THE EFFECT OF BIOLOGICAL, CHEMICAL, AND PHYSICAL PRE-TREATMENT ON SOLID PINEAPPLE WASTE FOR FERMENTABLE SUGAR PRODUCTION

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[I dedicate this thesis, first and foremost to my beloved Dad, who has been giving his blessing from above. To my mother and husband for their never ending support in the course of my study]

ABSTRACT

Solid pineapple waste is a good source for lactic acid production, as it is rich in sugar. Lactic acid major applications are in food, textile, leather and chemical industries. The pre-treatment of solid pineapple waste is really significant in order to improve lactic acid production. The type of pre-treatment is preferred based on the end product. Three types of pre-treatment methods were investigated to determine the highest sugar produced for lactic acid fermentation; physical, chemical and biological method. In the physical pre-treatment, a microwave was used. The pre-treatment was conducted under 150 rpm for 1 hour. Prior to the pre-treatment, the waste was treated with both acid and alkali solutions. Sampling was performed every 10 minutes. Next, the chemical pre-treatment was conducted by using H_2SO_4. The concentration used in the range of 1% (v/v) and 3% (v/v). The temperature was varied in the range of 100-120°C temperature. As for biological method, white-rot fungus *Phanerochaete chrysosporium* was used to remove the lignin. The fungi was inoculated into the hydrolysate and allowed to fermentate (pre-treatment) for 10 days under 30°C. All samples collected from the pre-treatment methods were analysed using HPLC (for sugar content) and ADF and NDF (for lignin, cellulose and hemicellulose content). The pre-treated waste was classified based on their sugar content and also percentage of lignin removal. The pre-treated waste was classified based on their sugar content and also percentage of lignin removal. The best pre-treatment method was then concluded based on the, sugar content, percentage of lignin, cellulose and hemicellulose before and after pretreatment for the production of Lactic acid.

ABSTRAK

Sisa nenas pepejal adalah sumber yang bagus dalam penghasilan asid laktik, kerana kandungan gula yang tinggi. Aplikasi terbesar bagi asid laktik adalah di dalam industri makanan, tekstil, kulit, dan industri kimia. Pra-rawatan sisa nanas pepejal adalah amat penting dalam usaha untuk meningkatkan pengeluaran asid laktik. Jenis-jenis pra-rawatan adalah berdasarkan pada produk akhir yang dikehendaki. . Tiga jenis kaedah pra-rawatan dikaji untuk menentukan kandungan gula yang terhasil bagi fermentasi asid laktik; kaedah fizikal, kimia dan biologi. Dalam prarawatan fizikal, gelombang mikro yang telah digunakan. Pra-rawatan telah dijalankan di bawah 150 rpm selama 1 jam. Sebelum pra-rawatan, sisa dirawat dengan acid dan alkali. Penyampelan telah dibuat setiap 10 minit. Seterusnya, kaedah pra-rawatan kimia telah dijalankan dengan menggunakan H_2SO_4. Kepekatan yang digunakan adalah 1% (v/v) dan 3% (v/v). Suhu dikawal dalam julat suhu 100-120°C. Dalam kaedah biologi, kulat rod-putih *Phanerochaete chrysosporium* telah digunakan untuk membuang lignin pada sisa nenas. Kulat tersebut di*inoculate* ke dalam sisa dan dibiarkan untuk difermentasi (pra-rawatan) selama 10 hari di bawah 30℃ suhu. Sampel daripada ketiga-tiga kaedah pra-rawatan yang dijalankan kemudianya diambil untuk dianalisis dengan menggunakan HPLC (untuk kandungan gula) dan kaedah ADF and NDF (untuk lignin, selulosa dan kandungan hemiselulosa). Sisa yang telah dipra-dirawat diklasifikasikan berdasarkan kandungan gula dan juga peratusan penyingkiran lignin. Kaedah pra-rawatan terbaik ditentukan berdasarkan kandungan gula tertinggi, kandungan peratusan lignin, selulosa dan hemiselulosa sebelum dan selepas pra-rawatan.

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia has a vast production in the field of plantation. The plantation industry contributes a major amount of the economic growth for this country. One of the provider's is from the pineapple canned industry. Back in 60's and late 70's, Malaysia was once ranked as one of the top three producers in the world (Chan, 2000). The producers of canned pineapple besides Malaysia are Thailand, Philippines, Indonesia and Kenya. In 1997, the canned pineapple production from Malaysia was 3.3% of total world production (MPIM, 1998).

Johor is the largest cultivation state in Malaysia due to its suitable state of peat soil. Due to its sustainable production of pineapple, the canned industries in Johor become important as source of economy, especially from the export ground. The latest and quality development of this industry starts from the growth of this fruit. The high quality of canning pineapple depends on the good and latest technique of growing and harvesting of the pineapples. The right and most suitable technique are applied throughout the plant breeding process up to the fertilising

process. During harvesting season, the best ripe condition is selected to be canned (Hanapi, 2007).

The increase production of canned pineapple promotes the increase of pineapple waste. Besides Malaysia, Indonesia and Thailand contributes a hefty quantity of the pineapple wastes. According to the records more than 1,651,672 tonnes are made by the world's pineapple canning industry (Sasaki *et al.*, 1991).

The waste produced from the pineapple canned industry can be divided into two main states, which are the liquid and the solid waste. The solid pineapple waste mainly consists of four major components which are the core, crown and skin. The pineapple wastes produced are prone to microbial infection (Sonja *et al.* 2009). This is due to the content of high amount of chemical oxygen demand (COD) and biological oxygen demand (BOD) of the solid pineapple waste. This constitutes from 40% to 80% of the pineapple fruit (Ban-Koffi and Han, 1990).

The untreated pineapple waste causes hazards and pollution to the environment if disposed. The pineapple waste has a great possibility to be utilized and converted into a useful by products. Some of the pineapple wastes are used as animal feed stock but in a very small scale. Many researchers have been carrying out studies to explore the potentials of these wastes for decades. Results from this research have led to the findings of pineapple waste as a good substrate for the production of organic acids and ethanol. This is possible due to its high content of sugar (Dacera *et al.*, 2009).

Many years back researches have proved that the solid pineapple waste has a valuable amount of sugar such as fructose, sucrose and glucose. These sugars are paragon for the production of organic acid, such as the lactic acid. The conversion of lactic acid from solid pineapple waste is still new in the field of research. The

production of lactic acid from other biomass apart from pineapple waste is more common (Hanapi, 2007).

Lactic acid is the major hydrocarboxylic acid which has important application in various fields such as in pharmaceutical, chemical, leather, food, and textile industries (Vickroy, 1985). The most recent is as the biodegradable polymers (Jin *et al.*, 2005). In America the biodegradable property of the acid which is the polylactate polymers provides the production of biodegradable plastics (Datta *et al.*, 1995). The world gross production and usage of lactic acid per year reaches about 40 000 tons and 50% of this amount is used for food processing.

The lactic acid is produced from various processes; the common and most versatile source is through fermentation. In the fermentation of lactic acid, sugars such as maltose, sucrose or glucose is essential. The fermentation of lactic acid is carried out by bacteria and fungus (Atkinson and Mavituna, 1991).

1.2 Objectives

1. To study the effect of three types of pre-treatments in the recovery of fermentable sugar.
2. To study the degradation of cellulose and hemicellulose.

1.3 Scope of Research

The demand of the production of lactic acid increase yearly, thus virtuous production of this organic acid is essential. The production of lactic acid worldwide depends on microbial fermentation. This method contributes around 90% of the world lactic acid production. A proper pre-treatment method is important in order to obtain a better yield production of lactic acid.

The pineapple canned industry produces tons of pineapple wastes. The pineapple waste, being a lignocellulose biomass is rich in cellulose and sugar. This property is beneficial for the production of lactic acid. The solid biomass need to be pre-treated in order to provide a better platform for the fermentation of lactic acid, thus the right pre-treatment method is crucial.

There are varieties of pre-treatment of lignocellulose biomass. The pre-treatment method which is carried out in this research is carried out to determine the best pre-treatment method at their best conditions.

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