Interactive Effects of Impeller Speed and Substrate Molar Ratio on Synthesis of Engkabang Fat Esters

Nur Fariza. Abdul Rahman, Mahiran. Basri

***Abstract*—** Engkabang Fat Esters are produced from the alcoholysis reaction of oleyl alcohol and its fat using enzyme as biocatalyst. The work has been previously carried out mainly on the optimization of Engkabang Fat esters production in organic solvents. However, the effect of impeller speed-substrate molar ratio has yet to be discussed in detail. In the present paper, the influences of impeller speed and substrate molar ratio were further investigated using the model generated by Response Surface Methodology (RSM). The maximum yield for reaction conducted in heptane was observed more than 90% at substrate molar ratio of 2.95 mmol at any impeller speed from 150 to 350 rpm. Meanwhile for hexane, highest yield (85%) was obtained at highest substrate molar ratio (4.00 mmol) and highest impeller speed (350 rpm).

***Keywords*—** Engkabang Fat Esters, enzyme, substrate molar ratio, impeller speed

I. Introduction

FAT esters are high molecular weight esters made up of long chain fatty acids that posses desirable characteristics of non-toxic, good fat soluble properties and leaving a non-drying and non-greasy effects at interfaces [1] which suitable in cosmetic formulation such as in cleanser and moisturizer. On the other hand, Engkabang Fat which also known as *Illipe* butter , is the fat extracted from the kernel of various botanical *Shorea* species that are abundantly produced in the forest of Sarawak and Kalimantan. This extractable fat is mostly made up of uniform desirable triglycerides, with main fatty acids composition of stearic acid, oleic acid and palmitic acid [2]. Despite, its high oxidative stability, Engkabang Fat has also reported to present soothing, anti-drying and protective virtues to the skin, keeping the skin moisturized [3] and this has made Engkabang Fat a luxurious raw material ingredient especially in cosmeceutical products. Furthermore, human skin hydration has been reported to increase after three hours application of Engkabang based emulsion [4], [5]. In previous studies, Engkabang Fat esters were produced in a bioreactor between oleyl alcohols and Engkabang Fat, utilizing enzyme as biocatalysts in the presence of organic solvents. Three interactive parameters effects, namely temperature-substrate molar ratio effects, impeller speed-enzyme amount effects and substrate molar ratio-enzyme amount effects on Engkabang Fat Esters production were highlighted. However, the effect of impeller speed-substrate molar ratio has yet to be discussed. In the present paper which continuity of the previous studies [4], the influences of impeller speed and substrate molar ratio were further explored using the model generated by Response Surface Methodology (RSM).

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II. Methodology

A. Alcoholysis Reaction of Engkabang Fat

Engkabang Fat was obtained from a local market in Kuching, Sarawak. The alcoholysis reaction was conducted in a 500 mL stirred tank reactor (STR). Fix amount of Engkabang Fat (1 mmol) and different molar ratio of oleyl alcohol were placed in the STR, followed by the addition of solvent to a total of 375 mL. Various amounts of enzyme were added subsequently and the reaction mixture was continuously reacted for 5 h. At the end of the reaction, 20 mL of samples was withdrawn for gas chromatography analysis**.** Parameter set including temperature (30-60℃), impeller speed (150.0-350.0 rpm,) substrate molar ratio of Engkabang Fat to oleyl alcohol (1:1.0 - 4.0 mmol) and amount of enzyme (3.5-7.5 g) were varied accordingly based on the data generated by RSM

B. Design of Experiment and Statistical Analysis

The experimental design as well as statistical analysis were based on the work reported previously [4]. Interactive effect of parameters, particularly impeller speed-substrate molar ratio will be further discussed in the present paper

III. Results And Discussion

Based on the regression analysis in Table 1 reported earlier in [4], the Prob > F value of interactive effect of impeller speed and substrate molar ratio for reaction conducted in heptane and hexane were 0.0422 and 0.3718, respectively which indicated a significant impact for reaction conducted in heptane instead of in hexane.

TABLE 1
VALUES OF SIGNIFICANCE OF REGRESSION COEFFICIENTS FOR ENGKABANG FAT ESTERS PRODUCTION (QUADRATIC MODEL)

Source	Heptane		Hexane	
	Value	Prob > F	Value	Prob > F
Impeller Speed-Molar ratio	6.26	0.0422 [a]	-1.07	0.3718 [b]

[a] Significant at "Prob>F" less than 0.05; [b] Insignificant at "Prob > F" more than 0.05

Fig. 1 and 2 depict the response surface plots as a function of impeller speed versus subsrate molar ratio for quadratic model of both reaction in heptane and hexane. The reaction temperature and amount of enzyme were fixed at 45°C and 5.5 g. The results revealed similar trend whereby increasing substrate molar ratio and impeller speed led to increase in percentage yield. The maximum yield was observed (>90%) for heptane at substrate molar ratio of 2.95 mmol at any impeller speed from 150.0 to 350.0 rpm. Meanwhile for hexane, highest yield (>85%) was obtained at highest substrate molar ratio (3.99 mmol) and highest impeller speed (350.0 rpm)

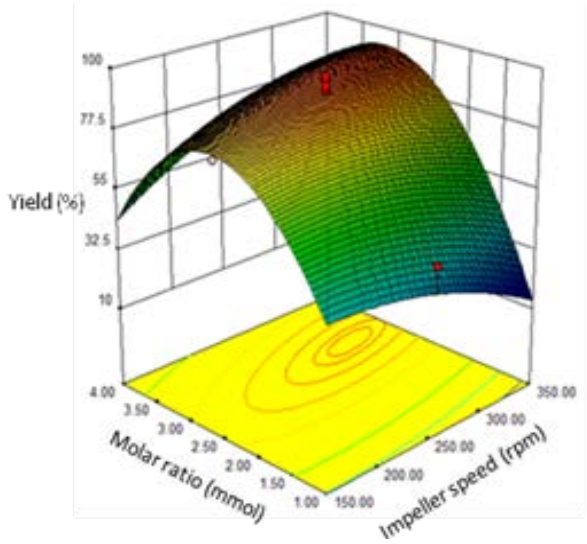

Fig. 1 Response surface plot of interactive effect of substrate molar ratio versus impeller speed on the production of Engkabang Fat Esters in heptane, at fixed temperature of 45°C and enzyme amount of 5.50 g

However, a decrease in yield was clearly observed for heptane after further increase of substrate molar ratio. This could be due to the limiting factor caused by Engkabang Fat which was significant at high amount of oleyl alcohol. The molar ratio has a stronger influence on the production yield as compared to impeller speed for both reaction in heptane and hexane. However, the increase in impeller speed could led to the increase of external mass transfer rates between the bulk phase of reaction mixture with enzyme surface by reducing the droplet size of reaction mixture. This would result in substantial increase of specific interfacial area between the substrate and enzyme, and at the same time induces the intense liquid movement in the reactor [6]-[8].

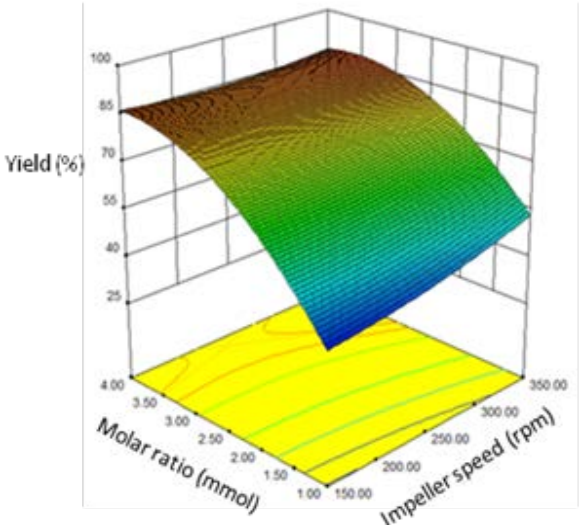

Fig. 2 Response surface plot of interactive effect of substrate molar ratio versus impeller speed on the production of Engkabang Fat Esters in hexane, at fixed temperature of 45°C and enzyme amount of 5.50 g

IV. CONCLUSION

Interactive effect of impeller speed and substrate molar ratio has shown similar trend for both reaction carried out in heptane and hexane. However, significant effect of impeller speed and substrate molar ratio on the production of Engkabang Fat esters was observed for heptane compared to hexane. Further studies should be conducted for a solventless and scale up production of Engkabang Fat esters in order to produce a high quality of fat esters using greener and environmentally process.

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