# Durian Fiberboards Using Different Types of Synthetic Resins as Binder

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*Abstract*—**This study was intended to produce durian fiberboards using three different synthetic resins: Urea Formaldehyde (U.F.), Polyvinyl Acetate (PVA), and Polyester binders. The physical properties such as shear strength, compressive strength, density, water absorbency rate, and flexural strength in which three samples per parameter were ascertained along with the fiberboard production. The data collected from the five physical property tests of the three different resins were statistically compared to those of the commercial fiberboard (Lawanit) to determine a significant difference between the values obtained. This research aims to determine which resin used would yield the best properties. The results imply that durian fiberboards using Polyester as a binder yield an average density of 421.73 kg/m3 and shear strength of 2,839.62 kPa. On the other hand, Urea Formaldehyde as binder yields an average water absorbency rate of 7.46kg H2O/min, compressive strength of 15,233.07 kPa, and flexural strength of 5,855.65 kPa. Among the three synthetic resins, Urea Formaldehyde has dominated. It is considered to have the potential to compete with commercial fiberboard.**

***Index Terms*— Urea Formaldehyde (U.F.), Polyvinyl Acetate (PVA), Polyester, fiberboards, synthetic resin, Lawanit, Durian Husk**

## I. Introduction

The Durian fruit is commonly known for its distinct scent but delectable taste. It is also known for its distinctive hard shell or rinds with spiky characteristics. Durian rinds collect in high piles throughout the durian season, as vendors typically remove the rinds for the convenience of buyers. For organic fertilizers and firewood, such rinds are considered suitable additives. They are not easily disposed of, however. Existing disposal methods of agricultural waste in landfills or by open burning create direct and significant impacts on the environment and general health standards. Nevertheless, waste can be treated in various ways, but reusing it to produce new goods is the most successful solution [1-7].

With its characteristics, durian husks are sought to be a potential source of fiber to manufacture fiberboards. Fiberboard is a generic term for sheets made from refined or partially refined wood or other vegetable fibers of varying densities. To expand strength, and resistance to moisture, fire, or decay or to enhance any other properties, bonding agents and other materials may be incorporated into the development of the board. The ISO definition is more descriptive in the technical sense: "sheet material generally exceeding 1.5 mm in thickness, manufactured from lignocellulosic fibers with a primary felting bond of the fibers and their inherent adhesive properties. There may be added bonding materials or additives." [8] The researchers would mainly produce medium-density fiberboards (MDF). Medium-density fiberboards are wet or dry in a density range (about 40 to 50 lb/ft3) similar to particleboard.

A study on durian husk as a potential source for the particleboard industry was conducted. Their experiment results show that the durian husk drying process can be carried out economically under the sun. From the initial moisture content of 85% to a final moisture content of 13%, the total drying period for durian husk is around seven days [9]. Another study entitled "Cement-Bonded Board from Durian Waste" was conducted to determine the recommended ratio of cement to durian waste which was found to be 1:4 to optimize the cost [10]. Based on the previous study, another study entitled "An Improved Durian Fiberboard Using Starch as Binder" was made possible. The mass ratio of durian fibers to the binder used was 1:1. The samples of durian fiberboard used had the exact measurements to achieve more accurate and precise performance [11]. Lastly, another study in 2016 was conducted in which the researchers attempted to synthesize resin mixtures from urea formaldehyde and phenol formaldehyde with different mass percentages. The resins produced have been used to manufacture medium-density composite boards based on jute. In order to make the board consistent with the Bureau of Indian Standards requirements, it was found that the binder content of a medium-density fiberboard must be 12 percent or more [12].

As mentioned earlier on fiberboards, this study will use synthetic resins of different kinds to produce durian fiberboards. This study aims to produce durian fiberboards using three different synthetic resins as binders and determine which resin would yield the best properties. Moreover, the researchers will also compare the properties of the samples with the properties of the commercial fibreboards. Specifically, this study sought to address the following: (1) test the physical properties of the fiberboards such as density, water absorbency rate, and mechanical properties (shear, compressive, and flexural strength); and (2) determine if there is a significant difference between the fibreboards produced and commercial fibreboard in terms of the properties as mentioned above.

This study will help decide which resin will produce the best durian fiberboard according to its quality in the experiment. It will also help reduce waste materials such as durian peelings and convert them into a functional products like fiberboard.

This study will compare the durian fiberboard quality using synthetic resin, namely, Urea-formaldehyde (U.F.), Polyvinyl acetate (PVA), and Polyester. Mixtures of binders used will not be used in the experiment. Also, it will use different varieties of durian sold in various fruit stalls in Davao City. However, the researchers will not focus on a specific variety of durian as it would not be economical. This study aims to help utilize durian waste from different vendors, regardless of the variety.

## II. Materials and Methods

### *A. Conceptual Framework*

Durian fibers shall be extracted from the collected husks. They will undergo the manufacturing process of fiberboards, as shown in Figure 1. The produced fiberboard samples will be tested for their density, water absorbency rate, and mechanical properties (shear, compressive, and flexural strength). The best resin used for each property will be determined by identifying which yielded the most favorable data out of the three.

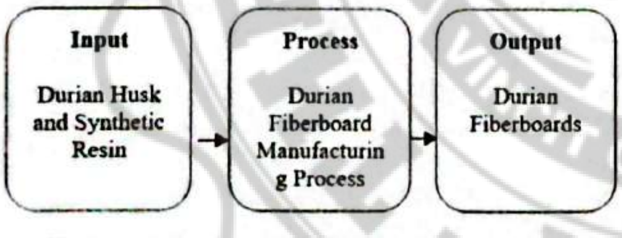


Fig. 1. Conceptual framework of the production of durian fiberboards

### *B. Materials and Resources*

Durian husks used as fiber sources were collected from durian vendors situated in Magsaysay Fruit Market in Davao City, Philippines. These were thoroughly washed to remove dirt and other contaminants. For the commercial fiberboard samples, lawanit boards sold in local lumber stores were used. The machine used for testing the strength properties of the fiberboard samples is Jinan Liangong WEW-100B Computer Screen Hydraulic Universal Testing Machine.

Fig. 2. Jinan Liangong WEW-100B Computer Screen Hydraulic UTM

Three resins were used to produce the durian fiberboard samples – urea-formaldehyde, polyvinyl acetate, and polyester resin. Due to their low cost and simple application, urea-formaldehyde adhesives are the most widely used resin in the particleboard industry. U.F. resins are used for about 90 percent or more of the world's particleboard manufacturing. Urea-formaldehyde in powder form was purchased for the research. For the preparation of the resin, the powder was mixed with water at a 1:1 ratio by weight [13]. Polyvinyl acetate (PVA) is commonly known as white glue or wood glue. It is the product formed by the polymerization of vinyl acetate. The researchers used Shelwood White Glue available in local hardware stores [14]. The polyester resin used for this study was R10-103 produced by Polymer Products (Phil.), Inc. R10-103 is a semi-flexible polymer resin used primarily for fiberglass reinforcements to manufacture glass-reinforced plastic products that need some resilience for higher strength and impact resistance, such as vessels, car bodies, tanks, etc. [15].

### *C. Methods and Procedures*

#### *1. Durian Fiberboard Manufacturing Process*

Durian husks were collected from stores in the Magsaysay Fruit Vendors' Association. The collected husks were then washed to remove dirt and other contaminants. After washing the collected durian husks, these were chopped and reduced to smaller sizes. The chopped husks were then boiled until they were soft enough to be processed in the durian fiber extractor machine. After getting pulped in the machine, the processed husks were rewashed to separate the lignin from the fibers. The obtained fibers were then sundried. The mass ratio of durian fibers to the binder used was 1:2, where the binder is composed of 100% resin by weight following a study in which it was found that the resin content of an MDF must be 12% or more to conform to standard specifications [6]. The mixtures were formed into boards with dimensions of 15 cm x 20 cm x 1 cm. The boards were sundried and allowed to cure at room temperature. The produced durian fiberboards were tested according to standard testing methods. The data collected for each test was recorded for statistical treatment, which includes the mean and T-test. Mean was used to determine which resin works best in density, water absorbency rate, shear strength, compressive strength, and flexural strength. In contrast, the T-test was used to interpret the mean values of the properties. This is to determine the differences regarding the properties between commercial fiberboard and durian fiberboard with synthetic resins as binders. The researchers used a two-tailed test with a significance level of 0.05. This was calculated using the SPSS Statistics software.

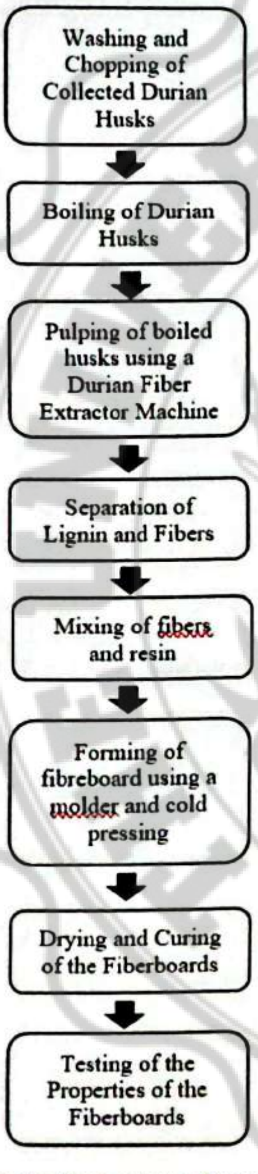


Fig. 3. Durian fiberboard manufacturing process

Fig. 4. Durian fiber extractor machine prototype by a group of mechanical engineering students

Fig. 5. Durian fiberboards produced

2. *Density*

The mass and volume of each sample were measured to find their density. The mean of the densities of the fiberboard samples for each resin was calculated.

3. *Water Absorbency Rate*

The initial mass, $m_i$, of each fiberboard sample was measured before soaking them in water. After 13 minutes, their final mass, mf, was taken. Each sample's water absorbency rate (kg $H_2O$/min) was obtained by dividing the difference between its $m_f$ and $m_i$ by the soaking time of 13 minutes.

4. *Shear Strength*

The researchers followed the ASTM D 143-83 standard to measure the shear strength of the fiberboards. In the shear apparatus, the fiberboard was positioned. The load was applied at a constant rate until the fiberboard collapsed.

5. *Compressive Strength*

The researchers followed the ASTM D 143-83 and ASTM D 198 specifications for fiberboard compressive strength testing.

6. *Flexural Strength*

To measure the flexural strength of fiberboards, the researchers adopted the ASTM D 1037 standard.

## III. Results and Discussions

### A. *Results of the Testing on the Properties of the Fiberboards*

1) *Density:* After calculating the mass and volume of each fiberboard using urea-formaldehyde, polyvinyl acetate,

and Polyester, the values of the mean density in kg/m3 were 380.24, 248.38, and 421.73, respectively. The mean density of commercial (Lawanit) fiberboard is 698.78 kg/m3. The standard deviation for the density data for urea formaldehyde, polyvinyl acetate, polyester resins, and the commercial fiberboard are 11.11, 2.32, 29.63, and 13.47, respectively, as shown in Fig. 6. This value shows that the mean density of durian fiberboard using polyester resin as the binder can be further investigated to improve its mean density and comparable to that of the commercial fiberboard.

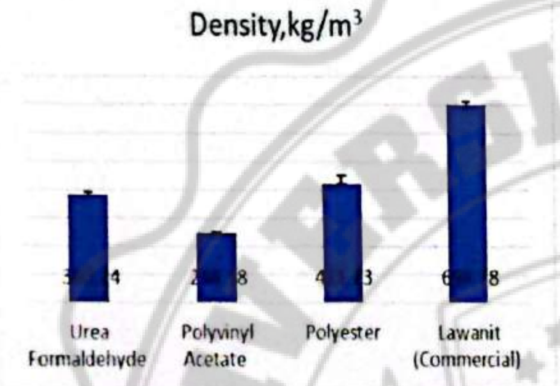


Fig. 6. Mean density of the fiberboard samples

2) *Water Absorbency Rate:* The mean water absorbency rate in kg H2O/min for the fiberboards using urea-formaldehyde, polyvinyl acetate, and polyester resins are 7.46, 11.62, and 9.26, respectively. The mean water absorbency rate of the commercial (Lawanit) fiberboard was 3.21 kg H2O/min. The standard deviation for the water absorbency rate data for urea formaldehyde, polyvinyl acetate, polyester resins, and the commercial fiberboard are 1.11, 3.55, 1.12, and 0.31, respectively, as shown in Fig. 7. This value shows that the mean water absorbency rate of durian fiberboard using polyester resin as the binder can be further investigated to improve its mean water absorbency rate and comparable to that of the commercial fiberboard.

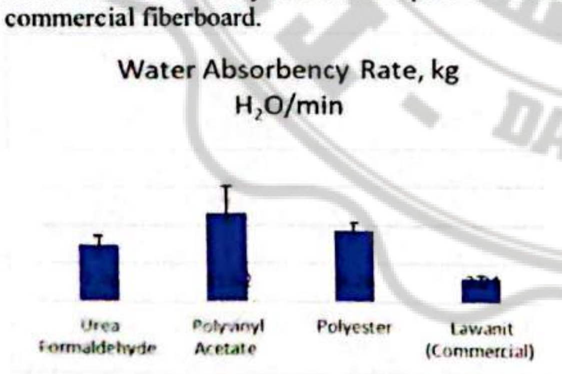


Fig. 7. Mean water absorbency rate of the fiberboard samples.

3) *Shear Strength:* The mean shear strength in kPa for the fiberboards using urea-formaldehyde, polyvinyl acetate, and polyester resins are 1642.16, 2771.24, and 2839.62, respectively. The mean shear strength of the commercial (Lawanit) fiberboard was 4040.40 kPa. The standard deviations for the shear strength data for urea formaldehyde, polyvinyl acetate, polyester resins, and the commercial fiberboard are 437.84, 416.75, 686.59, and 2149.88, respectively, as shown in Fig. 8. This value shows that the mean shear strength of durian fiberboard using polyester resin as the binder can be further investigated to improve its mean shear strength and comparable to that of the commercial fiberboard.

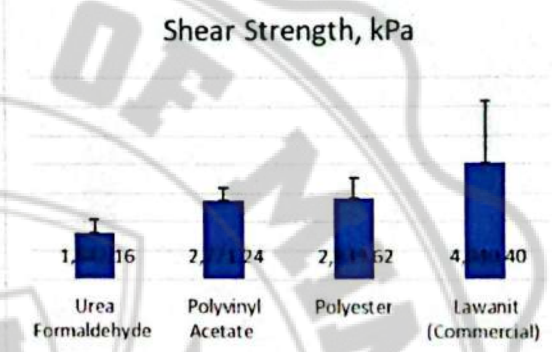


Fig. 8. Mean shear strength of the fiberboard samples

4) *Compressive Strength:* The mean compressive strength in kPa for the fiberboards using urea-formaldehyde, polyvinyl acetate, and polyester resins are 15233.07, 9660.14, and 13940.24, respectively. The mean compressive strength of the commercial (Lawanit) fiberboard was 24787.76 kPa. The standard deviations for the compressive strength data for urea formaldehyde, polyvinyl acetate, polyester resins, and the commercial fiberboard are 350.19, 987.40, 287.24, and 568.03, respectively, as shown in Fig. 9. This value shows that the mean compressive strength of durian fiberboard using urea-formaldehyde resin as the binder can be further investigated to improve its mean compressive strength and comparable to that of the commercial fiberboard.

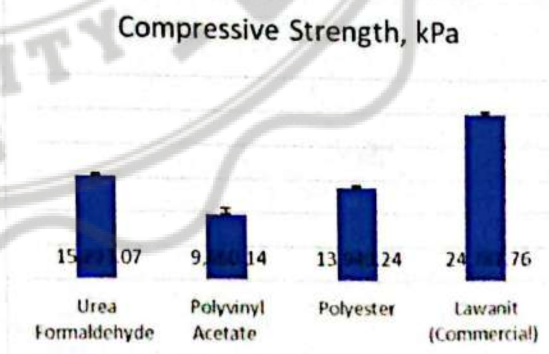


Fig. 9. Mean compressive strength of the fiberboard samples.

5) *Flexural Strength:* The mean shear strength in kPa for the fiberboards using urea-formaldehyde, polyvinyl acetate, and polyester resins are 5855.65, 4705.61, and 3531.49, respectively. The mean shear strength of the commercial (Lawanit) fiberboard was 92225.16 kPa. The standard deviations for the flexural strength data for urea formaldehyde, polyvinyl acetate, polyester resins, and the commercial fiberboard are 1856.09, 818.49, 148.09, and 5987.69, respectively, as shown in Fig. 10. This value shows that the mean flexural strength of durian fiberboard using urea-formaldehyde resin as the binder can be further investigated to improve its mean flexural strength comparable to that of the commercial fiberboard.

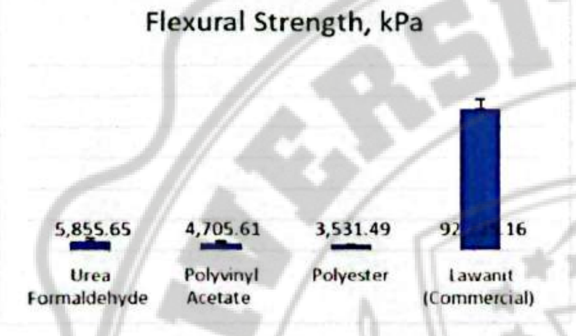


Fig. 10. Mean flexural strength of the fiberboard samples

### B. *Significant Difference in the Mean Values of the Produced Durian Fiberboards and the Commercial Fiberboards*

The data for the properties of the produced durian fiberboard samples from each type of synthetic resin was compared to those of the commercial fibreboard lawanit using the T-test, and p-values were obtained. A p-value less than 0.05 indicates a significant difference between the measured properties of the experimental samples and the commercial samples.

1) *Using Urea-Formaldehyde:* p-values obtained to compare the durian fibreboard samples using urea-formaldehyde as resin and commercial fiberboards were shown in Table I. Significant differences existed between their density, water absorption, compressive strength, and flexural strength. No significant difference was found in their shear strength property.

TABLE I

DURIAN FIBERBOARDS USING UREA FORMALDEHYDE VS. COMMERCIAL FIBERBOARDS

| Parameters | Mean | | p-value | Significance |
|---|---|---|---|---|
| | Produced Fiberboards | Commercial Fiberboard | | |
| Density, kg/m$^3$ | 380.24 | 698.78 | 0.000 | Significant |
| Water Absorption Rate, kg $H_2O$/min | 7.46 | 3.21 | 0.003 | Significant |
| Shear Strength, kPa | 1642.16 | 4040.40 | 0.131 | Not significant |

2) *Using Polyvinyl Acetate:* The p-values obtained for the comparison of the durian fiberboard samples using polyvinyl acetate as resin and commercial fiberboards were shown in Table II. Significant differences existed between their density, water absorption, compressive strength, and flexural strength. No significant difference was found in their shear strength property.

TABLE 2

DURIAN FIBERBOARDS USING POLYVINYL ACETATE VS. COMMERCIAL FIBERBOARDS

| Parameters | Mean | | p-value | Significance |
|---|---|---|---|---|
| | Produced Fiberboards | Commercial Fiberboard | | |
| Density, kg/m$^3$ | 248.38 | 698.78 | 0.000 | Significant |
| Water Absorption Rate, kg $H_2O$/min | 11.62 | 3.21 | 0.015 | Significant |
| Shear Strength, kPa | 2771.24 | 4040.40 | 0.372 | Not significant |
| Compressive Strength, kPa | 9660.14 | 24787.76 | 0.000 | Significant |
| Flexural Strength, kPa | 4705.61 | 92225.16 | 0.000 | Significant |

3) *Using Polyester:* The p-values obtained to compare the durian fibreboard samples using Polyester as resin and commercial fiberboards are shown in Table III. Significant differences existed between their density, water absorption, compressive strength, and flexural strength. No significant difference was found in their shear strength property.

TABLE 3

DURIAN FIBERBOARDS USING POLYESTER VS. COMMERCIAL FIBERBOARDS

| Parameters | Mean | | p-value | Significance |
|---|---|---|---|---|
| | Produced Fiberboards | Commercial Fiberboard | | |
| Density, kg/m$^3$ | 421.73 | 698.78 | 0.000 | Significant |
| Water Absorption Rate, kg $H_2O$/min | 9.26 | 3.21 | 0.001 | Significant |
| Shear Strength, kPa | 2839.62 | 4040.40 | 0.409 | Not significant |
| Compressive Strength, kPa | 13940.24 | 24787.76 | 0.000 | Significant |
| Flexural Strength, kPa | 3531.49 | 92225.16 | 0.000 | Significant |

## IV. CONCLUSIONS AND FUTURE WORKS

Test results showed that durian fiberboards using polyester resin yielded the best density and shear strength results at 421.73 kg/m3 and 2839.62 kPa, respectively. Moreover, durian fibreboards using Urea Formaldehyde yielded the best water absorption rate, compressive strength, and flexural strength at 7.46 kg H2O/min, 15233.07 kPa, and 5855.65 kPa, respectively. Using T-test, it was determined that the data obtained from durian fiberboards produced in terms of density, water absorption rate, compressive strength, and flexural strength showed a significant difference from those of the commercial fibreboard (Lawanit) samples. On the other hand, the durian fiberboard's shear strength data showed no significant difference from those of the commercial fibreboard (Lawanit) samples. Given the properties and strength of the produced durian fiberboards, they can be used for insulation, lightweight furniture cores, and other interior MDF applications.

For further research, the researchers recommend using a hot press in contrast to the cold press used in the study to determine if there will be a significant difference in the properties of the fiberboards produced. Future researchers also recommend using different mixing proportions of the fibers and resins to obtain the optimal mixing proportion. Lastly, future researchers are recommended to increase the number of samples to be tested to achieve more accurate results.

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