



DAFTAR PUSTAKA

- Aflalo, C., Meshulam, Y., Zarka, A. and Boussiba, S., 2007. On the relative efficiency of two-vs. one-stage production of astaxanthin by the green alga *Haematococcus pluvialis*. *Biotechnology and Bioengineering*, 98(1), pp.300-305.
- Ambati, R.R., Siew Moi, P., Ravi, S. and Aswathanarayana, R.G., 2014. Astaxanthin: Sources, extraction, stability, biological activities and its commercial applications—A review. *Marine drugs*, 12(1), 128-152.
- Backlund, M. 2022. *Haematococcus pluvialis* Flot. Dyntaxa. Svensk taxonomisk databas. SLU Artdatabanken. Checklist dataset. <https://www.gbif.org/spesies/160002198>. Diakses 25 Desember 2022.
- Bai, F., Gusbeth, C., Frey, W., and Nick, P, 2020, Nanosecnd Pulsed Electric Fields Modulate the Expression of the Astaxanthin Biosynthesis Genes psy, crtR-b and bkt 1 in *Haematococcus pluvialis*, *Scientific Reports*, 10 (1). 1-15.
- Basiony, M., Ouyang, L., Wang, D., Yu, J., Zhou, L., Zhu, M., Wang, X., Feng, J., Dai, J., Shen, Y. and Zhang, C., 2022. Optimization of microbial cell factories for astaxanthin production: Biosynthesis and regulations, engineering strategies and fermentation optimization strategies. *Synthetic and Systems Biotechnology*, 7(2), 689-704.
- Boussiba, S., and Vonshak, A, 1991, Astaxanthin Accumulation in the Green Alga *Haematococcus pluvialis*, *Plant and Cell Physiology*, 32 (7). 1077-1082.
- Boussiba, S., Bing, W., Yuan, J.P., Zarka, A. and Chen, F., 1999, Changes in Pigments Profile in the Green Alga *Haematococcus pluvialis* Exposed to Environmental Stresses, *Biotechnology Letters*, 21 (7). 601-604.
- Butler, T. O., McDougall, G. J., Campbell, R., Stanley, M. S., and Day, J. G, 2018, Media Screening for Obtaining *Haematococcus pluvialis* Red Motile Macrozooids Rich in Astaxanthin and Fatty Acids, *Biology*, 7 (1). 2.
- Cheirsilp, B., Wantip, K., Chai-issarapap, N., Maneechote, W., Pekkoh, J., Duangjan, K., Ruangrit, K., Pumas, C., Pathom-aree, W. and Srinuanpan, S., 2022. Enhanced production of astaxanthin and co-bioproducts from microalga *Haematococcus* sp. integrated with valorization of industrial wastewater under two-stage LED light illumination strategy. *Environmental Technology & Innovation*, 28, 102620.
- Cho, S.J., Sung, Y.J., Lee, J.S., Yu, B.S. and Sim, S.J., 2021. Robust cyst germination induction in *Haematococcus pluvialis* to enhance astaxanthin productivity in



a semi-continuous outdoor culture system using power plant flue gas. *Bioresource technology*, 338, 125533.

Cui, D., Hu, C., Zou, Z., Sun, X., Shi, J., and Xu, N, 2020, Comparative Transcriptome Analysis Unveils Mechanisms Underlying the Promoting Effect of Potassium Iodide on Astaxanthin Accumulation in *Haematococcus Pluvialis* Under High Light Stress, *Aquaculture*, 525, 735279.

Ding, W., Li, Q., Han, B., Zhao, Y., Geng, S., Ning, D., and Yu, X, 2019, Comparative Physiological and Metabolomic Analyses of The Hyper-Accumulation of Astaxanthin and Lipids in *Haematococcus Pluvialis* opon Treatment with Butylated Hydroxyanisole, *Bioresource technology*, 292, 122002.

Fábregas, J., Otero, A., Maseda, A. and Domínguez, A., 2001. Two-stage cultures for the production of astaxanthin from *Haematococcus pluvialis*. *Journal of Biotechnology*, 89(1), 65-71.

Gao, Z., Meng, C., Zhang, , Xu, D., Zhao, Y., Wang, Y., and Ye, N, 2012, Differential Expression of Carotenogenic Genes, Associated Changes on Astaxanthin Production and Photosynthesis Features Induced by JA in *H. pluvialis*, *PLoS One*, 7 (8), e42243.

Grewe, C. and Griehl, C., 2008. Time-and media-dependent secondary carotenoid accumulation in *Haematococcus pluvialis*. *Biotechnology Journal: Healthcare Nutrition Technology*, 3(9-10), 1232-1244.

Grewe, C. B., and Griehl, C, 2012, 8 The Carotenoid Astaxanthin from *Haematococcus pluvialis*, In *Microalgal Biotechnology: Integration and Economy*. 129-144.

Harker, M., Tsavalos, A.J. and Young, A.J., 1996. Factors responsible for astaxanthin formation in the chlorophyte *Haematococcus pluvialis*. *Bioresource Technology*, 55(3), 207-214.

Hu, C., Cui, ., Sun, X., Shi, J., and Xu, N, 2020, Primary Metabolism is Associated with the Astaxanthin Biosynthesis in the Green Algae *Haematococcus Pluvialis* under Light Stress, *Algal Research*, 46, 101768.

Huang, J.C., Chen, F., Sandmann G., 2006, Stress-related Differential Expression of Multiple Beta-carotene Ketolase Genes in the Unicellular Green Alga *Haematococcus pluvialis*, *Journal of Biotechnology*, 122 (2): 176-185.

Isnansetyo, A. dan Kurniastuty, 1995, Teknik Kultur Fitoplankton dan Zooplankton Pakan Alami untuk Pemberian Organisme Laut, Yogyakarta: Kanisius. 116.

Jin, H., Lao, Y. M., Zhou, J., Zhang, H. J., and Cai, Z. H, 2017, Simultaneous Determination of 13 Carotenoids by a Simple C18 Column-Based Ultra-High-



UNIVERSITAS
GADJAH MADA

Pressure Liquid Chromatography Method for Carotenoid Profiling in the Astaxanthin-accumulating *Haematococcus pluvialis*, *Journal of Chromatography A*, 1488. 93-103.

Katsuda, T., Lababpour, A., Shimahara, K. and Katoh, S., 2004. Astaxanthin production by *Haematococcus pluvialis* under illumination with LEDs. *Enzyme and microbial technology*, 35(1), 81-86.

Kawasaki, S., Mizuguchi, K., Sato, M., Kono, T. and Shimizu, H., 2013. A novel astaxanthin-binding photooxidative stress-inducible aqueous carotenoprotein from a eukaryotic microalga isolated from asphalt in midsummer. *Plant and cell physiology*, 54(7), 1027-1040.

Kim, B., Lee, S.Y., Narasimhan, A.L., Kim, S. and Oh, Y.K., 2022. Cell disruption and astaxanthin extraction from *Haematococcus pluvialis*: Recent advances. *Bioresource Technology*, 343, 126124.

Kim, J.H., Affan, A., Jang, J., Kang, M. H., Ko, A. R., Jeon, S. M., and Kang, D. H, 2015, Morphological, Molecular, and Biochemical Characterization of Astaxanthin-Producing Green Microalga *Haematococcus sp.* KORDI03 (*Haematococcaceae*, Chlorophyta) Isolated from Korea, *Journal of Microbiology and Biotechnology*, 25 (2). 238-246.

Kobayashi, M., Kakizono, T. and Nagai, S., 1991. Astaxanthin production by a green alga, *Haematococcus pluvialis* accompanied with morphological changes in acetate media. *Journal of Fermentation and Bioengineering*, 71(5), 335-339.

Lao, Y.M., Jin, H., Zhou, J., Zhang, H.J., Zhu, X.S. and Cai, Z.H., 2018. A novel hydrolytic activity of tri-functional geranylgeranyl pyrophosphate synthase in *Haematococcus pluvialis*. *Plant and Cell Physiology*, 59(12), 2536-2548.

Lavens, P. and Sorgeloos, P., 1996. *Manual on the production and use of live food for aquaculture* (No. 361). Food and Agriculture Organization (FAO). Rome. 295.

Li, F., Cai, M., Lin, M., Huang, X., Wang, J., Zheng, X., and An, Y, 2019, Accumulation of Astaxanthin was Improved by the Nonmotile Cells of *Haematococcus pluvialis*, *BioMed Research International*.

Li, Q., You, J., Qiao, T., Zhong, D.B. and Yu, X., 2022. Sodium chloride stimulates the biomass and astaxanthin production by *Haematococcus pluvialis* via a two-stage cultivation strategy. *Bioresource Technology*, 344, 126214.

Li, Q., Zhang, L. and Liu, J., 2019. Comparative transcriptome analysis at seven time points during *Haematococcus pluvialis* motile cell growth and astaxanthin accumulation. *Aquaculture*, 503, 304-311.



- Li, Q., Zhao, Y., Ding, W., Han, B., Geng, S., Ning, D., Ma, T. and Yu, X., 2021. Gamma-aminobutyric acid facilitates the simultaneous production of biomass, astaxanthin and lipids in *Haematococcus pluvialis* under salinity and high-light stress conditions. *Bioresource Technology*, 320, 124418.
- Livak, K. J. and Schmittgen, T. D, 2001, Analysis of Relative Gene Expression Data Using Real Time Quantitative PCR and the 2^{CT} Method, *Methods* 25. 402-408.
- Luo, Q., Bian, C., Tao, M., Huang, Y., Zheng, Y., Lv, Y., Li, J., Wang, C., You, X., Jia, B. and Xu, J., 2019. Genome and transcriptome sequencing of the astaxanthin-producing green microalga, *Haematococcus pluvialis*. *Genome biology and evolution*, 11(1), 166-173.
- Lv, H., Xia, F., Liu, M., Cui, X., Wahid, F., & Jia, S, 2016, Metabolomic Profiling of the Astaxanthin Accumulation Process Induced By High Light in *Haematococcus pluvialis*, *Algal Research*, 20. 35-43.
- Ma, R., Thomas-Hall, S. R., Chua, E. T., Alsenani, F., Eltanahy, E., Netzel, M. E., and Schenk, P. M, 2018, Gene Expression Profiling of Astaxanthin and Fatty Acid Pathways in *Haematococcus pluvialis* in Response to Different LED Lighting Conditions, *Bioresource Technology*, 250. 591-602.
- Meng, C., Liang, C., Su, Z., Qin, S. and Tseng, C., 2006. There are two 5'-flanking regions of bkt encoding beta-carotene ketolase in *Haematococcus pluvialis*. *Phycologia*, 45(2), 218-224.
- Mota, G.C.P., Moraes, L.B.S.D., Oliveira, C.Y.B., Oliveira, D.W.S., Abreu, J.L.D., Dantas, D.M.M. and Gálvez, A.O., 2022. Astaxanthin from *Haematococcus pluvialis*: processes, applications, and market. *Preparative Biochemistry & Biotechnology*, 52(5), 598-609.
- Mularczyk, M., Michalak, I., and Marycz, K, 2020. Astaxanthin and other Nutriens from *Haematococcus pluvialis*—Multifunctional Applications, *Marine Drugs*, 18 (9). 459.
- Nishshanka, G.K.S.H., Liyanaarachchi, V.C., Nimirashana, P.H.V., Ariyadasa, T.U. and Chang, J.S., 2022. *Haematococcus pluvialis*: A potential feedstock for multiple-product biorefining. *Journal of Cleaner Production*, 131103.
- Novoveská, L., Ross, M. E., Stanley, M. S., Pradelles, R., Wasiolek, V., and Sassi, J. F, 2019, Microalgal Carotenoids: A Review of Production, Current Markets, Regulations, and Future Direction, *Marine drugs*, 17 (11). 640.



- Orosa, M., Franqueira, D., Cid, A. and Abalde, J.J.B.T., 2005. Analysis and enhancement of astaxanthin accumulation in *Haematococcus pluvialis*. *Bioresource technology*, 96(3), 373-378.
- Osman, S.N.H., Osman, S.N., Mohamad, R., Tan, J.S., Yusoff, A.H., Matanjun, P., Mokhtar, R.A.M., Shapawi, R. and Huda, N., 2022. Bioprocess Strategy of *Haematococcus lacustris* for Biomass and Astaxanthin Production Keys to Commercialization: Perspective and Future Direction. *Fermentation*, 8(4), 179.
- Osman, S.N.H., Shoparwe, N.F., Yusoff, A.H., Rahim, A.A., Chang, C.S., Tan, J.S., Osman, S.N., Arumugam, K., Ariff, A.B., Sulaiman, A.Z. and Mohamed, M.S., 2021. A Review on *Haematococcus pluvialis* bioprocess optimization of green and red stage culture conditions for the production of natural astaxanthin. *Biomolecules*, 11(2), 256.
- Peled, E., Leu, S., Zarka, A., Weiss, M., Pick, U., Khozin-Goldberg, I. and Boussiba, S., 2011. Isolation of a novel oil globule protein from the green alga *Haematococcus pluvialis* (Chlorophyceae). *Lipids*, 46(9), 851-861.
- Rao, A.R., Sindhuja, H.N., Dharmesh, S.M., Sankar, K.U., Sarada, R. and Ravishankar, G.A., 2013. Effective inhibition of skin cancer, tyrosinase, and antioxidative properties by astaxanthin and astaxanthin esters from the green alga *Haematococcus pluvialis*. *Journal of agricultural and food chemistry*, 61(16), 3842-3851.
- Řezanka, T., Nedbalová, L., Kolouchová, I. and Sigler, K., 2013. LC-MS/APCI identification of glucoside esters and diesters of astaxanthin from the snow alga *Chlamydomonas nivalis* including their optical stereoisomers. *Phytochemistry*, 88, 34-42.
- Saha, S. K., McHugh, E., Hayes, J., Moane, S., Walsh, D., & Murray, P, 2013, Effect of Various Stress-Regulatory Factors on Biomass and Lipid Production in Microalga *Haematococcus pluvialis*, *Bioresource Technology*, 128. 118-124.
- Santos, B., da Conceição, D.P., Corrêa, D.O., Passos, M.F., Campos, M.P., Adamoski, D., Galli-Terasawa, L.V., Mariano, A.B., Vargas, J.V.C. and Kava, V.M., 2022. Changes in gene expression and biochemical composition of *Haematococcus pluvialis* grown under different light colors. *Journal of Applied Phycology*, 34(2), 729-743.
- Shah, M., Mahfuzur, R., Liang, Y., Cheng, J. J., & Daroch, M, 2016, Astaxanthin-producing Green Microalga *Haematococcus Pluvialis*: from Single Cell to High Value Commercial Products, *Frontiers in Plant Science*, 7. 531.



- Shang, M., Ding, W., Zhao, Y., Xu, J. W., Zhao, P., Li, T., and Yu, X, 2016, Enhanced Astaxanthin Production from *Haematococcus pluvialis* Using Butylated Hydroxyanisole, *Journal of Biotechnology*, 236. 199-207.
- Silva, D.L.B., de Moraes, L.B.S., Oliveira, C.Y.B., da Silva Campos, C.V.F., de Souza Bezerra, R. and Gálvez, A.O., 2022. Influence of culture medium on growth and protein production by *Haematococcus pluvialis*. *Acta Scientiarum. Technology*, 44, e59590-e59590.
- Šimat, V., Rathod, N.B., Čagalj, M., Hamed, I. and Generalić Mekinić, I., 2022. Astaxanthin from Crustaceans and Their Byproducts: A Bioactive Metabolite Candidate for Therapeutic Application. *Marine Drugs*, 20(3), 206.
- Sirotiya, V., Ahirwar, A., Mourya, M., Khan, M.J., Rai, A., Kwattra, R., Sharma, A.K., Schoefs, B., Marchand, J., Varjani, S. and Vinayak, V., 2022. Astaxanthin bioaccumulation in microalgae under environmental stress simulated in industrial effluents highlighting prospects of *Haematococcus pluvialis*: knowledge gaps and prospective approaches. *Phytochemistry Reviews*, 1-26.
- Sung, Y.J. and Sim, S.J., 2022. Multifaceted strategies for economic production of microalgae *Haematococcus pluvialis*-derived astaxanthin via direct conversion of CO₂. *Bioresource technology*, 344, 126255.
- Triki, A., Maillard, P., & Gudin, C, 1997, Gametogenesis in *Haematococcus pluvialis* Flotow (Volvocales, Chlorophyta), *Phycologia*, 36 (3). 190-194.
- Vidhyavathi, R., Venkatachalam, L., Sarada, R. and Ravishankar, G.A., 2008. Regulation of carotenoid biosynthetic genes expression and carotenoid accumulation in the green alga *Haematococcus pluvialis* under nutrient stress conditions. *Journal of experimental botany*, 59(6), 1409-1418
- Wang, J., Sommerfeld, M. and Hu, Q., 2011. Cloning and expression of isoenzymes of superoxide dismutase in *Haematococcus pluvialis* (Chlorophyceae) under oxidative stress. *Journal of applied phycology*, 23(6), 995-1003.
- Wang, X., Mou, J.H., Qin, Z.H., Hao, T.B., Zheng, L., Buhagiar, J., Liu, Y.H., Balamurugan, S., He, Y., Lin, C.S.K. and Yang, W.D., 2022. Supplementation with rac-GR24 Facilitates the Accumulation of Biomass and Astaxanthin in Two Successive Stages of *Haematococcus pluvialis* Cultivation. *Journal of Agricultural and Food Chemistry*, 70(15), 4677-4689.
- Wirosaputro, S. dan Sumarlini, T, 2016, Chlorella Makanan Kesehatan Global Alami, Yogyakarta: Gadjah Mada University Press. 111.
- Witono, J. R. B., Miryanti, Y. A., Santoso, H., Kumalaputri, A. J., Novianty, V., dan Gunadi, A, 2018, Studi Awal Pertumbuhan dan Induksi Mikroalga



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Kandungan Pigmen Astaxantin Mikroalga Haematococcus pluvialis Pada Dosis Nutrien dan Fotoperiode Berbeda

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Haematococcus pluvialis, Rekayasa Hijau: Jurnal Teknologi Ramah Lingkungan, 2(3).

Yu, B.S., Lee, S.Y. and Sim, S.J., 2022. Effective contamination control strategies facilitating axenic cultivation of *Haematococcus pluvialis*: Risks and challenges. *Bioresource technology*, 344, 126289.

Zhang, L., Zhang, C., Xu, R., Yu, W. and Liu, J., 2022. A strategy for promoting carbon flux into fatty acid and astaxanthin biosynthesis by inhibiting the alternative oxidase respiratory pathway in *Haematococcus pluvialis*. *Bioresource Technology*, 344, 126275.

Zhang, Z., Wang B., Hu Q., Sommerfeld M., Li Y., and Han D., 2016, A New Paradigm for Producing Astaxanthin from Unicellular Green Alga *Haematococcus pluvialis*, *Biotechnology and Bioengineering*, 113 (10). 2088-2099.

Zou, T.B., Jia, Q., Li, H.W., Wang, C.X. and Wu, H.F., 2013. Response surface methodology for ultrasound-assisted extraction of astaxanthin from *Haematococcus pluvialis*. *Marine drugs*, 11(5), 1644-1655.