CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Oil palm is a main economic crop in tropical and subtropical regions which is largely utilized for the production of vegetable oil. Malaysia is one of the leading countries in the production of the palm oil in the world. It has been reported that in 2015, a quantity of 19,961,581 tonnes of the crude palm oil was produced in Malaysia (MPOB, 2016).Being one of the largest palm oil producers in the world, Malaysia generated approximately 80 million tonnes of dry solid biomass from the oil palm industry in 2010. This figure is expected to reach up to 110 million tonnes in the year 2020. Although there is a large production of palm oil, the oil subsists of only around 10% of the overall biomass produced in the plantation. The rest consists of large amount of oil palm waste. One of the largest wastes from the oil palm plantation is the oil palm frond (OPF) petiole. Theoretically, sugary juice extracted from the OPF petiole can be recycled as renewable fermentation feedstock for valued added-products (Zahari *et al.*, 2012). OPF juice contains high amount of sugars and other minerals, making it a potential fermentation feedstock for various value-added products such as polyhydroxyalkanoates (PHA), bioethanol, biobutanol, lactic acid, and succinic acid. This shows that, oil palm biomass is useful material to be converted into valuable product such as biobutanol. While the Malaysian Government's Economic Transformation Programme (ETP) conclude that lignocellulosic biofuel such as bioethanol and biobutanol is a major economic pillar that can spearhead economic growth by 2020 (Ng *et al.*,2011).

Biobutanol could be produced from OPF juice via the acetone butanol ethanol (ABE) fermentation. This process is called biobutanol or the ABE production. Butyric and acetic acids are first produced by *C. acetobutylicum* (acidogenesis), and in the subsequent phase (solventogenesis) butanol, acetone and ethanol are formed. The biobutanol production consists of several stages prior to the ABE fermentation. In the first place, the biomass which is consisting of starch rich, sugar rich or lignocellulosics materials is pretreated in the upstream processing and used as a substrate. After that, the fermentation the desired product is recovered and purified in the downstream processing.

Nowadays the butanol becomes one of the most important industrial chemical and has been receiving great attention as a better biofuel than ethanol because it delivers many benefits that are highly valued by customers. It has more attractive and interesting features than bioethanol due to its advantages such as it contains a less volatile content, high energy density, and is less corrosive (Dűrre, 2008). Butanol is applied in various industries and it is a demanding biofuel. The butanol produced from petroleum based-materials is an expensive process which increases the petrol price and cause negative effect on the environment.It was found that, anaerobic bacteria particullary *Clostridium acetobutylicum* are capable of converting carbohydrates into a variety of solvents such as acetone, butanol and ethanol by acetone-butanol-ethanol (ABE) fermentation.

The aim of this research is to study several parameters which could affect the biobutanol production from OPF juice by using *Clostridium acetobutylicum*. Study on the effects of operating parameters such as temperature, initial medium pH, yeast extract concentration, inoculum size and rotation rate on fermentation process can be conducted by alter one factor at a time, or by modify several factors at the same time by using the factorial analysis method (Ranjan *et al.,* 2012). In this study, a wider range of parameters values will be used based on previously related studies to find the active factors that could affect the production of biobutanol from OPF juice by using a two level half factorial design (2^{5-1}) and will be analysed by the Design Expert Software Version 7.1.

1.2 Motivation

Butanol and butyl acetate showed good properties as solvents for this purpose and in 1920 butanol became the main product of the fermentation process. The ABE process was successful prior to the actual development of large scale, aseptic, submerged industrial fermentation technology (García *et al.,* 2011). Theoretically, about 60% to 70% of the total production cost in ABE fermentation is the cost of raw materials (Ennis *et al.,* 1986). This study will lead to optimization of biobutanol production from OPF juice.

The use of OPF juice, which is relatively an inexpensive carbon source, would reduce the cost of raw materials for this production. Furthermore, biobutanol is a type of bioalcohol which is derived exclusively from the ABE fermentation of plant starches. Butanol is used as a solvent, in cosmetics, hydraulic fluids, detergent formulations, drugs, antibiotics, hormones and vitamins, as a chemical intermediate in the production of butyl acrylate and methacrylate, and additionally as an extractant in the manufacture of pharmaceuticals. However, it may also be used as a fuel. Butanol, as compared to ethanol, is less volatile and explosive, has higher flash point, and lower vapor pressure, which makes it safer to handle. It contains more energy, it is less hygroscopic (thus does not pick up water) and can easily mix with gasoline in any proportion (García *et al.,* 2011).

Therefore butanol is a demanding biofuel. The butanol produced from petroleum based-materials is an expensive process and can affects the environment. Thus, a biological process for biobutanol production from cheapest biomass has been proposed. It will help to reduce consumption of petrol, reduce the petrol prices and cause less negative effect to the environment. Besides, biobutanol are used in various industries and agriculture. Therefore,an increase production of biobutanol will increase the productivity of industrial based butanol and indirectly increase the economic capital.

1.3 Problem Statement

Nowadays, butanol is chemically synthesized from non- renewable energy sources such as petrochemical-based materials. However, important problems are associated with the bioproduction of butanol such as the high substrate cost and low product yield. Many efforts have been made to overcome these problems, and the utilization of low-price lignocellulosic biomass is one of most worthy of strategies considered. Cost-effective and easily-degradable feedstocks are required for butanol production. These include wheat straw, corn stover, barleystraw, wood hydrolysate, switchgrass, and other agricultural byproducts that offer potential alternatives (Qureshi, 2010). However, the use of OPF juice as a substrate for biobutanol production has yet to be study. Thus, the significance of this study is to propose the active factors that could affect biobutanol production by using ABE fermentation from OPF juice. The optimization study for ABE production is very important to obtain a high biobutanol yield. This research gives more priority on the