

## ABSTRACT

Various structured lipids (SLs) have been synthesized with certain physical and chemical characteristics, including as a cocoa butter replacer (CBR). Some CBRs were synthesized by physical blending or interesterification of mixtures of palm based fats/oils, but the CBR had low compatibility (<10%). The objective of this research was to synthesize high mono- and diacylglycerol structured lipids, which was compatible to cocoa butter by enzymatic glycerolysis-interesterification based on a mixture of glycerol and blend of palm stearin (PS) and palm olein (PO). Glycerolysis-interesterification is a reaction that both glycerolysis reaction between triacylglycerol (TAG) and glycerol, and interesterification reaction between acylglycerols from different sources or fractions take place in one reaction system.

The design of this research was as follows: (i) immobilization of *Candida antarctica* lipase on hydrophobic modified IRA-96 free base amberlite matrix; (ii) enzymatic glycerolysis-interesterification to obtain structured lipids with the high MAG and DAG concentrations in batch stirrer tank reactor (BSTR) system, (iii) synthesis of high MAG and DAG structured lipids by enzymatic glycerolysis-interesterification at various palm stearin and palm olein ratios; and evaluation the compatibility of high MAG and DAG structured lipids to cocoa butter.

The results showed that the immobilization of *C. antarctica* lipase on the hydrophobic modified amberlite IRA-96 free base was optimum at modification time of 6 hours, lipase concentration was 60 Unit/mL, and adsorption time was 3 hours; which had adsorbed protein of 11.47 mg/g matrix, esterification activity was 26.81 U/g immobilized lipase, and hydrolytic activity was 31.60 U/g immobilized lipase. The high MAG and DAG SLs which synthesized by enzymatic glycerolysis-interesterification in the BSTR system optimum using finned stirrer type; solvent to substrate ratio was 2:1; glycerol to fat molar ratio was 1.5:1 (v/w); and 15% (w/w) of immobilized lipase at 50 °C for 24 hours. This condition produced the best SLs with MAG, DAG, and TAG concentrations were 11.39%, 27.24% and 59.60%, respectively. The high MAG and DAG structured lipids resulting from enzymatic glycerolysis-interesterification of palm stearin and palm olein blend at a ratio of PS:PO of 40:60 (w/w) had physicochemical characteristics were comparable to cocoa butter. The melting behavior, polymorphism, and crystals that were suitable as cocoa butter replacer (CBR) but had a lower hardness than CB. The high MAG and DAG structured lipid was compatible to cocoa butter partially up to 20%. Based on these characteristics, the SLs could be used as a cocoa butter replacers, especially in confectionary filling.

**Keywords:** enzymatic glycerolysis-interesterification, monoacylglycerol, diacylglycerol, palm stearin-palm olein, structured lipid, cocoa butter replacer

## INTISARI

Berbagai lipida terstruktur (SLs) telah banyak disintesis dengan karakteristik fisik dan kimia khusus, diantaranya sebagai *cocoa butter replacer* (CBR). Beberapa CBR disintesis melalui pencampuran fisik maupun interesterifikasi campuran lemak/minyak berbasis minyak sawit, namun CBR yang dihasilkan memiliki kompatibilitas yang masih rendah (<10%). Tujuan dari penelitian ini adalah mensintesis lipida terstruktur kaya monoasilgliserol (MAG) dan diasilgliserol (DAG) yang kompatibel dengan *cocoa butter* melalui gliserolisis-interesterifikasi enzimatis campuran palm stearin (PS), palm olein (PO), dan gliserol. Glycerolysis-interesterifikasi merupakan reaksi yang mana kedua reaksi, baik gliserolisis antara triacylglycerol (TAG) dan gliserol, dan interesterifikasi/transesterifikasi antara asilgliserol satu dan asilgliserol lainnya dari sumber atau fraksi yang berbeda terjadi dalam satu sistem reaksi.

Penelitian ini meliputi tahap-tahap sebagai berikut: (i) amobilisasi lipase *Candida antarctica* pada matriks *amberlite IRA-96 free base* termodifikasi hidrofobik; (ii) gliserolisis-interesterifikasi enzimatis untuk memperoleh lipida terstruktur dengan konsentrasi MAG dan DAG tertinggi pada sistem *batch stirrer tank reactor* (BSTR), (iii) sintesis lipida terstruktur kaya MAG dan DAG melalui gliserolisis-interesterifikasi enzimatis pada berbagai rasio palm stearin dan palm olein; serta evaluasi kompatibilitas lipida terstruktur kaya MAG dan DAG dengan *cocoa butter*.

Hasil penelitian menunjukkan bahwa amobilisasi lipase *C. antarctica* pada matriks *amberlite IRA-96 free base* termodifikasi hidrofobik optimum pada waktu kontak modifikasi 6 jam, konsentrasi lipase 60 Unit/mL, dan waktu adsorpsi 3 jam; memiliki protein teradsorpsi 11,47 mg/g matriks, aktivitas esterifikasi, 26,81 U/g lipase teramobil, dan aktivitas hidrolitik 31,60 U/g lipase teramobil. Sintesis SLs kaya MAG dan DAG melalui gliserolisis-interesterifikasi enzimatis pada sistem BSTR menggunakan jenis pengaduk bersirip; rasio pelarut:substrat 2:1 (v/b); rasio molar gliserol:lemak 1,5:1; dan konsentrasi lipase teramobil 15% (b/b) pada suhu 50 °C selama 24 jam, menghasilkan SLs terbaik dengan konsentrasi MAG, DAG, dan TAG berturut-turut 11,39%, 27,24%, dan 59,60%. Lipida terstruktur (SLs) kaya MAG dan DAG hasil gliserolisis-interesterifikasi enzimatis dari palm stearin dan palm olein pada rasio PS:PO 40:60 (b/b) memiliki karakteristik fisiko kimia mendekati *cocoa butter* dengan perilaku pelelehan, polimorfisme, dan kristal yang sesuai sebagai *cocoa butter replacer* (CBR) tetapi memiliki *hardness* lebih rendah daripada CB. SLs kaya MAG dan DAG *compatible* dengan *cocoa butter* secara parsial sampai 20%. Berdasarkan karakteristik tersebut, SLs dapat digunakan sebagai *cocoa butter replacer* secara parsial terutama pada *confectionary filling*.

**Kata kunci:** Glycerolysis-interesterifikasi enzimatis, monoasilgliserol, diasilgliserol, palm stearin-palm olein, lipida terstruktur, *cocoa butter replacer*