UNIVERSITI PUTRA MALAYSIA

BIOCONVERSION OF SAGO EFFLUENT TO ORGANIC ACIDS BY BATCH AND CONTINUOUS ANAEROBIC TREATMENT WITH POME SLUDGE AS INOCULUM

ONG MING HOOI

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By

ONG MING HOOI

Thesis Submitted in Fulfilment of the Requirement for the Degree of Master of Science in the Faculty of Food Science and Biotechnology Universiti Putra Malaysia

May 2001

Specially dedicated to,

My beloved parents who provided the opportunities

and my brother and friends,

for their invaluable love, patience and understanding…..

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Associate Professor Dr. Mohd. Ali Hassan

Faculty : Food Science and Biotechnology

This study reports on the utilisation of the residual organics in sago starch processing effluent for the production of organic acids. Treatments were conducted under anaerobic conditions with mild mixing in batch and continuous operations. The production of organic acids was conducted at different concentrations of sludge (0%, 10%, 20% and 30%), pH (no pH adjustment, controlled constantly at pH 7, manual adjustment to pH 7 every 12 hours, initial pH 5.5 and pH 7) and retention time (5 days and 7.5 days). The conversion of residual starch to organic acids was very poor at only 1-2 g/L when the raw sago effluent was treated with its natural microflora and pH in batch system. However, when 20%-30% (w/w) of sludge was added, about 12-13 g/L of organic acids were produced within 2 days of treatment, with lactic acid (9.5 g/L) and acetic acid (2.5 g/L) as the dominant acids, i.e. about 70% yield based on the initial COD of 18, 000 mg/L. The results showed that treatment with intermittent pH adjustment at pH 7 every 12 hours with 20% of sludge addition

appeared to give the highest organic acids concentration (13.4 g/L), with lactic, acetic and propionic acids at about 9.5 g/L, 2.5 g/L and 1.5 g/L respectively.

The acid composition was dependent on the pH. Acetic acid was mainly produced at neutral pH range with more than 60% selectivity and lactic acid at lower pH range. At pH 5.5, lactic acid remained in the medium much longer and a higher selectivity of more than 80% could be achieved.

During the continuous anaerobic treatment with 5 days retention time, about 7-8g/L of organic acids was attained under the steady state condition. By increasing the retention time to 7.5 days, total organic acids ranged from 6-6.5g/L was obtained during the steady state with total microbial population stabilized at 10^7cfu/mL in the reactor. The continuous treatment system succeeded to remove the suspended solids of the effluent which mainly comprised of residual starch from 18 000 mg/L to 2000 mg/L during the steady state. This represented more than 80% of suspended solids removal. The suspended solids which contributed to the COD of the effluent was converted to organic acids with 45% yield at steady state. After the recovery process by ion-exchange chromatography and evaporation, 7.5 and 8.2 times of organic acids concentration could be achieved with the final concentration attained at 52.3 g/L and 61.3 g/L respectively. The recovery system was capable of removing more than 80% COD from the sago effluent.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

BIOPENUKARAN SISA PEMPROSESAN SAGO UNTUK PENGHASILAN ASID ORGANIK MELALUI SISTEM ANAEROBIK SESEKELOMPOK DAN SELANJAR DENGAN MENGGUNAKAN ENAPCEMAR POME SEBAGAI INOKULUM

Oleh

ONG MING HOOI

Mei 2001

Pengerusi : Profesor Madya Dr. Mohd. Ali Hassan

Fakulti : Sains Makanan dan Bioteknologi

Kajian ini melaporkan penggunaan bahan organik dalam sisa pemprosesan sago sabagai substrat untuk penghasilan asid-asid organik. Penghasilan asid organik telah dijalankan secara rawatan anaerobik sesekelompok dan selanjar. Faktor-faktor yang dikaji dalam kajian ini termasuk penggunaan kepekatan enapcemar yang berlainan (0%, 10%, 20% dan 30%), pH (pH tidak dikawal, pH dikawal pada 7 sepanjang masa, pH dikawal pada 7 setiap 12 jam, pH dimula pada 7 dan 5.5 masing-masing dan tiada kawalan pH dikenakan seterusnya) dan masa mastautin yang berbeza (5 hari dan 7.5 hari). Apabila sisa pemprosesan sago dirawat dalam keadaan pH dan populasi mikroorganisma semulajadinya, penghasilan asid organik adalah sangat rendah dengan kepekatan mencapai 1-2g/L sahaja. Walaubagaimanapun, apabila 20-30% enapcemar ditambahkan dalam sistem rawatan sesekelompok, sebanyak 12-13g/L asid organik dapat dihasilkan dalam masa 2 hari dengan asid laktik (9.5g/L) dan asid

asetik (2.5g/L) sabagai asid penting. Ini memberi 70% penghasilan berasaskan COD awal 18,000mg/L. Keputusan kajian menunjukkan rawatan pada pH 7 dengan kawalan pH setiap 12 jam, penambahan 20% enapcemar memberi penghasilan asid organik yang terbaik (13.4g/L), dengan kepekatan asid laktik, asetik dan propionik mancapai 9.5g/L, 2.5g/L dan 1.5g/L masing-masing.

Komposisi asid yang terhasil adalah bergantung kepada pH. Asid asetik lebih cenderung dihasilkan pada pH neutral dengan peratus pemilihan lebih daripada 60% manakala asid laktik dihasilkan dalam keadaan pH yang lebih rendah. Pada pH 5.5, asid laktik didapati berada dalam medium pada jangka masa yang lebih panjang dengan peratus pemilihan lebih daripada 80%.

Semasa rawatan anaerobik selanjar pada masa mastautin 5 hari, sebanyak 7-8g/L asid organik telah dihasilkan pada keadaan mantap. Dengan menambahkan masa mastautin ke 7.5 hari, jumlah asid organik 6-6.5g/L telah dikuantitikan dengan populasi mikroorganisma mencapai kestabilan pada 10^7 koloni terbentuk/mL di dalam reaktor. Sistem selanjar didapati berjaya menyingkirkan bahan pepejal dari nilai awal 18 000mg/L ke nilai akhir 2000mg/L dalam keadaan mantap. Ini menunjukkan lebih daripada 80% penyingkiran bahan pepejal telah tercapai pada akhir eksperimen. Bahan pepejal yang terdapat di dalam sisa pemprosesan sago telah ditukarkan kepada asid organik dengan peratus penghasilan 45% dalam keadaan mantap.

Selepas proses pengasingan dengan menggunakan resin penukarganti anion dan pemeluapan, asid organik didapati boleh dipekatkan sebanyak 7.5 dan 8.2 kali dengan

kepekatan akhir tercapai pada 52.3g/L dan 61.3g/L masing-masing. Proses pengasingan asid organik telah berjaya menyingkirkan lebih daripada 80% COD daripada sisa cecair sago.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figures **Page**

LIST OF ABBREVIATIONS

APB	-	Acid producing bacteria
ASPS	-	Apparent starch plus sugar
ATP	-	Adenosine triphosphate
BCP	-	Bromocresol purple
BCP agar	-	Bromocresol purple agar
BOD	-	Biological oxygen demand
$CaCO_3$	-	Calcium carbonate
CO_2	-	Carbon dioxide
COD	-	Chemical oxygen demand
D	-	Dilution
DOE	-	Division of Environment
EMP	-	Embden-Meyerhof pathway
F	-	Flow rate
H_2	-	Hydrogen
H_2O	-	Water
H_2O_2	-	Hydrogen peroxide
HCl	-	Hydrochloric acid
HPLC	-	High pressure liquid chromatography
HRT	-	Hydraulic retention time
MPB	-	Methane producing bacteria
NaCl	-	Sodium chloride
NaOH	-	Sodium hydroxide

PHA	-	Polyhydroxyalkanoates
POME	-	Palm oil mill effluent
RT	-	Retention time
SS	-	Suspended solids
SRT	-	Solid retention time
TS	-	Total solids
TSS	-	Total suspeneded solids
UASB	-	Upflow anaerobic sludge blanket
V	-	Volume