

BAB V

KESIMPULAN DAN SARAN



5.1 Kesimpulan

1. Kondisi kultur yang aktif menghasilkan konstanta kinetika pertumbuhan yang lebih besar dibandingkan kultur yang tidak aktif (konstanta kinetika pertumbuhan kultur 2 yang diperoleh sebesar 0,066 bernilai lebih besar dibandingkan konstanta kinetika pertumbuhan kultur 1, yaitu sebesar 0,034).
2. Bahan dari wadah yang digunakan sangat mempengaruhi pertumbuhan sel mikroalga.
3. Dengan adanya aerasi dapat meningkatkan laju pertumbuhan dan produktivitas sel *Nannochloropsis sp.*
4. Semakin tinggi konsentrasi NaNO_3 , laju pertumbuhan dan produktivitas sel *Nannochloropsis sp.* yang diperoleh juga akan meningkat.
5. Produktivitas maksimum diperoleh pada rancangan percobaan 4, yaitu variasi percobaan dengan adanya aerasi dan konsentrasi nutrisi sebesar $900 \mu\text{mol/L NaNO}_3$ sehingga diperoleh produktivitas sel *Nannochloropsis sp.* sebesar $4,355 \times 10^7$ sel/mL.

5.2 Saran

1. Sebelum dilakukan pengkultivasian, sebaiknya kultur dipastikan dalam keadaan aktif sehingga dapat menghasilkan kondisi kultur yang optimal.
2. Dalam pengkultivasian sebaiknya digunakan sumber cahaya yang mengandung UV A sehingga proses fotosintesis dapat terjadi.
3. Dalam pengkultivasian sebaiknya selalu menggunakan wadah berbahan dasar kaca agar seluruh cahaya dapat masuk ke setiap sel mikroalga.

DAFTAR PUSTAKA



- (n.d.). www.sigmaaldrich.com.
- Afifah, A. H. (2013). Efek Aerasi dan Konsentrasi Substrat pada Laju Pertumbuhan Alga Menggunakan Sistem Bioreaktor Proses Batch. *Jurnal Teknik Pomits*, Vol 2 (1).
- Afterburn, L. O. (2008). Algal-oil capsules and cooked salmon : nutritionally equivalent sources of docosahexaenoic acid. *J Am Diet Assoc.*, 108, 1204-1209.
- Antolovich, M. e. (2002). Methods for testing Antioxidant Activity. *Analyst*, 127, 183-198.
- Arnata, W. G. (2010). *Produksi biomassa dan potensi nutrisi mikroalga Nannochloropsis sp.*
- Arts, M. A. (2001). Essential fatty acids in aquatic ecosystems : a crucial link between diet and human health and evolution. *Can J Fish Aquat Sci*, 122-137.
- Atkin, S. B. (2006). Topical Formulations Containing Sporopollenin. Google Patents.
- Bagchi, K. P. (1998). Free radicals and antioxidants in health and disease. *East Mediteranian Health Jr.*, 350-360.
- Balat, M. (2009). Bioethanol as a vehicular fuel : a critical review. *Energy Sources, Part A*, 31, 1242-1255.
- Balskus, E. W. (2010). The genetic and molecular basis for sunscreen biosynthesis in cyanobacteria. *Science*, 1653-1656.
- Baquero, F. M.-L. (2008). Antibiotics and antibiotic resistance in water environments. *Curr. Opin. Biotechnol.*, 19, 260-265.
- Barsanti, L. G. (2006). *Algae : Anatomy, Biochemistry, and Biotechnology*. Boca Raton, USA: CRC Press.
- Bendif, E. P. (2013). On the description of *Tisochrysis lutea* gen. nov. sp. nov. and *Isochrysis nuda* sp. nov. in the Isochrysidales, and the transfer of *Dicrateria* to the Prymnesiales (Haptophyta). *J. Appl. Phycol*, 1763-1776.
- Benemann, J. (1989). Algal and Cyanobacterial Biotechnology . In *The Future of Microalgal Biotechnology* (pp. 317-337). Harlow, UK: Longman Scientific & Technical.
- Boopathy, N. K. (2010). Anticancer drugs from marine flora ; an overview. *J Oncol* .
- Borowitzka, M. (2013). High-value products from microalgae-their development and commercialisation.

- Brown, M. B. (1996). Biochemical Composition of New Yeasts and Bacteria evaluated as food for bivalve aquaculture.
- Cardozo, K. G. (2007). Metabolites from algae with economical impact. *Comp. Biochem. Physiol., Part C : Toxicol. Pharmacol.*, 146, 60-78.
- Carmichael, W. (2001). Health effects of toxin-producing cyanobacteria : the CyanoHabs. *Hum Ecol Risk Asseses*, 1393-1407.
- Carvalho, P. S. (2011). Light Requirements in Microalgal Photobioreactors : An Overview of Biophotonic Aspects. *Appl Microbiol Biotechnol*, 1275-1288.
- Chamorro, G. P.-A.-G.-S. (2006). Spirulina maxima pretreatment partially protects against 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine neurotoxicity. *Nutr. Neurosci.*, 9, 207-212.
- Cheeseman, K. S. (1993). An introduction to free radicals chemistry. *Br Med Bull*, 481-493.
- Chen, C.-Y. Z.-Q.-W.-H.-L.-J.-W.-S. (2013). Microalgae-based carbohydrates for biofuel production. *Biochem. Eng. J.*, 78, 1-10.
- Chisti, Y. (2007). Biodiesel from microalgae. *Biotechnol. Adv.*, 25, 294-306.
- Chu, W. (2011). Potential applications of antioxidant compounds from algae. *Curr Top Nutraceut Res*, 9, 83-98.
- Chu, W. P. (2002). Influence of irradiance and inoculum density in the pigmentation of *Spirulina platensis*. *Asia Pac J Mol Biol Biotechnol*, 10, 109-117.
- Chu, W.-L. (2012). Biotechnological applications of microalgae. *Suppl 1*, 6, S24-S37.
- Dabrowski, A. H. (2004). Selective removal of the heavy metal ions from waters and industrial wastewaters by ion-exchange method. *Chemosphere*, 56, 91-106.
- Dale, B. (2007). Thinking clearly about biofuels : ending the irrelevant 'net energy' debate and developing better performance metrics for alternative fuels. *Biofuels Bioprod. Biorefin.*, 1, 14-17.
- Dortch, Q. (1990). The Interaction Between Ammonium and Nitrate Uptake in Phytoplankton. *Marine Ecology Progress Series*, 183-201.
- Doughman, S. K. (2007). Omega-3 fatty acids for nutrition and medicine : considering microalgae oil as a vegetarian source of EPA and DHA. *Diabetes Rev.*, 3, 198-203.
- E. Molina-Grima, F. G.-C.-P.-F.-S. (1997). Evaluation of photosynthetic efficiency in microalgal cultures using averaged irradiance. *Enzym. Microb. Technol.*, 375-381.

- Fachrullah, M. (2011). *Laju Pertumbuhan Mikroalga Penghasil Biofuel Jenis Chlorella sp. dan Nannochloropsis sp. yang Dikultivasi Menggunakan Air Limbah Hasil Penambangan Timah di Pulau Bangka*. Bogor: Institut Pertanian Bogor.
- Gantt, E. C. (1965). The ultrastructure of *Porphyridium cruentum*. *J. Cell Biol*, 365-381.
- Garcia-Camacho, F. G.-R.-M.-G.-G. (2007). Biotechnological significance of toxic marine dinoflagellates. *Biotechnol Adv*, 176-194.
- Garcia-Gonzales, M. M. (2005). Production of *Dunaliella salina* biomass rich in 9-cis-beta-carotene and lutein in a closed tubular photobioreactor. *J Biotechnol*, 115, 81-90.
- Gierhart, D. F. (2013). Protection against Sunburn and Skin Problems with Orally-ingested High-dosage Zeaxanthin. Google Patents.
- Grobbelaar, J. (2009). Factors governing algal growth in photobioreactors : the "open" versus "closed" debate. *J. Appl. Phycol*, 489-492.
- Guerin, M. H. (2003). Haematococcus astaxanthin : applications for human health and nutrition. *Trends Biotechnol*, 21, 210-216.
- Hallegraef, G. (2003). Harmful algal blooms : a global overview. In G. A. Hallegraef, *Manual on harmful marine microalgae* (pp. 25-49). Paris: UNESCO Publishing.
- Halliwell, B. (1995). How to characterize an antioxidant-An update. *Biochem Soc Symp.*, 73-101.
- Hariz, H. T. (2017). Growth and biomass production of native microalgae *Chlorella sp.*, *Chlamydomonas sp.*, and *Scenedesmus sp.* cultivated in palm oil mill effluent (POME) at different cultivation conditions. *Transactions on Science and Technology* 4, 298-311.
- Harris, W. K.-E. (2008). Intakes of long-chain omega-3 fatty acid associated with reduced risk for death from coronary heart disease in healthy adults.
- Harun, R. S. (2010). Bioprocess engineering of microalgae to produce a variety of consumer products. *Renewable Sustainable Energy Rev.*, 14, 1037-1047.
- He, J. Y. (2005). Olanzapine attenuates the okadaic acid-induced spatial memory impairment and hippocampus cell death in rats. *Neuropsychopharmacology*, 1511-1520.
- Hejazi, M. W. (2004). Milking Microalgae. *Trends Biotechnol*, 22, 184-194.
- Higuera-Ciapara, I. F.-V. (2006). Astaxanthin : a review of its chemistry and applications. *Crit Rev Food Sci Nutr*, 46, 185-196.

- Hu C., L. J. (2008). Determination of carotenoids in *Dunaliella salina* cultivated in Taiwan and antioxidant capacity of the algal carotenoid extract. *Food Chem*, 109, 439-446.
- Huang, Y. C. (2008). Effect of Nitrogen, Phosphorus, Light Formation, and Disappearance and Water Temperature on the of Blue - green Algae Bloom. *Journal of Northwest Science - Technology University of Agriculture and Forest (Nature Science Edition)*, 93-100.
- Ionita, P. (2003). Is DPPH Stable Free Radical a Good Scavenger for Oxygen Active Species? *Chem Pap*, 59, 11-16.
- Jiang, Y. C. (1999). Production potential of docosahexaenoic acid by the heterotrophic marine dinoflagellate *Cryptocodinium cohnii*. *Process Biochem*, 34, 633-637.
- Jin, D.-Q. L.-Y.-S. (154-158). *Ulva conglobata*, a marine algae, has neuroprotective and anti-inflammatory effects in murine hippocampal and microglial cells. *Neurosci. Lett.*, 402.
- Jiri Masojidek, G. T. (2013). Photosynthesis in Microalgae. In *Handbook of Microalgal Culture: Applied Phycology and Biotechnology* (pp. 21-36). Blackwell Publishing.
- Junedi, S. H. (2008). *Cancer Chemoprevention Research Center*. Retrieved from Fakultas Farmasi UGM Web Site: ccrc.farmasi.ugm.ac.id/wp-content/8-sop-perhitungan-sel.pdf
- Jung, J. S. (1995). Cytotoxic compounds from the two sponge association. *J Nat Prod*, 1722-1726.
- Kaplan, D. R. (1986). Algal nutrition. In *Handbook of Microalgal Mass Culture* (ed. A. Richmond) (pp. 147-198). Boca Raton: CRC Press.
- Karki, S. (2000). DPPH, Free Radical. 89.
- Kroes, R. S. (2003). A review if the safety of DHA 45-oil. *Food Chem Toxicol*, 41, 1433-1446.
- Kumar, N. S. (2009). Evaluation of protective efficacy of *Spirulina platensis* against collagen-induced arthritis in rats. In *Inflammopharmacology* (pp. 181-190).
- Lam, M. L. (2012). Microalgae biofuels : a critical review of issues, problems and the way forward. *Biotechnol. Adv.*, 30, 673-690.
- Lee, Y. D. (1996). Mixotrophic growth of *Chlorella sorokiniana* in outdoor enclosed photobioreactors. *J. Appl. Phycol*, 8, 163-169.
- Leon-Banares, R. G.-B. (2004). Transgenic microalgae as green cell-factories. . *Trends Biotechnol.*, 22, 45-52.

- Lestari. (2007).
- Levine, M. R. (1991). Criteria and recommendation for VitaminC intake. *JAMA*, 1415-1423.
- Li, X. X. (2009). Phycocyanin protects INS-IE pancreatic beta cells against human islet amyloid polypeptide-induced apoptosis through attenuating oxidative stress and modulating JNK and p38 mitogen-activated protein kinase pathways. *Int J Biochem Cell Biol* , 1526-1535.
- Liu J., S. Z. (2014). Recent Advances in Microalgal Biotechnology. OMICS Group International.
- Lorenz, R. C. (2000). Commercial potential for Haematococcus microalgae as a natural source of astaxanthin. *Trends Biotechnol*, 18, 160-167.
- Lorenz, R. C. (2000). Commercial potential for Haematococcus microalgae as a natural source of astaxanthin. *Trends Biotechnol.*, 18, 160-167.
- Mahajan, G. K. (1995). g-Linolenic acid production from *Spirulina platensis*.
- Mahdy, A. (2014). *Biogas from Microalgae*.
<http://www.energy.imdea.org/events/2014/biogas-microalgae>.
- Marxen, K. (2007). Determination of DPPH Radical Oxidation Caused by Methanolic Extracts of Some Microalgal Species by Linear Regression Analysis of Spectrophotometric Measurements. *Sensors*, 7, 2080-2095.
- Mata, T. M. (2010). Microalgae for biodiesel production and other applications : a review. *Renew. Sustain. Energy*, 14, 217-232.
- Mayer, A. H. (2005). Marine pharmacology in 2001-2002 : marine compounds with anthelmintic, antibacterial, anticoagulant, antidiabetic, antifungal, anti-inflammatory, antimalarial, antiplatelet, antiprotozoal, antituberculosis, and antiviral activities. *Comp. Biochem. Physiol. Part C: Toxicol. Pharmacol.*, 140, 265-286.
- Metting, F. (1996). Biodiversity and application of microalgae. *J Ind Microbiol*, 17, 477-489.
- Miao, X. W. (2004). Fast pyrolysis of microalgae to produce renewable fuels. *J. Anal. Appl. Pyrolysis*, 71, 855-863.
- Milipore, M. (n.d.). *DPPH, Free Radical- CAS 1898-66-4- Calbiochem*.
www.merckmillipore.com.
- Miller, N. R.-E. (1996). Spectrophotometric determination of antioxidant activity . *Redox Report*, 2, 161-171.

- Miller, N. S.-E. (1996). Antioxidant activities of carotenes and xanthophylls. *FEBS Lett*, 240-242.
- Miranda, M. C.-F. (1998). Antioxidant activity of the microalga *Spirulina maxima*. *Braz. J. Med. Biol. Res.*, 31, 1075-1079.
- Mozaffarian, D. R. (2006). Fish intake, contaminants and human health : evaluating the risks and the benefits. *JAMA* 296.
- Muller-Feuga, A. M. (2003). Live Feeds in Marine Aquaculture. In *The Microalgae of Aquaculture* (pp. 206-252). Oxford.
- Nagai, H. T. (1992). Gambieric acids : unprecedented potent antifungal substances isolated from cultures of a marine dinoflagellate *Gambierdiscus toxicus*. *J. Am. Chem. Soc.*, 114, 1102-1103.
- Ozgen, M. R. (2006). Modified 2,2-Azino-bis-3ethylbenzothiazoline-6-sulfonic acid (ABTS) Method to Measure Antioxidant Capacity of Selected Small Fruits and Comparison to Ferric Reducing Antioxidant Power (FRAP) and 2,2-Diphenyl-1-picrylhydrazil (DPPH) Methods . *Journal of Agricultural and Food Chemistry*, 1151-1158.
- Peterson, G. (1979). Review of the Folin phenol protein quantitation method of Lowry, Rosebrough, Farr and Randall.
- Pires, J. C. (2015). Mass Production of Microalgae. In S.-K. Kim (Ed.), *Handbook of Marine Microalgae Biotechnology* (pp. 55-68). Oxford, UK: Elsevier.
- Prabowo, D. H. (2013). Diversity of cryptothecodinium spp. (Dinophyceae) from Okinawa prefecture. *J. Mar. Sci. Technol*, 181-191.
- Qiang, H. R. (1996). Productivity and photosynthetic efficiency of *Spirulina platensis* as affected by light intensity, algal density and rate of mixing in a flat plate photobioreactor. *J. Appl. Phycol.*, 139-145.
- Raja, A. V. (2013). Biological importance of marine algae--an overview. *Int. J. Curr. Microbiol. APP. Sci.*, 2, 222-227.
- Rashid, N. R.-I. (2013). Current status, barriers, and developments in biohydrogen production by microalgae. *Renewable Sustainable Energy Rev.*, 22, 571-579.
- Ratnawati, R. (2011). *Efek Penambahan Unsur Kalium dan Aerasi Terhadap Kinerja Alga-Bakteri untuk Mereduksi Polutan pada Air Boezem Morokrembangan, Surabaya*. Surabaya: Institut Teknologi Sepuluh Nopember.
- Ren, T. (2014). Primary Factors Affecting Growth of Microalgae Optimal Light Exposure Duration and Frequency. *Graduate Theses and Dissertations*.

- Riss, J. D. (2007). Phycobiliprotein c-phycoyanin from *Spirulina platensis* is powerfully responsible for reducing oxidative stress and NADPH oxidase expression induced by an atherogenic diet in hamsters. *J Agric Food Chem*, 7962-7967.
- Romay, C. G. (2000). Phycocyanin is an antioxidant protector of human erythrocytes against lysis by peroxy radicals. *J Pharm Pharmacol*, 367-368.
- Rupprecht, J. (2009). From systems biology to fuel : *Chlamydomonas reinhardtii* as a model for a systems biology approach to improve biohydrogen in production. *J. Biotechnol.*, 142, 10-20.
- S. Sanchez, J. d. (2004). The influence of temperature on the growth and fatty-acid composition of *Skeletonema costatum* in a batch photobioreactor. *J. Chem. Technol. Biotechnol*, 148-152.
- Safi, C. Z.-G. (2014). Morphology, composition, production, processing, and applications of *Chlorella vulgaris* : a review. *Energy Rev.*, 265-278.
- Salisbury, B. R. (1992). *Plant Physiology* (4 ed.). Wadsworth Publishing Co.
- Sari, I. A. (2012). Pola Pertumbuhan *Nannochloropsis oculata* pada Skala Laboratorium, Intermediet, dan Massal. *Ilmiah Perikanan dan Kelautan*, 123-127.
- Senevirathne, M. K.-K. (2011). Marine macro-and microalgae as potential agents for the prevention of asthma : hyperresponsiveness and inflammatory subjects. *Adv. Food Nutr. Res.*, 64, 277-286.
- Setiyoko, D. (2014). *Pengaruh Suhu dan Konsentrasi Nitrogen terhadap Pertumbuhan dan Kandungan Lemak pada Nannochloropsis oculata dan Chlorella vulgaris untuk Produksi Biodiesel.*
- Shaish, A. H. (2009). Application of *Dunaliella* in atherosclerosis. In *The Alga Dunaliella : biodiversity, physiology, genomics and biotechnology* (pp. 475-494). Jersey Science Publisher.
- Shi, H. N. (1999). Comparative study on dynamics of antioxidative action of alfa-tocopheryl hydroquinone, ubiquinol and alfa-tocopherol, against lipid peroxidation. *Free Radoc Biol Med*, 3340346.
- Simoons, F. (1990). *Food in China : A Cultural and Historical Inquiry*. CRC Press.
- Singh, S. K. (2005). Bioactive macrolides and polyketides from cyanobacteria and microalgae : an overview. *Crit Rev Biotechnol*, 73-95.
- Sirenko, L. K. (1999). Influence of metabolites of certain algae on human and animal cell cultures. *Int. J. Algae*, 1.

- Sjollema, S. B.-H. (2015). Do plastic particles affect microalgal photosynthesis and growth? *Aquatic Toxicology*, 1-11.
- Skulberg, O. (2004). Bioactive chemicals in microalgae. In *In : Richmond A, ed. Handbook of microalgal culture : biotechnology and applied phycology* (pp. 312-351). Oxford: Blackwell Science.
- Spolaore, P. J.-C. (2006). Commercial Applications of Microalgae. *J Biosci Bioengr*, 101, 87-96.
- Stevenson, C. C. (2002). The identification and characterization of the marine natural product scytonemin as a novel antiproliferative pharmacophore. *J Pharmacol Exp Ther* , 858-866.
- Stolz, P. O. (2005). Manufacturing microalgae for skin care.
- Suda, S. A. (2002). Taxonomic characterization of a marine *Nannochloropsis* species, *N. oecania* sp. nov. (Eustigmatophyceae). *Phycologia*, 273-279.
- Takemura, N. I. (1985). Photosynthesis and Primary Production of *Microcystis agruginosa* in Lake Kasumigaura. *Journal of Plankton Research*, 303-312.
- Tan, X. K. (2009). Effects of Enhanced Temperature on Algae Recruitment and Phytoplankton Community Succession. *China Environmental Science* , 578-582.
- Vonshak, A. (1986). Laboratory techniques for the cultivation of microalgae. In *Handbook of Microalgal Mass Culture* (ed. A. Richmond) (pp. 117-145). Boca Raton: CRC Press.
- Walter, C. S. (2003). *Biomolec. Eng*, 261.
- Wang, L. (2006). Research on the Relevant Factors of the Algal Growth in Hydrodynamics Condition.
- Ward, O. S. (2005). Omega-3/6 fatty acids : alternative sources of production. *Process Biochem* , 40, 3627-3652.
- West, M. Z. (2012). Evaluation of microalgae for use as nutraceuticals and nutritional supplements. *Food Science*, 2, 147.
- Woertz, I. F. (2009). Algae Grown on Dairy and Municipal Wastewater for Simultaneous Nutrient Removal and Lipid Production for Biofuel Feedstock. *Journal of Environmental Engineering*, 1115-1122.
- Yi-Kai Chih, M.-C. Y. (2013). An 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulfonic-acid)-immobilized electrode for the simultaneous detection of dopamine and uric acid in the presence of ascorbic acid.

- Young, I. W. (2001). Antioxidants in health and disease. *J Clin Pathol*, 176-186.
- Yuan, J. P. (2011). Potential health-promoting effects of astaxanthin : a high-value carotenoid mostly from microalgae. *Mol Nutr Food Res*, 55, 150-165.
- Zang, C. H. (2011). Comparison of Relationships Between pH, Dissolved Oxygen, and Chlorophyll a for Aquaculture and Nonaquaculture Waters. *Water Air and Soil Pollution*, 157-174.
- Zhu, M. Z. (2003). Effect of Temperature, Salinity, and Illumination on the Growth of *Thalassiosira* sp. . *Marine Sciences*, 58-61.