The effect of seaweed (*Eucheuma cottonii*) age differences as a material on medium density fiberboard (MDF) manufacture

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Abstract. *Eucheuma cottonii* is a potential type of seaweed because of its abundant production. Its content of lignocellulose could be beneficial in Medium Density Fiberboard (MDF) manufacture since it could increase the market of this kind of seaweed. Lignocellulose itself is influenced by the age of seaweed. The aim of this study was to determine the different age in *Eucheuma cottonii* which could effect on its physical and mechanical properties of MDF product. Furthermore, the aim was also to investigate whether the product could meet standard set by JIS A 5908 2003. The study was designed using a Completely Randomized Design with five types of treatment and four times replications. This study used Eucheuma cottonii and sawdust. Manufacture of Medium Density Fiberboard (MDF) consisted of five types of treatment: T0: Sawdust 100%, T1: Seaweed 100%, T2: Sawdust 50 % + Seaweed 50 % aged 15 days, T3: Sawdust 50 % + Seaweed 50 % aged 30 days, T4 Sawdust 50 % + Seaweed 50 % aged 45 days. The results showed that different between physical and mechanical test for the each treatment.

1. Introduction

As an archipelago, Indonesia has good coastal waters and strategic positions to be a center for fishing commodity trade since it lies in between two continents [1]. One of the fishery products is seaweed. It makes profit and livelihood for coastal communities. The use of seaweed increases not only in food industry but also in beauty products, medicines, and raw material industry [2].

*Eucheuma cottonii* is a type of seaweed cultivated in Indonesia. According to Wijayanto et al. [1] this type of seaweed is mostly produced because the production is affordable and easy. Also, its post-harvest handling is relatively easy and simple. However, the use of this seaweed is not optimal, hence, its value is quite low. The harvest production is sold without any prior processing. Hence, some technique is needed to increase the selling value of E Cottonii. One way to increase the selling value of E Cottoni is its use as a mixture in MDF (Medium Density Fiberboard) manufacture. Hakim et al. [3] stated that MDF is a fiberboard made by dry process which uses hot press. Then, pressing with hot press with temperature 170°C and pressure 45 Pa for 25 minutes is executed after raw materials are mixed with adhesive.

The main materials of MDF are sawdust containing lignocellulose. According to Indriany et al. [4] lignocellulose is a biomass made of plants with main components of lignin, cellulose, and hemicellulose. Lignocellulose could be found in carbohydrates. One of the plants containing this substance is *E. Cottonii*. 
Marseno et al. [5] stated that the quality of seaweed is also influenced by the age of harvest. Generally, *E. Cottonii* is ready to be harvested at the age of 1.5 to 2 months. If harvested less than that age, low quality of seaweed will be produced since the content of the compound is low. One of them is the carbohydrate content. Hence, lignocellulose quality depends largely on the age of seaweed. The use of seaweed in the manufacture of MDF is expected to be able to address the decrease in forest ecosystems balance due to illegal logging and exploitation. According to Mawardi [6] the higher demand of timber industry, the less availability of good quality and number of timber. Seaweed could be a solution to this problem.

The aim of this study was to determine the effect of different age of *E. Cottonii* seaweed in Medium Density Fiberboard (MDF) manufacture on physical and mechanical properties and to investigate whether the use of different age of *E. Cottonii* in the manufacture could meet the standard set by JIS A 5908 2003. This significance of this study was to obtain data regarding the physical and mechanical properties of MDF manufacture made of *E. Cottonii* seaweed and to determine the best result of seaweed age as a substitute for sawdust in the manufacture of Medium Density Fiberboard (MDF). Hence, the manufacture could be more selective in using seaweed.

2. Materials and methods
The materials used in this study consisted of equipment and materials. The equipment was 20x20x20 cm³ iron plates as a tool for molding, electric oven, adhesives, press machine, stirrer, transparent plastics, ruler, calipers, Universal Testing Machine (UTM), and Wood Moisture Meter. The material used were *Eucheuma cottonii* obtained from farmers and seaweed collectors in Madura. Sawdust was collected from sawmill residuals in Mulyosari and additional material was bought in shops around Surabaya.

This study utilized five treatments: T0 (Sawdust 100%), T1(*Eucheuma Cottonii* waste 100%), T2 (Sawdust 50 % + *Eucheuma Cottonii* 50 % aged 15 days), T3 (Sawdust 50 % + *Eucheuma Cottonii* 50 % aged 30 days), T4 (Sawdust 50 % + *Eucheuma Cottonii* 50 % aged 45 days). This study utilized a Completely Randomized Design (CRD) because the mediums were treated the same [7] with five different age treatments of *Eucheuma Cottonii*.

2.1 Preparation
It was started with preparing the materials in MDF manufacture, such as: main material *Eucheuma cottonii* seaweed with different ages, sawdust, wood, and adhesives. The seaweed was sun-dried for approximately 3 days to reduce its moisture. Then, it was ground. Next, sawdust was filtered with a size of 40 mesh. The last material was synthetic adhesive. According to Ayrlmis in 2008, the dose of adhesive in MDF manufacture is 11% out of the total materials used.

2.2 Manufacturing process
The manufacture of MDF used dry process utilizing hot press. After the raw materials (sawdust and seaweed) were mixed with adhesive, they were pressed by hot press with temperature 170°C and pressure 45 PA for 25 minutes. The size of the board was 20x20x2 cm³ with the density target 0.4 – 0.9 g/cm³. Next, the board from the hot press was not removed from frame for 24 hours. It was to keep it straight. A high quality board could be produced within 2 days of manufacture [1].

2.3 Study parameter
The main parameter for this study was test results in form of value of both physical and mechanical properties of the produced Medium Density Fiberboard (MDF). Data of both physical and mechanical properties of the produced MDF results would be analyzed further.

2.4 Data analysis
The data was analyzed based on the results collected later using a complete random design with the objective to determine the effect of age difference in seaweed on MDF manufacture. If the results obtained was significant, another test would be conducted using Duncan’s Multiple Range Test (DMRT) analysis to discover the effect of the most influential seaweed age on physical and mechanical properties of MDF [7].

3. Results and discussion

3.1 Results of MDF physical and mechanical tests

MDF (Medium Density Fiberboard) product was physically and mechanically tested. The results of MDF product physical and mechanical tests as well as the JIS A 5908 2003 standard was explained on table 1 and 2 below.

| Physical Property | JIS A 5908 2003 | T0 | T1 | T2 | T3 | T4 |
|-------------------|-----------------|----|----|----|----|----|
| Moisture Content (%) | 5-13 | 6.71 | 14.71 | 8.11 | 8.51 | 8.79 |
| Water Absorption (%) | Not required | 100.78 | 38.8 | 75.193 | 94.527 | 99.49 |
| Thickness Swelling (%) | Maximum 12 | 5.3675 | 10.865 | 5.823 | 9.335 | 10.115 |
| Density (g/cm³) | 0.4-0.49 | 0.505 | 1.1075 | 0.61 | 0.64 | 0.66 |

| Mechanical Property | JIS A 5908 2003 | T0 | T1 | T2 | T3 | T4 |
|---------------------|-----------------|----|----|----|----|----|
| Modulus of Rupture (N/mm²) | Minimum 8 | 18.57 | 7.11 | 13.86 | 17.41 | 18.33 |
| Modulus of Elasticity (N/mm²) | Minimum 2000 | 934.99 | 2050.34 | 1069.54 | 1188.07 | 1226.14 |
| Screw-holding strength (N) | Minimum 300 | 5.3675 | 10.865 | 5.823 | 9.335 | 10.115 |

3.2 MDF physical properties

Treatment of T0 contained the lowest moisture because the sawdust used in this study was from wood growing on land so that it did not absorb much water. On the other hand, T1 treatment had the highest moisture since it was made of 100% seaweed. According to Serdiati dan Widiastuti [8], seaweed could grow well in the ocean with a depth of ± 30 cm so that it absorbs a lot of water from its habitat.

According to Mawardi [6] dried seaweed can absorb water vapor from the air, so that the moisture content at T1 treatment reaches an average of 14.71% even though it had been drained previously. The effect of high moisture content was the presence of bacteria / microorganisms in MDF product which resulted in low quality and moldy products.

Treatment of T1 showed the highest value of water absorption because it was related to a very high density value in T1 treatment. According to Trisna and Mahyudin [9] the higher the density, the higher the water absorption capacity. This is because the MDF board has a high density so the bond among the
particles becomes more compact. Hence, the air cavity in the board sheet decreases. This situation causes water or moisture hardly filling the cavity.

Thickness swelling value of T0 treatment illustrated in the above table had the lowest value because the raw material used was 100% made of sawdust. According to Hamdi [10] wood usually has many cavities and a low density. One of wood properties is the ability to absorb and release water based on its moisture content as well as its thickness swelling property which correlates with the nature of water absorption. T1 had the highest thickness swelling value because the main raw material of the MDF board compiler was 100% seaweed. From the previous analysis, the water absorption capacity of the T1 treatment was very high. Hence, its thickness swelling value was also high.

Treatment of T0 had the lowest density because the mass of sawdust was lower compared to treatment of T1. It was because seaweed had a higher mass compared to sawdust. The materials contained 100% sawdust would have weak bonds so that its large amount was needed in the manufacture of MDF board with the same volume size. In contrast to 100% seaweed waste, it had a high mass compared to sawdust. Therefore, MDF board manufacture required only a small amount of seaweed. Furthermore, the bonding among particles was also closer. This was in line with explanation of Hakim et al [3] that the density value is influenced by the thickness of the cell wall, moisture content, and gluing process. The increase in density was also caused by compaction due to compression during the MDF manufacture.

3.3 MDF mechanical properties
Treatment of T1 had the lowest value of Modulus of Rupture (MOR) because the raw material was made of seaweed waste. The T1 treatment had the highest density but it was not supported by the good quality of the main material. Hence, the final product had a low modulus of rupture value. According to Wulandari [11] the manufacture of particle boards should use the same particle sizes to produce high quality particle boards. Because T1 treatment used seaweed waste as the main material, it was difficult to uniform the same property particles.

Treatment of T0 had a high Modulus of Rupture (MOR) value because the bond among its particles was strong. It was also because the particle size and the sawdust type used were of the same size. This was in line with Wulandari's explanation [11] that the more uniform the particle size, the more stable the particle board produced. It is because the same amount of adhesive could enter the particle pores.

Based on the table above, the average value of Modulus of Elasticity (MOE) in each treatment was low. According to Hakim et al. [3] the low value of modulus of elasticity is influenced by the low lignocellulose bond among particles. T1 treatment had a high modulus of elasticity value because 100% of its raw material was made of seaweed which had high lignocellulose and gel. Hence, its modulus of elasticity was higher than the other treatments.

Another factor affecting the value of modulus of elasticity was the mixture process of raw materials with adhesive. The process in this study was executed manually which caused the inequality use of adhesive. Hence, the value of modulus of elasticity was low.

The data in table 2 shows that screw-holding strength of T0 treatment was 320 N which was a high average value. In contrast, T1 treatment screw-holding strength was 160.47 N which was the lowest one. The T1 treatment had the lowest screw-holding strength value due to its high moisture content (14.71%). It caused weak bonding among particles when the screw-holding strength was tested. In addition, inequality of adhesive use was caused by the manual process of material mixture. Hence, it affected the inter-particle strength during the screw-holding strength test. According to Hakim et al. [3] MDF has the same weaknesses as other types of boards, which are: weak screws on the thick side and ineffective adhesive on the surface which does not bind the nail as strong as solid wood.

4. Conclusion
The conclusion of this study is the use of different seaweed age in the treatments affected the physical properties of MDF boards, they were: moisture content, water absorption, and density. However, thickness swelling was not affected. The use of seaweed age had effects on the mechanical properties of MDF board, they were: modulus of rupture, modulus of elasticity and screw-holding strength. Alternative
use of *Eucheuma cottonii* seaweed as a mixture for MDF (Medium Density Fiberboard) manufacture could still be used because it meets the standard set by JIS A 5908 2003.

5. References

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