PRELIMINARY STUDY ON PHYSICAL CHARACTERISTICS OF PAPER MADE FROM DIFFERENT VARIETIES OF PADDY STRAW

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ABSTRACT

With paper demand increasing continuously, the deforestation process will be at a higher pace as the main raw material for paper production come from timber tree thus leads to unbalanced ecosystem problems. Using alternative fibre source especially from agriculture waste product for paper production seems like a right approach reducing the deforestation for paper raw material as it is available in abundance and low in cost. Therefore, a study on a physical characteristic of paper made from paddy straw was conducted to see the suitability of paddy straw as a raw material for paper production. Four variety type of paddy straw (MR219, MR220, MR269 and MRQ76) was used as the specimen to compare the physical characteristic of paper produced by different paddy straw variety. For each variety, three samples were treated with various concentrations of NaOH (20%, 25% and 30%) to determine the effect of concentration on paper produced. The material undergoes immersion, cooking, filtering and drying process for specimen preparation. The specimen is then cut into several pieces according to the requirement needed for thickness test, folding test, burst test and tensile test. All samples undergo mention test to obtain the physical properties of the paper. There was a significant result when a different concentration of NaOH used during paper preparation. 30% of NaOH concentration give the best result in physical properties for all types of paddy variety. For comparison between the paddy variety straw used and the physical characteristic, the MRQ 76 performed best compared to other variety. There are no significant differences between MR219, MR220, and MR269 in the physical characteristic.

INTRODUCTION

Paper can be classified as a material which is thin and flat with crossing network between cellulose fibres that bind with each other (Bahari, 2011). The paper created by pressing the processed natural fibre (pulp) to create a network of bind between the cellulose. Nowadays, most of the paper was produced from main resources which are wood tree. During the paper formation process, the fibre was cleaved before mix with an additional source (Jalaluddin, 2005).

Paper demand increased continuously according to current need and requirement. Nowadays, most of the paper production raw material comes from wood resources. Growing demand of paper will require more wood resources, and this leads to the uncontrolled felling of trees and occurrences of unbalanced ecosystem problems. Therefore, another alternative should be made to replace wood material as the main source of raw material in pulp and paper producing industry. Natural fibres from agricultural waste products are the best alternatives to reduces dependence on the main sources of timber tree in paper production. One of the available natural fibre resources from agriculture waste is paddy straw. Every hectare of paddy will produce five to six tonnes of residue, and it is a major challenge to manage the waste as paddy residue is not suitable for animal feed due to its high content of silica (Krishna, 2004). According to Reddy, N (2005), due to the high ratio of length and diameter of the paddy fibre, the paddy straw is suitable for paper making. Every paper that produces must have certain criteria; the criteria

are most important to differentiate the various types of paper. Nevertheless, the paper should be depending on their sources that are cellulose because it has a similar characteristic with existing properties of cellulose (Smook, 1994).

Therefore, this research is intended to study the feasibility of paddy straw as a replacement for raw material in paper production. Four types of paddy straw (MR219, MR220, MR269 and MRQ76) were used as the specimen to find the best physical characteristic of paper produced from them. The effect of sodium hydroxide in different percentage during paper production also were studied. The best variety is selected based on the result from thickness, tearing, burst, tensile and folding test. With the result from this research, the physical properties of the paper produced can be compared with existing paper from tree pulp in the current market.

MATERIALS AND PREPARATION METHODS

Paddy straw

The type of paddy straw that was being used is MR219, MR220, MR269 and MRQ76. The source of paddy straw is taken from a paddy field in Sungai Rambai, Melaka and Ledang, Johor.

Preparation of Raw Material

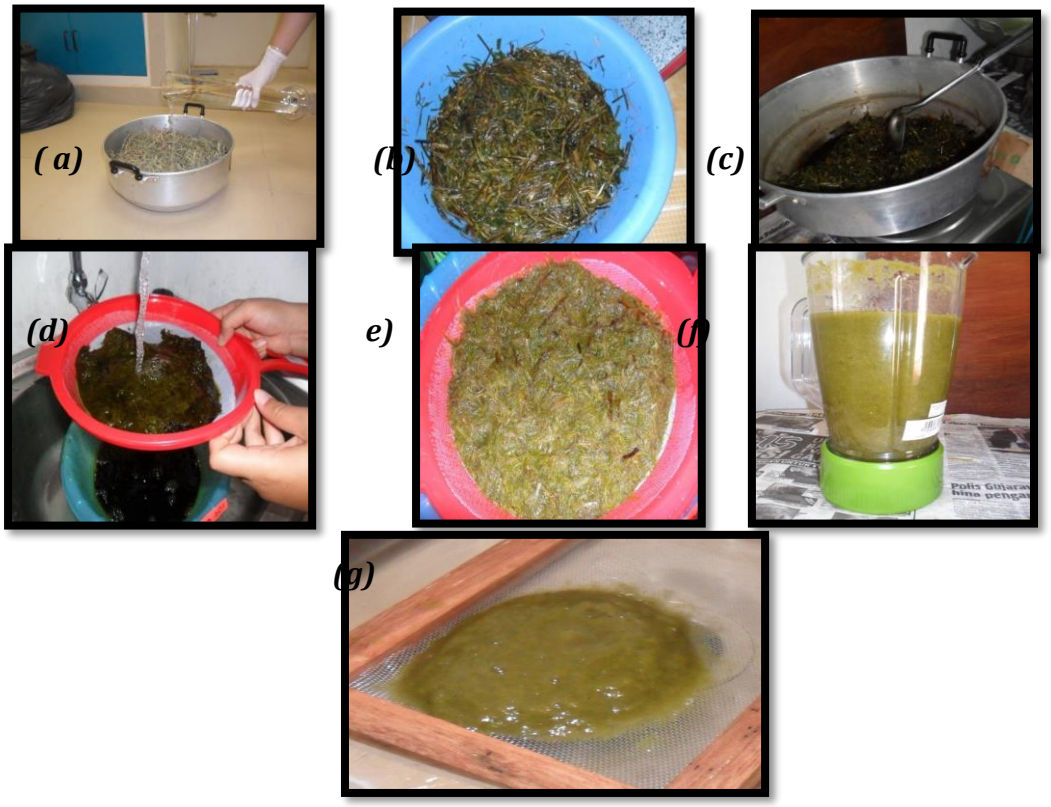
The first step is preparing the raw material. After the paddy straw was harvested, it was dried under direct sunlight for five days to ensure it dried completely. This to avoid bacteria and fungi activity in the paddy straw thus damage the straw required properties. The paddy straw is then put into the Cruncher Machine to cut the paddy into smaller piece. The paddy straw was placed continuously on small quantity to reduce the load on the crusher machine and enable it to cut the paddy straw effectively.

Figure 1: The process of preparation for paddy straw before pulping process a) drying paddy straw, b) paddy straw processed by crusher machine, c) paddy straw after processed,d) paddy straw ready for mix with concentration NaOH.

Pulp Preparation

Before the fibre of paddy straw becomes a sample, the pulp preparation is critical. The process can be divided into four stages which are immerse process, cooking process, rinsed process and lastly, grinding process. The paddy straw weighted at 100g for each sample. The Sodium Hydroxide (NaOH) was added based on the parameter that is 20%, 25% and 30%. The immersion process takes about 12-13 hour. The immersion process is performed to remove lignin, silica hemicelluloses, and pith from fibre thus create a better impregnation and increase the rough surface of the fibre for a better interaction. (Yu Tao,2009). After the immersion process, the paddy straw then cooked for 2 hours until it becomes smooth and separated like fabric thread. The fibre of paddy straw then cooled to room temperature before rinsing process is performed to remove the NaOH at the fibre. The fibre of paddy straw rinsed using clean water until it free from other impurities. The paddy straw then grinned with one litre of pure water added to smooth the process. The grinding process takes 5 minutes to complete.

Figure 2: The step preparation in making paper from the paddy straw. (a) mixture paddy straw with NaOH, (b) immersion process, (c) cooking process, (d) rinsed process, (e) paddy straw after immersion process, (f) grind process, and (g) pulp placed in the mould



Sample Preparation

In sample preparation process, the paddy straw that converted into fine pulp was placed into a wooden mould. The pulp placed evenly at the mould area and given a light pressure normal to all mould area to create a smooth and uniform paper. Then the pulp undergoes a filtering process. In this process, excess water is filtered out from the pump to minimise the drying process time. The mould then placed under direct sunlight for two days until it dried completely. The paper was then removed from the mould slowly to avoid damage.

Figure 3: The sample of paper that produce from the different types of paddy straw

PARAMETER (TEST METHOD FOR PAPER)

Thickness test

For this test, the sample of paper was put under measurement to determine their thickness. Clippers were used to measure the thickness of the paper.

Burst test

The burst machine was used to determine the burst strength of the paper. It functions by exerting an amount of hydrostatic pressure to the ball that pushes the paper until it burst, while record the maximum pressure the paper can hold.

Tearing test

In tearing test, a Geotech Testing Machine is used to check the tear strength of paper. The function of the machine is to measures the paper resistance to tearing once a small tear has been initiated.

Tensile test

The tensile test is conducted by using Universal Tensile Machine. Normal force exerted to the paper specimen and the force gradually increase until the specimen broke. The force exerted, and the elongation of the specimen is recorded through the test. The maximum force before the specimen break determines the tensile strength of the specimen and the relation between force and elongation can be calculated to produce modulus of elasticity of the paper. From this test, the strength of the fibre bonding can be calculated.

Folding Test

Folding test is a test performed to evaluate the durability of the paper produced when subjected to continuous folding. During the test, the specimen undergoes repetitive fold cycle until it torn. The number on fold experienced by the paper before it torn determined the folding endurance value of the paper.

Figure 4: Testing sample of the paper for each variety. (a) Thickness test, (b) burst test, (c) tearing test, (d) tensile test.

(a) **(b)** **(c)** **(d)**

RESULT AND DISCUSSION

Thickness Test

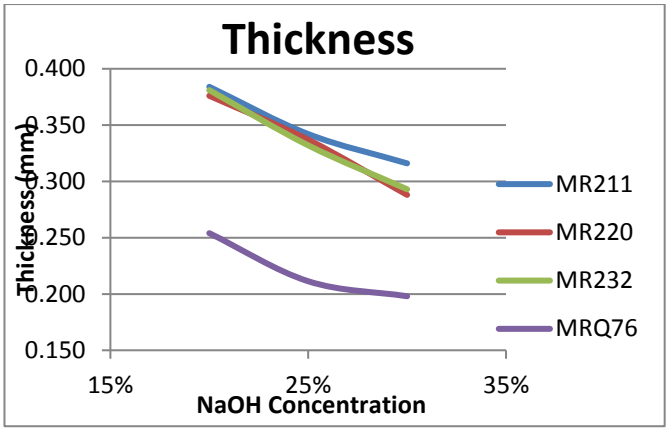
In Figure 5, the thickness test conducted to determine the effect of the different concentration of NaOH for the different variety of paddy straw in paper production is shown. The thickness test of the paper was being measured by using a digital calliper. The measurement process was done in three different location on the sample before the average value is calculated.

The highest value of the thickness is 0.384mm come from MR211 sample treated with 20% concentration of NaOH. The lowest is 0.198mm come from MRQ76 sample treated with 30% concentration of NaOH. The different value was influenced by pore, stiffness, hardness, and strength of paper. From the graph in Figure 5, the thickness of paper produce is governed by the variety of paddy used, and the concentration level of NaOH used. The higher concentration of NaOH used, the smaller thickness of the paper produced. This is as the NaOH remove impurities in the pulp means a higher concentration of NaOH remove a large quantity of impurities and lignin thus enable a more packed paper produced.

Table 1. The thickness test

	NaOH		
	20%	25%	30%
MR211	0.384	0.342	0.316
MR220	0.376	0.337	0.288
MR232	0.381	0.332	0.293
MRQ76	0.254	0.211	0.198

Figure 5: The graph of thickness test.



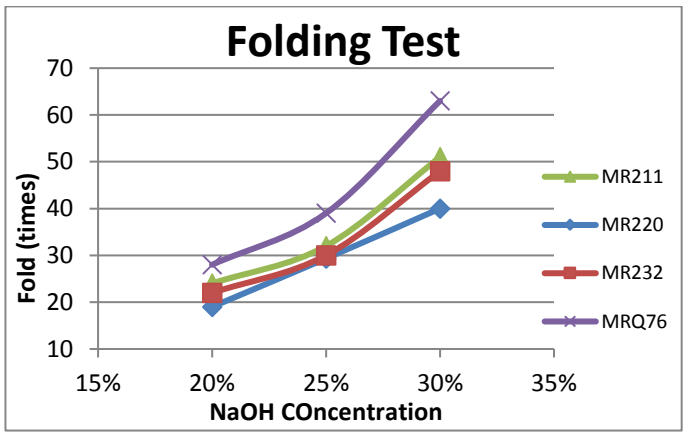
Folding Test

From folding test result in Table 2, the most durable paper is produced from MRQ76 variety treated with 30% NaOH concentration scored 63 fold before failed. The lowest folding endurance properties come from paper produced from MR220 variety with 20% NaOH concentration with only 19 fold before failed. As shown in Figure 6, the folding durability of paper produced increases with the increase of NaOH concentration. Paper produced from MRQ76 have better-folding properties compare to other paddy variety. The paper with higher folding endurance is likely to be selected for production to ensure it has a longer life cycle.

Table 2. Folding Test

	NaOH		
	20%	25%	30%
MR211	24	32	51
MR220	19	29	40
MR232	22	30	48
MRQ76	28	39	63

Figure 6: The graph of folding test.



Burst test

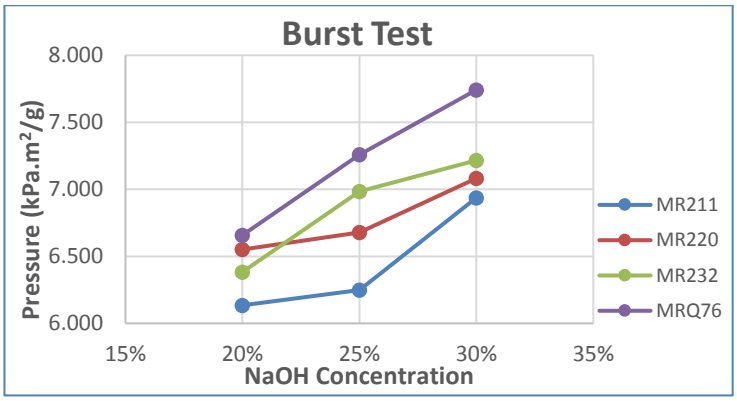
From the result obtained from the Burst Test as in Table 3, MR211 variety scores the lowest value of burst strength at 6.13 kPa.m^2/g. The highest burst strength value obtained by MRQ76 variety with 30% NaOH concentration at 7.742kPa.m^2/g. From Figure 7, the graph shows that burst pressure resistance increased with the increased in concentration of NaOH. Paper produced from MRQ76 excel among other variety in burst strength at any NaOH concentration used. The burst test determines the maximum resistance to pressure on the paper surface.

Table 3. Burst Test

	NaOH		
	20%	25%	30%
MR211	6.135	6.248	6.937

MR220	6.551	6.678	7.082
MR232	6.383	6.983	7.216
MRQ76	6.658	7.258	7.742

Figure 7: The graph of burst test



Tear Strength

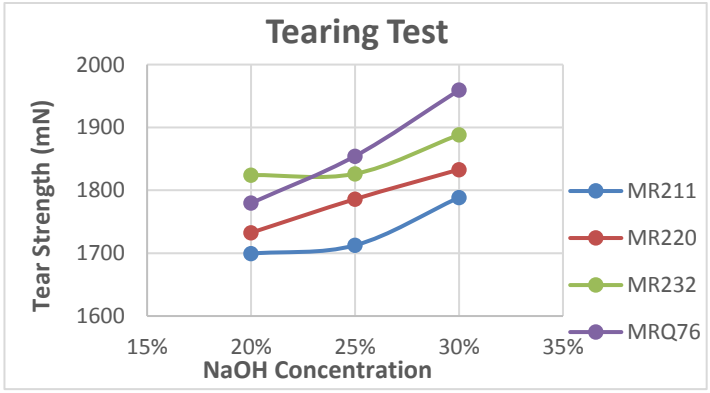
Tear strength is one important parameter used to identify the strength of paper in paper production. Based on the result showed from Figure 8, the different concentration of NaOH with different variety of paddy straw, there was a significant difference in tear strength since the p-value 0.039 is smaller than 0.05.

Tear strength is a maximum shear stress the paper can hold before tear occurs. In tear test, the sheer force exerted to the specimen and the maximum force required to break it is measured. As we can see from the Table 4, the highest reading is 1959.38mN.m^2/g for variety MRQ76 at 30% concentration of NaOH while the lowest result obtained by variety MR211 with 20% concentration of NaOH at 1699 mN.m^2/g.

Table 4. Tear Strength

	NaOH		
	20%	25%	30%
MR211	1699.36	1712.549	1788.623
MR220	1732.52	1786.000	1833.010
MR232	1824.26	1826.260	1888.38
MRQ76	1779.63	1854.410	1959.380

Figure 8: The graph of tear strength



Tensile test

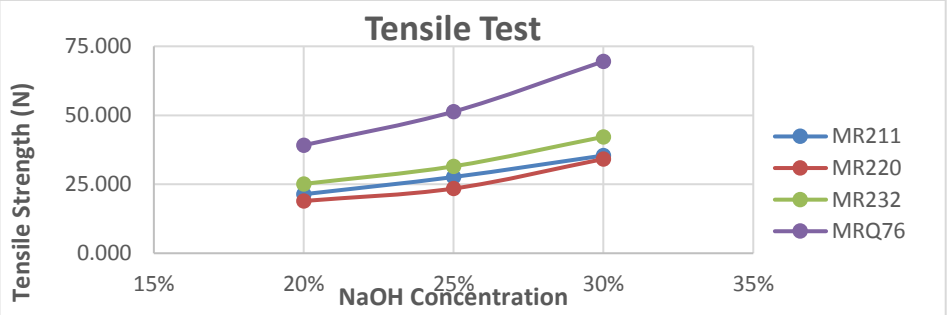
The tensile strength measures the normal maximum stress a specimen can hold before it breaks. Based on the tensile test result as in Table 5, the specimen with the highest tensile strength is achieved by MRQ76 variety processed with 30% of NaOH concentration with a value of 69.547 N. The weakest paper produced come from MR220 variety with 20% NaOH concentration with only 18.936 N of strength. Figure 8 shows the different concentration of NaOH with a different variety of paddy straw that there was a significant difference on the tensile test since the p-value is 0.00, smaller than 0.05. In term of paddy varieties used,

there is no significant difference between MR211, MR220 and MR232. However, for MRQ276, there is a significant difference in tensile strength where it scores 69.547 N in tensile strength for 30% NaOH concentration.

Table 5. Tensile Test

	NaOH		
	20%	25%	30%
MR211	21.386	27.630	35.413
MR220	18.936	23.452	34.157
MR232	25.127	31.521	42.184
MRQ76	39.156	51.328	69.547

Figure 8: The graph of the tensile test



CONCLUSION

This research was being done to identify the physical properties of paper products from MR211, MR220, MR232, and MRQ76 and to study the effect of Sodium Hydroxide (NaOH) concentration toward the paper production from the different variety of paddy straw. The concentration of NaOH that uses is 20%, 25% and 30%. From the result, we can conclude the properties of paper in tensile, thickness, tearing and burst were being done successfully for all variety. The effective concentration of NaOH significantly has influenced on the mechanical properties of the material. The best percent of the concentration of NaOH is 30% for all the paddy variety tested in the experiment. In finding the best type of paddy variety in producing paper, MRQ76 outperformed all MR211, MR220 and MR232. In all five tests in determining the physical properties of the paper, the MRQ76 variety scored the highest. MRQ test result obtains for thickness test is 0.198mm, 63 fold count before failed, 7.742 kPa.m^2/g for Burst Strength, 1959.38mN.m^2/g for Tear Strength and 69.547 N for Tensile Strength. Thus, the MRQ76 paddy straw is more suitable as an alternative fibre source for paper production compared to another paddy variety.

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