DIETARY SEAWEED SUPPLEMENTATION REDUCES ENTERIC METHANE EMISSIONS AND IMPROVES FEED EFFICIENCY IN TROPICAL BEEF CATTLE

Dr. Farid Hassan¹, Dr. Liyana Rahman², Prof. Daniel Okoro³*

ABSTRACT

Enteric methane emissions from ruminant livestock represent a major contributor to agricultural greenhouse gas outputs and global climate change. Climate-smart feeding strategies are increasingly being explored to mitigate methane emissions without compromising productivity. This study evaluated the effect of Asparagopsis taxiformis supplementation on methane production, rumen fermentation characteristics, growth performance, and feed efficiency in tropical beef cattle. Thirty-six Brahman crossbred steers (280 ± 15 kg) were randomly assigned to three dietary treatments: Control (0% seaweed), 0.5% seaweed (dry matter basis), and 1.0% seaweed (dry matter basis) over 90 days. Methane emissions were measured using open-circuit respiration chambers, and performance parameters were recorded weekly. Results indicated methane reductions of 18% and 32% in the 0.5% and 1.0% treatments, respectively (p < 0.05). Average daily gain increased significantly in supplemented groups, while feed conversion ratio improved by 9% in the 1.0% treatment. No adverse health or behavioral effects were observed.

INTRODUCTION

Livestock production contributes approximately 14–18% of total anthropogenic greenhouse gas emissions globally, with enteric methane accounting for nearly 40% of agricultural emissions. Methane has a global warming potential approximately 28 times greater than carbon dioxide over a 100-year period, making mitigation a critical priority for sustainable agriculture, Tropical beef systems are particularly important in developing regions where livestock contribute significantly to food security, livelihoods, and economic stability. However, these systems often exhibit lower feeding

¹Department of Animal Science, Universiti AgroTech, Malaysia
²Climate and Livestock Research Centre, Brunei Darussalam
³Institute for Sustainable Food Systems, University of Pretoria, South Africa
Corresponding Author: farid.hassan@uagrotech.edu.my

Marine macroalgae, particularly *Asparagopsis taxiformis*, contain bioactive compounds such as bromoform that inhibit methanogenic archaea in the rumen. While promising results have been reported in temperate systems, limited data exist under tropical production conditions. This study aimed to evaluate the methane mitigation potential and productivity impacts of seaweed supplementation in a tropical beef production system.

2. Literature Review

Recent studies have demonstrated methane reductions ranging from 20% to over 80% depending on inclusion rate and diet composition. Kinley et al. (2020) reported substantial methane suppression without negatively affecting feed intake or weight gain.

Mechanistically, bromoform inhibits the methyl-coenzyme M reductase enzyme involved in methanogenesis. This inhibition shifts rumen

fermentation toward increased propionate production, potentially improving feed efficiency.

However, concerns remain regarding long-term safety, residue risks, scalability of seaweed production, and economic feasibility in tropical systems. Therefore, region-specific evaluation is essential.

3. Materials and Methods

3.1 Experimental Design

The experiment was conducted at the Universiti AgroTech Research Farm, Malaysia. Thirty-six Brahman crossbred steers (average body weight 280 ± 15 kg) were randomly allocated into three treatment groups (n = 12 per treatment):

- T1: Control (basal diet)

- T2: Basal diet + 0.5% seaweed

- T3: Basal diet + 1.0% seaweed

The trial lasted 90 days following a 14-day adaptation period.

3.2 DIET FORMULATION

Diets were formulated to meet NRC nutrient requirements for growing beef cattle. The basal diet consisted of:

- 60% Napier grass

- 40% concentrate mix

Seaweed was dried, ground, and incorporated into the concentrate portion.

3.3 MEASUREMENTS

- Dry Matter Intake (DMI): recorded daily

- Body Weight: measured weekly

- Average Daily Gain (ADG): calculated

- Feed Conversion Ratio (FCR): DMI / ADG

- Methane Emissions: measured using open-circuit respiration chambers

- Rumen Fermentation: volatile fatty acid (VFA) profiles analyzed

3.4 Statistical Analysis

Data were analyzed using one-way analysis of variance (ANOVA) to determine the effect of farm type (conventional vs. PLF) on production, environmental, and welfare parameters. Prior to analysis, all data were checked for normality using the Shapiro–Wilk test and for homogeneity of variance using Levene's test.

Where assumptions were violated, data were log-transformed or square-root transformed to achieve normality. Differences among treatment means were assessed using Tukey's Honestly Significant Difference (HSD) test at a significance level of $p < 0.05$. All statistical analyses were performed using R software version 4.2.2 (R Core Team, 2023) and graphs were produced using ggplot2. Data are presented as mean ± standard error of the mean (SEM) unless otherwise specified.

Additionally, Pearson correlation analysis was conducted to examine relationships between methane intensity, milk yield, feed efficiency, and welfare indicators. Significance was set at $p < 0.05$.

4. RESULTS

Table 1. Growth Performance

Parameter	Control	0.5% Seaweed	1.0% Seaweed	p-value
DMI (kg/day)	8.2	8.1	8.0	0.42
ADG (kg/day)	1.05	1.12	1.18	0.03
FCR	7.8	7.2	7.1	0.02

Table 2. Methane Emissions

Parameter	Control	0.5%	1.0%
Methane (g/day)	220	180	150
Reduction (%)	—	18%	32%

Methane emissions decreased significantly with increasing seaweed inclusion (p < 0.01). Rumen analysis showed increased propionate concentration and reduced acetate:propionate ratio.

Implications for Planetary Health

Methane mitigation directly contributes to climate change mitigation goals. Additionally, improved feed efficiency reduces land, water, and resource

requirements per unit of beef produced. Adoption of such strategies aligns with sustainable livestock transitions and planetary health objectives.

Conclusion

Supplementation of *Asparagopsis taxiformis* at 1.0% dry matter reduced methane emissions by 32% while improving growth performance and feed efficiency in tropical beef cattle. This strategy offers scalable potential for climate-smart livestock systems.

References

Beauchemin, K.A., Kreuzer, M., O'Mara, F., & McAllister, T.A. (2008). Nutritional management for enteric methane abatement: A review. *Australian Journal of Experimental Agriculture*, 48, 21–27.

Berckmans, D. (2014). Precision livestock farming technologies for welfare management. *Animal Frontiers*, 4(1), 19–23.

Caja, G., Castro-Costa, A., & Knight, C.H. (2016). Engineering to support wellbeing of dairy animals. *Journal of Dairy Research*, 83, 136–147.

de Haas, Y., Veerkamp, R.F., & Kemp, B. (2013). Genetic and genomic aspects of dairy sustainability. *Animal*, 7(s1), 64–73.

Eastwood, C., Ayre, M., Nettle, R., & Dela Rue, B. (2019). Making sense in the cloud: Farm advisory services in a digital age. *NJAS – Wageningen Journal of Life Sciences*, 90–91, 100298.

Eckard, R.J., Grainger, C., & de Klein, C.A.M. (2010). Options for the abatement of methane and nitrous oxide from ruminant production. *Livestock Science*, 130, 47–56.

FAO. (2019). *Climate change and the global dairy cattle sector*. FAO Animal Production and Health Paper.

Gerber, P.J., et al. (2013). *Tackling climate change through livestock*. FAO.

Halachmi, I., & Guarino, M. (2016). Precision livestock farming: A review of dairy applications. *Animal Production Science*, 56, 1–12.

Herrero, M., Henderson, B., Havlík, P., et al. (2016). Greenhouse gas mitigation potentials in the livestock sector. *Nature Climate Change*, 6, 452–461.

Hristov, A.N., Oh, J., Firkins, J.L., et al. (2013). Mitigation of methane and nitrous oxide emissions from animal operations. *Journal of Animal Science*, 91, 5045–5069.

IPCC. (2021). *Climate Change 2021: The Physical Science Basis*.

Kinley, R.D., et al. (2020). Mitigating methane using seaweed supplementation. *Animal Production Science*, 60, 1–12.

Knapp, J.R., Laur, G.L., Vadas, P.A., Weiss, W.P., & Tricarico, J.M. (2014). Invited review: Enteric methane in dairy cattle production. *Journal of Dairy Science*, 97, 3231–3261.

Machado, L., Magnusson, M., Paul, N.A., de Nys, R., & Tomkins, N. (2014). Effects of marine and freshwater macroalgae on methane production in vitro. *Journal of Applied Phycology*, 26, 2381–2388.

O'Brien, D., Shalloo, L., Patton, J., Buckley, F., Grainger, C., & Wallace, M. (2012). A life cycle assessment of seasonal grass-based and confinement dairy systems. *Journal of Dairy Science*, 95, 4247–4261.

Roque, B.M., Venegas, M., Kinley, R., et al. (2021). Red seaweed (*Asparagopsis taxiformis*) supplementation reduces enteric methane by over 80% in beef steers. *PLOS ONE*, 16(3), e0247820.

Rutten, C.J., Velthuis, A.G.J., Steeneveld, W., & Hogeveen, H. (2013). Invited review: Sensors to support health management in dairy cows. *Journal of Dairy Science*, 96, 1928–1952.

Stanley, P.L., Rowntree, J.E., Beede, D.K., et al. (2018). Impacts of soil carbon sequestration on lifecycle greenhouse gas emissions in beef systems. *Agricultural Systems*, 162, 249–258.

Thornton, P.K., & Herrero, M. (2015). Adapting to climate change in livestock systems. *Annual Review of Animal Biosciences*, 3, 381–404.

Vijn, S., Compart, D., Dutta, N., et al. (2020). Key considerations for the use of seaweed to reduce enteric methane emissions from cattle. *Frontiers in Veterinary Science*, 7, 597430.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.J. (2017). Big data in smart farming. *Agricultural Systems*, 153, 69–80.