INTRODUCTION

According to Intergovernmental Panel on Climate Change (IPCC), every year livestock production in which mainly ruminant production has methane emission by one-third of global methane emission, and methane gas have global warming potential higher 25-29 times compared to CO₂ (IPCC, 2007). Mitigation methane emission to reduce greenhouse gases but not affect performance of animal is one of strategies ruminant development on the world (Hristov et al., 2013b). Methane from enteric fermentation is the byproduct of microbes’ metabolic activities in the digestive organs. Microbes in anaerobic rumen, especially, play a key role in digesting feed for ruminant, therefore, feed is the most important factor decide the methane emission in animal.

Protein or nitrogen is the key component in ruminants ration and an appropriate CP level is of utmost importance (Bailey et al., 2008). In fattening cattle, high CP level to encourage greater intake and in order to slaughter animals earlier. However, many studies have documented that greater protein levels are related to increased DM intake (Berends et al., 2014) and increased feed intake leads to an
increase in methane emission (Shibata and Terada, 2010; Chaokaur et al., 2015). Yan and Mayne (2007) found a negative relationship between methane emission per DM intake or other products unit and dietary CP concentration. In addition, previous studies reported that cattle have increased average daily gain (ADG) when concentrate supplementation increased (Marino et al., 2006; Manni et al., 2013). However, many studies reported that increased concentrate should be used to increase the production of ruminants (Purwin et al., 2016; Ruiz-Albarrán et al., 2016), and is regarded as an effective methane mitigation strategy (Hristov et al., 2013a). Concentrates favor propionate production in the rumen offering an alternative hydrogen sink to methanogenesis, and lower ruminal pH, which in turn inhibits methanogens directly and indirectly, as protozoal inhibition also decreases protozoal-associated methanogenesis (Grainger and Beauchemin, 2011). Concentrates supply greater amounts of digestible nutrients than roughages, increasing animal productivity, and consequently, decreasing CH4 emission intensity (emissions generated for each kilogram of products) (Capper et al., 2009; Muñoz et al., 2018).

The objectives of this study were to estimate the effects of CP levels in the concentrate and the concentrate levels in the diet on feed intake, meat productivity and methane emission of Vietnamese fattening local cattle.

MATERIAL AND METHOD

EXPERIMENTAL DESIGN AND FEEDING

Twenty four entire male local cattle of approximately 15 to 18 months of age, and liveweight of 150.3 ± 11.8 kg (experiment 1) or 145.1 ± 9.8 kg (experiment 2) were used. In each experiment, the animals were blocked on the basis of live weight (LW) into groups of 4, and allocated at random within each group to treatment. In experiment 1, the treatments consisted of CP levels in the concentrate of 10, 13, 16 and 19%. In experiment 2, treatments contained the concentrate feeding levels at 1.0, 1.4, 1.8 and 2.2% of LW (DM basis). Both experiments, roughage fed to each cattle consisted of ad libitum rice straw at night and 5 kg/d of native grass (fresh basis) at 0730 am and 1315 pm, twice daily in 2 equal amounts. Table 1 presents the feed ingredients and nutrient composition of experiment 1. Concentrate allowance for each cattle was 1.5% of LW (DM basis) daily and was adjusted weekly in accordance with changes to the body weight of the cattle. Table 2 shows the nutrient composition of concentrate, grass and rice straw, as well as the chemicals used in experiment 2. Concentrate was fed in 3 equal amounts at 7:15 am, 1:00 pm and 4:30 pm. When residue occurred in the next morning, it was weighed and subtracted from the concentrate provided. Drinking water was freely accessible. The experiment lasted for 74 days (experiment 1) and 60 days (experiment 2).

DATA COLLECTION AND ESTIMATION OF METHANE EMISSION

The intake of roughage and concentrate of each cattle were recorded daily. Live weight of cattle was measured at the beginning and at the end of each experiment. At the end of each experiment, all animals were slaughtered to determine the carcass weight proportion, lean meat proportion and crude protein content in the meat. Based on the live

---

**Table 1: Ingredients and chemical composition of diets with different crude protein levels in the concentrate (experiment 1)**

| Item                          | Crude protein levels in the concentrate (%) | Native grass | Rice straw |
|-------------------------------|---------------------------------------------|--------------|------------|
|                               | 10  | 13  | 16  | 19  |               |               |               |
| Ingredient (% fresh basis)    |     |     |     |     |               |               |               |
| Rice bran                     | 35  | 33  | 33  | 33  | -             | -             |
| Maize                         | 32.5| 30  | 30  | 30  | -             | -             |
| Cassava powder                | 30  | 29  | 25  | 17  | -             | -             |
| Fish meal                     | 0   | 5   | 8.5 | 16.5| -             | -             |
| Urea                          | 0.5 | 1   | 1.5 | 1.5 | -             | -             |
| Salt                          | 1   | 1   | 1   | 1   | -             | -             |
| Premix vitamin-mineral        | 1   | 1   | 1   | 1   | -             | -             |
| Chemical composition (% of dry matter) |     |     |     |     |               |               |               |
| Dry matter                    | 87.3| 89.5| 89.3| 88.6| 19.2| 89.8         |
| Organic matter                | 94.6| 93.5| 91.7| 89.2| 87.5| 87.1         |
| Crude protein                 | 10.1| 13.2| 16.9| 20.2| 12.0| 5.2          |
| Neutral detergent fibre       | 21.8| 19.2| 22.9| 18.4| 64.2| 72.7         |
| Ash                           | 5.5 | 6.5 | 8.3 | 10.8| 12.5| 12.9         |
| Gross energy (MJ/kg dry matter) | 18.1| 18.1| 18.1| 18.1| 17.1| 17.5         |
weight gain, carcass weight proportion, lean meat proportion and the crude protein content in the meat, the carcass weight, lean meat weight and edible protein increased during the experimental period were measured.

Enteric methane emission was estimated by ruminant model (Herrero et al., 2013; Ramírez-Restrepo et al., 2017). Ruminant model is designed to predict potental intake, digestion, animal performance and enteric methane production of individual ruminant, consuming forages, grains and other supplements. Enteric methane produced are calculated based on the quantities of different substrates fermented using the stoichiometries (Herrero et al., 2013). A dynamic component of the model estimates feed intake and supply of nutrients to the animal from knowledge of the fermentation kinetics and passage of feed constituents (carbohydrate and protein) through the gastrointestinal tract. A static component of the model determines the animal’s response to nutrients in terms of growth production. Validations have been carried out for more than 80 tropical and temperate diets and the results suggest that the model has the required accuracy not only as a research tool but also for providing decision support at the farm level (Herrero, 1997). Initial inputs to the model in this study were i) animal characteristics (age, body weight) ii) feed consumption of each animal; and iii) the chemical composition of the feed (Herrero et al., 2013). Output of ruminant model is enteric methane emission factor of cattle. The model has been previously used for estimating methane emission factors of the tropical livestock (Shikuku et al., 2017; Ramírez-Restrepo et al., 2017).

**RESULTS**

**D RY M A T T E R I N T A K E , A N I M A L G R O W T H A N D M E A T P R O D U C T I V I T Y**

The CP levels in the concentrate significantly affected the DM intake (P<0.05). The ADG of cattle had a positive linear relationship with the CP level in the concentrate; however, significant differences were found only between 10% CP compared to other CP levels (Table 3). Total DM intake increased linearly as the levels of the concentrate increased and ranged from 4.42 to 5.70 kg/d (P<0.001). The ADG increased (P<0.001) linearly with the increased levels of the concentrate in the diet (Table 4).

The CP levels in the concentrate and the concentrate levels in the diet significantly affected (P<0.01) carcass weight (CW), lean meat weight (i.e CW x proportion raw boneless meat) and edible protein (i.e. lean meat weight x raw meat protein content, 0.22, 0.23, 0.22, and 0.21 factor for the treatment of 10, 13, 16 and 19% CP in the concentrate, respectively, and 0.23, 0.24, 0.22 and 0.22 factor for the treatment with 1.0, 1.4, 1.8 and 2.2% BW concentrate,

| Item | Concentrate | Native grass | Rice straw |
|------|-------------|--------------|------------|
| Rice bran | 33 | - | - |
| Maize | 30 | - | - |
| Cassava powder | 25 | - | - |
| Fish meal | 8.5 | - | - |
| Urea | 1.5 | - | - |
| Salt | 1 | - | - |
| Mineral – vitamin premix | 1 | - | - |

Chemical composition (% of dry matter)

| Item | Concentrate | Native grass | Rice straw |
|------|-------------|--------------|------------|
| Dry matter | 85.9 | 21.8 | 87.5 |
| Organic matter | 92.3 | 88.9 | 87.2 |
| Neutral detergent fibre | 16.6 | 58.4 | 65.8 |
| Crude protein | 15.7 | 12.3 | 5.4 |
| Ash | 7.7 | 11.1 | 12.8 |
| Gross energy (MJ/kg dry matter) | 18.1 | 17.6 | 16.8 |

Statistical analyses were performed using the General Linear Models procedure of SPSS 16.0. Data were analysed using the model $Y_{ijk} = \mu + P_i + K_j + e_{ijk}$, where $Y_{ijk}$ is the observation from animal $k$, receiving treatment $i$, in block $j$; $\mu$ is the overall of mean; $P_i$ is the effect of the crude protein level in concentrate in experiment 1, or the effect of concentrate level in experiment 2 ($i= 1, 2, 3, 4$); $K_j$ is the effect of block ($j=1, 2, 3, 4, 5, 6$) and $e_{ijk}$ is the residual effect. The differences between means were compared using a least significant difference method (LSD). Statistical difference was declared at P<0.05.
Table 3: Feed intake, live weight gain, meat productivity and methane emission from Vietnam local cattle during 74 days fattening with different protein levels in the concentrate

| Items                        | CP levels in concentrate (%) | SEM | P    |
|------------------------------|-------------------------------|-----|------|
|                              | 10   | 13   | 16   | 19   |
| Animal on feed               |      |      |      |      |
| Concentrate intake (kg DM/day) | 2.34a | 2.64b | 2.62b | 2.68a | 0.096 | 0.023 |
| Forage intake (kg DM/day)    | 2.22  | 2.27  | 2.42  | 2.37  | 0.103 | 0.321 |
| Total DM intake (kg/day)     | 4.57a | 4.90b | 5.03b | 5.05a | 0.10  | 0.014 |
| Initial live weight (kg)     | 146.0 | 150.2 | 151.8 | 153.4 | 1.236 | 0.064 |
| Final live weight (kg)       | 189.0a| 201.1b| 208.0b| 210.6b| 3.291 | 0.001 |
| Live weight gain (kg)        | 43.1a | 50.9b | 56.2b | 57.2a | 2.202 | 0.002 |
| Average daily gain (kg/day)  | 0.58a | 0.69b | 0.76b | 0.77b | 0.030 | 0.001 |
| Carcass weight proportion (%)|      |      |      |      |      |
| Carcass weight (kg)          | 20.0a | 24.1b | 27.1b | 27.4a | 1.058 | 0.001 |
| Lean meat weight (kg)        | 14.3a | 17.3b | 19.5b | 19.6a | 0.794 | 0.001 |
| Edible protein (kg)          | 3.15a | 3.91b | 4.34b | 4.11b | 0.175 | 0.001 |
| Calculated methane emission  |      |      |      |      |
| Total emission (kg/animal/day)| 0.078a| 0.084bc| 0.082b| 0.086c| 0.001 | 0.001 |
| Total emission (kg/animal/74 days) | 5.74a | 6.21bc| 6.05b | 6.36c | 0.061 | 0.001 |
| Emission intensity (kg/kg average daily gain) | 0.14a | 0.13ab| 0.11b | 0.11a | 0.006 | 0.023 |
| Emission intensity (kg/kg carcass weight) | 0.30a | 0.26bc| 0.23b | 0.24a | 0.012 | 0.005 |
| Emission intensity (kg/kg edible protein) | 1.88a | 1.64b | 1.41b | 1.58c | 0.079 | 0.007 |
| CH₄ efficiency (kg CO₂eq/kg carcass weight) | 7.42a | 6.58ab| 5.69b | 5.90a | 0.304 | 0.005 |
| CH₄ efficiency (kg CO₂eq/kg edible protein) | 47.0a | 41.0b | 35.4a | 39.4b | 1.980 | 0.007 |

Values on the same row with different superscripts differ (P<0.05)
*Estimation carcass weight, lean meat weight and edible protein increased in the experiment period (74 days)

Table 4: Feed intake, live weight gain, meat productivity and methane emission from local cattle during 60 days fattening with different concentrate levels in the diet

| Items                        | Concentrate levels (% BW) | SEM | P    |
|------------------------------|----------------------------|-----|------|
|                              | 1.0   | 1.4   | 1.8   | 2.2   |
| Animal on feed               |      |      |      |      |
| Concentrate intake (kg DM/day) | 1.53a | 2.23b | 2.80a | 3.49d | 0.06  | 0.001 |
| Forage intake (kg DM/day)    | 2.90a | 2.67b | 2.30a | 2.22c | 0.05  | 0.001 |
| Total DM intake (kg/day)     | 4.42a | 4.90b | 5.10b | 5.70c | 0.071 | 0.001 |
| Initial live weight (kg)     | 146.0 | 145.8 | 144.6 | 144.1 | 1.053 | 0.515 |
| Final live weight (kg)       | 176.4a| 191.0b| 193.9b| 206.4c| 2.473 | 0.001 |
| Live weight gain (kg)        | 30.4a | 45.2b | 49.3b | 62.3b | 2.354 | 0.001 |
| Average daily gain (kg/day)  | 0.51a | 0.75b | 0.82a | 1.04a | 0.039 | 0.001 |
| Carcass weight proportion (%)|      |      |      |      |      |
| Carcass weight (kg)          | 46.8  | 47.2  | 49.3  | 48.4  | 0.300 | 0.052 |
| Lean meat weight (kg)        | 14.2a | 21.4b | 24.3b | 30.2b | 1.102 | 0.001 |
| Edible protein (kg)          | 2.38a | 3.86b | 3.76b | 4.75b | 0.202 | 0.001 |
| Calculated methane emission  |      |      |      |      |
| Total emission (kg/animal/day)| 0.084a| 0.097a| 0.11a | 0.12d | 0.001 | 0.001 |
| Total emission (kg/animal/60 days) | 5.02a | 5.83b | 6.44b | 7.26d | 0.070 | 0.001 |
| Emission intensity (kg/kg average daily gain) | 0.17a | 0.13b | 0.13b | 0.12a | 0.007 | 0.001 |
| Emission intensity (kg/kg carcass weight) | 0.36a | 0.28b | 0.27b | 0.24b | 0.015 | 0.001 |
Emission intensity (kg/kg edible protein) | 2.18a | 1.57b | 1.72b | 1.53c | 0.102 | 0.002  
CH₄ efficiency (kg CO₂eq/kg carcass weight) | 9.03a | 7.03b | 6.65b | 6.03b | 0.364 | 0.001  
CH₄ efficiency (kg CO₂eq/kg edible protein) | 54.6a | 39.2b | 42.9b | 38.3b | 2.554 | 0.002  

*abcd Values on the same row with different superscripts differ (P<0.05)  
*Estimation carcass weight, lean meat weight and edible protein increased in the experiment period (60 days)

Predicted and Calculated Methane Emission

The model showed that the CP levels in the concentrate and the concentrate levels significantly affected (P<0.01) enteric methane emission (Tables 3 and 4). Similarly, methane emission intensities (kg CH₄/ADG, kg CH₄/CW and kg CH₄/edible protein) and methane efficiencies (kg CO₂eq/kg CW and kg CO₂eq/kg edible protein) were significantly affected by different CP levels in the concentrate and concentrate levels (Tables 3 and 4). The methane emission intensity (kg CH₄/kg ADG) declined curvilinearly with the crude protein intake (Figure 1) and the amount of concentrate intake (Figure 2).

Figure 1: Relationship between crude protein intake and methane emission intensity (kg/kg ADG)

Figure 2: Relationship between concentrate intake and methane emission intensity (kg/kg ADG)

Discussion

The DM intake was improved by increasing the CP level in the concentrate. This observation is in agreement with previous studies (Paengkoum and Tatsapong, 2009; Chen et al., 2010). However, other studies (Archibeque et al., 2007; Chantiratikul et al., 2009) reported that CP levels had no significant effect on DM intake. These variations might have been caused by the different feed resources used in the respective experiments, such as the types of roughage and the ingredients of concentrate. The amount of concentrate intake had positive effects on DM intake (experiment 2). These observations are similar to the conclusion of many researchers (Manni et al., 2013; Arriola et al., 2011).

The CP levels in the concentrate and the concentrate levels significantly affected CW, lean meat weight and edible protein. Previous studies (Bailey al., 2008; Gleghorn et al., 2004) reported that increasing dietary CP concentration increased CW. In another study, Iwamoto et al. (2010) concluded that increasing dietary CP level from 12 to 18% did not significantly affect CW in Japanese Black steers. In the present study, the CP level affected CW, the differences between studies might have been caused by the different protein sources used in the respective experiments, slaughtering bodyweight and cattle genotypes. The effect of the concentrate level on carcass characteristic was reported by several authors. In a study of Jian et al. (2013) feeding 85% concentrate in the diet during the finishing phase produced greater CW than feeding 70% concentrate in the diet for Jersey steers. However, Lage et al. (2012) could not find the effects of the concentrate supplementation on CW. Based on results of current research, the effect of the concentrate level on carcass characteristic is not conclusive and it may also depend on the life stage of the animal when dietary treatments were applied, slaughtering body weight, feeding management and genotypes (Jiang et al., 2013).

Enteric methane emission of cattle in the present study ranged from 0.078 to 0.12 kg/animal/day, these results were lower than that of the recommendation of IPCC (2006) which documented that enteric methane emission of cattle in Asia is 0.13 kg/head/day (47 kg/year). Increasing CP levels or concentrate levels resulted in increased methane emission. Recent studies have demonstrated that greater protein levels are related to increased DM intake (Berends et al., 2014) and increased feed intake leads to
an increase in methane production (Shibata and Terada, 2010; Chaokaur et al., 2015). Similarly results were reported for the increase in the amount of concentrate intake for cattle. In the present study, the CP levels in the concentrate significantly affected methane emission per products unit (ADG, CW, adible protein), however, significant effects could only be found between 10% compared to other CP levels. The effects of protein levels on methane emission are not consistent in the literature, Yan and Mayne (2007) found a negative relationship between methane emission per DM intake or other products unit and dietary CP concentration. However, Hynes et al. (2016), Menezes et al. (2016) reported that, CP levels did not affect methane emission per product unit. The effect of CP levels on methane emission is likely not solely dependent on dietary CP concentration, but a result of the subsequent change in other dietary factors (e.g., fiber and starch concentrations) (Manezes et al., 2016).

Increasing concentrate levels in the diet resulted in decreased methane emission per product unit. These findings were similar to other researchers, Grainger and Beauchemin (2011) reported that, concentrates favor propionate production in the rumen offering an alternative hydrogen sink to methanogenesis, and lower ruminal pH, which in turn inhibits methanogens directly and indirectly, as protozoal inhibition also decreases protozoal-associated methanogenesis. In addition, Capper et al. (2009), Muñoz et al. (2018) documented that, concentrates supply greater amounts of digestible nutrients than roughages, increasing animal productivity, and consequently, decreasing CH4 emission intensity (emissions generated for each kilogram of products). Many studies reported that, supplementation of diets with concentrates are widely used to increase the production of ruminants (Purwin et al., 2016; Ruiz-Albarán et al., 2016), and is regarded as an effective methane mitigation strategy (Hristov et al., 2013a).

CONCLUSION

Increasing CP levels or concentrate levels in the diet resulted in increased DM intake, meat productivity and decreased methane emission intensity (emissions generated for each unit of product). Appropriate protein levels in the concentrate (the diet) or the concentrate level in diet may be a solution to improve animal productivity while decreasing methane emission/products unit of cattle.

ACKNOWLEDGEMENTS

The authors acknowledge the support from The Norwegian Agency for Development Cooperation for obtaining the ruminant model.
Gleghorn JF, Elam NA, Galyean ML, Duff GC, Cole NA, Rivera JD (2004). Effects of crude protein concentration and degradability on performance, carcass characteristics, and serum urea nitrogen concentrations in finishing beef steers. J. Anim. Sci. 82: 2705-2717. https://doi.org/10.2527/2004.8292705x

Herrero M, Havlík P, Valin V, Notenbaert A, Rufino MC, Hristov AN, Oh J, Firkins JL, Dijkstra J, Kebreab E, Waghorn G, Godoi LA, Rennó LN (2016). Does a reduction in dietary crude protein content affect performance, nutrient requirements, nitrogen losses, and methane emissions in finishing Nellore bulls? Agric. Ecosys. Environ. 223: 239-249. https://doi.org/10.1016/j.agee.2016.03.015

Ruiz-Albarrán M, Balocchi O, Wittwer F, Pulido R (2016). Effects of dietary concentrate supplementation on methane emissions from local and crossbreed beef cattle in Daklak province of Vietnam. Asian-Aust. J. Anim. Sci. 29(10): 1335-1343. https://doi.org/10.4171/ajas.16.0821

Puurn C, Wydzic I, Wiegosz-Groth Z, Sobczuk-Szl M, Michalski JP, Nogalski Z (2016). Fattening performance of crossbred (Polish Holstein-Friesian x Hereford, Limousin or Charolais) bulls and steers offered high-wilted grass silage-based rations. Chilean J. Agricul. Res. 76: 337-342. https://doi.org/10.4076/J.0718-58392016000300011

Ramirez-Restrepo CA, Dung VT, Ngoan LD, Herrero M, Phung LD, Dung DV, Sen LTH, Cuong VC, Solano-Mañez ACB, Valadares Filho SC, Costa e Silva FL, Pacheco MVC, Pereira JMV, Rotz A, Dell C, Adesogan A, Yang W, Tricarico J, Kebreab E, Dung DV, Sen LTH, Cuong VC, Solano-Marino R, Albenzio M, Girolami A, Muscio A, Sevi A, Tschida G (2013). Fatty acid composition of adipose tissue and serum urea nitrogen concentrations in finishing beef steers. J. Anim. Sci. 91: 5045-5069. https://doi.org/10.1093/jas/jkt020

Iwamoto E, Iwaki F, Oka A (2010). Effects of dietary protein level in the early fattening period on free amino acids and dipeptides in the blood and Longissimus thoracis muscle in Japanese Black steers. Anim. Sci. J. 81: 338-344. https://doi.org/10.1111/j.1740-9299.2010.00746.x

Jiang T, Mueller CJ, Busboom JR, Nelson ML, O’Fallon J, Tschida G (2013). Fatty acid composition of adipose tissue and muscle from Jersey steers was affected by finishing diet and tissue location. Meat Sci. 93: 153-161. https://doi.org/10.1016/j.meatsci.2012.08.013

Lage JF, Paulino PV, Filho SC, Souza EJ, Duarte MS, Benedeti PD, Souza NK, Cox RB (2012). Influence of genetic type and level of concentrate in the finishing diet on carcass and meat quality traits in beef heifers. Meat Sci. 90: 770-774. https://doi.org/10.1016/j.meatsci.2011.11.012

Manni K, Rinne M, Huhtanen P (2013). Comparison of concentrate feeding strategies for growing dairy cow. Livest. Sci. 152: 21-30. https://doi.org/10.1016/j.livsci.2012.12.006

Marino R, Albenzi M, Girolami A, Muscio A, Sevi A, Braghiro A (2006). Effect of forage to concentrate ratio on growth performance, and on carcass and meat quality of Podolian young bull. Meat Sci. 72: 415-424. https://doi.org/10.1016/j.meatsci.2005.08.007

Menezes ACB, Valadares Filho SC, Costa e Silva FL, Pacheco MVC, Pereira JMV, Rotz A, Dell C, Adesogan E, Silva FAS, Godoi LA, Rennó LN (2016). Does a reduction in dietary crude protein content affect performance, nutrient requirements, nitrogen losses, and methane emissions in finishing Nellore bulls? Agric. Ecosys. Environ. 223: 239-249. https://doi.org/10.1016/j.agee.2016.03.015

S., Otsuka, M., Sommart, K. (Eds.), Establishment of a Feeding Standard of Beef Cattle and a Feed Database for the IndoChoice Peninsula. JIRCAS, Tsukuba, Ibaraki, Japan, pp. 76–78.

Ruíz-Altún M, Balocchi O, Wittwer F, Pulido R (2016). Milk production, grazing behavior and nutritional status of dairy cows grazing two herbage allowances during winter. Chilean J. Agricul. Res. 76: 34-39. https://doi.org/10.4076/j.0718-58392016000100005

Shibata M, Terada F (2010). Factors affecting methane production and mitigation in ruminants. Anim. Sci. J. 81: 2–10. https://doi.org/10.1111/j.1740-9499.2009.00687.x

Shikuku KM, Valdivia RO, Paul BK, Mwongera C, Winowiecki L, Läderach P, Herrero M, Silvestri S (2016). Prioritizing climate-smart livestock technologies in rural Tanzania: A minimum data approach. Agricul. Sys. 151: 204–216. https://doi.org/10.1016/j.agsy.2016.06.004

Yan T, Mayne CS (2007). Mitigation strategies to reduce methane emission from dairy cows. Pages345-348 in Proc. Br. Soc. Anim. Sci., High Value Grassland: Providing Biodiversity, a Clean Environment and Premium Products. University of Keele, Staffordshire, UK.