Chemical and Fibre Properties by Lemon Grass in Chemical Pulping for Pulp Industry

Zawawi Daud¹, Husnul Azan Tajarudin², Nair Gomesh³, Ragunathan Santiagoo⁴, Halizah Awang⁵, Mohd Zainuri Mohd Hatta⁶, Mohd Arif Rosli⁷, Amir Detho⁸

¹Solid Waste Management and Resource Recovery Team (SMART), Micropollutant Research Centre, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia
²School of Industrial Technology, Universiti Sains Malaysia, 11800 Pulau Pinang, Malaysia
³Centre for Research and Innovation (CRI), UOW Malaysia KDU Penang University College, 10400 Pulau Pinang, Malaysia
⁴School of Environmental Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia
⁵Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia

E-mail: amirdetho@quest.edu.pk

Abstract. Malaysia has a high rate of depleting forest activities than any other tropical countries in the world. This lead to an increasing of pollution and loss of forest trees include animal to our nature. Lemon grasses as a substitute material from non-wood material had been choose for pulp and papermaking industry. This study was going through the chemical composition analysis and fibre properties for lemon grass pulp. These conclude that lemon grass had a high percentage of cellulose; with a low lignin content; good fibre length by TAPPI method. Thus, lemon grass has a potential to be alternative material for becoming waste-wealth product especially for Malaysia’s pulp and papermaking industry.

1. Introduction
Lemon grass, known in scientific terms as cymbopogon citratus, rises as perennial grass, it growth up to 1m and the leaves size about 2 cm [1]. Like some other non-woods products, lemon includes cellulose, hemicellulose, and content of lignin [2]. This type of plant is a robust grass with perennial roots. The plants give small, creepings 15-25 cm long rhizomes at the node with fine root [3,4]. Lemon was cultivated extensively in tropic and subtropics areas. Lemon is mainly used wildlife and livestock forage as is the case with other non-woods [5]. Alkaline cooked liquor or chemically sodium hydroxide pulping (NaOH) may affect the yield of color and fibre pulp by the reported physical property of pulp, evaluating fiber yield, and pulp color changes where dark color reveals that lignin is still high on pulp [6]. Paper is focused primarily on wood fibres, on sustainable and
reusable material [7]. The basic features of fibre material are that the strength of the paper comes from the bonding of hydrogen between the fibre individually [4,8]. The pulp developed in various ways have different characteristics, making them suitable for specific product [9]. The characterization and easy growth development, lemon can be a new material design for paper and pulp making based industries also for the entire world. The environment for another pollution act can be gradually safe [10,20].

2. Methodology

2.1. Preparation of material
Lemon grass collected from Parit Raja, Batu pahat, Johor, Malaysia. The leaves were cut into 2 cm pieces [19]. Lemon grass undergoes for air dry about 3 or 4 days. The cut lemon grass in totally dried to prevent any microorganisms to be attached with the material.

2.2. Chemical composition analysis
In such samples, chemical compositions was evaluated according with respect TAPPI standard methods; T 211 om-07 (ash content), and T 222 om-88 (lignin content). In cellulose and holocellulose the process was specific the quality of cellulose would be evaluated using the Kursher-Hoffener process and chlorination method to assess the sample's holocellulose.

2.3. Chemical pulping process
Lemon grass undergoes the cooking process for sodium hydroxide (NaOH) processes in digester autoclave were being done in table 1. The material were weight and fill into digester autoclave [11].

| Solvent cooking  | Concentration solution (%) | Time (Minutes) | Temperature (°C) |
|------------------|-----------------------------|----------------|------------------|
| NaOH (control)   | 18                          | 120            | 170              |

The partially delignified pulps obtained were washed with water to neutralize the reaction. The form of paper from pulp followed TAPPI Method 205 om-8.

2.4. Fibre analysis
Lemon grass undergoes test for length and thickness by Nikkon Optical Fibre Analyzer and Scanning Electron Microscopy (SEM).

3. Result and Discussion

3.1. Chemical composition analysis
Ash content indicated the unknown matter like metal and others of composition inside the materials [12]. Lemon grass had a quite high of ash content compared to date palm rachis and canola straw. Table 2 shows the composition of unknown matters inside the lemon grass can affect the strength of fibre on fibre formation.
Table 2. Chemical composition for lemon grass.

| Matter (%)     | Lemon grass | Date palm rachis [11] | Canola straw [8] |
|----------------|-------------|-----------------------|------------------|
| Ash content    | 20.46       | 35.20                 | 12.30            |
| Cellulose      | 34.31       | 40.21                 | 24.33            |
| Hemicellulose  | 19.50       | 12.52                 | 18.11            |
| Lignin         | 7.70        | 27.38                 | 10.70            |

Cellulose content of lemon grass was in the high range (20.46%) compared canola straw (36.6%) and Date palm rachis (45%) [13]. High content of cellulose can give a string of the fibre and the quality of papermaking or pulp will be increased [14, 15]. Previous studies indicated that cellulose content is the main component for pulp and paper industry [16]. For hemicellulose content, this study shows a high content (19.5%) compared date palm rachis (12.52%) and canola straw (18.11%) [17]. High hemicelluloses obtained a lower extractives and easier lignin to remove from natural materials [18]. The lignin content of lemon grass (7.70%) is fairly lower than canola straw (18.11%) and date palm rachis (27.38%) [19]. 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 [15, 20]. This analysis just determined the chemical composition of Napier grass material. The composition of cellulose is so important to know whether lemon grass had a potential or not. The chemical analysis in this study was thoroughly an independent analysis, which not related to chemical pulping for the next analysis [1, 2].

3.2. Fibre analysis of lemon grass

This analysis has analyzed the length and diameter of the fiber of lemon grass leaves. These fiber dimensions are important for the relation with the strength of mechanical properties in papermaking [12]. It also important in measuring the quality of the pulp produced. Table 3 shows that lemon grass has fiber length 6.75 mm and the cymbopogon nardus (8.74 mm), and date palm rachis (1.10 mm).

Table 3. Fibre properties for lemon grass.

| Material                  | Fibre length (mm) | Fibre thickness (μm) |
|---------------------------|-------------------|----------------------|
| Lemon grass               | 6.75              | 1.20                 |
| Pineapple leaf [6]        | 13.36             | 6.75                 |
| Cymbopogon nardus[3]      | 7.40              | 0.74                 |

The length of the fiber was determined from the pulp by soda pulping. The fiber was separated from the derivatives by this soda pulping process because the derivatives has no used for mechanical strength [14]. Based on fibre thickness by lemon grass (1.20 μm), more lowly compared to pineapple leaf (6.75 μm) size fibre diameter by fibre analyzer. High thickness makes the fibre stronger and not easy to break [9]. Due of highly react with chemical cooking process condition with material chemical composition also take plus value from it. Figure 1 shows the lemon grass fibre surface and formation, which determined the fibre lemon grass. This analysis to prove the thickness and formation of the fibre by lemon grass from this both image [4].
Figure 1. SEM image of lemon grass fibre surface and formation.

From the figure, the efficiency of lemon grass fibre to produce better result and shown a good of pulp for paper testing [20]. However, this fibre can be designed to be better by present of additives by chemical or biological additives in future study.

4. Conclusion

Lemon grass (cymbopogon citrates) shows the high probability to be an alternative fiber because it produced higher cellulose content than lignin content. It contains 20.46% cellulose content and 7.7% lignin content. High cellulose content but lower lignin content will give high fiber strength to the physical properties. A long fiber which is 6.75 mm with the diameter of 10 µm and condense fiber arrangement. The long fiber will form a strong structure of fiber bonding because the hydrogen bonding on fiber will increase the paper strength that give high probability on tensile strength.

Acknowledgements

This research was supported by Ministry of Higher Education of Malaysia, scholarship from Universiti Tun Hussein Onn Malaysia (UTHM) and Fundamental Research Grant (FRGS) for Vot 1457 from ORICC, UTHM and Quaid-e-Awam University of Engineering, Science & Technology (QUEST) Nawabshah, Sindh, Pakistan.

References

[1] Gurganul N Page D H and Paice M H 2001 J Pulp Pap Sci 288-95
[2] Dungani R Karina M Subyakto S Sulaeman A Hermawan D and A Hadiyane 2016 Asian J Plant Sci 1542-55
[3] Narendra R and Yiqi Y 2005 Polym Eng Sci 92212-2217
[4] Hosseinpour R Fatehi P Latibari A J Ni Y H and Sepiddehdem S J 2010 Bioresource 1014193-4197
[5] Khiari R Mhenni M F Belgacem M N and Mauret E 2010 Bioresour Technol 101775-80
[6] Waranyou Songklanakarin S 2010 J Sci Tech 32201-205
[7] George S Bhagawan S and Thomas S 1996 J Therm Anal 71121-1140
[8] Ansah T Osafo E L K and Hansen H H 2010 Agric Biol 1923-929
[9] Daud Z Hatta M Z M Kassim A S M Aripin A M and Awang H 2014 Bioresources 9872-880
[10] Daud Z Hatta M Z M Kassim A S M Aripin A M and Awang H 2014 Adv Res Mat 974384-388
[11] Daud Z Hatta M Z M Kassim A S M Aripin A M and Awang H 2014 Adv Res Mat 911331-335
[12] Aganga A A Omphile U J and Baitshotlhi T T 2005 *Biol Sci* 5 493-496
[13] Khalil A H P S Alwani S M and Omar M A K 2006 *Bioresource* 1 220-232
[14] Bhaduri B K Day A Mondal S B and Sen S K 1995 *Ind Crop Prod* 4 79-84
[15] Shahani C 1995 Proceeding from the ASTM/ISR Workshop on the Effects of Aging on Printing and Writing Papers in Philadelphia 1-18
[16] Ververis C Georghiou K Christodoulakis N Santas P and Santas R 1995 *Ind Crop Prod* 19 245-254
[17] Tsoumis G 1991 *Wood Mater Sci Eng* 1 50-52
[18] Han S and Rowell J S 1999 *Paper and Composites from Agro-Based Resources* 5 83-134
[19] Daud Z Hatta M Z M Kassim A S M Aripin A M and Awang H 2014 *Mat Res Inov* 18 S6-18
[20] Habeeb S A Latiff A A Daud Z and Ahmed Z 2011 *Env Asia* 4 63-68