and to the staff of Forest Research Institute Malaysia (FRIM) for rendering full cooperation during the completion of this study.

Acknowledgements are also extended to all the Institute of Tropical Forestry and Forest Products (INTROP) staff especially to Mr. Harmaen Ahmad Saffian,



the staffs of Faculty of Forestry, Mr. Mohd Rizal Abd. Rahman, Mrs. Halimah Hussien and Miss Siti Fazelin Mahamad, and Mr. Ali Rani Institute of Advanced Technology (ITMA) for kindly providing the facilities and assistance throughout the course of this study.

My appreciation also goes to Dr. Seyoum Kallemwork Haile, who had advised, gave invaluable ideas, critics and support in assisting me to strive for academic excellent and thanks to my project members Mrs. Aida Suyana Mohamad, Miss Juhaida Md Fadzil, Miss Ismawati Palle and Miss Fauziah Hj. Mohammed, which have always show their commitment from the beginning to the end of this study.

Special thanks to my beloved parents, and friends especially Mr. Mohd Yazid Mohd Noh, Miss Norul Izani Md Allwi, Chow Chew Chin @ Stephanie and Mrs. Rafidah Md Salim who are always concern with my study and have given me support to improve myself. Thanks also to all my friends.



I certify that an Examination Committee met on 17th January 2007 to conduct the final examination of Nor Hafizah Hj. Ab. Wahab on her Master of Science thesis entitled “Development of Multi-layered Kenaf (*Hibiscus cannabinus* L.) Board Using Core and Bast Fibres” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Edi Shuhaimi Bakar, PhD

Lecturer
Faculty of Forestry
Universiti Putra Malaysia
(Chairman)

H’ng Paik San, PhD

Lecturer
Faculty of Forestry
Universiti Putra Malaysia
(Internal Examiner)

Mohd Sapuan Salit, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Rokiah Hashim, PhD

Associate Professor
School of Industrial Technology
Universiti Sains Malaysia
(External Examiner)

HASANAH MOHD GHAZALI, PhD

Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date : 22 MARCH 2007



This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Paridah Md. Tahir, PhD

Associate Professor
Institute of Tropical Forestry and Forest Products
Universiti Putra Malaysia
(Chairman)

Jalaluddin Harun, PhD

Associate Professor
Institute of Tropical Forestry and Forest Products
Universiti Putra Malaysia
(Member)

Azmi Ibrahim, PhD

Associate Professor
Faculty of Civil Engineering
Universiti Teknologi MARA
(Member)

Mohd Nor Mohd Yusoff, PhD

Director
Wood Chemistry Division
Forest Research Institute Malaysia
(Member)

AINI IDERIS, PhD

Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date :



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.

NOR HAFIZAH HJ. AB. WAHAB

Date : 15 MARCH 2007

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4.18	Comparison of Thickness Swelling between Proportions of Core : Bast	4.73
4.19	Comparison of Water Absorption between Proportions of Core : Bast	4.74
4.20	Relationships between Internal Bonding and Thickness Swelling and between Internal Bonding and Water Absorption for (a) Internal Bonding and Thickness Swelling All Boards, (b) Internal Bonding and Thickness Swelling 70% Core: 30% Bast Board, (c) Internal Bonding and Thickness Swelling 100% Kenaf Core Board, (d) Internal Bonding and Water Absorption 70% Core: 30% Bast Board, and (e) Internal Bonding and Water Absorption 100% Kenaf Core Board	4.75

