Response Surface Methodological Approach for Optimization of Enzymatic Synthesis of Cetyl Octanoate and Cetyl 2-Ethylhex

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ABSTRACT

Waxes are esters of long-chain fatty acid and long-chain alcohol which are biodegradable, biocompatible, and nontoxic. Seafowl feather oil was natural mixture of wax ester which existed in the seafowl ’ s feather. Major ingredient of seafowl feather oil is cetyl octanoate (including cetyl octanoate and cetyl 2-ethylhexanoate) which was widely used in cosmetic industry as base oil because of its lubricity, moisture retention and non-toxic properties. It was long-chain wax esters which are combined octanoic acid acid with 1-hexadecanol (cetyl alcohol) by direct esterification. Cetyl octanoate and cetyl 2-ethylhexanoate were usually produced by chemical synthesis methods or extracted from traditional natural raw materials. However, with the growing demand for natural flavor compounds, lipase-catalyzed synthesis ester compounds had been researched in the last decade. In this research, we use Lipozyme? RMIM and Novozym? 435 to catalyst the cetyl octanoate and cetyl 2-ethylhexanoate synthesis. Response surface methodology (RSM) and central composite rotatable design (CCRD) were employed to evaluate the effect of synthesis parameter for two part experiments. Based on the analysis of ridge max, the optimum condition for cetyl octanoate synthesis by Novozym? 435 catalysis were: reaction time 3.75 hr, reaction temperature 48.32 ° C, molar ratio 2.26:1 and enzyme amount 41.77%. The maximum predict yield was 99.93 ± 2.74%. The actual experimental yield was 98.24 ± 0.11 %. The optimum condition for cetyl 2-ethylhexanoate synthesis were: reaction time 2.65 day, reaction temperature 56.18 ° C, molar ratio 2.55:1 and enzyme amount 251.39%. The maximum predict yield was 91.95 ± 4.30%. The actual experimental yield was 89.75 ± 1.06 %. It provides that synthesis of lipase-catalyzed seafowl feather oil was produce by effective in scale-up of industrialization.

Keywords : Cetyl 2-ethylhexanoate ; Cetyl octanoate ; Composite rotatable design (CCRD) ; Esterificantion ; Lipase ; Response surface methodology (RSM) ; Wax ester

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REFERENCES

1. 洪偉章及陳榮秀。1996。化妝品科技概論。第5—8頁。高立圖書有限公司。高雄，台灣。 2. 陳國誠。2000。生物固定化技術與產業應用。第121—155頁。茂昌圖書有限公司。台北，台灣。 3. 許德發，鄭智交，楊濟華，李仰川，溫慧萍，許照紅。2003。化妝品概論。第105—128頁。華格那企業有限公司。台中，台灣。 4. 張麗卿。1998。現代化妝品概論。高立圖書有限公司。第159頁，第173頁，第174頁。 5. 楊正剛。2006。已連續式填充床反應器探討月桂酸己酯之最優化酵素合成:第4—28頁。大葉大學生物產業科技研究所碩士論文。彰化，台灣。 6. 謝至涵。2005。以反應曲面法探討月桂酸己酯之最優化酵素合成。第4—8頁:第15—23頁。大葉大學生物產業科技研究所碩士論文。 7. 吳宗達。2007。以連續式填充床生物反應器探討脂解酵素催化生質柴油之最優化合成:第15—28頁。大葉大學生物產業科技研究所碩士論文。彰化，台灣。 8. Novo Nordisk company web site http://www.novozymes.com 9. Basri, M., Rahman, R. N. Z. R. A., Ebrahimpour, A., Salleh, A. B., Gunawan, E. R., Rahman, M. B. A. 2007. Comparison of estimation capabilities of response surface methodology (RSM) with artificial neural network (ANN) in lipase-catalyzed synthesis of palm-based wax ester. BMC Biotechnology 7, art. no. 53. 10. Berglund, P., Holmquist, M. and Hult, K. 1998. Reversed enantiopreference of Candida rugosa lipase supports different modes of binding enantiomers of a chiral acyl donor. Journal of Molecular Catalysis B: Enzymatic 5:283 – 287. 11. Bourg-Garros, S., Razafindramoboa, N. and Pavia, A. A. 1998. Optimization of lipase-catalyzed synthesis of (z)-3-hexen-1-yl actate by direct esterification in hexane and a solvent free medium. Enzyme and Microbial Technology 22:240-245. 12. Carri'n, M. E. and Crapiste, G. H. 2008. Enzymatic acidolysis of sunflower oil with a palmitic-stearic acid mixture. Journal of Food Engineering 84:243-249. 13. Ciafardini, G., Zullo, B. A., Iride, A. 2006. Lipase production by yeasts from extra vigin olive oil. Food Microbiology 23:60-67. 14. Chang, H. M., Liao H. F., Lee C. C. and Shieh C. J. 2005. Optimized synthesis of lipase-catalyzed biodiesel by Novozym 435. Journal of Chemical Technology and Biotechnology 80:307-312. 15. Chang, S. W., Shaw, J. F., Yang, K. H., Shih, I. L., Hsieh, C. H. and Shieh, C. J. 2005. Optimal lipase-catalyzed formation of hexyl laurate. Green Chemistry 7:547-551. 16. Chang, S.W., Shaw, J. F., Yang, C. K. and Shieh, C. J. 2007. Optimal continuous biosynthesis of hexyl laurate by a packed bed bioreactor. Process Biochemistry 42:1362-1366. 17. Chang, S. F., Chang, S. W., Yen, Y. H. and Shieh, C. J. 2007. Optimum immobilization of Candida rugosa lipase on Celite by RSM. Applied Clay Science 37:67-73.. 18. Cheong, L. Z., Tan, C. P., Long, K., Yusoff, M. S. A., Arifin N., Lo S. K. and Lai O. M. 2007. Production of a diacylglycerol-enriched palm olein using lipase-catalyzed partial hydrolysis: Optimization using response surface methodology. Food Chemistry 105:1614-1622. 19. Daneshfar, A., Ghaziaskar, H.S., Shiri, L., Manafi, M.H., Nikorazm, M. and Abassi, S. 2007. Synthesis of 2-ethylhexyl-2-ethylhexanoate catalyzed by immobilized lipase in n-hexane: A kinetic study. Biochemical Engineering Journal 37:279-284. 20. Diano?czki, C., Recseg, K., Kova?ri, K and Poppe, L. 2007. Convenient enzymatic preparation of conjugated linoleic acid alkyl esters with C6 – C22 alcohols. Journal of Molecular Catalysis B: Enzymatic 45:45-49. 21. Decagny, B., Jan, S., Vuillemard, J. C., Sarazin, C., Seguin, J. P., Gosselin, C., Barbotin, J. N. and Ergan, F. Synthesis of wax ester through triolein alcoholysis: Choice of the lipase and study of the mechanism. Enzyme and Microbial Technology 22: 578-582. 22. Duan, Y., Du, Z., Yao Y., Li, R. and Wu D.. 2006. Effect of molecular sieve on lipase-catalyzed esterification of rutin with stearic acid. Agricultural and Food Chemistry 54:6219-6225. 23. Garcia, T., Coteron, A.,Martinez, M. and Aracil, J. 2000. Kinetic model for the esterification of oleic acid and cetyl alcohol using an immobilized lipase as catalyst. Chemical Engineering Science 55:1411-1423. 24. Ghamgui, H., Miled, N., Rebai", A., Karra-chaa^bouni, M. and Gargouri, Y. 2006. Production of mono-olein by immobilized Staphylococcus simulans lipase in a solvent-free system Optimization by response surface methodology. Enzyme and Microbial Technology 39:717-723. 25. Guncheva, M. H. and Zhiryakova D. 2008. High-yield synthesis of wax esters catalysed by modified Candida rugosa lipase. Biotechnology Letter 30:509 – 512. 26. Gunawan, E. R., Basri, M., Abd. Rahman, M. B., Salleh, A. B. and Abd. Rahman, R. N.Z. 2005. Study on response surface methodology (RSM) of lipase-catalyzed synthesis of palm-based wax ester. Enzyme and Microbial Technology 37:739-744. 27. Gu"venc，, A., Kapucua, N., Kapucub, H., Aydog(an a, O"., and Mehmetog(lu, U". 2007. Enzymatic esterification of isoamyl alcohol obtained from fusel oil: Optimization by response surface methodology. Enzyme and Microbial Technology 40:778-785. 28. Hadzir, N. M., Basri, M., Rahman, M. B. A., Razak, C. N. A., Rahman, R. N. Z. A., Salleh, A. B. 2001. Enzymatic alcoholysis of triolein to produce wax ester. Journal of Chemical Technology and Biotechnology 76:511-515. 29. Isono, Y., Nabetani, H., Nakajima, M. 1995.

Lipase-surfactant complex as catalyst of interificantion and esterification in organic media. Journal of Fermentation and Bioengineering 2:170-175. 30. Joeng, G. T. and park, D. H. 2006. Response surface methodological approach for optimization of enzymatic synthesis of sorbitan methacrylate. Enzyme and Microbial Technology 39:381-386. 31. Kiran, K. R., Manohar, B. and Divakar S. 2001. A central composite rotatable design analysis of lipase catalyzed synthesis of lauroyl lactic acid at bench-scale level. Enzyme and microbial technology 29 122-128. 32. Kim, B. H. and Akoh C. C. 2007. Modeling and optization of lipase-catalyzed synthesis of phytosteryl ester of oleic acid by response surface methodology. Food Chemistry 102:336-342. 33. Kim, M. S., Kim, J. S., You, Y. H., Park, H.J., Lee, S., Park, J. S., and Hwang, S. J. 2007. Development and optimization of a novel oral controlled delivery system for tamsulosin hydrochloride using response surface methodology. International Journal of Pharmaceutics 341:97-104. 34. Palocci, C., Falconi, M., Chronopoulou L. and Cernia, E. 2008. Lipase-catalyzed regioselective acylation of tritylglycosides in supercritical carbon dioxide. Journal of Supercritical Fluids 45:88-93. 35. Petersson, A. E. V., Gustafsson, L. M., Nordblad, M., Borjesson, P., Mattiasson, B. and Adlercreutz, P. 2005. Wax esters produced by solvent-free energy-efficient enzymatic synthesis and their applicability as wood coatings. Green Chemistry 7:837-843. 36. Radzi, S. M., Basri, M., Salleh, A.B., Ariff, A., Mohammad, R., Abd. Rahman, M. B., and Abd. Rahman, R. N.Z.R. 2005. High performance enzymatic synthesis of oleyl oleate using immobilized lipase from Candida antartica. Electronic Journal of Biotechnology 8:292-298. 37. Rajendran, A. and Thangavelu, V. 2007. Sequential optimization of culture medium composition for extracellular lipase production by Bacillus sphaericus using statistical methods. Journal of Chemical Technology and Biotechnology 82:460-470. 38. Salis, A., Solinas, V. and Monduzzi, M. 2003. Wax esters synthesis from heavy fraction of sheep milk fat and cetyl alcohol by immobilized lipase. Journal of Molecular Catalysis B: Enzymatic 21:167-174. 39. Shih, I. L., Hung S. H., Chen, F. Y., Ju, H. Y., Shieh, C. J. 2007. Optimized synthesis of lipase-catalyzed L-menthyl butyrate by Candia rugosa lpase. Food Chemistry 100:1223-1228. 40. Torres, C. and Otero, C. 1999. Part I. Enzymeatic synthesis of lactate and glycolate esters of fatty alcohols. Enzyme and Microbial Technology 25:745-752. 41. Villeneuve, P., Muderhwa, J. M., Graille, J., Haas, M. J., 2000. Customizing lipases for biocatalysis: a survey of chemical, physical and molecular biological approaches. Journal of Molecular Catalysis B: Enzymatic 9: 113 – 148. 42. Wissing, S.A. and Muller, R. H. 2002. Solid lipid nanoparticles as carrier for sunscreens: in vivo skin penetration. Journal of Controlled Release 81:225-233.