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Procedia - Social and Behavioral Sciences 195 (2015) 2047 – 2050

Procedia
Social and Behavioral Sciences

World Conference on Technology, Innovation and Entrepreneurship

Oil Palm Leaf And Corn Stalk – Mechanical Properties And Surface Characterization

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Abstract

Agro waste can be defined as waste from agricultural plant. Oil palm leaf and corn stalk can be categorized as ago waste material. At first, the comparison between oil palm leaf and corn stalk by mechanical properties from soda pulping process. After that, this study focusing on surface characterization by Scanning Electron Microscopy (SEM). Both materials have a potential due to the mechanical properties (tensile, tear, burst and fold) and surface characterization but corn stalk shows more in strength and compactness due to fibre characterization compared to oil palm leaf. This study promoting the green technology in developing a friendly product and suitable to be used as an alternative pulp in paper making industry.

Peer-review under responsibility of Istanbul Univeristy.

Keywords: Oil palm leaf; Corn stalk; pulp and paper; green technology

1. Introduction

Normally, fibre resources for pulp and paper are obtained from trees or agricultural crops. These resources include plant materials harvested directly from the land (wood, straw and bamboo), plant material by-products or residual from other manufacturing processes (wood chips from sawmills, bagasse and cotton linear) and fibre recovered from recycled paper or paperboard. Generally, the oil palm tree is original to the tropical forest in West Africa and this tree was first planted in Malaysia on 1871 (Basiron and Weng, 2004). Oil palm leaves are one component of oil palm waste generated in Malaysia. The leaves are produced in spiral succession from the meristem (Dano, 2013). The crown consists of 40 to 50 opened leaves in various stages of development. One leaf is produced

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Peer-review under responsibility of Istanbul Univeristy.
doi:10.1016/j.sbspro.2015.06.226

per month until the seeding is 6 months old. Corn (*Zea mays*) plants are included in Poaceae family. In Malaysia, with large area of plantation of corn plant with around 8,600 Ha in 2010 (Daud *et al,* 2014) and it generates large quantities of corn stalk discard as wastes. The corn stalk residues produced after harvesting season is an environmentally friendly source for the production of cellulosic fibre. The explosive development of plantation in this country has generated massive amounts of corn stalk where this waste material creates great environmental problems (Pang *et al,* 2012).

2. Material and Method

2.1 Raw material

Corn stalk collected from Pontian, Johor and oil palm leaf collected from Batu Pahat, Johor. The samples were cut into 2-5 cm and thoroughly washed to eliminate and other particle contaminants

2.2 Chemical pulping

The cooking condition for both processes can be indicated in the table below in digester autoclave with ratio liquid to pulp was 1:7. The partially delignified pulps obtained were washed with water to neutralize the reaction. Then, the pulps will be disintegrated and pressurize the moisten soda pulps for fibrillation until the freeness of the fiber of soda pulps. The formation of paper followed TAPPI Method 205 om-8.

Table 1. Cooking condition for chemical pulping.

Condition	Chemical pulping
Concentration (%)	15
Cooking time (min)	90
Cooking temperature (^{0}C)	170

2.3 Paper properties

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.

2.4 Surface characterization

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

3. Result and discussion

3.1. Papermaking properties

Table 2 shows the mechanical properties by corn stalk and oil palm leaf. Result indicated that corn stalk has a high probability in becoming a good paper production due to high of certain mechanical properties (Tensile, Fold and Burst). From this study, a corn stalk paper has a tensile index of 9.1 Nm/g, compared oil palm leaf, 7.9 Nm/g between the Date Palm rachis (1.09 Nm/g) and Palmyra fruit (13.8 Nm/g).

Table 2. Cooking condition for chemical pulping.

Sample	Tensile Index (Nm/g)	Tear Index (Nm^2/g)	Burst Index ($kPa*m^2/g$)	Folding (Nm)
Corn stalk*	9.1	1.2	6.6	2.5
Oil Palm leaf *	7.9	1.8	0.9	1.9
Date Palm Rachi (Khiari *et al,* 2006)	1.1	4.4	1.3	n.a.
Palmyra fruit (Waranyou, 2010)	13.8	1.1	n.a.	n.a.

*This study

Besides that, oil palm leaf has a tear index (1.8 Nm^2/g) compared corn stalk (1.2 Nm/g); previous research, Date Palm rachis (4.4 Nm^2/g) and Palmyra fruit (1.1 Nm^2/g). High tensile strength given tear index lower because the behaviour between both tear and tensile index is contrarily (Khalil *et al,* 2006), where it respectively showed the inter-fibre bonding strength is high. The strength of properties of the sheets of paper was correlated to inter-fibre bonding. Corn stalk gives a good of burst index about 6.6 $kPa*m^2/g$ rather but Date palm rachis 1.32 $kPa*m^2/g$; oil palm leaf shows low in burst strength (0.9 $kPa*m^2/g$). The result from burst strength shows how strong the paper from corn stalk material. For folding test, corn stalk gives 2.5 Nm compared oil palm leaf shows 1.23 Nm where it show the strength of folding endurance to shows how the paper can have a maximum of fold where have an advantage to become a tissue paper with a tiny density compared oil palm, 1.9 Nm (Han and Rowell, 1999).

3.2. Surface characterization

The SEM analyses oil palm leaf fibre (Fig. 1a) and corn stalk (Fig. 1b). Those fibre surfaces inside the material can be seen from this analysis.

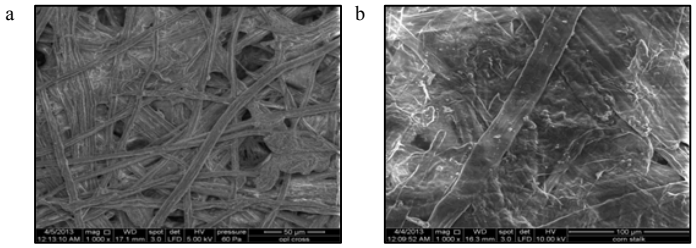

Fig.1 (a) Oil palm leaf fibre (b) Corn stalk fiber

From Fig 2, corn stalk fibres show a closely packed arrangement compared oil palm leaf. Corn stalks also show a thicker fibre could yield a stronger fibre bundle and hence give a higher strength of paper produced (Bhaduri *et al,* 1995). However, oil palm fibre (Fig. 1a) arrangement was not as compact as that found in corn stalk fiber's (Fig. 1b). Inevitably, the less dense arrangement and loose packing could make the paper produced become low in the strength and quality (Daud et al, 2013). The compactness and arrangement of fibres contributed to the factor of quality structure on produced paper beside the other factors such as cellulose content in the non-wood materials (Ververies *et al,* 2004).

4. Conclusion

Both agricultural materials have potential to become fibre substitution to wood material. However, corn stalk shows a high of measurement of mechanical properties test (Tensile index, Tear index, Burst index and Fold test) where have a same property with wood material compared oil palm leaf. Furthermore, scanning electron microscopy

(SEM) analysis shows the condensed arrangement of corn stalk fibre which give a significance of strong fiber structure compared oil palm leaf. Thus, both abundance Malaysia's agro waste material can become an effective source and has a high potential for alternative fiber in paper making industry

Acknowledgments

This research was supported by Ministry of Higher Education of Malaysia and scholarship from Universiti Tun Hussein Onn Malaysia (UTHM). The authors are thankful for this financial support.

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