

# A COMPARISON OF DIFFERENT TREATMENT TO REMOVE RESIDUAL OIL IN OIL PALM EMPTY FRUIT BUNCH (OPEFB) FOR MDF PERFORMANCES

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## Abstract

Empty fruit bunches (EFB) are readily available residues from the oil palm industry which have been reported to be the most potential material for medium density fibreboard (MDF) manufacture. Nevertheless the properties of MDF made from EFB are normally inferior compared to those from rubberwood due to the presence of residual oil. In this study, the effects of EFB fibre treatment (soaking in 2% NaOH; boiling in water; both soaking and boiling) on the properties of MDF were investigated. The MDF was manufactured using 12% UF as a binder. The boards were tested according to MS Standards 1787:2005. Among the treatment used, boiling in water improved the dimensional stability of the board. The results suggest that although much work remains to be done, EFB seems an eminently suitable raw material for MDF.

**Keywords:** *oil palm fibre, residual oil, EFB, urea formaldehyde, fibre treatment*

## 1 Introduction

Oil palm empty fruit bunch (OPEFB) is a form of fibrous lignocellulosic residue generated in significant quantities in the palm oil industry [1]. Natural fibres generated from agricultural wastes, such as palm oil, rice husks and pineapple leaf, are particularly important natural resources in the wood based industries. These natural fibres possess low density, low production costs, easy processing, light

weight and less abrasiveness to equipments [2]. The use of renewable biomass (agro-fibres) as a raw material in composite production was one approaches and the use of renewable biomass may result in several benefits such as environmental and socioeconomic.

Oil palm (*Elaeis guineensis*) production is a major agricultural industry in Malaysia. From oil palm tree, the biomasses from oil palm residue include the trunks (OPT), fronds (OPF), kernel shell, empty fruit bunch (EFB) and pressed fruit fibre (PFF). Among the various fibre sources in oil palm tree, EFB has potential to yield up to 73% fibres [3] and hence it is preferable in terms of availability and cost [4]. High cellulose content [5] and high toughness value [6] of OPEFB make it suitable for composite applications. However, In addition, there are some characteristics of the EFB that may affect the products. The compatibility is made worse in the case of EFB where residues of oil are still present on the fibre [4]. Oil palm fibres contain 4.5% of residual oil [7]. It is reported that the oil residues on the EFB fibres are still present even after the extraction process in the factory. This may explain why many studies have reported similar poor board performance either for particleboards or MDF.

Currently, there are many studies on the incorporation of empty fruit bunch (EFB) into composite products to gain a cost reduction and reinforcement by various workers. It is possible to produce medium density fibreboard (MDF) from EFB fibre and the MDF performance can be improved by a pre-treatment to remove the residual oil [8]. Abdul Khalil et al., (2001) [9] reported that

modified EFB has improved the mechanical properties and water resistance of the polyester/EFB composites. All these properties are very important information about the possibility of using EFB as an important material in manufacturing MDF and other wood-based products in Malaysia and worldwide.

In this study, treated oil palm empty fruit bunch (OPEFB) fibre was used for MDF manufacturing. The purpose of this study was to determine the effect of different fibre treatments on the mechanical properties, dimensional stability and bonding properties of fibre-boards bonded with urea formaldehyde (UF) resin.

## 2 Materials and Methods

Empty fruit bunch (EFB) was obtained from Sri Langat Oil Palm Mill, Dengkil, Selangor. Treated EFB were sent to Malaysian Palm Oil Board (MPOB), Bangi, Selangor for termomechanical pulping process. Different EFB fibre treatments used in this study listed in Table 1.

Table 1 Types of treatments applied to EFB fibre

	Treatment	Descriptions
1	Untreated	Untreated fibre
2	Soaking	Fibre were soaked in 2% sodium hydroxide (NaOH) for 30min
3	Boiling	Fibre were boiled in hot water for 30min
4	Soaking and boiling	Fibre were soaked in 2% NaOH, then boiled in hot water for 30min

### 2.1 Preparation of Medium Density Fiberboard

Medium density fibreboard (MDF) panels using treated fibres were manufactured at Biomass Laboratory, Malaysian Palm Oil Board (MPOB), Bangi. Dried fibres were then blended with UF resin in a rotating drum-type mixer fitted with a pneumatic spray gun. Based on oven dry particle weight, 12% UF resin was applied. The blended fibres were then placed in molding box and manually formed. The hand-formed mats were cold press. The mats were hot pressed at 175°C for 5min with 160kg/cm<sup>3</sup> press pressure. Twelve boards were produced with dimension of 300 x 300 x 12mm with

target density of 750 kg/m<sup>3</sup>. The samples were conditioned in a chamber at 33°C and a relative humidity of 65±2% for a week.

### 2.2 Mechanical and bonding properties

After conditioning, the test samples were cut and the mechanical properties (MOR, MOE) and internal bonding (IB) were determined according to MS Standards 1787:2005 [10].

The tests were determined using Instron Universal Testing Machine. The sizes of test samples were 250 mm x 50 mm x 12 mm. The dimensions for internal bond strength samples were 50 mm x 50 mm x 12 mm. Internal bond strength tests were conducted on specimens to determine if the fibre treatment had any effect on resin bond strength.

### 2.3 Dimensional Stability Test

The thickness swelling (TS) and water absorption (WA) were determined by measuring the thickness and weight respectively of the sample before and after immersed in distilled water at room temperature (25°C) for 24 h.

### 2.4 Statistical analysis

Data for each test were statistically analyzed. The effects of fibre treatments and resin content on the panel's properties were evaluated by analysis of variance (ANOVA) using the statistical analysis software (SAS). A least significance difference (LSD) method was used to identify the dominant factor and its interactions that affect the means at  $p \leq 0.05$ . This method ranks the means and calculates the least difference that occurs between the means and ranks them by denoting different alphabets means followed by the same alphabet is not significantly different at  $p \leq 0.05$ .

## 3 Results and Discussion

### 3.1 Mechanical and Bonding Properties

Modulus of rupture indicates the ability of a specimen to withstand a transverse (bending) force perpendicular to its longitudinal axis [11]. Modulus of elasticity refers to the stiffness of the material and is useful in the calculation for the deflection under

stress. The average of mechanical properties, internal bonding (IB) and dimensional stability properties for MDF from EFB fibre treated produced at 12% UF are summarized in Table 2. MOE for boiling treatment give no significant difference compared to that of untreated. However, it is significantly higher compared to other treatments. The MOR and MOE ranged from 15.6 to 30.4 N/mm<sup>2</sup> and 1386 to 2462 N/mm<sup>2</sup> respectively. Treatment using NaOH obviously reduce the strength properties of the board. A significant improvement in mechanical properties of the boiling treated fibre compared to other treatments is probably due to an increase in the extent of crystallinity and reduction of amorphous regions during boiling treatment.

On the other hand, significant reductions in the MOR and MOE of boards made from soaking-treated fibre. This might be due to the formation of fibre lumps after NaOH treatment. These lumps were not uniformly distributed especially during forming thus created a uniform densification in the board. Such density variation generates point of weakness which upon loading will break easily. The decreases in mechanical properties (MOE, MOR) of combination soaking and boiling (SB) treated fibres were probably due to the decrease in the degree of crystallinity and contribute to fibre damage. During alkali treatment by soaking for 30 min at 100°C, some materials (lignin, wax, oil) were removed from the surface of the fibres. Besides, it makes the fibres more fibrilled and fine which led to insufficient resin coverage on the surface and resulted a poor strength performance [12, 13].

The internal bonding (IB) strength indicates homogeneity of the adhesion between the fibres, which are bonded by adhesives and widely used in most wood based composite panels. Among the treatments, MDF made from boiling-treated fibre exhibited higher IB with 0.93N/mm<sup>2</sup>. This could be due to better fibres felting among them which created more fibre to fibre contact and glue line contact [14]. The boiling treatment in fiberboard effectively increased the bonding strength of the boards. This probably due to the removal of wax and pectin from the surfaces which improved the wettability of the fiber used. The wax which is form a thin film on the surfaces of the fibre will influence the bonding properties of board [15].

Apparently, there are no significant difference in bonding properties of boards made from fibres that have been both soaking treated and combination of soaking and boiling (SB) treatment.

### **3.2 Dimensional Stability**

The thickness swelling was mainly exposure to the lignocellulosic fibre on the surface of composite. However, dimension of lignocellulosic change with different moisture content. The hydrophilic properties of lignocellulosic materials and the capillary action caused the intake of water when the samples were soaked into water and thus increase the dimension of composite. Generally all the treatments improved the dimensional stability of the boards compared to untreated. It was observed that the swelling of the boiling-treated boards was in lowest value compared to others.

Boards made from boiling treated fibres were more stable board with the lowest TS and WA values, 50.9% and 14.8%, respectively. The reduction of TS could be related to the removal of hemicelluloses and oil substance of the fiber cell walls during the boiling treatment. Any removal of the hemicelluloses which are very hydrophilic compounds in the cell wall could affect significantly the swelling of the boards.

The chemical treatment can reduce the hydroxyl group in the cell wall of natural fibre molecule, which can decrease the water absorption of the composites. However, it is interesting to note that NaOH soaking-treated board gave higher TS. This could be due to the fact that the residual oil in EFB fibre, which form as a thin film and prevent water to penetrate into the board have been effectively removed by NaOH.

### **4 Conclusion**

This study revealed that it is possible to produce MDF from oil palm EFB fibre. Among the treatments, boiling in water was the most suitable treatment used to treat the EFB fibre in order to get the best properties in MDF produced when UF resin were applied. Soaking in NaOH and both soaking in NaOH and boiling treatments were the worst method to be applied to the EFB fibres.

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Table 2 Mechanical properties, bonding properties and dimensional stability values of MDF manufactured from different treated EFB fibres at 12% UF

	MOR (N/mm <sup>2</sup> )	MOE (N/mm <sup>2</sup> )	IB (N/mm <sup>2</sup> )	WA (%)	TS (%)
Untreated (UT)	27.5 <sup>b</sup> (2.63)	2397 <sup>a</sup> (111.5)	0.77 <sup>b</sup> (0.05)	63.9 <sup>a</sup> (2.78)	22.0 <sup>a</sup> (0.50)
Boiling (B)	30.4 <sup>a</sup> (1.66)	2462 <sup>a</sup> (108.3)	0.93 <sup>a</sup> (0.13)	50.9 <sup>b</sup> (2.89)	14.8 <sup>c</sup> (0.50)
NaOH (S)	15.8 <sup>c</sup> (1.47)	1386 <sup>b</sup> (110.1)	0.56 <sup>c</sup> (0.09)	60.5 <sup>a</sup> (2.55)	18.0 <sup>b</sup> (0.35)
NaOH+Boiling (SB)	15.6 <sup>c</sup> (1.20)	1436 <sup>b</sup> (54.24)	0.52 <sup>c</sup> (0.07)	60.4 <sup>a</sup> (2.87)	18.7 <sup>b</sup> (0.37)

Note: Values in parentheses are standard deviations. Means with the same letters <sup>a,b,c</sup> in the same column are not significantly different at p>0.05.