Chapter V

Conclusions and Recommendations

5.1 Conclusions

Alginate was proven to be more superior to chitosan for yeast immobilization. Low performance of chitosan based carrier was due to the inhibitory effect of the material on yeast activity. Adsorption method was less efficient for immobilizing yeast than entrapment because of its weak binding forces and low immobilization capacity. Based on its immobilization efficiency and high ethanol productivity, entrapment alginate-loofa cube (EALC) is proposed as the best form of loofa reinforced gel carrier in this work.

In term of ethanol fermentation performance, EALC was very promising. Ethanol fermentation outcome of EALC (8 x 8 x 1 mm) was comparable to compact size alginate bead (EAB, ∅ = 2 mm) even though its size was considerably larger. In a single batch system in fermentation 3, ethanol yields of suspended cell, alginate bead, and EALC were 68.3, 79.3, and 83.5 g/L respectively. Porous structure of EALC was thought as the main reason for the improvement. This distinctive structure was a direct consequence of loofa sponge and alginate combination in the carrier preparation process.

In repeated batch fermentation, EALC showed a good potential of reusability. It had been successfully reused in 2 subsequent batch fermentation cycles. Its ethanol production was proven to be more stable than suspended cell culture. In main batch, ethanol yield of EALC system (P_F = 77.8 g/L) was lower than suspended cell culture (P_F =91.7 g/L). However, P_F of suspended cell decreased drastically to 47.7 g/L while EALC system maintained a steady yield of 77.4 g/L at repeated batch 1.

The matrix of EALC along with its porous structure is suggested to play a major role in enhancing activity of the immobilized yeast. After passing through acclimatization period, ethanol yield of EALC was equivalent with suspended cell culture. In repeated batch 2, P_F of EALC reached 91.5 g/L. This value is comparable with 97.4 g/L obtained in suspended cell culture. The P_F value of EALC corresponds to ethanol yield factor ($Y_{P/S}$) of 0.456 g/g (g ethanol/ g sugar). The value was comparable to 0.450 g/g in suspended cell and larger than 0.438 g/g sugar in alginate bead culture. The result demonstrates the prospective performance of EALC in ethanol fermentation system. With a strong structure

of cellulose matrix inside, potential advantages including altered mechanical strength are expected in the application of the new EALC carrier.

5.2 Recommendations

In an effort to develop a high performance ethanol production scheme, further work involving a continuous fermentation in a scale larger than this work is considered necessary. By using a continuous system, the potential of EALC in term of productivity can be more ameliorated. High volumetric productivity of ethanol can be obtained by operating the bioreactor with high dilution rate.

By combining the advantageous properties of loofa sponge, flocculating yeast, and alginate, it is possible to construct highly productive and stable bed of biocatalyst from EALC. Comprehensive information on the level of mechanical alteration of the new EALC carrier can be obtained by comparing the bed strength and stability of EALC to conventional alginate bead.

The potential use of EALC in other similar biosystems should be evaluated in the future. Based on the positive outcomes gained in this study, the application of EALC for immobilizing other microorganisms or cells which produce high value extra cellular metabolites in particular is considered attractive and promising.