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Measurement of some properties of binderless particleboards made from young and old oil palm trunks

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ABSTRACT

The objective of this study was to evaluate variation of mechanical and physical properties of binderless particleboard panels manufactured from raw material of young and old oil palm (*Elaeis guineensis*) trunks. Results revealed that such experimental panels made from particles of young oil palm trunks had higher mechanical characteristics than those of made from old trunks. Addition of sugar compounds in the samples produced having particles from young trunks with and without extracted material enhanced their bending and internal bond strength values. Overall dimensional stability in the form of thickness swelling and water absorption those panels made from young trunks was adversely influenced. However adding sugars in the samples improved their thickness swelling and water absorption in both cases of with and without applying of extraction process.

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) originated from West Africa is a very important cash crop with a rapid expansion plantation in Malaysia (Hartley, 1988). The oil palm trunk, considered as a renewable and sustainable natural resource biomass has also been utilized as a cellulosic raw material in the production of panel products including particleboard, medium density fiberboard (MDF), cement-bonded particleboard, blockboard, plywood, and recently in the development of binderless board. The use of oil palm biomass will not only provide additional revenue to different industries but will also help achieve the long-term zero waste strategy adopted by composite panel industry [1].

Productivity of palm tree decreases after 20–25 years of age. Generally, the plant spends its first 11–15 months in the nursery, then first harvesting is done within 32–38 months, and peak yield is from the time of 5–10 years from planting. Normally, oil palm grows in the lowlands of the humid tropics with evenly distributed rainfall of 1800–5000 mm/year. According to Hartley [2], oil palm has a wide adaptability for range of soils and low pH, but sensitive to high pH (>7.5), and to stagnant water. Oil palms are cultivated on large plots of land with planting density of 128–148 plants per hectare. They are largely dependent on the environmental parameters such as soil, temperature and climate.

This valuable agricultural species has a better future with increasing world-wide demand for wood-based panels. Since all commercial panel products in the market use an adhesive to bind the constituent wood elements together, an alternative product are still under progress to reduce the use of adhesive and produce eco-friendly wood-based panels. In the production of particleboard, the problem faced by the producers is high cost of manufacturing due to the price of adhesives. Binderless boards are formed into panel products using hot pressing without

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addition of any resins or adhesives, by means of activating chemical components of the constituents of raw material [3]. Our previous research has proved that the chemical components that exist in the boards itself play a major role in bonding the particles together [4]. As a monocotyledonous species, anatomy and physical properties of oil palm also tend to contribute the properties of the boards. The growth of the oil palm changes some of the anatomy and properties of the trunks notably in height as the age of the palm increased.

The suitability of the raw materials that have been used in manufacture of binderless boards is based on their physical and mechanical properties. In a preview study characterization of the binderless boards manufactured from oil palm biomass and effect of the temperature on the properties of such boards were investigated [5,6]. It is a known fact that the size of particles plays an important role as the particle geometry affecting board characteristics including water absorption, thickness and linear stability, strength and surface roughness [7]. Fine particle can give a smooth surface but require high energy and time to produce them. Suchsland [8] and Hashim et al. [9] also reported that the particle size and shape played more important role on development of board properties rather than the actual mechanical properties of the fibers. Variation of particle shape and size also influences overall panel properties. It was also stated by Frybort et al. [10] that particle shape and size can build major impact on the properties of boards. As the particle size is influencing the performance and properties of the boards, determining the range of particle size used in making the board was an important parameter. Fine material content and the ratio of all particle size fractions positively influence the internal bond strength of the samples [11]. Miyamoto et al. [12] also determined that the particle shape affected the linear expansion of the boards.

Therefore, this research attempts to investigate the effects of the age of the oil palm on mechanical and physical properties of the binderless board. In order to achieve this objective, the method used was same with the previous research reported in Lamaming et al. [4] with the age of the raw materials using was 11 years old for young oil palm and 27–38 years for old oil palm. Extraction process was also conducted to the raw materials to eliminate the water soluble materials from the raw materials. The extracted particles were then formed into mats by adding additives. The board properties of the extracted panels made with young and old oil palm trunk particles were compared to those of unextracted panels made with the same materials.

2. Materials and methods

2.1. Preparation of samples and board manufacturing

Two types of oil palm trunks, namely those having age range from 27 to 38 years old and 11 years old samples were harvested in a plantation in Kedah, Malaysia. The trunks were cut into smaller size and the bark was removed. Then, they were converted into chips and later into fine particles employing Wiley Mill. 100 g of oil palm particles were screened on a sieve with a size of 1000 μm, 500 μm 100 μm, and 53 μm by RETSCH AS200 to obtain the particle size distribution. Later, the fine particles were dried in an oven to a moisture content of 7%. For extraction process of the particles they were run through equipment having a temperature of 60 ± 3 °C thermostat control unit using hot distilled water for 6 h before they were filtered on a Buchner funnel.

After chemicals were extracted from the particles they were dried in an oven to a moisture content of 7%. Particles from two different types of trunks also added 20% of xylose, sucrose and glucose. A total of sixteen types of panels were manufactured for the experiments. A total of 96 panels, 6 for each design were made in the work as displayed in Table 1. Particles with different combination were manually formed in a frame before the mats were compressed in a computer controlled press using a temperature of 180 °C at a pressure of 5 MPa for 20 min. Final size of the panels was 25 cm by 25 cm by 1 cm with a target density of 0.80 g/cm^3.

2.2. Evaluation of chemical components of the samples

Extractive free particles were prepared according to TAPPI 204-97 [13] standard with a modification of the solvent ethanol–toluene ratio of 2:1. Holocellulose content of the samples was carried out based on the procedure described by Wise [14] while alpha cellulose content was measured by the extraction of the cellulose with 17.5 sodium hydroxide. Lignin and starch content of the particles were also determined based on TAPPI 222-02 [15] and the method described by Humphreys and Kelly, respectively [16].

2.3. Evaluation of mechanical and physical properties of boards

Bending properties, modulus of rupture (MOR) and internal bond (IB) strength of the samples were tested on Instron Testing System Model UTM-5582 equipped with a load cell having a capacity of 1000 kg. Bending and IB specimens were prepared with dimensions of 50 by 200 mm with 2 span of 150 mm and 50 mm by 50 mm, respectively based on Japanese Thickness swelling and water absorption of the samples were also determined by soaking them in water for 24 h based on Japanese Industrial Standard (JIS A 508-2003) [17].

3. Results and discussion

3.1. Particle size distribution

Fig. 1 shows the particle distribution ratio that been used for manufacture of experimental binderless boards. Almost 70% particles size that has been used in producing the boards falls within the range of 100–500 μm for control boards while extractive removed boards had particle size ranged between 500 μm and 1000 μm. Boards made with the unextracted particles resulted in better strength properties for modulus of rupture and internal bond strength when compared to those of the board made with extracted