Assessing feed efficiency through blood and milk nitrogen isotope enrichment in grazing dairy cows

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Introduction

Achieving greater feed efficiency is a possible approach to improve sustainability of dairy production. Nevertheless, genetic selection for feed efficiency especially on pasture is hindered by the high costs and labour associated with individual feed intake measurements. In recent years, there has been an increased interest in finding biomarkers for the prediction and evaluation of feed efficiency. A promising predictor of feed efficiency is the use of N isotopic fractionation (Cantalapiedra-Hijar *et al*., 2015). As the ^{15}N natural abundance in animal proteins is higher than in the diet consumed, the variations in the isotopic N fractionation are correlated with feed efficiency (Cheng *et al*., 2013). The study investigated whether isotope N fraction of milk and blood can be utilised as an indicator of feed efficiency in grazing dairy cows.

Materials and Methods

The study comprised two mid- and one late-lactation experimental periods during 2 years, each entailed a 21-day adaption period and a 7-day measurement period. Per experimental period twenty-eight lactating dairy cows, approximately half of them primiparous, were grazed on established rotational pasture. Furthermore, Swiss Fleckvieh (FV) and Swiss Holstein (HO) cows were paired according to parity and calving date.

Individual herbage intake was estimated during grazing with the n-alkane double indicator technique (Rombach *et al*., 2019), and if concentrate was supplemented, it was registered individually through the automatic feeding stations. Based on the individual cow's dry matter intake, and milk yield as well as composition; nitrogen use efficiency (NUE), feed conversion efficiency (FCE) and residual intake (RI) expressed as; effective minus required total intake of dry matter (RFI), energy (REI) and nitrogen (RNI) were computed. The natural relative abundance (δ^{15}N) in animal proteins and diet was measured by isotopic ratio mass spectrometry against standard atmospheric N_2 following total combustion in an elemental analyser of the samples. The $\delta^{15}N$ was then calculated as follows: $\delta^{15}N = ((R_{sample}/R_{standard}) - 1) \times 1000$, where R represents the ratio between heavy and light isotopes in the sample and the standard. The N isotopic fraction ($\Delta^{15}N_{animal\text{-}diet}$) was defined as the difference $\delta^{15}N_{animal}$ and $\delta^{15}N_{diet}$. The recorded data (milk yield and composition, body weight and $\delta^{15}N$ of diet) were averaged per cow and period, as herbage intake was estimated per measurement period. One blood sample and one pooled milk sample per measurement period were used to determine $\delta^{15}N$. The data was statistically analysed with mixed linear regression with breed and measurement period as fixed factors and cow as random effect in R (R Core Team, 2021).

Results and Discussion

As animal tissues are generally ^{15}N enriched relative to their diet (DeNiro and Epstein, 1981), the $\delta^{15}N$ in blood (4.73 ‰, standard deviation (SD) = 0.21) and in milk (4.71 ‰, SD = 0.33) were higher than in the diet (1.41 ‰, SD = 0.71). The $\Delta^{15}N_{animal\text{-}diet}$ for blood and milk was 3.32 ‰ (SD = 0.68) and 3.30 ‰ (SD = 0.55), respectively. The $\Delta^{15}N_{animal\text{-}diet}$ was similar to values of Cheng *et al*. (2013) with no urea supplementation, although the $\delta^{15}N$ in blood, milk and in the diet was much higher.

The $\Delta^{15}N_{animal\text{-}diet}$ was negatively correlated with RI (R^2: 0.11-0.62), with the strongest correlation found between $\Delta^{15}N_{milk\text{-}diet}$ and RNI ($R^2 = 0.62$). The NUE and FCE was positively related (R^2: 0.33-0.58) to $\Delta^{15}N_{animal\text{-}diet}$ which is consistent with findings for milk and blood from Cheng *et al*. (2011) and Wheadon *et al*. (2014). The strongest correlation was found for $\Delta^{15}N_{milk\text{-}diet}$ and NUE ($R^2 = 0.58$). Significant differences were observed for breeds in RNI ($P = 0.012$) and NUE ($P = 0.009$). According to Cantalapiedra-Hijar *et al*. (2015) most of the $\Delta^{15}N_{animal\text{-}diet}$ is of metabolic origin (estimated at about 80%), with very little direct impact of the overall digestion process on the relationship between $\Delta^{15}N_{animal\text{-}diet}$ and feed efficiency**.** However, the relationship between $\Delta^{15}N_{animal\text{-}diet}$ and the feed efficiencies` NUE and RNI may be a biased prediction for animals close to zero, or in negative N balance, when part of protein originate from the body reserves (Cantalapiedra-Hijar *et al*., 2018).

Conclusion

The $\Delta^{15}N_{animal\text{-}diet}$ could predict feed efficiency variations across grazing dairy cows kept under similar conditions. The $\Delta^{15}N$ from milk and blood was a moderately good predictor of FCE and NUE (R^2: 0.31 – 0.59), and RI values (R^2: 0.12-0.61). Further exploration of this relationship across a larger number of animals and different conditions is necessary to determine its predictive robustness.

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