ES-13-Research 【Environment and Sustainability】

Research – Research that is or will be published in peer-reviewed journals

Suppression of methane production from rumens of dairy cows by feeding post-extracted black tea lees

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Highlights

- ✓ **Feeding dairy cows on partial mixed ration containing 2% of post-extracted black tea leaves (tea lees) has a suppressing effect on methane production by 7-9%.**
- ✓ **Milk productivity, health condition ,and milk flavor of dairy cows were not affected by feeding tea lees.**
- ✓ **Approximately 2.4 million tons of black tea is produced annually worldwide and, if all of the tea lees are fed to dairy cows under the conditions of this study, it would contribute to a reduction in 2.8 million tons of CO_2 per year.**

Objective

- Tea leaves are rich in plant secondary metabolites (PSMs) such as tannins and saponins, in addition to proteins and minerals. Several PSMs have been investigated and commercialized as feeding ingredients for the suppression of methanogenesis from the ruminant gastrointestinal tract (Bhatta et al., 2009, JDS 92:5512; Firkins&Mitchell, 2023, JDS 106:3053).
- In vitro methanogenesis inhibition studies with tea-derived materials have been conducted (Qiu et al., 2021, Anim Biotechnol: #1998092), but feeding studies with dairy cows have not been conducted.
- Using black tea lees, which are discarded of as industrial waste in manufacturing processes, this study aimed to elucidate the effect of feeding black tea lees on the reduction of enteric CH4 emission from lactating cows.

Materials & Methods

● Materials

- 20 dairy cows (average number of calves: 2.94, average days postpartum: 157.51) from Nosan Farm were divided into two groups for a cross-over study.
- 10 cows in the test group were fed partial mixed ration (PMR) with 2.0% dried black tea lees, while the control group was fed normal PMR.
- The composition of the black tea lees and the PMRs are shown in the Table 1,2, respectively.

● Methods

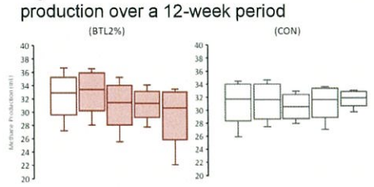
- Rumen fluid was collected three times through a gastric tube, i.e., on the first day of feeding, after 2 weeks of feeding, and after 3 weeks of feeding, and was subjected to an ex-vivo cultivation simulating enteric rumen fermentation. The vapor phase fraction was collected in a syringe and was analyzed by gas chromatography.
- Bacterial genomic DNA was also extracted from each rumen fluid and the gut microbiota was analyzed by next-generation sequencing. The proportion of methanogenic bacteria determined by quantitative PCR.
- A 3-week trial was also conducted using the same study method, changing the concentration of tea lees of 1.0%. In addition, a 12-week long-term feeding trial was also conducted with no change in the test and control groups. Rumen fluid was collected five times during the trial (on day 1, 3, 6, 9, and at 12 weeks), and gas production was measured as above.

Results

1. Reduction in methane production

- The three-week cross-over study, showed that methane proportion (CH4/(CH4+CO2)) in the control period increased by 1.0% from 15.9% to 16.9%, while it decreased by 0.6% from 17.2% to 16.5% in the test period.
- The 12-week long-term feeding trial showed that gas production in the control herd remained almost unchanged from 31.8 mL at baseline to 32.0 mL after 12 weeks, while gas production in the test herd decreased from 32.9 mL to 30.6 mL (Figure 1).

Figure 1. Trends in methane production over a 12-week period

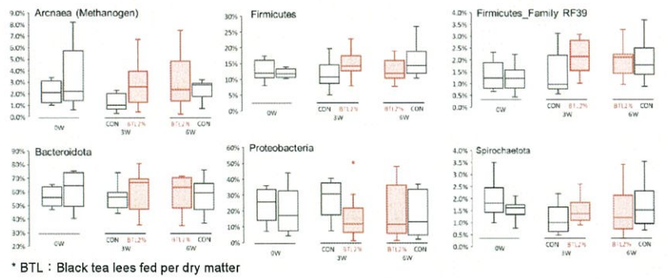


* BTL：Black tea lees fed per dry matter

2. Rumen microflora

- Genomic DNA extracted from gastric juice samples, composition of bacterial flora analysed by next-generation sequencing, proportion of methanogenic bacteria determined by quantitative PCR (Figure 2).
- Although there were large individual differences and little consistent variation, feeding black tea lees (BTL) for 3 weeks resulted in an increasing trend in Firmicutes (P=0.096) and a significant increase in RF39(*) belonging to Firmicutes (P<0.01). *Taxonomic name has not been give yet
- The composition of rumen microflora composition was altered by tea lees feeding, but this was different from the variation in bacteria often associated with methanogenesis inhibition, such as Succinivibrionaceae and Selenomonadaceae (Su et al., 2021, Anim Sci J; e1350)

Figure 2. Trends in Rumen microflora over a 6-week period



* BTL：Black tea lees fed per dry matter

Table 1 . Dried black tea lees compositional values

Analytes	Quantitative results (%)	Analytical method
Moisture	4.11	Dry weight method
CP	26.21	Dumas method
EE	1.10	Diethyl ether extraction method
C.Fiber	14.49	Filter method
C.Ash	3.47	Ashing method
NDF	49.30	AOAC method
ADF	27.66	AOAC method
Calcium	0.55	Atomic absorption spectrometry mthod
Phosphorus	0.26	Spectrophotometric method
Tannin	3.80	Folin-Denis method

Table 2 . Feed feeding menus for test and control groups

List of feeds		Test group (kg, AF)	Control group (kg, AF)
Compound feeding (milking robots)		5.0 *	5.0 *
PMR		44.4	50.9
Maize, flaked		1.3	1.5
High-protein feed (compound)		3.4	3.9
Beet pulp pellet		3.0	3.5
Dent corn silage		28.0	32.5
Grass silage		7.6	8.8
Calcium carbonate (CaCO3)		0.4	0.5
Premix		0.2	0.2
Tea lees		0.5 *	-
DM		25.9	25.9
DM%	CP	17.1	17.0
	NDF	33.8	34.0
	EE	3.7	3.8
	Ash	7.8	7.9
	NFC	39.2	39.0

* Compound feeding by milking robot to be increased or decreased depending on milk production.

* Tea meal adjusted to 2% of dry matter intake.

3. Equation for estimating the reduction in methane production by feeding black tea lees

- Data of methane production (by culture method) obtained from previous black tea lees supply tests* was integrated, and then aggregated according to black tea lees supply levels (Figure 3).
  * Implemented from September to November 2022 (20 cows), from January to March 2023 (24 cows),and from April to July 2023 (24 cows)
- Multiple linear regression analysis was conducted between methane production as the dependent variable and the amount of black tea lees fed to the cows and the milk production data on the day of collection as independent variables (n=207).

Methane production (mg/gDM) = 34.05 - 0.074 × Milk(kg) - 1.478 × (BTL*%)² + 2.130 × (BTL%)

* BTL：Black tea lees fed per dry matter

- Using this regression formula, we calculated the amount of methane reduction during the lactation period (Figure 4).

Figure 3. Effect of feeding tea lees on methane production

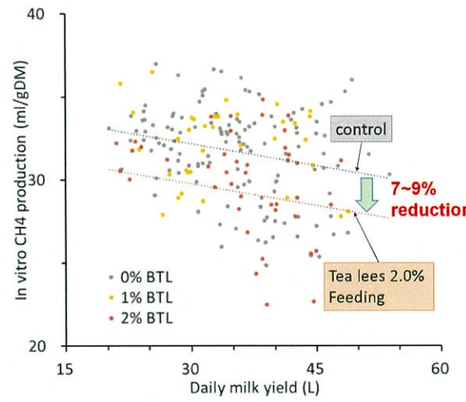
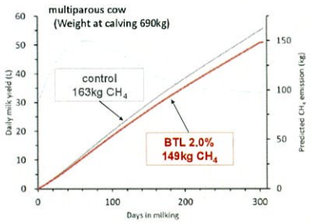


Figure 4. Estimation of methane reduction during milking period by regression equation



* Lactation curve and weight trends of model cows were extracted from dairy cow data owned by Nosan Farm Co., Ltd.
* The metabolic energy requirement was calculated based on daily milk production and body weight, and the PMR intake was estimated assuming 100% sufficiency.
* Methane loss of 6.5% was applied to the amount of gross energy (MJ) calculated from the compound feed intake and PMR intake, thereby calculating the amount of heat released a weight basis.

4. Impact on productivity

- Milk and blood sampling during the study period showed no effect of this experimental feeding regimen on milk production, cow's health status, and milk flavor in both groups.

Discussion

- ✓ Mixing post-extracted black tea leaves (tea lees) in dairy cows diets (2.0% dry matter) could reduce methane production by 7~9%.
- ✓ Feeding tea lees does not affect milk productivity, health condition, and flavor of milk, so the use of tea lees in dairy production areas around the world could make a small but substantial contribution to methane reduction in the dairy industry.

References

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