Measuring nitrogen use efficiency in cattle from stable isotope ratios in hair

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Cattle grazing seasonally-dry tropical rangelands usually depend on low quality senesced C4 grass pastures during the dry seasons when nitrogen (N) is the first limiting nutrient in the diet. In such conditions, one important factor contributing to the ability of individual animals to utilize the available forage is N use efficiency (NUE). Measurements of feed efficiency (FE) usually have to be conducted over extended periods to allow collection of representative feed intake and liveweight gain performance data (Asher *et al.* 2018). However, Cantalapiedra-Hijar *et al.* (2015) have recently demonstrated that the ^{15}N to ^{14}N stable isotopes enrichment ratio ($\delta^{15}N$) of ruminant plasma proteins was correlated with NUE; with higher NUE associated with lower $\delta^{15}N$. The natural abundance (enrichment) of ^{15}N is greater in animal tissues than in common diet forages and feedstuffs due to trophic shift of the ^{15}N and ^{14}N isotopes during metabolic processes. The extent of the fractionation depends on nature and complexity of metabolic pathways and generally the greater the trophic level, the greater the fractionation. Consequently, cattle with higher NUE are expected to have lower $\delta^{15}N$ in both plasma and tail hair proteins because of a lower urinary excretion of diet derived N (without passage through multiple metabolic cycles).

The objective of the present experiment was to evaluate whether the $\delta^{15}N$ in tail hair measured by mass spectrometry, as opposed to the $\delta^{15}N$ in plasma proteins, could be used to identify individual animals with the most efficient use of dietary N, measured as NUE, among growing cattle ingesting protein-limiting diets. Tail hair is composed mainly of keratin protein, and as hair grows the N present in amino acids is incorporated into new segments of hair providing a $\delta^{15}N$ signature associated with the fractionation between the ^{15}N and ^{14}N isotopes.

Fifty-nine Brahman steers [350 (s.e. 6.8) kg liveweight (LW)] were fed a low-protein diet (70% of the calculated ruminally degraded protein required) for 70 days. The most recently grown 10 mm segment of tail hair was sampled on day 70 and the $\delta^{15}N$ signature measured. The steers were classified into two groups based on their isotopes signature (average 6.95, 7.62, and 8.29 ‰ $\delta^{15}N_{tailhair}$). Steers were held in metabolism crates for 1 week with NUE measured during the last 5 days. Comparisons were made between the highest and lowest groups in the $\delta^{15}N$ categories (Table 1). The steers with lower $\delta^{15}N$ tended to gain LW more rapidly even though there was no difference in dry matter (DM) intake (1.95 kg DM/100 kg LW, P=0.90). There also tended to be less N excreted in the urine, and their NUE was higher. Most importantly, the FE measured as residual gain, feed conversion rate, and gain over feed ratio were all different between categories. This was in accord with the hypothesis that more efficient animals would exhibit lower $\delta^{15}N$ in tail hair.

Table 1. Comparison of liveweight gain performance data for steers assigned to low and high ¢^{15}N groups according to tail hair isotopic signatures

Measurement	Low $\delta^{15}N$ group	High $\delta^{15}N$ group	*P* value
Liveweight gain (kg LW/day)	1.09	0.93	0.08
N in urine (g N/100 g consumed N)	34.4	40.9	0.10
NUE (g N retained/100 g digested N)	44.9	31.8	0.05
Residual gain	0.05	-0.07	0.05
Feed conversion (kg DMI/ kg LW)	6.63	8.39	<0.01
Gain over feed ratio (kg LW/kg DMI)	0.16	0.13	<0.01

The experiment indicated that it may be possible to identify and select cattle with higher NUE and thus higher feed efficiency based on the $\delta^{15}N$ signature in their tail hair. This would represent an important step for the development of a tool for on-farm assessments of FE to guide the cattle selection for improved feed efficiency.

References

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