Suitability of Malaysia's Pineapple Leaf and Napier Grass as a Fiber Substitution for Paper Making Industry

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Abstract

The agro waste materials have a high potential to give benefit to paper industry. Two different crops will be studied include pineapple *(Ananas Comosus)* leaf and Napier grass (*Pennisetum purpureum*) where high potential to become an alternative fiber. The objective of this work was to analysis the chemical composition both material and to investigate the fiber morphology properties of pineapple leaves and napier grass fiber. The chemical composition of fiber was analyzed by TAPPI method (Ash, Lignin and Sodium Hydroxide soluble content), Chlorination method (Cellulose; Holocellulose) and Kuchner-Hoffner method (Kuchner-Hoofner). Both samples were undergoing Screen Electron Microscopic (SEM) use for observation. This research indicates pineapple leaf has a high Cellulose (66.2%) rather than napier grass (41.0%) content. Lignin content in Pineapple leaf is the lowest (4.2%) compared to other material and Napier grass (10.7%) in this study. Scanning Electron Microscopic (SEM) showed a condensed composition of fiber structure on both crops. The chemical compositions and morphology study of pineapple leaf indicate that it is more favourable than napier grass to be used as an alternative pulp in paper making industry and beneficial on promoting the green technology. These instructions give you guidelines for preparing papers.

Keywords**:** Fiber, Napier grass, Pineapple leaf, Chemical composition, Green technology, Pulp and Paper making.

I. INTRODUCTION

Malaysia has abundance of agro waste material that have not been fully utilized to a maximum production. Thus, the finding of a new alternative fiber in non wood material will be favorable in paper production. Depleting forest tree to get the wood material had made an impact for the environment and human especially. As this issue becomes a crucial one, alternative fiber from non wood material will give a good solution on save our environment from being destroy together developing of human life. Besides Malaysia, other Asian country like China had been accelerated growth economic over the past decade and has increase in the nations for paper and paperboard products [3]. Many paper industries applied the Kraft process to become their main process of pulp. Refer from the figure 1; we can see the process of paper production in industry. However, the uses of wood in paper production give an effect on our environment system. Thus, many countries had decided to utilize the non wood fiber in paper making industry [4].

Pineapple (*Ananas Comosus*) is the common tropical plant which consists of coalesced berries. This pineapple is leading member from family of Bromeliaceae and it came from genus *Ananas*. Fiber bundle from pineapple leaf can be separated from the cortex where it reveals the pineapple leaf fiber in multi-cellular and lignocelluloses pattern [13]. This leaf has a ribbon-like structure and cemented together by lignin, pentosan-like materials, where it contribute to the strength of fiber [2].

This grass has their scientific name which is *Pennisetum purpureum*. Napier grass are include in Poaceae family and genus of Pennisetum. Like other non-wood material, pineapple leaf and cornstalk, napier grass also contain of hemicelluloses, cellulose and lignin content [4]. This content of hemicelluose and cellulose show that this plant can be an alternative fiber to make a paper. Napier grass has a high lignin content due of large amounts of neutral detergent fiber [2]. Natural detergent fiber is the most common measure of fiber that will be measure of structural components in plants cell in example lignin, hemicelluloses and cellulose but not pectin. Napier grass considered to be high in structure cell wall carbohydrate that increases rapidly with advance ii paper making [1]. Plant with high contain of carbohydrate also give a high contain of fiber [8].

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Therefore, the purpose of this study was to analysis the chemical compositions and to investigate the fiber morphology properties of corn stalk fiber. From this study we can see the potential of this plant in paper making industry.

2. PROCEDURE FOR PAPER SUBMISSION

2.1 Raw material

The sample of pineapple (*Ananas Comosus*) leaf is collected from Ayer Hitam, Johor and Napier grass (*Pennisetum purpureum*) collected from Parit Sulong, Johor. This raw material was used as an alternative to wood content fibers in paper production of this study. This entire sample washed with water to remove all debris and suspended particles, followed by air-dried for 72 hours (3 days). The sample was further dried at 110^{o}C for 24 hours to make sure no water particles trapped. Next, the sample had been cut into smaller pieces prior to grinding and size selection using a sieve at approximately 0.4 mm. The sample was bagged for further analyses.

2.2 Preparation of Samples

The prepared sample undergoes T 264 om-97 TAPPI Test Method before analyses for chemical composition in pineapple leaf.

2.3 Chemical Composition Analysis

Chemical composition in these samples such as cellulose, lignin, hemicelluloses, holocelluloses, 1% sodium hydroxide soluble, hot water soluble and ash content 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). TAPPI standard methods were analyse by the weight of the sample in dried after being under chemicals Sodium hydroxide (NaOH), Nitric acid (HNO_3), Acetic acid, Sulphuric acid (H_2SO_4), Ethanol, Sodium chlorite ($NaClO_2$) and Acetone. For cellulose and holocellulose, the method were different where cellulose content will be analysed by following Kursher-Hoffener method; the sample under alcoholic nitric acid reflux where the percentage of the weight of sample from oven be taken and chlorination method for holocellulose content; the sample undergo chloroting process and then the weight of sample which is holocellulose content be determined.

2.4 Surface Observation

The samples were observed under Scanning Electron Microscope, SEM to study its fiber morphogical properties.

3. RESULT AND DISCUSSION

3.1 Characterization of the Raw Material

The chemical compositions of pineapple *(Ananascomosus)* leaf and Napier grass (*Pennisetumpurpureum)* are listed in Table 1, which shows that these raw materials have a high potential as alternative fibers for pulp.

Table 1 Chemical Composition of Pineapple Leaf and Napier Grass

Constituents/ Composition (%)	Pineapple leaf	Napier Grass
Ash Content	4.5	14.6
Cellulose Content	66.2	12.3
Holocellulose Content	85.7	80.4
Hemicellulose Content	19.5	68.2
1% NaOH Solubility	39.7	52.0
Lignin Content	4.2	10.7
Hot Water Solubility	32.5	84.4
Moisture Content	81.6	11.7

Pineapple leaf fibers have lower ash content (4.5%) than Napier grass (14.6%). The function of ash content is to show the absence or presence of other materials or slightly or in combination (TAPPI method 211 om-98). This shows that napier grass has a higher presence of other materials that are various chemical, metallic matter, and mineral matter and give an advantage in fiber composition of plant besides pineapple leaf fiber. The low ash content indicates that pineapple leaf pulp has the potential to produce good quality paper [9]. Pineapple leaf has very high moisture content (81.6%) compared to that Napier grass (11.7%). This high moisture content will affect the mechanical and surface properties of the paper where it has a less dimensional stability against the grain [7]. Quality paper needs a very good dimensional stability against the grains because the structure and the strength of the paper depend on it [15]. Cellulose fiber can swell from 15 to 20% from dry condition to saturation where it can cause the change dimension stability. Such change in dimension will make the dimensional stability decrease and affect the undesirable cockling and curling in the dimensional stability in the paper [17].

From Table 1, it can be seen that pineapple leaf contains a high holocellulose content (85.7%) then Napier grass (80.4%). Holocellulose is a combination of cellulose and hemicellulose content. The greater the holocellulose inside the material is, the better the quality of the paper produced. Cellulose content has a high significance in paper production. In this study, pineapple leaves have the highest cellulose content (66.2%) followed by Napier grass (12.3%).

Cellulose is the component that makes the fiber inside non-wood materials stronger [5]. For hemicellulose content, there is a different result: Napier grass has the highest hemicelluloses content (68.2%), followed by corn stalk (42.0%) and pineapple leaf (19.5%). These are important parameters in determining the suitability of a raw material for pulp and papermaking. The quality of fiber produced from non-wood materials depends on the contents of cellulose, hemicellulose, and holocellulose. Higher contents of cellulose can provide stronger fibers, increasing the quality of the paper produced [8].

Lower lignin content is normally found in non-wood fiber and lignin functions as adhesive to bind the cellulose together in the fiber. Lower lignin content makes the fiber strength greater and harder to break [14]. Pineapple leaf fiber has a low lignin content of 4.2% compared to Napier grass (10.7%). Lower lignin content is easier to discard from the pulp, and the paper that will be produced is of greater quality compared to that from other non-wood materials. Pineapple leaves have a 1% sodium hydroxide solubility of 39.7%, lower than that of Napier grass (52.0%). The solubility in 1% sodium hydroxide indicates the extent of fiber degradation during the pulping process. Napier grass has a high 1% sodium hydroxide solubility, and the production of chemical pulp will therefore be high [6]. It will give significance to the screen yield of chemical pulp. Napier grass has a high hot water solubility of 84.4%, followed by pineapple leaf (32.5%). The high hot water solubility of non-wood material indicates a high content of sugars and colouring agents, such as starch and proteins, which could consume pulping reagents and lengthen the pulping process [7].

3.2 Morphological Analysis

Scanning electron microscopy (SEM) analyses of pineapple leaf fibers and Napier grass fibers are shown in Figure 1 from the cross-sextion and surface of fiber from both materials.

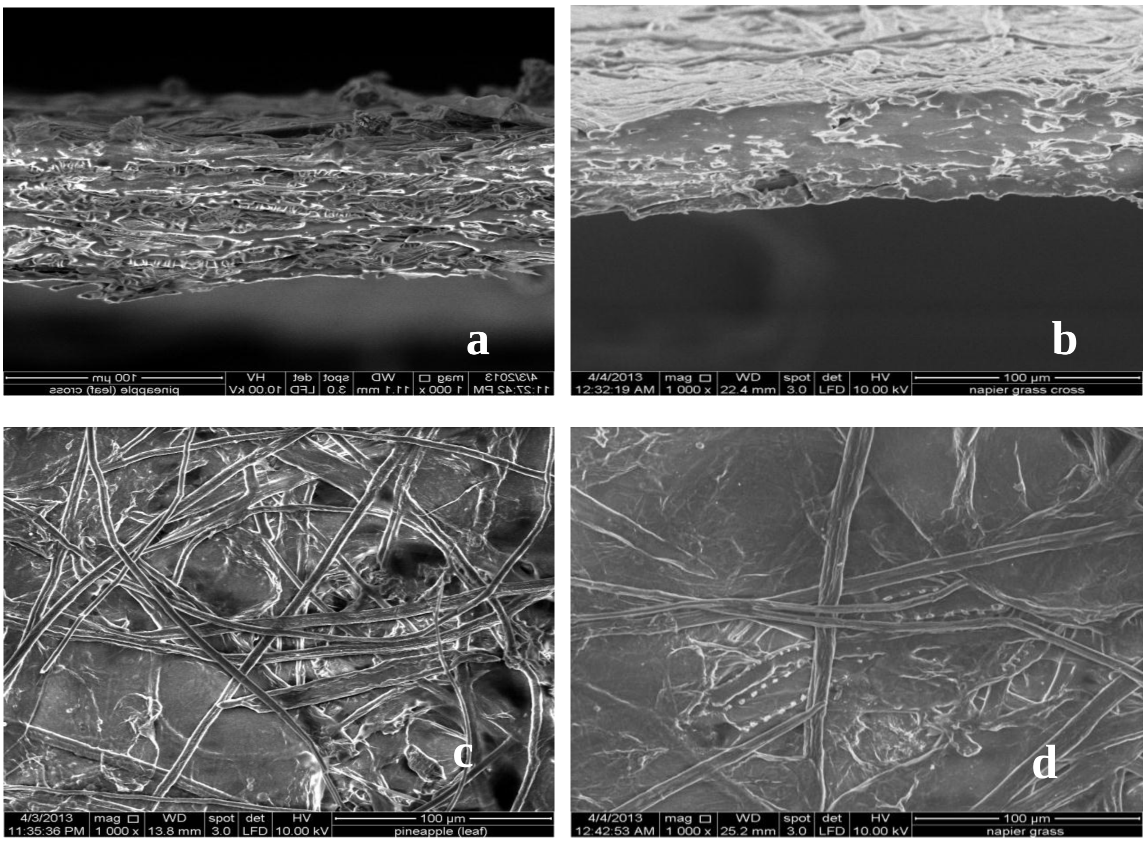

Figure 1 SEM cross-section images of pineapple leaf (a), Napier grass (b) and surface of fiber pineapple leaf (c), Napier grass (d).

The SEM micrographs of the cross-sections (Figure 1a, 1b) show fibrillation on the surface of all three non-wood materials. From these cross-sections,the fibrillation of the non-wood material can be seen. This fibrillation can be attributed to the removal of lignin and other structural effects [11]. The pineapple leaf cross-section has a rougher structure than that of Napier grass. The cross-section of Napier grass is smooth, and there is a space between the cell wall and the fiber itself. This morphology reveals the presence of lumen surrounding the cell wall of this material [10].

This analysis reveals the structure and shape of fiber bundles inside the the two materials. Using SEM, the strength of the fiber can be seen in the arrangement and packing of the fiber matrix. From this analysis, pineapple leaf fibers have many matrix of fiber in the surface rather than Napier grass. Pineapple leaf fiber has a higher fiber content because of it arrangement; from Figure 1 we can see that the structure of the pineapple leaf fiber is more closely packed than that of Napier grass fibers. However, Napier grass fibers were much unpacked, and the arrangement of the fiber matrix was very far from each other. The arrangement and packing also affect the paper production by affecting the strength and quality [12]. The condensed fiber is significant to the structure of the paper produced from non-wood material [16]. Matrix fibers and the arrangement of fibers make the fiber more strong where the quality of pulp and paper can be produced [17].

4. CONCLUSION

This study shows that pineapple leaf fiber becomes a favorite to become a highly potential of substitute fiber in paper production besides Napier grass. However Napier grass can also become a fiber substitution because they also have a characteristic in become paper making production same as pineapple leaf fiber. Favourable high amount of cellulose content and low lignin content could give a high quality of pulp and paper making production from pineapple leaf fiber. Furthermore, scanning electron microscopy (SEM) analysis shows the condensed arrangement of fiber which from a strong fiber structure in pineapple leaf. Thus, this abundance Malaysia's agro waste material can become an effective source and has a high potential for alternative fiber in paper making industry.

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