UNIVERSITI PUTRA MALAYSIA

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MASTER OF SCIENCE
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By

SABIHA SALIM

Thesis Submitted to the School of Graduates Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Specially dedicated to:

My mother

NORIMAH BT MD DALI

&

My father

SALIM B HARUN

Love is the only rationale act…

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

PRODUCTION AND PROPERTIES OF 'BULUH SEMANTAN' (*Gigantochloa scortechinii* Gamble) HARDBOARD COMPARED TO COMMERCIALLY PRODUCED PINE HARDBOARD

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SABIHA SALIM

September 2007

Chairman : Associate Professor Zaidon Ashaari, PhD

Faculty : Forestry

Bamboo, a fast-growing plant with great versatility is being manufactured into various products of wood composites. In Malaysia, Buluh Semantan (*G. scortechinii* Gamble) is the most commercially utilised bamboo species and currently, fast being studied on its anatomical, physical and mechanical properties for contribution towards expanding the bamboo industry. Another potential product utilising bamboo fibre is hardboard, due to its long fibres produced good fibre bonding and strong hardboard. A study was conducted to determine the potential of utilizing bamboo *(Gigantochloa scortechinii)* for hardboard production. The objective of this study were to prepare and evaluate the bamboo fibre after undergone pre-treatment processes prior to refiner mechanical pulping (RMP), to determine the optimum pre-treatment process

for fibre production, and to evaluate the mechanical and physical properties of hardboard from bamboo compared to those of commercial hardboard from pine. Bamboo chips were either treated by soaking in 2% (w/v) sodium hydroxide (NaOH) solution at 60^{o}C for 4, 6 and 8 h or by steaming at 170^{o}C at 5.95 kgcm^{-2} pressure for 3 h to soften them. The results showed that chips pre-treated with NaOH yielded higher fibre recovery (77.2%) compared to those of steamed (50.7%). Fibre recovered from NaOH pre-treatment produced more unbroken fibres than those of steam. Fibre after undergone steam pre-treatment produced darker fibres compared to those of NaOH treated. Thus, from these measurements of fibre recovery and morphology, fibre from NaOH pre-treated produced better fibre quality than those of steam-treated. It was also found that soaking in 2% NaOH for 6 h was the most optimum treatment condition for the bamboo fibre. Thirty 3-mm hardboards (density, 1000 kgm^{-3}) prepared from the pre-treated fibres of bamboo, with and without resin and additives were then fabricated. Phenol formaldehyde (PF) resin at two concentration levels, i.e., 1% and 2% (based on oven dry weight of board), wax emulsion at 1% and 2% (based on oven dry weight of board), and alum ($Al_2(SO_4)_3$) at 0.25% (based on oven dry weight of board) were added selectively to enhance the properties of the boards. Boards were hot pressed at 180^{0}C for 20 min and tempered in a forced circulation oven at 160^{0}C for 6 h. Physical and mechanical properties of the boards were evaluated in accordance with Japanese Industrial Standard for Fibreboard (JIS A 5305-2003). Properties of commercial hardboard made from

pine of the same thickness were also tested for comparison purposes. The results showed that all bamboo hardboards produced from NaOH pre-treated fibres showed higher Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) values compared to the commercial hardboard. NaOH pre-treated board with 2% PF resin+1% wax and 2% PF resin+2% wax had the highest bending strength values (MOR values) but poor in dimensional stability compared to the commercial hardboard. Bamboo hardboards without resin and additives produced from steam-treated fibres showed lower MOR and IB values compared to those produced from NaOH pre-treated fibres. The bamboo hardboards without resin and additives showed lower MOR and Internal Bond (IB) values compared to those with resin and additives. Increasing PF resin and wax levels of concentration from 1% to 2% had increased the strength and stiffness properties of bamboo hardboards; namely the MOR, MOE and IB and was significant at $p<0.01$. The Internal Bond (IB) value showed the highest for hardboard with 2% PF resin+2% wax though was lower than the commercial hardboard (1.64 and 1.92, respectively). Bamboo hardboard was superior in terms of bending strength when compared to the commercially produced hardboard. Meanwhile for dimensional stability, bamboo hardboards showed poorer resistant to water absorption (WA) than the commercial and the value did not meet the JIS Standard specified.

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

PEMBUATAN DAN PENILAIAN SIFAT PANEL GENTIAN BERKETUMPATAN TINGGI DIPERBUAT DARIPADA BULUH SEMANTAN (*Gigantochloa scortechinii* Gamble) DIBANDINGKAN DENGAN PANEL KOMERSIAL DARIPADA PINE

Oleh

SABIHA SALIM

September 2007

Pengerusi : Professor Madya Zaidon Ashaari, PhD

Fakulti : Perhutanan

Buluh merupakan tanaman spesis cepat tumbuh dan serbaguna yang digunakan untuk pembuatan pelbagai produk kayu gubah. Di Malaysia, Buluh Semantan (*G. scortechinii* Gamble) adalah spesies komersial yang popular digunakan dan pelbagai kajian dijalankan tentang sifat-sifat anatomi, fizikal dan mekanikal dalam membantu menaikkan industri buluh. Antara produk yang berpotensi untuk diperbuat daripada buluh ialah papan gentian berketumpatan tinggi, memandangkan gentian buluh adalah panjang dan berupaya menghasilkan produk tersebut yang kuat terutamanya dari segi kekuatan ikatan gentian. Penyelidikan ini dijalankan untuk mengkaji potensi penggunaan buluh tropika *(Gigantochloa scortechinii)* untuk penghasilan kayu

gentian berketumpatan tinggi. Objektif kajian ini adalah menganalisa kesan pra-rawatan sodium hidroksida (NaOH) dan pengewapan ke atas sifat gentian sebelum dipulpa menggunakan kaedah Pempulpaan mekanikal (RMP). Seterusnya, untuk menentukan pra-rawatan gentian yang optima, justeru itu mencirikan sifat-sifat mekanikal dan fizikal yang terhasil daripada gentian yang terawat. Cip-cip kayu terlebih dahulu dirawat dengan merendam di dalam larutan sodium hidroksida berkepekatan 2% (berat/isipadu) pada suhu tetap 60°C selama 4, 6 dan 8 jam atau mengewap/ menstim pada suhu 170°C dan tekanan 5.95 $kgcm^{-2}$ selama 3 jam untuk melembutkan cip-cip tersebut. Kedua-dua pra-rawatan ke atas cip-cip menggunakan stim dan NaOH mempengaruhi sifat morfologi gentian dan warna pulpa yang terhasil. Gentian terhasil dari rawatan dengan NaOH memberikan hasil gentian yang banyak, dengan 77.2% berbanding stim; hanya 50.7%. Gentian yang telah dirawat dengan NaOH menghasilkan lebih banyak gentian yang tidak patah daripada gentian yang dirawat dengan stim. Gentian yang dirawat dengan stim menghasilkan gentian yang berwarna gelap manakala gentian dirawat dengan NaOH menghasilkan gentian yang berwarna cerah. Daripada pengiraan pulangan gentian yang terhasil dan pengukuran morfologi gentian, gentian terawat dengan NaOH menghasilkan gentian yang lebih berkualiti berbanding gentian terawat dengan stim. Selain itu, didapati bahawa rawatan optimum untuk melembutkan cip buluh sebelum proses pempulpaan adalah dengan merendam cip buluh dalam 2% NaOH pada suhu 60°C dengan masa rendaman

selama 6 jam. Tiga puluh keping papan gentian berketumpatan tinggi (1000 kgm^{-3}) dihasilkan dengan ketebalan 3-mm diperbuat daripada batang buluh. Panel tersebut dihasilkan menggunakan perekat dan juga tanpa perekat dan aditif lain, kemudian perbandingan dibuat dengan panel komersil daripada pain dengan mengambilkira ketebalan panel yang sama. Perekat fenol formaldehid (PF) dengan dua kepekatan; 1% dan 2% (berasaskan berat kering oven panel), pengemulsi lilin pada 1% dan 2% kepekatan (berasaskan berat kering oven panel), dan 0.25% alum ($Al_2(SO_4)_3$) (berasaskan berat kering oven panel) ditambahkan mengikut kepekatan tertentu kepada panel daripada buluh *G. scortechinii* manakala panel daripada bahan lignoselulosa yang lain hanya ditambahkan dengan perekat PF berkepekatan 2% dan pengemulsi lilin 1% serta alum. Panel diberikan tekanan panas pada suhu 180°C selama 20 minit dan kemudian dipanaskan dalam oven pada suhu 160°C selama 6 jam. Semua sifat mekanikal dan fizikal panel yang dihasilkan diuji mengikut ketetapan piawaian papan gentian 'Japanese Industrial Standard for Fibreboard' (JIS A5305-2003). Sifat panel komersil daripada kayu pain dengan ketebalan yang sama juga diuji untuk perbandingan. Keputusan kajian menunjukkan semua panel gentian berketumpatan tinggi diperbuat daripada buluh menggunakan pra-rawatan dengan NaOH menunjukkan nilai rintangan terhadap kepecahan (MOR) dan kekenyalan (MOE) yang lebih tinggi berbanding panel komersil. Panel terawat dengan NaOH menggunakan 2% resin PF+1% pengemulsi lilin, dan 2% resin PF+2% pengemulsi lilin memberikan nilai ketahanan terhadap

kepecahan yang tertinggi (nilai MOR) tetapi lemah terhadap rintangan terhadap air dan kelembapan (nilai WA) berbanding panel komersil. Panel yang diperbuat menggunakan gentian buluh yang terawat dengan stim, tanpa resin dan bahan tambah lain menghasilkan panel dengan ketahanan terhadap kepecahan (MOR) dan kekuatan ikatan dalaman (IB) yang lebih rendah berbanding panel yang diperbuat menggunakan gentian terawat dengan NaOH. Panel yang diperbuat tanpa resin dan bahan tambah menunjukkan kekuatan (MOR) dan ikatan dalaman (IB) yang lebih rendah berbanding panel yang diperbuat menggunakan resin dan bahan tambah. Dengan pertambahan kepekatan resin PF dan pengemulsi lilin daripada 1% ke 2%, kekuatan dan kekerasan panel tersebut turut bertambah; iaitu nilai MOR, MOE dan IB adalah bererti pada $p<0.01$. Nilai kekuatan ikatan dalaman (IB) tertinggi terhasil daripada panel buluh yang diperbuat menggunakan 2% resin PF +2% pengemulsi lilin. Panel gentian berketumpatan tinggi yang diperbuat daripada buluh memberikan kekuatan yang superior. Manakala untuk kestabilan dimensi atau kadar resapan (WA), panel gentian berketumpatan tinggi daripada buluh adalah tidak tahan terhadap lembapan berbanding panel komersil dan nilai kadar resapan (WA) tidak mencapai piawaian yang ditetapkan oleh JIS A 5305-2003.

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…May Allah bless us always…

I certify that an Examination Committee met on 7th September 2007 to conduct the final examination of Sabiha bt. Salim on her Master of Science thesis entitled "Production and Properties Evaluation of Buluh Semantan (*Gigantochloa scortechinii* Gamble) Hardboard compared to Commercially Produced Pine Hardboard" 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. Member of the Examination Committee are as follows:

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This thesis was 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 were as follow:

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Date: 22 January 2008

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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SABIHA SALIM

Date: 7th November 2007

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