Unlicensed Published by De Gruyter July 21, 2021

Rendering waste oil as a new source for the synthesis of emulsifier: optimization, purification, and characterization

Meryem Göksel Saraç and Mahmut Doğan

From the journal International Journal of Food Engineering
https://doi.org/10.1515/ijfe-2020-0250

Abstract

The enzymatic glycerolysis conditions in the production emulsifier by using the rendering waste oil were optimized in the present study. The effects of changes in duration (1–27 h), temperature (50–80 °C), enzyme (5–20%), and glycerol (5–20%) concentration, addition of solvent (acetone, acetonitrile, chloroform, methanol, ethanol, and tert-butanol) and water addition (3.5% of glycerol rate), and ultrasound application on the enzymatic glycerolysis reaction medium for mono- and diglyceride production were investigated. After determining the optimum conditions, the effects of the ultrasonic bath on the physic-chemical and rheological properties of emulsifier, the oxidation tests were examined. Using the preparative column chromatography method, three different emulsifier compositions were achieved and named E100, E50-50, and E50-40-10 by their monoglyceride, diglyceride, and triglyceride contents, respectively. Then, the post-purification emulsion properties and rheological behaviors of emulsifier samples were determined. E50-40-10 emulsifier was found to be the best sample in terms of rheological properties and emulsion stability.

Keywords: enzymatic glycerolysis; emulsifier; rendering waste oil; solvent; ultrasound

Corresponding author: **Mahmut Doğan**, Department of Food Engineering, Erciyes University, Engineering College, Kayseri, Turkey, E-mail: dogan@erciyes.edu.tr

Funding source: Erciyes Üniversitesi10.13039/501100003062

Award Identifier / Grant number: FDK-2013-4561

Funding source: Türkiye Bilimsel ve Teknolojik Araştirma Kurumu10.13039/501100004410

Award Identifier / Grant number: BİDEB 2211-C

Author contributions: All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.

Research funding: I'd like to thank Erciyes University's Scientific Research Projects Coordination Unit (Project No: FDK-2013-4561) and Scientific and Technical Research Council of Turkey (TUBITAK) within the scope of BİDEB 2211-C National Doctoral Fellowship Program for the Priority Domains for their financial support in this thesis study.

Conflict of interest statement: The authors declare no conflicts of interest regarding this article.

References

1. ISEO. Food fats and oils; 2006. pp. 44.
http://www.iseo.org/.
Search in Google Scholar

2. Devi, B, Zhang, H, Damstrup, ML, Guo, Z, Zhang, L, Lue, BM, et al.. Enzymatic synthesis of designer lipids. *OCL-Ol Corps Gras Lipides* 2008;15:189–95.
https://doi.org/10.1051/ocl.2008.0194.
Search in Google Scholar

3. Ferreira-Dias, S, Correia, AC, Baptista, FO, Da Fonseca, MMR. Contribution of response surface design to the development of glycerolysis systems catalyzed by commercial immobilized lipases. *J Mol Catal-B Enzym* 2001;11:699–711.
https://doi.org/10.1016/s1381-1177(00)00079-5.
Search in Google Scholar

4. Gunstone, FD. Enzymes as biocatalysts in the modification of natural lipids. *J Sci Food Agric* 1999;79:1535–49.
https://doi.org/10.1002/(sici)1097-0010(199909)79:12<1535::aid-jsfa430>3.0.co;2-7.
10.1002/(SICI)1097-0010(199909)79:12<1535::AID-JSFA430>3.0.CO;2-7
Search in Google Scholar

5. Xu, X. Biocatalysis for lipid modifications. In: Dunford, NT, Dunford, HB, editors. *Nutritionally enhanced edible oil and oilseed processing*. Champaign, Illinois: AOCS Press; 2004:239–63 pp.
10.1201/9781439822272.ch14
Search in Google Scholar

6. Bornscheuer, UT. Lipase-catalyzed syntheses of monoacylglycerols. *Enzyme Microb Tech* 1995;17:578–86.
https://doi.org/10.1016/0141-0229(94)00096-a.
Search in Google Scholar

7. Damstrup, ML, Jensen, T, Sparso, FV, Kiil, SZ, Jensen, AD, Xu, X. Solvent optimization for efficient enzymatic monoacylglycerol production based on a glycerolysis reaction. *J Am Oil Chem Soc* 2005;82:559–64.
https://doi.org/10.1007/s11746-005-1109-y.
Search in Google Scholar

8. Corzo-Martínez, M, Vázquez, L, Arranz-Martínez, P, Menéndez, N, Reglero, G, Torres, CF. Production of a bioactive lipid-based delivery system from ratfish liver oil by enzymatic glycerolysis. *Food Bioprod Process* 2016;100:311–22.

https://doi.org/10.1016/j.fbp.2016.08.003.
Search in Google Scholar

9. Pawongrat, R, Xu, X, H-Kittikun, A. Synthesis of monoacylglycerol rich in polyunsaturated fatty acids from tuna oil with immobilized lipase AK. *Food Chem* 2007;104:251–8.
https://doi.org/10.1016/j.foodchem.2006.11.036.
Search in Google Scholar

10. Monteiro, JB, Nascimento, MG, Ninow, JL. Lipase-catalyzed synthesis of monoacylglycerol in a homogeneous system. *Biotechnol Lett* 2003;25:641–4.
https://doi.org/10.1023/a:1023016215537.
10.1023/A:1023016215537
Search in Google Scholar

11. Barouh, N, Piombo, G, Goli, T, BarÉa, B, Pina, M, Lago, R, et al.. Enzymatic production of conjugated linoleic acid monoacylglycerols from dehydrated isomerized castor bean oil. *J Food Lipids* 2008;15:13–27.
https://doi.org/10.1111/j.1745-4522.2007.00099.x.
Search in Google Scholar

12. Yang, T, Rebsdorf, M, Engelrud, U, Xu, X. Enzymatic production of monoacylglycerols containing polyunsaturated fatty acids through an efficient glycerolysis system. *J Agric Food Chem* 2005;53:1475–81.
https://doi.org/10.1021/jf048405g.
Search in Google Scholar

13. Fiametti, KG, Rovani, S, De Oliveira, D, Corazza, ML, Treichel, H, Oliveira, JV. Kinetics of solvent-free lipase-catalyzed production of monoacylglycerols from olive oil in aerosol-OT surfactant. *Ind Eng Chem Res* 2009;48:708–12.
https://doi.org/10.1021/ie8013956.
Search in Google Scholar

14. Yang, T, Rebsdorf, M, Engelrud, U, Xu, X. Monoacylglycerol synthesis via enzymatic glycerolysis using a simple and efficient reaction system. *J Food Lipids* 2005;12:299–312.
https://doi.org/10.1111/j.1745-4522.2005.00025.x.
Search in Google Scholar

15. Ahmed, J, Ramaswamy, HS, Kasapis, S, Boye, JI. *Novel Food Processing: Effects on Rheological and Functional Properties*. USA: CRC Press; 2009.
Search in Google Scholar

16. Awad, TS, Moharram, HA, Shaltout, OE, Asker, D, Youssef, MM. Applications of ultrasound in analysis, processing and quality control of food: a review. *Food Res Int* 2012;48:410–27.
https://doi.org/10.1016/j.foodres.2012.05.004.
Search in Google Scholar

17. Salazar, J, Chávez, JA, Turó, A, García-Hernández, MJ. *Effects on Rheological and Functional Properties*. Boca Raton, USA: CRC Press; 2009.
Search in Google Scholar

18. Franco, DA, Swanson, W. The original recyclers. In: *The Animal Protein Producers Industry: The Fats & Proteins*. Research Foundation: The National Renderers Association; 1996.
Search in Google Scholar

19. Romans, JR, Costello, WJ, Carlson, CW, Greaser, ML, Jones, KW. Packing house by products. In: *The Meat We Eat*. Danville, Illinois: Interstate Publishers, Inc; 2001.
Search in Google Scholar

20. Fregolente, PBL, Fregolente, LV, Pinto, GMF, Batistella, BC, Wolf-Maciel, MR, Filho, RM. Monoglycerides and diglycerides synthesis in a solvent-free system by lipase-catalyzed glycerolysis. *Appl Biochem Biotechnol* 2008;146:165–72.
https://doi.org/10.1007/s12010-008-8133-3.
Search in Google Scholar

21. Fregolente, PBL, Pinto, GMF, Wolf-Maciel, MR, Filho, RM. Monoglyceride and diglyceride production through lipase-catalyzed glycerolysis and molecular distillation. *Appl Biochem Biotechnol* 2010;160:1879–87.
https://doi.org/10.1007/s12010-009-8822-6.
Search in Google Scholar

22. Naik, MK, Naik, SN, Mohanty, S. Enzymatic glycerolysis for conversion of sunflower oil to food based. *Catal Today* 2014;237:145–9.
https://doi.org/10.1016/j.cattod.2013.11.005.
Search in Google Scholar

23. AOAC. *Official Methods of Analysis*, 17th ed. Washington: Association of Official Analytical Chemists;
Search in Google Scholar

24. Yıldırım, G. *Effect of storage time on olive oil quality*. İzmir: İzmir Institute of Technology; 2009.
Search in Google Scholar

25. Aslan, D, Dogan, M. The influence of ultrasound on the stability of dairy-based, emulsifier-free emulsions: rheological and morphological aspect. *Eur Food Res Technol* 2018;244:409–21.
https://doi.org/10.1007/s00217-017-2966-3.
Search in Google Scholar

26. Firebaugh, JD, Daubert, CR. Emulsifying and foaming properties of a derivatized whey protein ingredient. *Int J Food Prop* 2005;8:243–53.
https://doi.org/10.1081/jfp-200060245.
Search in Google Scholar

27. Gadhave, A. Determination of hydrophilic-lipophilic balance value. *Int J Sci Res* 2014;3:573–5.
Search in Google Scholar

28. Yaman, T, Sung, TK, Katsuyoshi, KYK. High-yield diacylglycerol formation by solid-phase enzymatic glycerolysis of hydrogenated beef tallow. *J Am Oil Chem Soc* 1994;71:339–42.
https://doi.org/10.1007/bf02638064.
Search in Google Scholar

29. Krüger, RL, Valério, A, Balen, M, Ninow, JL, Oliveira, JV, de Oliveira, D, et al.. Improvement of mono and diacylglycerol production via enzymatic glycerolysis in tert-butanol system. *Eur J Lipid Sci Technol* 2010;112:921–7.
https://doi.org/10.1002/ejlt.200900253.
Search in Google Scholar

30. Zhong, N, Li, L, Xu, X, Cheong, LZ, Zhao, X, Li, B. Production of diacylglycerols through low-temperature chemical glycerolysis. *Food Chem* 2010;122:228–32.
https://doi.org/10.1016/j.foodchem.2010.02.067.
Search in Google Scholar

31. Solaesa, ÁG, Sanz, MT, Melgosa, R, Beltrán, S. Substrates emulsification process to improve lipase-catalyzed sardine oil glycerolysis in different systems. Evaluation of lipid oxidation of the reaction products. *Food Res Int* 2017;100:572–8.
https://doi.org/10.1016/j.foodres.2017.07.048.
Search in Google Scholar

32. Valério, A, Fiametti, KG, Rovani, S, Franceschi, E, Corazza, ML, Treichel, H, et al.. Enzymatic production of mono- and diglycerides in compressed n-butane and AOT surfactant. *J Supercrit Fluids* 2009;49:216–20.
https://doi.org/10.1016/j.supflu.2009.02.001.
Search in Google Scholar

33. Watanabe, T, Shimizu, M, Sugiura, M, Sato, M, Kohori, J, Yamada, N, et al.. Optimization of reaction conditions for the production of DAG using immobilized 1,3-regiospecific lipase lipozyme RM IM. *J Am Oil Chem Soc* 2003;80:1201–7.
https://doi.org/10.1007/s11746-003-0843-5.
Search in Google Scholar

34. Wang, X, He, L, Huang, J, Zhong, N. Immobilization of lipases onto the halogen & haloalkanes modified SBA-15: enzymatic activity and glycerolysis performance study. *Int J Biol Macromol* 2021;169:239–50.
https://doi.org/10.1016/j.ijbiomac.2020.12.111.
Search in Google Scholar

35. Kaewthong, W, H-Kittikun, A. Glycerolysis of palm olein by immobilized lipase PS in organic solvents. *Enzym Microb Technol* 2004;35:218–22.
https://doi.org/10.1016/j.enzmictec.2004.04.011.
Search in Google Scholar

36. Cheong, LZ, Tan, CP, Long, K, Yusoff, MSA, Arifin, N, Lo, SK, et al.. Production of a diacylglycerol-enriched palm olein using lipase-catalyzed partial hydrolysis: optimization using response surface methodology. *Food Chem* 2007;105:1614–22.
https://doi.org/10.1016/j.foodchem.2007.03.070.
Search in Google Scholar

37. Yesiloglu, Y, Kilic, I. Lipase-catalyzed esterification of glycerol and oleic acid. *J Am Oil Chem Soc* 2004;81:281–4.
https://doi.org/10.1007/s11746-004-0896-5.
Search in Google Scholar

38. Piyatheerawong, W, Iwasaki, Y, Xu, X, Yamane, T. Dependency of water concentration on ethanolysis of trioleoylglycerol by lipases. *J Mol Catal B Enzym* 2004;28:19–24.
https://doi.org/10.1016/j.molcatb.2004.01.008.
Search in Google Scholar

39. Fiametti, KG, Sychoski, MM, De Cesaro, A, Furigo, A, Bretanha, LC, Pereira, CMP, et al.. Ultrasound irradiation promoted efficient solvent-free lipase-catalyzed production of mono- and diacylglycerols from olive oil. *Ultrason Sonochem* 2011;18:981–7.
https://doi.org/10.1016/j.ultsonch.2010.11.010.
Search in Google Scholar

40. Babicz, I, Leite, SGF, de Souza, R, Antunes, OAC. Lipase-catalyzed diacylglycerol production under sonochemical irradiation. *Ultrason Sonochem* 2010;17:4–6.
https://doi.org/10.1016/j.ultsonch.2009.07.005.
Search in Google Scholar

41. Paradiso, VM, Giarnetti, M, Summo, C, Pasqualone, A, Minervini, F, Caponio, F. Production and characterization of emulsion filled gels based on inulin and extra virgin olive oil. *Food Hydrocolloids* 2015;45:30–40.
https://doi.org/10.1016/j.foodhyd.2014.10.027.
Search in Google Scholar

42. Chemat, F, Grondin, I, Sing, ASC, Smadja, J. Deterioration of edible oils during food processing by ultrasound. *Ultrason Sonochem* 2004;11:13–5.
https://doi.org/10.1016/s1350-4177(03)00127-5.
Search in Google Scholar

43. Teh, SS, Birch, J. Physicochemical and quality characteristics of cold-pressed hemp, flax and canola seed oils. *J Food Compos Anal* 2013;30:26–31.
https://doi.org/10.1016/j.jfca.2013.01.004.
Search in Google Scholar

44. Srimiati, M, Kusharto, CM, Tanziha, I, Suseno, SH. Effect of different bleaching temperatures on the quality of refined catfish (Clarias gariepinus) oil. *Procedia Food Sci* 2015;3:223–30.
https://doi.org/10.1016/j.profoo.2015.01.025.
Search in Google Scholar

45. Kantekin Erdogan, MN. *Effect of partial glycerides on the stability and rheology of mayonnaise*. Ankara: Ankara University; 2014.
Search in Google Scholar

46. Çelebi, N. Emülsiyonlar. In: *Modern Farmosetik Teknolojisiodern Farmosetik Teknolojisi*. Ankara: Türk Eczacılar Birliği Eczacılık Akademisi Yayını; 2009:277–9 pp.
Search in Google Scholar

Supplementary Material

The online version of this article offers supplementary material (https://doi.org/10.1515/ijfe-2020-0250).

Received: 2020-10-05
Accepted: 2021-06-19
Published Online: 2021-07-21

Articles in the same Issue

Subjects

Architecture and Design

Arts

Asian and Pacific Studies

Business and Economics

Chemistry

Classical and Ancient Near Eastern Studies

Computer Sciences

Cultural Studies

Engineering

General Interest

Geosciences

History

Industrial Chemistry

Islamic and Middle Eastern Studies

Jewish Studies

Law

Library and Information Science, Book Studies

Life Sciences

Linguistics and Semiotics

Literary Studies

Materials Sciences

Mathematics

Medicine

Music

Pharmacy

Philosophy

Physics

Social Sciences

Sports and Recreation

Theology and Religion

Services

For journal authors

For book authors

For librarians

Rights & Permissions

Publications

Publication types

Open Access

About

Contact

Career

About De Gruyter

Partnerships

Press

New website FAQs

Winner of the OpenAthens Best Publisher UX Award 2022