Garlic and Methane

LITERATURE SUMMARY: Interaction between garlic oil and enteric methanogens

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Introduction

Methane (CH_4) is among the most potent of greenhouse gasses and is linked with livestock production in the eyes of consumers. For producers, methane production is a sign of a less efficient fermentation and lost productivity. Research summarized below suggests that allyl sulfides in garlic oil can selectively inhibit methanogens without negatively impacting fermentation.

Trials

Numerous trials have demonstrated the repressive effects of garlic oil on methane emissions *in vitro*

- 45 to 70% reduction in methane emissions[1] **(Figure 1)**.
- 40 and 76% reduction in methane production[2] **(Figure 2)**.

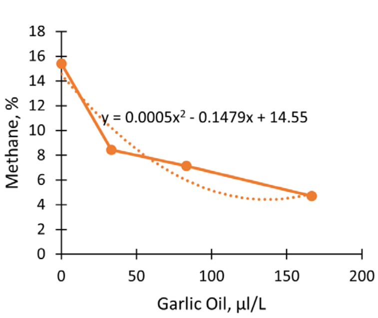

Figure 1. Methane content of head space by garlic oil concentration in rumen fluid[1].

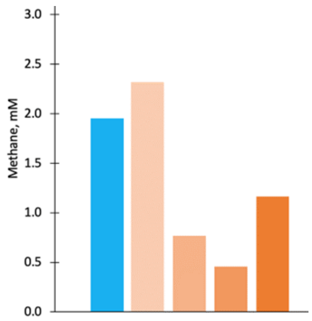

Figure 2. Methane emissions in control (blue) vs graded levels of garlic oil (orange)[2].

- 43% reduction while maintaining normal fermentation (gas production, VFA synthesis, degradability of dry matter and NDF)[3].

Mode of Action

Allyl sulfides are responsible for the characteristically pungent aroma of garlic. These sulfur compounds inhibit the activity of the enzyme responsible for building the cell membranes of archaeal methanogens[4]. Unlike other microbiota, which create their membranes from lipids built from repeating 2-carbon units, Archaea phospholipids arise from repeating 5-carbon isoprene units **(Figure 3)**. By targeting isoprene synthesis, garlic oil can inhibit methanogen abundance without inhibiting other ruminal microbiota, thus protecting normal fermentation even as methane synthesis is reduced.

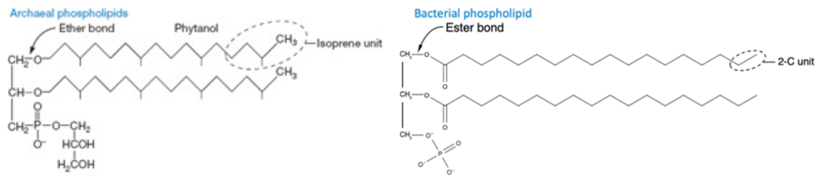

Figure 3. Archaeal and Bacterial phospholipids used for cell membranes.

Archaea drive methane synthesis by converting CO_2 to CH_4 via the Wolfe cycle, and yielding for themselves 31 kcals/mole of methane produced at the expense of the animal. By suppressing isoprenoid synthesis and thereby inhibiting methanogen numbers, energy losses from methanogensis may be reduced as the CO_2 is instead metabolized into something usable by the cow.

The CO_2 and H_2 not being utilized to synthesize CH_4 can be metabolized by other microorganism via alternative pathways such as homo-acetogenesis (yielding additional acetate), or feedback mechanisms which favor glucose fermentation to propionate **(Figure 4)** as well as increased conversion of Acetyl-CoA to butyrate instead of acetate.

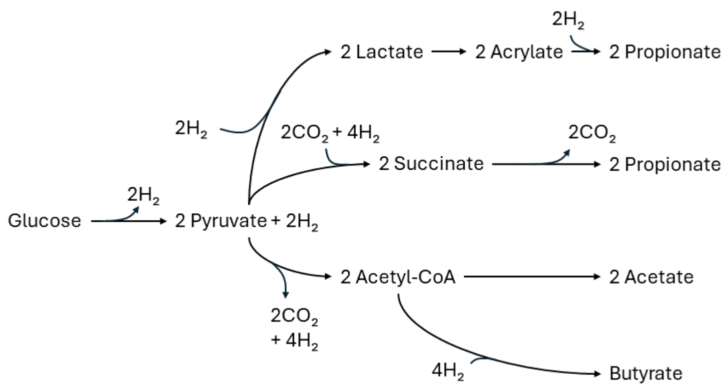

Figure 4. Fermentation of glucose to short-chain fatty acids.

Summary

It may be possible to exploit natural interactions between Garlic oil and archaea populations in the rumen to improve energy yield, while having a beneficial impact on enteric methane emissions.

References
1. Dey et al., 2021. DOI: 10.1007/s42452-021-04264-6
2. Espinoza-Rock et al., 2019. JAS. 97:165
3. Patra & Yu, 2012. DOI: 10.1128/AEM.00309-12
4. Glasson et al., 2022. DOI: 10.1016/j.algal.2022.102673