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Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
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DAFTAR PUSTAKA

Abbas, A.K., Lichtman, A.H., Pillai, S., 2007. Innate immunity in celluler and molecular immunology. 6 ed. Philadelphia, WB Saunders Co. p 19-46.

Abu-Elala, N.M., Mohamed, S.H., Zaki, M.M., Eissa, A.E., 2015. Assessment of the immune-modulatory and antimicrobial effects of dietary chitosan on Nile tilapia (*Oreochrmis niloticus*) with special emphasis to its bio-remediating impacts. Fish Shellfish Immunol. 46, 678–685. https://doi.org/10.1016/j.fsi.2015.08.004

Akira, S., Uematsu, S., Takeuchi, O., 2006. Pathogen recognition and innate immunity. Cell 124, 783–801. https://doi.org/10.1016/j.cell.2006.02.015

Alexander, C., Sahu, N.P., Pal, A.K., Akhtar, M.S., 2011. Haemato-immunological and stress responses of *Labeo rohita* (Hamilton) fingerlings: Effect of rearing temperature and dietary gelatinized carbohydrate. J. Anim. Physiol. Anim. Nutr. (Berl). 95, 653–663. https://doi.org/10.1111/j.1439-0396.2010.01096.x

Aliprantis, A.Q., Yang, R.-B., Mark, M.R., Suggett, S., Devaux, B., Radolf, J.D., KLimpel, G.R., Godowski, P., Zychlinsky, A., 1999. Cell activation and apoptosis by aacterial lipoproteins through toll-like receptor-2, Science. https://doi.org/10.1007/978-3-642-79437-7_2

Alvarez-Pellitero, P., 2008. Fish immunity and parasite infections: from innate immunity to immunoprophylactic prospects. Vet. Immunol. Immunopathol. 126, 171–198. https://doi.org/10.1016/j.vetimm.2008.07.013

Amal, M.N.A., Ismail, A., Saad, M.Z., Md Yasin, I.S., Nasruddin, N.S., Mastor, S.S., Abdul Rahman, M.H., Mohamad, N., 2019. Study on *Streptococcus agalactiae* infection in Javanese medaka (*Oryzias javanicus* Bleeker, 1854) model. Microb. Pathog. 131, 47–52. https://doi.org/10.1016/j.micpath.2019.03.034

Amal, M.N.A., Zamri-Saad, M., 2011. Streptococcosis in tilapia (*Oreochromis niloticus*): A review. Pertanika J. Trop. Agric. Sci. 34, 195–206.

Amri, K., Khairuman, 2008. Budidaya ikan Nila secara intensif. Agromedia Pustaka. Jakarta.

Anderson, D., Siwicki, A., 1995. Basic hematology and serology for fish health programs. In: M. Shariff, J.R. Arthur & R.P. Subasinghe (eds): diseases in Asian aquaculture. Asian Fish. Soc. Fish Heal. Sect. 185–202.

Anderson, D.P., 1992. Immunostimulants, adjuvants, and vaccine carriers in fish: Applications to aquaculture. Annu. Rev. Fish Dis. 2, 281–307. https://doi.org/10.1016/0959-8030(92)90067-8

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Anderson, D.P., 1974. Fish immunology. TFH Publ. Ltd. Hongkong.

Andriamanantoanina, H., Rinaudo, M., 2010. Characterization of the alginates from five madagascan brown algae. Carbohydr. Polym. 82, 555–560. https://doi.org/10.1016/j.carbpol.2010.05.002

Ashouri, G., Mahboobi, N., Hossein, S., Amir, S., Jalali, H., Morshedi, V., Doan, H. Van, Tor, M., 2018. Combined effects of dietary low molecular weight sodium alginate and *Pediococcus acidilactici* MA18/5M on growth performance, haematological and innate immune responses of Asian sea bass (*Lates calcalifer*) juveniles 79, 34–41. https://doi.org/10.1016/j.fsi.2018.05.009

Ashouri, G., Mahboobi Soofiani, N., Hoseinifar, S.H., Jalali, S.A.H., Morshedi, V., Valinassab, T., Bagheri, D., Van Doan, H., Torfi Mozanzadeh, M., Carnevali, O., 2020. Influence of dietary sodium alginate and *Pediococcus acidilactici* on liver antioxidant status, intestinal lysozyme gene expression, histomorphology, microbiota, and digestive enzymes activity, in Asian sea bass (*Lates calcarifer*) juveniles. Aquaculture 518, 734638. https://doi.org/10.1016/j.aquaculture.2019.734638

Baldissera, M.D., Souza, C.F., Parmeggiani, B.S., Santos, R.C.V., Leipnitz, G., Moreira, K.L.S., da Rocha, M.I.U.M., da Veiga, M.L., Baldisserotto, B., 2017. *Streptococcus agalactiae* impairs cerebral bioenergetics in experimentally infected silver catfish. Microb. Pathog. 111, 28–32. https://doi.org/10.1016/j.micpath.2017.08.013

Baratawijaya, K.G., 2004. Imunologi dasar. Edisi keenam. FK UI. Jakarta.

Barbalat, R., Lau, L., Locksley, R.M., Barton, G.M., 2009. Toll-like receptor 2 on inflammatory monocytes induces type i interferon in response to viral but not bacterial ligands. Nat. Immunol. 10, 1200–1209. https://doi.org/10.1038/ni.1792

Barkham, T., Zadoks, R.N., Azmai, M.N.A., Baker, S., Bich, V.T.N., Chalker, V., Chau, M.L., Dance, D., Deepak, R.N., van Doorn, H.R., Gutierrez, R.A., Holmes, M.A., Huong, L.N.P., Koh, T.H., Martins, E., Mehershahi, K., Newton, P., Ng, L.C., Phuoc, N.N., Sangwichian, O., Sawatwong, P., Surin, U., Tan, T.Y., Tang, W.Y., Thuy, N.V., Turner, P., Vongsouvath, M., Zhang, D., Whistler, T., Chen, S.L., 2019. One hypervirulent clone, sequence type 283, accounts for a large proportion of invasive *Streptococcus agalactiae* isolated from humans and diseased tilapia in Southeast Asia. PLoS Negl. Trop. Dis. 13, 1–20. https://doi.org/10.1371/journal.pntd.0007421

Barnes, A.C., Trewin, B., Snape, N., Kvennefors, E.C.E., Baiano, J.C.F., 2011. Two

UNIVERSITAS
GADJAH MADA
**Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah
(Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis**
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hepcidin-like antimicrobial peptides in Barramundi *Lates calcarifer* exhibit differing tissue tropism and are induced in response to lipopolysaccharide. Fish Shellfish Immunol. 31, 350–357. https://doi.org/10.1016/j.fsi.2011.05.027

Barros, M.M., Falcon, D.R., De Oliveira Orsi, R., Pezzato, L.E., Fernandes, A.C., Guimarães, I.G., Fernandes, A., Padovani, C.R., Sartori, M.M.P., 2014. Non-specific immune parameters and physiological response of Nile tilapia fed β-glucan and vitamin C for different periods and submitted to stress and bacterial challenge. Fish Shellfish Immunol. 39, 188–195. https://doi.org/10.1016/j.fsi.2014.05.004

Beauchamp, C., Fridovich, I., 1971. Superoxide dismutase: Improved assays and an assay applicable to acrylamide gels. Anal. Biochem. 44, 276–287. https://doi.org/10.1016/0003-2697(71)90370-8

Benvegnu, T., Sassi, J.-F., 2010. Oligomannuronates from Seaweeds as Renewable Sources for the Development of Green Surfactants. Top Curr Chem. https://doi.org/10.1007/128

Biller-Takahashi, J., Takahashi, L., Saita, M., Gimbo, R., Urbinati, E., 2013. Leukocytes respiratory burst activity as indicator of innate immunity of pacu *Piaractus mesopotamicus*. Brazilian J. Biol. 73, 425–429. https://doi.org/10.1590/s1519-69842013000200026

Bold, H.C., Wynne, M.J., 1985. Introduction to the algae: structure and reproduction. Englewood Cliffs, N.J.: Prentice-Hall.

Boshra, H., Li, J., Sunyer, J.O., 2006. Recent advances on the complement system of teleost fish. Fish Shellfish Immunol. 20, 239–262. https://doi.org/10.1016/j.fsi.2005.04.004

Bowater, R.O., Forbes-Faulkner, J., Anderson, I.G., Condon, K., Robinson, B., Kong, F., Gilbert, G.L., Reynolds, A., Hyland, S., Mcpherson, G., Brien, J.O., Blyde, D., 2012. Natural outbreak of *Streptococcus agalactiae* (GBS) infection in wild giant Queensland grouper, *Epinephelus lanceolatus* (Bloch), and other wild fish in northern Queensland, Australia. J. Fish Dis. 35, 173–186. https://doi.org/10.1111/j.1365-2761.2011.01332.x

Bradford, M.M., 1976. A Rapid and Sensitive Method for the Quantitation Microgram Quantities of Protein Utilizing the Principle of Protein-Dye Binding. Anal. Biochem. 72, 248–254. https://doi.org/https://doi.org/10.1016/0003-2697(76)90527-3

Bricknell, I., Dalmo, R.A., 2005. The use of immunostimulants in fish larval

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

aquaculture. Fish Shellfish Immunol. 19, 457–472. https://doi.org/10.1016/j.fsi.2005.03.008

Brightbill, H.D., Libraty, D.H., Krutzik, S.R., Yang, R.B., Belisle, J.T., Bleharski, J.R., Maitland, M., Norgard, M. V., Plevy, S.E., Smale, S.T., Brennan, P.J., Bloom, B.R., Godowski, P.J., Modlin, R.L., 1999. Host defense mechanisms triggered by microbial lipoproteins through toll-like receptors. Science (80-.). 285, 732–736. https://doi.org/10.1126/science.285.5428.732

Bu, X., Lian, X., Wang, Y., Luo, C., Tao, S., Liao, Y., Yang, J., Chen, A., Yang, Y., 2019. Dietary yeast culture modulates immune response related to TLR2-MyD88-NF-kβ signaling pathway, antioxidant capability and disease resistance against *Aeromonas hydrophila* for Ussuri catfish (*Pseudobagrus ussuriensis*). Fish Shellfish Immunol. 84, 711–718. https://doi.org/10.1016/j.fsi.2018.10.049

Bustin, S.A., 2004. A to z quantitative PCR. La Jolla, California: Intl Univ Line.

Campos, M.A.S., Almeida, I.C., Takeuchi, O., Akira, S., Valente, E.P., Procópio, D.O., Travassos, L.R., Smith, J.A., Golenbock, D.T., Gazzinelli, R.T., 2001. Activation of toll-like receptor-2 by glycosylphosphatidylinositol anchors from a protozoan parasite. J. Immunol. 167, 416–423. https://doi.org/10.4049/jimmunol.167.1.416

Capone, D.G., Weston, D.P., Miller, V., Shoemaker, C., 1996. Antibacterial residues in marine sediments and invertebrates following chemotherapy in aquaculture. Aquaculture 145, 55–75. https://doi.org/10.1016/S0044-8486(96)01330-0

Carl, V.S., Brown-Steinke, K., Nicklin, M.J.H., Smith, M.F., 2002. Toll-like receptor 2 and 4 (TLR2 and TLR4) agonists differentially regulate secretory interleukin-1 receptor antagonist gene expression in macrophages. J. Biol. Chem. 277, 17448–17456. https://doi.org/10.1074/jbc.M111847200

Chambaud, I., Wróblewski, H., Blanchard, A., 1999. Interactions between mycoplasma lipoproteins and the host immune system. Trends Microbiol. 7, 493–499. https://doi.org/10.1016/S0966-842X(99)01641-8

Chandía, N.P., Matsuhiro, B., Mejías, E., Moenne, A., 2004. Alginic acids in Lessonia vadosa: Partial hydrolysis and elicitor properties of the polymannuronic acid fraction. J. Appl. Phycol. 16, 127–133. https://doi.org/10.1023/B:JAPH.0000044778.44193.a8

Chandia, N.P., Matsuhiro, B., Vasquez, A.E., 2001. Alginic acids in Lessonia trabeculata: Characterization by formic acid hydrolysis and FT-IR spectroscopy. Carbohydr. Polym. 46, 81–87. https://doi.org/10.1016/S0144-8617(00)00286-1

Chandini, S.K., Ganesan, P., Bhaskar, N., 2008. In vitro antioxidant activities of three

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
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Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

selected brown seaweeds of India. Food Chem. 107, 707–713. https://doi.org/10.1016/j.foodchem.2007.08.081

Chen, C., Sun, B., Guan, W., Bi, Y., Li, P., Ma, J., Chen, F., Pan, Q., Xie, Q., 2016. N-3 essential fatty acids in Nile tilapia, *Oreochromis niloticus*: Effects of linolenic acid on non-specific immunity and anti-inflammatory responses in juvenile fish. Aquaculture 450, 250–257. https://doi.org/10.1016/j.aquaculture.2015.08.005

Chen, G., Feng, L., Kuang, S., Liu, Y., Jiang, J., Hu, K., Jiang, W., Li, S., Tang, L., Zhou, X., 2012. Effect of dietary arginine on growth, intestinal enzyme activities and gene expression in muscle, hepatopancreas and intestine of juvenile Jian carp (*Cyprinus carpio* var. Jian). Br. J. Nutr. 108, 195–207. https://doi.org/10.1017/S0007114511005459

Chen, Y.-B., Hu, J., Lyu, Q.-J., Liu, L.-J., Wen, L.-F., Yang, X.-K., Zhao, H.-H., 2016. The effects of Natucin C-Natucin P mixture on blood biochemical parameters, antioxidant activity and non-specific immune responses in tilapia (*Oreochromis niloticus*). Fish Shellfish Immunol. 55, 367–373. https://doi.org/http://dx.doi.org/10.1016/j.fsi.2016.06.016

Chen, Y.Y., Chen, J.C., Lin, Y.C., Putra, D.F., Kitikiew, S., Li, C.C., Hsieh, J.F., Liou, C.H., Yeh, S.T., 2014. Shrimp that have received carrageenan via immersion and diet exhibit immunocompetence in phagocytosis despite a post-plateau in immune parameters. Fish Shellfish Immunol. 36, 352–366. https://doi.org/10.1016/j.fsi.2013.12.004

Chen, Y.Y., Kitikiew, S., Yeh, S.T., Chen, J.C., 2016. White shrimp *Litopenaeus vannamei* that have received fucoidan exhibit a defense against *Vibrio alginolyticus* and WSSV despite their recovery of immune parameters to background levels. Fish Shellfish Immunol. 59, 414–426. https://doi.org/10.1016/j.fsi.2016.10.050

Cheng, A.-C., Chen, Y.-Y., Chen, J.-C., 2008. Dietary administration of sodium alginate and κ-carrageenan enhances the innate immune response of brown-marbled grouper *Epinephelus fuscoguttatus* and its resistance against *Vibrio alginolyticus*. Vet. Immunol. Immunopathol. 121, 206–215. https://doi.org/10.1016/j.vetimm.2007.09.011

Cheng, A.-C., Tu, C.-W., Chen, Y.-Y., Nan, F.-H., Chen, J.-C., 2007. The immunostimulatory effects of sodium alginate and iota-carrageenan on orange-spotted grouper *Epinephelus coicoides* and its resistance against *Vibrio alginolyticus*. Fish Shellfish Immunol. 22, 197–205.

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
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https://doi.org/10.1016/j.fsi.2006.04.009

Cheng, A., Chen, Y., Chen, J., 2008. Dietary administration of sodium alginate and k-carrageenan enhances the innate immune response of brown-marbled grouper *Epinephelus fuscoguttatus* and its resistance against *Vibrio alginolyticus*. Vet. Immunol. Immunopathol. 121, 206–215. https://doi.org/10.1016/j.vetimm.2007.09.011

Cheng, W., Liu, C.H., Kuo, C.M., Chen, J.C., 2005. Dietary administration of sodium alginate enhances the immune ability of white shrimp *Litopenaeus vannamei* and its resistance against *Vibrio alginolyticus*. Fish Shellfish Immunol. 18, 1–12. https://doi.org/10.1016/j.fsi.2004.03.002

Cheng, W., Liu, C.H., Yeh, S.T., Chen, J.C., 2004. The immune stimulatory effect of sodium alginate on the white shrimp *Litopenaeus vannamei* and its resistance against *Vibrio alginolyticus*. Fish Shellfish Immunol. 17, 41–51. https://doi.org/10.1016/j.fsi.2003.11.004

Cheng, W., Yu, J.S., 2013. Effects of the dietary administration of sodium alginate on the immune responses and disease resistance of Taiwan abalone, *Haliotis diversicolor supertexta*. Fish Shellfish Immunol. 34, 902–908. https://doi.org/10.1016/j.fsi.2012.12.020

Chideroli, R.T., Amoroso, N., Mainardi, R.M., Suphoronski, S.A., de Padua, S.B., Alfieri, A.F., Alfieri, A.A., Mosela, M., Moralez, A.T.P., de Oliveira, A.G., Zanolo, R., Di Santis, G.W., Pereira, U.P., 2017. Emergence of a new multidrug-resistant and highly virulent serotype of *Streptococcus agalactiae* in fish farms from Brazil. Aquaculture 479, 45–51. https://doi.org/10.1016/j.aquaculture.2017.05.013

Chiu, S.T., Tsai, R.T., Hsu, J.P., Liu, C.H., Cheng, W., 2008. Dietary sodium alginate administration to enhance the non-specific immune responses, and disease resistance of the juvenile grouper *Epinephelus fuscoguttatus*. Aquaculture 277, 66–72. https://doi.org/10.1016/j.aquaculture.2008.01.032

Christobel, G.., Lipton, A.P., Aishwarya, M.S., Sarika, A.R., Udayakumar, A., 2011. Antibacterial activity of aqueous extract from selected macroalgae of southwest coast of India. Seaweed Res. Util. 33, 67–75.

Christybapita, D., Divyagnaneswari, M., Dinakaran Michael, R., 2007. Oral administration of Eclipta alba leaf aqueous extract enhances the non-specific immune responses and disease resistance of *Oreochromis mossambicus*. Fish Shellfish Immunol. 23, 840–852. https://doi.org/10.1016/j.fsi.2007.03.010

Conti, P., Kempuraj, D., Kandere, K., Gioacchino, M. Di, Barbacane, R.C., Castellani,

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

M.L., Felaco, M., Boucher, W., Letourneau, R., Theoharides, T.C., 2003. IL-10, an inflammatory/inhibitory cytokine, but not always. Immunol. Lett. 86, 123–129. https://doi.org/10.1016/S0165-2478(03)00002-6

Cuesta, A., Meseguer, J., Esteban, M. ´Angeles, 2008. The antimicrobial peptide hepcidin exerts an important role in the innate immunity against bacteria in the bony fish gilthead seabream. Mol. Immunol. 45, 2333–2342. https://doi.org/10.1016/j.molimm.2007.11.007

Cunningham, M.D., Bajorath, J., Somerville, J.E., Darveau, R.P., 1999. *Escherichia coli* and *Porphyromonas gingivalis* lipopolysaccharide interactions with CD14: Implications for myeloid and nonmyeloid cell activation. Clin. Infect. Dis. 28, 497–504. https://doi.org/10.1086/515158

Daemi, H., Barikani, M., 2012. Synthesis and characterization of calcium alginate nanoparticles, sodium homopolymannuronate salt and its calcium nanoparticles. Sci. Iran. 19, 2023–2028. https://doi.org/10.1016/j.scient.2012.10.005

Dawood, M.A.O., Koshio, S., 2016. Recent advances in the role of probiotics and prebiotics in carp aquaculture: A review. Aquaculture 454, 243–251. https://doi.org/10.1016/j.aquaculture.2015.12.033

Delamare-Deboutteville, J., Kawasaki, M., Zoccola, E., Heath, C.M., Bowater, R.O., Barnes, A.C., 2019. Interactions of head-kidney leucocytes from giant grouper, *Epinephelus lanceolatus*, with pathogenic *Streptococcus agalactiae* strains from marine and terrestrial origins. Fish Shellfish Immunol. 90, 250–263. https://doi.org/10.1016/j.fsi.2019.04.058

Dietrich, C.P., Fariasa, G.G.M., Abreu, L.R.D. De, Leitea, E.L., Silva, L.F., Naderb, H.B., 1995. A new approach for the characterization of polysaccharides from algae: presence of four main acidic polysaccharides in three species of the class Phaeophycea. Plant Sci. 108, 143–153. https://doi.org/https://doi.org/10.1016/0168-9452(95)04142-H

DKP Prov. Jawa Tengah, 2012. Laporan akhir permohonan pelepasan induk nila putih Janti (SS) jantan dan induk nila hitam Janti (GG) betina sebagai induk unggul.

Doan, H. Van, Hoseinifar, S.H., Tapingkae, W., Khamtavee, P., 2017. The effects of dietary kefir and low molecular weight sodium alginate on serum immune parameters, resistance against *Streptococcus agalactiae* and growth performance in Nile tilapia (*Oreochromis niloticus*). Fish Shellfish Immunol. 62, 139–146. https://doi.org/10.1016/j.fsi.2017.01.014

Doan, H. Van, Hoseinifar, S.H., Tapingkae, W., Tongsiri, S., Khamtavee, P., 2016a.

UNIVERSITAS
GADJAH MADA
**Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah
(Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis**
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Combined administration of low molecular weight sodium alginate boosted immunomodulatory, disease resistance and growth enhancing effects of *Lactobacillus plantarum* in Nile tilapia (*Oreochromis niloticus*). Fish Shellfish Immunol. 58, 678–685. https://doi.org/10.1016/j.fsi.2016.10.013

Doan, H. Van, Tapingkae, W., Moonmanee, T., Seepai, A., 2016b. Effects of low molecular weight sodium alginate on growth performance, immunity, and disease resistance of tilapia, *Oreochromis niloticus*. Fish Shellfish Immunol. 55, 186–194. https://doi.org/10.1016/j.fsi.2016.05.034

Dolcet, X., Llobet, D., Pallares, J., Matias-Guiu, X., 2005. NF-kB in development and progression of human cancer. Virchows Arch. 446, 475–482. https://doi.org/10.1007/s00428-005-1264-9

Dotta, G., de Andrade, J.I.A., Tavares Gonçalves, E.L., Brum, A., Mattos, J.J., Maraschin, M., Martins, M.L., 2014. Leukocyte phagocytosis and lysozyme activity in *Nile tilapia* fed supplemented diet with natural extracts of propolis and *Aloe barbadensis*. Fish Shellfish Immunol. 39, 280–284. https://doi.org/10.1016/j.fsi.2014.05.020

Draget, K.I., Smidsrot, D., Skajak-Braek, G., 2005. Alginates from algae. Wiley-VCH Verlag GmbH & Co. KgaA. Weinheim. 1-30.

Ellis, A.E., 2001. Innate host defense mechanisms of fish against viruses and bacteria. Dev. Comp. Immunol. 25, 827–839. https://doi.org/10.1016/S0145-305X(01)00038-6

Ellis, A.E., 1990. Lysozyme Assays. In: Stolen, J.S., Fletcher, T.C., Anderson, D.P., Roberson, B.S. and Van Muiswinkel, W.B., Eds., Techniques in Fish Immunology, SOS Publications, Fair Haven, 101–103.

Evans, J.J., Bohnsack, J.F., Klesius, P.H., Whiting, A.A., Garcia, J.C., Shoemaker, C.A., Takahashi, S., 2008. Phylogenetic relationships among *Streptococcus agalactiae* isolated from piscine, dolphin, bovine and human sources: A dolphin and piscine lineage associated with a fish epidemic in Kuwait is also associated with human neonatal infections in Japan. J. Med. Microbiol. 57, 1369–1376. https://doi.org/10.1099/jmm.0.47815-0

Falkeborg, M., Cheong, L.Z., Gianfico, C., Sztukiel, K.M., Kristensen, K., Glasius, M., Xu, X., Guo, Z., 2014. Alginate oligosaccharides: Enzymatic preparation and antioxidant property evaluation. Food Chem. 164, 185–194. https://doi.org/10.1016/j.foodchem.2014.05.053

Faure, E., Equils, O., Sieling, P.A., Thomas, L., Zhang, F.X., Kirschning, C.J.,

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Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Polentarutti, N., Muzio, M., Arditi, M., 2000. Bacterial lipopolysaccharide activates NF-κB through toll-like receptor 4 (TLR-4) in cultured human dermal endothelial cells: Differential expression of TLR-4 and TLR-2 in endothelial cells. J. Biol. Chem. 275, 11058–11063. https://doi.org/10.1074/jbc.275.15.11058

Feng, L., Gan, L., Jiang, W.-D., Wu, P., Liu, Y., Jiang, J., Tang, L., Kuang, S.-Y., Tang, W.-N., Zhang, Y.-A., Zhou, X.-Q., 2017a. Gill structural integrity changes in fish deficient or excessive in dietary isoleucine: Towards the modulation of tight junction protein, inflammation, apoptosis and antioxidant defense via NF-kB, TOR and Nrf2 signaling pathways. Fish Shellfish Immunol. 63, 127–138. https://doi.org/http://dx.doi.org/10.1016/j.fsi.2017.02.010

Feng, L., Ni, P.J., Jiang, W.D., Wu, P., Liu, Y., Jiang, J., Kuang, S.Y., Tang, L., Tang, W.N., Zhang, Y.A., Tang, X., Shi, H.Q., Zhou, X.Q., 2017b. Decreased enteritis resistance ability by dietary low or excess levels of lipids through impairing the intestinal physical and immune barriers function of young grass carp (*Ctenopharyngodon idella*). Fish Shellfish Immunol. 67, 493–512. https://doi.org/10.1016/j.fsi.2017.06.041

Filippov, M.P., Kohn, R., 1974. Determination of composition of alginates by infrared spectroscopic method. Chem. Zvesti 28, 817–819.

Fujiki, K., Matsuyama, H., Yano, T., 1994. Protective effect of sodium alginates against bacterial infection in common carp, *Cyprinus carpio* L. J. Fish Dis. 17, 349–355. https://doi.org/10.1111/j.1365-2761.1994.tb00230.x

Fujiki, K., Yano, T., 1997. Effects of sodium alginate on the non-specific defence system of the common carp (*Cyprinus carpio* L.). Fish Shellfish Immunol. 7, 417–427. https://doi.org/10.1006/fsim.1997.0095

Gatlin III, D.M., 2003. Nutrition and Fish Health, in: J.E. Halver, R.W. Hardy (Eds.), Fish Nutrition. Academic Press, pp. 671–702. https://doi.org/10.1016/B978-012319652-1/50013-6

Ghaednia, B., Mehrabi, M.R., Mirbakhsh, M., Yeganeh, V., Hoseinkhezri, P., Garibi, G., Ghaffar, J.A., 2011. Effect of hot-water extract of brown seaweed *Sargassum glaucescens* via immersion route on immune responses of *Fenneropenaeus indicus*. Iran. J. Fish. Sci. 10, 616–630.

Ghosh, S., May, M.J., Kopp, E.B., 1998. NF-κB and rel proteins: Evolutionarily Conserved Mediators of Immune Responses. Annu. Rev. Immunol. 16, 60–225. https://doi.org/doi: 10.1146/annurev.immunol.16.1.225

Giuliani, M.E., Regoli, F., 2014. Identification of the Nrf2-Keap1 pathway in the

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

European eel *Anguilla anguilla*: Role for a transcriptional regulation of antioxidant genes in aquatic organisms. Aquat. Toxicol. 150, 117–123. https://doi.org/10.1016/j.aquatox.2014.03.003

Gobi, N., Ramya, C., Vaseeharan, B., Malaikozhundan, B., Vijayakumar, S., Murugan, K., Benelli, G., 2016. *Oreochromis mossambicus* diet supplementation with *Psidium guajava* leaf extracts enhance growth, immune, antioxidant response and resistance to *Aeromonas hydrophila*. Fish Shellfish Immunol. 58, 572–583. https://doi.org/10.1016/j.fsi.2016.09.062

Gobi, N., Vaseeharan, B., Chen, J.C., Rekha, R., Vijayakumar, S., Anjugam, M., Iswarya, A., 2018. Dietary supplementation of probiotic *Bacillus licheniformis* Dahb1 improves growth performance, mucus and serum immune parameters, antioxidant enzyme activity as well as resistance against *Aeromonas hydrophila* in tilapia *Oreochromis mossambicus*. Fish Shellfish Immunol. 74, 501–508. https://doi.org/10.1016/j.fsi.2017.12.066

Gomez, C.G., Pérez, M. V, Lozano, J.E., Rinaudo, M., Villar, M.A., 2009. Influence of the extraction–purification conditions on final properties of alginates obtained from brown algae (*Macrocystis pyrifera*). Int. J. Biol. Macromol. 44, 365–371. https://doi.org/10.1016/j.ijbiomac.2009.02.005

Gu, D., Hu, Y., Wei, H., Zhu, Y., Mu, X., Luo, D., Xu, M., Yang, Y., 2017. Chapter 22 - Nile Tilapia *Oreochromis niloticus* (L.), Biological Invasions and Its Management in China, Volume 2. https://doi.org/10.1007/978-981-10-3427-5

Guiry, M.D., Guiry, G.M., 2015. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway.

Guo, S., Li, W., Chen, F., Yang, S., Huang, Y., Tian, Y., Xu, D., Cao, N., 2021. Polysaccharide of *Atractylodes macrocephala* Koidz regulates LPS-mediated mouse hepatitis through the TLR4-MyD88-NFκB signaling pathway. Int. Immunopharmacol. 98, 107692. https://doi.org/10.1016/j.intimp.2021.107692

Hajjar, A.M., O'Mahony, D.S., Ozinsky, A., Underhill, D.M., Aderem, A., Klebanoff, S.J., Wilson, C.B., 2001. Cutting edge: Functional interactions between toll-like receptor (TLR) 2 and TLR1 or TLR6 in response to phenol-soluble modulin. J. Immunol. 166, 15–19. https://doi.org/10.4049/jimmunol.166.1.15

Halliwell, B., Gutteridge, J.M.C., 1999. Free radicals in biology and medicine. 3 ed. Oxford University. Oxford.

Handayani, T., Sutarno, Setyawan, A.D., 2004. Analisis Komposisi Nutrisi Rumput Laut *Sargassum crassifolium* J. Agardh. Biofarmasi 2, 45–52.

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
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https://doi.org/10.13057/biofar/f020201

Harikrishnan, R., Devi, G., Van Doan, H., Balasundaram, C., Arockiaraj, J., Jagruthi, C., 2021a. Efficacy of ulvan on immune response and immuno-antioxidant gene modulation in *Labeo rohita* against columnaris disease. Fish Shellfish Immunol. 117, 262–273. https://doi.org/10.1016/j.fsi.2021.08.004

Harikrishnan, R., Devi, G., Van Doan, H., Balasundaram, C., Thamizharasan, S., Hoseinifar, S.H., Abdel-Tawwab, M., 2021b. Effect of diet enriched with *Agaricus bisporus* polysaccharides (ABPs) on antioxidant property, innate-adaptive immune response and pro-anti inflammatory genes expression in *Ctenopharyngodon idella* against *Aeromonas hydrophila*. Fish Shellfish Immunol. 114, 238–252. https://doi.org/10.1016/j.fsi.2021.04.025

Harikrishnan, R., Kim, M.C., Kim, J.S., Han, Y.J., Jang, I.S., Balasundaram, C., Heo, M.S., 2011. Immunomodulatory effect of sodium alginate enriched diet in kelp grouper *Epinephelus brneus* against *Streptococcus iniae*. Fish Shellfish Immunol. 30, 543–549. https://doi.org/10.1016/j.fsi.2010.11.023

Hay, N., Sonenberg, N., 2004. Upstream and downstream of mTOR. Genes Dev. 18, 1926–1945. https://doi.org/10.1101/gad.1212704

Henderson, B., Poole, S., Wilson, M., 1996. Bacterial modulins: A novel class of virulence factors which cause host tissue pathology by inducing cytokine synthesis. Microbiol. Rev. 60, 316–341. https://doi.org/10.1128/mmbr.60.2.316-341.1996

Hindu, S.V., Thanigaivel, S., Vijayakumar, S., Chandrasekaran, N., Mukherjee, A., Thomas, J., 2018. Effect of microencapsulated probiotic *Bacillus vireti* 01-polysaccharide extract of *Gracilaria folifera* with alginate-chitosan on immunity, antioxidant activity and disease resistance of *Macrobrachium rosenbergii* against *Aeromonas hydrophila* infection. Fish Shellfish Immunol. 73, 112–120. https://doi.org/10.1016/j.fsi.2017.12.007

Hirschfeld, M., Weis, J.J., Toshchakov, V., Salkowski, C.A., Cody, M.J., Ward, D.C., Qureshi, N., Michalek, S.M., Vogel, S.N., 2001. Signaling by toll-like receptor 2 and 4 agonists results in differential gene expression in murine macrophages. Infect. Immun. 69, 1477–1482. https://doi.org/10.1128/IAI.69.3.1477-1482.2001

Holland, M.C.H., Lambris, J.D., 2002. The complement system in teleosts. Fish Shellfish Immunol. 12, 399–420. https://doi.org/10.1006/fsim.2001.0408

Honda, K., Takaoka, A., Taniguchi, T., 2006. Type I Inteferon Gene Induction by the Interferon Regulatory Factor Family of Transcription Factors. Immunity 25, 349–

UNIVERSITAS
GADJAH MADA
**Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah
(Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis**
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

360. https://doi.org/10.1016/j.immuni.2006.08.009

Hoseinifar, S.H., Ahmadi, A., Khalili, M., Raeisi, M., Van Doan, H., Caipang, C.M., 2017. The study of antioxidant enzymes and immune-related genes expression in common carp (*Cyprinus carpio*) fingerlings fed different prebiotics. Aquac. Res. 48, 5447–5454. https://doi.org/10.1111/are.13359

Hoseinifar, S.H., Esteban, M.Á., Cuesta, A., Sun, Y.Z., 2015. Prebiotics and Fish Immune Response: A Review of Current Knowledge and Future Perspectives. Rev. Fish. Sci. Aquac. 23, 315–328. https://doi.org/10.1080/23308249.2015.1052365

Hoseinifar, S.H., Fazelan, Z., Bayani, M., Yousefi, M., Doan, H. Van, Yazici, M., 2022. Dietary red macroalgae (*Halopithys incurva*) improved systemic an mucosal immune and antioxidant parameters and modulated related gene expression in zebrafish (*Danio rerio*). Fish Shellfish Immunol. 123, 164–171. https://doi.org/https://doi.org/10.1016/j.fsi.2022.02.047

Hoyle, I., Shaw, B.J., Handy, R.D., 2007. Dietary copper exposure in the African walking catfish, *Clarias gariepinus*: Transient osmoregulatory disturbances and oxidative stress. Aquat. Toxicol. 83, 62–72. https://doi.org/10.1016/j.aquatox.2007.03.014

Hubert, J.J., 1992. Bioassay. Dubuque, Iowa: Kendall/Hunt Pub. Co.

Huising, M.O., Stet, R.J.M., Savelkoul, H.F.J., Kemenade, B.M.L.V., 2004. The molecular evolution of the interleukin-1 family of cytokines; IL-18 in teleost fish. Dev. Comp. Immunol. 28, 395–413. https://doi.org/10.1016/j.dci.2003.09.005

Immanuel, G., Sivagnanavelmurugan, M., Marudhupandi, T., Radhakrishnan, S., Palavesam, A., 2012. The effect of fucoidan from brown seaweed *Sargassum wightii* on WSSV resistance and immune activity in shrimp *Penaeus monodon* (Fab). Fish Shellfish Immunol. 32, 551–564. https://doi.org/10.1016/j.fsi.2012.01.003

Isnansetyo, A., Fikriyah, A., Kasanah, N., Murwantoko, 2016. Non-specific immune potentiating activity of fucoidan from a tropical brown algae (Phaeophyceae), *Sargassum cristaefolium* in tilapia (*Oreochromis niloticus*). Aquac. Int. 24, 465–477. https://doi.org/DOI 10.1007/s10499-015-9938-z

Isnansetyo, A., Irpani, H.M., Wulansari, T.A., Kasanah, N., 2014. Oral administration of alginate from a tropical brown seaweed, *Sargassum* sp. to enhance non-spesific defense in walking catfish (*Clarias* sp.), in: Aquaculture Indonesia. pp. 73–80. https://doi.org/10.21534/ai.v15i1.29

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Jaglarz, A., Gurgul, A., Leigh, W.J., Costa, J.Z., Thompson, K.D., 2018. Complete genome sequences of three fish-associated *Streptococcus agalactiae* isolates. Genome Announc 6e00025-18. 1–2. https://doi.org/https://doi.org/10.1128/genomeA.00025-18

Janeway, C.A., Medzhitov, R., 2002. Innate immune recognition. Annu. Rev. Immunol. 20, 197–216. https://doi.org/10.1146/annurev.immunol.20.083001.084359

Jiang, J., Yin, L., Li, J.Y., Li, Q., Shi, D., Feng, L., Liu, Y., Jiang, W.D., Wu, P., Zhao, Y., Zhou, X.Q., 2017. Glutamate attenuates lipopolysaccharide-induced oxidative damage and mRNA expression changes of tight junction and defensin proteins, inflammatory and apoptosis response signaling molecules in the intestine of fish. Fish Shellfish Immunol. 70, 473–484. https://doi.org/10.1016/j.fsi.2017.09.035

Jiang, W.-D., Tang, R.-J., Liu, Y., Wu, P., Kuang, S.-Y., Jiang, J., Tang, L., Tang, W.-N., Zhang, Y.-A., Zhou, X.-Q., Feng, L., 2017. Impairment of gill structural integrity by manganese deficiency or excess related to induction of oxidative damage, apoptosis and dysfunction of the physical barrier as regulated by NF-kB, caspase and Nrf2 signaling in fish. Fish Shellfish Immunol. 70, 280–292. https://doi.org/http://dx.doi.org/10.1016/j.fsi.2017.09.022

Jiang, W.D., Liu, Y., Hu, K., Jiang, J., Li, S.H., Feng, L., Zhou, X.Q., 2014. Copper exposure induces oxidative injury, disturbs the antioxidant system and changes the Nrf2/ARE (CuZnSOD) signaling in the fish brain: Protective effects of myo-inositol. Aquat. Toxicol. 155, 301–313. https://doi.org/10.1016/j.aquatox.2014.07.003

Jiang, W.D., Wu, P., Tang, R.J., Liu, Y., Kuang, S.Y., Jiang, J., Tang, L., Tang, W.N., Zhang, Y.A., Zhou, X.Q., Feng, L., 2016. Nutritive values, flavor amino acids, healthcare fatty acids and flesh quality improved by manganese referring to up-regulating the antioxidant capacity and signaling molecules TOR and Nrf2 in the muscle of fish. Food Res. Int. 89, 670–678. https://doi.org/10.1016/j.foodres.2016.09.020

Jin, M.S., Kim, S.E., Heo, J.Y., Lee, M.E., Kim, H.M., Paik, S.G., Lee, H., Lee, J.O., 2007. Crystal structure of the TLR1-TLR2 heterodimer induced by binding of a tri-acylated lipopeptide. Cell 130, 1071–1082. https://doi.org/10.1016/j.cell.2007.09.008

Jork, A., ThuÈrmer, F., Cramer, H., Thu, A.J.F., Hofmann, G., Ha, P.G.K., Hahn, H.,

UNIVERSITAS
GADJAH MADA
**Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah
(Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis**
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Fritsch, O.J.K., Zimmermann, U., 2000. Biocompatible alginate from freshly collected *Laminaria pallida* for implantation. Appl Microbiol Biotechnol 53, 224–229. https://doi.org/10.1007/s002530050012

Karlen, Y., Mcnair, A., Perseguers, S., Mazza, C., Mermod, N., 2007. Statistical significance of quantitative PCR. BMC Bioinformatics 16, 1–16. https://doi.org/10.1186/1471-2105-8-131

Karmakar, P., Pujol, C.A., Damonte, E.B., Ghosh, T., Ray, B., 2010. Polysaccharides from *Padina tetrastromatica*: Structural features, chemical modification and antiviral activity. Carbohydr. Polym. https://doi.org/10.1016/j.carbpol.2009.12.014

Kayansamruaj, P., Pirarat, N., Hirono, I., Rodkhum, C., 2014. Increasing of temperature induces pathogenicity of *Streptococcus agalactiae* and the up-regulation of inflammatory related genes in infected Nile tilapia (*Oreochromis niloticus*). Vet. Microbiol. 172, 265–271. https://doi.org/10.1016/j.vetmic.2014.04.013

Khairuman, Amri, K., 2013. Budidaya ikan Nila. Agromedia Pustaka. Jakarta.

Kiadaliri, M., Firouzbakhsh, F., Deldar, H., 2020. Effects of feeding with red algae (*Laurencia caspica*) hydroalcoholic extract on antioxidant defense, immune responses, and immune gene expression of kidney in rainbow trout (*Oncorhynchus mykiss*) infected with *Aeromonas hydrophila*. Aquaculture 526, 735361. https://doi.org/10.1016/j.aquaculture.2020.735361

Kobayashi, A., Kang, M.-I., Watai, Y., Tong, K.I., Shibata, T., Uchida, K., Yamamoto, M., 2006. Oxidative and electrophilic stresses activate Nrf2 through inhibition of ubiquitination activity of Keap1. Mol. Cell. Biol. 26, 221–229. https://doi.org/10.1128/mcb.26.1.221-229.2006

Kobayashi, M., Li, L., Iwamoto, N., Nakajima-Takagi, Y., Kaneko, H., Nakayama, Y., Eguchi, M., Wada, Y., Kumagai, Y., Yamamoto, M., 2009. The antioxidant defense system Keap1-Nrf2 comprises a multiple sensing mechanism for responding to a wide range of chemical compounds. Mol. Cell. Biol. 29, 493–502. https://doi.org/10.1128/mcb.01080-08

Kresno, S.B., 2013. Imunologi: Diagnosis dan prosedur laboratorium. Edisi kelima. Badan Penerbit Fakultas Kedokteran UI. Jakarta.

Labh, S.N., Shakya, S.R., 2014. Application of immunostimulants as an alternative to vaccines for health management in aquaculture. Int. J. Fish. Aquat. Stud. 2, 153–156.

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Leal, D., Matsuhiro, B., Rossi, M., Caruso, F., 2008. FT-IR spectra of alginic acid block fractions in three species of brown seaweeds. Carbohydr. Res. 343, 308–316. https://doi.org/10.1016/j.carres.2007.10.016

Lee, K.Y., Mooney, D.J., 2012. Alginate: Properties and biomedical applications. Prog. Polym. Sci. 37, 106–126. https://doi.org/10.1016/j.progpolymsci.2011.06.003

Lee, P.P., Lin, Y.H., Chen, M.C., Cheng, W., 2017. Dietary administration of sodium alginate ameliorated stress and promoted immune resistance of grouper *Epinephelus coioides* under cold stress. Fish Shellfish Immunol. 65, 127–135. https://doi.org/10.1016/j.fsi.2017.04.007

Lee, P.T., Quan Tran, H.T., Huang, H.T., Nan, F.H., Lee, M.C., 2020. *Sargassum horneri* extracts stimulate innate immunity, enhance growth performance, and upregulate immune genes in the white shrimp *Litopenaeus vannamei*. Fish Shellfish Immunol. 102, 276–285. https://doi.org/10.1016/j.fsi.2020.04.049

Leonardi, M., Sandino, A.M., Klempau, A., 2003. Effect of a nucleotide-enriched diet on the immune system, plasma cortisol levels and resistance to infectious pancreatic necrosis (IPN) in juvenile rainbow trout (*Oncorhynchus mykiss*). Bull. Eur. Assoc. Fish Pathol. 23, 52–59.

Li, M.-Y., Guo, W.-Q., Guo, G.-L., Zhu, X.-M., Niu, X.-T., Shan, X.-F., Tian, J.-X., Wang, G.-Q., Zhang, D.-M., 2020. Effects of dietary astaxanthin on lipopolysaccharide-induced oxidative stress, immune responses and glucocorticoid receptor (GR)-related gene expression in *Channa argus*. Aquaculture 517, 734816. https://doi.org/10.1016/j.aquaculture.2019.734816

Li, M.O., Wan, Y.Y., Sanjabi, S., Robertson, A.L., Flavell, R.A., 2006. Transforming growth factor-β regulation of immune responses. Annu. Rev. Immunol. 24, 99–146. https://doi.org/10.1146/annurev.immunol.24.021605.090737

Li, P., Lewis, D.H., Gatlin, D.M., 2004. Dietary oligonucleotides from yeast RNA influence immune responses and resistance of hybrid striped bass (*Morone chrysops* X *Morone saxatilis*) to *Streptococcus iniae* infection. Fish Shellfish Immunol. 16, 561–569. https://doi.org/10.1016/j.fsi.2003.09.005

Liu, C.H., Yeh, S.P., Kuo, C.M., Cheng, W., Chou, C.H., 2006. The effect of sodium alginate on the immune response of tiger shrimp via dietary administration: Activity and gene transcription. Fish Shellfish Immunol. 21, 442–452. https://doi.org/10.1016/j.fsi.2006.02.003

Liu, H., Wang, S., Cai, Y., Guo, X., Cao, Z., Zhang, Y., Liu, S., Yuan, W., Zhu, W.,

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Zheng, Y., Xie, Z., Guo, W., Zhou, Y., 2017. Dietary administration of *Bacillus subtilis* HAINUP40 enhances growth, digestive enzyme activities, innate immune responses and disease resistance of tilapia, *Oreochromis niloticus*. Fish Shellfish Immunol. 60, 326–333. https://doi.org/10.1016/j.fsi.2016.12.003

Liu, J., Zhang, P., Wang, B., Lu, Y., Li, L., Li, Y., Liu, S., 2022. Evaluation of the effects of *Astragalus polysaccharides* as immunostimulants on the immune response of crucian carp and against SVCV in vitro and in vivo. Comp. Biochem. Physiol. Part C Toxicol. Pharmacol. 253. https://doi.org/https://doi.org/10.1016/j.cbpc.2021.109249

Liu, P.C., Lin, P.W., Huang, C.L., Hsu, C.H., Chen, J.C., 2019. Long-term administration of diets containing *Gracilaria tenuistipitata* extract induce the expression of immune-related genes and increase the immune response and resistance against *Vibrio harveyi* in white shrimp *Litopenaeus vannamei*. Gene Reports 15, 100378. https://doi.org/10.1016/j.genrep.2019.100378

Livak, K.J., Schmittgen, T.D., 2001. Analysis of Relative Gene Expression Data Using Real- Time Quantitative PCR and the 2⩥⌬⌬CT Method. Methods 25, 402–408. https://doi.org/doi:https://doi.org/10.1006/meth.2001.1262

Loiselle, P.V., 1994. The Cichlid Aquarium. Tetra Press.

Ma, Q., 2013. Role of Nrf2 in oxidative stress and toxicity. Annu. Rev. Pharmacol. Toxicol. 53, 401–426. https://doi.org/10.1146/annurev-pharmtox-011112-140320

Mackenzie, S., Planas, J. V, Goetz, F.W., 2003. LPS-stimulated expression of a tumor necrosis factor-alpha mRNA in primary trout monocytes and in vitro differentiated macrophages. Dev. Comp. Immunol. 27, 393–400. https://doi.org/10.1016/s0145-305x(02)00135-0

Madigan, M.T., Martinko, J.M., 2000. Brock biology of microorganims. Upper Saddle River, New Jersey, USA: Prentice Hall, Inc.

Magnadóttir, B., 2006. Innate immunity of fish (overview). Fish Shellfish Immunol. 20, 137–151. https://doi.org/10.1016/j.fsi.2004.09.006

Magnadottir, B., Lange, S., Gudmundsdottir, S., Bøgwald, J., Dalmo, R.A., 2005. Ontogeny of humoral immune parameters in fish. Fish Shellfish Immunol. 19, 429–439. https://doi.org/10.1016/j.fsi.2005.03.010

Maheswaran, M.L., Padmavathy, S., Gunalan, B., 2013. Screening and Characterization of Marine Seaweeds and its Antimicrobial Potential against Fish Pathogens. Int. J. Fish. Aquat. Stud. 1, 1–13.

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Mariano, G., Stilo, R., Terrazzano, G., Coccia, E., Vito, P., Varricchio, E., Paolucci, M., 2013. Effects of recombinant trout leptin in superoxide production and NF-κB/MAPK phosphorylation in blood leukocytes. Peptides 48, 59–69. https://doi.org/10.1016/j.peptides.2013.07.026

Martínez-Álvarez, R.M., Morales, A.E., Sanz, A., 2005. Antioxidant defenses in fish: Biotic and abiotic factors. Rev. Fish Biol. Fish. 15, 75–88. https://doi.org/10.1007/s11160-005-7846-4

Mathlouthi, M., Koenig, J.L., 1987. Vibrational spectra of carbohydrates. Adv. Carbohydr. Chem. Biochem. 44, 7–89. https://doi.org/10.1016/S0065-2318(08)60077-3

Means, T.K., E, L., A, Y., S, W., D.T., G., M.J., F., 1999. The CD14 ligands lipoarabinomannan and lipopolysaccharide differ in their requirement for toll-like receptors. J. Immunol. 163, 6748–6755.

Medzhitov, R., 2008. Origin and physiological roles of inflammation. Nature 454, 428–435. https://doi.org/10.1038/nature07201

Medzhitov, R., 2007. Recognition of microorganisms and activation of the immune response. Nature 449, 819–826. https://doi.org/10.1038/nature06246

Medzhitov, R., 2001. Toll-like receptors and innate immunity. Nat. Rev. Immunol. 1, 135–145. https://doi.org/https://doi.org/10.1038/35100529

Medzhitov, R., Janeway, C., 2000. Innate Immunity. Adv. Immunol. 338–344. https://doi.org/10.1056/NEJM200008033430506

Menshova, R. V., Ermakova, S.P., Rachidi, S.M., Zvyagintseva, T.N., Kanaan, H.M., 2012. Seasonal variation of the composition, structural features, and antitumor properties of polysaccharides from *Padina pavonica* (Lebanon) as a function of composition. Chem. Nat. Compd. 47, 764–769. https://doi.org/10.1007/s10600-012-0091-x

Mian, G.F., Godoy, D.T., Leal, C.A.G., Yuhara, T.Y., Costa, G.M., Figueiredo, H.C.P., 2009. Aspects of the natural history and virulence of *S. agalactiae* infection in nile tilapia. Vet. Microbiol. 136, 180–183. https://doi.org/10.1016/j.vetmic.2008.10.016

Miandare, H.K., Farvardin, S., Shabani, A., Hoseinifar, S.H., Ramezanpour, S.S., 2016. The effects of galactooligosaccharide on systemic and mucosal immune response, growth performance and appetite related gene transcript in goldfish (*Carassius auratus gibelio*). Fish Shellfish Immunol. 55, 479–483. https://doi.org/10.1016/j.fsi.2016.06.020

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Mulero, V., Jose Meseguer, 1998. Functional characterisation of a macrophage-activating factor produced by leucocytes of gilthead seabream (*Sparus aurata* L .). Fish Shellfish Immunol. 8, 143–156. https://doi.org/https://doi.org/10.1006/fsim.1997.0127

Musa, Najiah, Wei, L.S., Musa, Nadirah, Hamdan, R.H., Leong, L.K., Wee, W., Amal, M.N., Kutty, B.M., Abdullah, S.Z., 2009. Streptococcosis in red hybrid tilapia (*Oreochromis niloticus*) commercial farms in Malaysia. Aquac. Res. 40, 630–632. https://doi.org/10.1111/j.1365-2109.2008.02142.x

Mushollaeni, W., 2011. The physicochemical characteristics of sodium alginate from Indonesian brown seaweeds. African J. Food Sci. 5, 349–352.

Mushollaeni, W., Rusdiana, E., 2011. Characterization of sodium alginate from *Sargassum* sp., *Turbinaria* sp. and *Padina* sp. J. Teknol. dan Ind. Pangan XXII, 26–32.

Na-Phatthalung, P., Teles, M., Voravuthikunchai, S.P., Tort, L., Fierro-Castro, C., 2018. Immune-related gene expression and physiological responses in rainbow trout (*Oncorhynchus mykiss*) after intraperitoneal administration of *Rhodomyrtus tomentosa* leaf extract: A potent phytoimmunostimulant. Fish Shellfish Immunol. 77, 429–437. https://doi.org/10.1016/j.fsi.2018.03.035

Nayak, S.K., 2010. Probiotics and immunity: A fish perspective. Fish Shellfish Immunol. 29, 2–14. https://doi.org/10.1016/j.fsi.2010.02.017

Neumann, N.F., Stafford, J.L., Barreda, D., Ainsworth, A.J., Belosevic, M., 2001. Antimicrobial mechanisms of fish phagocytes and their role in host defense. Dev. Comp. Immunol. 25, 807–825. https://doi.org/10.1016/S0145-305X(01)00037-4

Newman, S.G., 1999. A Review of the Use of Non Specific Immune-Stimulants to Reduce the Impact of the WSSV. Pap. Present. Fifth Ecuadorian Aquac. Conf. 19–25.

Nojima, H., Tokunaga, C., Eguchi, S., Oshiro, N., Hidayat, S., Yoshino, K.I., Hara, K., Tanaka, N., Avruch, J., Yonezawa, K., 2003. The mammalian target of rapamycin (mTOR) partner, raptor, binds the mTOR substrates p70 S6 kinase and 4E-BP1 through their TOR signaling (TOS) motif. J. Biol. Chem. 278, 15461–15464. https://doi.org/10.1074/jbc.C200665200

Nontji, A., 1993. Laut Nusantara. Djambatan. Jakarta.

Obluchinskaia, E.D., Voskoboĭnikov, G.M., Galynkin, V.A., 2002. Content of alginic acid and fucoidan in fucus algae of the Barents sea. Prikl Biokhim Mikrobiol 38, 213–216.

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Ortuno, J., Esteban, M.A., Meseguer, J., 2002. Effects of phenoxyethanol on the innate immune system of gilthead seabream (*Sparus aurata* L.) exposed to crowding stress. Vet. Immunol. Immunopathol. 89, 29–36. https://doi.org/10.1016/s0165-2427(02)00183-6

Ozinsky, A., Underhill, D.M., Fontenot, J.D., Hajjar, A.M., Smith, K.D., Wilson, C.B., Schroeder, L., Aderem, A., 2000. The repertoire for pattern recognition of pathogens by the innate immune system is defined by cooperation between toll-like receptors. Proc. Natl. Acad. Sci. U. S. A. 97, 13766–13771. https://doi.org/10.1073/pnas.250476497

Parthiban, C., Parameswari, K., Saranya, C., Hemalatha, A., 2012. Production of sodium alginate from selected seaweeds and their physiochemical and biochemical properties. Asian Pacific J. Trop. Biomed. 1–4.

Pawar, S.N., Edgar, K.J., 2012. Alginate derivatization: A review of chemistry, properties and applications. Biomaterials 33, 3279–3305. https://doi.org/10.1016/j.biomaterials.2012.01.007

Phuoc, N.N., Linh, N.T.H., Crestani, C., Zadoks, R.N., 2021. Effect of strain and enviromental conditions on the virulence of *Streptococcus agalactiae* (Group B Streptococcus; GBS) in red tilapia (*Oreochromis* sp.). Aquaculture 534, 736256. https://doi.org/10.1016/j.aquaculture.2020.736256

Plant, K.P., Lapatra, S.E., 2011. Advances in fish vaccine delivery. Dev. Comp. Immunol. 35, 1256–1262. https://doi.org/10.1016/j.dci.2011.03.007

Playfair, J.H.., Chain, B.M., 2009. Immunology: At a glance imunologi, 9th ed. Blackwell Publishing. UK.

Plumb, J.A., Hanson, L.A., 1999. Tilapia bacterial diseases, in: Health Maintenance and Principal Microbial Diseases of Cultured Fishes. Wiley-Blackwell, pp. 445–463.

Radhika, C, V., R, P., A, M., 2014. A Comparative Study of Biopotentioal of Crude and Fractionated Extracts of Some Sea Weeds from Tuticorin Coast. Int. J. Phytopharm. 3, 27–30.

Rajendran, P., Subramani, P.A., Michael, D., 2016. Polysaccharides from marine macroalga, *Padina gymnospora* improve the nonspecific and specific immune responses of *Cyprinus carpio* and protect it from different pathogens. Fish Shellfish Immunol. 58, 220–228. https://doi.org/10.1016/j.fsi.2016.09.016

Reda, R.M., Mahmoud, R., Selim, K.M., El-Araby, I.E., 2016. Effects of dietary acidifiers on growth, hematology, immune response and disease resistance of

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Nile tilapia, *Oreochromis niloticus*. Fish Shellfish Immunol. 50, 255–262. https://doi.org/10.1016/j.fsi.2016.01.040

Redaa, R.M., Selim, K.M., Mahmoud, R., El-Araby, I.E., Reda, R.M., Selim, K.M., Mahmoud, R., El-Araby, I.E., 2018. Effect of dietary yeast nucleotide on antioxidant activity, non-specific immunity, intestinal cytokines, and disease resistance in Nile Tilapia. Fish Shellfish Immunol. 80, 281–290. https://doi.org/10.1016/j.fsi.2018.06.016

Reverter, M., Bontemps, N., Lecchini, D., Banaigs, B., Sasal, P., 2014. Use of plant extracts in fish aquaculture as an alternative to chemotherapy: Current status and future perspectives. Aquaculture 433, 50–61. https://doi.org/10.1016/j.aquaculture.2014.05.048

Riche, M., 2007. Analysis of refractometry for determining total plasma protein in hybrid striped bass (*Morone chrysops* × *M. saxatilis*) at various salinities. Aquaculture 264, 279–284. https://doi.org/10.1016/j.aquaculture.2006.12.018

Roberts, R.J., Rodger, H.D., 2012. The Pathophysiology and Systematic Pathology of Teleosts. Fish Pathol. Fourth Ed. 62–143. https://doi.org/10.1002/9781118222942.ch3

Rodkhum, C., Kayansamruaj, P., Pirarat, N., 2011. Effect of water temperature on susceptibility to *Streptococcus agalactiae* serotype ia infection in nile tilapia (*Oreochromis niloticus*). Thai J. Vet. Med. 41, 309–314.

Sakai, M., 1999. Current research status of fish immunostimulants. Aquaculture 172, 63–92. https://doi.org/10.1016/S0044-8486(98)00436-0

Salah, A.S., El Nahas, A.F., Mahmoud, S., 2017. Modulatory effect of different doses of β-1,3/1,6-glucan on the expression of antioxidant, inflammatory, stress and immune-related genes of *Oreochromis niloticus* challenged with *Streptococcus iniae*. Fish Shellfish Immunol. 70, 204–213. https://doi.org/10.1016/j.fsi.2017.09.008

Saralahti, A., Rämet, M., 2015. Zebrafish and Streptococcal infections. Scand. J. Immunol. 82, 174–183. https://doi.org/10.1111/sji.12320

Saunders, N.A., 2009. Introduction to the application of real time PCR in J. Logan, K. Edwards and N. Saunders (eds): Real Time PCR. Current technology and applications. Caister Academic Press. 105-10.

Saurabh, S., Sahoo, P.K., 2008. Lysozyme: An important defence molecule of fish innate immune system. Aquac. Res. 39, 223–239. https://doi.org/10.1111/j.1365-2109.2007.01883.x

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Schroder, K., Tschopp, J., 2010. The Inflammasomes. Cell 140, 821–832. https://doi.org/10.1016/j.cell.2010.01.040

Schwandner, R., Dziarski, R., Wesche, H., Rothe, M., Kirschning, C.J., 1999. Peptidoglycan- and lipoteichoic acid-induced cell activation is mediated by toll-like receptor 2. J. Biol. Chem. 274, 17406–17409. https://doi.org/10.1074/jbc.274.25.17406

Secombes, C.J., Fletcher, T.C., 1992. The role of phagocytes in the protective mechanisms of fish. Annu. Rev. Fish Dis. 2, 53–71. https://doi.org/10.1016/0959-8030(92)90056-4

Selim, K.M., Reda, R.M., 2015. Improvement of immunity and disease resistance in the Nile tilapia, *Oreochromis niloticus*, by dietary supplementation with *Bacillus amyloliquefaciens*. Fish Shellfish Immunol. 1–8. https://doi.org/10.1016/j.fsi.2015.03.004

Setyawan, A., Isnansetyo, A., Murwantoko, Indarjulianto, S., Handayani, C.R., 2018. Comparative immune response of dietary fucoidan from three indonesian brown algae in white shrimp *Litopenaeus vannamei*. AACL Bioflux 11, 1707–1723.

Shakibaei, M., John, T., Schulze-Tanzil, G., Lehmann, I., Mobasheri, A., 2007. Suppression of NF-κB activation by curcumin leads to inhibition of expression of cyclo-oxygenase-2 and matrix metalloproteinase-9 in human articular chondrocytes: Implications for the treatment of osteoarthritis. Biochem. Pharmacol. 73, 1434–1445. https://doi.org/10.1016/j.bcp.2007.01.005

Shiau, S., Gabaudan, J., Lin, Y., 2015. Dietary nucleotide supplementation enhances immune responses and survival to *Streptococcus iniae* in hybrid tilapia fed diet containing low fish meal. Aquac. Reports 2, 77–81. https://doi.org/10.1016/j.aqrep.2015.08.002

Silva, J., Alves, C., Pinteus, S., Horta, A., Pedrosa, R., 2013. High antioxidant activity of *Sargassum muticum* and *Padina pavonica* collected from Peniche coast (Portugal). Curr. Opin. Biotechnol. 24, S116. https://doi.org/10.1016/j.copbio.2013.05.361

Silverstein, R.M., Webster, F.X., Kiemle, D.J., Bryce, D.L., 2014. Spectrometric Identification of Organic Compounds, 8th Edition. Wiley, USA.

Singh, M., Subramanian, M., Kumaraguru, A., 2014. In Vitro Antibacterial Activity of Selected Brown Marine Macroalgae Extracts collected from the Pudumadam Coast of “Gulf of Manna ” region against Fish Pathogens. Int. J. Hum. Genet. Med. Biotechnol. Microbiol. Stud. 1.

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Skjermo, J., Bergh, 2004. High-M alginate immunostimulation of Atlantic halibut (*Hippoglossus hippoglossus* L.) larvae using Artemia for delivery, increases resistance against vibriosis. Aquaculture 238, 107–113. https://doi.org/10.1016/j.aquaculture.2004.05.038

Sohn, K.S., Kim, M.K., Kim, J.D., Han, I.K., 2000. The Role of Immunostimulants in Monogastric Animal and Fish - Review -. Asian Australas. J. Anim. Sci. 13, 1178–1187. https://doi.org/10.5713/ajas.2000.1178

Song, Z.-X., Jiang, W.-D., Liu, Y., Wu, P., Jiang, J., Zhou, X.-Q., Kuang, S.-Y., Tang, L., Tang, W.-N., Zhang, Y.-A., Feng, L., 2017. Dietary zinc deficiency reduced growth performance, intestinal immune and physical barrier functions related to NF-kB, TOR, Nrf2, JNK and MLCK signaling pathway of young grass carp (*Ctenopharyngodon idella*). Fish Shellfish Immunol. 66, 497–523. https://doi.org/http://dx.doi.org/10.1016/j.fsi.2017.05.048

Suanyuk, N., Kong, F., Ko, D., Gilbert, G.L., Supamattaya, K., 2008. Occurrence of rare genotypes of *Streptococcus agalactiae* in cultured red tilapia *Oreochromis* sp. and Nile tilapia *O. niloticus* in Thailand-Relationship to human isolates? Aquaculture 284, 35–40. https://doi.org/10.1016/j.aquaculture.2008.07.034

Sudaryono, A., Haditomo, A.H.C., Isnansetyo, A., 2015. Evaluation of dietary supplementation of aqueous extract of brown algae *Sargassum cristaefolium* on growth performance and feed utilization of juvenile white shrimp *Litopenaeus vannamei*. AACL Bioflux.

Susanto, T., Rakhmadiono, S., Mujianto, 2001. Karakterisasi ekstrak aliginat dari *Padina* sp. J. Teknol. Pertan. 2, 96–109.

Takeuchi, O., Akira, S., 2010. Pattern recognition receptors and inflammation. Cell 140, 805–820. https://doi.org/10.1016/j.cell.2010.01.022

Takeuchi, O., Hoshino, K., Kawai, T., Sanjo, H., Takada, H., Ogawa, T., Takeda, K., Akira, S., 1999. Differential roles of TLR2 and TLR4 in recognition of gram-negative and gram-positive bacterial cell wall components. Immunity 11, 443–451. https://doi.org/10.1016/S1074-7613(00)80119-3

Takeuchi, O., Kaufmann, A., Grote, K., Kawai, T., Hoshino, K., Morr, M., Mühlradt, P.F., Akira, S., 2000. Cutting edge: Preferentially the R-stereoisomer of the mycoplasmal lipopeptide macrophage-activating lipopeptide-2 activates immune cells through a toll-like receptor 2- and MyD88-dependent signaling pathway. J. Immunol. 164, 554–557. https://doi.org/10.4049/jimmunol.164.2.554

Takeuchi, O., Kawai, T., Mühlradt, P.F., Morr, M., Radolf, J.D., Zychlinsky, A., Takeda,

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

K., Akira, S., 2001. Discrimination of bacterial lipoproteins by toll-like recepttor 6. Int. Immunol. 13, 933–940. https://doi.org/10.1093/intimm/13.7.933

Takeuchi, O., Sato, S., Horiuchi, T., Hoshino, K., Takeda, K., Dong, Z., Modlin, R.L., Akira, S., 2002. Cutting edge: Role of toll-like receptor 1 in mediating immune response to microbial lipoproteins. J. Immunol. 169, 10–14. https://doi.org/10.4049/jimmunol.169.1.10

Tang, J., Cai, J., Liu, R., Wang, J., Lu, Y., Wu, Z., Jian, J., 2014. Immunostimulatory effects of artificial feed supplemented with a Chinese herbal mixture on *Oreochromis niloticus* against *Aeromonas hydrophila*. Fish Shellfish Immunol. 39, 401–406. https://doi.org/10.1016/j.fsi.2014.05.028

Tassanakajon, A., Somboonwiwat, K., Supungul, P., Tang, S., 2013. Discovery of immune molecules and their crucial functions in shrimp immunity. Fish Shellfish Immunol. 34, 954–967. https://doi.org/10.1016/j.fsi.2012.09.021

Thanigaivel, S., Chandrasekaran, N., Mukherjee, A., John Thomas, 2015. Investigation of seaweed extracts as a source of treatment against bacterial fish pathogen. Aquaculture 448, 82–86. https://doi.org/10.1016/j.aquaculture.2015.05.039

Thannickal, V.J., Fanburg, B.L., 2000. Reactive oxygen species in cell signaling. Am. J. Physiol. - Lung Cell. Mol. Physiol. 279. https://doi.org/10.1152/ajplung.2000.279.6.l1005

Tian, W., De La Vega, M.R., Schmidlin, C.J., Ooi, A., Zhang, D.D., 2018. Kelch-like ECH-Associated protein 1 (KEAP1) differentially regulates nuclear factor erythroid-2-related factors 1 and 2 (NRF1 and NRF2). J. Biol. Chem. 293, 2029–2040. https://doi.org/10.1074/jbc.RA117.000428

Tiengtam, N., Khempaka, S., Paengkoum, P., Boonanuntanasarn, S., 2015. Effects of inulin and Jerusalem artichoke (*Helianthus tuberosus*) as prebiotic ingredients in the diet of juvenile Nile tilapia (*Oreochromis niloticus*). Anim. Feed Sci. Technol. 207, 120–129. https://doi.org/10.1016/j.anifeedsci.2015.05.008

Ting, C., Chen, Y., Chen, J., 2018. Nile tilapia fry fed on antimicrobial peptide Epinecidin-1-expressing Artemia cyst exhibit enhanced immunity against acute bacterial infection. Fish Shellfish Immunol. 81, 37–48. https://doi.org/10.1016/j.fsi.2018.07.008

Tipping, P.G., 2006. Toll-Like Receptors: The Interface between Innate and Adaptive Immunity. J Am Soc Nephrol 17 17, 1769–1771. https://doi.org/10.1681/ASN.2006050489

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

Traifalgar, R., Serrano, A., Corre, V., Kira, H., Tung, H., Michael, F., Kader, M., Laining, A., Yokoyama, S., Ishikawa, M., Koshio, S., 2009. Evaluation of dietary fucoidan supplementation effects on growth performance and Vibriosis resistance of *Penaeus monodon* postlarvae. Aquac. Sci. 57, 167–174. https://doi.org/10.11233/aquaculturesci.57.167

Trewavas, E., 1983. Tilapiine fishes of the genera Sarotherodon, Oreochromis and Danakilia. British Museum (Natural History), London.

Tul'chinsky, V.M., Zurabyan, Z.E., Asankoshoev, K.A., Kogan, G.A., Khorlin, A.Y., 1976. Study of the infrared spectra of oligosaccharides in the region 1,000-40 cm−1. Carbohyrtate Res. 51, 1–8. https://doi.org/https://doi.org/10.1016/S0008-6215(00)84031-8

Udayangani, R.M.C., Dananjaya, S.H.S., Fronte, B., Kim, C.H., Lee, J., De Zoysa, M., 2017. Feeding of nano scale oats β-glucan enhances the host resistance against *Edwardsiella tarda* and protective immune modulation in zebrafish larvae. Fish Shellfish Immunol. 60, 72–77. https://doi.org/10.1016/j.fsi.2016.11.035

Underhill, D.M., Ozinsky, A., Hajjar, A.M., Stevens, A., Wilson, C.B., Bassetti, M., Aderem, A., 1999. The toll-like receptor 2 is recruited to macrophage phagosomes and discriminates between pathogens. Nature 401, 811–815. https://doi.org/10.1038/44605

Uribe, C., Folch, H., Enriquez, R., Moran, G., 2011. Innate and adaptive immunity in teleost fish: a review. Vet. Med. (Praha). 56, 486–503. https://doi.org/10.17221/3294-VETMED

Vassalli, P., 1992. The pathophysiology of tumor necrosis factors. Annu. Rev. Immunol. 10, 411–452. https://doi.org/10.1146/annurev.immunol.10.1.411

Vazquez, L., Alpuche, J., Maldonado, G., Agundis, C., Pereyra-Morales, A., Zenteno, E., 2009. Review: Immunity mechanisms in crustaceans. Innate Immun. 15, 179–188. https://doi.org/10.1177/1753425909102876

Vollstad, D., Bøgwald, J., Gåserød, O., Dalmo, R.A., 2006. Influence of high-M alginate on the growth and survival of Atlantic cod (*Gadus morhua* L.) and spotted wolffish (*Anarhichas minor* Olafsen) fry. Fish Shellfish Immunol. 20, 548–561. https://doi.org/10.1016/j.fsi.2005.07.004

Wang, T., Secombes, C.J., 2013. The cytokine networks of adaptive immunity in fish. Fish Shellfish Immunol. 35, 1703–1718. https://doi.org/10.1016/j.fsi.2013.08.030

Watzke, J., Schirmer, K., Scholz, S., 2007. Bacterial lipopolysaccharides induce genes involved in the innate immune response in embryos of the zebrafish

UNIVERSITAS
GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
TONI KUSWOYO, Prof. Dr. Ir. Alim Isnansetyo, M.Sc.
Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

(*Danio rerio*). Fish Shellfish Immunol. 23, 901–905. https://doi.org/10.1016/j.fsi.2007.03.004

Webster, C.D., Lim, C., 2006. Tilapia: Biology, culture, and nutrition. CRC Press, Florida, USA.

Wedemeyer, G.A., Yasutake, W.T., 1977. Clinical methods for the assesment of the effects of environmental stress on fish health. United States Department Of The Interior Fish And Wildlife Service. 89, 1–25.

Weichhart, T., Costantino, G., Poglitsch, M., Rosner, M., Zeyda, M., Stuhlmeier, K.M., Kolbe, T., Stulnig, T.M., Hörl, W.H., Hengstschläger, M., Müller, M., Säemann, M.D., 2008. The TSC-mTOR Signaling Pathway Regulates the Innate Inflammatory Response. Immunity 29, 565–577. https://doi.org/10.1016/j.immuni.2008.08.012

Weissensteiner, T., Griffin, H.G., Griffin, A., 2003. PCR technology: Curent innovations. ed 2. Boca Roton. Florida, CRC Press.

Wenger, M., Sattler, U., Goldschmidt-Clermont, E., Segner, H., 2011. 17Beta-estradiol affects the response of complement components and survival of rainbow trout (*Oncorhynchus mykiss*) challenged by bacterial infection. Fish Shellfish Immunol. 31, 90–97. https://doi.org/10.1016/j.fsi.2011.04.007

Werts, C., Tapping, R.I., Mathison, J.C., Chuang, T.H., Kravchenko, V., Saint Girons, I., Haake, D.A., Godowski, P.J., Hayashi, F., Ozinsky, A., Underhill, D.M., Kirschning, C.J., Wagner, H., Aderem, A., Tobias, P.S., Ulevitch, R.J., 2001. Leptospiral lipopolysaccharide activates cells through a TLR2-dependent mechanism. Nat. Immunol. 2, 346–352. https://doi.org/10.1038/86354

Wiegertjes, G.F., Stet, R.J., Parmentier, H.K., Muiswinkel, W.B. van, 1996. Immunogenetics of disease resistance in fish: a comparable approach. Dev. Comp. Immunol. 20, 365–381. https://doi.org/10.1016/s0145-305x(96)00032-8

Winarsi, H., 2007. Antioksidan Alami dan Radikal Bebas. Kanisius. Yogyakarta.

Wiradharma, D., Pusparini, Alvina, 2015. Konsep imunologi dasar. Sagung Seto. Jakarta. p 76- 79.

Wu, B., Xu, Z., Cao, J., Wang, Q., Mei, J., Xie, J., 2022. Effects of β -1 ,3-glucan and ascorbic acid on the nutritional-immune response and antioxidant signaling pathways of live tiger grouper during simulated transport. Aquac. Fish. 1–8. https://doi.org/https://doi.org/10.1016/j.aaf.2022.03.001

Wu, Y. rui, Gong, Q. fang, Fang, H., Liang, W. wen, Chen, M., He, R. jie, 2013. Effect of Sophora flavescens on non-specific immune response of tilapia (GIFT

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Oreochromis niloticus) and disease resistance against *Streptococcus agalactiae*. Fish Shellfish Immunol. 34, 220–227. https://doi.org/10.1016/j.fsi.2012.10.020

Xie, S., Zhou, W., Tian, L., Niu, J., Liu, Y., 2016. Effect of N-acetyl cysteine and glycine supplementation on growth performance, glutathione synthesis, anti-oxidative and immune ability of Nile tilapia, *Oreochromis niloticus*. Fish Shellfish Immunol. 55, 233–241. https://doi.org/10.1016/j.fsi.2016.05.033

Xu, J., Wu, P., Jiang, W.D., Liu, Y., Jiang, J., Kuang, S.Y., Tang, L., Tang, W.N., Zhang, Y.A., Zhou, X.Q., Feng, L., 2016. Optimal dietary protein level improved growth, disease resistance, intestinal immune and physical barrier function of young grass carp (*Ctenopharyngodon idella*). Fish Shellfish Immunol. 55, 64–87. https://doi.org/10.1016/j.fsi.2016.05.021

Xu, L., Ran, C., He, S., Zhang, J., Hu, J., Yang, Yalin, Du, Z., Yang, Yanou, Zhou, Z., 2015. Effects of dietary yeast nucleotides on growth, non-specific immunity, intestine growth and intestinal microbiota of juvenile hybrid tilapia *Oreochromis niloticus* ♀ x *Oreochromis aureus* ♂. Anim. Nutr. 1, 244–251. https://doi.org/10.1016/j.aninu.2015.08.006

Ye, X., Li, J., Lu, M., Deng, G., Jiang, X., Tian, Y., Quan, Y., Jian, Q., 2011. Identification and molecular typing of *Streptococcus agalactiae* isolated from pond-cultured tilapia in China. Fish. Sci. 77, 623–632. https://doi.org/10.1007/s12562-011-0365-4

Yeh, M.S., Lai, C.Y., Liu, C.H., Kuo, C.M., Cheng, W., 2009. A second proPO present in white shrimp *Litopenaeus vannamei* and expression of the proPOs during a *Vibrio alginolyticus* injection, molt stage, and oral sodium alginate ingestion. Fish Shellfish Immunol. 26, 49–55. https://doi.org/10.1016/j.fsi.2008.10.003

Yeh, S.-P., Chang, C.A., Chang, C.Y., Liu, C.H., Cheng, W., 2008. Dietary sodium alginate administration affects fingerling growth and resistance to *Streptococcus* sp. and iridovirus, and juvenile non-specific immune responses of the orange-spotted grouper, *Epinephelus coioides*. Fish Shellfish Immunol. 25, 19–27. https://doi.org/10.1016/j.fsi.2007.11.011

Yeh, S.-T., Lee, C.S., Chen, J.C., 2006. Administration of hot-water extract of brown seaweed *Sargassum duplicatum* via immersion and injection enhances the immune resistance of white shrimp *Litopenaeus vannamei*. Fish Shellfish Immunol. 20, 332–345. https://doi.org/10.1016/j.fsi.2005.05.008

Yeh, S., Lee, C., Chen, J., 2006. Administration of hot-water extract of brown seaweed

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GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
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Sargassum duplicatum via immersion and injection enhances the immune resistance of white shrimp *Litopenaeus vannamei*. Fish Shellfish Immunol. 20, 332–345. https://doi.org/10.1016/j.fsi.2005.05.008

Yilmaz, S., 2019. Effects of dietary blackberry syrup supplement on growth performance, antioxidant, and immunological responses, and resistance of Nile tilapia, *Oreochromis niloticus* to *Plesiomonas shigelloides*. Fish Shellfish Immunol. 84, 1125–1133. https://doi.org/10.1016/j.fsi.2018.11.012

Yousefi, S., Hoseinifar, S.H., Paknejad, H., Hajimoradloo, A., 2018. The effects of dietary supplement of galactooligosaccharide on innate immunity, immune related genes expression and growth performance in zebrafish (*Danio rerio*). Fish Shellfish Immunol. 73, 192–196. https://doi.org/10.1016/j.fsi.2017.12.022

Yu, Z., Zhao, L., Zhao, J.-L., Xu, W., Guo, Z., Zhang, A.-Z., Li, M.-Y., 2022. Dietary *Taraxacum mongolicum* polysaccharide ameliorates the growth, immune response, and antioxidant status in association with NF-κB, Nrf2 and TOR in Jian carp (*Cyprinus carpio* var. Jian). Aquaculture 547. https://doi.org/https://doi.org/10.1016/j.aquaculture.2021.737522

Yudiati, E., Isnansetyo, A., 2017. Characterizing the Three Different Alginate Type of *Sargassum siliquosum*. ILMU Kelaut. Indones. J. Mar. Sci. 22, 7. https://doi.org/10.14710/ik.ijms.22.1.7-14

Yudiati, E., Isnansetyo, A., Murwantoko, Ayuningtyas, Triyanto, Handayani, C.R., 2016. Innate immune-stimulating and immune genes up-regulating activities of three types of alginate from *Sargassum siliquosum* in Pacific white shrimp, *Litopenaeus vannamei*. Fish Shellfish Immunol. 54, 46–53. https://doi.org/http://dx.doi.org/10.1016/j.fsi.2016.03.022

Yuwono, T., 2005. Biologi Molekuler. Erlangga. Jakarta.

Zahran, E., Risha, E., Abdelhamid, F., Mahgoub, H.A., Ibrahim, T., 2014. Effects of dietary *Astragalus polysaccharides* (APS) on growth performance, immunological parameters, digestive enzymes, and intestinal morphology of Nile tilapia (*Oreochromis niloticus*). Fish Shellfish Immunol. 1–9. https://doi.org/10.1016/j.fsi.2014.03.002

Zhang, J., Kong, X., Zhou, C., Li, L., Nie, G., Li, X., 2014. Toll-like receptor recognition of bacteria in fish: Ligand specificity and signal pathways. Fish Shellfish Immunol. 41, 380–388. https://doi.org/10.1016/j.fsi.2014.09.022

Zhou, K., Cui, T.T., Li, P.L., Liang, N.J., Liu, S.C., Ma, C.W., Peng, Z.H., 2008. Modelling and predicting the effect of temperature, water activity and pH on

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GADJAH MADA
Peningkatan Respon Imun Non-Spesifik, Ekspresi Gen Imun, dan Ketahanan Penyakit pada Ikan Nila Merah (Oreochromis sp.) Melalui Pemberian Sodium Alginat dari Padina australis
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Universitas Gadjah Mada, 2023 | Diunduh dari http://etd.repository.ugm.ac.id/

growth of *Streptococcus iniae* in Tilapia. J. Appl. Microbiol. 105, 1956–1965. https://doi.org/10.1111/j.1365-2672.2008.03969.x

Zhu, L. yun, Nie, L., Zhu, G., Xiang, L. xing, Shao, J. zhong, 2013. Advances in research of fish immune-relevant genes: A comparative overview of innate and adaptive immunity in teleosts. Dev. Comp. Immunol. 39, 39–62. https://doi.org/10.1016/j.dci.2012.04.001

Zubia, M., Payri, C., Deslandes, E., 2008. Alginate, mannitol, phenolic compounds and biological activities of two range-extending brown algae, *Sargassum mangarevense* and *Turbinaria ornata* (Phaeophyta: Fucales), from Tahiti (French Polynesia). J Appl Phycol 20, 1033–1043. https://doi.org/10.1007/s10811-007-9303-3