Comprehensive Assessment of Greenhouse Gas Emissions From Thai Beef Cattle Production and the Effect of Rice Straw Amendment on the Manure Microbiome

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Background and the objectives

- The livestock sector is a significant source of GHG emissions, it accounted for 5.6–7.5 Gt CO_2 eq yr^{-1} of GHG emissions during the period 1995–2005. The major contributors are the emissions of enteric CH_4 and N_2O associated with feed production, but manure is also a significant source for both. Since the global GHG emissions from livestock increased by 51% during the 50-year period 1961–2010, it is an urgent issue how to mitigate GHG emissions from the livestock sector for the sustainable growth of the livestock industry.
- IPCC guideline provides default values for the countries that do not have a country-specific emission factor. For higher-tier approaches that reflect the country-specific factors such as cattle breeds, a comprehensive dataset obtained in the local condition is needed. However, there are no studies that provide an emission factor from beef cattle manure, which is a strong limitation of the current circumstance for precise estimation of GHG emission from this sector.
- Here, we made a series of comprehensive GHG measurements covering the period from enteric fermentation to manure storage for 84 days. We also estimated the effect of mixing rice straw into the manure on the GHG emission and manure microbiome.

Materials and methods

- Four Thai native cattle were used. The cattle were fed a restricted amount (2% of BW, dry matter [DM] basis) of a diet comprised of 70% Pangola grass and 30% commercial concentrate to meet their digestible energy requirements.
- The cattle were kept in individual tie-stall pens equipped with a ventilated head-hood system for CH4 emission measurement for 6 days.
- CH_4 and N_2O emissions from manure were measured using a dynamic chamber system.

Results: 1. Enteric CH_4 emission

- The results of the CH4 emission measurement and feed digestibility are summarized in Table 1. The values for the digestibility of DM, OM, CP, EE, NDF and GE fell in the normal range, indicating that the values and manure obtained in this study can be used as representative of the typical beef manure in the local production of beef cattle.

Table 1 Body weight, dry matter intake, CH_4 emission and nutrient digestibility

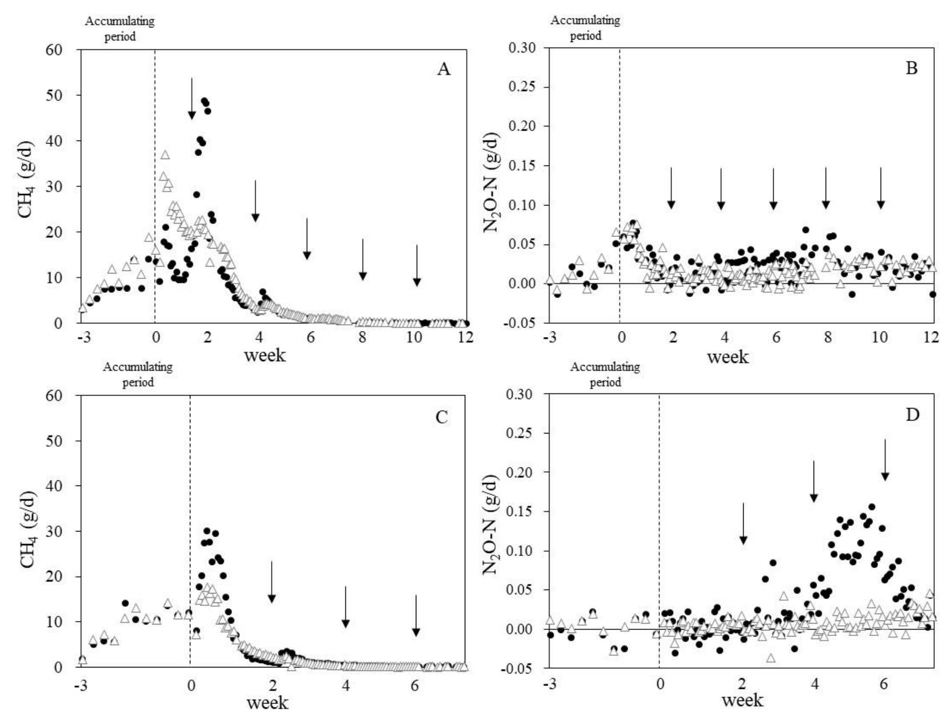
	Run 1		Run 2	
	average	sd	average	sd
BW (kg)	313.8	20.4	354.7	21.6
DMI (kg/d)	5.4	0.4	5.6	0.4
CH_4 (L/d)	155.0	15.7	174.1	22.1
DM (%)	55.42	1.26	53.68	3.20
OM (%)	60.51	1.23	57.57	3.37
CP (%)	46.45	1.95	51.99	3.76
EE (%)	80.82	1.57	81.30	6.62
NDF (%)	55.73	3.90	54.09	4.11
GE (%)	57.18	1.15	54.97	3.34

BW: body weight, DMI: dry matter intake, DM, dry matter; OM, organic matter; CP, crude protein; EE, ethel extract; NDF, neutral detergent fiber; GE, gross energy

Table 2 Summary of the GHG emission during beef manure storage

Run	Treatment	Initial weight	Final weight	CH_4	N_2O-N	CH_4	N_2O-N
		kg	kg	g/kgVS	g/kg$N_{initial}$	kg/head/yr	g/head/yr
1	control	516.5	183.1	7.60	1.46	5.14	17.1
2	control	546.5	89.7	4.22	0.92	4.01	11.3
1	rice straw	541.5	168.0	8.93	1.26	6.05	14.8
2	rice straw	546.5	98.2	3.71	0.24	2.90	3.0

Results: 2. GHG emission during manure storage

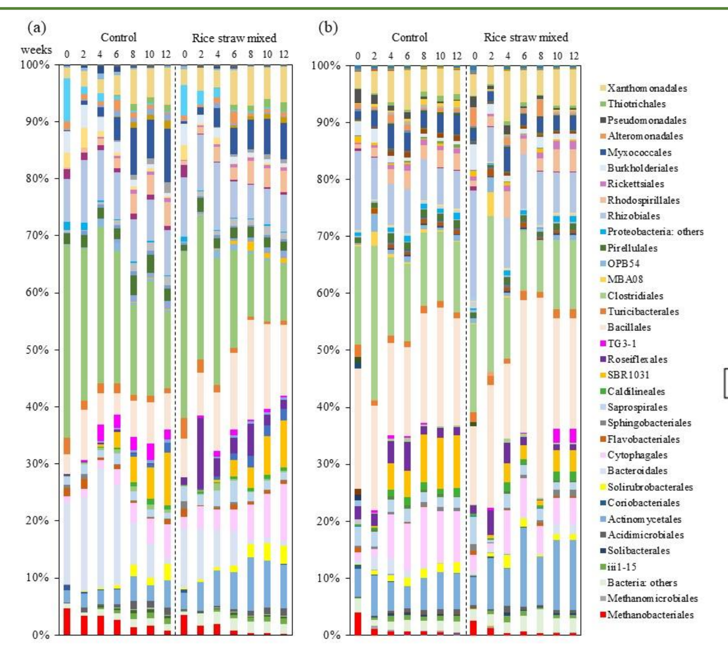


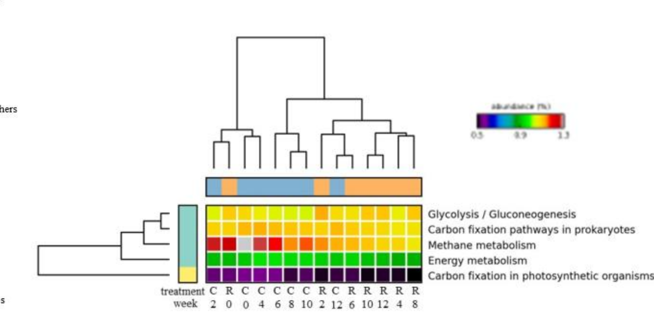
Methane and N2O emission during the beef cattle manure storage. Black circles: Control heap. White triangles: Rice straw-mixed heap. Arrows: The mixings for the sampling to monitor manure microbiome. (A,B): Run 1. (C,D): Run 2. Dashed lines: The end of the manure accumulation period.

- The maximum temperatures in the manure heap without rice straw were 43.8 and 47.4°C for Runs 1 and 2, respectively, whereas the max. temperatures reached 66.2 and 65.1°C in the heap with rice straw mixed into it.
- We detected significant emissions during the manure accumulation period. The manure heap with rice straw had lower CH4 and N2O emission peaks in both runs. In Run 2, the manure mixed with rice straw did not have an obvious N2O emission peak, and the manure-only heap had an emission peak between weeks 4 and 6.
- Effect of rice straw on total GHG emission was not statistically significant.

Results: 4. Manure microbiome

- Significant differences were observed at the order level, especially in Run 1 . The abundance of the order *Methanobacteriales* decreased significantly during the process in both treatments, but the decrease of their relative abundance was much faster in the rice straw-mixed heap than the control heap-, indicating that the rice straw amendment significantly enhanced the decay of the methanogens.
- The addition of rice straw significantly affected the function of the manure microbiome, in 65 (Run 1) and 60 (Run 2) of the 328 features in total. In Run 1 with a clear difference between the treatments, the methane metabolism (p = 0.042) and others.





Changes in the bacterial/archaeal community at the order level (a,b). (c) Estimated microbiome functions in Run 1.

Conclusion

- We measured the GHG emission from feeding to manure management in a replication of the typical beef cattle production system in Thailand. The values that we obtained can be used for the potential national emission factor. The amendment of the manure with rice straw tended to result in lower GHG emission, and the manure microbiome data support that this technique has some potential to inhibit the activity of methanogens and nitrifiers during manure storage. The results of our functional estimation of the manure microbiome also suggest that many metabolism pathways were affected by the addition of rice straw.

Acknowledgement

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