Utilization of Coconut Fronds as Raw Material for Making Art Paper

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Abstract. Coconut fronds are part of a coconut tree that has been rarely used while the amount is abundant. Therefore, there is a concern of how to more utilize coconut fronds. Coconut fronds can be used as raw material for making art paper because it has good amount of fiber and cellulose. The utilization of coconut fronds for making art paper can minimize the coconut fronds waste. Additionally, it also has an impact on forest conservation, since most of raw materials for paper pulp are coming from woods in the forest. The objective of this study is to utilize coconut fronds as agricultural solid waste as raw material for making art paper. The method used to make the paper is chemical pulp, which including pulping and bleaching, as well as art paper molding. The prepared art paper was then characterized by tensile strength test, strength test stretch and grammature. The art paper samples that have been prepared met the minimum SNI grammature of 100 g/m². While, for the best tensile resistance test was about 19,800 for sample 30/75. Meanwhile, the best stretch resistance test was 0.955 for sample 60/75.

1. Introduction

Human are significantly depended on paper for several applications since ancient time. In 1990, the production of pulp in the world reached above than 160 million metric tons. Around 90% of pulp and paper of the world is supplied by wood from the plantations and natural forests [1]. While, the log production could only supply about 10% world capacity. This condition has caused the destruction of forest, which also led to the availability problem of raw material for production of pulp and paper. Hence, alternative raw materials for production of pulp and paper are necessary to promote forest conservation as well as fulfilling the pulp and paper demand [2]. Several pulp and paper industries that used alternative raw materials already exist in these modern days [3], [4]. The most important component to make pulp and paper is lignocellulose. It is majorly composed of cellulose (about 40 to 60%); hemicellulose (about 10 to 40%), and lignin (about 15 to 30%), and also small amounts of proteins, extractives, and organic compounds [4]. Lignocellulose can be obtained from woody and non-woody biomass. Woody biomass is the common raw material for production of pulp and paper, such as pine, poplar, eucalypt, etc. While, non-woody biomass such as kenaf, hemp, bamboo, abaca, tagasaste, etc. and also including agricultural waste such as barley and wheat straw, oil palm empty fruit bunch (EFB), bagasse, etc [3].

One of non-woody biomass that has potential to be used as raw materials for making pulp and paper is mid-ribs of coconut leaves (i.e. coconut fronds) [2], [5]. Coconut (Cocos nucifera) is belong to the
palm family of Arecaceae and the only living species of the genus Cocos [6]. Coconut leaves are commonly called fronds with the length in the range of 4.5 – 5.5 m (15 – 18 ft). The leaflets are about 0.15 – 0.50 m (wide) and 5 – 15 m (long). The coconut tree can produce about 12 – 18 fronds per year. The old fronds will peel away and left the trunk cleanly [7], [8]. The studies about the use of coconut fronds as raw materials to make pulp and paper are very limited [2], [5]. Therefore, the objective of the current study is to utilize coconut fronds as agricultural solid waste as raw material for making art paper.

2. Experimental

2.1. Materials and apparatus
Art Paper that is produced using materials in the form of coconut fronds that have been waste smoothed with a size of 1-2 cm by the delignification process using NaOH after that washing using aquadest, bleaching with Hydrogen Peroxide and the addition of adhesives PVAc and finally the printing or molding process. Figure 1 shows the photographs of coconut plant and coconut fronds waste. The apparatus prepared in this study are beaker cups, measuring flasks, measuring cups, hotplate, magnetic stirrer, stirrer, mold and blender.

![Figure 1. The photographs of a) coconut plant, and b) dried coconut fronds waste.](image)

2.2. Production of the art paper
Dry coconut fronds are cut and then washed after which they are dried in the sun to reduce oisture content, then mashed by grinding or blended in sizes 1-2 cm. Next process in delignification, which is the process of removing lignin in lignocellulosic material. This delignification using Sodium Hydroxide (NaOH) as a cooking solution. With temperatures of 100 °C and cooking time variations of 30, 60 and 90 minutes. The next process is bleaching process of the pulp. Pulp produced from the delignification process is still brownish yellow, so it needs to be bleached. In this study Hydrogen Peroxide (H2O2) was used as a bleaching agent. The final process is molding. All the materials are mixed using a blender and then added with PVAc glue with a variation of adhesive weight of 50, 75, and 100 grams. Afterward, the samples were molded and dried under the sun. The art paper samples were molded using a screen with a size of 40x60 cm. Election the type of screen may affect the resulting paper. Fineness and roughness of the mold determined based on the mesh.

2.3. Characterization of the art paper
The art papers produced in this work will be characterized for their grammature. Grammature is the mass of sheets of paper in grams divided by the unit area of paper in meters square in g / m2 (gsm) units. Art Paper that meets SNI 0123: 2008 standards is Art Paper which has a minimum of 100 gsm grammature. Additionally, the art papers will also be tested for their tensile strength and % strain.

3. Results and discussion

3.1. The appearances of the art papers
In this study, the art paper samples were prepared by varying the cooking time (i.e. 30, 60, and 90 minutes) and the adhesive weight (i.e. 50, 75, and 100 g), and each of them was replicated 3 times, which make the total number of samples is 27. Figure 2 shows the appearances of the art papers produced in this work. The code used in sample name was the combination of cooking time and adhesive weight. For example, sample code “30/50” indicating the art paper sample was prepared at cooking time of 30 minutes and adhesive weight of 50 g. All the samples were then tested for the weight test (grammature) as well as the tensile strength and strain tests.

Figure 2. The appearances of the art papers produced in this work.

3.2. Grammature of the art papers
Grammature is the mass of sheets of paper in grams divided by the unit area of paper in square meters with units of g/m² (gsm). Art Paper that meets SNI 0123:2008 standard is Art Paper that has a minimum grammature of 100-150 gsm. The grammature of the art paper samples are exhibited in Figure 3. In the figure, it is noticed that the grammature of art paper sample 60/100 is the highest. This is likely due to our lack of knowledge in arranging sample results in printing tools, so that when the sample is dry, the sample can be thick at the top, thin at the bottom, or otherwise. Nevertheless, all the results still meet the criteria of standard art paper, because some art paper also has a thickness of more than 150 gsm.

Figure 3. The grammature (average values) of the art paper samples produced in this work.

3.3. Tensile strength test
According to SNI (Standard National Indonesia), tensile strength is measured in kN/m unit, while in this work, the tensile strenght is measured in gram unit. Figure 4 shows the tensile strength in average values of the art paper samples produced in this work.
Figure 4. Tensile strength (average values) of the art paper samples produced in this work.

As seen in the figure, the highest tensile strength value (i.e. 19,300 g) occurred at art paper sample code 90/75. While, the lowest one (i.e. 5,100 g) occurred at sample code 60/50. It is known that the higher the reaction temperature the delignification rate constants will increase, so that at high temperatures the more lignin can be removed from the biomass. At the time of cooking where the cooking temperature is high the formation of the pulp is perfect so that it is easier to mold the paper and reduces cracks in the paper produced. So that the attraction is getting better or stronger.

3.4. Strain test

According to SNI (Standard National Indonesia), the strain is measured in N/m unit, while in this work, the strain is measured in % (percentage). Figure 5 shows the strain in average values of the art paper samples produced in this work. As seen in the figure, the highest % strain value (i.e. 0.955 %) occurred at art paper sample code 60/75. While the lowest % strain value (i.e. 0.644) occurred at art paper sample codes 60/50 and 30/100.

Figure 5. Percentage strain (average values) of the art paper samples produced in this work.
4. Conclusion
In this work, the art paper has been successfully produced by using coconut fronds as the raw material. The paper bleaching process is affected by the high temperature during the H2O2 (Bleaching) cooking process. All the trees sample A is the use Fox PVAc glue to make the art paper was good because Fox PVAc glue has an adhesive level that is in accordance with the Indonesian National Standard (SNI) so that it makes the fiber mix perfectly. Tensile test results showed that the highest average value of tensile strength occurred at sample code 90/75 with the value of 19,300 g. While, the lowest one (i.e. 5,100 g) occurred at sample code 60/50. In the other hand, the highest % strain value (i.e. 0.955 %) occurred at art paper sample code 60/75. While the lowest % strain value (i.e. 0.644) occurred at art paper sample codes 60/50 and 30/100. Additionally, almost all the art paper samples produced in this work have met SNI 0123:2008 Standard, in which the art paper should has grammature in the range of 100-150 gsm.

5. References
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