Filtration of Protein in Tempe Wastewater Using Cellulose Acetate Membrane

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Abstract - The protein content in the wastewater tempe high enough. Filtration of tempe wastewater can use cellulose acetate membranes. Type cellulose acetate membranes used is ultrafiltration membranes. Pressure and protein concentration influenced on the flux, rejection, and fouling resistance. Membrane characteristics included flux, pore asymmetries, time compaction and permeability coefficient. The results showed that fouling resistance is influenced by the pressure and concentration of the feed solution. The higher the pressure will cause increased fouling resistance, while higher concentrations will cause fouling resistance decreases. The pressure and the higher the concentration of protein causes rejection decreased.

Keywords: cellulose acetate, flux, rejection, protein. tempe wastewater

INTRODUCTION

The liquid waste generated in the production process tempe quite large due to the amount of water consumption in the process of making tempe. Byproducts are widely released into the environment thereby contributing to environmental pollution. Content of nutrients contained in wastewater tempe is N amounted to 164.9 ppm, 15.66 ppm of P, K at 625 ppm and a pH of 3.9 [1]. The nutritional value of the soybean cooking water turns out to have a protein content of 5.29%, 0.54% fat, 72.08% water, 3.38% ash and some other minerals.

Protein has many benefits in human life for example be used as a functional food, food supplements and infant formula. So far, few efforts have been made to obtain the protein using ultrafiltration process. Ultrafiltration (UF) to get protein from milk [2], coconut milk protein [3], and even wastewater [4]. However, the process efficiency Ultrafiltration is hampered because the process of fouling that occurs in the process of UF.

The influence of various operating pressure (1.8, 2.0, 2.2 and 2.4 bar) on the membrane fouling processes coconut UF solution that uses PSF membrane with Molecular Weight Cut-Off (MWCO) 10 kDa and a constant temperature (60°C) resulted in a decrease in flux at various operating pressures [5]. The study showed that at a pressure of 2.4 bar normalization obtained flux decline is most significant in comparison to the others. The concentration of the feed solution also greatly affects the occurrence of fouling seen from the flux decline. The concentration of the feed solution that will affect the flux varied and type of fouling that occurs [6].

Membrane material used in this study is cellulose acetate (CA). Cellulose acetate as the membrane material is easy to produce and the main material is a renewable source (renewable) [7]. Shortage of cellulose acetate as the membrane material is very sensitive to pH and are very susceptible to microbes that exist in nature [7]. This study uses a cellulose acetate membrane (CA) that has a Molecular Weight Cut-Off (MWCO) below 100 kDa, with the composition of the polymer solution of 22% CA, 3% DMP (dimethyl phthalate), 15% acetone and 60% dimethyl sulfoxide (DMSO) [8].

METHOD

The equipment used in this study include glassware, analytical balance, magnetic stirrer, micrometer, plate glass, a stopwatch, a set of ultrafiltration modules flat dead-end system, Labu Kjeldahl, and Set distillation equipment.

The materials used in this study include liquid waste tempe, filter paper, cellulose acetate (CA) Aldrich (BM 30000), dimethyl phthalate (Merck Schuchardt; ρ = 1.19 g / mL , pa), acetone (Bratako; ρ = 0.79 g / mL, pa), dimethyl sulfoxide (DMSO) (Merck Schuchardt; ρ = 1.11 g / mL), distilled water, aluminum foil, tape, H_2SO_4 98% (Merck), calcium sulfate, sodium sulfate, NaOH 40%, boric acid 4%, phenolphthalein, methyl red, methyl blue, HCl 0.1 N.

1. Preparation of Membrane

Manufacture of cellulose acetate membranes using phase inversion methods. Cellulose acetate membranes with the composition of the polymer solution is 22% CA, 3% DMP, 15% acetone and 60% DMSO. Dimethyl phthalate (ρDMP = 1,179 g / mL) of 0.5 mL was added to the mixture and stirred with a magnetic stirrer until a homogeneous solution. Homogeneous polymer solution was then allowed to stand until it does not contain air bubbles. The polymer solution containing no air bubbles printed on the glass plate edges have given the tape to set the thickness of the membrane. Membrane evaporated by means of settling on the open air by evaporation time of 3 minutes and immersed in a water bath, then the membrane was washed with water. The membranes were selected to have a uniform thickness is by using a micrometer to measure at some point later the results are averaged (Kartika, 2010).

2. Preparation Liquid Waste Tempe

The liquid waste is taken out of the process of making tempe tempeh at home industry. The solution is already cool (room temperature) protein levels measured by the method kjehdal and then varied the concentration by dilution methods. The first solution (I) was prepared in a manner without liquid (mother liquor). The second solution (II) was prepared by diluting 1.7 times (take 60 ml of the parent then diluted to 100 mL). The third solution (III) was prepared by diluting 2 times (take 50 ml of the parent then diluted to 100 mL). The fourth solution (IV) was prepared by diluting 2.5 times (take 40 ml of the parent then diluted to 100 mL).

3. Characterization of Cellulose Acetate Membranes

a. Flux

The cellulose acetate membrane was cut into a circle that is adapted to the tool set ultrafiltration system used dead end. Membrane thickness measured in advance using a micrometer. Measurements were made in several sections and taken the average value. Membrane then feed into an ultrafiltration and coated filter paper on the bottom. Before testing the water flux, first made the timing of the compacting of the membrane.The time of compaction carried by at a pressure of 2 bar to obtain a constant water flux. Feed Volume was 100 mL. Each one mL of water were accommodated recorded flow time required. Flux volume is determined by the equation (1). Having obtained a constant flux and then tested the flux of the membrane with the same procedure in the timing of compaction, filtration is performed for 1 hour then measured volume being stored and calculated permeate flux of water by equation (1).

$$J_v = \frac{V}{A\,t} \quad ....(1)$$

b. Permeability coefficient

As much as 100 ml of water put into the ultrafiltration cell. Stirring using a magnetic stirrer and rapid kept constant. Each cellulose acetate membranes of the process of making the membrane by the pressure variation is 1.5; 1.9; 2.7; and 3 bar for 1 hour. Such treatment will be obtained flux value for each pressure on each membrane. The results of measurements, then graphed change of pressure versus the flux. Value Lp (constant permeability) determined from the slope obtained at each of the graph.

c. Rejection Coefficient (R)

Rejection coefficient was measured by determining the concentration of the permeate and retentate from ultrafiltration process. The concentration of the permeate and retentate were determined by methods kjehdal. Rejection coefficient calculated by the equation (2).

$$R = \left(1 - \left(\frac{C_p}{C_f}\right)\right) x100\%$$

4. Determination of N Total In Liquid Waste Tempe

Determination of total N in wastewater tempe using Kjeldahl method. Liquid waste tempe taken as many as 5 mL then inserted into the Kjeldahl flask. Solution of concentrated sulfuric acid is added as much as 5 mL Kjeldahl flask into carefully. A mixture of $CuSO_4$: Na_2SO_4 (1: 8) as much as 3 grams added to the Kjeldahl flask. Destruction process is done in a fume hood until liquid blue or green clear. Pumpkin Kjeldahl cooled with water. The solution was clear diluted with distilled water and then added NaOH 40% (w / v) until the brown solution is formed. The solution is distilled with a series of Kjeldahl distillation equipment. Distillate reacted with 4% boric acid which has been added 2 drops of a mixture of methyl red indicator and methyl blue. Distillation is stopped until distillate changes color to blue. The resulting distillate titrated with 0.1N HCl standardized. Shells are made in the same way without the use of samples.

5. Ultrafiltration process

The solution (liquid waste tempe) is inserted into the module flat dead-end system that is equipped with a magnetic stirrer. The first ultrafiltration process carried out at different pressures (1.5; 1.9; 2.7; and 3.0 bar) using feed solution (liquid waste tempe) whose concentrations remain to determine the effect that the pressure on fouling. The second ultrafiltration process carried out at different concentrations of the feed solution and the pressure remains to determine the effect of concentration on the type of fouling. Each time the process of ultrafiltration is set for 75 minutes. The intercepted permeate volume measured at minute 15, 30, 45, 60, 75 and the calculated value of the flux. All experiments were carried out in this study be repeated three times to ensure the results.

RESULT AND DISCUSSION

1. characterization Membrane

Membrane permeability coefficient is the ability of a membrane to pass a species per unit of pressure [8]. The coefficient of correlation is taken from the gradient flux under pressure through the point (0,0). Figure 1 shows the permeability coefficient obtained. Based on the results obtained membranes used have a permeability coefficient of 12.677 L / m^{2}jam bar.

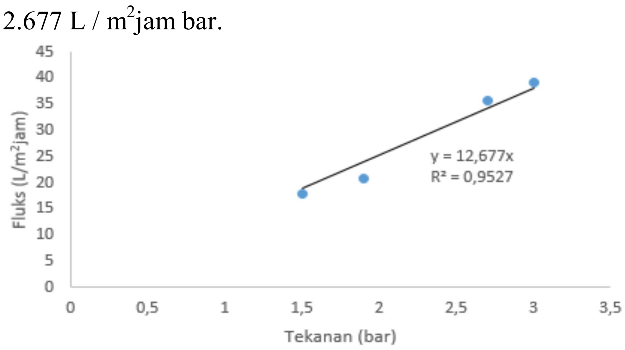

Figure 1. permeability coefficient

Asymmetries of the membrane was tested by comparing the surface flux membranes top to the bottom. Figure 2 shows that the lower surface of the membrane flux is greater than the value of the upper surface flux. This is because the top surface of the membranes have pores that are narrow and the lower surface of the membrane has a pore width. This shows that the membrane used is most likely the asymmetric membrane.

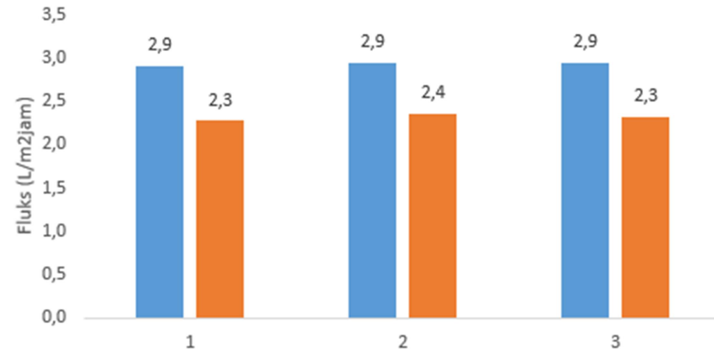

Figure 2. membrane fluks on normal and abnormal position

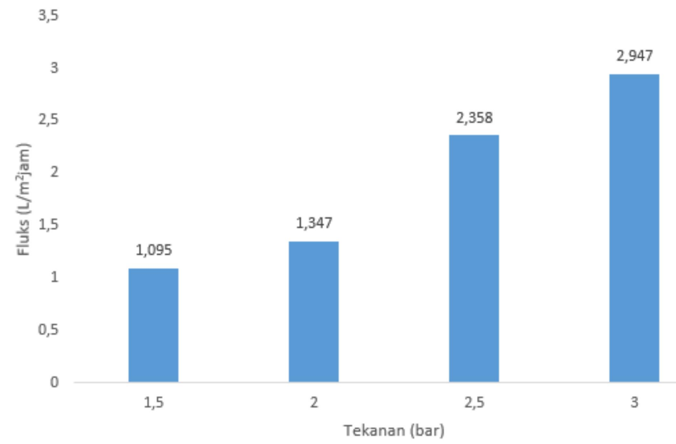

Figure 3. Flux Dependence on pressure

The flux is influenced by pressure. Hagen-Poiseuille through equation states that the flux is proportional to the pressure difference. more and more great pressure, then the flux will be greater. Figure 3 shows that the water flux increased along with increasing pressure exerted. This is because the greater the pressure or the thrust of the water to pass through the membrane, it will causing ability of the water passes through the membrane also bigger and great flux.

2. Effect of Pressure and Concentration on rejection coefficient

Rejection coefficient (R) is one of the parameters to express the selectivity of a membrane. R ranged from 100% (if the solute can be held perfectly) and 0% solute and solvent through the membrane freely.

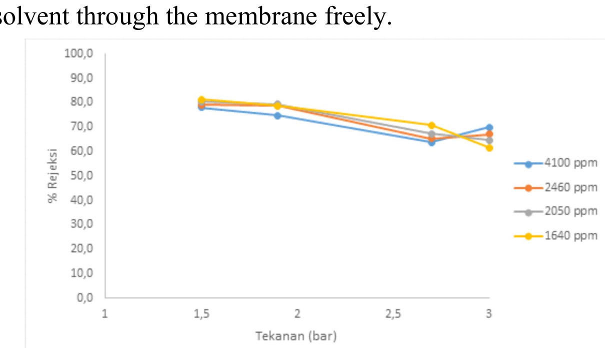

Figure 4 Rejection coefficient dependence on pressure

Figure 4 shows that the pressure greatly affects rejection coefficient of the membrane. rejection coefficient decreases when the pressure increased. This is because the greater the pressure exerted, it will cause the feed solution to pass through the membrane increases. However, at a concentration of 4100 ppm and 2460 ppm rejection coefficient an increase in pressure of 3 bar. This is because both the concentration of protein molecules have a number of more than 2050 ppm and 1640 ppm.

Figure 5 shows that the concentration of the feed solution affects the membrane rejection coefficient. Rejection coefficient decreased during concentration varied. This can be explained that the concentration increases, the number of protein molecules is increased. However, when the pressure of 3 bar indicates a rejection coefficient increases. This is likely due to the pressure exerted large enough so that pore closure occurs by protein molecules and causes the protein molecules will pass through the membrane less or more muffled. This causes the protein concentration in the permeate becomes less.

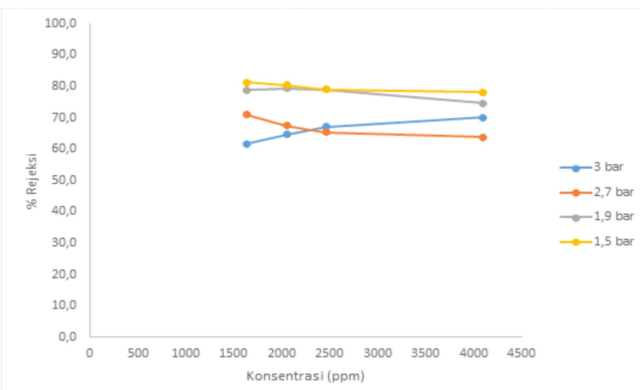

Figure 5 concentration dependence on rejection coefficient

CONCLUSION

Cellulosa acetate membranes used an asymmetric membrane. The flux is strongly influenced by pressure. The pressure and the higher the concentration of proteins that cause rejection coefficient decreased. Fouling on the filtration of wastewater tempe occur.

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