

Napier Grass as Alternative Pulps : From Physical and Chemical Properties

Zawawi Daud

Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia
Batu Pahat, Johor, Malaysia
zawawi@uthm.edu.my

Mohd Zainuri Mohd Hatta

Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia

Batu Pahat, Johor, Malaysia
mzainuri88@gmail.com

Halizah Awang

Faculty of Technical and Vocational Education
Universiti Tun Hussein Onn Malaysia
Batu Pahat, Johor, Malaysia
halizah@uthm.edu.my

Abstract—Fiber were derived non-wood plant where is the demand for fiber raw material increasing from year to year. The objective of this study is to determine the potential of napier grass as alternative fibr for papermaking industry by chemical and physical properties. The chemical properties involved in this study (cellulose, hemicellulose and lignin) according to TAPPI test, Kurschner-Hoffener and Chlorite method. For physical characteristic were determined by TAPPI method. Result shows that Napier grass have high potential; high content of cellulose and lower lignin and good of mechanical properties. Thus, it can be conclude that Napier grass shows a potential to substitute raw materials of wood in pulp and papermaking industry.

Keywords—Napier grass; pulp; Chemical properties; Mechanical properties

I. INTRODUCTION

Napier grass plant is a perennial grass, where it can be grow to 2-4.4 metres, with leaves 30-120 centimetres [1]. Napier grass has their scientific name which is *Pennisetum purpureum*. Napier grass are include in Poaceae family and genus of *Pennisetum*. The plant gives a short, creeping rhizome from 15 to 25 cm long with fine roots at the nodes. [11]. Napier grass also planted as hedgerows where it will avoid from erosion of soil. Napier grass considered to be high carbohydrate in structure cell wall that increase rapidly with advance in paper making [14]. Plant with high contain of carbohydrate also give a high contain of fiber [7]. Napier grass can lead a future of papermaking industry by analysis of chemical composition and mechanical properties

II. METHODOLOGY

A. Raw materials.

Napier grass collected from Parit Sulong, Johor. The sampels were being prepared by TAPPI Method T264 om-97 before analyses of chemical composition in napier grass.

B. Chemical composition.

Chemical composition in these samples were determined accordance with respective TAPPI standards method ; T 211 om-07 (ash content), T 207 om-88 (hot water soluble), T 212 om-88 (1% sodium hydroxide solubility) and T 222 om-88 (lignin content). For cellulose and holocellulose, the method were different where cellulose content will be analyzed by following Kursher-Hoffener method and chlorination method for determination of holocellulose of the sample.

C. Chemical pulping

The cooking condition for both processes can be indicated in the table below in digester autoclave. The partially delignified pulps obtained were washed with water to neutralize the reaction. The formation of paper followed TAPPI Method 205 om-8.

Table 1. Sodium Hydroxide (NaOH) Pulping Process.

Item	Soda Pulping
Concentration (%)	15
Cooking time (min)	90
Cooking temperature (°C)	170
Liquor to wood ratio	7

D. Paper properties.

A set of paper-sheets (60g/m²) were made from the pulp of sample in one attempt according to Tappi T205 and keep overnight in a conditioning room in accordance with Tappi T402. The tensile and tear index were measured according to Tappi T494 and T414. The burst index of papers was also measured according Tappi T403. Besides that, Tappi T511 was used to measure the fold of the paper sample.

III. RESULTS AND DISCUSSION

A. Chemical composition

The ash contents of napier grass fibres are 14.6% where is more than canola straw and date palm rachis. In comparison with other non wood materials, from previous studied, napier grass fibre is higher than date palm rachis with 5% [10]. Besides date palm rachis, canola straw with 6.6% [9] also lower than napier grass ash content. The composition of the ash indicates the presence or absence of any material napier grass. Table 2 shows the mean values of chemical composition of napier grass and its comparison with canola straw and date palm rachis.

Table 2. The Chemical Composition of Napier grass between Canola Straw and Date Palm Rachis.

Composition (%)	Napier Grass*	Canola Straw [10]	Date Palm Rachis [11]
Ash Content	14.6	6.6	9.0
Cellulose Content	12.3	36.6	45.0
1% NaOH Solubility Content	52.0	46.1	20.8
Lignin Content	10.7	17.3	27.2

Cellulose content of napier grass was in the lower range of canola straw (36.6%) and Date palm rachis (45%) about 12.3% of napier grass fibre. High content of cellulose can give a string of the fibre and the quality of papermaking or pulp will be increased [2]. The lignin content of napier grass (10.73%) is fairly lower than canola stalk (17.3%) and date palm rachis (27.2%). Lower lignin content was functioning as an adhesive to bind the cellulose in fibre. Lower lignin content makes the fibre strength more strong and uneasy to break [6]. As indicate in Table 2, napier grass has a high content of 1% NaOH Solubility Content (52%) where it will give significance to the screen yield of chemical pulp⁶.

B. Mechanical properties

The mechanical properties of pulp sheets are reported in Table 3. These properties include the measurement of tear index, tensile index, burst index, folding endurance and tear index. As seen from the Table 3, napier grass fibers have a good condition to become a quality paper production. Tensile index and tear index are probably the main used for the direct measurement of the paper strength. Tensile and tearing are some of the mostly used for testing the properties of natural fiber [13]. From this study, napier grass sheet of paper has a tensile index of 6.93 Nm/g, which is between the Date Palm rachis (1.09 Nm/g) and Palmyra fruit (13.8 Nm/g). besides that, napier grass shows of tear index (1.44 Nm²/g) compared Date Palm rachis (4.4 Nm²/g) and Palmyra fruit (1.12 Nm²/g). The strength of properties of the sheets of paper was correlated to interfiber bonding [3]. The fiber strength is

directly proportional to cellulose content for fiber pulp by cooking process where it determines the strength properties of the paper that were being produced [8].

Table 3. Properties of Pineapple Leaf Chemical Pulping fiber

Sample	Tensile Index (Nm/g)	Tear Index (Nm ² /g)	Burst Index (kPa*m ² /g)	Folding (Nm)
Napier grass*	6.93	1.44	4.69	2.45
Date Palm Rachis [11]	1.09	4.4	1.32	n.a.
Palmyra fruit [12]	13.80	1.12	n.a.	n.a.

*n.a. Not available

Napier grass papers gives a good of burst index about 4.69 kPa*m²/g rather but Date palm rachis was a little high about 1.32 kPa*m²/g. However, pineapple leaf paper properties still in a good range for a paper quality. The result from burst strength shows how strong the paper from pineapple leaf material. Bursting strength was done for rupture of the paper material when consistently increases the pressure as the maximum hydrostatic pressure [5]. For folding test, pineapple leaf gives 2.45 Nm the strength of folding endurance from the test pineapple leaf papermaking. High quality test of folding endurance shows how the paper can have a maximum of fold where have an advantage to become a tissue paper with a tiny density [4].

IV. CONCLUSION

Based on the result, napier grass fiber becomes a favorite to become a highly potential of substitute fiber in pulp and papermaking industry. Napier grass have a characteristic in becoming paper making production same as wood fiber. Favourable high amount of cellulose content and low lignin content could give a high quality of pulp and paper making production. Mechanical properties test (Tensile index, Tear index, Burst index and Fold test) shows a high of measurement where have a same property with wood materials. This Malaysia's agro waste material can become an effective source and has a high potential for alternative fiber in paper making industry. This study give confirmation of the suitability of Napier grass as an alternative pulp for papermaking industry.

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