Diurnal dynamics of gaseous and dissolved metabolites in the bovine rumen in relation to control of fermentation pathways

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Introduction

Concentrations of gaseous and dissolved metabolites in the bovine rumen are elevated following feeding (Brask et al. 2015). Partial pressure of hydrogen (P_{H_2}) dictates the redox state of coenzyme NAD and thermodynamically controls the yield of individual VFA and CH_4 (Van Lingen et al., submitted). Increased understanding of these rumen fermentation dynamics may improve model predictions of type of VFA formed and CH_4 emitted. Nonetheless, studies reporting diurnal patterns of gaseous and dissolved metabolites in the rumen together with gaseous emissions from the rumen are limited. Furthermore, rumen fermentation and yield of CH_4 are affected by feeds supplemented with fats and oils sources, particularly by products high in C18:3 such as linseed oil (Patra, 2013). The aim of this study is to monitor daily patterns of gaseous and dissolved metabolite concentrations in the rumen, H_2 and CH_4 emitted from the rumen, and the effect of dietary inclusion of linseed oil on these patterns.

Materials and methods

Four multiparous rumen fistulated HF cows in late-lactation were used in a cross-over design with two 17-d experimental periods and two dietary treatments. A control diet (40% corn silage, 30% grass silage and 30% concentrates on DM basis; fat content 2.9% of DM) was compared with a diet supplemented with linseed oil (fat content 5.4% of DM). On day 11, rumen headspace gas and fluid were sampled at 0, 0.5, 1, 1.5, 2, 3, 4, 5, 6, 8 and 10h after morning feeding using a custom fistula lid. Gas samples were analyzed for partial pressure of H_2 and CH_4, fluid samples for concentrations of dissolved metabolites. From day 13 to 17 cows were housed in respiration chambers to relate instantaneous rumen headspace pressure to emissions of H_2 and CH_4. Profiles of metabolites in the rumen and gaseous emissions were analyzed using a linear and a non-linear mixed model, respectively.

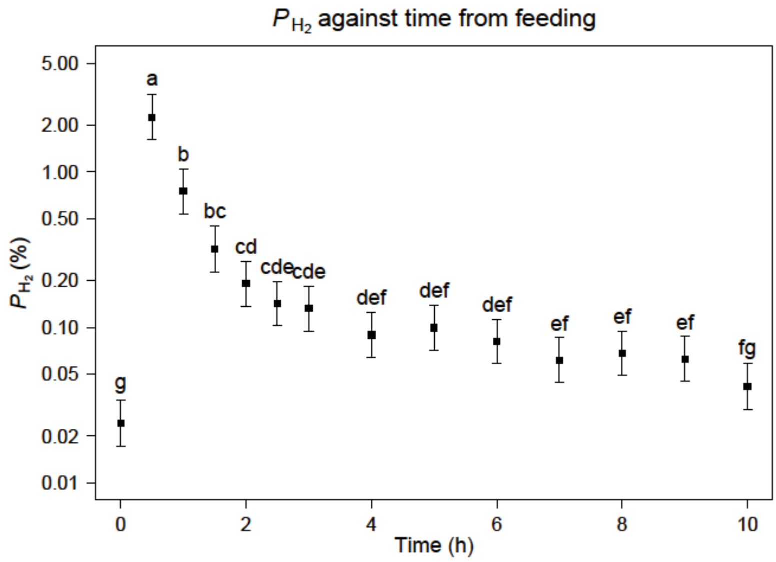

Figure 3 – Rumen H_2 partial pressure (P_{H_2}) over the first 10h after feeding. Values represent mean ± standard error, different letters indicate significant differences (P > 0.05), no diet effect was observed.

Results and discussion

A 100-fold increase in P_{H_2} was observed at 0.5h after feeding, followed by a decline (Fig. 1). Similarly, increased H_2 and CH_4 emission, ethanol and lactate concentrations, and acetate, propionate and butyrate concentrations, and decreased acetate to propionate ratios were observed after feeding (see Fig. 2 for selection of dissolved metabolites). This finding is explained by H_2 partial pressure inhibited oxidation of reduced NAD, which shifts fermentation end products to ethanol, lactate, and propionate at the expense of acetate. Only partial pressure and emission of CH_4 were significantly decreased by linseed oil. The metabolite profiles obtained in the present study support the key role of the redox state of NAD in rumen fermentation. Representing the redox state of NAD in rumen fermentation models will likely improve prediction of type of VFA formed and enteric CH_4 emitted.

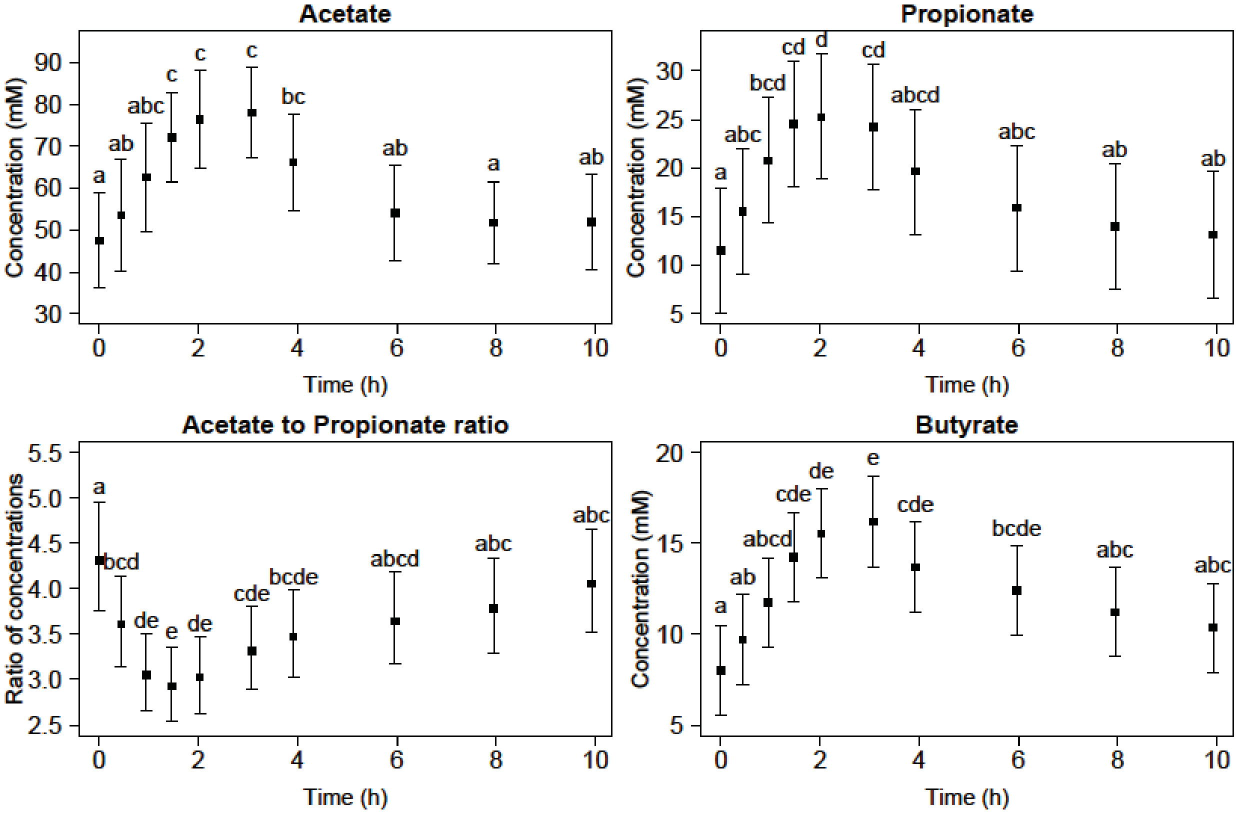

Figure 2 – Selected dissolved rumen metabolite concentrations over the first 10h after feeding. Values represent mean ± standard error, different letters indicate significant differences (P < 0.05), no diet effect was observed.

References

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