Characterization of Biocomposite Materials based on the Durian Fiber *(Durio Zibethinus Murr)* Reinforced using Polyester Resin

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Abstract
Characterization of composites based on the of Durian (Durio Zibethinus Murr) fiber using polyester resin had been done by the method of random orientation. The fibers of 2 cm length in average were extracted using 5% of NaOH chemical solution for 1.5 hours. The obtained fibers were measured with compositions of 0 gr, 0.1 gr, 0.2 gr, 0.3 g and 0.4 gr. Then, those fibers were mixed by polyester resin and catalyst then pressed uniformly to reduce void on each sample. The mechanical and physical properties of composites were tested by the Electronics System Universal Tensile Machine Type SC–2DE. The values of tensile strength, flexural strength and strong impact were obtained as 39.165MPa, 46.439MPa and 13.65kJ/mm² respectively. On the other hand, the bulk density was measured as 1.022/cm³ and the content of water was 2.0%. The results showed that the mechanical and physical properties are mostly in the required range of the Standard JIS A 5905:2003 such as tensile strength >0.4 MPa, flexural strength >32.0 MPa, bulk density 1.07 – 1.3 gr/cm³ and percentage of water absorption was 5-13%.

1. Introduction
Durian *(Durio Zibethinus Murr)* is one of the most important seasonal fruit in tropical countries such as Indonesia, Thailand, Malaysia, Philippines, etc. The consumption of this fruits and its products become phenomenal in the global trade market, especially in South East countries. North Sumatera province of Indonesia is one of the biggest provinces producing Durian with 79.659 ton in 2011 (BPS, 2013) [1], and this number is sharply increasing by the time being.

Consequently, the abundance of durian fruits result in environmental problems, in which the durian seeds and shells become a large amount of biological waste [3,4]. In common practice, durian residues are burned or sent to landfills, without regard to the surrounding environment. On the other hand, durian seeds grow wildly everywhere.

Durian skin fibers are one of the newly explored fibers as reinforcement for thermoset and thermoplastic to produce biocomposite materials. In general, composite materials consist of a matrix as a binding agent and filler as a reinforced material. There are some advantages of using biocomposite materials in everyday tools such as anticorrosive, strong and cheap materials. In the recent years, some research works have been performed in durian peel and other aquiculture such as coconut for composites material in building and insulation particle boards. In this experiment, hot
compressed process with urea-formaldehyde (UF) as binder [1-4] had been used. Moreover, new durian compressed fiber boards have been produced from durian’s fiber for compressed fiber boards of mixing-latex as binder instead of UF [5]. The durian’s fiber-latex composites to form compressed fiber boards can be achieved by hot compression processing that no volatile of formaldehyde contaminated in environment. From above experiment, it was concluded that the particle boards free UF is good for furniture production, material in house or office [6,7]. Therefore, it is important to understand their physical and mechanical characteristics of this natural fiber composite so that it can be used in appropriate and variety of applications [6]. The purpose of this study is to examine the influence of durian fiber’s composition on biomaterial composite reinforced with polyester resin as a function of physical and mechanical properties.

2. Experiment

2.1 Materials

The durian fruits as samples were obtained from a local market. The type of durian was intentionally chosen from the district of Sidikalang, a southern part of Sumatera province. It is commonly that durian from Sidikalang has a skin relatively thicker than those of other durian. The freshly skins were chopped in to several parts and washed thoroughly with tap water to remove any adhering particles and dust. Then, a 1000 g of dried durian skins were boiled at 70˚C using a beaker glass on a hot plate. In order to obtain its fiber, the skins were extracted using a 5 % of NaOH solution for 1.5 hours. Next, the obtained durian fibers were again washed by water to separate from residual lignin. After that, durian’s fibers were dried inside oven drying for reducing moisture completely. Durian’s fibers of 2 cm length were measured with a composition of 0; 0.1; 0.2; 0.3 and 0.4 g.

Figure 1. Durian fruit (*Durio Zibethinus Murr*) harvested from Sidikalang district of North Sumatera province was prepared as a sample. The skin of this fruit is commonly thicker than those from other places.

Polyester resin of Handneer *methylene keton peroxide* (MEKPO) purchased from PT. Justun Kimia Raya Medan was used. This kind of resin has a 1.215 g/cm³ of density, 0.188 % of water absorption, 9.4 kg/mm² of flexural strength and 300 kg/mm² of flexural modulus. A mixing of 100 gr of polyester resin and 1 g of catalyst were put in a molten then the durian fiber with various compositions of 0; 0.1; 0.2; 0.3 and 0.4 gr was placed randomly. Each sample was pressed using hot press at temperature of 70°C for 20 minutes. Electronics System Universal Tensile Machine was used to perform mechanical properties with a 100 kgf of load for flexural strength and 200 kgf load for tensile strength tests.

2.2. Physical Properties

In order to determine the bulk density of durian fiber composite materials reinforced with polyester resin, the weight and dimension of the composite samples were measured based on the following formula:
\[ D = \frac{W_t}{L \times W \times H} \quad (1) \]

where \( W_t, L, W \) and \( H \) are weight, length, width and height of sample composite, respectively. All the samples were dried at the temperature of 50 \(^\circ\)C for 24 hours before measuring the bulk density. Average bulk densities were obtained using results from five samples of each various composition.

Physical properties of water absorption ability were performed for all samples. For this purpose, each composite sample was soaking in to four glass beaker containing 5 \%, 10 \%, 15 \% and 20 \% of water at room temperature and atmospheric pressure. The weight of each samples was measured before immersion in to the water. After a certain period of time interval, each samples were taken out from the beaker glass, wiped out using tissue papers and then measured final weight by analytical balance. The water uptake (mass gained) was measured by subtraction of initial weight from the final weight. The percentage of water absorption was calculated by the following formula:

\[ W_s = \frac{W_f - W_i}{W_i} \times 100 \% \quad (2) \]

where \( W_f \) and \( W_i \) are the weight of samples after and before soaking in to water, respectively.

2.3. Mechanical Properties

Mechanical properties of the durian fiber composites such as tensile and flexural strengths were measured by a universal testing machine by keeping at a cross head speed of 2 mm/min, and gauge length of 50 mm. The percentages of flexural stress and strain were also measured by the same machine, keeping a distance of 70 mm between two supports on which the composite samples were placed to employ load. All the samples were performed under a condition of 50 \(^\circ\)C.

3. Results and Discussion

Physical and mechanical properties of the reinforced durian fiber composite are summarized in the following table:

| Fiber content (g) | Tensile Strength (MPa) | Impact Strength (KJ/mm\(^2\)) | Flexural Strength (MPa) | Water Absorption (%) | Density (g/cm\(^3\)) |
|------------------|------------------------|------------------------------|-------------------------|----------------------|---------------------|
| 0                | 12.88                  | 8.58                         | 10.32                   | 0.188                | 1.215               |
| 0.1              | 27.44                  | 10.56                        | 32.44                   | 0.783                | 1.081               |
| 0.2              | 37.22                  | 11.32                        | 34.62                   | 0.812                | 0.992               |
| 0.3              | 47.54                  | 13.62                        | 48.88                   | 1.404                | 0.964               |
| 0.4              | 45.02                  | 11.56                        | 45.06                   | 1.881                | 0.948               |

Figure 2 shows the tensile strength as a function of various compositions of durian skin fiber composites.
It can be seen that the tensile strength increased as increasing compositions of durian skin fiber composites reinforced by polyester resin. The maximum value of the tensile strength was found to be 47.54 MPa at 0.3 g of fiber composition. Based on the Japanese Industrial Standard, JIS A 5905: 2003 that the biocomposite fiberboard requires the tensile strength greater than 0.4 MPa.

**Flextural Strength**

The flextural strength as a function of durian skin fiber composites is depicted in Figure 3. This mechanical behavior is increasing almost linearly as increase of composition up to 3 g of durian fiber composite in which its maximum flextural strength was 48.88 MPa. At composition of 0.4 gram, the flextural strength decreased at about 45.06 MPa, implying that the polyester resin matrix was unable to bind the durian fiber homogenously.

![Flextural Strength Graph](image)

**Figure 3.** Flextural strength as a function of durian skin fiber composition reinforced with polyester resin. The maximum value of flextural strength was 48.88 MPa at 0.3 g of fiber composition.

Based on the Japanese Industrial Standard, JIS A 5905: 2003 that the biocomposite fiberboard requires the flextural strength greater than 32 MPa.

**Impact Strength**

Figure 4 shows the impact strength of biocomposite composition based on durian fiber reinforced by polyester resin. This impact strength is quite similar to other mechanical behaviors in which the values
are increasing as increase durian fiber composition. The maximum value of impact strength was 13.62 kJ/mm² at composition of 0.3 g. Then, it decreased as increase of fiber composition.

**Figure 4.** Impact strength as a function of durian skin fiber composition reinforced with polyester resin. The maximum value of impact strength was 13.62 KJ/mm² at 0.3 g of fiber composition.

Figure 4 shows the impact strength as a function of durian fiber composition. It is clearly seen that the impact strength increased as increasing compositions of durian skin fiber composites reinforced by polyester resin. The maximum value of the impact strength was found to be 13.6 MPa with a composition of 0.3 g. Then, this mechanical property decreased as increase of fiber composition. One of the causes is that as fiber composition is greater some voids appear on the fiber composites.

The relationship between density and durian skin fiber composition is depicted in Figure 5. It is clearly seen that the density is decreased as the composition of durian skin fiber increased. The density of durian fiber was about 1.288 g/cm³, which is in the range of density of other natural fibers between 1.2 g/cm³ to 1.5 g/cm³. Our result was similarly to the result by Manshor, et al, in which the average density of durian skin composites was 1.243 g/cm³. On the other hand, the percentage of water content investigated was between 7.66 to 8.89 %. This experimental result is also similar to other natural fiber whose values between 5 – 15 %.

**Figure 5.** Density as a function of durian skin fiber composition reinforced with polyester resin. The density decreased as increase of fiber composition.

Based on the Japanese Industrial Standard, JIS A 5905:2003 that the density of biocomposite materials should have the values between 0.35 g/cm³ to 1.3 g/cm³.
**Water Absorption**

Figure 6 shows the data of the water content as a function of durian skin’s fiber compositions. The water content was found to be 1.081 % to 0.948 %.

![Figure 6](image)

**Figure 6.** Water absorption as a function of durian fiber composition reinforced with polyester resin. The maximum value of water content was 1.404 % at 0.3 g of fiber composition.

4. **Conclusion**

Based on the experimental data, it can be drawn some conclusion as the following:

1. The physical properties of biocomposites based on the durian skin fiber reinforced by polyester resin decreased as increase of fiber compositions. These physical properties include its density and content of water.
2. On the other hand the mechanical behaviors such as tensile strength, impact strength, flexural strength increased as increased the durian fiber composition up to its maximum value. In general, the maximum value of the mechanical behavior was found on the composition fiber of 0.3 g, in which tensile strength, impact strength, flexural strength values are 47.54 MPa, 13.62 KJ/mm$^2$ and 48.88 MPa, respectively. Then, the values of the mechanical properties decreased as increase durian fiber composition.
3. Based on the Japanese Industrial Standard JIS A 5905: 2003, the values of mechanical properties found in this experiment are in the range of requirements.
4. Compared to other experimental work based on natural fiber, in fact, the physical and mechanical properties of durian skin fibers composites are suitable for blending and processing with other biopolymer. Then, it can be possible to produce biocomposites material for various applications in the everyday life.

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**References**

[1] Badan Penelitian Statistik (BPS). 2013. Produksi Buah-Buahan dan Sayuran Tahunan di Indonesia 1995-2013. http://www.bps.go.id

[2] Lertsutthiwong, S. Khunthon, K. Siralertmukul, K. Noomum, and S. Chandrkrachang, 2008 *Bioresource Technol.* 99 4854
[3] Manshor, R.M. Anuar, H. Wan Nazri W.B and Ahmad Fitrie M.I. 2012 Advanced Materials Research 576 212

[4] Foo K. Y., Hameed B. H. 2011 Biomass and Bioenergy 35 2470

[5] Z. Pan, A. Cathcart, and D. Wang, 2006 Ind Crops Prod. 23 40

[6] J. Khedari, S. Chavoenvai, and J. Hirunlabh 2003 Build Environ. 38 435

[7] Jones R.M, 1975. Mechanics of Composite Materials, Scripta Book Company Washington D.C, USA.