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Methane Emission Factor at Different Total Digestible Nutrients and Feeding Level in Ram

Restitrisnani V, Nugroho TA, Rianto E, Purnomoadi A

Faculty of Animal and Agricultural Sciences, Diponegoro University
Kompl. Drh. R. Soejono Koesoemowardojo, Tembalang, Semarang 50275, Central Java, Indonesia
agung194@yahoo.com

ABSTRACT

Effect of total digestible nutrients (TDN) and feeding level on methane emission factor was discussed. Methane which is a trace gas that formed from feed fermentation process in the rumen and is influenced by many factors such as feed quality and feed intake levels. Forty four individual data of methane emission and feed intake level and TDN of rams were used in this study. The TDN was determined by total collection method, and was separated into low (TDN less than 55%) and high (TDN higher than 55%), while the feeding level was calculated as the percentage of dry matter intake (DMI) to the body weight and was grouped into low (DMI less than 4%body weight; BW) and high (DMI higher than 4%BW). Methane production was measured by Facemask method. The result showed that level of TDN did not affect (P>0.05) methane production per unit dry matter intake (DMI) with an average of30.92 g/kgDMI, but significantly affected (P<0.05) methane production per unit TDN (low TDN = 0.06 vs. high TDN = 0.04 gCH_4/gTDN; P = 0.019) and total methane production (low TDN = 28.82 vs. high TDN = 27.04 g/d; P = 0.043). In the other hand, the high feeding level significantly affected (P<0.01) methane production per unit DMI (low feeding level = 32.89 vs. high feeding level: 26.96 g/kg; P = 0.001) and methane production per unit average daily gain (ADG) (low feeding level = 0.98 vs. high feeding level = 0.35 g; P = 0.007), but did not affect (P>0.05) total methane production (average 27.37 g/d). It can be concluded that methane emission factor for rams must be calculated based on their TDN and DMI levels.

Key Words: Methane emission factor, total digestible nutrient, dry matter intake

INTRODUCTION

Methane is one of the greenhouse gases as well as N_2O, CO_2 and CFC (Gerber et al. 2013; Young 2002). The largest sector contributing to methane emission in the atmosphere is livestock (89%) (Steinfeld et al. 2006; Shibata 1994). Methane has a destructive power greater than the other greenhouse gases due to its long life in the atmosphere for 9-15 years and takes more than four years to repair the damage. (McCourt 2006; Jiao et al. 2014). The increasing concentration of methane will cause changes in the atmosphere and affect on the climate (Wang et al. 1994). IPCC has demonstrated that global temperature has risen by 0.85°C and warming is predicted will continuously increase to 0.3-0.7°C in 2016 to 2035 (IPCC 2014). The surface temperature of the earth that continuously rising will threaten the survival of living beings (Gerber et al. 2013; Moss 2000; Liang 2011; Andersson 2005). Therefore, the factors that cause methane emissions need to be studied.

In livestock, methane is a trace gas that formed from feed fermentation process in the rumen (ZhongRong-Zhen et al. 2016). The rumen fermentation of ruminants is influenced by many factors such as feed quality and diet intake levels (Beauchemin & McGinn 2006; Hammond et al. 2013). Generally, feed quality is reflected by TDN value of feeding. Increase in feed intake as well as nutrient intake may affect on rumen environmental and nutrient digestibility, and therefore methane emissions (Gregorini et al. 2010; Dijkstra et al. 2011; Gerber et al. 2013).

Since, methane emission in atmosphere is globally causing negative impacts, thus further action is needed to mitigate methane emission. The first step to mitigate methane emission is by building the bench mark of methane emission, which is required methane emission factor. In this stage, based on the reasons above the methane emission factors based on total digestible nutrient (TDN) and feeding level was studied. Data in this paper is expected to support and could be used as national inventory data on methane emission factors.

MATERIAL AND METHODS

Data characteristics used in this study

This study was used methane emission, total digestible nutrients (TDN) and dry matter intake obtained from 44 individual rams raised at various feeding treatments. The rams were mature aged 1-2 years old with bodyweight (BW) ranged at 15-25 kg. The feed given to rams were formulated to fulfill the nutrients requirements for maintenance and for production (daily gain).The data of methane emission factors were then grouped by TDN level (low = less than 55%; high = higher than 55%) and dry matter intake (DMI) level (low = less than 4% BW and high = higher than 4% BW).

Table 1. Nutritional content of the experimental diet

Variables	Low TDN (<55%)	High TDN (>55%)
Crude protein (CP) (%)	8.65-14.25	8.65-16.15
Crude fiber (CF) (%)	16.75-31.16	16.75-31.16
TDN (%)	39.19-54.55	55.01-72.48
N (%)	17	27
	Low DMI (<4%)	High DMI (>4%)
DMI (%)	2.4-3.9	4.0-5.4
N (%)	29	15

Methane emission was measured using facemask method for two days (2×24 h) using a mask which is connected to a methane analyzer (Horiba Ltd. Japan) and air flow meter. Methane emissions were recorded automatically by IBM PC for 10 minute at 3 hours intervals. The results obtained are converted into energy units (1 liter CH_4 = 9.45 kcal). The data were analyzed with t-test using SPSS program.

Feed intake and TDN measurement

Feed intake was determined by subtracting the residual feed to the feed given. TDN was determined as described by Hartadi et al. (1997) by sum up digestible protein, digestible extract ether, digestible crude fiber and digestible nitrogen free extract (NFE). The feed digestibility was determined by total collection method, which was conducted in the 7^{th} week of experiment. Feces collected were sprayed with 20% H_2SO_4, placed into the plastic bag and stored in 16°C cooled room. Feces from 7 days collection was blended homogenized and sampled for 20 g. The samples feces were then analyzed to determine the chemical composition.

RESULTS AND DISCUSSION

Data distribution of the nutritional content used in this study is presented in Table 1. Nutritional content of each treatment in this study was grouped into two TDN levels, *i.e.* less than 55% and higher than 55%, but CP and CF were in similar range. The feed utilization by rams was reflected on the TDN value which is sum of digestible nutrients of protein, fiber and extract ether (×2.25) in the diet. TDN is a representation of the number of potential substrate that possible to form methane gases.

The methane emission in rams at two levels of TDN is presented in Table 2. This table shows that the amount of TDN contributed to methane emission. The differences were found in total methane production (g/d) and methane per unit TDN (g/g) which total methane production and methane per unit TDN in low TDN were higher ($P<0.05$) than in high TDN.

Table 2. Methane emission in rams consuming various TDN level on diets

Variables	Low TDN (<55%)	High TDN (>55%)	P
CH_4 (g/d)	28.82±12.66	27.04±9.03	0.043
CH_4 (g/kg DMI)	31.17±8.58	30.68±8.45	0.628
CH_4 (g/g TDN)	0.06±0.02	0.04±0.01	0.019

TDN represents the feed that utilized energetically by animal because TDN was measured by sum of nutrients digested by animal. The nutrients absorbed by intestine (Wang et al. 1994; McCarthy et al. 1989) is 80% digested by rumen. When the feed digestibility was high, it means the feed digestion occurs in the rumen is progressing well.The good digestion occurs in the rumen will result in increasing ruminal outflow rate (Liu et al. 2005; Gabel et al. 2003), or in another words the existence of feed in the rumen is relatively short. The brief existence of feed in the rumen will affect the fermentation process to become shorter time (Chaokaur et al. 2015; Gabel et al. 2003).This condition led methane production and methane per unit TDN on low TDN level was higher than high TDN level. The feed containing high TDN has high digestibility and short feed existence in the rumen.

However, the methane production per unit DMI was not different between the low and high TDN, being averaged 30.93 g/kg. This was caused by the fact that only a part of the feed consumed can be ingested by livestock. On the other hand, methane is a byproduct of the digestion process of feed in the rumen (Kumar et al. 2013).

Table 3. Methane emissionin rams consuming various feeding level

Variables	Low DMI (<4%BW)	High DMI (>4%BW)	P
CH_4 (g/d)	28.51±10.33	26.23±10.96	0.345
CH_4 (g/kg DMI)	32.89±9.41	26.96±3.85	0.001
CH_4 (g/g ADG)	0.98±1.01	0.35±0.10	0.007

The data showed an effect of feed intake level (%BW) on total methane production, methane production per unit DMI and methane production per ADG; those are presented in Table 3. The data showed that the level of feeding (DMI) did not affect total methane production (g/d).Increasing DMI level (%BW) will increase ruminal outflow rate (Burn et al. 2005; Liu et al. 2005). As discussed above, the increasing feed intake will increase the movement of ingesta out of the rumen. Thus, the ruminal outflow rate becomes faster and less feed fermented in the rumen. This may explain an increasing DMI level in the percentage of BW did not affect methane production.

The differences were found in methane production per DMI and methane production per ADG. Increase in DMI level in percentage of BW did not lead to the increased methane production. Methane production per DMI was higher on low DMI level than high DMI level. The observed differences in methane production per DMI were attributed to methane production and DMI (Chaokaur et al. 2015). Therefore, higher DMI for ram might lead to lower methane production per unit DMI. The similar result was found in methane production per ADG. Methane production per ADG at low DMI level was significantly higher than on high DMI level. This was due to rams that have high DMI level have more nutrient to increase their body weight gain (Riaz et al. 2014).

CONCLUSION

This study showed that higher TDN and DMI for rams led lower methane production per unit TDN, methane production per DMI and methane production per ADG. However, methane production was not affected by increasing DMI, but affected by increasing TDN.

REFERENCES

Andersson A. 2005. Greenhouse gas reduction. In: Rubin ES, Keith DW, Gilboy CF, Wilson M, Morris T, Gale J, Thambimuthu K, editors. Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies. 5-9 September 2004, Vancouver, Canada. Volume II. Oxford (UK): Elsevier Ltd. 2331-2333.

Beauchemin KA, McGinn SM. 2006. Enteric methane emissions from growing beef cattle as affected by diet and level of intake. Can J Anim Sci. 86:401-408.

Burns JC, Mayland HF, Fisher DS. 2005. Dry matter intake and digestion of alfalfa hay harvested at sunset and sunrise. J Anim Sci. 83:262-270.

Chaokaur A, Nishida T, Phaowphaisal I, Sommart K. 2015. Effects of feeding level on methane emissions and energy utilization of Brahman cattle in the tropics. Agric Ecosyst Env. 199:225-230.

Dijkstra J, Oenema O, Bannink A. 2011. Dietary strategies to reducing N excretion from cattle: implications for methane emissions. Curr Opin Environ Sustain. 3:414-422.

Gabel M, B Pieper, K Friedel, Radke M, Hagemann A, Voigt J, Kuhla S. 2003. Influence of nutrition level on digestibility in high yielding cows and effects on energy evaluation systems. J Dairy Sci. 86:3992-3998.

Gerber P, Hristov A, Henderson B, Makkar H, Oh J, Lee C, Meinen R, Montes F, Ott T, Firkins J. 2013. Technical options for the mitigation of direct methane and nitrous oxide emissions from livestock: a review. Animal. 7:220-234.

Gregorini P, Beukes P, Bryant R, Romera A. 2010. A brief overview and simulation of the effects of some feeding strategies on nitrogen excretion and enteric methane emission from grazing dairy cows. In: Edwards GR, Bryant R, editors. Proceedings of the 4th Australasian Dairy Science Symposium. Lincoln (New Zealand): Caxton Press.

Hammond KJ, Burke JL, Koolaard JP, Muetzel S, Pinares-Patino CS, Waghorn GC. 2013. The effect of feed intake on enteric methane emissions fromsheep fed fresh white clover (Trifoliumrepens) and perennial ryegrass (Loliumperenne) forages. Anim Feed Sci Technol. 179:121-132.

Hartadi H, Reksohadiprodjo S, Tillman AD. 2005. Tabel komposisi pakan untuk Indonesia. Yogyakarta (Indonesia): Gadjah Mada University Press.

IPCC. 2014. Climate Change 2013: The physical science basis. Intergovernmental Panel on Climate Change. Cambridge (UK): Cambridge University Press.

Jiao H, Yan T, Wills DA, Carson AF, McDowell DA. 2014. Development of prediction models for quantification of total methane emission from enteric fermentation of young Holstein cattle at various age. Agric Ecosyst Env. 183:160-166.

Kumar S, Dagar SS, Puniya AK, Upadhyay RC. 2013. Changes in methane emission, rumen fermentation in response to diet and microbial interactions. Res Vet Sci. 94:263-268.

Liang JB. 2011. Greenhouse gases and animal agriculture in Asia. In: Takahashi J, Young BA, editors. Proceedings of the 1st International Conference on Greenhouse Gases and Animal Agriculture. Obihiro, Japan, 7-11 November. 2001. p. 15-20.

Liu X, Wang Z, Lee F. 2005. Influence of concentrate level on dry matter intake, N balance, nutrient digestibility, ruminal outflow rate, and nutrient degradability in sheep. Small Rum Res. 58:55-62.

McCourt A, Yan T, Mayne CS, Porter MG. 2006. Prediction of methane output in beef cattle from indirect respiration calorimetry data. Intestinal Congress Series. 1293:46-49.

McCarthy RD, Klusmeyer TH, Vicini JL, Clark JH. 1989. Effects of source of protein and carbohydrate on ruminal fermentation and passage of nutrients to the small intestine of lactating cows. J Dairy Sci. 72:2002-2016.

Moss AR, Jouany JP, Newbold J. 2000. Methane production by ruminant: its contribution to global warming. Ann Zootech. 49:231-253.

Riaz MQ, Sudekum KH, Clauss M, Jayanegara A. 2014. Voluntary feed intake and digestibility of four domestic ruminant species as influenced by dietary constituents: A meta-analysis. Livest Science. 162:76-85.

Shibata M. 1994. Methane production in ruminants. In: Minami K, Mosier A, Sass R, editors. CH_4 and N_2O Global Emission and Control from Ricefields and Other Agricultural and Industrial Sources. NIAES Series 2. p. 105-115.

Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, De Haan C. 2006. Live-stock's Long Shadow – Environmental Issues and Options. Food and Agriculture Organisation of the United Nations, Rome, Italy.

Wang M, Aiguo D, Xingjian S, Lixin R, Renxing S, Schutz H, Seiler W, Rasmussen RA, Khalil MAK. 1994. Source of methane in China. In: Minami K, Mosier A, Sass R, editors. CH_4 and N_2O Global Emission and Control from Ricefields and Other Agricultural and Industrial Sources. NIAES Series 2. p. 9-26.

Young BA. 2002. Greenhouse gases and the animal industries. Greenhouse Gases and Animal Agriculture. In: Takahashi J, Young BA, editors. Proceedings of the 1st International Conference on Greenhouse Gases and Animal Agriculture. Obihiro, Japan, 7-11 November. 2001. p. 9-14.

Rong-Zhen Z, Yi Fang, Hai-Xia S, Min W, Dao-Wei Z. 2016. Rumen methane output and fermentation characteristics of gramineous forage and leguminous forage at differing harvest dates determined using an *in vitro* gas production technique. J Integ Agric. 15:414-423.