

**ISOLASI DAN IDENTIFIKASI BAKTERI SELULOLITIK JERAMI PADI
(*Oryza sativa* L.) DAN KAJIAN TEORITIS OPTIMASI PRODUKSI
ENZIM SELULASE**

SKRIPSI

diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Sains
Program Studi Biologi Departemen Pendidikan Biologi



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UNIVERSITAS PENDIDIKAN INDONESIA**

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Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Sains pada Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

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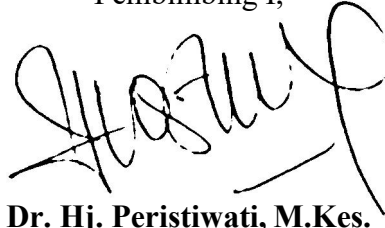
LEMBAR PENGESAHAN

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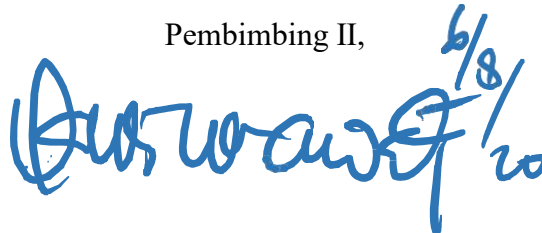
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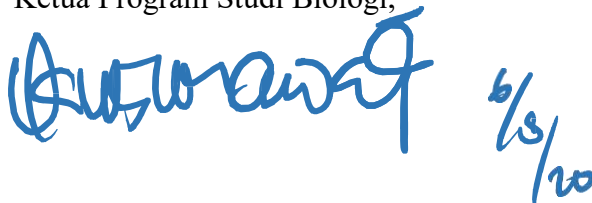


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PERNYATAAN

Dengan ini saya menyatakan bahwa skripsi dengan judul “Isolasi dan Identifikasi Bakteri Selulolitik Jerami Padi (Oryza sativa L.) dan Kajian Teoritis Optimasi Produksi Enzim Selulase” beserta seluruh isinya adalah benar-benar karya saya sendiri, dan saya tidak melakukan penjiplakan atau pengutipan dengan cara yang tidak sesuai dengan etika keilmuan yang berlaku dalam masyarakat keilmuan. Atas pernyataan ini, saya siap menanggung resiko atau sanksi yang dijatuhkan kepada saya apabila ditemukan adanya pelanggaran terhadap etika keilmuan dalam karya saya ini, atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

Bandung, Juli 2020

Yang membuat pernyataan

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KATA PENGANTAR

Puji syukur kehadirat Allah SWT atas segenap limpahan rahmat, anugerah dan karunia-Nya sehingga penulis dapat menyelesaikan skripsi yang berjudul **“ISOLASI DAN IDENTIFIKASI BAKTERI SELULOLITIK JERAMI PADI (*Oryza sativa* L.) DAN KAJIAN TEORITIS OPTIMASI PRODUKSI ENZIM SELULASE”**. Skripsi ini diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Sains pada Program Studi Biologi Strata Satu (S1), Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia.

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Bandung, Juli 2020

Penulis

Zahra Ramadhani Tayubi

**ISOLASI DAN IDENTIFIKASI BAKTERI SELULOLITIK JERAMI PADI
(*Oryza sativa* L.) DAN KAJIAN TEORITIS OPTIMASI PRODUKSI
ENZIM SELULASE**

ABSTRAK

Enzim selulase merupakan enzim komersial yang banyak digunakan dalam bidang industri dengan jumlah banyak sehingga mengakibatkan kebutuhan akan enzim selulase terus meningkat dengan rata-rata 5-7% per tahun. Pembuatan enzim selulase diperlukan substrat yang mengandung bahan selulosa, salah satunya berasal dari limbah jerami padi. Selain itu, mikroorganisme yang mampu memproduksi enzim selulase disebut bakteri selulolitik. Bakteri selulolitik ini dapat ditemukan pada jerami padi, karena mendukung lingkungan tempat hidup dan nutrisi bagi bakteri, sementara bakteri dalam mencerna selulosa dengan menghasilkan enzim selulase. Bakteri yang ditemukan pada jerami padi yaitu *Bacillus* sp. dan *Pseudomonas* sp. Pada penelitian ini telah dilakukan identifikasi dan karakterisasi bakteri selulolitik yang berhasil diisolasi dari jerami padi (*Oryza sativa* L.). Seleksi bakteri selulolitik dilakukan dengan menggunakan medium selektif *carboxymethyl cellulose* (CMC) dengan indikasi keberadaan zona bening di sekitar koloni pada bakteri selulolitik. Hasil penelitian diperoleh 4 isolat bakteri selulolitik yaitu isolat J-1, J-2, J-4, dan J-5 yang merupakan bakteri *Pseudomonas* sp. Produksi enzim selulase maksimum akan sangat bergantung pada pH dan suhu optimum bakteri selulolitik *Bacillus* sp. dan *Pseudomonas* sp. Tujuan penelitian studi literatur ini adalah untuk mengetahui pH dan suhu optimum yang dapat menghasilkan enzim selulase tertinggi oleh bakteri selulolitik. Berdasarkan hasil studi literatur, pH optimum bakteri selulolitik *Bacillus* sp. yaitu 6.5 dan suhu optimum 60°C yang menghasilkan aktivitas enzim selulase tertinggi 0.85 U/mL, sedangkan pH optimum bakteri selulolitik *Pseudomonas* sp. adalah 5 dan suhu optimum 37°C yang menghasilkan aktivitas enzim selulase (CMCase) maksimum berkisar 0,48 U/mL.

Kata Kunci: Enzim selulase, jerami padi, lignoselulosa, bakteri selulolitik, aktivitas selulolitik

**ISOLATION AND IDENTIFICATION OF CELLULOLYTIC BACTERIA
IN RICE STRAW (*Oryza sativa* L.) AND THEORY OF OPTIMIZATION
CELLULASE ENZYME PRODUCTION**

ABSTRACT

Cellulase enzymes are commercial enzymes that are widely used in industrial fields with large quantities resulting in the need for cellulase enzymes to continue to increase by an average of 5-7% per year. Cellulase enzyme making is needed substrate containing cellulose material, one of which is derived from rice straw waste. In addition, microorganisms that are able to produce cellulase enzymes are called cellulolytic bacteria. Cellulolytic bacteria can be found in rice straw, because it supports a living environment and nutrients for bacteria, while bacteria digest cellulose by producing cellulase enzymes. Bacteria found in rice straw are *Bacillus* sp. and *Pseudomonas* sp. In this study identification and characterization of cellulolytic bacteria have been isolated from rice straw (*Oryza sativa* L.). Cellulolytic bacterial selection is carried out using a selective *carboxymethyl cellulose* (CMC) medium with an indication of the presence of clear zones around the colony in cellulolytic bacteria. The results obtained by 4 isolates of cellulolytic bacteria namely isolates J-1, J-2, J-4, and J-5 which are *Pseudomonas* sp. Maximum cellulase enzyme production will depend on the optimum pH and temperature of the cellulolytic bacteria *Bacillus* sp. and *Pseudomonas* sp. The purpose of this literature study was to determine the optimum pH and temperature that can produce the highest cellulase enzymes by cellulolytic bacteria. Based on the results of literature studies, the optimum pH and temperature of cellulolytic bacteria *Bacillus* sp. were 6.5 and 60°C which produces the highest cellulase enzyme activity 0.85 U/mL, while the optimum pH of cellulolytic bacteria *Pseudomonas* sp. was 5 and the optimum temperature was 37°C which produces maximum cellulase (CMCase) enzyme activity ranging from 0.48 U/mL.

Key Words: Cellulase enzyme, rice straw, cellulolytic bacteria, *pretreatment*, CMCase

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DAFTAR PUSTAKA

- Abo-Sereih, N.A., Mahmoud, A.E., El-Ghamery, A.A., El-Kawokgy, T.M., & El-Sayed, A.F. (2020). Screening, Isolation, Optimization and Molecular Identification of *Pseudomonas aeruginosa* NRC-S4 and Investigation of its β -glucosidase production. *Plant Archives*, 20(1), 115–124.
- Agbor V.B., Cicek N., Sparling R., Berlin A., & Levin DB. (2011). Biomass Pretreatment: Fundamentals Toward Application. *Biotechnol Advances*. 29, 675–685. doi: <http://dx.doi.org/10.1016/j.biotechadv.2011.05.005>
- Agarwal, T., Saxena, M.K., & Chandrawat, M.P.S. (2014). Production and Optimization of Cellulase Enzyme by *Pseudomonas aeruginosa* MTCC 4643 Using Sawdust as a Substrate. *International Journal of Scientific and Research Publications*, 4(1), 4–6.
- Agustini, L. & Efiyanti, L. (2015). The Effects of Delignification Treatments on Cellulose Hydrolysis and Ethanol Production from Lignocellulosic Wastes. *Jurnal Penelitian Hasil Hutan*, 33(1), 69–80.
- Alam, M.S., Sarjono, P.R., & Aminin, A.L.N. (2013). Isolasi dan Karakterisasi Selulase dari Bakteri Selulolitik Termofilik Kompos Pertanian Desa Bayat, Klaten, Jawa Tengah. *Jurnal Sains dan Matematika*, 21(2), 48-53.
- Allinya, Putri. (2019). *Optimasi Aktivitas Enzim Selulase Ekstrak Kasar oleh Isolat Bakteri Selulolitik R4-3 Dari Saluran Pencernaan Rayap *Cryptotermes* sp. menggunakan Media Serbuk Jerami Padi (*Oryza sativa*, Linn). (Skripsi). Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam. Universitas Pendidikan Indonesia, Bandung.*
- Alvarez-Chavez, B.J., Godbout, S., Palacios-Rios, J.H., Le Roux, É., & Raghavan, V. (2019). Physical, Chemical, Thermal and Biological Pre-treatment Technologies in Fast Pyrolysis to Maximize Bio-oil quality: A critical review. *Biomass and Bioenergy*. doi: <https://doi.org/10.1016/j.biombioe.2019.105333>
- Amelia, A. (2012). *Pengaruh Variasi Konsentrasi Enzim dan Substrat Terhadap Sakarifikasi Limbah Pengolahan Kertas Menggunakan Enzim Selulase dari *Bacillus* sp. BPPT CC RK2.* (Skripsi). Fakultas Kedokteran dan Ilmu Kesehatan. Universitas Islam Negeri Syarif Hidayatullah, Jakarta.
- Breed, R.S., E.G.D. Murray, & N.R. Smith. (1957). *Bergey's Manual of Determinative Bacteriology*, 7th editions. [Online]. Diakses dari: <https://www.biodiversitylibrary.org/ia/bergeysmanualofd1957amer#page/635/mode/1up>

- Arato, C., Pye, E.K., & Gjennestad, G. (2005). The Lignol Approach to Biorefining of Woody Biomass to Produce Ethanol and Chemicals. *Applied Biochemistry Biotechnology*, 121–124, 871–882.
- Arusha, P.N., Kiran, R.K., Shanti, G.G., & Arun, S.K. (2016). Optimization of Cellulase Production for *Bacillus* sp. and *Pseudomonas* sp. Soil Isolates. *African Journal of Microbiology Research*, 10(13), 410–419. doi: <https://doi.org/10.5897/ajmr2016.7954>
- Ariffin, H., Abdullah, N., Md Shah, U.K., Shirai, Y., & Hassan, M.A. (2006). Production and characterization of cellulases by *Bacillus pumilus* EB3. *International Journal of Engineering and Technology*, 3(1), 47–53.
- Asghar, U., Irfan, M., Nadeem, M., Nelofer, R., & Syed, Q. (2017). Effect of KOH Pretreatment on Lignocellulosic Waste to be Used as Substrate for Ethanol Production. *Iranian Journal of Science and Technology, Transaction A: Science*, 41(3), 659–663. doi: <https://doi.org/10.1007/s40995-017-0284-z>
- Atika, N., Remli, M., Mohamad, R., & Abd-aziz, S. (2014). Effects of Chemical and Thermal Pretreatments on the Enzymatic Saccharification of Rice Straw for Sugars Production. *BioResources*, 9 (1), 510–522.
- Azizah, S. N. (2017). Isolasi dan Karakteristik Bakteri Selulolitik Asal Jerami Padi di Persawahan Bogor Barat. *Jurnal Ilmiah Farmasi Akademi Farmasi Jember*. 2(1).
- Baehaki, A., Rinto, & Budiman. (2011). Isolasi dan Karakterisasi Protease dari Bakteri Tanah Rawa Indralaya Sumatera Selatan. *Jurnal Teknologi dan Industri Pangan*, 12(1), 37 -42.
- Baharuddin, M., Patong, A.R., Ahmad, A., & Nafie, N.La. (2014). Isolasi Dan Karakterisasi Bakteri Simbion Larva Kupu-Kupu *Cossus cossus* Penghasil Enzim Selulase. *Al-Kimia*, 2(2), 58–68. doi: <https://doi.org/10.24252/AL-KIMIA.V2I2.1653>
- Bai, B., Yan, C.G., & Li, G.C. (2017). Study on the Characteristics of Straw ol pro Fermentation by *Bacillus megaterium* MYB3. *IOP Conference Series: Earth and Environmental Science*, 81(1). doi: <https://doi.org/10.1088/1755-1315/81/1/012010>
- Bai, X., Wang, G., Zhu, Z., Cai, C., Wang, Z., & Wang, D. (2019). Investigation of Improving the Yields and Qualities of Pyrolysis Products with Combination Rod-milled and Torrefaction Pretreatment. *Renewable Energy*. doi: <https://doi.org/10.1016/j.renene.2019.11.040>

- Bak, J.S., Kim, M.D., Choi, I.G., & Kim, K.H. (2010). Biological pretreatment of rice straw by fermenting with *Dichomitus squalens*. *New Biotechnology*, 27(4), 424–434.
- Beena, V.V.A.K. & Silva, J.D. (2018). Characterization of a Cellulase Producing *Pseudomonas fluorescens* Isolated from Agricultural Waste. *Biotechnological*, 4(4), 109–113
- Belal, E. B. (2013). Bioethanduction from Rice Straw Residues. *Brazilian Journal of Microbiology*, 44(1), 225–234. doi: <https://doi.org/10.1590/S1517-83822013000100033>
- Blanco, A. & Blanco, G. (2017). Enzymes. *Medical Biochemistry*, 153–175. doi:10.1016/b978-0-12-803550-4.00008-2
- Bochmann, G. (2019). Storage and feedstock preparation. *Substitute Natural Gas from Waste: Technical Assessment and Industrial Applications of Biochemical and Thermochemical Processes*, 49–62. doi: <https://doi.org/10.1016/B978-0-12-815554-7.00004-0>
- Brooks, G.F., Carroll K.C., Butel J.S., & Morse. (2013). Mikrobiologi Kedokteran *Jawetz, Melnick, & Adelberg*. Ed. 25. Penerbit Buku Kedokteran EGC: Jakarta.
- Brooks G.F, Carroll K.C., Butel J.S., & Morse SA. (2007). *Jawetz, Melnick, & Adelberg's Medical Microbiology*. 24th Ed. New York. The McGraw-Hill Companies.
- Cappuccino, J.G. & Sherman, N. (2014). *Microbiology: A Laboratory Manual-10th ed.* New York: Pearson.
- Chang, V.S., Burr, B., & Holtzapple, M.T. (1997). Lime pretreatment of switchgrass. *Applied Biochemistry Biotechnology*, 63–65, 3–19.
- Chen, T. & Ramos, J. (2010). “Enzyme Kinetics”. *Applicaion of UV-VIS Spectrophotometry*.
- Clark, William A. (2012). *Public Domain Picture: Bacillus brevis. Gram stain.* [Online]. Diakses dari: http://www.publicdomainfiles.com/show_file.php?id=13546609817284
- Cronquist, A. (1981). *Integrated System of Classification of Flowering Plants. Columbia Univ. Press, NY. 1262.* [Online]. Diakses dari: <https://plants.usda.gov/java/ClassificationServlet?source=display&classid=ORSA>
- Dashtban, Mehdi., Maki, Miranda., Leung, Kam Tin., Mao, Canquan & Qin, Wensheng. (2010). Cellulase Activities in Biomass Conversion:

- Measurement Methods and Comparison. *Journal Critical Reviews in Biotechnology*. 1-8.
- Deka, D., Das, S.P., Sahoo, N., Das, D., Jawed, M., Goyal, D., & Goyal, A. (2013). Enhanced Cellulase Production from *Bacillus subtilis* by Optimizing Physical Parameters for Bioethanol Production . *ISRN Biotechnology*, 1–11. doi: <https://doi.org/10.5402/2013/965310>
- Dewi. (2002). Hidrolisis Limbah Hasil Pertanian Secara Enzimatik. *Akta Agrosia*, 2(5), 67 – 71.
- Eun, J.S., Beauchemin, K.A., Hong, S.H., & Bauer, M.W. (2006). Exogenous Enzymes Added to Untreated or Ammoniated Rice Straw : Effect on In Vitro Fermentation Characteristic and Degradability. *Journal of Animal Science and Technology*, 131, 86- 101. doi:10.1016/j.anifeedsci.2006.01.026
- Fardiaz. (1989). *Mikrobiologi Pangan*. Pusat Antar Universitas Institut Pertanian Bogor: Bogor.
- Fox, P.F. (1991). *Food Enzymology*. New York: Elsevier Applied Science Ltd.
- Gautam, S.P., Bundela, P.S., Pandey, A.K., Awasthi, M.K., & Sarsaiya, S. (2010). Cellulase Production By Pseudomonas Sp . Isolated From Municipal Solid Waste Compost. *International Journal of Academic Research*, 2(6), 330–333.
- Gayang, F. (2013). *Konversi lignoselulosa tandan kosong kelapa sawit menjadi gula pereduksi menggunakan enzim xilanase dan selulase komersial*. (Skripsi). Departemen Kimia, Fakultas Matematika dan Ilmu Pengetahuan Alam. Institut Pertanian Bogor, Bogor.
- Ghaffar, S.H. & Fan, M. (2014). Lignin in Straw and Its Applications as a Adhesive. *International Journal of Adhesion & Adhesives*, 48, 92–10.
- Gogate P.R., Sutkar V.S., & Pandit A.B. (2011). Sonochemical reactors: Important Design and Scale up Considerations with a Special Emphasis on Heterogeneous Systems. *Chemical Engineering Journal*, 166, 1066–1082.
- Goyal, A., Shuchi S., S.T.P. Bharadwaja., Pawan K.Y., & Vijayanand S.M. (2014). Mechanic Investigation in Ultrasound–Assited (Alkaline) Delignification of Parthenium Hysterophorus Biomass. *Journal of Industrial and Engineering Chemistry Research*, 55, 14241-14252.
- Guangyin, Z. & Youcai, Z. (2017). Harvest of Bioenergy From Sewage Sludge by Anaerobic Digestion. *In Pollution Control and Resource Recovery*. doi: <https://doi.org/10.1016/b978-0-12-811639-5.00005-x>

- Gultom, L., Winandi, R., & Jahroh, Siti. (2014). Analisis Efisiensi Teknis Usahatani Padi Semi Organik Di Kecamatan Cigombong, Bogor. *Informatika Pertanian*, 23(1).
- Gunam, Buda, I.B.W., Guna, K., & Semara, I.M.Y. (2010). Pengaruh Perlakuan Delignifikasi Dengan Larutan Naoh Dan Konsentrasi Substrat Jerami Padi Terhadap Produksi Enzim Selulase Dari *Aspergillus Niger*. *Jurnal Biologi*, 14(2). doi: <http://ojs.unud.ac.id/index.php/BIO/article/view/596>
- Gunam, I.B.W. & Antara, N.S. (1999). Study on Sodium Hydroxide Treatment of Corn Stalk to Increase Its Cellulose Saccharification Enzymatically by Using Culture Filtrate of *Trichoderma reesei*. *Gitayana Agricultural Technology Journal*, 5(1), 34-38.
- Hames, D. & Hooper. (2005). *Biochemistry Third Edition*. United Kingdom: Taylor & Francis.
- Han, Y.W. & Callihan, C. D. (1974). *Cellulose Fermentation: Effect of Substrate Pretreatment on Microbial Growth*. [Online]. *Applied microbiology*, 27(1), 159–165. Diakses dari: <http://www.ncbi.nlm.nih.gov/pubmed/4809907> <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC379986>
- Harahap, N. (2014). Penelitian Kepustakaan. *Jurnal Iqra'*, 08(01), 68–73.
- H. Argun, P. Gokfiliz, & I. Karapinar. (2017). Biohydrogen Production Potential of Different Biomass Sources. *Biohydrogen Production: Sustainability of Current Technology and Future Perspective*, 11-48. doi: https://doi.org/10.1007/978-81-322-3577-4_2
- Hatakka, A. (2000). *Biodegradation of Lignin*. University of Helsinki, Viikki Biocenter, Department of Applied Chemistry dan Microbiology. Helsinki.Kingdom: Taylor & Francis.
- Hatmanti, A. (2000). Pengenalan *Bacillus* spp. *Oseana*, 25(1), 31–41.
- Hendriks, A.T.W.M. & G. Zeeman. (2009). Pretreatments to Enhance the Digestibility of Lignocellulose Biomass. *Bioresource Technology*, 100: 10-18.
- Herlini, H. (2017). *Isolasi dan Identifikasi Bakteri Selulolitik dari Usus Rayap (Cryptotermes sp.) dalam Media Serbuk Jerami Padi (Oryza sativa)*. (Skripsi). Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam. Universitas Pendidikan Indonesia, Bandung.
- Howard, R.L., Abotsi, E., Van Rensburg, E.L.J., & Howard, S. (2003). Lignocellulose Biotechnology: Issues of Bioconversion and Enzyme Production. *African Journal of Biotechnology*, 2(12), 702–733. doi:

<https://doi.org/10.5897/ajb2003.000-1115>

- Ileana.(2014). *Pretreatment Bahan Lignoselulosa*. [Online]: Diakses dari: <https://cropstechnology.com/2014/03/31/pretreatment-bahan-lignoselulosa/>
- Immanuel, G., Dhanusha, R., Prema, P., & Palavesam, A. (2006). Effect of Different Growth Parameters on Endoglucanase Enzyme Activity by Bacteria Isolated from Coir Retting Effluents of Estuarine Environment. *International Journal of Environmental Science and Technology*, 3(1), 25–34. doi: <https://doi.org/10.1007/BF03325904>
- Islam, M., Sarkar, P.K., Mohiuddin, A.K.M., & Suzauddula, M. (2020). Optimization of Fermentation Condition for Cellulase Enzyme Production from *Bacillus* sp. *Malaysian Journal of Halal Research*, 2(2), 19–24. doi:<https://doi.org/10.2478/mjhr-2019-0009>
- Jawetz, Melnick. & Adelberg. (2010). *Mikrobiologi Kedokteran*. 25th edn. Jakarta: Penerbit Buku Kedokteran EGC.
- Ji W, D. Ming,. L. Yan-Hong., C.Qing-Xi,. X.Gen-Jun & Z.Fu-Kun. (2003). Isolation Functional Endogenous Cellulase Gene from Mollusc, *Ampullaria crossean*. *Jurnal Acta Biochimica et Biophysica Sinica*, 35(10), 941-946.
- Kapoor, K., Garg, N., Diwan, R K., Varshney, L., & Tyagi, A.K. (2017). Study the Effect of Gamma Radiation Pretreatment of Sugarcane Bagasse on Its Physico-chemical Morphological and Structural Properties. *Radiation Physics and Chemistry*, 141, 190–195. doi: <https://doi.org/10.1016/j.radphyschem.2017.07.010>
- Kasper, D.L., Hauser, S.L., Jameson, J.L., Fauci A., Longo, D.L., & Loscalzo, J. (2015). Harrison's Principles of Internal Medicine. 19th ed. *McGraw-Hill Education*. 523-532.
- Kausar, H., Sariah, M., Mohd Saud, H., Zahangir Alam, M., & Razi Ismail, M. (2010). Development of Compatible Lignocellulolytic Fungal Consortium for Rapid Composting of Rice straw. *International Biodeterioration and Biodegradation*, 64(7), 594–600. doi: <https://doi.org/10.1016/j.ibiod.2010.06.012>
- Khatiwada, P., Ahmed, J., Sohag, M.H., Islam, K., & Azad, A.K. (2016). Isolation, Screening and Characterization of Cellulase Producing Bacterial Isolates from Municipal Solid Wastes and Rice Straw Wastes. *Journal of Bioprocessing & Biotechniques*. doi: <https://doi.org/10.4172/2155-9821.1000280>

- Khedr, F.G., Tohamy, E.Y., Darwish El-Gamal, A., & Abouelwafa, A.M. (2019). Bioconversion of Rice Straw into Bioethanol by Enzymatic Hydrolysis of *Bacillus subtilis*. *IOSR Journal Of Pharmacy And Biological Sciences (IOSR-JPBS)*, 14, 9–29. <https://doi.org/10.9790/3008-1404040929>
- Kim, B., Lee, B., Lee, Y., Jin, H., Chung, C., & Lee, J. (2009). Purification and Characterization of Carboxymethylcellulase Isolated from a Marine Bacterium, *Bacillus subtilis* subsp. *subtilis* A-53. *Enzyme and Microbial Technology*, 44, 411–416.
- Kim, C.H. (1995). Characterization and Substrate Specificity of an Endo-beta-1,4-D-glucanase I (Avicelase I) from an Extracellular Multienzyme Complex of *Bacillus circulans*. *Applied and Environmental Microbiology*, 61, 959–965.
- Kim, J.S., Lee, Y.Y., & Kim, T.H. (2016). A review on Alkaline Pretreatment Technology for Bioconversion of Lignocellulosic Biomass. *Bioresource Technology*, 199, 42–48. doi: <https://doi.org/10.1016/j.biortech.2015.08.085>
- Kim, K.H. & Hong, J. (2001). Supercritical CO₂ Pretreatment of Lignocellulose Enhances Enzymatic Cellulose Hydrolysis. *Bioresource Technology*, 77(2), 139-144.
- Kobayashi, H., Ohta, H., & Fukuoka, A. (2012). Conversion of Lignocellulose into Renewable Chemicals by Heterogeneous Catalysis. *Catalysis Science and Technology*, 2(5), 869–883. doi: <https://doi.org/10.1039/c2cy00500j>
- Kohli, K., Katuwal, S., Biswas, A., & Sharma, B.K. (2020). Effective Delignification of Lignocellulosic Biomass by Microwave assisted Deep Eutectic Solvents. *Bioresource Technology*, 303, 122897. doi: <https://doi.org/10.1016/j.biortech.2020.122897>
- Kolawole, F.O., Rees, A.M., Etuk-Udo, G.A., Odusunya, S., & Soboyejo, W.O. (2015). Effects of Pre-Treatment on Lignocellulosic Butanol as a Bio-Fuel Produced from Bamboo Using *Clostridium acetobutylicum*. *Advanced Materials Research*, 1132, 295–312. doi: <https://doi.org/10.4028/www.scientific.net/amr.1132.295>
- Kotchoni, O.S., Shonukan, O.O., & Gachomo, W.E. (2003). *Bacillus pumilus* BpCRI 6, a Promising Candidate for Cellulase Production under Conditions of Catabolite Repression. *African Journal of Biotechnology*, 2, 140–146.
- Kumar, A. K. & Sharma, S. (2017). Recent updates on Different Methods of Pretreatment of Lignocellulosic Feedstocks: a review. *Bioresources and Bioprocessing*, 4(1). doi: <https://doi.org/10.1186/s40643-017-0137-9>

- Kumar, Satheesh., Bontha Rajasekhar Reddy., M.Subhosh Chandra & Yong-Lark Choi. (2009). Cellulolytic Enzymes Production from Submerged Fermentation of Different Substrates by Newly Isolated *Bacillus* spp. FME. *Jurnal Applied Biological Chemistry*. 52(1), 17-21.
- Kumari, D. & Singh, R. (2018). Pretreatment of Lignocellulosic Wastes for Biofuel Production. a critical review: *Renewable and Sustainable Energy Reviews*, 90, 877-891.
- Liu, J.J., Liu, X. P., Ren, J.W., Zhao, H.Y., Yuan, X.F., Wang, X.F., & Cui, Z.J. (2015). The Effects of Fermentation and Adsorption using Lactic Acid Bacteria Culture Broth on The Feed Quality of Rice Straw. *Journal of Integrative Agriculture*, 14(3), 503–513. doi: [https://doi.org/10.1016/S2095-3119\(14\)60831-5](https://doi.org/10.1016/S2095-3119(14)60831-5)
- Lokapirnasari, W.P., Nazar, D.S., Nurhajati, T., Supranianondo, K & Yulianto, A.B. (2015). Production and Assay of Cellulolytic Enzyme Activity of *Enterobacter cloacae* WPL 214 Isolated From Bovine rumen Fluid Waste of Surabaya Abbatoir, Indonesia. *Journal Veterinary World*, 8, 367-371.
- Lorenci Woiciechowski, A., Dalmas Neto, C. J., Porto de Souza Vandenberghe, L., de Carvalho Neto, D. P., Novak Sydney, A. C., Letti, L. A. J., & Soccol, C. R. (2020). Lignocellulosic biomass: Acid and Alkaline Pretreatments and their Effects on Biomass Recalcitrance – Conventional Processing and recent Advances. *Bioresource Technology*, 304, 122848. doi: <https://doi.org/10.1016/j.biortech.2020.122848>
- Maki, M., Leung, K.T., & Qin, W. (2009). The Prospects of Cellulase-producing Bacteria for the Bioconversion of Lignocellulosic Biomass. *International Journal of Biological Sciences*, 5(5), 500–516. doi: <https://doi.org/10.7150/ijbs.5.500>
- Malakar, S., Paul, S.K., & Jolvis Pou, K.R. (2020). Biotechnological Interventions in Beverage Production. *Biotechnological Progress and Beverage Consumption*. doi: <https://doi.org/10.1016/b978-0-12-816678-9.00001-1>
- Malik, K., Tokkas, J., Anand, R.C., & Kumari, N. (2015). Pretreated Rice Straw as an Improved Fodder for Ruminants-An overview. *Journal of Applied and Natural Science*, 7(1), 514–520. doi: <https://doi.org/10.31018/jans.v7i1.640>
- Mandels, M., Andreotti, R., & Roche, C. (1976). Measurements of saccarifying cellulase. Di dalam Gaden EL (Penyunting). Enzymatic Conversion of Cellulolistic Materials. *Technology Applications, Biotechnology Application, Biotechnology Bioengineering System*. New York: Interscience Publications.

- Marsden, W.L. & Gray, P.P. (1986). Enzymatic Hydrolysis of Cellulases in Lignocellulosic Material. CRC. *Critical Reviews in Biotechnology*, 3(3), 235-276. doi: doi.org/10.3109/0738855850915 0785
- Martien, R. (2000). *Isolasi dan Identifikasi Bakteri Selulolitik serta Kemampuannya dalam Memproduksi Enzim Selulase dengan Waktu Inkubasi yang Berbeda dari Hutan Mangrove Tegakan Rhizophora spdi Desa Kemujan, Karimunjawa*. (Skripsi). Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Diponegoro, Bandung.
- Martínez-Merino, V., Gil, M.J., & Cornejo, A. (2013). Biomass Sources for Hydrogen Production. *Renewable Hydrogen Technologies: Production, Purification, Storage, Applications and Safety*, 87–110. doi: <https://doi.org/10.1016/B978-0-444-56352-1.00005-2>
- Mawadza, C., Hatti-Kaul, R., Zvauya, R., & Mattiasson, B. (2000). Purification and Characterization of Cellulases Produced by Two *Bacillus* Strains. *Journal of Biotechnology*, 83, 177–187.
- Menristekdikti. (2017). *Menristekdikti Resmikan Fasilitas Unit Produksi Enzim BPPT-PT Petrosida Gresik*. [Online]. Diakses dari: <https://www.ristekdikti.go.id/siaran-pers/menristekdikti-resmikan-fasilitas-unit-produksi-enzim-bppt-pt-petrosida-gresik/>.
- Meryandini, A., Widosari, W., Maranatha, B., dan Sunarti, T. (2009). Isolasi Bakteri Selulolitik dan Karakterisasi Enzimnya. *Sains*, 13(1), 33-38.
- Miller, G.L. (1959). Use of Dinitrosalicylic Acid Reagent for Determination of Reducing Sugar. *Analytical Chemistry*, 31, 426-428.
- Mishra, B.K., Pandey, A.K., & Lata. (2007). Lignocellulolytic Enzyme Production from Submerged Fermentation of Paddy Straw. *Indian Journal of Microbiology*, 47(2), 176–179. doi: <https://doi.org/10.1007/s12088-007-0034-6>
- Moodley, P., Sewsynker-Sukai, Y., & Gueguim Kana, E. B. (2020). Progress in The Development of Alkali and Metal Salt Catalysed Lignocellulosic Pretreatment Regimes: Potential for Bioethanol Production. *Bioresource Technology*, 310, 123372. doi: <https://doi.org/10.1016/j.biortech.2020.123372>
- Mrudula, Soma. & Murugammal, Rangasamy. (2010). Production of Cellulase by *Aspergillus niger* Under Submerged and Solid State Fermentation Using Coir Waste as a Substrate. *Journal Brazillian Microbiology*, 42, 1119-1127.

- Murtiyaningsih, H. & Hazmi, M. (2017). Isolasi dan Uji Aktivitas Enzim Selulase pada Bakteri Selulolitik Asal Tanah Sampah. *Journal of Agricultural Science*, 15(2), 293–308. doi <https://doi.org/10.3969/j.issn.1006-6896.2011.11.003>
- Najafpour, Ghasem. (2015). *Biochemical Engineering and Biotechnology*, Elsevier Sci & Tech., ProQuest Ebook Central. [Online]. Diakses dari: <https://ebookcentral.proquest.com/lib/indonesiaebooks/detail.action?docID=1983595>.
- Nlandu, H., Belkacemi, K., Chorfa, N., Elkoun, S., Robert, M., & Hamoudi, S. (2020). Flax Nanofibrils Production via Supercritical Carbon dioxide Pre-treatment and Enzymatic Hydrolysis. *Canadian Journal of Chemical Engineering*, 98(1), 84–95. doi: <https://doi.org/10.1002/cjce.23596>
- Nenci. (2012). *Isolasi dan karakterisasi selulose dari Trichoderma viride Strain TO51 dengan Substrat Jerami*. (Skripsi). Universitas Indonesia, Jakarta.
- Ningsih, R., Khotimah, S., & Lovadi, I. (2014). Bakteri Pendegradasi Selulosa dari Serasah Daun Avicennia alba Blume di Kawasan Hutan Mangrove Peniti Kabupaten Pontianak. *Protobiont*, 3(1), 34–40.
- Nugroho, A.W. (2010). *Mikrobiologi Kedokteran Jawetz, Melnick, and Adelberg's /Geo F. Brooks et al.* 25th edn. Edited by A. Adityaputri. Jakarta: Buku Kedokteran EGC.
- Odeinyi, O.A., Onilude, A.A., & Ayodele, M.A. (2009). Production Characteristics and Properties of Cellulase/Polygalacturonase by a *Bacillus coagulans* Strain from a Fermenting Palm-fruit Industrial Residue. *African Journal of Microbiology Research*, 3, 407–417.
- Pelczar, J.M. & Chan E.C.C. (2010). *Dasar-Dasar Mikrobiologi*. Terjemahan oleh Ratna Siri Hadiotomo, Teja Imas, S. Sutarmi Tjitrosomo, Sri Lestari Angka. UI-Press: Jakarta.
- Pelczar, J.M. (1998). *Dasar-Dasar Mikrobiologi Jilid 2. Alih Bahasa: Ratna Ratna Siri Hadiotomo*. Jakarta: UI Press.
- Peripolli, V., Barcellos, J.O.J., Prates, E.R., McManus, C., da Silva, L.P., Stella, L.A., Costa Jr, J.B.G., & Lopes, R.B. (2016). Nutritional Value of Baled Rice Straw for Ruminant Feed. *Revista Brasileira de Zootecnia*, 45(7), 392-399. doi: <http://dx.doi.org/10.1590/S1806-92902016000700006>
- Prima, A., Devi,S., & Saryono, S. (2015). Optimalisasi pH Produksi Enzim Selulase dari *Pseudomonas cepacia* LBKURCC48 dan *Pseudomonas stutzeri* LBKURCC59. 2(1), 199–204.

- Purwarida, M.B.T. (1988). *Purification and characterization of Cellulomonas cellulase complex*. (Tesis). University of New South Wales, Sydney.
- Putri, Syarafina. (2016). *Karakterisasi enzim Selulase yang Dihasilkan oleh Lactobacillus plantarum Pada Variasi Suhu, PH dan Konsentrat Substrat*. (Skripsi). Fakultas Sains dan Teknologi. Universitas Islam Negeri Maulana Malik Ibrahim, Malang.
- Rabemanolontsoa, H. & Saka, S. (2016). Various Pretreatments of Lignocellulosics, *Bioresource Technology*, 199, 83-91. doi: <https://doi.org/10.1016/j.biortech.2015.08.029>.
- Rahmadian, C.A., Ismail, Abrar, M., Erina, Rastina, & Fahrimal, Y. (2018). Isolasi dan Identifikasi Bakteri Pseudomonas sp Pada Ikan Asin Di Tempat Pelelangan Ikan LabuanHaji Aceh Selatan. *Jurnal Ilmiah Mahasiswa Veteriner*, 2(4), 493–502.
- Rasouli, N. & Khalili, A. (2017). *Enhanced Adsorption Capability of Congo Red Dye onto Novel Polypyrrole/ ZnO/ ZnCr2O4 Composite*. Payame Noor University. Tehran.
- Reddy, K.V., Lakshmi, T.V., Reddy, A.V.K., Bindu, V.H., & Narasu, M.L. (2016). Isolation, Screening, Identification and Optimized Production of Extracellular Cellulase from *Bacillus subtilis* Sub.sps using Cellulosic Waste as Carbon Source. *International Journal of Current Microbiology and Applied Sciences*, 5(4), 442–451.
- Reddy, N. & Yang Y. (2006). Properties of High-Quality Long Natural Cellulose Fibers from Rice Straw. *Journal of Agricultural and Food Chemistry*, 54 (21), 8077– 8081. doi: 10.1021/jf0617723
- Roboson, L.M. & Chambliss, G.H. (1989). Celluases of bacterial origin. *Enzyme and Microbial Technology*, 11, 626–644.
- Rosgaard, L., Pedersen, S., & Meyer, A.S. (2007). Comparison of Different Pretreatment Strategies for Enzymatic Hydrolysis of Wheat and Barley Straw Comparison of Different Pretreatment Strategies for Enzymatic Hydrolysis of Wheat and Barley Straw. *Applied Biochemistry Biotechnology*, 143, 284–296. <https://doi.org/10.1007/s12010-007-8001-6>
- Rudiansyah, D., Rahmawati, & Rafdinal. (2017). Eksplorasi Bakteri Selulolitik dari Tanah Hutan Mangrove Peniti, Kecamatan Segedong, Kabupaten Mempawah. *Jurnal Protoniont*, 6(3), 255-262.
- Sadhu, S.,sh Saha, P., Sen, S.K., Mayilraj, S., & Miti, T. (2013). Production, Purification and Characterization of Novel Thermotolerant Endoglucanase (CMCase) from *Bacillus* Strain Isolated from Cow Dung. *Springerplus Jurnal*. India.

- Saha, B.C. (2004). Lignocellulose Biodegradation and Application in Biotechnology. US Government Work. *American Chemical Society*. 2-14.
- Salma, S. & Gunarto, L. (1999). Enzim Selulase dari *Trichoderma* sp. *Buletin Agro Bio*. 2, 9-16.
- Samira, Majidi., Mohammad, Roayaei & Gholamreza, Ghezelbash. (2011). Carboxymethyl-cellulase and Filter-paperase Activity of New Strains Isolated from Persian Gulf. *Journal Microbiology*, 1(1), 8-16. doi: 10.3923/mj.2011.8.16
- Santos, M.B., Nader, G.A., Robinson, P.H., Kiran, D., Krishnamoorthy, U., & Gomes, M.J. (2010). Impact of Simulated Field Drying on In Vitro Gas Production and Voluntary Dry Matter Intake of Rice Straw. *Animal Feed Science and Technology*, 159(3-4), 96-104. DOI: <http://dx.doi.org/10.1016/j>.
- Saritha, M., R. Tiwari, S. Singh, S. Rana, A. Adak, A. Sharma, A. Arora & L. Nain. (2015). Bioprospecting for Superior Biomass Hydrolysing Fungi from Diverse Habitats. *Biodiversity, Bioprospecting and Development*, 2(2), 1-7 doi:10.4172/2376-0214.1000149
- Sarnklong, C., Cone, J.W., Pellikaan, W., & Hendriks. W.H. (2010). Utilization of Rice Straw and Different Treatments to Improve Its Feed Value for Ruminants: A Review. *Asian-Australasian Journal of Animal Sciences*, 23(5), 680 – 692. doi: <https://doi.org/10.5713/ajas.2010.80619anifeedsci.2010.05.012>
- Saropah, D. (2012). Penentuan Kondisi Optimal Ekstrak Kasar Selulase Bakteri Selulolitik Hasil Isolasi dari Bekatul. Universitas Islam Negeri Maulana Malik Ibrahim, Malang.
- Selim, A.S.M., Pan, J., Takano, T., Suzuki, T., Koike, S., Kobayashi, Y. & Tanaka, K. (2004). Effect of Ammonia Treatment on Physical Strength of Rice Straw, Distribution of Straw Particles and Particle-associated Bacteria in Sheep Rumen. *Animal Feed Science and Technology*, 115, 117-128. doi: <http://dx.doi.org/10.1016/j.anifeedsci.2004.01.011>
- Sethi, S., Datta, A., Gupta, B.L., & Gupta, S. (2013). Optimization of Cellulase Production from Bacteria Isolated from Soil. *ISRN Biotechnology*, 1–7. doi: <https://doi.org/10.5402/2013/985685>
- Sethuraman, P. & Balasubramanian, N. (2010). Removal of Cr (VI) from Aqueous Solution using *Bacillus subtilis* , *Pseudomonas aeruginosa* and *Enterobacter cloacae*. *International Journal of Engineering Science and Technology*, 2(6), 1811–1825.

- Shahid, Z.H., M. Irfan, M. Nadem, Quratulain S., & Javed I.Q. (2016). Production, Purification, and Characterization of Carboxymethyl Cellulase from Novel Strain *Bacillus megaterium*. *Journal of Environmental Progress and Sustainable Energy*.
- Shetty, D.J., Kshirsagar, P., Tapadia-Maheshwari, S., Lanjekar, V., Singh, S.K., & Dhakephalkar, P.K. (2017). Alkali Pretreatment at Ambient Temperature: a Promising Method to Enhance Biomethanation of Rice Straw. *Bioresource Technology*, 226, 80–88. doi: 10.1016/j.biortech.2016.12.003
- Shi, Q., Li, Y., Li, Y., Cheng, Y., & Zhu, W. (2019). Effects of Steam Explosion on Lignocellulosic Degradation of and Methane Production from Corn Stover by a Co-cultured Anaerobic Fungus and Methanogen. *Bioresource Technology*, 290, 121796. doi: <https://doi.org/10.1016/j.biortech.2019.121796>
- Sholihati, A.M., Baharuddin, M., & Santi. (2015). Produksi dan Uji Aktivitas Enzim Selulase dari Bakteri *Bacillus subtilis*. *Al Kimia*, 78–90.
- Sinaga, R.E. (2013). *Karakterisasi Enzim Selulase dan Aplikasinya pada Substrat Limbah Pertanian*. (Tesis). Program Studi Bioteknologi. Institut Pertanian Bogor.
- Sindhu, R., Pandey, A., & Binod, P. (2015). Alkaline Treatment. *Pretreatment of Biomass: Processes and Technologies*, 51–60. doi: <https://doi.org/10.1016/B978-0-12-800080-9.00004-9>
- Singh D. & Chen S. (2008). The White-rot Fungus *Phanerochaete Chrysosporium*: Conditions for the Production of Lignin-degrading Enzymes. *Applied Microbiology Biotechnology*, 81(3), 399–417.
- Sirisena, D., & Manamendra, T. (1995). Isolation and Characterization of Cellulolytic Bacteria from Decomposing Rice Straw. *Journal of the National Science Foundation of Sri Lanka*, 23(1), 25. doi: <https://doi.org/10.4038/jnsfsr.v23i1.5568>
- Slamet. (2009). *Isolasi dan Identifikasi Bakteri Limbah Cair Tekstil pada Instalasi Pengolahan Air Limbah (IPAL) Terpadu Cisirung Dayeuh Kolot Bandung*. (Skripsi). Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam. Universitas Pendidikan Indonesia, Bandung.
- Soekiman, S. (2016). *Infeksi Nosokomial Di Rumah Sakit-Hospital Nosocomial Infections*. Pertama. Edited by Mariyam. Surabaya: CV.Sagung Seto.
- Somen Acharya. (2012). Alkaline Cellulase Produced by a Newly Isolated Thermophilic *Aneurinibacillus Thermoaerophilus* WBS2 from Hot Spring, India. *African Journal of Microbiology Research*, 6(26). doi:

<https://doi.org/10.5897/ajmr11.1491>

- Song Y., Zhou J., Zhang L., & Wu X. (2008). Homogenous Modification of Cellulose with Acrylamide in NaOH/urea Aqueous Solutions. *Carbohydrate Polymers* 73,18-25.
- Sorn, V., Chang, K.L., Phitsuwan, P., Ratanakhanokchai, K., & Dong, C. Di. (2019). Effect of Microwave-assisted Ionic liquid/Acidic ionic liquid Pretreatment on the Morphology, Structure, and Enhanced Delignification of Rice Straw. *Bioresource Technology*, 293, 121929. doi: <https://doi.org/10.1016/j.biortech.2019.121929>
- Suardi, M., Hamdani, A.S., Ariyati, B., Lalfari, R.S., Lutfrian, D., Dewi, A.P., & Djamaan, A. (2018). Utilization of Rice Straw (*Oryza sativa* Linn) Agricultural Waste as Substrate for Poly(3-hydroxybutyrate) Production using *Pseudomonas aeruginosa*. *Journal of Pure and Applied Microbiology*, 12(3), 1163–1169. doi: <https://doi.org/10.22207/JPAM.12.3.15>
- Sugiyono. (2013). Metode Penelitian Kuantitatif, Kualitatif dan R&D. Bandung: Alfabeta.CV.
- Sujan, S.M.A., Bari, M.L., & Fakhrudin, A.N.M. (2018). Effects of Physical Pretreatment (Crushing and Ball milling) on Sugarcane Bagasse for Bioethanol Production. *Bangladesh Journal of Botany*, 47(2), 257–264.
- Sulistiyowati, Eddy., Salirawati, Das & Amanatie. (2016). Karakterisasi Beberapa Ion Logam Terhadap AktivitasEnzim Tripsin. *Jurnal Penelitian Saintek*, 2(21), 107-120.
- Sun, Y. & Cheng, J. (2002). Hydrolysis of Lignocellulosic Materials for Ethanol Production : a review, 83, 1–11.
- Sun, Y., Sun, F., Feng, W., Qiu, X., Liu, Y., Yang, B., & Xia, P. (2017). Hyperoside Inhibits Biofilm Formation of *Pseudomonas aeruginosa*. *Experimental and Therapeutic Medicine*, 14(2), 1647–1652. <https://doi.org/10.3892/etm.2017.4641>
- Teather, R.M. & Wood, P.J. (1982). Use of Congo red-olysaccharide Interactions in Enumeration and Characterization of Cellulolytic Bacteria from The Bovine Rumen. *Applied and Environmental Microbiology*, 43(4), 777–780. doi: <https://doi.org/10.1128/aem.43.4.777-780.1982>
- Todar, Kenneth. (2020). *Pseudomonas aeruginosa*. [Online]. Diakses dari: <http://textbookofbacteriology.net/pseudomonas.html>
- Tsegaye, B., Balomajumder, C., & Roy, P. (2018). Biodelignification and Hydrolysis of Rice Straw by Novel Bacteria Isolated from Wood Feeding

Termite. *3 Biotechnology*, 8(10), 0. doi: <https://doi.org/10.1007/s13205-018-1471-0>

- Uppugundla, N., Da Costa Sousa, L., Chundawat, S.P.S., Yu, X., Simmons, B., Singh, S., Gao, X., Kumar, R., Wyman, C.E., Dale, B.E., & Balan, V. (2014). A Comparative Study of Ethanol Production using Dilute acid, Ionic liquid and AFEXTM Pretreated Corn Stover. *Biotechnology Biofuel*, 7, 72–85.
- Vanholme, R., Demedts, B., Morreel, K., Ralph, J., & Boerjan, W. (2010). Lignin Biosynthesis and Structure. *Plant Physiology*. 153.
- Van Soest, P.J. (1983). *Nutritional Ecology of the Ruminant*. O&B Books, Inc . Corvallis, Oregon, 3, 895-905. doi: <http://dx.doi.org/10.1104/pp.110.155119>
- Vijayakumar, G., Tamilarasan, R., & Dharmendra Kumar, M. (2011). Removal of Cd 2+ions from Aqueous Solution using Live and Dead *Bacillus subtilis*. *Chemical Engineering Research Bulletin*, 15(1), 18–24.
- Volk, W.A & Wheeler, M.F. (1988). *Mikrobiologi Dasar*. Jakarta: Pustaka Azzam
- Waghmare, P.R., Kshirsagar, S.D., Saratale, R.G., Govindwar, S.P., & Saratale, G.D. (2014). Production and Characterization of Cellulolytic Enzymes by Isolated *Klebsiella* sp. prw-1 using agricultural waste biomass. *Emirates Journal of Food and Agriculture*, 26(1), 44–59. doi: <https://doi.org/10.9755/ejfa.v26i1.15296>
- Watanabe, K. & K. Hayano, (1993). Distribution and Identification of Proteolytic *Bacillus* spp. in Paddy Field Soil under Rice Cultivation. *Canadian Journal of Microbiology*, 39(7), 674-680. doi: <https://doi.org/10.1139/m93-097>
- Weissman, Eli. (2018). *Compounds in Rice Plants Protect the Plant from Competitors by Suppressing Growth in Competing Plants*. [Online]. Diakses dari: <https://asknature.org/strategy/plant-compounds-protect-from-competitors/#.XmNT3qgzbiU>
- Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2011). *Prescott's Microbiology*, 8th Ed. New York. McGraw-Hill Education.
- Withers, S.G. & Aebersold, R. (1995). Approaches to Labeling and Identification of Active Site Residues in Glycosidases. *Protein Science*, 4(3), 361-372.
- Wu, X., Chen, L., He, W., Qi, H., Zhang, Y., Zhou, Y., & Wang, K. (2020). Characterize the Physicochemical Structure and Enzymatic Efficiency of Agricultural Residues Exposed to γ -irradiation Pretreatment. *Industrial Crops and Products*, 150, 112228. doi:

<https://doi.org/10.1016/j.indcrop.2020.112228>

- Yan, S., Sun, X., Zhang, W., & Zhu, L. (2019). Isolation, Identification and Cellulase-Producing Condition Pptimization of *Bacillus subtilis* Q3 Strain. *AIP Conference Proceedings*, 2110. doi: <https://doi.org/10.1063/1.5110798>
- Yang, J.H., Kim, I.S., Oh, C.H., & Oh, N.S. (2012). Protease and γ glutamyltranspeptidase Activities of *Bacillus* spp. Isolated from Rice Straw. *Food Science and Biotechnology*, 21(1), 291–294. doi: <https://doi.org/10.1007/s10068-012-0039-8>
- Young, Kevin D. (2007). *Bacterial Morphology: Why Have Different Shapes?.* [Online]. Diakses dari : <https://doi.org/10.1016/j.mib.2007.09.009>
- Zahiroddini, H., Baah, J., Absalom, W., & McAllister, T.A. (2004). Effect of an Inoculant and Hydrolytic Enzymes on Fermentation and Nutritive Value of Whole Crop Barley Silage. *Animal Feed Science and Technology*, 117(3–4), 317–330. doi: <https://doi.org/10.1016/j.anifeedsci.2004.08.013>
- Zhang, J.G., Kawamoto, H., & Cai, Y.M. (2010). Relationships Between the Addition Rates of Cellulase or Glucose and Silage Fermentation at Different Temperatures. *Animal Science Journal*, 81(3), 325–330. doi: <https://doi.org/10.1111/j.1740-0929.2010.00745.x>
- Zhang, J., Zhou, H., Liu, D., & Zhao, X. (2020). Pretreatment of Lignocellulosic Biomass for Efficient Enzymatic Saccharification of Cellulose. In *Lignocellulosic Biomass to Liquid Biofuels*. doi: <https://doi.org/10.1016/b978-0-12-815936-1.00002-2>