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UNIVERSITI PUTRA MALAYSIA

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

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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

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

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

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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 choosen 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 than 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

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Kenaf (*Hibiscus cannabinus* L.) merupakan tanaman yang agak baru di Malaysia. Spesis 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 kemudianya 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 menampan 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 poros 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).

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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:

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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:

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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.

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NOR HAFIZAH HJ. AB. WAHAB

Date : 15 MARCH 2007

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