Methane emissions and energy utilization of zebu cattle in the tropics

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1. Introduction

The loss of enteric methane energy from ruminant livestock is a problem not only with respect to its impact on climate change, but also to its effect on the efficiency of feed energy utilization; it is therefore strongly associated with animal productivity. The key reasons for the low productivity of cattle in the tropical developing countries are the animal's genetic potential, feed availability, and feeding systems that depend on rice straw or other low-quality crop by-products; this dependency affects feed intake, digestion and energy supply, thus limit productivity and environmental sustainability. Here, we have outlined and discussed enteric methane emission and its relationship with the efficiency of energy utilization in zebu beef cattle.

2. Energy utilization and methane emission

1) Enteric methane emissions

Ruminant animals, particularly cattle (*Bos taurus* and *Bos indicus*) produce significant amounts of methane via anaerobic gut digestion. Because of their larger size, energy intake requirement, and populations compared with other, beef and dairy cattle are the major methane emission contributors, producing 61% of the total emission from all domestic animals (Gerber et al., 2013) and causing enteric methane energy losses accounting for 2 to 12% of gross energy intake (GEI). In the tropical developing countries, zebu (*Bos indicus*) beef cattle production systems have high methane emission rates (from 4.8 to 13.7% of gross energy intake; Table 1) because their major feeding systems utilize low-quality roughage (Kaewpila, 2016). Ogino et al. (2016) also demonstrated that the environmental impacts of the extensive and intensive finishing zebu beef production systems were 14.0 and 10.6 kg CO_2 equivalents for climate change, 3.5 and 11.3 MJ for energy consumption, and 47.4 and 61.8 g SO_2 equivalents for acidification, respectively. Shortage of good quality roughage force farmers to use rice straw and/or other crop residues, resulting in limited voluntary intake, digestibility, nutrient and energy balance, which consequently, impact on productivity and environmental sustainability. This has become a particular challenge for the livestock sector given that stocks of zebu cattle in developing countries in tropical regions now account for more than half of the global beef cattle population.

2) Energy utilization

Research on the relationship between enteric methane emission and energy utilization of zebu cattle are limited. Chaokaur et al. (2015) reported that increasing feeding level caused an increase in the daily weight gain of Brahman cattle and that the observed increase in energy efficiency was attributed to reduced energy losses in urine, methane and heat production. Enteric methane energy losses decreased (from 11.5 to 7.3% of GEI) with increasing feeding level. Tangjitwattanachai et al. (2015) confirmed that greater dietary intake feeding levels in Thai native beef cattle resulted in improved efficiency of energy utilization, and thus enhanced energy retention because of the reduction in enteric methane energy emission and heat production dilution. Enteric methane energy and heat energy production losses also linearly decreased with increasing metabolizable energy intake levels. Enteric methane energy losses ranged from 8.4 to 10.0%, although these values are much higher than the IPCC recommended value (6.5% of GEI) for calculation of national inventory of enteric methane emissions. The relationship between the carbon footprint and the daily weight gain or feed per gain (Figure 1) suggested that increasing productivity reduced GHG emissions, thus improved environmental sustainability (Kaewpila, 2016).

3. Conclusion

Methane emission is not only an important source of greenhouse gas that has great impact on climate change, but also a critical factor that affects the efficiency of feed energy utilization, and is therefore considered to be strongly associated with cattle productivity. More research work is needed to develop a practical and economical zebu beef farming system to improve productivity and environmental sustainability.

Table 1 Summary statistics of zebu beef cattle fed with low-quality crop residues and by-products in the tropics (n = 53)[1]

Item	Mean	SD	Minimum	Maximum
Beef cattle				
Age (month)	23	10	12	48
Body weight (kg)	277	80	113	432
Diet composition (g kg^{-1} dry matter)				
Roughage proportion	526	287	220	1000
Organic matter	911	25	840	962
Crude protein	106	33	40	213
Ether extract	36	16	10	78
Neutral detergent fiber	507	142	293	756
Acid detergent fiber	296	93	162	472
Energy content (MJ kg^{-1} dry matter)				
Gross energy	17.6	1.4	15.0	19.9
Metabolizable energy	10.1	1.7	6.7	12.9
Digestibility (g kg^{-1})				
Dry matter digestibility	643	70	464	746
Organic matter digestibility	677	72	508	790
Total digestible nutrients	604	86	454	737
Feeding level				
Dry matter intake (kg day^{-1})	4.6	1.5	2.2	7.7
Dry matter intake (% body weight)	1.7	0.3	1.2	2.2
Metabolizable energy intake†	1.4	0.3	1.0	2.2
Enteric methane emission				
Methane emission (g day^{-1})	123	53	38	311
Y_m (% gross energy intake)	8.2	1.7	4.8	13.7

†Expressed as multiple time of maintenance requirement (0.48 MJ ME kg^{-1} BW$^{0.75}$, WTSR 2010) (Kaewpila, 2016).

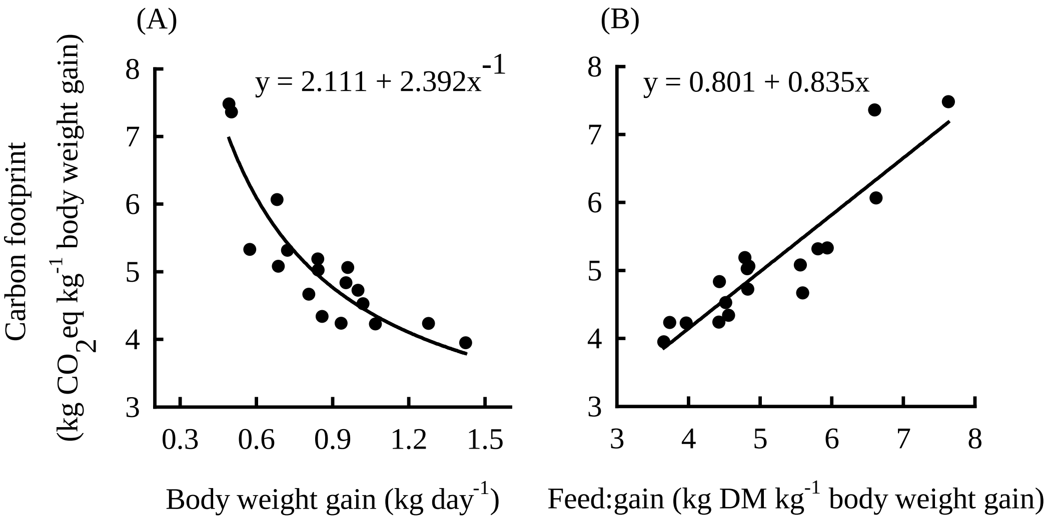

Figure 1 The relationship between (A) daily body weight gain and carbon footprint (n = 18, coefficient of determination = 0.820, P<0.001, residual SD = 0.226), and (B) feed per gain and carbon footprint (n = 18, coefficient of determination = 0.823, P<0.001, residual SD = 0.246) of native Thai beef crossbred cattle fed fermented total mixed ration diets. CO_2eq, carbon dioxide equivalent; DM, dry matter (Kaewpila, 2016).

References

Chaokaur, A., T. Nishida, I. Phaowphaisal, and K. Sommart. 2015. Effects of feeding level on methane emissions and energy utilization of Brahman cattle in the tropics. Agriculture, Ecosystems & Environment. 199:225–230.

Kaewpila, C. 2016. Metabolizable energy requirement for maintenace in native Thai-European crossbred beef cattle. PhD Thesis, Khon Kaen University, Khon Kaen, Thailand.

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

Tangjitwattanachai, N., I. Phaowphaisal, M. Otsuka, and K. Sommart. 2015. Enteric methane emission, energetic efficiency and energy requirements for maintenance of beef cattle in the tropics. Japan Agricultural Research Quarterly. 49:399–407.