Journal of Academia Vol. 8, Issue 2 (2020) 15 – 21

# PHYSICAL AND MECHANICAL PROPERTIES OF THIN PAPER SHEETS MADE FROM ONION PEELS *(Allium cepa)*

Mohammad Harris M. Yahya[1*], Normala Hassim[1], Mohd Rozi Ahmad[2]

[1]*Department of Textile Technology, Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM) Negeri Sembilan, Kuala Pilah Campus, 72000 Kuala Pilah, Negeri Sembilan*
[2]*Textile Research Group, Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor*

[*]*Corresponding author: harrisyahya@uitm.edu.my*

## Abstract

The present work deals with the production of paper materials from onion peels *(Allium Cepa)* fibers as an alternative potential non-wood fiber. The onion peels were obtained from a local small and medium food industry. The onion peels were cooked at 120, 150 and 180 minutes. The peels were grinded and poured in a set of mould and deckle for the formation of a thin sheet of paper. The physical, mechanical, morphological characteristics and water rise capillary values (KLEMM Method) were evaluated to determine its suitability for a paper material. The results show that the increase in cooking time from 120 to 180 minutes resulted in an increase in the tensile index from 32.28N*m/g to 42.13N*m/g and tear index from 9.80mN*$m^2$/g to 15.62mN*$m^2$/g. The bonding strength increased due to higher number of fibers, finer fiber size, and increase in the fiber contact area and fiber distribution. The high porosity area affects the performance of water rise capillary values of the paper sheets. The onion peels fiber gave impressive handsheets characteristics when compared with other sources of non-wood fibers.

**Keywords**: Onion peels, Allium Cepa, tensile properties, tearing strength, water rise capillary

*Article History:- Received: 22 March 2020; Accepted: 01 September 2020; Published: 31 October 2020*


## Introduction

Since ancient times, paper has been an important medium in communication as a writing tool and printed items. Although the world is getting more digitalized, computerized and electronically networking (Padmanabha, 2016), demand for paper is still expected to increase due to its versatility as well as the increasing total number of population in developing countries (Mandy et al., 2018). At present, virgin wood fiber is the main component to produce paper. Padmanabha (2016) stated that the production of one ton of paper requires at least twelve trees with 540,000 liters of water and involving many chemicals during the pulping process. Thus, the process destroys the forests and pollute water and air especially from the industrial effluent discharge. Nevertheless, the improvised legislative regulations enacted in various countries to restrict the logging activities are expected to affect the supply and price of virgin wood fibers to the international pulp and paper industry (Mandy et al., 2018).

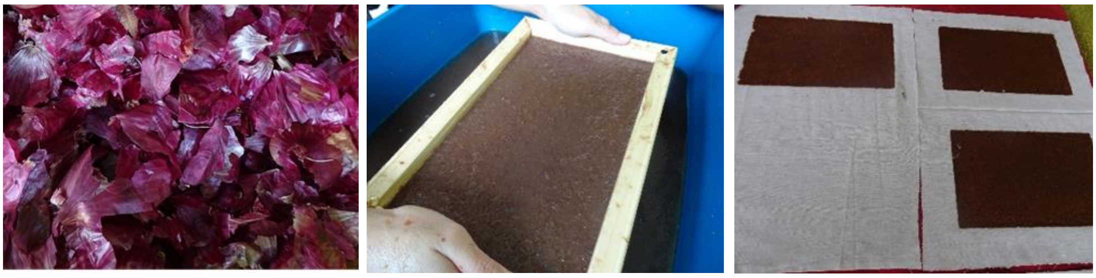
Consequently, the vast consumption and high demand of paper globally has led to an introduction of non-wood fibers particularly as a fibrous material in papermaking in the 21st century (Mandy et al., 2018; Taghi et al., 2017; Taiwo et al., 2014). Over the last several years, many studies have been carried out to produce paper from non-wood fibrous raw materials such as A. Inerbrians, Napier Grass, pineapple leaf fiber, corn straw, kenaf, oil palm leaf, sugarcane baggase, durian rind, coconut coir, bamboo, banana stem and aquatic plants (Li et al., 2015; Zawawi et al., 2013; Yusri et al., 2012; Aremu et al., 2015; Umair et al., 2018; Soloi & Hou, 2019; Marcela & Jorge, 2014; Masrol et al., 2017; Khiril, 2013; Susi et al., 2015; Tripathi et al., 2019; Bidin et al., 2015). Furthermore, non-wood plants may provide an alternative source of fiber to papermakers and advantages by giving a short growth cycle of plants, moderate irrigation and fertilization requirements and low lignin content resulting in less chemical and energy usage for treatment during pulping process (Amit & Pratima, 2017; Sarwar et al., 2013).

There is an abundance of non-wood fibers, such as onion peels, available domestically that can be a new source to substitute wood fibers for papermaking. Based on proximate analysis, onion peels possess high content of carbohydrates, flavonoids and phenol (Beatrice, 2017). Indeed, the food industry produces a large quantity of onion peels waste and there is a need to search for possible ways of their utilization. Although it is a biodegradable waste, the food industries are facing problems to dispose the onion peels because they are normally burned or dumped. This study looks at this issue and make use of onion peel wastes for pulp and paper production.

## Methods

### Fiber preparation and production of handsheets

The Onion peels of the *Allium Cepa* variety (as shown in Figure 1(a)) were collected from a food industry,MAHFAS Enterprise based in Kuala Pilah, Negeri Sembilan, Malaysia. The onion peels were first cleaned with tap water to remove any dirt and debris. The onion peels were then weighed and boiled for 120, 150 and 180 minutes. Next, the fibers were grinded for several minutes until it becomes slurry. The slurry was then poured into a screening bath to allow a handmade papermaking process using a set of mould and deckle as shown in Figure 1(b). Finally, the onion peel hand sheets samples were pressed at constant load and dried at room temperature for a day (refer Figure 1(c)).



(a) (b) (c)

Figure 1. Production of handsheets

### Measurements and Testing

The physical properties of the paper handsheets including areal density (g/m$^2$) and thickness (mm). The tensile properties for the paper handsheet were performed on a TENSO LAB Strength Tester equipped with a 1000N load cell according to the ISO 1924-2 standard. Specimen strips of 250mm in length and 25mm in width were tested with a test speed of 10mm/min. Five specimens were tested per sample. Meanwhile, the tearing strength test was carried out using Elmendorf Tearing Strength Tester according to ISO 1974 standard. Water rise capillary (KLEMM Method) was carried out to determine the water absorbency of the paper handsheets according to the ISO 8787: 1986 standard. An optical light microscope (Olympus) was used to view the surface morphology of the paper handsheets.

## Result and Discussion

Figure 2 shows the areal density and thickness of the onion peel handsheets at 120, 150 and 180 minutes of cooking time. The areal density increased at 140 g/m$^2$ for sample 180 minutes cooking time due to the large amounts of fibers which were fully occupied in the paper handsheet. As the longer cooking time, the fibers become shorter and finer. Furthermore, this could contribute to higher contact area between fibers, thus tend to increase the amount of fibers in the paper handsheet and this statement are similar with the previous work done by Sezgin & Serhat, (2017). In addition, the even distribution and packed arrangement of the fine fibers in the paper handsheets can be seen in Figure 3(c). In contrast, the samples 150 minutes cooking time show the lowest areal density of 118 g/m$^2$ as compared with others. These results are unexpected and may have occurred due to several few factors such as the uneven distribution of fibers, irregular size of fibers and presence of thin and thick places (see Figure 3(b)) in the paper handsheets.

Figure 2 also shows the thickness results of the paper handsheets for the three cooking times. From these results, it can be observed that the samples from the 150 minutes cooking time gave the thickest sample of 0.47mm. It is possible that there are some fibers that have been clumped together, with uneven fiber distribution resulting in some thick places on most of the surface area on the paper handsheet (see Figure 3(b)). The average thickness of the samples from the 120 and 180 minutes are 0.45mm and 0.34mm respectively. The finer fibers in the slurry obtained from the 180 minutes cooking time resulted in closely packed and even fiber distribution, although there were also some thick and thin places on the surface of the paper handsheets (see Figure 3(c)).

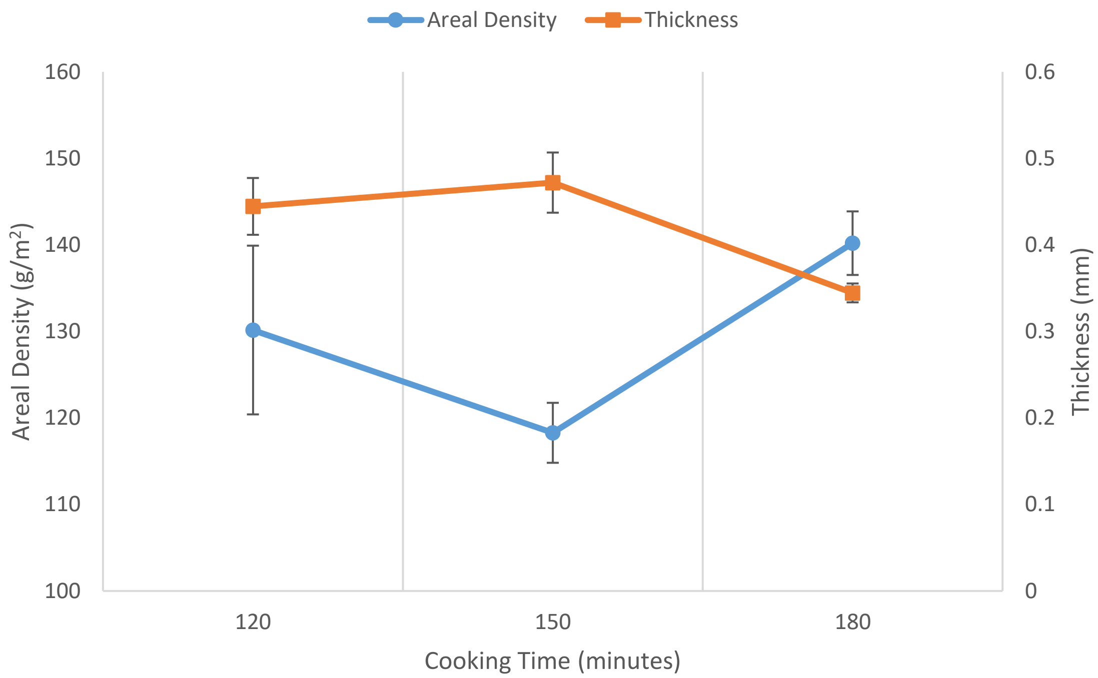
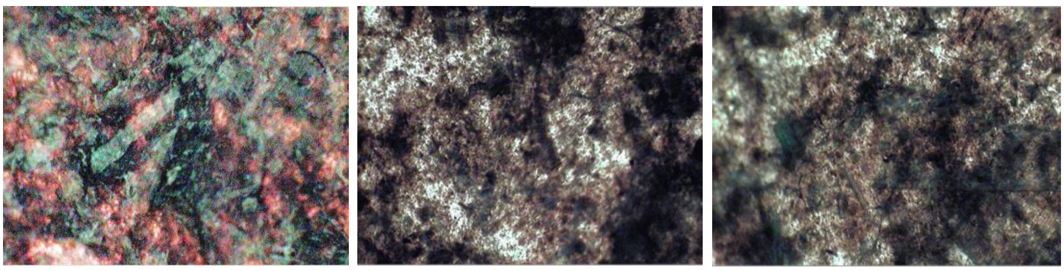



Figure 2. Physical properties of onion peels handsheet at certain cooking time (minutes)



(a) (b) (c)

Figure 3. Microscopic picture of onion peels handsheet at magnification of ×40 for certain cooking time (a) 120 minutes, (b) 150 minutes and (c) 180 minutes

As expected, longer cooking time of the onion peels increased the tensile strength of the corresponding paper handsheets. Figure 4 shows the paper handsheets gradually increased their tensile index from 32.28 to 42.13 N*m/g for the 120 to 180 minutes cooking time, respectively. The tensile index values are in agreement with those obtained by Abdel-Aal (2013), who found that the increase in the cooking time from 60 to 120 minutes resulted in an increase in the tensile index from 54.35 to 77.45 N*m/g. This is maybe because longer cooking time would soften the fibers and make it easily to be grinded and produced a finer fiber structure in the paper handsheet. Hence, this may lead to greater packing of fiber and increase of inter-fibre bonding. These results are in agreement with Khan et al., (2017).

In this study, the tear index was found to be around 15.62 mN*m$^2$/g and it is among the highest of tear index than other types of non-wood fibers as shown in Table 1. Tear index is a measurement of tear strength which is dependent of areal density. It can be seen that the tear index of the paper handsheets increases in increment of cooking time from 120 to 180 minutes (Figure 4). Figure 3(a) - 3(c) shows the paper handsheet's surface morphology at a magnification of ×40 for certain cooking time. The sample prepared under 120 minutes has coarser and looks like flakes than that prepared at 150 and 180 minutes which are finer. The formation of flakes weakened the individual fibers because of less fiber contact area thus reduces the tear strength performance of the paper handsheets. Nevertheless, the finer fiber allows enhancement of the bonding strength due to the increase in inter fiber bonding and this finding was similarly reported by Motamedian et al., (2019).

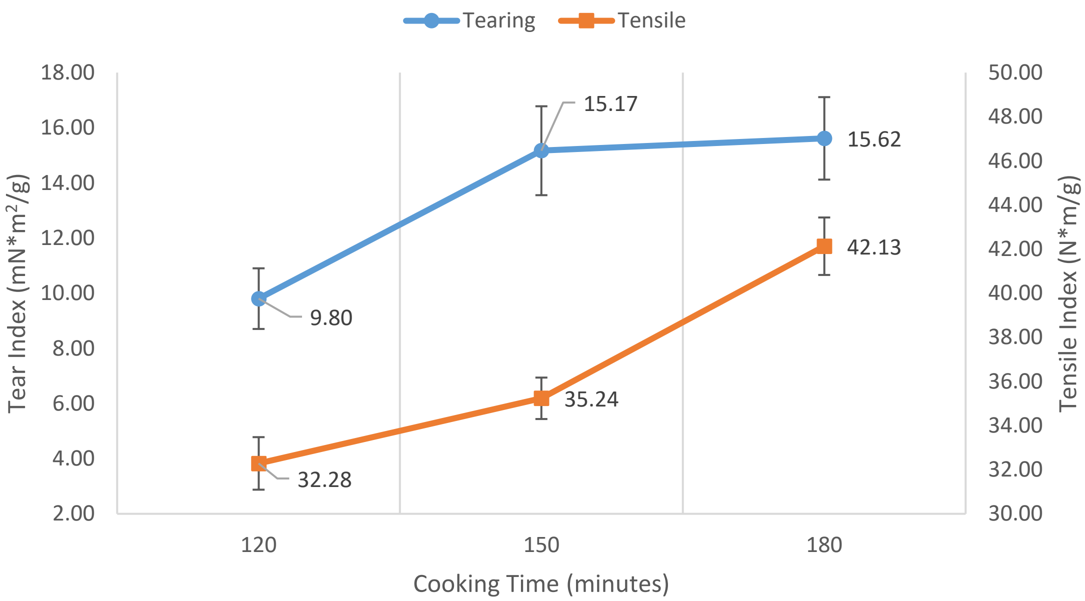



Figure 4. Tearing and tensile strength properties at certain cooking time

Table 1. Comparison of the mechanical properties of various non-wood raw materials for paper handsheets

| Sources | Raw materials | Tensile index (N*m/g) | Tear index (mN*m$^2$/g) |
|---|---|---|---|
| Present study | Onion peels *(Allium Cepa)* fiber | 42.13 | 15.62 |
| Li et al., (2015) | Drunken horse grass *(Achnatherum inebrians)* straw | 18.11 | 5.27 |
| Aremu et al., (2015) | Pineapple leaves | 0.19 | 17.19 |
| | Corn straw | 5.03 | 12.29 |
| Masrol et al., (2017) | Durian rind | 57.59 | 7.09 |
| Abdel-Aal (2013) | Buttonwood residues *(Conocarpus erectus L.)* | 77.45 | 5.01 |
| Madakadze et al., (2010) | Elephant grass *(Pennisetum purpureum schum)* | 93.25 | 4.40 |
| | Switchgrass *(Panicum virgatum L.)* | 75.98 | 5.64 |
| Rafidah et al., (2011) | Kenaf Stalks | 82.89 | 16.42 |
| Aya et al., (2016) | Banana leaves | 26.1 | 9.51 |

It was also observed that the water rise capillary values were highest at 150 minutes cooking time in comparison with the other two cooking times, as shown in Figure 5. One of the possible explanations is related to the clumps that occurred in the handsheets (as shown in Figure 3(b)) which contribute to thick and thin places. The greater number of thin places leads to increased porosity area in the handsheets. Therefore, this resulted in higher water absorption through the thin places caused easy water movement into the handsheets.

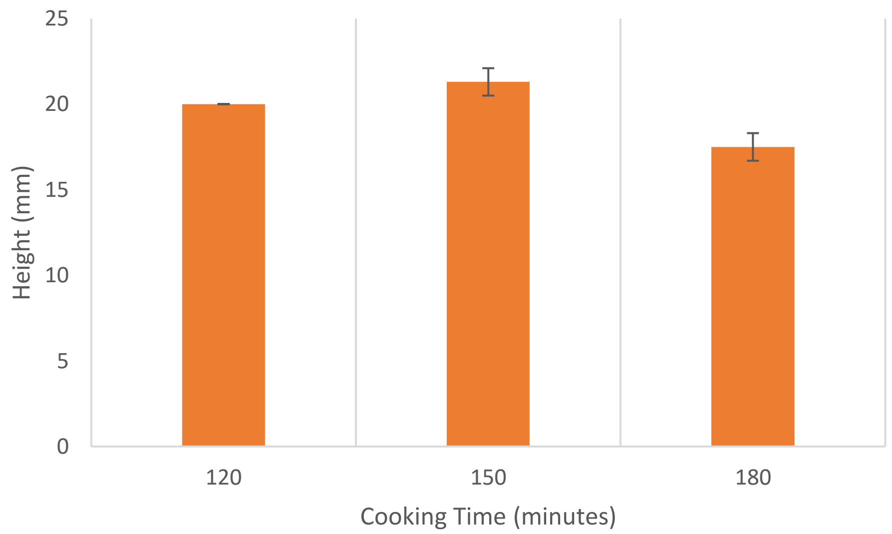



Figure 5. KLEMM capillary rise test at certain cooking time

## Conclusion

As a conclusion, the onion peel fibers have potential as an alternative fiber in paper production as the mechanical properties are comparable with other non-wood fibers. Test results revealed that the number of fibers and fiber size have great influence on the physical performance of the paper handsheets. Furthermore, increasing of cooking time, positively affected all the mechanical properties such as tensile and tearing properties. This may be due to the fiber contact area and fiber distribution in the handsheets that finally increase the inter fiber bonding. In addition, the sample prepared at 150 minutes cooking time had a higher water rise capillary values due to the presence of the large area of thick and thin places resulted in increased porosity area in the handsheets.

**Acknowledgement**

The authors would like to thank MAHFAS Enterprise at Kuala Pilah, Negeri Sembilan for the supply of raw materials for this project.

**References**

Abdel-Aal M. A. (2013). Effect of Cooking Time, Active Alkali Concentration and Refining Process on the Pulping and Papermaking Properties of Buttonwood Residues (*Conocarpus Erectus L.*). *World Applied Sciences Journal*, 27(1), 1-9.

Amit R. & Pratima J. (2017). Production of Wrapping Paper from Banana Fibres. *Journal Environmental Chemical Engineering*, 5, 4298-4306.

Aremu M. O., Rafiu M. A., & Adedeji K. K. (2015). Pulp and Paper Production from Nigerian Pineapple Leaves and Corn Straw as Substitute to Wood Source, *International Research Journal of Engineering and Technology (IRJET)*, 2(4), 1180-1188.

Aya A., Marwa R., Gehad O., Mostafa A. M., & Mamdouh M. N. (2016). New Raw Materials for Paper Pulp. *B.Sc. Project*, Faculty of Engineering, Minia University, 1-55.

Beatrice O. T. I. (2017). Chemical Composition of Onion Peels (*Allium Cepa*) and its Ability to Serve as a Preservative in Cooked Beef. *International Journal of Science and Research Methodology*, 7(4), 26-34.

Bidin, N., Zakaria, M. H., Bujang, J. S., & Abdul Aziz, N. A. (2015). Suitability of aquatic plant fibers for handmade papermaking. *International Journal of Polymer Science*, *2015,* 1-10. http://dx.doi.org/10.1155/2015/165868

Khan M. Z. H., Sarkar M. A. R., Forhad I. A. I., Zahid M., Khan H., & Malinen R. O. (2017). The Effect of Hand Sheet Grammage on Strength Properties of Test Liner Papers. *Journal of Bartin Faculty of Forestry,* 19(1), 117-122.

Khiril N. H. (2013). Paper Making Process from Coconut Coir as an Alternative to Wood. *Masters thesis*, Universiti Teknologi MARA.

Li, H., Sun, H., & He, Z. (2015). Achnatherum inebrians straw as a potential raw material for pulp and paper production. *Journal of Cleaner Production*, *101*, 193-196. http://dx.doi.org/10.1016/j.jclepro.2015.03.061

Madakadze I. C., Masamvu T. M., Radiotis T., Li J., & Smith D. L. (2010). Evaluation of Pulp and Paper Making Characteristics of Elephant Grass (*Pennisetum Purpureum Schum*) and Switchgrass (*Panicum Virgatum L.*). *African Journal of Environmental Science and Technology*, 4(7), 465-470.

Mandy H., Susan K., Sergio B., Patrick A., Jim F., Rune L., Emmanuelle N., Neva M. & Bas T. (2018). The State of the Global Paper Industry, *Environmental Paper Network*. Retrieved from: http://epd.canopyplanet.org.
Marcela F. A., & Jorge L. C. (2014). Dissolving pulp production from sugar cane bagasse. *Industrial Crops and Products*, 52, 58-64.

Masrol, S. R., Ibrahim, M. H. I., Adnan, S., Sa'adon, A. M., Sukarno, K. I., & Yusoff, M. F. H. (2017). Soda-anthraquinone durian (Durio Zibethinus Murr.) rind linerboard and corrugated medium paper: A preliminary test. *IOP Conf. Series: Materials Science and Engineering*, 226(2017), 012174. doi:10.1088/1757-

899X/226/1/012174

Motamedian, H. R., Halilovic, A. E., & Kulachenko, A. (2019). Mechanisms of strength and stiffness improvement of paper after PFI refining with a focus on the effect of fines. *Cellulose*, *26*(6), 4099-4124. https://doi.org/10.1007/s10570-019-02349-5

Padmanabha S. (2016). A Study on the History of Paper and possible Paper Free World. *International Journal of Management, IT and Engineering*, 6(1), 337–355.

Rafidah D., Ainun Z. M. A., Rushdan I., Jalaludin H., & Nazila G. (2011). Effect of Beating Revolution on Kenaf Bleached Kraft Pulp Properties. *Universiti Putra Malaysia Press*, Serdang, Malaysia, 34-42.

Sarwar J., Bilkis R., Mir M. B., Laboni A., Pedram F., & Yonghao N. (2013). Pulping of Non-wood and its Related Biorefinery Potential in Bangladesh: *A Review, Current Organic Chemistry,* 17, 1570-1576.

Sezgin K. G., & Serhat Ş. (2017). The Effect of Hand Sheet Grammage on Strength Properties of Test Liner Papers. *Journal of Bartin Faculty of Forestry*, 19(1), 117-122.

Soloi, S., & Hou, E. K. Z. (2019). The Potential of oil palm leaf fibre in paper-making industry. *Journal of Physics: Conference Series*, 1358(1), 012005. doi:10.1088/1742-6596/1358/012005

Susi S., Teddy K., & Henggar H., (2015). Bamboo as Raw Materials for Dissolving Pulp with Environmental Friendly Technology for Rayon Fiber. *Procedia Chemistry*, 17, 194-199.

Taghi T., Somayeh S., Alireza A., Mahdi M. & Abolghasem K. (2017). Preparation and characterization of reinforced papers using nano bacterial cellulose. *International Journal of Biological Macromolecules*, 101, 334-340.

Taiwo, K. F., Fagbemi, O. D., Otitoju, O., Mgbachiuzor, E., & Igwe, C. C. (2014). Pulp and paper-making potential of corn husk. *International Journal of AgriScience*, *4*(4), 209-213.

Tripathi S. K., Bhardwaj N. K., Chechi S., & Varadhan R. (2019). Suitability of Banana Stem Pulp as Replacement of Softwood Pulp for Making Superior Grade Unbleached Paper from Agro Residue Pulp. *Appita Journal*, 72(3), 163-178.

Umair, M., Azis, N., Halis, R., & Jasni, J. (2018). Investigation on the Effect of Beating on the Physical and Mechanical Properties of Untreated Kenaf Based Insulation. *2018 IEEE 5th International Conference on Smart Instrumentation, Measurement and Application (ICSIMA)*, 1-6.

Yusri Y., Mohd Rizal A., & Md Saidin W. (2012). Producing Paper using Pineapple Leaf Fiber, *Advanced Materials Research*, 383-390, 3382-3386.

Zawawi D., Mohd Zainuri M. H., Angzzas Sari M. K., & Ashuvila M. A. (2013). Suitability of Malaysia's Pineapple Leaf and Napier Grass as a Fiber Substitution for Paper Making Industry. *EnCon 2013, 6th Engineering Conference, "Energy and Environment",* 1-4.