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Utilization of Cocunut Coir Waste and Cassava Peel as Opaque Paper Raw Material in Indonesia

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Abstract

Coconut coir is an important part of coconuts with a portion about 35% of total weight. Coconut coir fiber has a high cellulose content, as such this fiber can be used as a raw material for pulping in paper production. This research utilizes coconut coir waste which has high fiber as raw material for paper production. Coconut coir is combined with cassava peel that has been mashed then processed through a delignification process. Next step the pulp mixture is filtered and rinsed, then formed into paper and dried. This study aims to determine the effects of NaOH concentration on tensile strength and tear strength of paper. From the results of the tensile strength and tear strength tests, it was concluded that the higher the NaOH concentration in the delignification process, the lower the results obtained. At 5%, 7%, 9%, 11% and 13% NaOH concentrations, the tensile test results were obtained with values (2.83, 2.24, 1.48, 1.25 and 1.08 kN/m) and the results tear test with values of (47.25, 43.05, 35.05, 32.15 and 25.12 gf).

Keywords: Coconut Coir; Delignification; Fiber; NaOH; Paper

1. Introduction

The paper industry is still relying heavily on wood sources for pulp production. This practice is considered less sustainable because of the extensive resource it employs. Research related to paper production is still being conducted to address such issues to find alternative sources of fiber that can substitute wood sources. Studies have been done to answer the challenges of using new sources of fiber, in addition to wood and cotton. Some of them show diverse information and promising results. A trial on the utilization of tofu solid waste as raw making paper materials was conducted in 2017. They showed that this tofu by-product was not suitable as the main ingredient of paper because its fiber was difficult to unite (Farabi et. al., 2017).

In another study, banana peel and corncob were used as the raw materials. It showed that the optimum result of recycled paper could be obtained at the ratio of the weights of corncob to newspaper at 1 : 4 with the most optimum tensile index value of 17.07 Nm/g and the tear index of 0.0178 Nm^2/g (Fenny, 2016). Some other ingredients that have been examined for cellulose content and have the potential to be used as raw material for the production of recycled paper include rice straw, water hyacinth, bagasse and coconut fiber. the results of previous research are shown in the table 1.

Table 1: Results of previous related studies

No	Topic	Method	Analysis	Result	Author, year
1	Making pulp from rice straw using sodium hydroxide	Delignification, Variables: ethanol concentration (50%), NaOH catalyst concentration (2,4,8)%, cooking temperature (100,110,120,130) ºC	Cellulose, Hemicellulose and lignin	Cellulose, hemicellulose and lignin were 87.833%, 6.713%, and 9.6% at cooking temperatures of 110ºC with 120 minutes	(Rizal, 2005)
2	Effect of concentration of cooking solution on the delignification process of water hyacinth by organosolv process	Organosolv process, variable ethanol concentration (60-80)%, acetic acid concentration (50-90)%	α-cellulose and lignin	The acquisition of α-cellulose and lignin was 81% and 78.6%, the optimum time to cook 2 hours with 80% ethanol concentration	(Artati, 2009)

3	Extraction of cellulose fiber from water hyacinth (eichornia crassipes) plants with a variety of solvents	Extraction	FTIR, TGA and HPLC	FTIR: effective solvent NaClO2. TGA: NaClO2 solvent, evaporation occurs at temperatures of 250ºC and 320ºC. HPLC : content of hemicellulose in NaClO2 solvents: 0.113%	(Putera, 2012)
4	Effect of solvent concentration, temperature and cooking time on pulping from young coconut fiber	Delignification, Variable NaOH Concentration (5,10,15)%, cooking time (60, 90, 120 minutes)	Percent of yield	The optimum results at 10% NaOH concentration, 80ºC temperature, 90 minutes cooking time with 39.72% percent yield	(Saleh, 2009)
5	The use of coconut fiber as a raw material for making alternative composite paper	Delignification, Variation in NaOH concentration (3,6,9)%, cooking time (2,3,4,5,6) Hours.	Tensile strength and absorption	The best characteristics of paper in the mass ratio of 20 : 80 with tensile strength 65,28x106 N / m2, with hydrolysis time of 4 hours and 6% NaOH concentration	(Paskawati, 2010)
6	Delignification of bagasse for the manufacture of high yield pulp with alkaline peroxide process	Delignification	Pulp yield	The highest pulp yield is 53.94%, optimum concentration of 5% NaOH	(Gustriani, 2013)

The delignification process chosen in this study used NaOH solution. Cellulose is taken from coconut fiber and cassava peel, other impurities will dissolve in NaOH so that the desired cellulose is obtained. The advantage of using NaOH solution is that it can be used at room temperature or room conditions, does not require a long time (the delignification process is relatively shorter), can separate lignin from other structures properly (does not damage other contents), and is more economical (Yannasandy, 2017). Factors that influence the delignification process include heating time, which is influenced by the amount of lignin, and high concentration of NaOH solution if the levels of lignin to be processed are large. The mixing of ingredients is influenced by stirring. This process can flatten the solution with the raw material that will be separated from the lignin. The time for this process is influence by the material size, ie. the larger, the longer (Erka, 2011).

This research was carried out by utilizing coconut coir waste and cassava peel as raw material for making paper, because they contain ingredients needed for paper making. The utilization of these materials in paper making has the potential to help reduce pollution caused by waste from the food industry, as well as that from the paper industry. Moreover, this avenue may help reduce the use of wood pulp that can lead to stronger forest sustainability. This study aimed to study the process of making paper using mixture of coconut coir waste and cassava peel as raw materials. In addition, it was also to study the effect of NaOH concentration on the process of delignification, tensile index and paper tear index. This experimental design was carried out with the variable NaOH concentrations in the delignification process, at 5%, 7%, 9%, 11%, and 13%. Coconut coir and cassava peel were mixed with a ratio of 35g : 25g for 60 minutes at 100^{o}C.

2. Methodology

Materials used in this study are as follows, coconut coir and cassava peel from waste, tapioca starch from grocery store, and other chemicals such as NaOH and distilled water from chemical stores. Waste coconut coir was cleaned from the outer skin and the waste of cassava peel was cleaned from impurities. These were placed a clean container. Coconut coir waste was completely dehydrated and 35 grams was pureed in a blender in the absence of water. While 25 grams of cassava peel was blended in the presence of water. Delignification of mashed materials was carried out using NaOH solution with variations in weight concentrations of 5%, 7%, 9%, 11%, and 13% in 1000 ml of distilled water for 60 minutes at 100^{o}C.

The processed samples were filtered using a piece of cloth to remove the cellulose content. The remaining lignin in the material was removed by rinsing using distilled water repeatedly until the rinse water become clear. Each sample that had been mixed was placed on a board that had been coated with rigid plastic, then flattened and pressed using a ruler until the pulp mixture had an even thickness level. The preparation was then dried under the sun or spotlights. Paper tensile strength test was performed using a Horizontal Tensile Tester cutting tool with a width of 15 mm and a length of 300 mm. At least ten strips of samples were obtained and tested from each experimental treatment with the dimension

of 15 x 300 mm^2. These strips were individually tested on the tester, which gave the values for tensile and stretch resistance.

The tensile resistance of paper or cardboard is calculated based on the average value of the tensile scale reading (in kg force) of each test sample line for engine direction. Pull resistance can be expressed in kilograms of style or in kilonewton per meter; 1 kg force/15mm = 0.654 kN/m. The value of tensile strength can be calculated with the formula 1 and 2.

$$\text{Tensile Strenght (kg/15mm)} = \frac{\text{T S a (k /m)}}{0{,}6} \quad (1)$$

$$\text{Tensile Index} = \frac{\text{T S (N/m)}}{\text{G (g/m}^2\text{)}} \quad (2)$$

Each treatment was tested four times and each set contained four sheets of paper. The tear direction was set at 63 mm with the length of 43 mm.

The initial tear was performed by pressing the blade handle down until it stopped. In this study, the initial tear value was determined to be 20 mm. Press the PEND button so that the pendulum swings to tear the paper. Symmetrical tear (object in the middle position). The pendulum was set to its stopping position. The value of tear strength was recorded from the display with the unit of mN. Test at least 4 sets of test samples from each MD and CD.

The tear strength of each sample was determined from the average value of the test series (4 sets) by supporting the NO button. The results obtained can be verified in SI units with conversion, 1 gf = 9.81 mN, and stated in the formula 3 and 4 (Badan Standar Nasional, 2000).

$$\text{Tear Strenght (gf)} = \frac{\text{T s a (mN)}}{9{,}8} \quad (3)$$

$$\text{Tear Index} = \frac{\text{T S (m)}}{\text{G (g/m}^2\text{)}} \quad (4)$$

3. Results and discussion

The following table is the results of delignification of coconut coir waste and cassava peel . The delignification process was carried out at 100^{o}C and 60 minutes with varied NaOH concentrations of 5%, 7%, 9%, 11%, and 13% in 1000 ml distilled water.

In table 2, it can be seen that after delignification of coconut coir waste and cassava peel with mass and the concentration listed above, the mass yield decreases at a concentration of 5% and so on.

Table 2: Results of Delignification of Coconut Fiber and Cassava Peel (per 60 gr sample)

Sample	Variation of NaOH Concentration (%)	Mass Yield (gram)
1	5	58,41
2	7	57,77
3	9	54,03
4	11	53,56
5	13	51,72

The table 3 contains the tensile strength test results from the sample of coconut coir and cassava peel with ratio 35 gram : 25 gram. Tensile strength appeared to decrease with the increased concentrations of NaOH (Badan Standar Nasional, 2010).

Table 3: Tensile strength test results

Sample	NaOH Concentration (%)	Tensile Test Standard (kN/m)	Tensile Test Results (kN/m)	Standard Deviation (%)
1	5	1,98	2,83	43
2	7	1,98	2,24	13
3	9	1,98	1,48	25
4	11	1,98	1,25	37
5	13	1,98	1,08	45

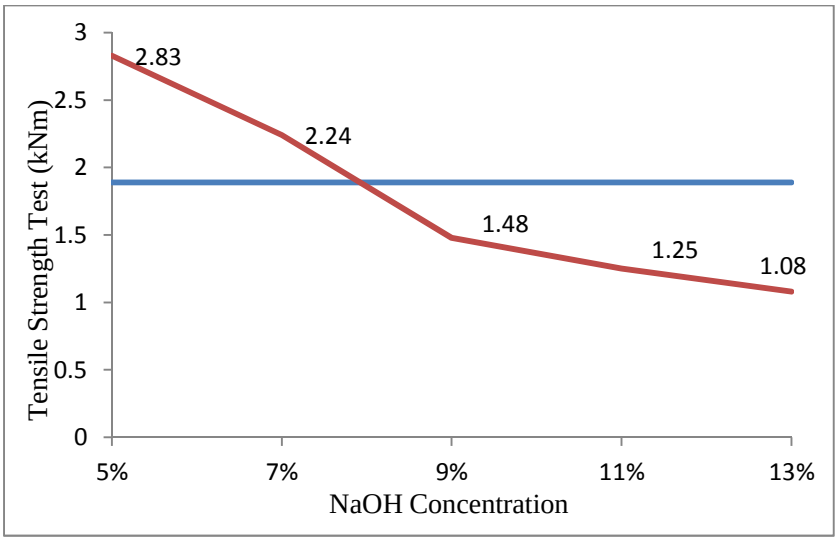

Figure 1 : Tensile strength test result (red line) vs Tensile strength standard value (blue line)

The table 4 is the tear strength test results from the sample of coconut coir and cassava peel with ratio 35 gram : 25 gram. It shows the results of the tear strength tests with the variation of NaOH concentrations. There is a tendency of decreasing strength with the increasing concentrations of NaOH (Badan Standar Nasional, 2009).

Table 4 : Tear strength test results

Sample	Variation of NaOH Concentration (%)	Tear Test Standard (gf)	Tear Test Results (gf)	Standard Deviation (%)
1	5	40	47,25	18
2	7	40	43,05	8
3	9	40	35,05	12
4	11	40	32,15	20
5	13	40	25,12	37

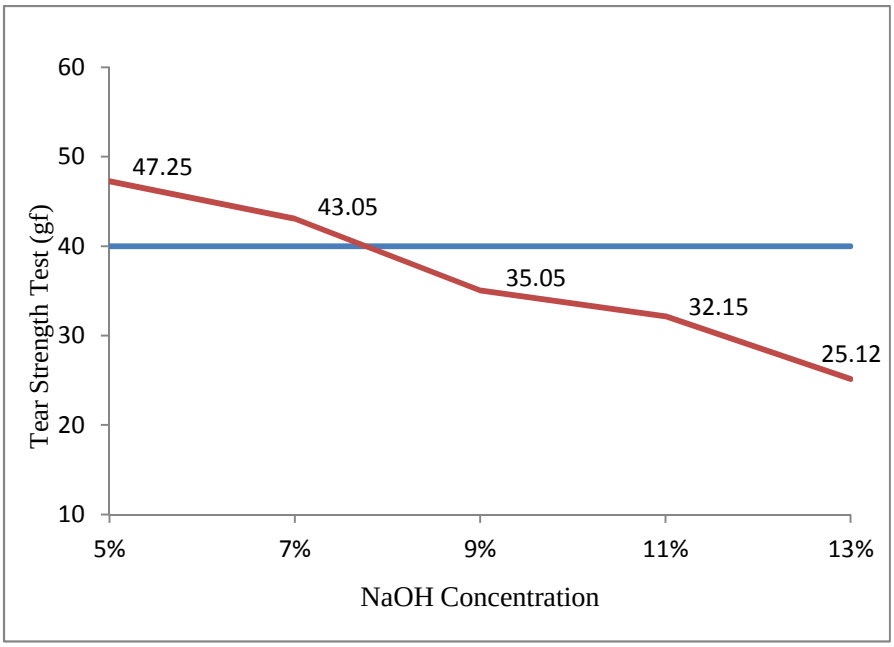

Figure 2 : Tear strength test result (red line) vs Tear strength standard value (blue line)

The results show that increased NaOH concentrations decrease mass yield. This phenomenon takes place because the higher NaOH concentration dissolves more lignin from the raw materials. NaOH breaks cellulose bonds from lignin and other substances. The higher NaOH concentration in the delignification process would leave only cellulose which includes alpha, beta and gamma cellulose. In the pulping process, lignin must be removed because it will interfere with the formation of pulp in paper making. The effects of lignin presence in the pulping process include low-strength, paper stiffness, and difficulty to bleaching, which produces yellow color and low quality paper. But for some types of paper, slightly high content of lignin is needed for paper tear strength and tensile strength (Kenneth, 1970).

From the research that has been done, delignification using 7% NaOH produces alpha cellulose, hemicellulose and lignin content that is very close to the test standard of opaque paper. In this case the residual lignin and cellulose have little effect in the quality of opaque paper. The yield content is also obtained after a thorough rinsing process using distilled water to ensure a complete delignification. Presence of lignin makes paper feel slippery, which is undesirable.

Chart 2 shows that the tensile strength decreases with increased NaOH concentrations. The 7% NaOH was determined to produce the optimal results because the other treatments produced less opaque paper than the standard. The tensile strength of 2.24 kN/m from 7% NaOH is the closest value to that of 1.98 kN/m of the opaque paper standard. Figure 3 shows that the tear strength also decreases with the increased NaOH concentrations. In these tests, the 7% NaOH treatment also produced the closest tear strength value to that of the standard paper than the other treatments. Those values are 43.05 gf and 40 gf respectively.

4. Conclusions

NaOH concentration of 7% in delignification process at 100^{o}C for 60 minutes produces the tensile strength and tear strength approaching those of Indonesian standards, which are 2.24 kN / m and 43.05 gf, respectively. From the results of the tensile strength test and tear strength test, it is concluded that the higher the NaOH concentrations in the delignification process, the lower the results obtained.

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