Use of supplementary nitrate to mitigate methane production and provide rumen degradable N for ruminants [+]

J.V. Nolan[A], *R.S. Hegarty*[B], *J. Hegarty*[A], *I.R. Godwin*[A] and *R. Woodgate*[B]

[A] School of Environmental and Rural Science, University of New England, Armidale NSW Australia
[B]Industry and Investment NSW Australia

In Australia, enteric methane from ruminants represents 11% of total agricultural GH emissions. Practical ways of reducing methane emissions from ruminants in Australia are required to enable the livestock industries to reduce their carbon footprint.

When rumen microorganisms ferment feed organic matter, they generate the reduced cofactor NADH which is in equilibrium with rumen H_2. In ruminants, the H_2 is normally removed by the reduction of CO_2 to form methane. However, NO_3^- (present in some fresh pasture forage) has a higher affinity for H_2 than CO_2 and, when it is present, H_2 is first used in the reduction of NO_3^- to NO_2^- and NO_2^- to NH_3 thereby reducing the production of methane from CO_2. After reviewing the literature and considering the potential for NO_2^- poisoning, Leng (2008) concluded that supplementation of ruminants with NO_3^- (as an alternative to urea) is entirely feasible. This study therefore examined digestion, microbial growth and methane production in sheep given a diet of chaffed oaten hay supplemented with iso-nitrogenous amounts of KNO_3, urea, or both N sources.

Eight Merino wethers (38.6 kg, SE 2.4; aged 3 years with long-established rumen fistulas) were housed in metabolism cages in 2 rooms (15-20^{o}C, continuous lighting) and allocated to 2 treatment groups. Two iso-nitrogenous diets based on chaffed oat hay were prepared. A diet with 4% added KNO_3 was prepared by sprinkling a solution of KNO_3 onto the hay while it was stirred in a rotary feed mixer. Another diet (0% KNO_3) was similarly prepared using a urea solution so that 5.54 g N was added per kg hay for both diets. The sheep were gradually acclimated to the NO_3^- containing diet over 18 days. The daily ration (1 kg/d air-dry feed) was delivered to both groups of sheep in equal portions each hour by automatic feeders during a 4-day digestibility trial, and every 2 h while the sheep were in respiration chambers to determine their methane output.

Table 1. Physiological and fermentation characteristics of sheep fed iso-nitrogenous diets of oaten hay supplemented with 5.54 gN/kg feed as urea (control) or nitrate salt (4% KNO_3)

Measure	0% KNO_3	4% KNO_3	Pooled SD	Probability
DM intake (g/day)	863	870	34.0	ns
DM Digestibility (%)	59.4	56.8	4.89	ns
Total VFA (mM)	82.8	97.8	6.79	0.02
Methane (L/kg DMI per day)	29.8	22.9	3.71	0.04
Microbial CP flow (g/day)	58.4	73.9	16.2	ns
Rumen pH	6.37	6.45	0.14	ns
Rumen ammonia (mgN/L)	102	115	17.9	ns
Blood methaemoglobin (%)	0.48	0.62	0.156	ns

Nitrate in the diet (4% KNO_3) reduced methane production by 67% of that predicted biochemically (Table 1). The less-than-predicted reduction may have been a consequence of a greater ruminal fermentation rate as suggested by a higher total VFA concentration, leading to increased H_2 availability, in NO_3^- supplemented sheep. However, there was no associated increase in whole tract DM digestibility. Another possibility is that small fractions of NO_3^- and NO_2^- were absorbed into the blood before their use in reduction reactions. Such absorption, however, did not produce clinically significant blood methaemoglobin concentrations (Table 1). Guo *et al.* (2009) found that microbial CP synthesis was higher in NO_3^- treated rumen fluid *in vitro*, but in our study between-animal variation in microbial CP flow was high and the treatment means did not differ significantly.

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Email: jnolan@une.edu.au

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