Production of Organic Plate from Napier Grass Fiber

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***Abstract*—Napier has been studied its potential in replacing plastic as main source of raw material in manufacturing industry for goods. The usage of plastic has been increasing in line with the demands which consequently has negatively affecting our environment. Abundance of plastic waste has led to solid waste management problem and 5.25 trillion plastic floating in our ocean. The objectives of this study were to fabricate organic plate from Napier grass and characterize its chemical, physical and mechanical properties. Soda pulping was applied in this study to soften the grass and produced a pulp. The pulp was then sieved and shaped into plate mold to form a plate. Based on the analysis, SEM images showed there was changes occurred between untreated and treated Napier grass fiber where the treatment managed to give a higher tensile strength to the plate compared to condition before treated. The organic plate has suitable thickness to be used in commercial. Moreover, FTIR analysis proved that soda pulping managed to remove hemicellulose and lignin and left only cellulose to the grass fiber. Drying process removed 85% of moisture content from the organic plate and it has higher resistance to water than oil. Therefore, it is proved that grass can be used as alternative raw material to replace plastic in industry to produce goods.**

Keywords*— Napier grass; plastic; soda pulping; organic plate;

I. INTRODUCTION

Plastic materials can be categorized into three groups based on its functionality and properties which are thermosets, elastomers and thermoplastics [1]. Due to its unique properties such as light in weight, low material cost, excellence resistance to acid and base, flexible, attractive mechanical properties and better durability, it has been widely used in industry such as automotive, construction, household appliances and electronics and the demands in continuously increasing to fulfill human satisfaction [2]. This results in the production of plastic globally that has been increasing since 1950 to 2016 from 1.5 million metric tons to 335 million metric tons [3]. In Malaysia itself produced solid waste around 25,000 tonnes per day in Peninsular Malaysia for 2012 projection with 24% from it contributed by plastic waste [4]. However, ironically presence of plastic over decades has caused negative impact towards environment including the natural resources exhaustion. One of the main factors is their long lifetime on earth as plastic degradability could be for thousand years and the release of toxic chemicals from plastic to soil and water stream.

There had been many efforts to reduce the usage of plastic among society and creating alternative to substitute consumption of plastic in many industries as a way of preventing more production on plastic align with the concept of 'Waste to Wealth'. For examples starts using reusable shopping bag, eco-friendly water bottles and some companies such as Mensilin Green Energy Sdn. Bhd. in Malaysia has developed a machine turning plastic waste into diesel fuel based in Terengganu[5]. In 2011 in India, there was one man named 'Narayana Peesapaty' who was the founder of 'Bakeys' has invented an edible cutlery produced from organic raw materials which were wheat flours, sorghum and rice with no preservatives, chemicals, additives and animal ingredient which made it 100% vegan and 100% degradable. The aim was to stop using more plastic that has many chemicals and reduce the production of waste being landfilled[6]. However, it is still a long process to go globally because the difference of status between the developed and developing country and the interrelationship between the people, natural resources, environment, political and economic development that need to be satisfied equally. Recently there are many researches regarding agricultural waste as a new alternative raw material in manufacturing of building product, paper-making and chemical industry. For example, rice husk has no commercial value in market and pose threat to environment due to its disposable problem. Hence, there was research that utilize rice husk to produce cardboard. Not only it utilized the agricultural waste, it also helped to reduce the usage of woods and save the forest[7]. Furthermore, green building that has come into concern has result in utilizing agricultural waste such as oat husk and barley husk for production of fire clay bricks. Physical and mechanical properties of oat husk and barley husk showed a similar property with the eco-friendly fire clay bricks. Hence, agricultural waste can be used as a combustible additive in the production of ceramic items[8]. In this study, we were using grass to produce organic plate that is biodegradable but not edible. Grass is categorized as agricultural waste where it contained three basic component which are cellulose, hemicellulose and lignin[9]. Lignocellulose plays important role to plant cell wall where it provides stability and shape. Cellulose also rich in hydrophilic hydroxyl group that contribute to the main strength maker of plate[10]. Therefore, it is believed to have potential in forming an organic plate that is 100% degradable. The importance of this study, it will help in reducing the consumption of plastic, therefore minimize production of plastic waste that is non-degradable and consequently lengthen the landfill lifespan. This study support 'Waste-to-Wealth' concept by turning grass waste into useful product in moving towards sustainable development.

II. MATERIALS AND METHODOLOGY

A. Materials

Figure 1: Napier grass

Figure 1 shows Napier grass used in this study where it was collected from University of Technology Mara, Shah Alam field which was green in colour during the collection state. The Napier grass fiber was cut into a range of length of 2cm to 5cm long ready for pulping method. Other than that, Kings Bicarbonate of Soda powder was used in pulping process to soften the grass during boiling. When the organic plate has formed, corn starch by Nona brand was used to enhance the surface smoothness and water and chemical proof.

B. Pulping

Pulping method that being used in this study is soda pulping to extract the fiber[11]. 300g of Napier grass is submerged in 2.5liter tap water in a pot. 25g of sodium bicarbonate powder was added into the pot. The mixture of Napier grass fiber with sodium bicarbonate powder and tap water was then boiled and stirred for two hours to soften the grass by breaking fiber bundles to smaller bundles where it will increase the surface area of fiber strands. Fibrillation of grass fiber will increase the tensile strength because the fiber can be propagated by large amount of stress due to energy dissipation in large surface area. The mixture of Napier grass fiber in sodium bicarbonate solution was then left to be cooled at room temperature. The alkali treatment discarded the hemicellulose where the fiber was split into fibrils and the internal strain of packed cellulose chain was released hence improved the mechanical properties of fiber[12].

C. Blending

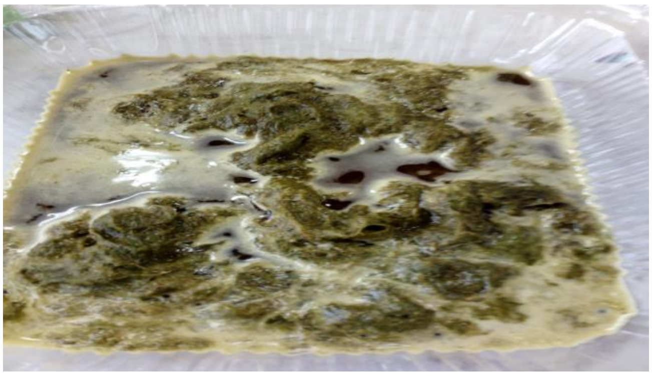


Figure 2: Pulp ready to be used

The boiled Napier grass was blended using Panasonic blender with 480 W electric power to produce softer pulp. A portion of boiled grass mix with tap water until it submerged in a blender. The mixture was then being blended for 30 min to one hour to obtain the softer pulp. Figure 2 shows the pulp produced ready to be used to form the organic plate using mold.

D. Sieving and Molding

The pulp was sieved to get the Napier grass fiber. The Napier grass fiber was then added in between two aluminum plate which act as a mold, and being compressed with a little force to remove excess moisture. The pulp was taken out from the aluminum plates, and being covered with two layers of aluminum foil.

E. Drying

The covered molded pulp was then dried naturally for three days under direct sunlight. After the Napier grass plate formed dried, it was quickly being compressed using hot press at room temperature with 140kg/cm2 force for 2 minutes to remove excess moisture and leveling the surface.

F. Coating

Figure 3: Organic plate produced from the pulp

The organic plate formed was then coated with corn starch solution to improve the total surface smoothness. The alkali treatment of grass with sodium bicarbonate enhance the ability of the fiber surface area to be wetted by the corn starch[12]. Figure 3 shows the organic plate that has been produced from the pulp. The dried organic plate produced was then sent for physical, chemical and mechanical analysis.

G. Scanning Electron Microscope (SEM) Analysis

The surface morphology of the Napier grass was observed using Scanning Electron Microscope (SEM) by Perkin Elmer. The sample was coated using platinum before being examined by using SEM[13]. Untreated and treated Napier grass with alkali treatment were subjected to different magnifications of 500SE and 1000 SE with 1.5kV.

H. Tensile Strength Analysis

Tensile strength analysis was conducted on a sample of organic plate produced to check its physical property using Universal Testing Machine by Tinius Olsen. The ultimate stress recorded is the highest force required to break the organic plate[14].

I. Thickness Measurement

The organic plate produced was measured its thickness using thickness measurement tester to compare with the commercial biodegradable disposable dinner plate to see its suitableness used in commercial.

J. FTIR Analysis

FTIR analysis was conducted on the Napier grass before and after pulping process to check the differences on lignocellulosic content using FTIR spectrophotometer by Perkin Elmer with KBR pellets. The sample was mixed with acetone before being added in the FTIR and being purge by the region 4000-400 cm^{-1} of Fourier-transform infrared spectroscopy (FTIR)[15].

K. Moisture Content Removal

After the organic plate produced using pulp through sieving and molding, the organic plate was dried naturally for three days under direct sunlight. The weight of organic plate was measured before and after the drying process using Sartorious moisture content analyzer. The percent of weight reduced can be calculated by using equation as follows;

$$Weight\ Reduced\ (\%) = \frac{Initial\,Weight - Final\,Weight}{Initial\,Weight} \times 100\%$$

L. Chemical Resistance

Chemical resistance analysis was conducted based on ASTM D 543-87 standard method was employed[16]. A sample of organic plate was weighed using weighing equipment before dipped into tap water and cooking oil for 24 hours. After 24 hours, it was removed immediately, washed with water and it was dried by pressed it between filter paper. The sample was then weighed again to calculate the percent of weight loss or gain of organic plate by the process using the equation below[16].

$$Weight\ gain\ (\%) = \frac{Final\ Weight - Initial\,Weight}{Final\ Weight} \times 100\%$$

III. RESULTS AND DISCUSSION

A. Scanning Electron Microscope (SEM) Analysis

Figure 4-5 (a) and (b) shows the image of SEM analysis for untreated and treated Napier grass at 100µm and 50µm. Figure 4(a) shows the impurities presence on the surface of untreated Napier grass fiber. Untreated Napier grass fiber contain multi cellular where hemicellulose and lignin bind together the individual fiber cells. Therefore, treated Napier grass fiber with sodium bicarbonate helped to remove the impurities and eliminated the hemicellulose and lignin that bind together fiber cells. This is shown in figure 5(a) where the cell was ruptured. Removal of hemicellulose and lignin caused the cellulose to more exposure on fiber surface which resulted in more reaction sites. Hence, it promoted the surface roughness and caused the mechanical interlocking better[13].

(a) (b)

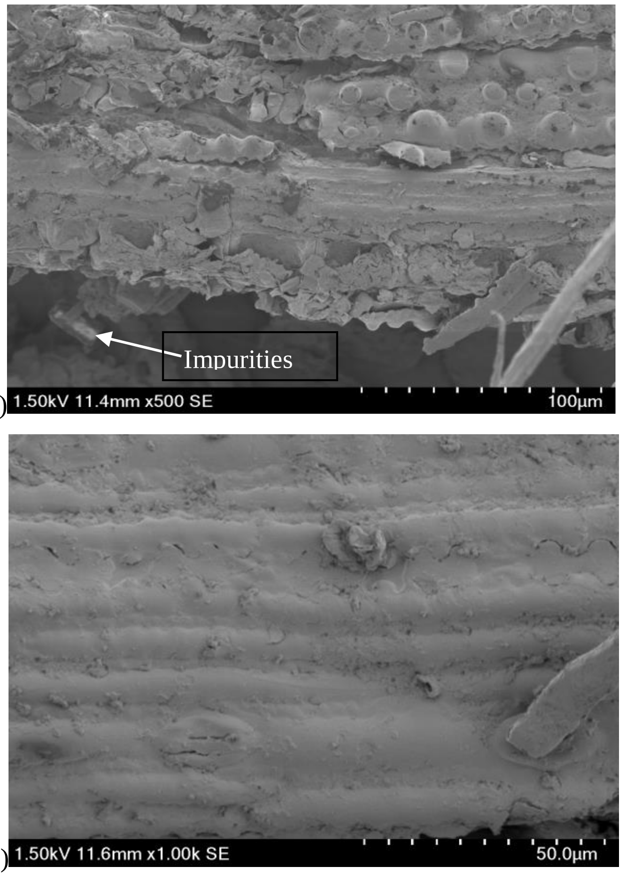
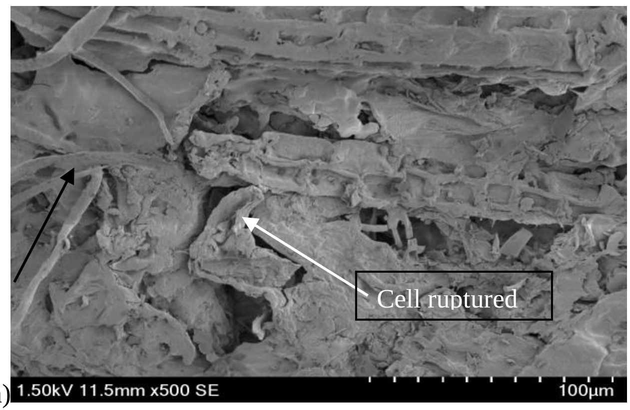
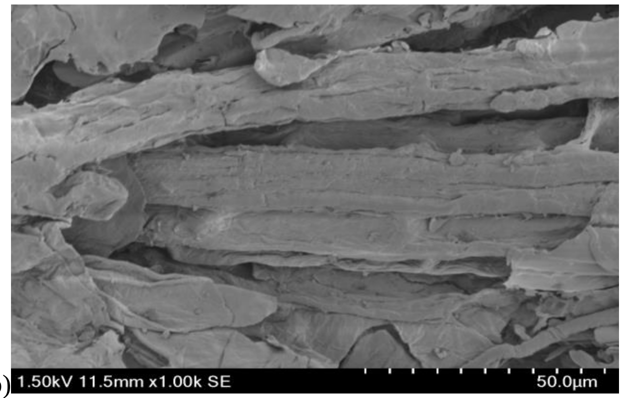


Figure 4: Photo of SEM (a)100µm and (b)50µm of untreated Napier grass

(a)





(b)

Figure 5: Photo of SEM (a)100µm and (b)50µm of treated Napier grass with sodium bicarbonate

B. Tensile Strength

From figure 6, it can be seen that at the force of 280N, the break of organic plate occurred. Therefore, the ultimate stress force over area of this tensile strength analysis is 5.83Mpa.

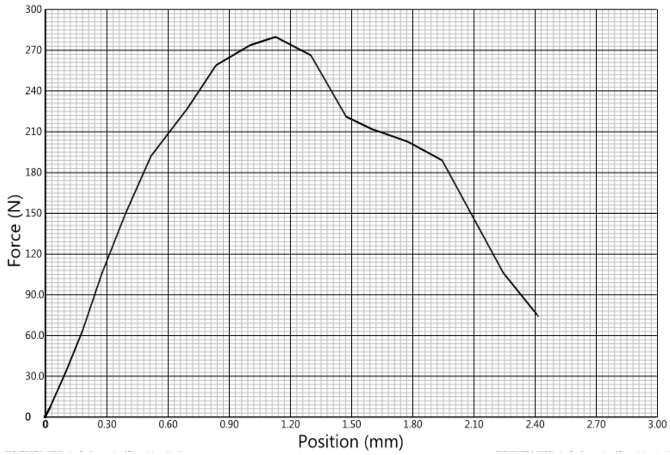


Figure 6: Tensile strength of organic plate

C. Thickness

Table 1: Thickness of organic plate and polystyrene plate

Organic Plate	Biodegradable Disposable Dinner Plates [17] (REAL ACCESSORIES)
2mm	1.6mm

From table 1, organic plate produced has closer thickness to standard biodegradable plate by Real Accessories which are 2mm and 1.6mm respectively. Therefore, the organic plate produced has suitable thickness for commercial used as food container which is relative to standard strength required.

D. FTIR Analysis

Figure 7: FTIR spectra of untreated and treated Napier grass

Table 2: The functional group and the wavenumber with the possible compound from the FTIR analysis from Figure 7.

Wavenumber cm^{-1}	Functional Groups	Lignocellulosic Compounds
Peak Before Pulping		
3317.73	Carboxyl group	Hemicellulose
1635.51	C=C	Lignin
1034.48	C-O-H and C-O	Cellulose
Peak After Pulping		
1029.91	C-O-H and C-O	Cellulose

The presence of lignocellulosic component in the untreated and treated Napier grass was checked using FTIR analysis. The FTIR spectra for the lignocellulosic component Napier grass before and after pulping showed at the figure 7 above. Table 2 is the reference for the wavenumber presents in the analysis result relative to the functional group that represent the lignocellulosic compound in the untreated and treated Napier grass[18]. It shows that FTIR absorbance peak appear at $1034cm^{-1}$, $1635cm^{-1}$ and $3317cm^{-1}$ for untreated grass and $1029.93cm^{-1}$ for treated grass. For untreated grass, the absorbance peak at $1034cm^{-1}$ correspond to cellulose because it contains C-O and OH group. Absorbance peak at $1635cm^{-1}$ and $3317cm^{-1}$ show the presence of lignin and hemicellulose respectively. This is because lignin might be rich in C=C stretching aromatic compound whereas hemicellulose is rich with carboxyl group and acid compound[18]. For treated Napier grass with alkali treatment, it eliminated the presence of lignin and hemicellulose and left only cellulose. This indicated by the only presence of FTIR spectra at $1029.93cm^{-1}$. Cellulose contains of carbonyl group such as C-O and C-O-H group[18]. Cellulose contain is the important component in producing fiber with greater strength and resistance to water and oil.

E. Moisture Content Removal

Table 3: Initial and final weight of organic plate

Organic Plate	
Initial Weight	Final Weight
265.31g	37.31g
(%) Weight Reduced	85.94

From the table 3, it shows the weight of the organic plate was reduced from 265.21g to 37.31g after three days of drying under direct sunlight. Therefore, there was 85.94% of moisture removal from the initial weight of organic plate during the drying process. Removal of moisture is important to prevent bacterial growth in the plate during storage based on observation made.

F. Chemical Resistance

Table 4: Percentage of weight gain of sample in water and oil

Weight gain %	Water	Oil
	52.5%	68%

From table 4 above, it shows that percentage of weight gain of sample in water is lower which is 52.5% than weight gain in oil which is 68%. Therefore, it can be concluded that the organic plate produced is more resistance to water compared to oil. Hence the organic plate can be used as food container where leakage can be minimized when it is used with foods.

IV. Conclusion

The organic plate was fabricated using pulp produced from Napier grass fiber through soda pulping method. The Napier grass fiber content was checked using chemical analysis for a condition before and after pulping. It was found that alkali treatment managed to eliminate lignin and hemicellulose content and left only cellulose fiber for strong physical property of organic plate. Morphological study also showed that after soda pulping method, no impurities present and there was cellular breakage due to lignin and hemicellulose removal. For organic plate, other than having a typical thickness for commercial use, it also showed higher chemical resistance to water than oil. Therefore, these analysis showed that Napier grass fiber is suitable to be used as raw material in producing plate for commercial used to replace plastic. This alternative will reduce the solid waste management problem and utilizing agricultural waste into useful product in line with sustainable development goal.

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