PRODUCTION OF RENEWABLE GLUCOSE FROM OIL PALM FROND BAGASSE BY USING SACCHARISEB C6 THROUGH ENZYMATIC HYDROLYSIS

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science in Chemical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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LIST OF SYMBOLS

A_1	Weight of crucibles
A_2	Initial weight of OPF bagasse
A_3	Final weight of crucibles and ash
E_1	Weight of fiberglass filter
E_2	Weight of wet biomass added to extraction cell
E_3	Weight of oven-dry extracted biomass and filter
E_4	Volume of water extract
$E_{5, Glu}$	Glucose content in HPLC standard
E_6	Concentration of monomer sugar after acid hydrolysis
E_7	Concentration of monomer sugar before acid hydrolysis
E_8	Water extract samples solutions using HPLC
EE	Ethanol extractives
ET	Total extractives
H_2	Mass of monomer sugar after acid hydrolysis
H_5	Concentration of monomer sugars after acid hydrolysis
I_{am}	Peak intensity of the amorphous phase
I_{002}	Peak intensity of the 002 crystal plane
L_1	Weight of filter paper prior to filtration
L_2	Final weight of the residue and filter paper
M	Mass
MC_{TWB}	Moisture content
MW_{EXT}	Moisture content of oven-dry extracted biomass and filter
SC	Structural carbohydrate
SS_{Glu}	Glucose soluble sugar
V	Volume
W	Weight

LIST OF ABBREVIATIONS

AFEX	Ammonia fiber explosion
ANOVA	Analysis of variance
CCD	Central composite design
DOE	Design of experiments
DP	Degree of polymerization
EFB	Empty fruit bunch
FTIR	Fourier transform infrared
HMF	5-hydroxymethyl-furfural
HPLC	High performance liquid chromatography
LCB	Lignocellulosic biomass
LHW	Liquid hot water
MPOB	Malaysian palm oil board
NREL	National renewable energy laboratory
OFAT	One-factor-at-a-time
OPF	Oil palm frond
OPT	Oil palm tree
PPS	Palm pressed fiber
RSM	Response surface methodology
SEM	Scanning electron microscopy
XRD	X-ray diffraction

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ABSTRAK

Biojisim lignoselulosa (LCB) adalah biojisim yang paling banyak diperbaharui daripada sumber-sumber yang berpotensi tinggi untuk pengeluaran pelbagai jenis produk yang berfaedah. Terkini, kelapa sawit telah dikenal pasti sebagai sumber LCB yang paling berpotensi dan boleh digunakan untuk penghasilan gula. Biasanya, sisa buangan daripada tanaman kelapa sawit digunakan sebagai makanan haiwan tetapi ia bukanlah kaedah yang terbaik dari segi ekonomi dalam memanipulasi penggunaan sisa buangan. Selain itu, kewujudan sisa buangan menimbulkan masalah dari segi pelupusan dan sering dilupuskan melalui pembakaran secara terbuka dan mengakibatkan kepada pencemaran alam sekitar. Oleh itu, hampas pelepah kelapa sawit (OPF) diperkenalkan sebagai bahan mentah dalam kajian ini untuk memaksimumkan penggunaan sisa kelapa sawit. Objektif kajian ini adalah untuk mengenalpasti komponen yang terdapat di dalam hampas OPF sebelum dan selepas pra-rawatan alkali dan untuk menyaring dan mengoptimumkan faktor-faktor yang memberi kesan terhadap penguraian enzim menggunakan Sacchariseb C6 bagi penghasilan gula. Hampas OPF ditelah melalui pra-rawatan alkali dan natrium hidroksida digunakan sebagai pelarut sebelum meneruskan proses rawatan penguraian enzim dengan menggunakan Sacchariseb C6. Semasa proses pra-rawatan, struktur biojisim selulosa akan diubah dan delignifikasi telah berlaku yang membuatkan struktur selulosa lebih terbuka untuk proses seterusnya iaitu rawatan penguraian enzim dengan menukarkan selulosa kepada gula. Kaedah gerak balas permukaan (RSM) telah digunakan untuk menyaring dan mengoptimumkan keadaan penguraian enzim. Pencirian hampas OPF mentah yang dihasilkan adalah sebanyak 40.7% glukosa, 26.1% xylan, 4.5% ekstraktif, 26.2% lignin dan 1.8% abu. Sementara itu, bagi hampas OPF yang telah melalui pra-rawatan mengandungi 61.4% glukosa, 20.4% xylan, 0.3% ekstraktif, 13.3% lignin dan 1.3% abu. Daripada kajian analisis faktorial, penguraian enzim yang terbaik telah menghasilkan 33.01 ± 0.73 g / L glukosa pada kelajuan kisaran 200 rpm, 60 FPU/g pengisian enzim, 4% (w/v) pengisian glucan, suhu pada 55 ℃ dan 72 jam masa tindak balas. Dalam reka bentuk komposit pusat (CCD), keadaan optimum bagi rawatan penguraian enzim diperolehi pada 50 ℃ untuk 87.93 jam masa penguraian yang menghasilkan 41.11 ± 0.11 g/L glukosa. Secara keseluruhannya, rawatan penguraian enzim Sacchariseb C6 keatas hampas OPF berpotensi menghasilkan glukosa di mana glukosa ini boleh digunakan dalam pelbagai industri bagi menghasilkan produk yang bernilai.

ABSTRACT

Lignocellulosic biomass (LCB) is the most abundant renewable biomass that gives high potential source in production of various beneficial products. Recently, oil palm crops are known as the most potential LCB which can be employed for sugar production. Normally, wastes from oil palm crops are used as animal feed but this is not the ideal economically valuable method of manipulating the wastes. Besides, the existence of wastes created disposal problems and often been disposed off by open burning that may lead to the environmental pollution. Therefore, oil palm frond (OPF) bagasse was introduced as a raw material in this study to maximize the utilization of oil palm waste. This study aims to characterize the composition of OPF bagasse before and after alkaline pretreatment and to screen and optimize the factors affecting enzymatic hydrolysis by using Sacchariseb C6 for glucose production. OPF bagasse was treated using alkaline pretreatment and sodium hydroxide used as a solvent before proceeding with enzymatic hydrolysis using Sacchariseb C6. During pretreatment process, cellulosic biomass structure will be altered and delignification occurred which make cellulose more accessible to the subsequent enzymatic hydrolysis process by converting it into simple sugars. Response Surface Methodology (RSM) was employed to screen and optimize the enzymatic hydrolysis condition. Characterization of raw OPF bagasse produced 40.7 % glucan, 26.1 % xylan, 4.5 % extractives, 26.2 % lignin and 1.8 % ash. Meanwhile, pre-treated OPF bagasse composed of 61.4 % glucan, 20.4 % xylan, 0.3 % extractives, 13.3 % lignin and 1.3 % ash. In factorial analysis study, the best enzymatic hydrolysis condition yielded 33.01 ± 0.73 g/L of glucose when performed at 200 rpm of agitation speed, 60 FPU/g of enzyme loading, 4% (w/v) of glucan loading, temperature at 55 °C and 72 hours of reaction time. In central composite design (CCD), the optimum condition for enzymatic hydrolysis was obtained at 50 °C for 87.93 hours of hydrolysis time which produced 41.11 ± 0.11 g/L of glucose. Overall, enzymatic hydrolysis of OPF bagasse by using Sacchariseb C6 has high potential for production of glucose which later can be utilized for various industrial application to produce valuable value-added products.

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