Model of Continuous Cheese Whey Fermentation by *Candida Pseudotropicalis*

Rudy Agustriyanto and Akbarningrum Fatmawati

***Abstract*—**The utilization of cheese whey as a fermentation substrate to produce bio-ethanol is an effort to supply bio-ethanol demand as a renewable energy. Like other process systems, modeling is also required for fermentation process design, optimization and plant operation. This research aims to study the fermentation process of cheese whey by applying mathematics and fundamental concept in chemical engineering, and to investigate the characteristic of the cheese whey fermentation process. Steady state simulation results for inlet substrate concentration of 50, 100 and 150 g/l, and various values of hydraulic retention time, showed that the ethanol productivity maximum values were 0.1091, 0.3163 and 0.5639 g/l.h respectively. Those values were achieved at hydraulic retention time of 20 hours, which was the minimum value used in this modeling. This showed that operating reactor at low hydraulic retention time was favorable. Model of bio-ethanol production from cheese whey will enhance the understanding of what really happen in the fermentation process.

***Keywords*—**Cheese whey, ethanol, fermentation, modeling

I. Introduction

Currently, the shortage of fossil fuel has encouraged the investigation on some alternative energy sources. One of the alternative energy sources is bio-ethanol, which can be produced from fermentation. The raw materials that are usually fermented to produce ethanol come from crop products such as corn, sweet sorghum, and sugar cane. Hence, to produce ethanol, it always needs land opening for plantation which ultimately will result in deforestation. To reduce land utilization for plantation, and to eliminate the land competition between food and energy orientation, the use of alternative non-crop raw materials needs to be explored. Such raw materials could be from industrial waste.

Cheese whey is waste from cheese production. Whey is watery portion that separates from the curds during conventional cheesemaking or casein manufacture. There are two types of cheese whey, i.e. sweet and acidic whey. Sweet whey is produced from ripened cheese with pH 5.9 to 6.3. While, acidic whey is produced from unripened fresh cheeses with pH 4.4 to 4.6. About nine kilograms of whey are usually produced from one kilogram of cheese production [8]. Generally, cheese whey still contains some nutrients for growth which consist of 5-6% lactose, 0.8-1% protein, and 0.06% fat [5]. There is more lactic acid, calcium, phosphorous, and lactose in acid whey.

In Canada, about 0.22 million t/year cheese whey is produced of which over half is discarded as waste [2]. In Brazil, production of cheese whey is estimated to be around 3 millions t/year [3]. In USA more than 1.7 x 10^{10} kg of whey are generated annually [4].

There have been some researches concerning the use of cheese whey fermentation to produce ethanol [1],[2],[5],[8]. The effect of operating parameters such as initial pH, cheese whey powder (CWP) concentration, and external nutrient (N,P) supplementation on the cheese whey powder (CWP) fermentation has been investigated by Kargi and Ozmihci [5]. They used cheese whey powder as the substrate of batch fermentation and found that initial pH of 5 was the most suitable for producing maximum final ethanol concentration and ethanol formation rate. The external addition of N and P source did not improve the ethanol formation. The final ethanol concentration and ethanol formation rate increased with sugar concentration. The ethanol production from batch fermentation of crude whey by *Kluyveromyces marxianus* has been investigated by Zafar and Owais [8]. They reported that the specific cellular growth rate and product formation rate reached maximum values of 0.157 and 0.046 1/h at exponential phase. Ghaly and Taweel [1],[2] have studied the kinetic of batch and continuous fermentation of cheese whey by yeast *Candida pseudotropicalis*. They produced kinetic parameter from batch fermentation and recommended the operating parameters for continuous cheese whey fermentation that gave the maximum ethanol concentration are 150 g/l inlet substrate concentration and 42 h hydraulic retention time. Ethanol production from sweet whey permeate and sweet whey permeate-grain batch fermentation has also been investigated [4]. The yeast cells used were *Kluyveromyces fragilis* and *Saccharomyces lactis*. The ethanol concentration produced from 24 h whey permeate fermentation was 20 g/l. As much as 97 and 94 g/l of ethanol was produced from whey permeate-grain fermentation using yeast *K. fragilis* and *S. cerevisiae* respectively in 36 h.

Mathematical models are necessary for the design, scale-up, optimal control and economic analysis of ethanol fermentation process. These models may lead to the development of better strategies of the fermentation optimization to ensure its

Rudy Agustriyanto is with the Department of Chemical Engineering, Surabaya University, Surabaya, Indonesia (e-mail: rudy.agustriyanto@ubaya.ac.id).

Akbaringrum Fatmawi. is with the Surabaya University, Surabaya - Indonesia (Jl. Raya Kalirungkut, Surabaya, Indonesia phone: +62 31 2981158; fax: +62-31 2981178; e-mail: akbarningrum@ ubaya.ac.id).