ABSTRACT

Abstract of thesis presented to the Faculty of Biotechnology and Biomolecular Sciences in fulfilment of the requirement for the Bachelor of Science Biotechnology with Honours.

Production Of Lignin-Containing Cellulose Nanofibrils from Oil Palm Empty Fruit Bunch Using a Pilot Scale Wet Disc Mill

By

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Lignin-containing cellulose nanofibrils (LCNF) is a form of nanocellulose which still has intact of lignin. Previous study shows that LCNF can be produced from oil palm empty fruit bunch (OPEFB) using a wet disc mill (WDM). To date, the production is conducted in lab scale. Due to its high potential applications especially in polymer biocomposites and coatings, there is a need to determine the suitable processing parameters for pilot-scale production of LCNF. In this research, pilot scale LCNF processing was conducted using a semi-automated WDM. OPEFB was pre-treated using potassium hydroxide (KOH) at 6% (w/v) for 48 hours for the removal of hemicellulose while maintaining the lignin content. Then, the pre-treated fibres underwent two-steps pre-grinding process using a mechanical refiner and a colloid mill for fibre size reduction prior to nanofibrillation in WDM. The fibre content and number of passes were fixed at 4 wt% and 20 cycles, respectively, while the effect of WDM rotational speed was tested at 1500, 1800 and 2100 rpm. Data shows that LCNF processed at these conditions had productivity of 1.95 – 2.70 kg/h, with energy consumption of about 1.04 – 1.55 kWh/kg. Rotational speed of 1800 rpm contributed to the highest productivity and lowest energy consumption. All of the LCNF produced had an average diameter of less than 100 nm. Overall, this work has proven that the LCNF produced by a pilot-scale wet disc mill has improved the LCNF productivity while maintaining low energy consumption as compared to the lab-scale processing.

KEYWORDS: Lignin-containing cellulose nanofibrils, oil palm empty fruit bunch, wet disc mill, pilot scale, productivity, energy consumption

ABSTRAK

Abstrak tesis yang dikemukakan kepada Fakulti Bioteknologi dan Sains Biomolekul sebagai memenuhi keperluan untuk Bacelor Sains dalam Bioteknologi Dengan Kepujian

Penghasilan Nanofibril Selulosa Mengandungi Lignin daripada Tandan Buah Kosong Kelapa Sawit Menggunakan Penggilingan Cakera Basah pada Skala Perintis

Oleh

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Nanofibril Selulosa Mengandungi Lignin (LCNF) adalah sebahagian daripada nanofibril selulosa (CNF) yang masih mempunyai kandungan lignin. LCNF mempunyai potensi besar dalam pelbagai aplikasi seperti polimer komposit. Kajian lepas menunjukkan bahawa LCNF boleh dihasilkan daripada tandan buah kosong kelapa sawit (OPEFB) melalui proses mekanikal menggunakan penggilingan cakera basah (WDM). Walau bagaimanapun sehingga kini, penghasilan LCNF adalah masih lagi pada skala makmal. Oleh kerana LCNF berpotensi tinggi untuk diaplikasi dalam bidang polimer komposit dan penglitup, terdapat keperluan untuk menentukan parameter proses yang sesuai bagi penghasilan LCNF pada skala perintis. Dalam penyelidikan ini, penghasilan LCNF pada skala perintis telah dilakukan dengan menggunakan WDM yang beroperasi secara semi-otomatik. OPEFB perlu diprosetelah dipra-rawat menggunakan kalium hidroksida (KOH) pada kepekatan 6% (w/v) selama 48 jam bagi menyingkirkan hemiselulosa dan pada masa yang sama, mengekalkan kandungan lignin. Setelah itu, sampel pra-rawatan tersebut perlu menjalani dua peringkat pra-pengisaran iaitu dengan menggunakan penapis mekanikal dan mesin koloid untuk mengurangkat saiz serat sebelum proses nanofibrilasi di dalam WDM. Kandungan serat dan bilangan kitaran ditetapkan pada 4% dan 20 kitaran, manakala kesan kelajuan putaran WDM diuji pada 1500,

1800 dan 2100 rpm. Data menunjukkan bahawa LCNF yang diproses pada keadaan tersebut mempunyai produktiviti di antara 1.95 – 2.70 kg/h, dengan nilai penggunaan tenaga yang rendah iaitu pada 1.04 – 1.55 kWh/kg. Kelajuan putaran pada 2100 rpm menunjukkan produktiviti LCNF paling tinggi, manakala penggunaan tenaga paling rendah dicatatkan oleh kitaran putaran 1500 rpm. Kesemua LCNF yang dihasilkan mempunyai saiz purata diameter kurang daripada 100 nm disamping mengekalkan ciri-ciri lain. Secara keseluhurannya, penyelidikan ini membuktikan bahawa LCNF yang dihasilkan oleh penggilingan cakera basah di skala perintis telah meningkatkan produktiviti LCNF di waktu yang sama mengurangkan penggunaan tenaga jika dibandingkan dengan pemprosesan skala makmal.

Katakunci: Nanofibril Selulosa mengandungii Lignin, tandan buah kosong kelapa sawit, penggilingan cakera basah, produktiviti, penggunaan tenaga

PRODUCTION OF LIGNIN-CONTAINING CELLULOSE NANOFIBRILS FROM OIL PALM EMPTY FRUIT BUNCH USING A PILOT SCALE WET DISC MILL

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INTRODUCTION

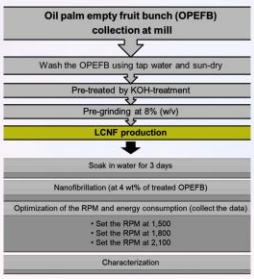
RECENT EFFORTS HAVE FOCUSED ON UTILIZING OPEFB IN A MORE SUSTAINABLE WAY, CONVERTING THEM INTO VALUE-ADDED PRODUCTS. **NANOCELLULOSE CAN BE EXTRACTED FROM THE CELLULOSE STREAM OF OIL PALM BIOMASS**. HOWEVER, THE PROCESS OF CREATING NANOCELLULOSE REQUIRES THE REMOVAL OF LIGNIN, WHICH CAN BE AN ENVIRONMENTALLY-HARMFUL PROCESS. RECENT RESEARCH SUGGESTS THAT INCORPORATING A SMALL AMOUNT OF **LIGNIN CAN IMPROVE THE PROPERTIES OF NANOCELLULOSE.**

OPEFB LCNF

OBJECTIVE

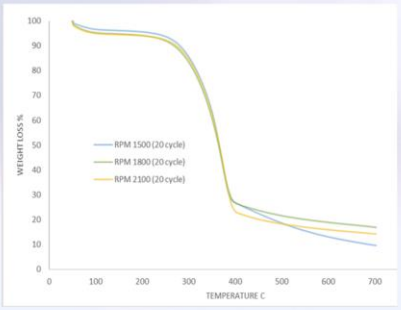
The research aimed to produce LCNF in pilot scale wet disc mill by using lab-optimized processing parameters and introducing a pre-grinding process, productivity and energy consumption in the production of LCNF with WDM.

METHODOLOGY



RESULTS

The results of the research is demonstrate on figure 1,2 and 3 as well as on table 1 &2.



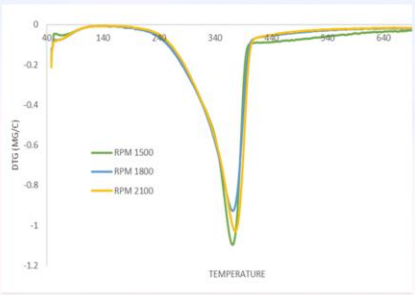


FIGURE 1: TG and DTG chromatograms of LCNF at different process

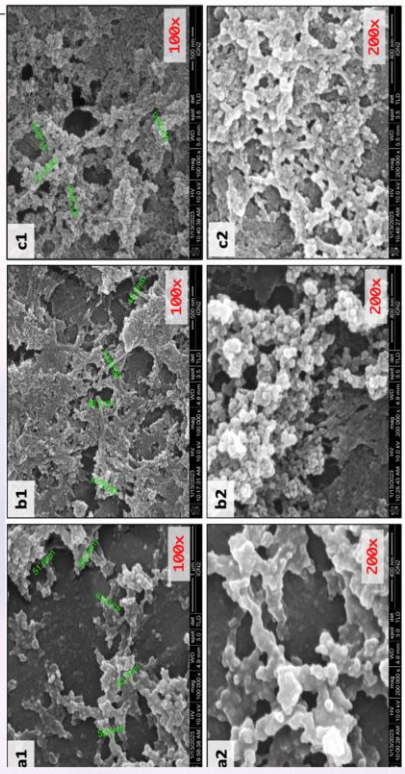


FIGURE 2: FE-SEM IMAGES OF LCNF GENERATE AT 100000X AND 200000X OF HIGH MAGNIFICATION VIEW; (A1 & A2) LCNF-1500; (B1 & B2) LCNF-1800; (C1 & C2) LCNF-2100

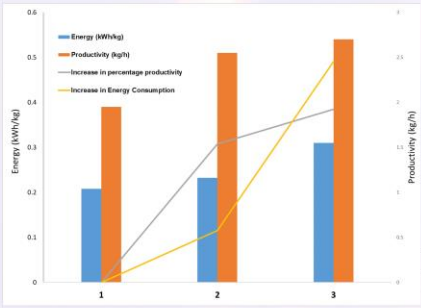


FIGURE 3: A GRAPHICAL COMPARISON OF THE ENERGY, PRODUCTIVITY, PERCENTAGE PRODUCTIVITY INCREASE AND PERCENTAGE ENERGY CONSUMPTION INCREASE

TABLE 1: THE CHEMICAL COMPOSITION (%) OF UNTREATED AND KOH-TREATED OPEFB

Sample	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Extractive (%)
Untreated OPEFB	47.14 ± 0.6	28.71 ± 1.4	20.14 ± 0.4	4.01 ± 0.2
1 Day KOH-treated	48.33 ± 1.0	19.54 ± 4.0	30.42 ± 4.0	1.71 ±1.0
2 Day KOH-treated	48.38 ± 2.0	14.65 ± 3.5	35.29 ± 3.5	1.68 ± 0.6

TABLE 2: THE YIELD AND ENERGY CONSUMPTION OF LCNF PRODUCTION

LCNF at different speed (rpm)	Pilot scale WDM (This work)		Lab scale WDM (Jusoh et. al., n.d.)	
	Energy (kWh/kg)	Productivity (kg/h)	Energy (kWh/kg)	Productivity (kg/h)
LCNF – 1500	1.04	1.95	–	–
LCNF – 1800	1.16	2.55	–	–
LCNF – 2100	1.55	2.70	27.38	0.054

DISCUSSION

KOH treatment was used to partially remove hemicellulose, and the duration of treatment affected the amount of residual hemicellulose in the OPEFB. Pre-grinding of KOH-treated OPEFB fiber contributed to the size reduction of OPEFB prior to nanofibrillation. The research demonstrated lower energy consumption and higher productivity of LCNF processed in pilot scale WDM, as compared to previous work at lab scale. At RPM1800 shows the optimum process parameter in WDM pilot scale .

CONCLUSION

In conclusion, a process of pre-treatment, pre-grinding, and wet disc milling are required to produce LCNF. In order to produce fibers with the necessary qualities and attributes, each step is crucial.

REFERENCES

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