UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF MEDIUM DENSITY FIBREBOARD FROM OIL PALM (ELAEIS GUINEENSIS , JACQ .) FIBRES

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PROPERTIES OF MEDIUM DENSITY FIBREBOARD FROM OIL PALM (*Elaeis guineensis*, Jacq.) FIBRES

By

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Specially dedicated to my,

Mum and Dad,

Uncle Bernard and Aunties

FOR ALL THE LOVE AND CARE

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LIST OF ABBREVIATIONS

CV	coefficient of variation
EFB	empty fruit bunch
FRIM	Forest Research Institute of Malaysia
IB	internal bond
JIS	Japanese Industrial Standard
MAC	Malayan Adhesives & Chemical Sendirian Berhad
MC	moisture content
MDF	medium density fibreboard
MOE	modulus of elasticity
MOR	modulus of rupture
MPa	mega Pascal
OD	oven dry
OPTUC	Oil Palm Tree Utilisation Committee
PORIM	Palm Oil Research Institute of Malaysia
STD	standard deviation
TS	thickness swelling
UF	urea formaldehyde
UPM	Universiti Pertanian Malaysia
WA	water absorption

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This study aimed to determine the possibility of processing the oil palm trunk, frond and empty fruit bunch (EFB) fibres for medium density fibreboard (MDF) production. Vascular bundles from the three major fibrous components of oil palm tree was collected after they were disintegrated by an 'All Palm Fractionator' machine. A study on the vascular bundles recovery on the three parts of oil palm tree revealed that EFB has the highest vascular bundles recovery rate (90.49%) followed by frond (75.28%) and trunk (48.65%). However, vascular bundle from the trunk has the most favourable colour (light creamy) for MDF manufacturing. The fibre morphology study indicated that the morphological properties of all the three types of fibres were adequate to produce good strength fibre composite eventhough their fibre length, coefficient of suppleness and Runkle ratio might not be as good as softwood fibre. Of the three different types of urea formaldehyde resin

formulations used on the trunk, frond and EFB fibre with and without incorporation of 1% wax, only Resin 2 (R2) and Resin 3 (R3) resin exhibited good compatibility with trunk, frond and EFB fibre. Trunk and frond MDF board manufactured in all three resin formulations by far exceeded the requirements set for Type 200 board in JIS A 5906 specifications where trunk MDF bonded with R3 resin recorded the highest strength and almost met the requirement for Type 300 board. On the contrary, MDF from EFB in all three resin formulations was hardly able to fulfill the requirement of Type 150 board. In fact, most of it can only reach Type 50 board in JIS A 5906 specifications. In general, the incorporation of 1% wax (Experiment 1) resulted in deduction in all mechanical strength properties of trunk, frond and EFB MDF with all three resin formulations but pronounced improvement in board dimensional stability. Incorporation of 0.5% hardener (NH_4Cl) (Experiment 2) on the other hand, was found to have insignificant ($P \leq 0.05$) effect on the performance of trunk MDF bonded with R1, R2 and R3 resins but most of the mechanical properties, especially internal bond improved with the addition of 0.5% hardener. Test results in experiment 3 revealed that fibre size not only significantly ($P \leq 0.05$) influenced trunk MDF properties but also better coverage with different resin formulation used. Most trunk MDF fabricated with fine screen fraction (<0.5 mm) has higher bending strength but lower internal bond property when compared to board fabricated from coarse screen fraction (>2.0 mm). However, the internal bond strength of all specimen board including those fabricated from fine screen fraction was still exceedingly higher than the 0.49 MPa required for Type 300 board. In fact, fibre from screen fraction <0.5 mm bonded with R2 resin could satisfy Type 300 board.

Abstrak tesis dikemukakan kepada Senat Universiti Pertanian Malaysia untuk memenuhi keperluan Ijazah Master Sains

SIFAT PAPAN GENTIAN KETUMPATAN SEDERHANA (MDF) DARIPADA GENTIAN KELAPA SAWIT (*Elaeis guineensis*, Jacq.)

By

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Pengerusi: Dr. Jalaluddin Harun

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Kajian ini tertumpu untuk menentukan kemungkinan pemprosesan gentian batang kelapa sawit serta pelepah dan tandan kelapa sawit (EFB) untuk penghasilan papan gentian ketumpatan sederhana. Kelompok vaskular dari tiga komponen utama gentian pokok kelapa sawit dikutip setelah ketiga-tiga komponen ini dihancurkan dengan menggunakan mesin 'All Palm Fractionator'. Kajian tentang kadar pulangan kelompok vaskular menunjukkan bahawa EFB mempunyai kadar yang tertinggi (90.49%) diikuti pelepah (75.28%) dan batang (48.65%). Akan tetapi kelompok vaskular batang mempunyai warna yang sesuai untuk pengeluaran MDF. Kajian tentang morphologi gentian menunjukkan bahawa sifat morphologi dari ketiga-tiga jenis gentian adalah memadai untuk menghasilkan gentian komposit yang mempunyai kekuatan yang boleh diterima walaupun panjang gentian angkali lentur dan nisbah Runkle ketiga-tiga jenis gentian mungkin tidak sebaik dengan gentian daripada kayu lembut. Dari tiga

jenis formulasi urea formaldehid (UF) yang digunakan dalam eksperimen 1 untuk merekat gentian batang, pelepah dan EFB dengan atau tanpa campuran 1% lilin, hanya resin R2 dan R3 memperlihatkan penyesuaian yang baik dengan gentian batang, pelepah dan EFB. MDF daripada gentian batang dan pelepah di dalam ketiga-tiga formulasi resin adalah jauh melepasi keperluan untuk papan jenis 200 dalam spesifikasi Standard Industri Jepun (JIS A 5906 1986). Di samping itu, MDF batang yang direkat dengan resin R3 telah direkod mempunyai kekuatan yang tertinggi, di mana ia hampir memenuhi kekuatan papan jenis 300. Bertentangan dengan ini, hampir ke semua MDF EFB didapati jarang mampu memenuhi keperluan papan jenis 150 di dalam ketiga-tiga formulasi resin, malah kebanyakannya hanya boleh mencapai papan jenis 50 dalam spesifikasi JIS A 5906 1986. Secara keseluruhannya campuran lilin sebanyak 1% dalam eksperimen 1 menyebabkan berlakunya penurunan dalam semua sifat mekanikal MDF yang diperbuat daripada batang, pelepah dan tandan dalam ketiga-tiga formulasi resin tetapi mengemukakan kemajuan dalam kestabilan dimensi papan. Campuran dengan 0.5% bahan pengeras (NH_4Cl) dalam eksperimen 2 didapati tidak menjejaskan prestasi MDF batang kelapa sawit yang direkat dengan resin R1, R2 dan R3 tetapi kebanyakan sifat mekanikal terutamanya rekatan dalaman telah mengalami kemajuan dengan tambahan 0.5% bahan pengeras. Keputusan ujian dalam eksperimen 3 menunjukkan bahawa saiz fibre bukan saja didapati mempengaruhi sifat MDF batang kelapa sawit secara sigfinikan ($P \leq 0.05$) tetapi juga meningkatkan salutan dengan jenis formulasi resin yang digunakan. Kebanyakan MDF batang kelapa sawit yang diperbuat dengan pecahan skrin halus (<0.5 mm) mempunyai kekuatan lentur yang tertinggi tetapi mempunyai rekatan dalaman yang rendah jika di banding dengan MDF yang diperbuat daripada pecahan skrin kasar (>2.0 mm). Namum bergitu, kekuatan rekatan dalaman bagi ke semua MDF yang diperbuat daripada pecahan skrin halus masih lebh tinggi daripada 0.49 MPa, keperluan untuk papan jenis 300. Padahalnya gentian dalam pecahan skrin <0.5 mm yang direkat dengan resin R2 didapati layak dari segi sifat mekanikal untuk papan jenis 300.

CHAPTER I

INTRODUCTION

Background

As Malaysia prepares to join global trends in industrialization for the coming millennium, areas covered by natural forests are reducing drastically. As a result, wood raw materials are alarmingly becoming scarce. Good quality logs with large diameters essential in the production of plywood and lumber products are increasingly difficult and expensive to obtain as timber stands left in the forest are often from the low quality grades. In addition, shortage in raw material supplies are getting more acute as the rapid increase in Malaysia's population places an even greater demand on wood based products. Therefore, to meet the demand, the wood based industry has had to become more efficient, not only in the field of technological development and advancement but also in the optimum utilization of raw materials as well as to intensify or introduce other little-used or previously unused materials from agricultural crops.

In Malaysia, optimum utilization of agricultural crops such as Rubberwood has been brought about through the results of intense research and technology development which in turn has saved numerous natural forests from further destruction. Apart from research in utilizing agricultural residues, considerable studies has also been underway in forest plantation species for many years, using genetics and silviculture to improve the physical properties of trees. However, the cultivation of timber in plantation often needs long term investment, as compared to raw materials available from agricultural activities. Nonetheless, both agricultural residues and the current forest plantation species have similar inherent characteristics that made both difficult to be used in the form of lumber. Owed to the inherent characteristics, both plantation wood and agricultural residues create great opportunities for the development of engineered composite wood products. From a raw material standpoint, composite products technology offer a degree of flexibility not available in solid wood processing. For instance, if both resources are converted into lumber or veneer products, the inherent characteristics not only reduce the yields but also the quality. In addition to it, conversion cost will increase.

Currently, in Malaysia there are number of different wood composite products found in the market considering the constituents from which these products are made. The basic wood elements utilised in the production of wood composite panels come in a great variety of sizes and shapes and may be used alone or in combination. However, from the range of composite products available in the market, the 1990s will witness the start-off phase and sharply increase rate in the production of Medium Density Fibreboard (MDF) compared to any composite panel produced in Malaysia. The main reason for the advanced or rapid expansion of MDF in Malaysia lies in their good physical and mechanical properties that resemble the performance of solid timber when compared to other composite panels. For instance, MDF, which is well known for its very smooth surfaces, fine texture and homogeneous structure throughout the board, has machinability as its premium property. It can, therefore, be sawn, routed and embossed easily, whilst intricate machining and moulding can be carried out without exposure of core voids (Batllori, 1980). In addition to it, there are no end grain or splintering problems, and with its 'tight' edges, no edge banding or lipping is required for profiled edges. Thus, overcoming problems which have for long time inhibited furniture designers. Besides the good strength, MDF also has a high quality substrate for veneering, painting, grain printing or laminating. With all these advantages, MDF is without doubt highly preferred for furniture manufacture especially when current fashions in furniture design are away from plain flat slabs to design with deep relief effects on the surface and more elaborate treatment on edges (Parkins, 1980).

However, besides the good board properties, difficulties in obtaining raw material and rising price for large diameter peeler logs have also contributed to the rapid growth of MDF manufacturing. At present, MDF has been produced to replace plywood in many applications, notably the furniture industry. It is generally known that furniture industry is one of the largest outlet for wood based panel and will remain as such in the future. Therefore, high consumer demand for wooden furniture will continue to be met by the use of MDF laminated with wood veneers or printed papers in the future.

Despite having the advantage for being able to use wide varieties of raw materials in MDF manufacturing, sustainable supply of homogeneous raw material is still the prime choice in MDF manufacturing. In Malaysia, the sustainable supply of cheap homogeneous raw material lies on agricultural residues. To this date, oil palm and rubber trees are the major agricultural crops planted in Malaysia. In 1994 there were 1.72 million ha. of rubber plantation in Malaysia while the total area under oil palm plantation was 2.36 million ha. (Ministry of Primary Industries, 1995).

Looking at the present scenario, wood composites industry in Malaysia is solely dependent on Rubberwood as its raw material. As several more wood composite plants, especially the MDF plant, will be established soon, the demand for Rubberwood will ultimately be increased. This would inevitably results in shortage of supply of the material. Oil palm tree, therefore, appears to be one of the potential alternate sources of raw material to Malaysia wood composites industry.

In general, oil palm fibres originate from 3 major fibrous components viz. , trunks, fronds and empty fruit bunches. Tremendous amount of trunks and fronds are generated during the replanting since the economic life span of oil palm tree is about 25-30 years. In addition, large amount of fronds will also be generated when pruning is carried out throughout the year (Gurmit Singh, 1995). Apart from trunks and fronds, empty fruit bunches is another important fibrous component generated during the extraction of oil palm fruit into palm oil. At present, oil palm fibres from all the three fibrous components are not effectively used. It has been estimated that from 1995 to year 2000, these three components would constitute approximately 25 to 30 million tones (dry weight basis) raw fibres (Gurmit Singh, 1995).

However, oil palm fibres being a new source of materials, some of its properties and characteristics are not fully understood. Inevitably, this would cause some concern on the MDF or other composite products manufactured from oil palm fibres. In addition, there are limited technological researches on the processing and utilization of oil palm fibres into MDF. More often than not, the methods used in the previous studies (Liew, 1994) were restricted to conventional processing methods. Nonetheless, recent advances in the development of pilot scale equipment for extracting oil palm fibres from the three types of fibre sources have been regarded as a giant step forward for down stream processing of oil palm fibres. Therefore, to gauge the level of success for MDF fabricated from oil palm fibres, the interaction between inherent fibre properties and manufacturing variables with regards to board performances need to be emphasized. It is certain that the possibility of using oil palm fibres to manufacture MDF at comercial scale with desirable properties and money-making promise is close provided effort is emphasized on the search for the right manufacturing variables which is compatible with oil palm fibres.

Objectives of the Study

With the increasing oil palm plantation area, there will be tremendous amount of fibrous components available in