



BAB 5

KESIMPULAN DAN SARAN

5.1 Kesimpulan

Kesimpulan yang dapat diambil dari penelitian ini adalah:

1. Pada tingkat kepercayaan 95% jenis pelarut berpengaruh terhadap rendemen minyak spirulina dari proses ekstraksi minyak spirulina sp.
2. Perolehan tertinggi didapatkan dari jenis pelarut metanol dengan:
 - a. Rendemen sebesar 11,06 g/100 g spirulina
 - b. Bilangan asam lemak bebas sebesar 26,21 g/100 g sampel
 - c. Bilangan penyabunan sebesar 31,92 g KOH/100 g sampel
 - d. Bilangan iodin sebesar 211,12 g Iod/100 g sampel

5.2 Saran

Saran yang dapat diberikan pada penelitian selanjutnya adalah:

1. Disrupsi sel dapat dilakukan dengan metode lain seperti homogenasi atau sonifikasi untuk mencapai rendemen minyak yang lebih tinggi.
2. Ekstraksi minyak dapat dilakukan bersamaan dengan disrupsi sel menggunakan alat ekstraktor yang telah dipasang pemancar ultraviolet untuk disrupsi sel sehingga dapat mempersingkat waktu ekstraksi.
3. Minyak yang dihasilkan dapat dilakukan proses pemurnian seperti pemisahan gum, *refining*, *bleaching*, dan *deodorising* untuk mendapat kualitas minyak yang diinginkan.
4. Dicari metode ekstraksi yang lebih ekonomis sehingga dapat diaplikasikan untuk skala pilot maupun industri.
5. Sebaiknya analisa dilakukan dalam waktu maksimal 1x24 jam setelah dilakukan ekstraksi dan dengan penyimpanan minyak yang benar sehingga minyak tidak mengalami oksidasi atau pencemaran lain yang dapat mempengaruhi hasil analisa kualitas minyak.



DAFTAR PUSTAKA

- [1] "Global Pertol Prices," 7 Oktober 2015. [Daring]. Tersedia: <http://www.globalpetrolprices.com/articles/39/>. [Diakses 21 September 2017].
- [2] "BP Statistical Review of World Energy," BP p.l.c., Juni 2017. [Daring]. Tersedia: <https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf>. [Diakses 21 September 2017].
- [3] "Organic Facts," 2017. [Daring]. Tersedia: <https://www.organicfacts.net/vegetable-oils.html>. [Diakses 21 September 2017].
- [4] Examine, "Spirulina," [Daring]. Tersedia: <https://examine.com/supplements/spirulina/>. [Diakses 21 September 2017].
- [5] M. Rosenthal, "Algae Industry Project Book 2013," Algae Biomass Organization, 2013.
- [6] PR Newswire, "Spirulina Market to Reach US\$ 1,855.8 Mn Value by end of 2026 - Persistence Market Research," *Proquest*, 2017.
- [7] M. Parvin and M. A. B. Habib, "A Review on Culture, Production and Use of Spirulina as Food for Humans and Feeds for Domestic Animals and Fish," *FOA Fisheries and Aquaculture*, vol. 1034, pp. 1-10, 2008.
- [8] Algae Industry Magazine, "Algae Industry Magazine," 2017. [Daring]. Tersedia: www.algaeindustrymagazine.com. [Diakses 5 November 2017].
- [9] S. R. Medipally, F. M. Yusof, S. Banerjee and M. Shariff, "Microalgae as Sustainable Renewable Energy Feedstock for Biofuel Production," *BioMed Research International*, vol. 2015, no. Article ID 519513, pp. 1-13, 2015.
- [10] A. Wati and S. A. Motto, "Ekstraksi Minyak dari Mikroalga Jenis *Chlorella* sp Berbantuan Ultrasonik," Universitas Diponegoro, Semarang.

- [11] A. Rahman and K. Nahar, "Production and Characterization of Algal Biodiesel from *Spirulina Maxima*," *Global Journals*, vol. 16, no. 1, 2016.
- [12] O. Rachmaniah, E. Y. R. and D. H. W., "Algae *Spirulina Sp.* Oil Extraction Method Using The Osmotic and Percolation and The Effect on Extractable Components," *e-journal UPN veteran jatim*, 2010.
- [13] H. Kanda, P. Li, M. Goto and H. Makino, "Energy-Saving Lipid Extraction from Wet *Euglena gracilis* by the Low-Boiling-Point Solvent Dimethyl Ether," *energies*, vol. 8, pp. 610-620, 2015.
- [14] H. El Shimi, N. Attia, A. A. A. El Aal, G. I. El Sheltawy and G. I. El Diwani, "Quality Profile of *Spirulina-platensis* Oilgae Extraction for Biodiesel Production," *Research Paper*, vol. 5, no. 3, pp. 1-6, 2015.
- [15] J. V. Ambrozova, L. Misurcova, R. Vicha, L. Machu, D. Samek, M. Baron, J. Mlcek, J. Sochor and T. Jurikova, "Influence of Extractive Solvents on Lipid and Fatty Acids Content of Edible Freshwater Algal and Seaweed Products, the Green Microalga *Chlorella kessleri* and the Cyanobacterium *Spirulina platensis*," *molecules*, vol. 19, pp. 2344-2360, 2014.
- [16] O. Rachmaniah, R. D. Setyarini and L. Maulida, "Pemilihan Metode Ekstraksi Minyak Alga dari *Chlorella sp.* dan Prediksinya sebagai Biodiesel," Institut Teknologi Sepuluh Nopember, Surabaya, 2010.
- [17] S. Amini and S. , "Kandungan Minyak Mikroalga Jenis *Tetraselmis sp.* dan *Chlorella sp.* Berdasarkan Umur Pertumbuhannya," Balai Besar Riset Pengolahan Produk dan Bioteknologi Kelautan dan Perikanan, Jakarta.
- [18] S. Melanie and D. Fithriani, "Rendemen Minyak Dari Mikroalga *Spirulina sp.* dan *Chlorella sp.* Dengan Teknik Pemecahan Dinding Sel," 2015.
- [19] S. Baíasubramanian, J. D. Allen, A. Kanitkar and D. Boldor, "Oil Extraction from *Scenedesmus obliquus* Using a Continuous Microwave System - design, optimization, and quality characterization," *Elsevier*, vol. 102, pp. 3396-3403, 2011.

- [20] W. S. Barqi, "Pengambilan Minyak Mirkroalga Chlorella sp. dengan Metode Microwave Assisted Extraction," Universitas Negeri Semarang, Semarang, 2015.
- [21] W. A. Kristanti, S. S and N. Fachrizal, "Ekstraksi Minyak Nabati dari Mikroalga Scenedesmus sp. Menggunakan Gelombang Ultrasonik," Balai Besar Teknologi Energi, Badan Pengkajian dan Penerapan Teknologi, Tangerang, 2012.
- [22] UNILA, "Diggilib Unila," UNILA, [Daring]. Tersedia: <http://digilib.unila.ac.id/3686/16/BAB%20II.pdf>. [Diakses 28 Oktober 2017].
- [23] Holistik Health, "Spirulina," [Daring]. Tersedia: <http://holistikhealth.com/superfoods/spirulina/>. [Diakses Febuari 2017].
- [24] "Vista Ampliada," [Daring]. Tersedia: <http://www.google-earth.es/foros.php?t=1396>. [Diakses 28 Oktober 2017].
- [25] D. R. Amanatin, E. Rofidah and D. N. S. Rosady, "Produksi Protein Sel Tunggal (PST) Spirulina Sp. Sebagai Super Food Dalam Upaya Penanggulangan Gizi Buruk dan Kerawanan Pangan di Indonesia," *Institut Teknologi Sepuluh Nopember*, p. 7, 2013.
- [26] O. Ciferri, "Spirulina, the edible microorganism.," *Microbiological Reviews*, vol. 47, no. 4, pp. 551-578, 1983.
- [27] Pengertian Menurut Para Ahli, "Pengertian Inokulum," 2017. [Daring]. Tersedia: <http://www.pengertianmenurutparaahli.net/pengertian-inokulum/>. [Diakses 27 Maret 2017].
- [28] "China Fully Financial Investment Foundation," [Daring]. Tersedia: www.cnffif.hk. [Diakses 15 April 2017].
- [29] S. Bensehaila, A. Doumandji, L. Boutekrabt, H. Manafikhi, I. Peluso, K. Bensehaila, A. Kouache and A. Bensehaila, "The nutritional quality of Spirulina platensis of Tamanrasset, Algeria," *African Journal of Biotechnology*, vol. 14(19), pp. 1649-1654, 2015.

- [30] E. Koru, "Earth Food Spirulina (Arthrospira): Production and Quality Standarts," in *Food Additive*, Rijeka, InTech, 2012, pp. 191-202.
- [31] A. Presser, P. & G. Bruno, MS and MHS, "Vitamins," *Smart Supplementation*, pp. 1-3, 2009.
- [32] Nutrition Data, "Vegetables and Vegetable Products," [Daring]. Tersedia: <http://nutritiondata.self.com/facts/vegetables-and-vegetable-products/2765/2>. [Diakses Febuari 2017].
- [33] "Information supplied to FDA by industry as part of the VCRP FDA database," Food and Drug Administration (FDA), Washington, D.C, 2012.
- [34] J. Kestin, M. Sokolov and W. A. Wakeham, "Viscosity of Liquid Water in the Range -8°C to 150°C," *Brown University*, vol. 7, no. 3, pp. 1-8, 1978.
- [35] Wikipedia, "Palmitic Acid," [Daring]. Tersedia: https://en.wikipedia.org/wiki/Palmitic_acid#cite_note-chemister-5. [Diakses 15 April 2017].
- [36] N. Nita, D. Elfidasari, A. T. Perdana, N. Wulandari and W. Wijayanti, "Analisis Penggunaan dan Syarat Mutu Minyak Goreng pada Penjaja Makanan di Food Court UAI," *Jurnal AL-AZHAR INDONESIA SERI SAINS DAN TEKNOLOGI*, vol. 1, no. 3, pp. 147-154, 2012.
- [37] H. I. E. Shimi, N. K. Attia, A. A. A. Allah, S. T. E. Sheltawy and G. I. E. Diwani, "Quality Profile of Spirulina-platensis Oilgae Extraction for Biodiesel Production," *Research Paper*, vol. 5, no. 3, pp. 1-6, 2015.
- [38] "Minyak Kelapa Sawit Mentah (Crude Palm Oil)," *Standar Nasional Indonesia*, vol. 01, no. 2901, pp. 1-15, 2006.
- [39] Badan Standarisasi Nasional, "Cara Uji Minyak dan Lemak SNI 01-3555-1998," Badan Standarisasi Nasional, 1998.

- [40] Universitas Sumatera Utara, "Tinjauan Pustaka," [Daring]. Tersedia: <http://repository.usu.ac.id/bitstream/123456789/28630/4/Chapter%20II.pdf>. [Diakses 30 Maret 2017].
- [41] C. J. Rhodes, "Oil from algae; salvation from peak oil?," *Science Progress*, vol. 92, no. 1, pp. 39-90, 2009.
- [42] R. Zhang, P. X. Pham, S. Kook and A. R. Masri, "Influence of Carbon Chain Length on Biodiesel Combustion in an Optically Accessible Diesel Engine," in *20th Australasian Fluid Mechanics Conference*, Perth, 2016.
- [43] Defender Tuning, "500 Variable Rpm Steel Oil Expeller Press," [Daring]. Tersedia: <http://www.defendertuning.com.au/nf-500-variable-rpm-steel-oil-expeller-press.html>. [Diakses 25 April 2017].
- [44] G. N. Sapakale, S. M. Patil, U. S. Surwase and P. K. Bhatbhage, "Supercritical Fluid Extraction," *Int. J. Chem. Sci*, vol. 8, no. 2, pp. 729-743, 2010.
- [45] SCFE, "Supercritical Fluid Extraction Equipment," [Daring]. Tersedia: http://scfe.en.ecplaza.net/products/supercritical-fluid-extraction-equipment_1298561. [Diakses 25 April 2017].
- [46] H. V. Parekh, *Solvent Extraction of Vegetable Oils*, New Delhi: Indian Central Oilseeds Committee, 1958.
- [47] Muharniati, "Perbandingan Keunggulan Proses Ekstraksi Minyak Alga Sebagai Bahan Baku Pembuatan Biodiesel Alga," *Politeknik Bandung*, 2012.
- [48] Pubchem, [Daring]. Tersedia: <https://pubchem.ncbi.nlm.nih.gov/>. [Diakses 19 April 2017].
- [49] Ilmu Kimia, "Harga Bahan Kimia," [Daring]. Tersedia: <http://www.ilmukimia.co.id/p/harga-bahan-kimia.html>. [Diakses 24 April 2017].
- [50] E. R. Bäumlér, C. E. María and A. A. Carelli, "Extraction of sunflower oil using ethanol as solvent," *Journal of Food Engineering*, vol. 178, pp. 190-197, 2016.

- [51] S. F. Dias, D. G. Valente and J. M. Abreu, "Comparison between ethanol and hexane for oil extraction from *Quercus suber* L. fruits," vol. 54, no. 4, pp. 378-383, 2003.
- [52] H. I. El-Shimi, N. K. Attia, S. T. El-Sheltawy and G. I. El-Diwani, "Biodiesel Production from *Spirulina-Platensis* Microalgae by In-Situ Transesterification Process," *Journal of Sustainable Bioenergy Systems*, vol. 3, pp. 224-233, 2013.
- [53] Biomateindia, "Rotary Vacuum Evaporator," [Daring]. Tersedia: <http://biomateindia.tradeindia.com/rotary-vacuum-evaporator-1569321.html>. [Diakses 26 April 2017].
- [54] E. Marina, "Kajian Perpindahan Massa pada Ekstraksi Minyak Biji Teh Menggunakan Pelarut Heksana," Universitas Katolik Parahyangan, Bandung, 2011.
- [55] BBC, "Using carbon fuel," BBC, 2014. [Daring]. Tersedia: http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway/carbon_chemistry/carbon_fuelsrev2.shtml. [Diakses 24 April 2018].
- [56] A. Rich and C. Rich, "Extraction of Chlorophyll and Carotenes from Spinach," University of Louisville, Louisville.
- [57] Geankoplis, "Chapter 3 Separation Processes (Unit operations)," The Hong Kong Polytechnic University, 23 Oktober 2006. [Daring]. Tersedia: http://www.polyu.edu.hk/edc/tdg/userfiles/file/490Q_ABCT/ICBPT_cht3Sep.pdf. [Diakses 29 November 2017].
- [58] "Lipid Extraction," [Daring]. Tersedia: <http://www.cyberlipid.org/extract/extr0001.htm#top>. [Diakses 26 April 2018].
- [59] A. D. Susanti, D. Ardiana, G. G. P. and Y. B. G., "Polaritas Pelarut Sebagai Pertimbangan Dalam Pemilihan Pelarut Untuk Ekstraksi Minyak Bekatul dari Bekatul Varietas Ketan," *Simposium Nasional RAPI XI FT UMS*, vol. 1412, no. 9612, pp. 1-7, 2012.
- [60] D. Agrawal, Interviewee, *Indian Institute of Petroleum (IIP)*. [Interview]. 2014.

- [61] Finar Chemicals, "HPLC Solvent Properties," [Daring]. Tersedia: http://www.finarchemicals.com/pdf/hplc_solvent_properties_solvent_miscibility_table.pdf. [Diakses 1 Juni 2018].
- [62] K. Budiono, "Pengaruh Jenis Pelarut (Metanol, Metanol-Air, Air), Temperatur dan Rasio F:S Terhadap Aktifitas Antioksidan Hasil Ekstraksi Kulit Buah Manggis," Fakultas Teknologi Industri UNPAR, Bandung, 2012.
- [63] S. P. Cuellar-Bermudez, I. Aguilar-Hernandez, D. L. Cardenas-Chavez, N. Ornelas-Soto, M. A. Romero-Ogawa and R. Parra-Saldivar, "Extraction and purification of high-value metabolites from microalgae: essential lipids, astaxanthin and phycobiliproteins," *Microbial Biotechnology*, vol. 8, no. 2, pp. 190-209, 2015.
- [64] B. Wiyarno, R. M. Yunus and M. Mei, "Extraction of Algae Oil from *Nannocloropsis* sp.: A Study of Soxhlet and Ultrasonic-Assisted Extractions," *Science Alert*, vol. 11, pp. 3607-3612, 2011.
- [65] U.S Pharmacopeia, "NF Monographs: Palmitic Acid," Mei 2017. [Daring]. Tersedia: <https://www.pharmacompass.com/jAssets/pdf/pubchem/Palmitic-Acid-Excipient-pubchem-1499251086.pdf>. [Diakses 1 Mei 2018].
- [66] A. Mancini, E. Imperlini, E. Nigro, C. Montagnese, A. Daniele, S. Orrù and P. Buono, "Biological and Nutritional Properties of Palm Oil and Palmitic Acid: Effects on Health," *Molecules*, vol. 20, pp. 17339-17361, 2015.
- [67] University of Central Missouri, "Gas Chromatography/Mass Spectroscopy (GC/MS/MS) Background Information," pp. 1-10, 2008.
- [68] M. A. Rahman, M. A. Aziz, R. A. Al-khulaidi, N. Sakib and M. Islam, "Biodiesel production from microalgae *Spirulina maxima* by two step process: Optimization of process variable," *Radiation Research and Applied Sciences*, pp. 1-8, 2017.
- [69] W. Muilbry, S. Kondrad, J. Buyer and L. D. Luthria, "Optimization of an Oil Extraction Process for Algae from the Treatment of Manure Effluent," *J Am Oil Chem Soc*, vol. 86, pp. 909-915, 2009.

- [70] G. Zheng, C. Li, L. Guo, W. Ruo and S. Wang, "Purification of Extracted Fatty Acids from the Microalgae *Spirulina*," *J Am Oil Chem Soc*, vol. 89, pp. 562-566, 2012.
- [71] S. R. Putri, I. M. Lutfi, MP and D. I. B. Susilo, M. Sc. Agr, "Ekstraksi Minyak dari Microalga Jenis *Chlorella* Sp. Dengan Menggunakan Metode Osmotik Berbantuan Ultrasonik," Universitas Brawijaya, Malang.
- [72] Y. Sato, S. Fujimoto, E. Mukai, H. Sato, Y. Tahara, K. Ogura, G. Yamano, M. Ogura, K. Nagashima and N. Inagaki, "Palmitate induces reactive oxygen species production and b-cell dysfunction by activating nicotinamide adenine dinucleotide phosphate oxidase through Src signaling," *Journal of Diabeter Investigation*, vol. 5, no. 1, pp. 19-26, 2014.
- [73] "Research Gate," Research Gate, [Daring]. Tersedia: https://www.researchgate.net/figure/283005167_fig1_Figure-1-Soxhlet-extraction-apparatus. [Diakses 17 April 2017].
- [74] A. U. Siregar, C. D. Hasibuan, H. S. Agustina and N. Yanthy, "Slide Share," [Daring]. Tersedia: <https://www.slideshare.net/hotnidadakanda/pemisahan-zat-dalam-organik>. [Diakses 20 April 2017].
- [75] W. Mulbry, S. Kondrad, J. Buyer and D. L. Luthria, "Optimization of an Oil Extraction Process for Algae from the Treatment of Manure Effluent," *J Am Oil Chem Soc*, vol. 86, pp. 909-915, 2009.
- [76] N. Kakko, N. Ivanova and A. Rantasalo, "Cell Disruption Methods," Aalto-yliopisto, Helsinki.
- [77] E. Ningsih, "Penentuan Kadar Bilangan Iodin dari RBD Palm Olein dengan Metode Pelarut Campuran n-Heksana-Asam Asetat dan Pelarut Campuran Sikliheksana-Asam Asetat," Universitas Sumatera Utara, Medan, 2008.
- [78] American Laboratory Trading, "American Laboratory Trading," [Daring]. Tersedia: http://americanlaboratorytrading.com/lab-equipment-products/dionex-ase-200-accelerated-solvent-extraction-system_10474. [Diakses 26 April 2017].

- [79] Healthy Eating, "Benefits Vitamins Minerals," [Daring]. Tersedia: <http://healthyeating.sfgate.com/benefits-vitamins-minerals-5991.html>. [Diakses Maret 2017].
- [80] Jalan Kemenangan Koe, "Gambar Alat Penyarian," [Daring]. Tersedia: <http://jalankemenangankoe.blogspot.co.id/2012/06/gambar-alat-penyarian.html>. [Diakses 26 April 2017].
- [81] W. R. Serth and G. T. Lestina, *Process Heat Transfer 2nd Edition*, Amsterdam: Academic Press, 2014.
- [82] A. S. Babadzhinov, N. Abdusamatova, F. M. Yusupova, N. Faizullaeva, L. G. Mezhlumyan and M. K. Malikova, "Chemical Composition of *Spirulina platensis* Cultivated in Uzbekistan," *Chemistry of Natural Compounds*, vol. 40, no. 3, pp. 276-277, 2004.
- [83] J. R. McMillan, I. A. Watson, M. Ali and W. Jaafar, "Evaluation and comparison of algal cell disruption methods: Microwave, waterbath, blender, ultrasonic and laser treatment," *Elsevier*, vol. 103, pp. 128-134, 2013.
- [84] C. Very, "Macam - Macam Pengaduk (Agitator)," 7 Oktober 2013. [Daring]. Tersedia: <https://www.caesarvery.com/2013/10/macam-macam-pengaduk-agitator.html>. [Diakses 24 April 2018].
- [85] H. Santoso, S.T., M.T.M., PhD, D. M. Inggrid, M.Sc. and D. I. J. R. Witono, M.App.Sc, "Pembuatan Biodiesel dari Minyak Biji Karet Menggunakan Katalis Berbahan Dasar Gula," *Lembaga Penelitian dan Pengabdian kepada Masyarakat UNPAR*, pp. 1-39, 2013.
- [86] H. Y. Shin, S. H. Shim, Y. J. Ryu, J. H. Yang, S. M. Lim and C. G. Lee, "Lipid Extraction from *Tetraselmis* sp. Microalgae for Biodiesel Production Using Hexane-based Solvent Mixtures," *Springer*, vol. 23, pp. 16-22, 2018.
- [87] K. Kusakabe, M. Ezaki and M. Nishida, "Selective Removal of Saturated Fatty Acid Methyl Ester from Biodiesel Fuel by Hot Water Treatment," *International Journal of Biomass & Renewables*, vol. 1, no. 4, pp. 1-4, 2015.

- [88] L. Yao and T. Wang, "Comparison of Lipid Extraction from Microalgae and Soybeans with Aqueous Isopropanol," *Journal of the American Oil Chemists Society*, p. April, 2013.
- [89] S. Kennedy, "DNA Precipitation: Ethanol vs. Isopropanol," BitesizeBio, 23 Juni 2015. [Daring]. Tersedia: <https://bitesizebio.com/2839/dna-precipitation-ethanol-vs-isopropanol/>. [Diakses 3 Mei 2018].
- [90] J. E. Wampler, "The 20 Amino Acids and Their Role in Protein Structures," *Protein Structures*, [Daring]. Tersedia: <https://proteinstructures.com/Structure/Structure/amino-acids.html>. [Diakses 6 Juni 2018].
- [91] N. Harimurti and D. Sumangat, "Aplikasi Fluida Superkritis Pada Ekstraksi Minyak Atsiri," *Prosiding Seminar Nasional Teknologi Inovatif Pascapanen untuk Pengembangan Industri Berbasis Pertanian*, pp. 801-810.