



UNIVERSITAS  
GADJAH MADA

PENAMBAHAN CAMPURAN DAUN MAHONI (*Swietenia mahagoni*), JATI (*Tectona grandis*), dan NANGKA (*Artocarpus heterophyllus*) SEBAGAI SUMBER TANIN UNTUK MENURUNKAN PRODUKSI METHAN PADA FERMENTASI RUMEN SECARA IN VITRO

DANAWIRA DIPTA, Prof. Dr. Ir. Lies Mira Yusiaty, SU., IPU., ASEAN Eng; Ir. Muhsin, S.Pt., M.Agr., Ph.D., IPP.  
Universitas Gadjah Mada, 2021 | Diunduh dari <http://etd.repository.ugm.ac.id/>

## DAFTAR PUSTAKA

- Abrar, A dan A. Fariani. 2018. Pengaruh penambahan ekstrak tanin dari biji sorgum terhadap produksi gas dan metana secara *in vitro*. Jurnal Peternakan Sriwijaya. 7(1): 40-52.
- Adamczyk, B., J. Simon, V. Kitunen, S. Adamczyk, dan A. Smolander. 2017. Tannins and Their Complex Interaction with Different Organic Nitrogen Compounds and Enzymes: Old Paradigms versus Recent Advances. *J.Chem. Pub. Soc. Europe.* 6(5):610-614.
- Addisu, S. 2016. Effect of Dietary Tannin Source Feeds on Ruminal Fermentation and Production of Cattle: A Review. *Online Journal of Animal and Feed Research.* 6(2): 45-56.
- Alam, M. R., A. K. M. A. Kabir., M. R. Amin dan D. M. McNeill. 2005. The effect of calcium hydroide treatment on the nutritive and feeding value of *Albizia procera* for growing goats. *Journal of Animal Feed Science and Technology.* 122(1-2): 135-148.
- Aldred, M. E. 2009. *Pharmacology: A Handbook for Complementary Healthcare Professionals*. Elsevier. Amsterdam. pp 163-164.
- Anam, M.S. 2019. Pengaruh suplementasi kombinasi minyak jagung terproteksi dan non terproteksi terhadap karakteristik fermentasi, produksi gas metan, dan kecernaan nutrient secara *in vitro*. Tesis Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta.
- Anas, M. A. 2015. Penambahan tanaman pakan sumber tanin sebagai agensi penghambat produksi metan ternak domba secara *in vitro*. Skripsi Sarjana Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta.
- Anas, M. A., L. M. Yusiaty, A. Kurniawati, and C. Hanim. 2015. Evaluation of *Albazia chinensis* as tanin s source for *in vitro* methane production inhibitor agents sheep rumen liquor. International Seminar on Tropical Animal Production. 261-265.
- Animut, G., R. Puchala., A. L. Goetsch., A. K. Patra., T. Sahlu., V. H. Varel., dan J. Wells. 2008. Methane emission by goats consuming different sources of condensed tannins. *Journal of Animal Feed Science and Technology.* 144: 228-241.
- Annison, E. F. dan W. L. Bryden. 1998. Perspectives on ruminant nutrition and metabolism. *Nutrition Research Reviews*. Department of Animal Science, University of Sydney. Camden. 11: 173-198.
- Anonim. 2019. Nature Resources Conversation Service. Tersedia pada <https://plants.usda.gov/core/profile?symbol=SWMA2>. Diakses pada 08 Oktober 2020.



- Arora, S. P. 1995. Pencernaan Mikroba pada Ruminansia. Gadjah Mada University Press. Yogyakarta.
- Arruda, T.P.M., M.L.A. Valle, C.J. Sartori, J.S.M. DaSilva, A.J.V. Zanuncio, L.S. Amaral, dan L.D. Lucia. 2012. Tannic substances in *Tectona grandis L. F.* University of Matto Grosso.
- Astuti, M. 2007. Pengantar Ilmu Statistik untuk Peternakan dan Kesehatan Hewan. Binasti Publisher. Bogor.
- Azad, A.K., J.G. Jones, dan N. Haq. 2007. Assessing morphological and isozyme variation of jackfruit (*Artocarpus heterophyllus* Lam.) in Bangladesh. Journal of Agroforest Systems. 71: 109-125.
- Behlke, E.J. 2007. Attenuation of ruminal methanogenesis. Dissertation the University of Nebraska. Lincoln, Nebrasca.
- BPOM. 2004. Merkuri dan bahayanya bagi Kesehatan. 5(4): 1-12
- Chavan, U. D. 2018. Phenolic: Antioxidants and Health Benefits. Scientific Publishers. Jodhpur. P 64.
- Christiyanto, M., M. Soejono, R. Utomo, H. Hartadi, dan B.P. Widjyobroto. 2005. Konsumsi dan kecernaan nutrien ransum yang berbeda prekursor protein-energi dengan pakan basal rumput raja pada sapi perah. J. Indon. Trop. Anim. Agric. 30(4): 242-247.
- Cieslak, A., P. Zmora, E. Pers-Kamczyc, dan M. Szumacher-Stabel. 2012. Effect of tannins source (*Vaccinium vitis-idaea L.*) on rumen microbial fermentation *in vivo*. Anim. Feed. Sci. Tech. 176:102- 106.
- Clemens, J. dan H.J. Ahlgren. 2001. Greenhouse gases from animal husbandry mitigation option. Nutrient Cycling in Agro ecosystems 60: 287-300.
- Coates J.D., C.F. Michael, dan E. Colleran. 1996. Simple method for the measurement of the hydrogenotrophic methanogenic activity of anaerobic sludges. Journal of Microbiological Methods. 26(3): 237 - 246.
- Cobellis, G., M. Trabalza-Marinucci, and Z. Yu. 2016. Critical evaluation of essential oils as rumen modifiers in ruminant nutrition: A review. Science of the Total Environment. 545(1): 556-568.
- Daning, D. R. A. 2010. Tanin limbah teh hitam (*Camellia sinensis*) sebagai agen defaunasi untuk menurunkan produksi metan secara *in vitro*. Fakultas Peternakan UGM.
- DeRamus, H.A, T.C. Clement, D.D. Giampola, dan P.C. Dickison. 2003. Methane emissions of beef cattle on forages: efficiency of grazing management system. Journal of Environmental Science Societies. 32: 269-277.



- Desmiaty, Y., H. Ratih, M.A. Dewi, dan R. Agustin. 2008. Penentuan jumlah tanin total pada daun jati belanda (*Guazma ulmifolia Lamk*) dan daun sambaing darah (*Excoecaria bicolor Hassk*) secara kolorimetri dengan pereaksi biru prusia. *Ortocarpus*. 106-109.
- Dewhurst, R.J., D.R. Davies, dan R.J. Merry. 2000. Microbial protein supply from the rumen. *Journal of Animal Feed Science Technology*. 85:1
- Divya, K., H. R. Pradeep, K. K. Kumar, V. K. . Hari, and T. Jyothi. 2012. Herbal Drug *Swietenia mahogany* Jacq. : A Review. *Global Journal Research. Medicinal Plants Indigenous Medicine*. 1(10): 557–567.
- El-Zaiat, H.M., A.E. Khalil, M.S. Moharam, M.F. Attia, A.L. Abdalla, dan S.M.A. Sallam. 2020. The ability of tanniniferous legumes to reduce methane production and enhance feed utilization in Barki rams; *in vitro* and *in vivo* evaluation. *Journal of Small Ruminant Research*. 193:1-8.
- Erwanto, T. Sutardi, D. Sastradipradja and M. A. Nur. 1993. Effects of ammoniated zeolite on metabolic parameters of rumen microbes. *Journal of Tropical Agriculture*. 5: 5-6.
- Fahey, G. C. dan L. L. Berger. 1988. Carbohydrate nutrition of ruminants. In: D.C Chruch (Ed). *Digestive Physiology and Nutrition of Ruminants. The Ruminant Animal*. Prentice Hall Eglewood Cliifs, New Jersey.
- FAO. 2013. Tackling Climate through Livestock: A Global Assessment of Emissions and Mitigation Opportunities. Rome: FAO.
- Ferry, J. G. dan K. A. Kastead. 2007. Methanogenesis. In *Archaea: Molecular cell biology*. R Cavicchioli (ed.). Washington. DC: ASM Press. 288-314.
- Finlay, B. J., G. Esteban, K. J. Clarke, A. G. Williams, T. M. Embley, and R. P. Hirt. 1994. Some rumen ciliates have endosymbiotic methanogens. *EMS Microbial*. 117: 157-162.
- Foster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz, dan R.V. Dorland. 2007. Changes in Atmospheric constituents and in radiative forcing. In: Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds) *Climate change 2007: the physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change*. Cambridge University Press, Cambridge, pp 131–217.
- Frutos, P., R.R. Doce, G. Hervas, P.G. Toral, F.J. Giraldez, A.R. Mantecon, dan V. Perez. 2007. The consumption of a large amount of immature oak leaves (*Quercus pyrenaica*) is not necessarily toxic for cattle. *XXXVIII Jornadas de Estudio, XII Jornadas sobre Producción*



Animal, Zaragoza, Spain, 16-17 Mayo, 2007. Tomo I and II Zaragoza: Gobierno de Aragon, Servicio de Investigacion Agroalimentaria, 2007, 282-284

Gandra, J.R., P.C.N. Gil, N.R.B. Cónsolo, E.R.S. Gandra, dan A.A.O. Gobesso. 2012. Addition of increasing doses of ricinoleic acid from castor oil (*Ricinus communis* L.) in diets of Nellore steers in feedlots. Journal of Animal and Feed Science. 21: 566–576.

Gerber, P.J., H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falucci, dan G. Tempio. 2013. Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO). Rome.

Goel, G., H.P.S. Makkar, dan K. Becker. 2008. Effect of *Sesbania sesban* and *Carduus pynocephalus* and Fenugreek (*Trigonella foenum-graecum* L.) seeds and their extracts on partitioning of nutrients from roughage and concentrate-based feeds to methane. Journal of Animal Feed Science Technology. 21: 59-65.

Gonzales, L., J. Salmeron, V. R. Cormenzana, A. Silva-Colomer, dan J. Boza. 1990. Influence of several feeds on bacteria in sheep and goat rumen liquor *in vitro*. Journal of Microbiologies. 62:75-81.

Gosselink, J.M.J., C. Poncet, J.P. Dulphy, dan J.W. Cone. 2003. Estimation of the duodenal flow of microbial nitrogen in ruminants based in the chemical composition of forages. Journal of Animal Research. 229-243.

GRIN Verlag. Munich. P 3.

Gustiar, F., R.A. Suwignyo., Suheryanto, dan Munandar. 2014. Reduksi gas metan ( $\text{CH}_4$ ) dengan meningkatkan komposisi konsentrat dalam pakan ternak sapi. Jurnal Peternakan Sriwijaya. 3(1): 14-24.

Hanim, C., L.M. Yusiaty, dan S. Alim. 2009. Effect of saponin as defaunating agent on *in vitro* ruminal fermentation of forage and concentrate. Journal Indonesia Tropical Animal Agriculture. 34(4):231-235.

Hasanah, C. 2019. Pengaruh penggunaan tanaman sumber tanin mahoni (*Swietenia mahagoni*) terhadap produksi metan dan keragaman bakteri metanogenik pada fermentasi rumen secara *in vitro*. Skripsi Sarjana Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta

Hendratiningrum, N., B. Muhammad, dan S.A. Santosa. 2011. Produk fermentasi rumen dan produksi protein mikroba sapi lokal yang diberi jerami amoniasi dan beberapa bahan pakan sumber energi. Jurnal Agripet 11 (2): 29-34.



- Hess, H. D., M. Kreuzer, T. E. Diaz, C. E. Lascano, J. E. Carulla, dan C. R. Soliva. 2003. Saponin rich tropical methanogenesis in faunated and fruits affect fermentation and defaunated fluid. *Journal of Animal Feed Science Technology*. 109:79-94
- Hidayah, N. 2016. Pemanfaatan senyawa metabolit sekunder tanaman (tanin dan saponin) dalam mengurangi emisi metan ternak ruminansia. *Jurnal Sains Peternakan Nasional*. 11(2):89-98.
- Hook, S.E., A.D. Wright, dan B.W. McBride. 2010. Metanogens: metane producers of the rumen and mitigation strategies. Hindawi Publishing Corporation, Archaea. doi:10.1155/2010/945785, Article ID 945785.
- Hungate, R.E. 1966. *The Rumen and Its Microbes*. Academic Press. New York.
- Idayati, R. 2007. Pengaruh pemanasan global (Global Warming) terhadap lingkungan dan kesehatan. *Jurnal Kesehatan Syiah Kuala*. 7(1): 43-47.
- Issazadeh, K., P. Nejati, F. Zare, and O. Laczai. 2013. Diversity of methanogenic bacteria in ecological niches. *Annals of Biological Research*. 4(2): 36–42.
- Jackson, R. S. 2000. *Wine Science: Principles, Practice, Perception*. 2<sup>nd</sup> ed. Academic Press. United States. P 371.
- Jackson, R. S. 2014. *Wine Science: Principles and Applications*. 4<sup>th</sup> ed. Academic Press. Unites States. P 560.
- Jayanegara, A. 2008. Reducing methane emissions from livestock: nutritional approaches. Proceedings of Indonesian Students Scientific Meeting (ISSM), Institute for Science and Technology Studies (ISTECS) European Chapter, 13-15 May 2008, Delft, the Netherlands: 18-21.
- Jayanegara, A. dan A. Sofyan. 2008. Penentuan aktivitas biologis tanin beberapa hijauan secara *in vitro* menggunakan “Honheim Gas Test” dengan polietilen glikol sebagai determinan. *Media Peternakan*. 51: 44-52.
- Jayanegara, A., A. Sofyan, H.P.S. Makkar, dan K. Becker. 2009a. Kinetika produksi gas, kecernaan bahan organik dan produksi gas metana *in vitro* pada hay dan jerami yang disuplementasi hijauan mengandung tanin. *J. Media Peternakan*. 32:120-129.
- Jayanegara, A., E. Wina, C. R. Soliva, S. Marquadt, M. Kreuzer, dan F. Leiber. 2011. Dependence of forage quality and methanogenic potential of tropical plants on their phenolic of tropical plants on their phenolic fractions as determined by principal component analysis. *Journal of Animal Science Technology*. 163:231-243.



- Jayanegara, A., G. Goel, H. P. S. Makkar and K. Becker. 2015. Divergence between purified hydrolysable and condensed tannin effects on methane emission, rumen fermentation and microbial population in vitro. *Anim Feed Sci Tech.* 209: 60-68.
- Jayanegara, A., H.P.S. Makkar, dan K. Becker. 2009b. Emisi metan dan fermentasi rumen *in vitro* ransum hay yang mengandung tanin murni pada konsentrasi rendah. *Media Peternakan.* 32(3): 184-194.
- Jenny, I., Surono., dan M. Christiyanto. 2012. Produksi amonia, *undergraded protein* dan protein total secara *in vitro* bungkil biji kapuk yang diproteksi dengan tanin alami. *Jurnal Peternakan.* 1(1): 277-284.
- Jouany, J.P. 1991. Defaunation of the Rumen. In: *Rumen Microbial Metabolism and Ruminant Digestion.* INRA. Paris.
- K. Hartung, and M. Rodehutscord. 2014. Effects of long-term supplementation of chestnut and valonea extracts on methane release, digestibility and nitrogen excretion in sheep. *Animal.* 8(6):938-948.
- Kähkönen, M.P., A.I. Hopia, dan M. Heinonen. 2001. Berry phenolics and their antioxidant activity. *Journal of Agricultural and Food Chemistry.* 49: 4076-4082.
- Kamra, D.N., M. Pawar, dan B. Singh. 2012. Effect of plant secondary metabolites on rumen metanogens and methane emissions by ruminants. *Dietary Phytochemicals and Microbes.* 12: 351-370.
- Kementerian Lingkungan Hidup Republik Indonesia. 2010. *Indonesia Second National Communication. Under The United Nations Framework Convention on Climate Change (UNFCCC)*, Jakarta.
- Key, N. dan G. Tallard. 2012. Mitigating methane emissions from livestock: a global analysis of sector policies. *Climatic Change.* 112: 387-414.
- Khera, N. dan S. Bhargava. 2013. Phytochemical & pharmacological evaluation of *Tectona grandis* Linn. *International Journal Pharm Pharm Science.* 5(3): 923– 927.
- Kongmanila, D., and I. Ledin. 2009. Chemical composition of some tropical foliage species and their intake and digestibility by goats. *Asia-Australia. Journal of Animal Science.* 22:803-811.
- Kreuzer, M. dan C. R. Soliva. 2008. Nutrition: key to methane mitigation in ruminants. *Proc. Soc. Nutr. Physiol.* 17: 168-171.
- Kumar, S., S.S. Dagar, A.K. Puniya, dan R.C. Upadhyay. 2013. Changes in methane emission, rumen fermentation in response to diet and microbial interactions. *Research in Veterinary Science.* 94: 263-268.



- Le-Bourvellac, C. dan C.M.G.C. Renard. 2012. Interactions between polyphenols and macromolecules: quantification methods and mechanisms. Critical Reviews in Food Science and Nutrition. 52(3):213-248
- Leng, R.A. 1985. Principle and Practice of Feeding Tropical Crop and By Product to Ruminant. Department of Biochemistry and Nutritional University of England. Armidale, Australia.
- Liu, Y. dan Whitman, W. B. 2008. Metabolic, phylogenetic, and ecological diversity of methanogenic archaea. Annals of New York Academy of Sciences. 1125: 171-189.
- Lovett, D.K., L.J. Stack, S. Lovell, J. Callan, B. Flynn, M. Hawkins, dan F.P. O'Mara. 2005. Manipulating enteric methane emissions and animal performance of late lactation dairy cows through concentrate supplementation at pasture. Journal of Dairy Science. 88(8): 2836-2842.
- Lovley, D.R., R.C. Greening, dan J.G. Ferry. 1984. Rapidly growing rumen methanogenic organism that synthesizes coenzyme M and has a high affinity for formate. Applied Environmental Microbiology. 48(1): 81 - 87.
- Macheboeuf, D., D.P. Morgavi, Y. Papon, J.L. Mousset, dan M. Arturo-Schaan. 2008. Dose response effects of essential oils on *in vitro* fermentation activity of the rumen microbial population. Animal Feed Science and Technology. 145: 335-350.
- Mahanani, M.M.P. 2019. Pengaruh Penggunaan Daun Lamtoro (*Leucaena leucocephala*) Sebagai Sumber Tanin Terhadap Aktivitas Enzim Dan Kinetika Produksi Gas. Skripsi Sarjana Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta
- Makkar, H. P. S. 1998. Roles of Tannins and Saponins in Nutrition. Proceedings of the seventh scientific Workshop in Tromso.
- Makkar, H.P.S. 2003. Effects and fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. Small Ruminant Research, 49(3): 241-256.
- Makkar, H.P.S. 2003. Quantification of Tanin in Tree and Shrub Legumes: A Laboratory Manual. Kluwer Academic Publishers, Dordrecht. The Netherlands.
- Mara, F. P. O., K. A. Beauchemin., M. Kreuzer., dan T. A. Mc Allister. 2008. Nutritional management for enteric methane abatement: A review. Australian Journal of Experimental Agriculture. 48(1-2): 21-27.
- Martin, C., M. Doreau, dan D. P. Morgavi. 2008. Methane mitigation in ruminants: from rumen microbes to the animal. Herbivores Research



- Unit. France.Martin, C., D.P. Morgavi, dan M. Doreau. 2010. Methane mitigation in ruminants: From microbe to the farm scale. Animal. 4(3): 351-365.
- Masito, G. A. T., D. W. Respatie, dan R. Rogomulyo. 2014. The effect of five kinds of organic fertilizers on the growth and bioactive compounds of the soursop leaves (*Annona muricata L.*). Jurnal UGM. 3:97-105.
- Mastika, M. 2015. Teknik Mengurangi dan Menekan Populasi Protozoa Rumen Pada Ternak Ruminansia. Udayana University Press. Denpasar. Bali.
- McAllister, T.A., E.K. Okine, G.W. Mathison, dan K.J. Cheng. 1996. Dietary, environmental and microbiological aspects of methane production in ruminants. Canadian Journal of Animal Science. 76(2): 231-243.
- McDonald, P., R.A. Edwards, J.F.D. Greetham, dan C.A. Morgan. 2002. Animal Nutrition Sixth Edition. England: Pearson Education Limited.
- McSweeney, C., S. B. Palmer, D. M. McNeil, dan D. O. Krause. 2001. Microbial interactions with tannins: nutritional consequences for ruminants. Journal of Animal Feed Science. 81:83-93.
- McSweeney, C., S. B. Palmer, R. Bunch, dan D. O. Krause. 2001. Effect of the tropical forage calliandra on microbial protein synthesis and ecology in the Rumen. Journal of Applied Microbiology. 90(1): 78-88.
- Meissner, H. H. M. Smith and W. A. Niekerk. 1993. Rumen ammonia concentrations and non ammonia nitrogen passage to and apparent absorption from the small intestine of sheep ingesting subtropical and temperate tannin containing forage. South African Journal of Animal Science. 23(3): 92-97.
- Miller, T.I. 1995. Ecology of methane production and hydrogen sinks in the rumen. 3: 317 - 331.
- Mills, S. dan K. Bone. 2000. Pengaruh daun jati belanda terhadap kerja enzim lipase secara *in vitro*. Warta Tumbuhan Obat Indonesia. 6(2):6-8.
- Morgavi, D. P., E. Forano, C. Martin, dan J. Newbold. 2010. Microbial ecosystem and methanogenesis in ruminants. J. Anim Sci.. 4:1024-1036.
- Moss, A.R., J.P. Jounany, dan J. Neebold. 2000. Metane production by ruminants: its contribution to global warming. Annales de Zootechnie. 49: 231-253.
- Mueller, H.I. 2006. Unravelling the conundrum of tannins in animal nutrition and health. Journal of Scientific Food Agriculture. 86: 2010-2037



Muhi, A.H. 2011. Praktek lingkungan hidup. Institut Pemerintahan Dalam Negeri (IPDN). Bandung.

Muhlisin, M.A. Anas, C. Hanim, dan L.M. Yusiaty. 2017. *Calliandra calothyrsus* as tannins source for *in vitro* methane production inhibitor agents. *Prosiding; Contribution of Livestock Production on Food Sovereignty in Tropical Countries*, Yogyakarta 12-14 September 2017. Hal 133–136.

Muktiari, B. N. 2019. Penggunaan daun lamtoro (*leucaena leucocephala*) sebagai sumber tanin untuk menurunkan produksi metan pada fermentasi rumen domba secara *in vitro*. Skripsi Sarjana Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta.

Niderkorn, V., E. Barbier, D. Machebueuf, A. Torrent, I. Mueller-Harvey, dan H. Hoste. 2020. *In vitro* fermentation of diets with different types of condensed tannins derived from sainfoin (*Onobrychis viciifolia* Scop.) pellets and hazelnut (*Corylus avellana* L.) pericarps. *J. Anim. Feed. Sci. Tech.* 259:114357.

Ningrat, R. W. S., M. Zain, Erpomen, dan H. Suryani. 2017. Effects of doses and different sources of tannin on *in vitro* ruminal methane, volatile fatty acids production and on bacteria and protozoa populations. *Asian J. Anim. Sci.* 11:47-53.

Nugroho, Y. 2009. Diagnosis faktor penghambat pertumbuhan jati (*Tectona grandis* L. F) pada tanah podzolik merah kuning. *Jurnal Hutan Tropis Borneo*. 25: 24-34

Nuswantara, L. K. 2000. Parameter Fermentasi Rumen dan Sintesis Protein Mikroba pada Sapi Peranakan Ongole dan Kerbau yang Diberi Pakan Tunggal Glirisidia, Jerami Jagung, dan Kaliandra. Program Pascasarjana, Universitas Gadjah Mada, Yogyakarta. (Tesis-S2).

Orskov, E. R. 1992. Protein Nutrition in Ruminant. 2<sup>nd</sup> Edition. Academic Press Limited. London.

Orskov, E. R. dan M. Ryle. 1990. Energy Nutrition in Ruminant. Elsevier Applied Science. London

Orwa, C., A. Mutua, R. Kindt, R. Jamnadass, dan S. Anthony. 2009. *Artocarpus heterophyllus*. Tersedia pada: Agroforestry.org. Diakses pada tanggal 25 September 2020.

Patra, A.K. dan J. Saxena. 2010. A new perspective on the use of plant secondary metabolites to inhibit metanogenesis in the rumen. *Phytochemistry*. 71: 1198-1222.

Pikoli, M.R., F.M. Zadfa., dan I. Sugoro. 2017. Bakteri denitrifikasi inaktif sebagai suplemen untuk mengurangi gas metana dari cairan rumen sapi. *Jurnal Ilmiah Aplikasi Isotop dan Radiasi*. 13(2): 69-78.



- Popp, A., H. Lotze-Campen, dan B. Bodirsky. 2010. 'Food consumption, diet shifts and associated non-CO<sub>2</sub> greenhouse gases from agricultural production', *global environmental change*, 20, pp. 451–62.
- Pratama, R. dan L. Parinduri. 2019. Penanggulangan Pemasaran Global. *Jurnal Utama Teknik*. 15:91-95.
- Preston, T.R dan A. Leng. 1987. Matching Ruminant Production System with Available Sources in Tropics. Penabul book. Aemidale.
- Priambudi, R.A., Kendi, T.T., dan Siswanti. 2020. Ekstrak Sabut Kelapa (*Cocos nucifera*) Sebagai Biomordan pada Bahan Tekstil Dengan Pewarna Alami Daun Jati (*Tectona grandis* L.f). Seminar Nasional Teknik Kimia "Kejuangan". Yogyakarta.
- Puchala, R., Min, B.R., Goetsch, dan A.L., Sahlu, T. 2005. The effect of a condensed tannin-containing forage on methane emission by goats. *Journal of Animal Science*. 83: 182-186.
- Purwanta, W. 2009. Perhitungan emisi Gas Rumah Kaca (GRK) di sektor sampah perkotaan di Indonesia. *Jurnal Teknik Lingkungan*. 10:1-8.
- Ragsdale, S.W. dan E. Pierce. 2008. Acetogenesis and the Wood - Ljungdahl pathway of CO<sub>2</sub> fixation. *Biochimica et Biophysica Acta*. 1784: 1873 – 1898.
- Ranjhan, S. K. 1980. Animal Nutrition in Tropic. 2nd Edition. Vikas Publishing House. Pvt. Ltd, New Delhi.
- Reay, D., P. Smith., dan A. van Amstel. 2010. Metane and climate change. Earthscan. UK.
- Riedl, K. M. and A. E. Hagerman. 2001. Tannin-Protein Complexes as Radical Scavengers and Radical Sinks. *J. Agric. Food Chem.* 49(10): 4917-4923.
- Russell, J. B., and D. B. Wilson. 1996. Why are ruminal cellulolytic bacteria unable to digest cellulose at low pH? *J. Dairy Sci.* 79:1503–1509.
- Santos-Buelga, C. dan de Freitas, V. 2008. Wine Chemistry and Biochemistry: Influence of Phenolics on Wine Organoleptic Properties. Springer Science & Business Media. Page 569.
- Santoso, B dan B.T. Hariadi. 2007. Pengaruh suplementasi *Acacia mangium* Willd pada *Pennisetum purpureum* terhadap karakteristik fermentasi dan produksi gas metana in Vitro. *Jurnal Media Peternakan* 30(2):101-133.
- Sarnataro, C. dan M. Spanghero. 2020. *In vitro* rumen fermentation of feed substrates added with chestnut tannins or an extract from *Stevia rebaudiana* Bertoni. *Journal of Animal Nutrition*. 6:54-60.



- Sasongko, W. T., L. M. Yusiaty, Z. Bachruddin, dan Mugiono. 2010. Optimalisasi pengikatan tanin daun nangka dengan protein *bovine serum albumin*. *J. Media Peternakan*. 34:154-158.
- Sasongko, W.T. 2010. Pemanfaatan tanin daun nangka untuk meningkatkan nilai rumen undegradated protein pada bahan pakan protein tinggi. Tesis. Fakultas Peternakan UGM.
- Sayuti, N. 1989. Ruminologi. Fakultas Peternakan. Universitas Andalas, Padang
- Sejian, V., R. Lal., J. Lakritz, dan T. Ezeji. 2011. Measurement and prediction of enteric metane emission. *International Journal of Biometeorology*. 55: 1-16.
- Selinger, L.B., C.W. Forsberg, dan K.J. Cheng. 1996. The rumen: a unique source of enzymes for enhancing livestock production. *Anaerobe*. 2: 263-284.
- Simbala, H.E.I. 2009. Analisis senyawa alkaloid beberapa jenis tumbuhan obat sebagai bahan aktif fitofarmaka. *Pacific Journal*. 1: 489-494.
- Sinha, R. K. 2004. Modern Plant Physiology. Alpha Science International.
- Steinfeld, A., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, dan C deHaan. 2006. Livestock's Long Shadow. Food and Agriculture Organization of United Nation: Rome.
- Subrata, A. 2005. Pemanfaatan Tanin Ampas Teh terhadap Efek Defaunasi, Parameter Fermentasi Rumen dan SIntesis Protein Mikrobia secara *In Vitro*. Program Pasca Sarjana Universitas Gadjah Mada, Yogyakarta. (Tesis Magister Peternakan).
- Sugiyono, A. 2006. Penanggulangan pemanasan global di sektor pengguna energi. *Jurnal Sains dan Teknologi Modifikasi Cuaca*. 7:15-19.
- Suharti S, Kurniawan A, Astuti DA, Wina E. 2010. Microbial population and fermentation characteristic in response to sapindus rarak mineral block supplementation. *Media Peternakan* 33(3): 150-154.
- Suhono, B. 2010. Ensiklopedia Biologi Dunia Tumbuhan. PT. Lentera Abadi. Jakarta.
- Sukmadjaya, D dan I. Mariska. 2003. Perbanyak Bibit Jati Melalui Kultur Jaringan. Balai Penelitian Bioteknologi dan Sumberdaya Genetik Pertanian.
- Susanti, S. dan E. Marhaeniyanto. 2014. Kadar saponin daun tanaman yang berpotensi menekan gas metana secara *in-vitro*. *Jurnal Buana Sains*. 14:29-38.
- Syamsuhidayat, S., dan J. R. Hutapea. 1991. Inventaris tanaman obat Indonesia. Edisi kedua. Departemen Kesehatan RI. Jakarta.



- Szumacher-Strabel, M. and A. Cieslak. 2012. Greenhouse Gases: Capturing, Utilization and Reduction: Dietary Possibilities to Mitigate Rumen Methane and Ammonia Production. G. Liu (ed.). Intech. London. pp 199-238.
- Calsamiglia, S., M. Busquet, P. Cardozo, L. Castillejos, A. Ferret. 2007. Invited review: essential oils as modifiers of rumen microbial fermentation. *Journal Dairy Science* 90: 2580-2595.
- Takahashi, J. 2001. Nutritional manipulation of methanogenesis in ruminants. *Asian-Australia. Journal of Animal Science*. 14: 131–135.
- Tan H. Y., C. C. Sieo, N. Abdullah, J. B. Liang, X. D. Huang, & Y. W. Ho. 2011. Effects of condensed tannins from Leucaena on methane production, rumen fermentation and populations of methanogens and protozoa in vitro. *Journal Animal Feed Science and Technology*. 169: 185–193.
- Tan, H.Y., C.C. Sieo, N. Abdullah, J.B. Liang, X.D. Huang, dan Y.W. Hoa. 2011. Effects of condensed tannins from leucaena on metane production, rumen fermentation and populations of metanogens and protozoa *in vitro*. *Journal of Animal Feed Science and Technology*. 169: 185-193.
- Tavendale, M.H., L.P. Meagher, D. Pacheco, N. Walker, G.T. Attwood, dan S. Sivakumaran. 2005. Methane production from *in vitro* rumen incubations with *Lotus pedunculatus* and *Medicago sativa*, and effects of extractable condensed tannin fractions on metanogenesis. *Journal of Animal Feed Science and Technology*. 123: 403-419.
- Thalib, A. 2010. Teknologi Balitnak. Aksapon SR: Penekan Emisi Gas Metan. Leaflet Balai Penelitian Ternak.
- Ungerfeld, E., R. Kohn, R. Wallace, dan C. Newbold. 2007. A meta-analysis of fumarate effects on metane production in ruminal batch cultures. *Journal of Animal Science*. 85: 2556-2563.
- United Kingdom. P 168.
- Uyeno, Y. 2015. Rumen Microbiology: From Evolution to Revolution. *Rumen Microbiology: An Overview*. A. K. Puniya, R. Singh, and D.N. Kamra (eds.). Springer. New Delhi. pp 199-212.
- Vlaeminck, B., V. Fievez, Tamminga, R.J. Dewhurst, A. van Vuuren, D. de Brabander, dan D. Demeyer. 2006. Milk odd -and branched- chain fatty acids in relation to the rumen fermentation pattern. *J. Dairy Sc.* 89(10):3954-3964.
- Wahyono, T., W. T. Sasongko., M. Sholihah., dan M. R. Pikoli. 2017. Pengaruh penambahan tanin daun nangka (*Artocarpus heterophyllus*) terhadap nilai biologis daun kelor (*Moringa oleifera*) dan jerami kacang hijau (*Vigna radiata*) secara in vitro. *Buletin Peternakan*. 41(1): 15-25.



UNIVERSITAS  
GADJAH MADA

PENAMBAHAN CAMPURAN DAUN MAHONI (*Swietenia mahagoni*), JATI (*Tectona grandis*), dan NANGKA (*Artocarpus heterophyllus*) SEBAGAI SUMBER TANIN UNTUK MENURUNKAN PRODUKSI METHAN PADA FERMENTASI RUMEN SECARA IN VITRO

DANAWIRA DIPTA, Prof. Dr. Ir. Lies Mira Yusiaty, SU., IPU., ASEAN Eng; Ir. Muhsin, S.Pt., M.Agr., Ph.D., IPP.  
Universitas Gadjah Mada, 2021 | Diunduh dari <http://etd.repository.ugm.ac.id/>

Wayesa, B. T. 2017. Livestock and Climate Change Mitigation Strategies.

Wicaksono, H. A. D. 2015. Pengaruh penambahan serasah daun jati (*Tectona grandis*) sebagai sumber tanin terhadap produksi gas secara *in vitro*. Skripsi Sarjana Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta

Widiawati, Y., M. Winugroho., dan P. Mahyudin. 2010. Estimasi produksi gas metana dari rumput dan tanaman leguminosayang diukur secara *in vitro*, Seminar Nasional Teknologi Peternakan dan Veteriner. Balai Penelitian Ternak. Bogor.

Wiryawan, K. G., E. Wina & R. Ernawati. 1999. Pemanfaatan tanin kaliandra sebagai agen pelindung beberapa sumber protein bakan (*in vitro*). Prosiding Seminar Hasil-Hasil Penelitian Bidang Ilmu Hayati. hal: 278-289.

Wischer, G., A. M. Greiling, J. Boguhn, H. Steingass, M. Schollenberger,

Yuliana, P., E.B. Laconi, E. Wina, dan A. Jayanegara. 2014. Extraction of tanins and saponins from plant sources and their effects on *in vitro* methanogenesis and rumen fermentation. Journal of Indonesian Tropic Animal Agriculture. 39:91-97.

Yusiati, L. M., A. Kurniawati, C. Hanim, dan M. A. Anas. 2018. Protein Binding Capacity of Different Forages Tannin. IOP Conf. Ser. Earth Environ. Sci. 119:0-5.

Yusiati, L.M., Z. Bachrudin, C. Hanim, dan L. Indriana. 2010. The effect of Ketepeng Cina leaf (*Cassia Alata* L.) as a source of antraquinone, methanogenesis inhibitor agent on rumen microbial protein synthesis for beef cattle in Sedyo Rukun farmer group. Proceeding, ISTAP-5, UGM.

Yustanto, W.P. 2020. Pengaruh penggunaan daun mahoni (*Swietenia mahagoni*) sebagai bahan pakan sumber tanin terhadap kecernaan dan parameter fermentasi secara *in vitro*. Skripsi Sarjana Peternakan. Fakultas Peternakan, Universitas Gadjah Mada, Yogyakarta.