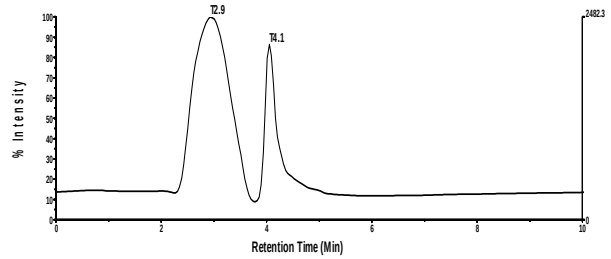

Fig. 17. Chromatogram of an extract of HSYDC separated by MF membrane at T2.9 and T4.1 with retention time 0 – 10 minutes.

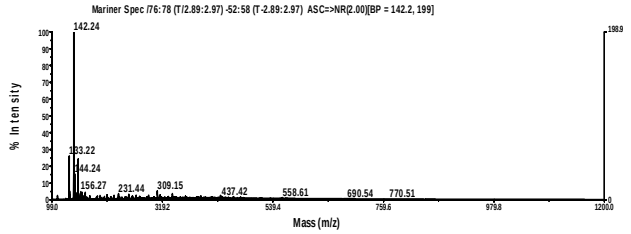

Fig. 18. Mass spectra range m/z 99 – 1200 of HSYDC extract separated by MF membrane.

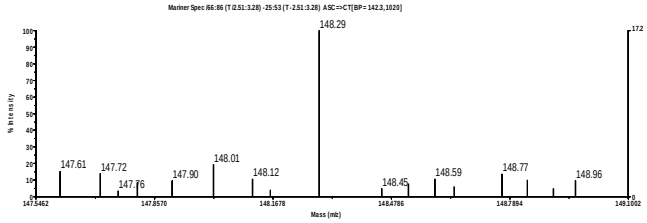

Fig. 19. Mass spectra for the glutamic acid monomer of HSYDC extract separated by MF membrane at T2.9.

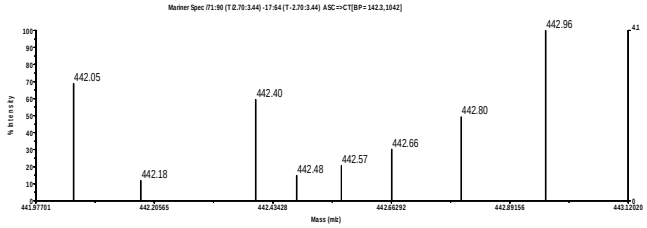

Fig. 20. Mass spectra for the folic acid monomer of HSYDC extract separated by MF membrane at T2.9.

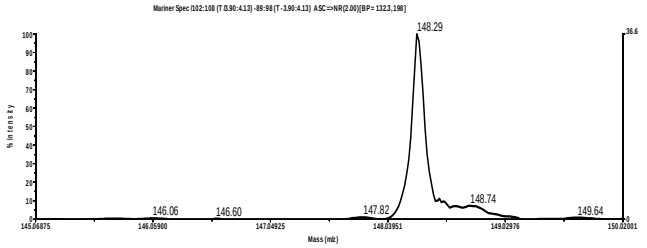

Fig. 21. Mass spectra for the glutamic acid monomer of HSYDC extract separated by MF membrane at T4.1.

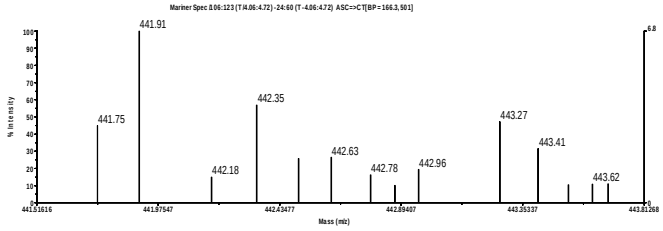

Fig. 22. Mass spectra for the folic acid monomer of HSYDC extract separated by MF membrane at T4.1.

IV. Conclusion

Both MF and UF processes can effectively be used to separate and recover folic acid as a target and desired component from HSYDC and HSWDC. Based on one of the most important membrane performances, the highest permeate flux was achieved by MF membrane (0.45 µm) operated at 400 rpm and TMP 40 psia using HSYDC due to larger pores size compared with UF membrane and gave 0.0534 mL/cm2.min. Meanwhile, based on other one of the most important membrane performances, the highest recovery of folic acid from HSYDC feed or retentate was obtained via UF membrane operated at 400 rpm and TMP 40 psia using HSYDC and gave 92.92 µg/mL. The UF membrane has a better performance compared to the MF membrane. To recovery target and desired components from HSYDC maximally, such as folic acid (MW 441), HSYDC containing folic acid was filtered firstly using the membrane of largest pore size (MF membrane) followed by concentration and recovery of by UF membrane.

The conclusion for selecting a proper membrane for downstream processing of agricultural products-based hydrolysis and fermentation broth depends on the average size of the desired components, and on the reusability of the membrane and broth for further fermentation steps. Based on permeate flux, identification on the monomer in HSYDC from the optimum condition of UF membrane showed recoveries of a monomer of glutamic acid with MWs of 148.49 and 148.32 Da. and relative intensities of 100 % and 100 %, respectively, and a monomer of folic acids with MW of 442.6 Da. and 441.24 Da. Meanwhile, on HSYDC introduced to MF membrane using fitting in SFC was recovered monomer of glutamic acid with MW of 148.29 Da. and relative intensity of 100 %, and a monomer of folic acid with MWs of 442.98 Da. and 441.91 Da. and relative intensities of 100 % and 100 % relating with the best mass spectra.

References

[1] R.V. Reis and A.L. Zydney, "Bioprocess membrane technology," *Journal of Membrane Science.* 297, pp.16.2007.

[2] B. Bhayani, I.R. Yasarla and B.V. Ramarao, "Membrane filtration of lignocellulosic hydrolysates: Comparison of crossflow and dead-end microfiltration," *Center for Energy Initiatives (CEI),* American Institute of Chemical Engineers (AlChE). October 18, 2011.

[3] FDA News Release, FDA approves folic acid fortification of corn masa flour. April 14, 2016.

[4] J.S. Phale and Y.J. Chendake, "Polysulfone based Ultrafiltration Membrane Preparation by Phase Inversion: Parameter Optimization," *International Journal of Science and Research (IJSR),* June 2016.

[5] I. Ahmed, "High-performance UF polyester - polysulfone membrane," [Ph.D. Thesis]. University Technology Malaysia, Malaysia. 2009.

[6] L.L. Ngoc and S.P. Nunes, "Materials and membrane technologies for water and energy sustainability," *Journal of Sustainable Materials and Technologies,* 7, pp.5. 2016.

[7] NIST. National Institute of Standards and Technology (NIST) Chemistry WebBook, SRD 69, U.S.A. 2017.

[8] O.J. Olsen, "Operating Manual of DSS LabUnit M20," *Danish Separation Systems AS,* DK-4900 Nakskov, Denmark. January 2000.

[9] A.L. Zydney, *High-Performance Ultrafiltration Membranes: Pore Geometry and Charge Effects,* in S.T. Oyama and S.M. Stagg-Williams (Eds.). Membrane Science and Technology, Elsevier, Amsterdam, Vol. 14, pp.333. 2011.

[10] P. Kumar, N. Sharma, R. Ranjan, S. Kumar, Z.F. Bhat, and D.K. Jeong, "Perspective of Membrane Technology in Dairy Industry: A Review," *Asian-Australasian Journal of Animal Sciences (AJAS)*, 26 (9), pp.1347. 2013. DOI: http://dx.doi.org/10. 5713/ajas.2013.13082.

[11] W.J. Koros, Y.H. Ma and T. Shimidzu, T. "Terminology for membranes and membrane process (IUPAC Recommendations 1996)," *Journal of Membrane Science*, 120, pp.149. 1996.

[12] D. Onggo, "General Principles in Electrospray Mass Spectrometry: A New Technique in Mass Spectral Analysis," *Journal of Mass Spectrum*, Vol. 3, No. 2, pp.115. Accessed on February 3, 2013.

[13] MILLIPORE, "Catalogue and Product Information of Stirred Ultrafiltration Cell," *Amicon Bioseparation, MILLIPORE*, Bedford, U. S. A. www.millipore.com. 2008.

[14] A.O.A.C., "Official Methods of Analysis," *Association of Official Analytical Chemists International*, 20th. Edition, Washington D. C. 2016.

[15] W. Ruengsitagoon and N. Hattanat, *Simple spectrophotometric method for determination of folic acid. The 4th Annual Northeast Pharmacy Research Conference*, Thailand. 2012.

[16] P. Eichhorn and T.P. Knepper, "Electrospray ionization mass spectrometric studies on the amphoteric surfactant cocamidopropylbetaine," *Journal of Mass Spectrum*, 36 (6), pp.677 – 84. June 2001. DOI: 10.1002/jms.170.

[17] A. Susilowati, Y.M. Iskandar, H. Melanie, Y. Maryati, P.D. Lotulung and D.G. Aryani, "Pengembangan konsentrat sayuran hijau dan kacang-kacangan terfermentasi pada jagung (*Zea mays* L.) pramasak sebagai sumber asam folat untuk formula pangan pintar," *Laporan Hasil Penelitian, Program Tematik, Kedeputian IPT*, Pusat Penelitian Kimia – LIPI, Kawasan PUSPIPTEK, Serpong, Tangerang Selatan. 2016.

[18] N.A. Rodríguez-Martínez, M.G. Salazar-García, B.R. Wong, A.R. Islas-Rubio, L.C. Platt-Lucero, Morales-Rosas, R. Marquez-Melendez and F. Martínez-Bustos, "Effect of Malting and Nixtamalization Processes on the Physicochemical Properties of Instant Extruded Corn Flour and Tortilla Quality," *Plant Foods Hum. Nutr*. 70, pp.275. Published online: 10 June 2015. Springer Science+Business Media New York. DOI : 10.1007/s 11130-015-0490-9. CrossMark.

[19] A.S. Grandison and M.J. Lewis, *Separation Processes in the Food and Biotechnology Industries: Principles and Applications.* Technomic Publishing Company Inc., Lancaster, Pennsylvania, U.S.A. First publication. 1996.

[20] D. Mancinelli and C. Hallé, "Nano-Filtration and Ultra-Filtration Ceramic Membranes for Food Processing: A Mini Review," *Journal of Membrane Science and Technology*, Vol. 5, Issue 2. 2015. http://dx.doi.org/10. 4172/2155-9589.1000140.