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DAFTAR PUSTAKA

Abdel-Aziz, N.A., A.Z. Salem, M.M. El-Adawy, L.M Camacho, A.E. Kholif, M.M. Elghandour, and B.E. Borhami. 2015. Biological treatments as a mean to improve feed utilization in agriculture animals—An overview. J. Integr. Agric.14(3): 534-543. https://doi.org/10.1016/S2095-3119(14)60829-7

Abdeltawab, A. M., and M. S, Khattab. 2018. Utilization of palm kernel cake as a ruminant feed for animal: A review. Asian Journal of Biological Science. 11(4): 157-164. https://doi.org/10.3923/ajbs.2018.157.164

Abolore, R. S., S. Jaiswal and A. K. Jaiswal. 2024. Green and sustainable pretreatment methods for cellulose extraction from lignocellulosic biomass and its applications: A review. Carbohydr. Polym. Technol. Appl. 7: 100396. https://doi.org/10.1016/j.carpta.2023.100396.

Adesogan, A. T., K. G. Arriola, Y. Jiang, A. Oyebade, E. M. Paula, A. A. Pech-Cervantes, J. J. Romero, L. F. Ferraretto, and D. Vyas. 2019. Symposium review: Technologies for improving fiber utilization. J. Dairy Sci. 102(6): 5726–5755. https://doi.org/10.3168/jds.2018-15334

Alagbe, J.O. 2020. Chemical evaluation of proximate, vitamin and amino acid profile of leaf, stem bark and root of Indigofera Tinctoria. Biomedical Research and Clinical Reviews. 3(1). https://doi.org/10.31579/2692-9406/026

Alberts, B., R. Heald, A. Johnson, D. O. Morgan, M. C. Raff, K. Roberts, and P. Walter. 2022. Molecular biology of the cell. 7th ed. New York, NY: W. W. Norton and Company.

Alhotan, R.A., G.M. Pesti and L. Billard. 2024. The linear relationship between true protein and nitrogen contents of feed and food ingredients: calculating true protein from a new conversion factor. Cogent Food Agric. 10(1): 2428821. https://doi.org/10.1080/23311932.2024.2428821

Ali, A., A. Rias, T. Adelina, dan R. Misrianti. 2021. Komponen dinding sel Indigofera (Indigofera zollingeriana) di lahan gambut berdasarkan umur panen 2, 3, 4 dan 5 bulan setelah pemangkasan. Jurnal Peternakan. 18(2): 115-121. http://dx.doi.org/10.24014/jupet.v18i2:12741.

Ali, A., Riswandi, Muhakka, S. Sandi., and A. N. T. Pratama. 2025. Effect of combining leucaena and indigofera leaves in swamp grass-based diets on digestibility, rumen fermentability and methanogenesis. Iraqi Journal of Agricultural Sciences. 56(1): 391-401. https://doi.org/10.36103/kk0g8487.

Ali, M.F. and M. Tahir. 2021. An overview on the factors affecting water-soluble carbohydrates concentration during ensiling of silage. J. Plant Environ. 03(01): 63-80. https://doi.org/10.33687/jpe.003.01.3702

Almassri, N., F.J. Trujillo and N.S. Terefe. 2024. Microencapsulation technology for delivery of enzymes in ruminant feed. Front. Vet. Sci. 11: 1352375. https://doi.org/10.3389/fvets.2024.1352375

Amanlou, H., T.A. Farahani, and N.E. Farsuni. 2017. Effects of rumen undegradable protein supplementation on productive performance and indicators of protein and energy metabolism in Holstein fresh cows. J. Dairy Sci. 100(5): 3628-3640. https://doi.org/10.3168/jds.2016-11794.

UNIVERSITAS
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Arya, A., P.M. Lunagariya, R. J. Modi and Y. G. Patel. 2024. Rumen fermentation. International Journal of Veterinary Sciences and Animal Husbandry. 9(5): 09-12. https://doi.org/10.22271/veterinary.2024.v9.i5a.1639

Ankom Technology. 2022. Ankom Fiber Analyzer 2000 Operator's Manual. Ankom Technology, Macedon, NY, USA.

Ankom Technology. 2023. Daisy II Incubator Operator's Manual. Ankom Technology, Macedon, NY, USA.

Antari, R., S. P. Ginting, Y. N. Anggraeny, and S. R. McLennan. 2023. The potential role of Indigofera zollingeriana as a high-quality forage for cattle in Indonesia. Trop. Grasslands. 11(3): 183-197. https://doi.org/10.17138/tgft(11)183-197

Antari, R., Y.N. Anggraeny, A.S. Putri, P.K. Sukmasari, N.H. Krishna, M. Mariyono, M.N. Aprilliza, and S. Ginting, 2022. Nutritive and antinutritive contents of Indigofera zollingeriana: Its potency for cattle feed in Indonesia. Livestock Research for Rural Development, 34(2). https://lrrd.cipav.org.co/lrrd34/2/3412risa.html

AOAC. 2005. Official Methods of Analysis, 18th ed.; Association of Official Analytical Chemists: Washington DC, USA..

Aprilliza, M.N., N.H. Krishna and D. Pamungkas. 2023. Feed Durability and Feed Quality of Concentrate Feed with Addition of Monosodium Glutamate Manufacturing by-products. In IOP Conference Series: Earth and Environmental Science. 1177 (1): 012053. IOP Publishing. https://doi.org/10.1088/1755-1315/1177/1/012053.

Astuti T., U. Santoso and Y. Amir. 2017. Nutritional value of fermented palm oil fronds as a basis for complete feed for ruminants. Pak. J. Nutr. 16: 96-100. https://doi.org/10.3923/pjn.2017.96.100

Ayaşan, T., E. Sucu, I. Ülger, H. Hizli, P. Cubukcu and B. D. Ozcan. 2020. Determination of in vitro rumen digestibility and potential feed value of tiger nut varieties. South African Journal Animal Science. 50: 738-744. https://doi.org/10.4314/sajas.v50i5.12.

Badarina, I., D. Dwatmadji and R. Rapelino. 2023. In vitro digestibility and rumen pH of diet comprised by different level of Indigofera zollingeriana and Pennisetum purpureum. In E3S Web of Conferences. 373, 01009. EDP Sciences. https://doi.org/10.1051/e3sconf/202337301009.

Bahar, S., M.A. Harahap and T.P. Priyatno. 2023. Meta-analysis: the effect of feeding indigofera leaves (Indigofera zollingeriana) on goat livestock performance. In IOP Conference Series: Earth and Environmental Science, 1230 (1), 012054. IOP Publishing. https://doi.org/10.1088/1755-1315/1230/1/012054.

Bai, J., Z. Ding, W. Ke, D. Xu, M. Wang, W. Huang, Y. Zhang, F. Liu, and X. Guo. 2021. Different lactic acid bacteria and their combinations regulated the fermentation process of ensiled alfalfa: ensiling characteristics, dynamics of bacterial community and their functional shifts. Microb. Biotechnol. 14(3): 1171-1182. https://doi.org/10.1111/1751-7915.13785

Bai, M., G. Qin, Z. Sun and G. Long. 2015. Relationship between molecular structure characteristics of feed proteins and protein in vitro digestibility and

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

solubility. Asian-Australas. J. Anim. Sci. 29(8): 1159. https://doi.org/10.5713/ajas.15.0701.

Bakri, M.K.B. and M.R. Rahman. 2022. Cellulose interunit linkages and model compounds. In M. R. Rahman. Fundamentals and Recent Advances in Nanocomposites Based on Polymers and Nanocellulose: 41-52. https://doi.org/10.1016/B978-0-323-85771-0.00004-X.

Baksi, S., D. Saha, S. Saha, U. Sarkar, D. Basu, and J. C. Kuniyal. 2023. Pre-treatment of lignocellulosic biomass: review of various physico-chemical and biological methods influencing the extent of biomass depolymerization. Int. J. Environ. Sci. Technol. 20(12): 13895–13922. https://doi.org/10.1007/s13762-023-04838-4

Batubara, U.M., M. Mardalisa, S. Suparjo, H.U. Maritsa, E. Pujianto and M. Herlini. 2021. Isolation and characterization of cellulolytic bacteria diversity in peatland ecosystem and their cellulolytic activities. In IOP Conference Series: Earth and Environmental Science. 934 (1): 012028. IOP Publishing. https://doi.org/10.1088/1755-1315/934/1/012028

Bernardes, T. F., J. R. S. Gervásio, G. De Morais and D. R. Casagrande. 2019. Technical note: A comparison of methods to determine pH in silages. J. Dairy Sci. 102(10): 9039–9042. https://doi.org/10.3168/jds.2019-16553

Brodeur, G., E. Yau, K. Badal, J. Collier, K. B. Ramachandran and S. Ramakrishnan. 2011. Chemical and physicochemical pretreatment of lignocellulosic biomass: A review. Enzyme Res. 2011(1). https://doi.org/10.4061/2011/787532

Capstaff, N.M. and A. J. Miller. 2018. Improving the yield and nutritional quality of forage crops. Front. Plant Sci. 9: 535. https://doi.org/10.3389/fpls.2018.00535.

Castro-Montoya, J. M., and U. Dickhoefer. 2020. The nutritional value of tropical legume forages fed to ruminants as affected by their growth habit and fed form: A systematic review. Anim. Feed Sci. Technol. 269: 114641. https://doi.org/10.1016/j.anifeedsci.2020.11464

Chen, H. 2014. Chemical Composition and Structure of Natural Lignocellulose. In: Biotechnology of Lignocellulose. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-6898-7_2

Chen, J., X. Ma, M. Liang, Z. Guo, Y. Cai, C. Zhu, Z. Wang, S. Wang, J. Xu, and H. Ying. 2024. Physical–Chemical–Biological Pretreatment for Biomass Degradation and Industrial Applications: A Review. Waste. 2(4): 451-473. https://doi.org/10.3390/waste2040024.

Cherdthong, A. 2025. An overview of alternative protein sources for ruminants in the tropical area. Ann. Anim. Sci. 25(1): 103-118. https://doi.org/10.2478/aoas-2024-0049

Collins, M., and Y. C. Newman 2017. Forage Quality. In Collins, M., et al. 2017. Forages Volume 1 An Introduction to Grassland Agriculture 7th edition (pp 269-286). Waley Backwel, New Jersey USA.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

da Silva, T.C., L.D. da Silva, E. M. Santos, J.S. Oliveira and A.F. Perazzo. 2017. Importance of the fermentation to produce high-quality silage. In Fermentation processes. IntechOpen. http://dx.doi.org/10.5772/64887

Darma, I.N.G., A. Jayanegara, A. Sofyan, E. Budiartilaconi, M. Ridla and H. Herdian. 2023. Evaluation of nutritional values of tree-forage legume leaves from gunungkidul district, indonesia. Biodiversitas Journal of Biological Diversity. 24(5). https://doi.org/10.13057/biodiv/d240527.

Das, L. K., S.S. Kundu, D. Kumar, and C. Datt. 2014. Metabolizable protein systems in ruminant nutrition: A review. Veterinary World. 7(8). https://doi.org/10.14202/vetworld.2014.622-629

Das, L.K., Kundu, S.S., Kumar, D. and Datt, C. 2015. Fractionation of carbohydrate and protein content of some forage feeds of ruminants for nutritive evaluation. Veterinary world. 8(2): 97. https://doi.org/10.14202/vetworld.2015.197-202.

Deshavath, N.N., M. Mohan, V. D. Veeranki, V. V. Goud, S. R. Pinnamaneni and T. Benarjee. 2017. Dilute acid pretreatment of sorghum biomass to maximize the hemicellulose hydrolysis with minimized levels of fermentative inhibitors for bioethanol production. 3 Biotech. 7: 139. https://doi.org/10.1007/s13205-017-0752-3

Dilaga, S. H., R. A. Putra, A. N. Pratama, O. Yanuarianto, M. Amin and S. Suhubdy. 2022. Nutritional quality and in vitro digestibility of fermented rice bran based on different types and doses of inoculants. Journal of Advanced Veterinary and Animal Research. 9(4): 625. https://doi.org/10.5455/javar.2022.i632

Direkvandi, E., T. Mohammadabadi, M. Chaji, M. M. Elghandour, A. Barbabosa-Pleigo. and A. Z. Salem. 2020. Effect of sulfuric acid and molasses on the chemical composition, ruminal fermentation, and digestibility of silage of Conocarpus erectus L. tree leaves and branches. Agrofor. Syst. 94(4): 1601-1609. https://doi.org/10.1007/s10457-020-00495-5

Du, B., L. N. Sharma, C. Becker, S. F. Chen, R. A. Mowery, G. P. van Walsum and C. K. Chambliss. 2010. Effect of varying feedstock-pretreatment chemistry combinations on the formation and accumulation of potentially inhibitory degradation products in biomass hydrolysates. Biotechnol. Bioeng. 107(3): 430–440. https://doi.org/10.1002/bit.22829

Du, S., M. Xu and J. Yao. 2016. Relationship between fibre degradation kinetics and chemical composition of forages and by-products in ruminants. J. Appl. Anim. Res. 44(1): 189-193. https://doi.org/10.1080/09712119.2015.1031767

Elgersma, A., and K. Søegaard. 2018. Changes in nutritive value and herbage yield during extended growth intervals in grass–legume mixtures: effects of species, maturity at harvest, and relationships between productivity and components of feed quality. Grass Forage Sci. 73(1): 78-93. https://doi.org/10.1111/gfs.12287

Encyclopedia of Life. 2023, December 3. Indigofera zollingeriana Miq. EOL. https://eol.org/pages/639869. Diakses pada: 29 March 2025

Ertekin, I., I. Atis, Y. Z. Aygun, S. Yilmaz and M. Kizilsimsek. 2021. Effects of different nitrogen doses and cultivars on fermentation quality and nutritive

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

value of Italian ryegrass (Lolium multiflorum Lam.) silages. Anim. Biosci. 35(1): 39. https://doi.org/10.5713/ab.21.0113

Evitayani, E., L. Warly and F. Rifaldy. 2022. Indigofera zollingerianan effect as a subtitute of concentrate on growth of etawa goats to digestibility of fiber fractions. In 9th International Seminar on Tropical Animal Production (ISTAP 2021): 39-44. Atlantis Press. https://doi.org/10.2991/absr.k.220207.009.

Fahey, G. C., L. Novotny, B. Layton and D. R. Mertens. 2019. Critical factors in determining fiber content of feeds and foods and their ingredients. J. AOAC Int. 102(1): 52-62. https://doi.org/10.5740/jaoacint.18-0067

Fijałkowska, M., B. Pysera, K. Lipiński and D. Strusińska. 2015. Changes of nitrogen compounds during ensiling of high protein herbages-a review. Ann. Anim. Sci. 15 (2): 289–305. https://doi.org/10.1515/aoas-2015-0008

Fletcher, M.T., R. A. Al Jassim and A. J. Cawdell-Smith. 2015. The occurrence and toxicity of indospicine to grazing animals. Agric. 5(3): 427-440. https://doi.org/10.3390/agriculture5030427.

Fontes-Candia, C., L. Díaz-Piñero, L. M. Vega-Gómez, I. Molina-Gilarranz and M. Martínez-Sanz. 2025. Relevance of Protein–Polysaccharide Interactions on Nutritional Quality and Gastrointestinal Digestion of Protein-Based Foods. J. Agric. Food. Chem. 73(9): 4998-5004. https://doi.org/10.1021/acs.jafc.4c11949.

Francis, P. S., S. W. Lewis and K. F. Lim. 2002. Analytical methodology for the determination of urea: current practice and future trends. TrAC, Trends Anal. Chem. 21(5): 389-400. https://doi.org/10.1016/S0165-9936(02)00507-1

Gharechahi, J., M. F. Vahidi, G. Sharifi, S. Ariaeenejad, X. Z. Ding, J. L. Han and G. H. Salekdeh. 2023. Lignocellulose degradation by rumen bacterial communities: New insights from metagenome analyses. Environ. Res. 229: 115925. https://doi.org/10.1016/j.envres.2023.115925.

Ginting, S. P. 2021. Processing Technologies of Lignocellulosic Biomass: Potentials and Constraints for Ruminant Feed Production. Indonesian Bulletin of Animal and Veterinary Sciences. 31(2): 55. https://doi.org/10.14334/wartazoa.v31i2.2737

Głab S. and A. Hulanicki. 2004. pH. In: Encyclopedia of Analytical Science: Second Edition (p. 72 – 78) University of Warsaw, Warsaw, Poland. https://doi.org/10.1016/B0-12-369397-7/00445-3.

Gonda, H., I. Nikodinoska, K. Le Cocq and C.A. Moran. 2023. Efficacy of six lactic acid bacteria strains as silage inoculants in forages with different dry matter and water-soluble carbohydrate content. Grass Forage Sci. 78(4): 636-647. https://doi.org/10.1111/gfs.12622.

Guo, X. S., J. Bai, F. H. Li, D. M. Xu, Y. X. Zhang, D. P. Bu, and L. S. Zhao. 2020. Effects of malate, citrate, succinate and fumarate on fermentation, chemical composition, aerobic stability and digestibility of alfalfa silage. Anim. Feed Sci. Technol. 268: 114604. https://doi.org/10.1016/j.anifeedsci.2020.114604

Gürsoy, E., A. Kaya and M. Gül. 2021. Determining the nutrient content, energy, and in vitro true digestibility of some grass forage plants. Emir. J. Food Agric. 33(5): 417-422. https://doi.org/10.9755/ejfa.2021.v33.i5.2696.

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Hafid, H., A. Napirah, M. F. Febiano and S. H. Ananda. 2021. Slaughter weight, carcass and giblets percentage of broiler chicken with addition of Indigofera zollingeriana leaves in feed. In IOP Conference Series: Earth and Environmental Science, 788 (1). IOP Publishing. https://doi.org/10.1088/1755-1315/788/1/012184.

Hamacher, M., C. S. Malisch, T. Reinsch, F. Taube and R. Loges. 2021. Evaluation of yield formation and nutritive value of forage legumes and herbs with potential for diverse grasslands due to their concentration in plant specialized metabolites. Eur. J. Agron. 128: 126307. https://doi.org/10.1016/j.eja.2021.126307

Hao, W., P. Tian, M. Zheng, H. Wang and C. Xu. 2019. Characteristics of proteolytic microorganisms and their effects on proteolysis in total mixed ration silages of soybean curd residue. Asian-Australas. J. Anim. Sci. 33(1): 100. https://doi.org/10.5713/ajas.18.0933.

Harahap, R. P., S. S. Nahrowi, A. Jayanegara and S. Fakhri. 2023. Enhancing silage quality of Elephant grass and Indigofera legume using shrimp shell-derived chitin and chitosan additives. Development. 35: 11. https://www.lrrd.org/lrrd35/11/35100rakh.html

Harper, K. J., and D. M. McNeill. 2015. The role iNDF in the regulation of feed intake and the importance of its assessment in subtropical ruminant systems (the role of iNDF in the regulation of forage intake). Agric. 5(3): 778-790. https://doi.org/10.3390/agriculture5030778

Haryati, T., B. P. Soewandi, N. Pratiwi and K. Komarudin. 2021. The effect of Indigofera zollingeriana supplementation to performance of rabbit. In IOP Conference Series: Earth and Environmental Science888, No. 1, p. 012073). IOP Publishing. https://doi.org/10.1088/1755-1315/888/1/012073.

Has, H., R. Ribriani and A. Napirah. 2021. Effect of Indigofera leaves as a subtitute for soybean meal in laying quail (Coturnix-coturnix japonica) ration on egg production, feed conversion ratio, and yolk color score. In IOP Conference Series: Earth and Environmental Science, 788 (1). IOP Publishing https://doi.org/10.1088/1755-1315/788/1/012180.

He, L., H. Lu, C. Wang, W. Zhou, R. Pian, Q. Zhang and X. Chen. 2020. Dynamics of fermentation quality, physiochemical property and enzymatic hydrolysis of high-moisture corn stover ensiled with sulfuric acid or sodium hydroxide. Bioresour. Technol. 298: 122510. https://doi.org/10.1016/j.biortech.2019.122510

He, L., W. Zhou, C. Wang, F. Yang, X. Chen and Q. Zhang. 2019a. Effect of cellulase and Lactobacillus casei on ensiling characteristics, chemical composition, antioxidant activity, and digestibility of mulberry leaf silage. J. dairy sci. 102(11): 9919-9931. https://doi.org/10.3168/jds.2019-16468

He, L., C. Wang, Y. Xing, W. Zhou, R. Pian, F. Yang, X. Chen and Q. Zhang, 2019b. Dynamics of proteolysis, protease activity and bacterial community of Neolamarckia cadamba leaves silage and the effects of formic acid and Lactobacillus farciminis. Bioresour. Technol. 294: 122127. https://doi.org/10.1016/j.biortech.2019.122127

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GADJAH MADA
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Herdiawan, I., and R. Krisnan. 2014. Productivity and utilization of Leguminous tree Indigofera zollingeriana on dry land. Indonesian Bulletin of Animal and Veterinary Sciences, 24(2). http://dx.doi.org/10.14334/wartazoa.v24i2.1051

Hristov, A. N., M. T. Harper, G. Roth, C. Canale, P. Huhtanen, T. L. Richard and K. DiMarco. 2020. Effects of ensiling time on corn silage neutral detergent fiber degradability and relationship between laboratory fiber analyses and in vivo digestibility. J. dairy sci. 103(3): 2333-2346. https://doi.org/10.3168/jds.2019-16917

Ilmana, M., N. Humaidah, dan U. Kalsum. 2023. Pengaruh lama fermentasi rumput raja (pennnisetum purpureophoides) dengan fermentor saus burger pakan terhadap kualitas rumput. Dinamika Rekasatwa: Jurnal Ilmiah (e-Journal), 6(2). https://jim.unisma.ac.id/index.php/fapet/article/view/20479/15211

Indah, A.S. and I. G. Permana. 2020. Determination dry matter digestibility of tropical forage using nutrient compisition. In IOP Conference Series: Earth and Environmental Science (Vol. 484, No. 1, p. 012113). IOP Publishing. https://doi.org/10.1088/1755-1315/484/1/012113.

Iommelli, P., F. Zicarelli, N. Musco, F. Sarubbi, M. Grossi, D. Lotito, P. Lombardi, F. Infascelli and R. Tudisco. 2022. Effect of Cereals and Legumes Processing on In Situ Rumen Protein Degradability: A Review. Fermentation. 8(8): 363. https://doi.org/10.3390/fermentation8080363

Ismartoyo, I., S. Syahriani and S. Sarwan. 2022. The Feed ADF and NDF Digestibilityof Goat Fed Four Difference Diets. Hasanuddin Journal of Animal Science (HAJAS). 4(1): 41-47. https://doi.org/10.20956/hajas.v4i1.20192.

Jamaldheen, S. B., M. B. Kurade, B. Basak, C. G. Yoo, K. K. Oh, B. H. Jeon and T. H. Kim. 2022. A review on physico-chemical delignification as a pretreatment of lignocellulosic biomass for enhanced bioconversion. Bioresour. Technol. 346: 126591. https://doi.org/10.1016/j.biortech.2021.126591

Jamie L. F., W. B. Smith, F. M. Rouquette, L. O. Tedeschi. 2023. Forages and pastures symposium: an update on in vitro and in situ experimental techniques for approximation of ruminal fiber degradation, J. Anim. Sci. 101: skad097. https://doi.org/10.1093/jas/skad097.

Jayanegara, A., V. Ardani and H. A. Sukria. 2019. Nutritional comparison between dried and ensiled indigofera, papaya and moringa leaves. Journal of the Indonesian Tropical Animal Agriculture. 44(1): 77–83. https://doi.org/10.14710/jitaa.44.1.77-83

Jayanegara, A., Wardiman, B., Kondo, M., Ridla, M., and Laconi, E. B. 2020. Fermentative quality of silage as affected by protein level in the ensiled material: A meta-analysis. In IOP Conference Series: Earth and Environmental Science (Vol. 462, No. 1, p. 012001). IOP Publishing. https://doi.org/10.1088/1755-1315/462/1/012001

Jiang, F.G., Cheng, H.J., Liu, D., Wei, C., An, W.J., Wang, Y.F., Sun, H.T. and Song, E.L., 2020. Treatment of whole-plant corn silage with lactic acid bacteria and organic acid enhances quality by elevating acid content, reducing pH, and inhibiting undesirable microorganisms. Front. Microbiol. 11: 593088. https://doi.org/10.3168/jds.2017-12875.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
YUSRI, Ir. Andriyani Astuti, S.Pt., M.Sc., Ph.D., IPM., ASEAN Eng.; Ir. Dimas Hand Vidya Paradhipta, S.Pt., M.Sc., P
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Jones, C.M., A.J. Heinrichs, G. W. Roth and A. A. Ishler. 2004. From harvest to feed: understanding silage management. Pennsylvania State University. College of Agricultural Sciences. 2(1):2-11.

Karastogianni S., S. Girousi and S. Sotiropoulos. 2016. pH: Principles and Measurement. In: Caballero, B., Finglas, P., and Toldrá, F. (eds.) The Encyclopedia of Food and Health vol. 4, 333-338. Oxford: Academic Press

Katoch, R., 2022. Forage quality components. In Techniques in Forage Quality Analysis (pp. 17-32). Singapore: Springer Nature Singapore.

Katsumata, S., W. Angthong, R. Narmsilee, K. Oishi, H. Hirooka, and H. Kumagai. 2020. Effects of feeding mother liquor, by-product of monosodium glutamate, on digestibility, energy and nitrogen balances, and rumen condition in Thai native bulls. Anim. Sci. J. 91(1): e13421. https://doi.org/10.1111/asj.13421

Keaokliang O, T. Kawashima, W. Angthong, T. Suzuki, R. Narmseelee. 2018. Chemical composition and nutritional values of cassava pulp for cattle. Anim. Sci. J. 89(8):1120-1128. https://doi.org/10.1111/asj.13039.

Kim, S. W., J. F. Less, L. Wang, T. Yan, V. Kiron, S. J. Kaushik, and X. G. Lei. 2019. Meeting global feed protein demand: challenge, opportunity, and strategy. Annu. Rev. Anim. Biosci., 7(1): 221-243. https://doi.org/10.1146/annurev-animal-030117-014838

Kresnawaty, I., R. Wahyu and A. Sasongko. 2019. Aktivitas amilase bakteri amilolitik asal larva black soldier fly (Hermetia illucens). Menara Perkebunan. 87(2). https://doi.org/10.22302/iribb.jur.mp.v87i2.341

Krul, E.S., 2019. Calculation of nitrogen-to-protein conversion factors: A review with a focus on soy protein. J. Am. Oil Chem. Soc. 96(4): 339-364. https://doi.org/10.1002/aocs.12196.

Kulkarni, K. P., R. Tayade, S. Asekova, J. T. Song, J. G. Shannon, and J. D. Lee. 2018. Harnessing the potential of forage legumes, alfalfa, soybean, and cowpea for sustainable agriculture and global food security. Front. Plant Sci. 9: 1314. https://doi.org/10.3389/fpls.2018.01314

Kumar, Rakesh, M. R. Yadav, Mohd Arif, D. M. Mahala, Dinesh Kumar, P. C. Ghasal, K. C. Yadav, and R. K. Verma. 2020. Multiple agroecosystem services of forage legumes towards agriculture sustainability: An overview. The Indian Journal of Agricultural Sciences. 90(8): 1367-1377. https://doi.org/10.56093/ijas.v90i8.105882

Kung Jr, L., R. D. Shaver, R. J. Grant and R. J. Schmidt. 2018. Silage review: Interpretation of chemical, microbial, and organoleptic components of silages. J. dairy Sci. 101(5): 4020-4033. https://doi.org/10.3168/jds.2017-13909

Kung, L., 2018. Silage fermentation and additives. Archivos Latinoamericanos de Producción Animal. 26(3-4): 61-66.

Li J.H., J. Zhang, S. Y. Yu, Z. R. Wang and C. C. Liu. 2023. Research progress of evolution and classification systems in the family of Leguminosae. Legume Genomics and Genetics. 14(3): 1-12. https://doi.org/10.5376/lgg.2023.14.0003

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Li, J., X. Tang, J. Zhao, S. Chen, S. Wang and T. Shao. 2021. Improvement of fermentation quality and cellulose convertibility of Napier grass silage by inoculation of cellulolytic bacteria from Tibetan yak (Bos grunniens). J. Appl. Microbiol. 130(6): 1857-1867. https://doi.org/10.1111/jam.14917.

Li, X. 2021. Plant cell wall chemistry: Implications for ruminant utilisation. J. Appl. Anim. Nutr. 9(1): 31-56. https://doi.org/10.3920/JAAN2020.0017

Li, X., J. Tian, Q. Zhang, Y. Jiang, J. Hou, Z. Wu and Z. Yu. 2018. Effects of applying Lactobacillus plantarum and Chinese gallnut tannin on the dynamics of protein degradation and proteases activity in alfalfa silage. Grass Forage Sci. 73(3): 648-659. https://doi.org/10.1111/gfs.12364

Li, Y., S. Du, L. Sun, Q. Cheng, J. Hao, Q. Lu, G. Ge, Z. Wang and Y. Jia. 2022. Effects of lactic acid bacteria and molasses additives on dynamic fermentation quality and microbial community of native grass silage. Front. Microbiol. 13: 830121. https://doi.org/10.3389/fmicb.2022.830121

Lima, J., W. Ingabire, R. Roehe and R. J. Dewhurst. 2023. Estimating microbial protein synthesis in the rumen—Can 'omics' methods provide new insights into a long-standing question?. Vet. Sci. 10(12): 679. https://doi.org/10.3390/vetsci10120679

Lokhande, S. and A. S. Pethe. 2017. Isolation and screening of cellulolytic bacteria from soil and optimization of cellulase production. Int. J. Life Sci. 5(2): 277-282.

Mankar, A. R., A. Pandey, A. Modak and K. K. Pant. 2021. Pretreatment of lignocellulosic biomass: A review on recent advances. Bioresour. Technol. 334: 125235. https://doi.org/10.1016/j.biortech.2021.125235

Meenakshisundaram, S., A. Fayeulle, E. Leonard, C. Ceballos and A. Pauss. 2021. Fiber degradation and carbohydrate production by combined biological and chemical/physicochemical pretreatment methods of lignocellulosic biomass–a review. Bioresour. Technol. 331: 125053. https://doi.org/10.1016/j.biortech.2021.125053

Muck, R.E., L. Kung Jr. and M. Collins. 2020. Silage production. Forages: The Science of Grassland Agriculture. 2: 767-787. https://doi.org/10.1002/9781119436669.ch42.

Muck, R.E., E.M.G. Nadeau, T.A. McAllister, F. E. Contreras-Govea, M. C. Santos and L. Kung Jr. 2018. Silage review: Recent advances and future uses of silage additives. J. dairy sci. 101(5): 3980-4000. https://doi.org/10.3168/jds.2017-13839

Mukherjee, A., T. Mandal, A. Ganguly and P. K. Chatterjee. 2016. Lignin degradation in the production of bioethanol–A review. ChemBioEng Rev. 3(2): 86-96. https://doi.org/10.1002/cben.201500016.

Nadir, M., S. Syahrir, A. L. Munasirah, I. Warni, N. S. Sari, A. Sulistiawati and M. P. Anugrah. 2024. Exploration of Nutritional Value of Indigofera Shoot Leaves Based on Different Ages. Int. J. Chem. Biochem. Sci. 25(19): 773–778. https://doi.org/10.62877/91-ijcbs-24-25-19-91

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Nagaraja, T.G. 2016. Microbiology of the Rumen. In: Millen, D., De Beni Arrigoni, M., Lauritano Pacheco, R. (eds) Rumenology. Springer, Cham. https://doi.org/10.1007/978-3-319-30533-2_2

Ni, K., F. Wang, B. Zhu, J. Yang, G. Zhou, Y. I. Pan, Y. Tao and J. Zhong. 2017. Effects of lactic acid bacteria and molasses additives on the microbial community and fermentation quality of soybean silage. Bioresour. Technol. 238: 706-715. https://doi.org/10.1016/j.biortech.2017.04.055

Ning, T., H. Wang, M. Zheng, D. Niu, S. Zuo, and C. Xu. 2016. Effects of microbial enzymes on starch and hemicellulose degradation in total mixed ration silages. Asian-Australas. J. Anim. Sci. 30(2): 171. https://doi.org/10.5713/ajas.16.0046.

Nurhayu, A. and A. B. L. Ishak. 2015. Indigofera Sp as a Source of Protein in Forages for Kacang Goat in Lactation and Weaning Period. In International Seminar on Tropical Animal Production (ISTAP), 228-232. https://journal.ugm.ac.id/istapproceeding/article/view/30619.

Nurjannah, S. and R. Krisnan. 2022. Digestibility of Calliandra, Indigofera sp. and the Mixture in the Ration as a Substitute for the Concentrate Given to the Tup Garut. In International Conference on Improving Tropical Animal Production for Food Security (ISTAP 2021), 244-249. Atlantis Press. https://doi.org/10.2991/absr.k.220309.049.

Ogunade, I. M., Queiroz, C. P. Oscar, Arriola, and G. Kathy. 2019. Lactic Acid Bacteria and Silage Fermentation. In: Lactic Acid Bacteria: Microbiological and Functional Aspects. 275-286. CRC Press. https://doi.org/10.1201/9780429057465-17.

Ojo, A. O. 2023. An overview of lignocellulose and its biotechnological importance in high-value product production. Fermentation. 9(11): 990. https://doi.org/10.3390/fermentation9110990

Oliveira, E.R., C. S. Takiya, T. A. Del Valle, F. P. Rennó, R. H. T. Goes, R. S. Leite, K. M. Oliveira, J. D. Batista, H. M. Araki, J. Damiani and M. S. J. Da Silva. 2019. Effects of exogenous amylolytic enzymes on fermentation, nutritive value, and in vivo digestibility of rehydrated corn silage. Anim. Feed Sci. Technol. 251: 86-95. https://doi.org/10.1016/j.anifeedsci.2019.03.001.

Oskoueian, E., M. F. Jahromi, S. Jafari, M. Shakeri, H. H. Le and M. Ebrahimi. 2021. Manipulation of rice straw silage fermentation with different types of lactic acid bacteria inoculant affects rumen microbial fermentation characteristics and methane production. Vet. Sci. 8(6): 100. https://doi.org/10.3390/vetsci8060100

Padunglerk, A., S. Prasanpanich and P. Kongmun. 2017. Use of monosodium glutamate by-product in cow diet on performance of lactating dairy cows. Anim. Sci. J. 88(1): 86-93. https://doi.org/10.1111/asj.12572

Palmonari, A., Gallo, A., M. Fustini, G. Canestrari, F. Masoero, C. J. Sniffen, and A. Formigoni. 2016. Estimation of the indigestible fiber in different forage types. J. Anim. Sci. 94(1): 248-254. https://doi.org/10.2527/jas.2015-9649.

Paradhipta, D.H.V., C. Hanim, A. Agus, B. Leksono, A. Umroni, S. Maharani, a. R. D. Wardani and Z. Mukmila. 2025. Effects of moisture and fermentation

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

length on the quality and digestibility of fermented concentrate using tamanu kernel cake as the main protein source through an in vitro study. Adv. Anim. Vet. Sci. 12(2): 433. https://doi.org/10.5455/javar.2025.l910

Paradhipta, D.H.V., S. S. Lee, B. Kang, Y. H. Joo, H. J. Lee, Y. Lee, J. Kim and S. C. Kim. 2020. Dual-purpose inoculants and their effects on corn silage. Microorganisms. 8(5): 765. https://doi.org/10.3390/microorganisms8050765

Paradhipta, D.H.V., Y. H. Joo, H. J. Lee, S. S. Lee, H. T. Noh, J. S. Choi, J. Kim, H. G. Min and S. C. Kim. 2021. Effects of inoculants producing antifungal and carboxylesterase activities on corn silage and its shelf life against mold contamination at feed-out phase. Microorganisms. 9(3): 558. https://doi.org/10.3390/microorganisms9030558

Parrini, S., C. Aquilani, C. Pugliese, R. Bozzi and F. Sirtori. 2023. Soybean replacement by alternative protein sources in pig nutrition and its effect on meat quality. Animals. 13(3): 494. https://doi.org/10.3390/ani13030494.

Petersen, A. M., J. Louw and J. F. Görgens. 2024. Economic and Environmental Comparison of the Monosodium Glutamate (MSG) Production Processes from A-Molasses in an Integrated Sugarcane Biorefinery. Int. J. Chem. Eng. 2024(1); 2077515. https://doi.org/10.1155/2024/2077515

Pratama, S.M., S. Wajizah, A. Jayanegara and S. Samadi. 2022. Evaluation of some forage as feed for ruminant animal: chemical composition, in vitro rumen fermentation, and methane emissions. Animal Production. 24(3): 150-160. https://doi.org/10.20884/1.jap.2022.24.3.179.

Proskina, L., and S. Cerina. 2017. Economic gains from consumption of legumes in dairy farming. Proceeding. Jelgava, Latvia, 1196. https://doi.org/10.22616/ERDev2017.16.N263.

Puastuti, W., D. Yulistiani, T. Haryati, S. I. W. Rakhmani, Y. Widiawati, D. A. Kusumaningrum, W. Elizabth, A. Jayanegara and M. Anda. 2024. Enhancing feed fermentation in rice straw basal diets using leaf protein concentrate as a novel ruminant supplement derived from Indigofera zollingeriana. Veterinary World. 17(9): 2077. https://doi.org/10.14202/vetworld.2024.2077-2087

Putri, E. M., M. Zain, L. Warly and H. Hermon. 2019. In vitro evaluation of ruminant feed from West Sumatera based on chemical composition and content of rumen degradable and rumen undegradable proteins. Veterinary World. 12(9): 1478. https://doi.org/10.14202/vetworld.2019.1478-1483

Queiroz, O. C. M., Ogunade, I. M., Weinberg, Z., and Adesogan, A. T. 2018. Silage review: Foodborne pathogens in silage and their mitigation by silage additives. J. dairy sci. 101(5): 4132-4142. https://doi.org/10.3168/jds.2017-13901

Rakhmawati, R., A. Sofiana, N. Indariyanti and R. J. M. Bokau. 2022. Decreasing of Crude Fibre in Indigofera Leaves Flour Hydrolysed with Cellulase Enzyme as a Source of Feed Protein. In IOP Conference Series: Earth and Environmental Science, 1012 (1), 012060. IOP Publishing. https://doi.org/10.1088/1755-1315/1012/1/012060.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
YUSRI, Ir. Andriyani Astuti, S.Pt., M.Sc., Ph.D., IPM., ASEAN Eng.; Ir. Dimas Hand Vidya Paradhipta, S.Pt., M.Sc., P
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Rehemujiang, H., H. A. Yusuf, T. Ma, Q. Diao, L. Kong, L. Kang and Y. Tu. 2023. Evaluating Fermentation Quality, Aerobic Stability, and Rumen-Degradation (In Situ) Characteristics of Various Protein-Based Total Mixed Rations. Animals. 13(17): 2730. https://doi.org/10.3390/ani13172730

Rodrigues, P. H. M., L. A. Pinedo, C.T. Marino, P. M. Meyer, L. M. O. Borgatti and F. M. J. Franco. 2015. Effects of microbial inoculants and by-product from amino acids production on fermentation, chemical composition and aerobic stability of corn silage. Archivos de zootecnia. 64(246): 131-137.

Rusli, N. D., A. A. Ghani, K. Mat, M. T. Yusof, M. Zamri-Saad and H. A. Hassim. 2021. The potential of pretreated oil palm frond in enhancing rumen degradability and growth performance: A review. Adv. Anim. Vet. Sci. Sciences. http://dx.doi.org/10.17582/journal.aavs/2021/9.6.811.822

Sabir, A. M., M. Moloy and P. S. Bhasin. 2016. HPLC Method Development and Validation: a Review. International Research Journal of Pharmacy. 4(4): 39-46. https://doi.org/10.7897/2230-8407.04407

Samadi, S., S. Wajizah and Y. Usman. 2015. In Vitro Study of Fermented Complete Feed by Using Sago Residues as Main Source Diet. Animal Production. 17(3): 129-137. http://www.animalproduction.net/index.php/JAP/article/view/542/452

Sanjorjo, R.A., T. Tseten, M. K. Kang, M. Kwon and S. W. Kim. 2023. In pursuit of understanding the rumen microbiome. Fermentation. 9(2): 114. https://doi.org/10.3390/fermentation9020114.

Santamaría-Fernández, M., and M. Lübeck. 2020. Production of leaf protein concentrates in green biorefineries as alternative feed for monogastric animals. Anim. Feed Sci. Technol. 268: 114605. https://doi.org/10.1016/j.anifeedsci.2020.114605

Santoso, B., T. W. Widayati and B. T. Hariadi. 2020. Improvement of fermentation and the in vitro digestibility characteristics of agricultural waste-based complete feed silage with cellulase enzyme treatment. Adv. Anim. Vet. Sci. 8(8): 873-881. https://doi.org/10.17582/journal.aavs/2020/8.8.873.881

Saphaphan, S., K. T. Rangubhet and P. Kongmun. 2024. The effects of monosodium glutamate by product treated rice straw in total mixed rations on rumen fermentation and ruminal microbial populations using an in vitro gas technique. Adv. Anim. Vet. Sci. 12(6): 1157-1165. https://doi.org/10.17582/journal.aavs/2024/12.6.1157.1165

Sari, E. D., L. Abdullah, N. R. Kumalasari and A. Fanindi. 2024. The evaluation of Indigofera seed production and quality in different environments. In IOP Conference Series: Earth and Environmental Science, 1362 (1). IOP Publishing. https://doi.org/0.1088/1755-1315/1362/1/012006

Sariri, A. K., and S. Sukaryani. 2021. Peningkatan Nutrien Silase Pennisetum purpureum dengan Penambahan Berbagai Konsentrasi Asam Formiat. Bulletin of Applied Animal Research. Baar. 3(2): 47–53. https://www.ejournal.unper.ac.id/index.php/.

Sato, Y., T. Nakanishi, M. Takeda, K. Oishi, H. Hirooka and H. Kumagai. 2019. Effects of supplementary mother liquor, by-product of monosodium

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

glutamate, on in vitro ruminal fermentation characteristics. Anim. Sci. J. 90(1): 90-97. https://doi.org/10.1111/asj.13132

Savari, M., M. Khorvash, H. Amanlou, G. R. Ghorbani, E. Ghasemi and M. Mirzaei. 2018. Effects of rumen-degradable protein: rumen-undegradable protein ratio and corn processing on production performance, nitrogen efficiency, and feeding behavior of Holstein dairy cows. J. dairy sci. 101(2): 1111-1122. https://doi.org/10.3168/jds.2017-12776.

Shao, T., Shimojo, M., Wang, T. and Masuda, Y., 2005. Effect of additives on the fermentation quality and residual mono-and disaccharides compositions of forage oats (Avena sativa L.) and Italian ryegrass (Lolium multiflorum Lam.) silages. Asian-Australas. J. Anim. Sci. 18(11): 1582-1588. https://doi.org/10.5713/ajas.2005.1582

Shi, F.Y., N. Guo, A. A. Degen, J. H. Niu, H. Y. Wei, X. P. Jing, L. M. Ding, Z. h. Shang and R. J. Long. 2020. Effects of level of feed intake and season on digestibility of dietary components, efficiency of microbial protein synthesis, rumen fermentation and ruminal microbiota in yaks. Anim. Feed Sci. Technol. 259: 14359. https://doi.org/10.1016/j.anifeedsci.2019.114359

Shiddiq, S., Y. Usman and S. Wajizah. 2017. Evaluasi Kualitas Nutrisi Jerami Padi yang Difermentasi Menggunakan Saus Burger Pakan (SBP). Jurnal Ilmiah Mahasiswa Pertanian. 2(4). https://doi.org/10.17969/jimfp.v2i4.5591

Solati, Z., U. Jørgensen, J. Eriksen and K. Søegaard. 2018. Estimation of extractable protein in botanical fractions of legume and grass species. Grass Forage Sci. 73(2): 572-581. https://doi.org/10.1111/gfs.12325.

Sonta, M., and A. Rekiel. 2020. Legumes-use for nutritional and feeding purposes. J. Elementol. 25(3). http://dx.doi.org/10.5601/jelem.2020.25.1.1953

Stepanova, G.V. and M. V. Volovik. 2021. Dependence of the buffer capacity on the chemical composition of dry matter of alfalfa. In IOP Conference Series: Earth and Environmental Science (Vol. 901, No. 1, p. 012044). IOP Publishing. https://doi.org/10.1088/1755-1315/901/1/012044

Su, R., K. Ni, T. Wang, X. Yang, J. Zhang, Y. Liu, W. Shi, L. Yan, C. Jie and J. Zhong. 2019. Effects of ferulic acid esterase-producing Lactobacillus fermentum and cellulase additives on the fermentation quality and microbial community of alfalfa silage. PeerJ. 7: e7712. https://doi.org/10.7287/peerj.7712v0.2/reviews/2

Sun, B., G. Peng, L. Duan, A. Xu and X. Li. 2015. Pretreatment by NaOH swelling and then HCl regeneration to enhance the acid hydrolysis of cellulose to glucose. Bioresour. Technol. 196: 454-458. https://doi.org/10.1016/j.biortech.2015.08.009.

Sun, H., C. Liao, L. Chen, Q. Cheng, Y. Zheng, C. Wang, Y. Xie, C. Chen and P. Li. 2023. Potential for volatile fatty acid production via anaerobically-fermenting rice straw pretreated with silage effluent and phenyllactic acid. Bioresour. Technol. 369: 28355. https://doi.org/10.1016/j.biortech.2022.128355.

Tadele, Y., and N. Amha. 2015. Use of different non protein nitrogen sources in ruminant nutrition: A review. Advances in Life Science and Technology. 29: 100-105. https://doi.org/10.14202/vetworld.2014.622-629

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
YUSRI, Ir. Andriyani Astuti, S.Pt., M.Sc., Ph.D., IPM., ASEAN Eng.; Ir. Dimas Hand Vidya Paradhipta, S.Pt., M.Sc., P
Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Tan, E.T., C. M. Materne, R. G. Silcock, B. R. D'Arcy, R. Al Jassim and M. T. Fletcher. 2016. Seasonal and species variation of the hepatotoxin indospicine in Australian Indigofera legumes as measured by UPLC-MS/MS. J. Agric. Food. Chem. 64(34): 6613-6621. https://doi.org/10.1021/acs.jafc.6b02437.

Tao, X., S. Wang, J. Zhao, Z. Dong, J. Li, Q. Liu, F. Sun and T. Shao. 2020. Effect of ensiling alfalfa with citric acid residue on fermentation quality and aerobic stability. Anim. Feed Sci. and Technol. 269: 114622. https://doi.org/10.1016/j.anifeedsci.2020.114622

Tarigan, A., S. P. Ginting, A. Ali, D. A. Astuti and L. Abdullah. 2018b. Body Weight Gain, Nutrients Degradability and Fermentation Rumen Characteristics of Boerka Goat Supplemented Green Concentrate Pellets (GCP) Based on Indigofera zollingeriana. Pak. J. Biol. Sci. 21(2): 87-94. https://doi.org/10.3923/pjbs.2018.87.94

Tarigan, A., S. P. Ginting, I. I. Arief, D. A. Astuti and L. Abdullah. 2018a. Physical quality and digestibility in vitro determination of green pellet concentrate based on Indigofera zollingeriana. Jurnal Ilmu Ternak dan Veteriner. 22(3): 114-123. https://doi.org/10.14334/jitv.v22i3.1651.

Tassone, S., R. Fortina and P. G. Peiretti. 2020. In vitro techniques using the daisyII incubator for the assessment of digestibility: A review. Animals. 10(5): 1–24. https://doi.org/10.3390/ani10050775

Tedeschi, L. O., J. M. Adams and R. A. Vieira. 2023. Forages and Pastures Symposium: revisiting mechanisms, methods, and models for altering forage cell wall utilization for ruminants. J. Anim. Sci. 101: skad009. https://doi.org/10.1093/jas/skad009

Tenorio, A. T., K. E. Kyriakopoulou, E. Suarez-Garcia, C. van den Berg and A. J. van der Goot. 2018. Understanding differences in protein fractionation from conventional crops, and herbaceous and aquatic biomass-consequences for industrial use. Trends Food Sci. Technol. 71: 235-245. https://doi.org/10.1016/j.tifs.2017.11.010

Tyrolová, Y., L. Bartoň and R. Loučka. 2017. Effects of biological and chemical additives on fermentation progress in maize silage. Czech J. Anim. Sci. 62(7): 306-312. https://doi.org/10.17221/67/2016-CJAS.

U.S. Department of Agriculture. n.d. Classification for Kingdom Plantae Down to Genus Indigofera L. USDA Plants Database. https://plants.usda.gov/classification/79540. Diakses pada: 29 March 2025

Ungerfeld, E. M., N. Cancino-Padilla, N. Vera-Aguilera. 2023 fermentation in the rumen. In: Christon J. Hurst. Microbial Fermentations in Nature and as Designed Processes: 133-165. https://doi.org/10.1002/9781119850007.ch4

Ungerfeld, E.M., 2020. Metabolic hydrogen flows. In: Hurst, C. J., Rumen fermentation: principles and possibilities of interventions. Front. Microbiol. 11: 589. https://doi.org/10.3389/fmicb.2020.00589

Utomo, R. 2020. Konservasi Hijauan Pakan dan Peningkatan Kualitas Bahan Pakan Berserat Tinggi (Edisi Revisi). Gadjah Mada University Press, Yogyakarta.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Utomo, R., A. Agus, C. T. Noviandi, A. Astuti and A. R. Alimon. 2021. Bahan pakan dan formulasi ransum. Gadjah Mada University Press, Yogyakarta.

Vanholme, R., B. De Meester, J. Ralph and W. Boerjan. 2019. Lignin biosynthesis and its integration into metabolism. Curr. Opin. Biotechnol. 56: 230-239. https://doi.org/10.1016/j.copbio.2019.02.018

VanSomeren, L.L., P.S. Barboza, D.P. Thompson and D.D. Gustine. 2015. Monitoring digestibility of forages for herbivores: a new application for an old approach. Can. J. Zool. 93(3): 187-195. https://doi.org/10.1139/cjz-2014-0207.

Vasmara, C., S. Galletti, S. Cianchetta and E. Ceotto. 2023. Advancements in Giant Reed (Arundo donax L.) Biomass Pre-Treatments for Biogas Production: A Review. Energies. 16(2): 949. https://doi.org/10.3390/en16020949

Wang, L., G. Zhang, Y. Li and Y. Zhang. 2020. Effects of high forage/concentrate diet on volatile fatty acid production and the microorganisms involved in VFA production in cow rumen. Animals. 10(2): 223. https://doi.org/10.3390/ani10020223.

Wang, S., J. Li, Z. Dong, L. Chen, and T. Shao. 2019. Effect of microbial inoculants on the fermentation characteristics, nutritive value, and in vitro digestibility of various forages. Anim. Sci. J. 90(2): 178-188. https://doi.org/10.1111/asj.13134

Wang, S., X. Yuan, Z. Dong, J. Li, G. Guo, Y. Bai, J. Zhang and T. Shao. 2016. Characteristics of isolated lactic acid bacteria and their effects on the silage quality. Asian-Australas. J. Anim. Sci. 30(6): 819. https://doi.org/10.5713/ajas.16.0589

Wang, Y., L. Jin, Q. N. Wen, N. K. Kopparapu, J. Liu, X. L. Liu and Y. G. Zhang. 2015. Rumen degradability and small intestinal digestibility of the amino acids in four protein supplements. Asian-Australas. J. Anim. Sci. 29(2): 241. https://doi.org/10.5713/ajas.15.0342

Wardono, H. P., A. Agus, A. Astuti, N. Ngadiyono and B. Suhartanto. 2021. Potential of sago hampas for ruminants feed. In E3S Web of Conferences, 306, 05012. EDP Sciences. https://doi.org/10.1051/e3sconf/202130605012.

Wardono, H. P., A. Agus, A. Astuti, N. Ngadiyono and B. Suhartanto. 2022. The effect of fermentation time on the nutritional value of sago hampas. In 9th International Seminar on Tropical Animal Production (ISTAP 2021), 97-102. Atlantis Press. https://doi.org/10.2991/absr.k.220207.020

Watford, M. and Wu, G., 2018. Protein. Adv. Nutr. 9(5): 651-653. https://doi.org/10.1093/advances/nmy027.

Weinberg, Z.G. 2019. The ensiling fermentation of forage crops. In: Microbial Fermentations in Nature and as Designed Processes. Wiley Blackwell. Pages 353 – 372. https://doi.org/10.1002/9781119850007.ch14.

Weng, H., L. C. Kao, S. Wang, C. S. Chen, T. Lee, H. T. Chang, S. L. Young and J. Lin. 2021. Effects of a dual-purpose inoculant on the quality and aerobic stability of corn silage at the laboratory and field scales. Applied Sciences. 11 (17): 8257. https://doi.org/10.3390/app11178257.

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

Widodo, E. 2017. Ilmu Bahan Pakan Ternak dan Formulasi Pakan Unggas. Universitas Brawijaya Press, Malang.

Widodo, S., Shiddieqy, M.I., Wahyono, T., Widiawati, Y. and Muttaqin, Z., 2023. Analysis of correlation between nutrient content, digestibility, and gas production of forages in Indonesia. Adv. Anim. Vet. Sci. 11(11): 1770-1778. https://dx.doi.org/10.17582/journal.aavs/2023/11.11.1770.1778

Wunderlich, G., M. Bull, T. Ross, M. Rose and B. Chapman. 2023. Understanding the microbial fibre degrading communities and processes in the equine gut. Anim. Microbiome. 5(1): 3. https://doi.org/10.1186/s42523-022-00224-6

Xie, Y., L. Wang, W. Li, S. Xu, J. Bao, J. Deng, Z. Wu and S. Yu. 2022. Fermentation quality, in vitro digestibility, and aerobic stability of total mixed ration silage in response to varying proportion alfalfa silage. Animals. 12(8): 1039. https://doi.org/10.3390/ani12081039

Xu, J., K. Zhang, Y. Lin, M. Li, X. Wang, Q. Yu, H. Sun, Q. Cheng, Y. Xie, C. Wang and P. Li. 2022. Effect of cellulase and lactic acid bacteria on the fermentation quality, carbohydrate conversion, and microbial community of ensiling oat with different moisture contents. Front. Microbiol. 13: 1013258. https://doi.org/10.3389/fmicb.2022.1013258.

Yang, H., Wang, B., Zhang, Q., Cheng, H., and Yu, Z. 2021. Improvement of fermentation quality in the fermented total mixed ration with oat silage. Microorganisms. 9(2): 420. https://doi.org/10.3390/microorganisms9020420

Yang, L., X. Yuan, J. Li, Z. Dong and T. Shao. 2019. Dynamics of microbial community and fermentation quality during ensiling of sterile and nonsterile alfalfa with or without Lactobacillus plantarum inoculant. Bioresour. Technol. 275: 280-287. https://doi.org/10.1016/j.biortech.2018.12.067

Yanuarianto, O., Al Gifari, Z., and Budiman. 2025. Pengaruh Fermentasi dengan SBP (Saus Burger Pakan) terhadap Kecernaan Bahan Kering dan Bahan Organik Tumpi Jagung. Journal of Microbiology, Biotechnology and Conservation. 1(3): 28–35. https://doi.org/10.29303/jmbc.v1i3.8278)

Yin, J., J. Jin, J. Wang, H. Fang, X. Yu, J. He and T. Chen. 2025. Targeted volatile fatty acid production based on lactate platform in mixed culture fermentation: Insights into carbon conversion and microbial metabolic traits. Bioresour. Technol. 417: 131835. https://doi.org/10.1016/j.biortech.2024.131835.

Yoon, S. Y., S. H. Han and S. J. Shin. 2014. The effect of hemicelluloses and lignin on acid hydrolysis of cellulose. Energy. 77: 19–24. https://doi.org/10.1016/j.energy.2014.01.104

Yulanda, N., N. Hidajati, A. B. Achmad, and D. Chrismanto. 2021. The Effect of Molasses Addition on Physical and Chemical Quality of Corn Plant Silage Given Fermented Mother Liquor. Journal of Applied Veterinary Science and Technology. 2(1): 10-14. https://doi.org/10.20473/javest.v2.i1.2021.10-14

Zewdie, A.K., 2019. The different methods of measuring feed digestibility: A review. EC Nutrition. 14 (1): 68-74.

Zhang, J., N. Zheng, W. Shen, S. Zhao and J. Wang. 2020. Synchrony degree of dietary energy and nitrogen release influences microbial community,

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GADJAH MADA
Pengaruh Kombinasi Perlakuan Biologi dan Kimia terhadap Komposisi Kimia dan Kecernaan In-vitro Indigofera sp. sebagai Pakan Tinggi Protein
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Universitas Gadjah Mada, 2025 | Diunduh dari http://etd.repository.ugm.ac.id/

fermentation, and protein synthesis in a rumen simulation system. Microorganisms. 8(2): 231. https://doi.org/10.3390/microorganisms8020231.

Zhang, Y. C., D. X. Li, X. K. Wang, Y. L. Lin, Q. Zhang, X. Y. Chen and F. Y. Yang. 2019. Fermentation dynamics and diversity of bacterial community in four typical woody forages. Ann. Microbiol., 69, 233-240. https://doi.org/10.1007/s13213-018-1398-z

Zhao, C., L. Wang, G. Ma, X. Jiang, K. Yang, J. Lv and Y. Zhang. 2021. Cellulase Interacts with Lactic Acid Bacteria to Affect Fermentation Quality, Microbial Community, and Ruminal Degradability in Mixed Silage of Soybean Residue and Corn Stover. Animals. 11(2): 334. https://doi.org/10.3390/ani11020334

Zhao, J., X. Tao, J. Li, Y. Jia and T. Shao. 2021. Enhancement of biomass conservation and enzymatic hydrolysis of rice straw by dilute acid-assisted ensiling pretreatment. Bioresour. Technol. 320: 124341. https://doi.org/10.1016/j.biortech.2020.124341

Zhao, Y., U. Shakeel, M. S. U. Rehman, H. Li, X. Xu and J. Xu. 2020. Lignin-carbohydrate complexes (LCCs) and its role in biorefinery. J. Cleaner Prod. 253: 120076. https://doi.org/10.1016/j.jclepro.2020.120076

Zheng, J., S. Wittouck, E. Salvetti, C. M. A. P. Franz, H. M. B. Harris, P. Mattarelli, P. W. O'Toole, B. Pot, P. Vandamme, J. Walter, K. Watanabe, S. Wyuts, G. E. Felis, M.G. Ganzle and S. Lebeer. 2020. A taxonomic note on the genus Lactobacillus: Description of 23 novel genera, emended description of the genus Lactobacillus Beijerinck 1901, and union of Lactobacillaceae and Leuconostocaceae. The International Journal of Systematic and Evolutionary Microbiology. 70: 2782-2858. https://doi.org/10.1099/ijsem.0.004107.

Zhou, X., H. Zhang and Y. Xu. 2017. Biodegradation and Utilization of Hemicellulose. In Functional Carbohydrates (pp. 183-218). CRC Press.

Zhou, X., Y. Lu, L. Huang, Q. Zhang, X. Wang and J. Zhu. 2021. Effect of pH on volatile fatty acid production and the microbial community during anaerobic digestion of Chinese cabbage waste. Bioresour. Technol. 336: 125338. https://doi.org/10.1016/j.biortech.2021.125338