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Analysis the Chemical Composition and Fiber Morphology Structure of Corn Stalk

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Abstract: Paper industry is one of the main industries that required a forest tree for their beneficial and pulp production. However, the sources from tree become decrease from year to year. Due to this problem, fiber substitution from non wood material can overcome the decrease of source forest in the world. Corn stalks have a high potential to become one of substitution fiber for pulp and paper making. Corn plant are from Poaceae family and a genus of *Zea* which is species of *Zea mays.* This crop was characterized as agro waste material in Malaysia and has a high potential to become an alternative fiber for pulp and paper making. The objective of this work was to analysis the chemical composition pineapple leaf; to investigate the fiber morphology of properties of corn stalk fiber. The chemical composition of fiber was analyzed by TAPPI Test method, Chlorination method and Kuchner-Hoffner method. Every chemical components analyse; Cellulose (Kuchner-Hoofner), Holocellulose (Chlorination method), Hemicellulose (Chlorination method), Hemicellulose, Ash content (T211-om-93), Lignin content (T222-om-98) and Sodium Hydroxide soluble (T203-om-88). From this research, Holocellulose content (83.05%) shows a higher content than others chemical composition in this corn stalks. Besides that, hemicelluloses content (41.02%), cellulose content (42.04%) and lignin content (7.3%) also be done in this research. This crops morphology was observed by Scanning Electron Microscopic (SEM) which showed a condensed composition of fiber structure. The chemical compositions and morphology study of corn stalk indicate that it is suitable to be used as an alternative pulp in paper making industry and promoting the green technology in develop a friendly product.

Key words: Fiber, Corn stalk, Chemical composition, Green technology, Pulp and Paper making.

INTRODUCTION

Malaysia and other Asian country like China had been accelerated growth economic over the past decade and have increase in the nations for paper and paperboard products (Barr and Stafford, 2008). They had seen a potential of recycling paper and non-wood material to make a new brand of paper. No matter what the source of the fiber that is getting from the recycle paper or non-wood material, it can be reused repeatedly rather than requiring new raw resources for every production of paper (Aziz *et al.,* 2006).

Corn plant in our contry had become one of the food plant that use as a food production and many more. However the abundance of the stalk from this plant had that had been use only for a food to ruminant's animal, this had overcome a new of idea to make this plant as an alternative fiber in paper making industry. Corn stalks have a high percentage to becoming a fiber substitute only we see the appearances of stalk itself.

Corn plant are from Poaceae family and a genus of *Zea* which is species of *Zea mays.* This plant mostly can be found in the Americas with 332 million metric tons grown annually in this country. It has a distinct growth form where the leaves generally 50-100 centimetres long and the stems can be erect conventionally to 2-3 metres in height (Reddy and Yang, 2005). Flandez *et al.* (2010) reported that corn stalk where it becomes one of the agricultural residues could be good source of lignocelluloses fibers for the production of pulp for paper making. Each non-wood pulp has different characteristics according to their fiber form where corn stalk has their own fiber characteristics, chemical composition and types and amount of fibers cell (Ryu *et al.,* 2007).

Chemical content of corn stalk contains cellulose (35-50%), lignin (5-34%) and petosan around 20-41%. %. The morphological properties of corn stalks have fiber length (1.32mm), fiber width (24.3 mm), lumen width (24.3 mm) and cell wall thickness (6.8 mm) (Akhgul *et al.,* 2010).

Table 1: Comparison between Corn Stalks and Hardwoods (Abolfazl and Ahmad, 2011).

Constituents	Corn stalks	Hardwoods
Fiber length, mm	1.0-1.5	0.7-1.6
Fiber Diameter, µm	20	20-40

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From the table above, we can see the fiber length and diameter from corn stalks are in the range of hardwood range. Thus, fibers from corn stalks have a high potential to become a alternative fiber. It is because it have a very familiar characteristic to the source of paper making itself. Lignocellulosic from cornstalk are composed of single cells of cellulose that are only about 0.5-3.0 mm in length (Reddy and Yang, 2005). Cornstalks are a cheap and annually renewable resource suitable for producing natural cellulose fibers (Azubuike *et al.,* 2012). The present of highest by hemicelluloses and lower lignin content make cornstalk become more suitable to undergo in paper production (Narenda and Yiqi, 2005a).

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.

MATERIALS AND METHODS

Raw Material:

The sample of corn stalk is collected from Pontian, 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 in 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.

Preparation of Samples:

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

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). For cellulose and holocellulose, the method were different where cellulose content will be analysed by following Kursher-Hoffener method and chlorination method for determination of holocellulose in sample.

Surface Observation:

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

RESULT AND DISCUSSION

Analysis of Chemical:

The chemical composition corn stalk fiber is listed in **Table 1**. The ash content of the fibers is 24.9%. This amount of ash content is a function of the absence or presence others material or singly or in combination. Corn stalk gives greater ash content than other non wood fibers especially from plant. In comparison with other non wood materials, from previous studied, the corn stalk fiber is high than date palm rachis with 5% (Khiari *et al.,* 2010). Besides date palm rachis, canola stalk with 6.6% (Enayati *et al.,* 2009) also lower than corn stalk ash content. The composition of the ash indicates the presence or absence of any material (various chemical, metallic matter and mineral matter) in corn stalk fiber. High ash content influence the quality of paper that will be produced from the pulp of decrease whereas the various material inside the corn stalk interrupt the structure of cellulose (Lopez, *et al.,* 2004)

The moisture content is very low with content about 7.3% of content in corn stalk which is higher than other non woods. This high moisture content will affect the mechanical and surface of the paper where it has a less dimensional stability against the grain (Khampan *et al.,* 2010). The quality that paper production from this corn stalk plant will make the paper production more stability in grain and have more good in mechanical affect when the paper production had been completely process.

Table 2 shows the mean values of chemical composition of corn stalk and its comparison with canola stalk, date palm rachis and cotton stalk. Those all of the comparison will be differ with the other non wood fiber fraction with corn stalk fiber. Cellulose content of corn stalk was in similar range of canola stalk about close from 36% to 39%. However, cotton stalk have a high cellulose content rather than corn stalk but it the percentage is still same in the range of high content of cellulose in non wood material. With a nearly similar content of holocellulose content of corn stalk with both three other of previous studies material. The percentage of holocellulose is in the high range of holocellulose content. However, the corn stalk and canola stalk have same of range of holocellulose content whereas close to or above 40%. This range of content is satisfactory for pulp and paper production. It is higher than the other two material of non wood, date palm rachis (29.8%) and

cotton stalk (14.4%). The quality of fiber from non wood material that will be produced depends on the content of cellulose, hemicelluloses and holocellulose in this non wood material. High content of cellulose can give a strong of fiber and the quality of papermaking or pulp will be increase (Khalil *et al*., 2006).

Table 2: Chemical Composition of Corn Stalk.

Constituents/ Composition (%)	Corn Stalk (This study)	Canola Straw Hosseinpour *et al.*, (2010)	Date Palm Rachis Khiari *et al.*, (2010)	Cotton Stalk Enayati *et al.*, (2009)
Ash Content	24.9	6.6	9.0	2.2
Cellulose Content	39.0	36.6	45.0	58.5
Holocelluose Content	82.1	73.6	74.8	72.9
Hemicellulose Content	42.0	42.0	29.8	14.4
1% NaOH Solubility Content	69.6	46.1	20.8	20.3
Lignin Content	7.3	17.3	27.2	21.4
Hot Water Soluble Content	12.6	18.0	8.1	3.3
Moisture Content	7.3	n.a.	5.0	17.5

*n.a.: not available, NaOH: Sodium Hydroxide

The lignin content of canola stalks (7.3%) is fairly low than canola stalk (17.3%), date palm rachis (27.2%) and cotton stalk (21.4%). Lower lignin content is normally found in non wood fiber and function as adhesive to bind the cellulose in fiber. Lower lignin content makes the fiber strength more strong and uneasy to break (Tsoumis, 1991). As indicate in **Table 2**, corn stalk has a high content of 1% NaOH Solubility Content where it will give significance to the screen yield of chemical pulp (Holia and Jovita, 2005). The high content of hot water solubility in indicates high content of sugars, colouring matters, such as starch and proteins and could consume pulping reagents and lengthen the pulping process (Khiari *et al.*, 2010). Although corn stalk not a high content of hot water solubility where canola straw more high but it still in the range of high content than others non wood composition.

Analysis Morphological:

Scanning electron microscopy (SEM) analysis is shown in **Figure 1**. From this analysis, corn stalk fibers have many matrix of fiber in the surface.

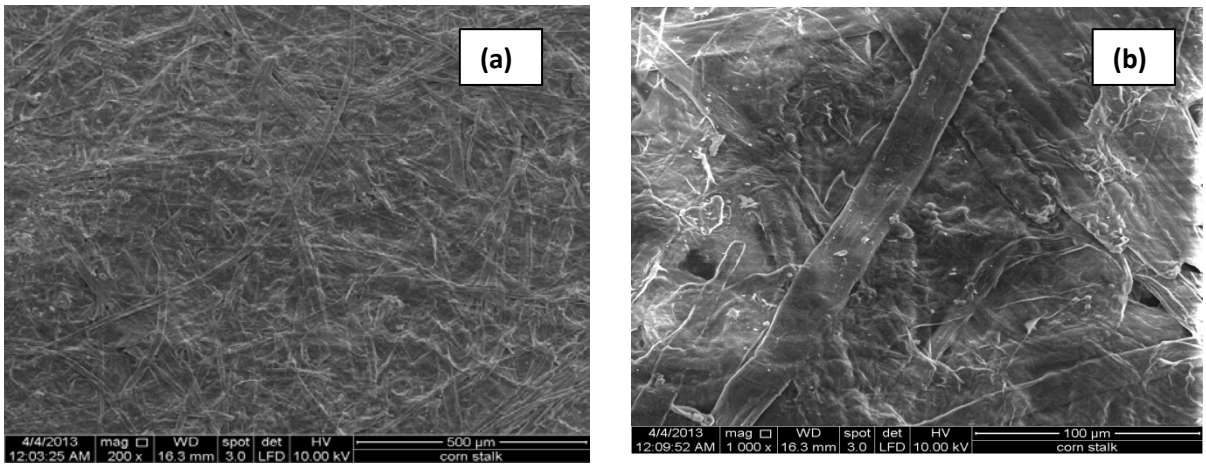

Fig. 1: SEM microphotograph of the fracture corn stalk fiber (a) pack of fiber in the surface with magnification 200x and (b) corn stalk fiber with magnification 1000x.

This shows that corn stalk have a fewer of fiber bundle matrix in the surface of corn stalk. From **Figure 1 (a)**, SEM analysis with magnifation 200x shows bundle of packed fiber on the surface area of corn stalk fiber. The surface of corn stalk fiber had been filled with many of fiber matrix where were packed together. From **Figure 1 (b),** shows the fiber seems to be closely packed but the fiber were not very pack and the matrix of fiber were very fewer from the magnification 1000x. However, it give a little of significance on the fiber whereas the more important is the corn stalk have a bunch of bundle to develop for paper and pulp process. The arrangement and packed of fiber matrix on the surface and fiber of pineapple leaf will affect the strength of the fiber itself (Narenda and Yiqi, 2005b). The fiber surface contain of the waxes and other of entrusting substances like lignin, pectin and hemicelluloses. These substances form a thick layer to protect the substances of cellulose inside the matrix layer of fiber (Rowell *et al.*, 2000). The condensed fiber is significance in the structure of the paper produced from the corn stalk (Waranyou, 2010). Those figures show the surface area of the corn stalk and the

condensed arrangement of the fiber where it can increase the fibre strength and the quality of the paper produced (Han and Rowell, 1997).

Conclusion:

From this study, the chemical composition analysis show that have a quite high of cellulose content and low lignin content where could give a high quality of pulp and paper making production. Besides that, scanning electron microscopy (SEM) analysis shows the condensed and packed arrangement of fiber but have a less of layer fiber matrix in corn stalk. The overall result showed that corn stalk has a promising potential to be used in combination with softwood or hardwood pulps in paper making. 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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