CHEMICAL, PHYSICAL AND MECHANICAL PROPERTIES ON PRODUCTION OF MEDIEVAL PAPER AND CARDBORD BY USING GRASS

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Abstract-Grass has potential to be developed as paper and cardboard production because they have the lignocellulosic content that almost same as tree, which is main sources for paper production all over the years. The process for paper and card board production was adapted from paper production industry. For this production, grass was cut into very small size to make it easily boiled, then the grass was blend until it soft as pulp. Lastly, the pulp was mold into paper and cardboard using suitable molder and dried under sunlight. The paper sample was analyzed using SEM to show the paper structure, FTIR to analyzed lignocellulosic content and tensile to know the paper strength. Based on result of this study, the thickness of paper and cardboard was 0.1 and 0.5 cm respectively, the moisture removal exceed 90% after left 24 hours in 110º C oven, under SEM magnification, untreated pulp has more impurities, rigid and strong bonds whereas treated pulp have ruptured surface due to lignin removal. For FTIR analysis, the result shows presence of cellulose, hemicellulose and lignin for untreated grass and for treated pulp, only cellulose was presented. The tensile strength for paper and cardboard were 70 N and 63 N respectively. The objectives of this study were achieved since the paper produced from grass have almost same characteristic as paper produced from wood.

Keywords-paper production, pulp, lignocellulosic, SEM, FTIR

I. INTRODUCTION

Paper was used for various application such as writing notes, food packaging and painting. Industrial paper production too depends on woods for raw material in paper making. Too much codependency for wood since wood have so much to offer in various production such as lumber for home applications, furniture, carpenter tools, aircraft and so on cause the forest depletion sources. Since paper and pulp industry received the most demands, the world currently searching another suitable raw material to replace the wood. Grass has almost same characteristics that suitable in paper making production. Wood contained cellulose, that easily blends with another solvent which is water and dye, biodegradability, high tensile strength, capacity for broad chemical modification depends on the product application, and ability to form semicrystalline fiber morphologies [1] There are various previous research proposed to substitute wood as papermaking raw material such as pineapple leaves, banana fibres, rice straw and another fibrous agriculture waste. These materials consist of cellulose fibers that essential cell for papermaking and we take initiatives to utilize trash to treasure [2]

In this study, the idea is producing paper from grass since grass also agriculture waste that are abundant, primarily compose of cellulose, hemicellulose and phenolic polymers lignin, a phenolic polymer that have complex bonds along with other compounds such as proteins, minerals acids and salt that almost same with wood contents [3]. The grass will go through several process to become medieval paper and cardboard and they will be characterized by chemical, physical and mechanical properties in order to conclude either grass suitable or not to be used in papermaking industry.

II. METHODOLOGY

A. *Materials*

Figure 1: Napier grass

1.Napier Grass

As shown in figure 1, Napier Grass was chosen as raw material for this study. Napier grass have potential to be developed in papermaking and cardboard industry. The grass was collected from UITM Shah Alam field. Then, grass was cut into small size about 2-5 cm.

2.Corn Starch

In this study, corn starch was used to give the paper and cardboard smooth surface and shiny. The corn starch was applied after the paper was mold.

3.Oil
Oil was used during chemical resistance analysis. The paper sample was submerged in oil for 24 hours to analyzed paper resistance to oil.

B. Chemical

1.Sodium bicarbonate
The grass was boiled with water and sodium bicarbonate to remove lignin.

C. Equipment

1.Blender
Panasonic blender was used to get the pulp form after boiled.

2.Hot press
Hot Press was used after the paper and cardboard were dried and hot press was used to flat the paper and cardboard surface. The hot press was set at room temperature,140 psig for 2 minutes.

Chemical analysis

1.*Sartorius* Weight scale
Paper and Carboard sample were weighed using sartorius model weight scale to know the moisture content before and after 24 hours dried in oven at 110 °C.

2. *Perkin elmer* FTIR
0.5 g powder before and after pulping of grass were put in a clean plate and then inserted the sample into hole and purge the sample by using the region 4000-400 cm^{-1} of perkin elmer fourier-transform infrared spectroscopy (FTIR).

Physical analysis

3. Thickness ruler.
the sample will be putted at smooth surface to read the exactly thickness.
4. *Perkin Elmer* SEM
The surface morphology of the *napie*r gras was observed using Perkin Elmer Scanning Electron Microscope (SEM). *Napier Grass* was subjected to different magnifications of 500SE and 1000 SE that will show the image of treated and untreated grass.

Mechanical analysis

5. Tinius Olsen Universal testing machine
Using Tinius Olsen Universal testing machine, the paper sample was cut into small pieces (2mm x 4mm) and then a force (50N) applied so that we can determine highest forces per width required to rupture the paper sample.

D. Pulping

As shown in figure 2 that show process production of paper and cardboard,200g of cut grass were submerged and boiled in a pot with 2.5L tap water and 20g sodium bicarbonate for delignification. After boiled for 2 hours, cooled for 3 hours at room temperature. Then, the mixture was blend to get soft pulp that suitable for paper and cardboard surface.

E. Forming Paper and cardboard

The pulp mixture was then sieve using frame mold and another side of paper was pressed to remove excess moisture content using cloth. The mold was removed and paper shape was covered with cloth before dried under sunlight for half day. To get smooth surface, the paper and cardboard was pressed using Hot press at room temperature,140 psig for 2 minutes. Lastly, to get better and shiny surface, corn starch solution was used as paper and cardboard coating.

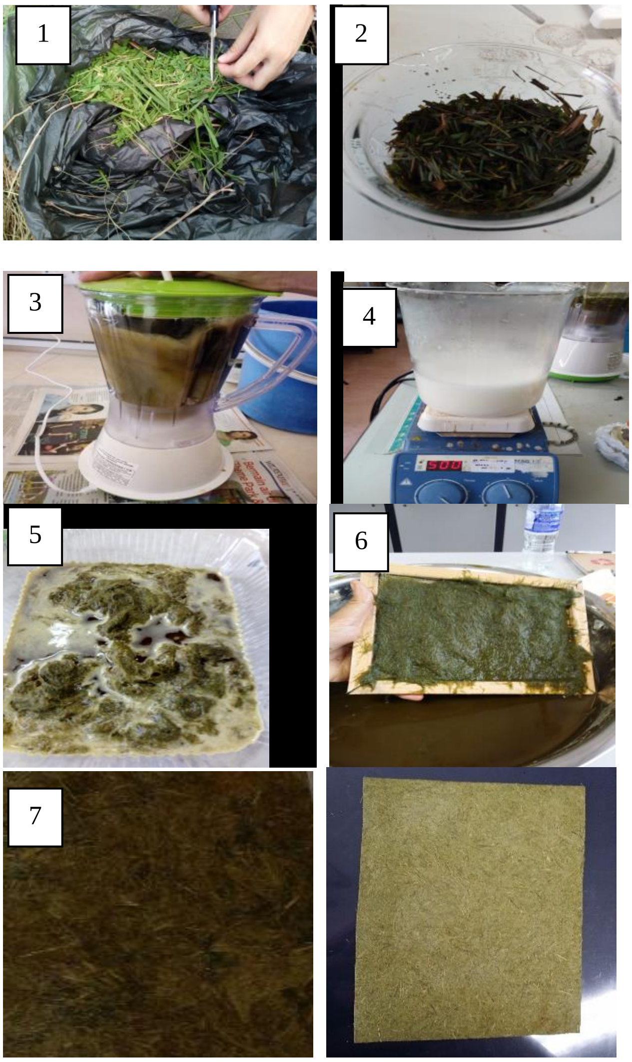
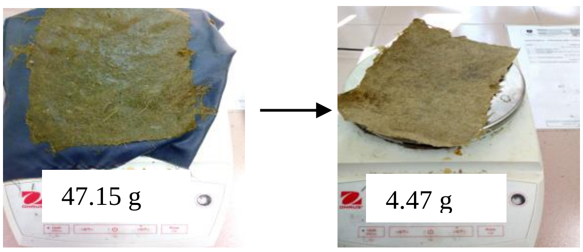


Figure 2 that show process production of paper and cardboard

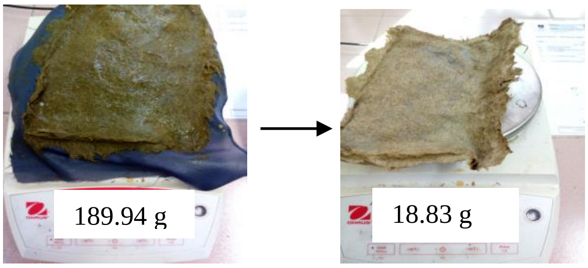
III. RESULTS AND DISCUSSION

Experimental for chemical, physical and mechanical analysis

1.moisture content
Paper:



Card board:



Both paper and cardboard were dryed in oven for 1 days at 110° C. The materials were weighted using weight scale to know the weight before and after drying. Based on calculation using formula [4]:

Paper:

$$\% \text{ Moisture content} = \frac{wet - dry}{wet} \text{ X } 100$$

$$= \frac{47.15 - 4.47}{47.15} \text{ X } 100$$

$$= 90.52\%$$

Cardboard:

$$\% \text{ Moisture content} = \frac{189.94 - 18.63}{189.94} \text{ X } 100$$

$$= 90.23\%$$

From this calculation, we knew both of them exceed 90% moisture removal after drying process. Based on this result we can conclude that when the percentage of moisture content removal high, the paper structure strength will also improve.

2)Fourier (FTIR)

Table 1: Before sodium bicarbonate treated:

Wave number (cm^{-1}) References [5]	Wave number(cm^{-1}) -Result	Functional group	Compound	Lignocellulosic
1060	1034.48	C–O stretching and C–O deformation	C–OH (ethanol)	Cellulose
1632	1635.51	C=C Benzene stretching	Benzene stretching ring	Lignin
3600-3000	3317.73	OH stretching	Acid, methanol	Hemicellulose

Table 2: After sodium bicarbonate treated

Wave number (cm^{-1}) References [5]	Wave number(cm^{-1}) -Result	Functional group	Compound	Lignocellulosic
1029.23	1029.23	C–O stretching and C–O deformation	C–OH (ethanol)	Cellulose

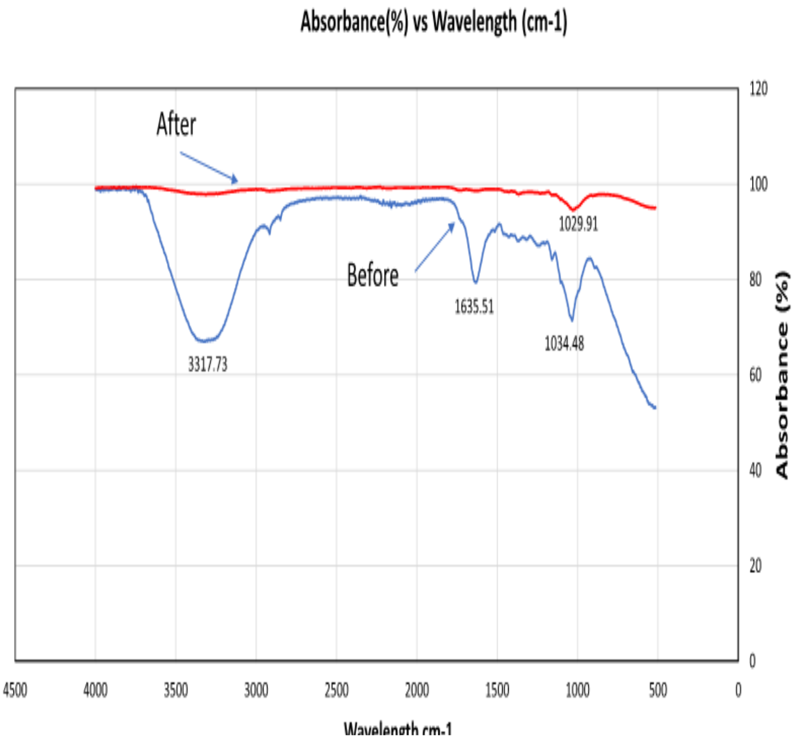


Figure 3: FTIR spectra of before and after pulping

Based on Yang, Yan, Chen, Lee, & Zheng, (2007) from FTIR analysis perspectives,they stated that untreated grass contain functional group of C-O streching and C-O deformation,C=C bonds and OH streching which represent cellulose,lignin and hemicellulose respectively as shown in table 1.For treated pulp,supposely cellulose and hemicellulose presence without lignin as lignin already removed [5].

In this study,for untreated grass as shown in figure 3, it shows that FTIR absorbance peak appear at 1034.48cm^{-1}, 1635.51cm^{-1} and 3317.75 cm^{-1} respectively and 1029.93cm^{-1} for treated pulp. Based on comparison for untreated grass with Yang, Yan, Chen, Lee, & Zheng, (2007), the result proved the presence of cellulose, hemicellulose and lignin based on functional group representative. C-O bond represented cellulose rich with C–O stretching and C–O deformation and C–OH bond, lignin rich with benzene bonds and hemicellulose with carboxyl group and acid compound. This result proved that grass contain lignocellulosic group that bind and held each other to make the bonds stronger [5]. Whereas after treated, only cellulose in the fiber since lignin was removed during the process. It is desired to remove lignin because even though lignin had a strong bond but due to lignin bonds complexity make them difficult to modify for various application [5].

3. Chemical resistance

Based on J.A.M. Hammeen and Majid,(2016),they stated that the higher the percentage of paper and cardbord adsorb chemical used on them,the lower their resistance to chemical.This is because the hydroxyl bonds of grass fibers that act as adhesive agents started to rupture and split.Based on this study we proved that by using this formula[6]:

$$\frac{After\ adsorption - Before\ adsorption}{After\ adsorption} \text{ X } 100$$

Using this formula for paper adsorption to water and oil after left for 24 hours were 80.6% and 61.0% respectively whereas for cardboard, adsorption to water and oil were 62.5 % and 51.85% respectively. We proved that, hydroxyl group inside the fiber is hydrophilic that why the adsorption percentage is high, for oil the fatty acid contained inside the oil repelled and act as hydrophobic to hydroxyl group that why the percentage was low compared to water.

4. Analysis of fiber morphology for napier grass using SEM

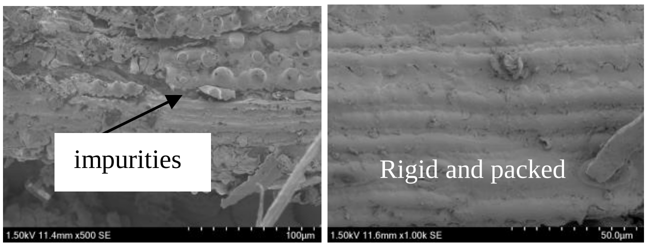


Figure 4: Before pulping (Raw napier grass)

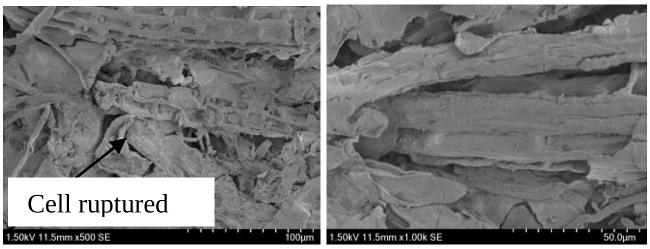


Figure 5: After pulping (treated with sodium bicarbonate)

Based on research by Kamarullah et all,(2015),they stated that when the grass fibers did not be treated before the process,the grass surface more rough and high strength due to lots of fibers component inside the grass which are cellulose,hemicellulose,lignin and protein component[3].Not only that, Daud, Hatta, Kassim, Awang, & Aripin,(2013) also proved this statement by stated that the untreated pulp contain more impurities and strong bonds held each component to make fibers more strong.Then,when pulp be treated,the surface ruptured due to lignin removal and this removal reduce the fibers strength[2].

Based on result of this study as shown in figure 4 and 5,the cross sectional untreated *napier* grass have more impurities, surface more rigid and packed due to cellulose,hemicellulose and lignin bind with each other. After pulping, the surface more disorganized and no more rigid bonds between main component inside the fibers due to lignocellulose ruptured.

5. *Thickness of paper:*

Criteria	Dimension(cm)	Dimension(cm) comparison paper (A5) Brand: Double A
Length	7.7	8.0
width	2.5	3.0
thickness	0.1	0.1

Criteria	Dimension(cm)	Dimension(cm) comparison cardboard (A5) Brand: Stone
Length	7.7	8.0
width	2.5	3.0
thickness	0.5	1-20

Based on Dr.Kruszelnicki,(2014) and Basford, K.E., Mclachlan, & York., (1997) and standard international paper(Double A),the thickness of paper in this study is 0.1 cm compared to standard paper thickness which is 0.1-0.2 cm[7].The fabricated paper have thickness that almost similar to double AA paper.For card board,there are various kind of their thickness based on their uses at the range from 1-20 cm. So,based on this comparison we succesly fabricated the standard paper and cardboard thickness.

6.. *Tensile strength*

Based on J.A.Hameen,Majid,etl, (2016),the tensile strength for napier grass supposely 16-20 mpa whereas Reddy, Maheswari, Shukla, & Muzenda, (2014) stated that tensile strength is 78.2N m/g.Tensile strength represent the strength and maximum force required to tear the paper and cardboard [6].Based on this study,as shown in figure 6 and 7, the maximum tensile strength for paper and cardbord were 70N and 63N respectively.The product proved had the high strength despite after lignin removal during pre treatment process.

For paper:

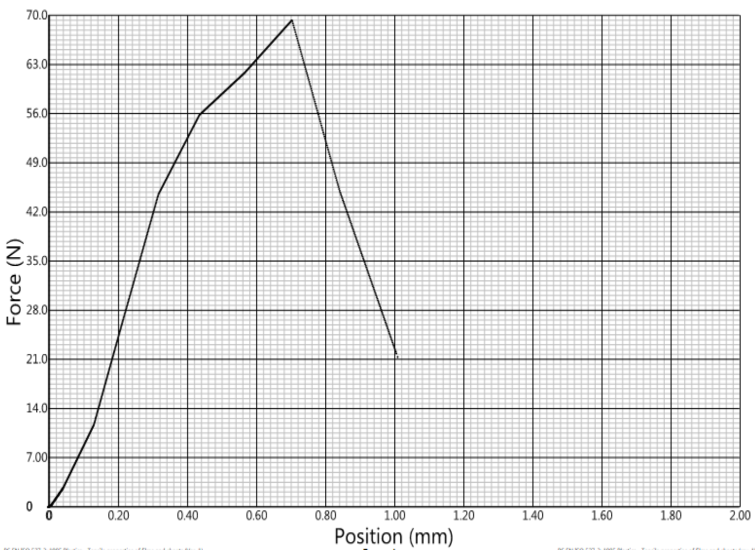


Figure 6: Tensile strength for paper

For cardboard:

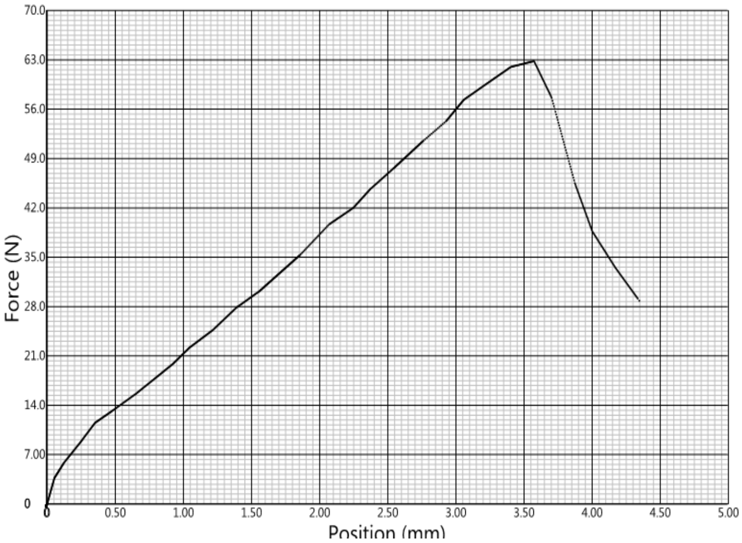


Figure 7: Tensile strength for Cardboard

IV. CONCLUSION

Based on this study, the lignocellulosic presented inside *napier grass* was analyzed using FTIR. The untreated pulp possessed the characteristics same as wood, raw materials all over the years for papermaking industries. Next, the morphologies of untreated pulp contain impurities, rigid and packed due to strong bonds hold the fiber. Whereas, for treated pulp, the bonds seem to rupture since lignin be removed. The tensile strength for this study were 70 N and 63 N for paper and cardboard respectively. The objectives to fabricate paper and cardboard was success with 0.1 cm and 0.5 cm thickness respectively. Napier grass can be used for future uses in paper production industries. The analysis that were performed also proved the ability of grass as good raw material for this application.

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V. REFERENCES

[1] Y. fahmy, f. mubarak, T. y. fahmy and m. e. -sakhawy, "Agricultural Residues (Wastes) for Manufacture of Paper, Board, and Miscellaneous Products," *international journal of chemtech research,* vol. Vol.10 No.2 , pp. 424-448, 2017.

[2] Z. Daud, M. Z. M. Hatta, A. S. M. Kassim, H. Awang and A. M. Aripin, "Exploring of Agro Waste (Pineapple Leaf, Corn Stalk, and Napier Grass) by Chemical Composition and Morphological Study," *bioresources,* pp. 872-880, 2013.

[3] S. H. Kamarullah, M. M. Mydin, W. S. A. W. Omar, S. S. Harith, B. H. M. Noor, N. Z. A. Alias, S. Manap and R. Mohamad, "SURFACE MORPHOLOGY AND CHEMICAL COMPOSITION OF NAPIER GRASS FIBER," *Analytical science,* vol. Vol 19 No 4 , pp. 889 - 895, (2015):.

[4] A. Ramdhonee and P. Jeetah, "Production of wrapping paper from banana fibres," *Journal of Environmental Chemical Engineering,* p. 4298–4306, 2017.

[5] H. Yang, R. Yan, H. Chen, D. H. Lee and C. Zheng, "Characteristics of hemicellulose, cellulose and lignin pyrolysis," *Science direct,* vol. 86, p. 1781–1788, 2007.

[6] M. H. J.A., M. A. Majid, M. Afendi, H. Marzuki, E. A. Hilmi and I. Fahmi, "Effects of water absorption on Napier grass fibre/polyester composites," *Composite Structures,* p. 138–146, 2016.

[7] Basford, K.E., G. Mclachlan and M. York., "Modeling the distribution of stamp paper thickness via finite normal mixtures: The 1872 Hidalgo stamp issue of Mexico revisited.," *Applied Statistics.,* pp. 169-180., 1997.