**Isotopic N fractionation as a biomarker of nitrogen use efficiency by ruminants: A meta-analysis**

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**Abstract**

We evaluated the potential to use the naturally occurring isotopic N fractionation between plasma or milk of ruminants and their diet (Δ15Nanimal-diet) to predict between-animal variation in N use efficiency (NUE), as well as assessed the main mechanisms by which Δ15Nanimal-diet is related to NUE under common feeding conditions. Individual values for NUE (n = 217) and Δ15Nanimal-diet (n = 274) from 11 published experiments were analyzed by meta- analysis. All dietary treatments were characterized according to the newly-updated French feeding system. The Δ15Nanimal-diet reflects between-animal variation in NUE and underlying mechanisms by which Δ15Nanimal-diet is related to NUE across diets are at both the metabolic and rumen levels.

**Keywords:** Feed efficiency, 15N, Individual variability

**Introduction**

Nitrogen use efficiency (**NUE**; nitrogen gain or milk nitrogen yield/N intake) is an important component of animal feed efficiency. A promising biomarker for NUE is based on the phenomenon of N isotopic fractionation (**Δ15Nanimal-diet**; the difference between animals and their diet in natural abundance of 15N). This approach may have potential to discriminate individuals fed the same diet, but with different N partitioning. A number of studies over the last 5 years have evaluated this new biomarker for NUE in ruminants, but its potential to reflect individual variation has not been yet assessed. The objectives of this study were to i) assess the potential of Δ15Nanimal-diet to predict variation in NUE at the individual level and ii) disentangle the main mechanisms by which this biomarker is related to NUE.

**Material and methods**

Eight publications (Cabrita *et al.,* 2014; Cantalapiedra-Hijar *et al.,* 2015, 2016; Cheng *et al.,* 2011, 2013a, 2013b, 2014, 2015) reporting NUE and Δ15Nanimal-diet values in ruminants were analyzed. There were 11 separate experiments, 42 treatments and individual values for NUE (n = 217) and Δ15Nanimal-diet (nmilk = 145 and nplasma= 129). Meta-analysis was performed by GLM (Minitab v14), adopting both between-experiment and within-treatment approaches. Dietary treatments were characterized using the newly updated INRA feeding system and the main determinants of NUE were analyzed by partial least square (PLS) regression (XLStat v2015.2.02). Independent variables were: rumen protein balance (**RPB**; g/kg DM), rumen degradable protein (**RDP**, g/kg DM), efficiency of microbial protein synthesis according to either available energy (**EMPS\_E**, g/g rumen fermentable OM) or available protein (**EMPS\_N**, g /g RDP), the metabolizable protein (**MP**) to net energy ratio (**MP/NE**, g MP/MJ), the digestive efficiency of N use (**DENU**, g MP/g crude protein), the efficiency of MP utilization for either production (**EMPU\_prod**, g protein in milk or gain/g MP) or the sum of production and non-productive (Sauvant et al., 2015) losses (**EMPU\_absol,** g/g MP).

**Results and discussion**

A between-experiment quadratic relationship (P<0.001; r2 = 0.78; RSE = 0.63) between individual Δ15N and NUE values was identified (Fig. 1), indicating that Δ15Nanimal-diet progressively reaches maximum values as NUE approaches zero. The within-treatment linear relationship (P<0.001; Fig. 1) between individual Δ15N and NUE values was significant highlights the potential of this isotopic biomarker to predict between-animal variation in NUE. The proposed PLS model made good predictions of variation in Δ15N resulting from dietary characteristics (Q2 = 0.88; RMSE = 0.37) and contributed to explain most of the variability in observed values (R2(Y) = 0.91).

The most important variables explaining Δ15N variation were related to the metabolic efficiency of N use (VIP = 1.10-1.19) but there were also relationships with rumen and digestive N use (VIP = 0.85-1.00).

Figure 1. Between-experiment ( ) and within-treatment (**--**) relationships between individual Δ15Nanimal-diet and NUE.



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