How fast are dietary carbon and nitrogen incorporated into bovine muscle?

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INTRODUCTION

Bovine tissues reflect the isotopic composition of the diet consumed by the cattle. Stable isotope analysis (SIA) of light elements including Carbon (C) and Nitrogen (N) of beef therefore has potential to provide information on the dietary history of cattle which has implications for meat authentication. However, a time delay can occur before a tissue reflects the isotopic composition of diet which is determined by the elemental turnover rate of the tissue. To predict any dietary shift in beef cattle, quantification of this time lag is important.

The objective of this experiment was to estimate the turnover rates of C and N in the bovine *Longissimus dorsi* and *Psoas major* muscle

MATERIALS AND METHODS

ANIMAL FEEDING

In a reverse diet switch experiment, the diets of five groups (n=10 each) of continental crossbred beef cattle were switched from a control ration to an isotopically distinct ration for C and N (Table 1) for 168, 112, 56, 28 and 14 days pre-slaughter. The control and isotopic rations were similar in terms of their energy and protein content. Ten animals fed the control ration for 168 days served as an experimental control. Animals were blocked on breed and initial bodyweight within the breed.

ISOTOPE ANALYSIS

Samples of *L. dorsi* and *P. major* muscles were collected at 24 h post-mortem and stored at -20 ˚C until analysis. Tissue sub-samples (5 g) were sliced and freeze-dried for 48 h and pulverised using a ball mill. Total lipids were extracted from the ground samples using hexane: isopropanol (3:2 v/v) and 0.9-1.1 mg lipid-free tissue samples were analysed using a Europa Scientific ANCA-NT 20-20 Stable Isotope Analyser with ANCA-NT Solid/Liquid Prepadiet Module (PDZ Europa Ltd., Northwich, UK). The isotopic compositions were determined relative to Vienna Pee Dee Belemnite (C) and air N_2 (for N) standards and are expressed in delta (δ) notation.

STATISTICAL ANALYSIS

The $\delta^{13}C$ and $\delta^{15}N$ data were fitted to the equation $d = a + b\ exp^{ct}$, where d is the isotopic composition of the tissue at time t (days since diet switch), a is related to the asymptotic isotopic value of the tissue on the isotopic diet, b refers to the difference between the initial and asymptotic isotopic value of the tissue, and c is the turnover rate in the tissue. The half-life of C and N were calculated from the formula $-ln(0.5)/c$.

Table 1: Composition of rations and their $\delta^{13}C$ and $\delta^{15}N$ values (±1 SD)

	Isotopic ration	(g/kg)	Control ration	(g/kg)
Target Element				
C	Maize	883	Barley	942
N	^{15}N urea (10 atom%)	0.021	–	–
N	Unlabelled urea	13	Unlabelled urea	24
–	Molasses	20	Molasses	20
–	Minerals/Vitamin	25	Minerals/Vitamin	25
Isotope composition				
$\delta^{13}C$	−13.1 ±1.18	–	−28.1 ±0.43	–
$\delta^{15}N$	11.7 ±3.81	–	1.0 ±0.37	–

RESULTS AND DISCUSSION

For $\delta^{13}C$, isotopic equilibrium was not reached in *L. dorsi* and *P. major* muscle after 168 days of feeding of the isotopic ration (Fig 1). The C half-lives were calculated to be 151 and 134 days for *L. dorsi* and *P. major*, respectively. The slower turnover rates of C in these two skeletal muscles compared to that in skeletal muscle of smaller mammals like gerbils (28 days) and mice (24 days) available in the literature is likely related to the differences in body mass since the metabolism is slower in the animals with higher body mass. In general, tissues with slow metabolic rates tend to have slow elemental turnover.

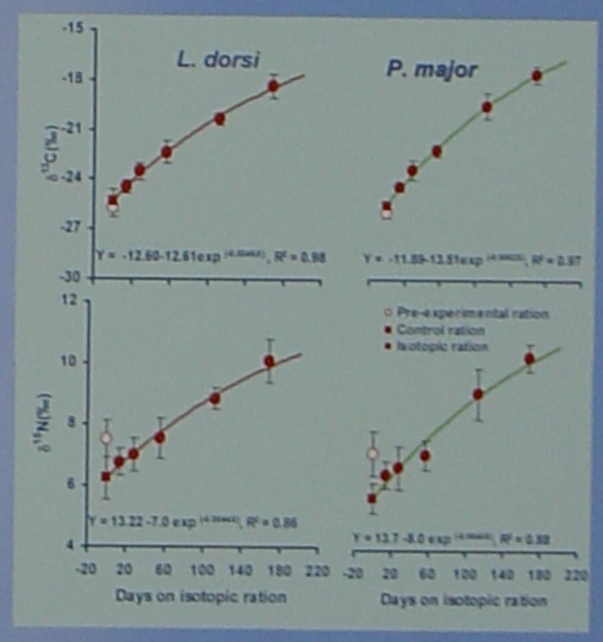

Figure 1: Turnover of C (top) and N (bottom) in bovine *L. dorsi* and *P. major* muscles.

For $\delta^{15}N$, isotopic equilibrium was not reached in *L. dorsi* and *P. major* muscles after 168 days of feeding of the isotopic ration. The N half-lives were calculated to be 157 and 145 days for *L. dorsi* and *P. major*, respectively. The turnover rates of C and N were very similar to each other which is probably due to the fact that these two elements are present in most biomolecules such as proteins and have a close coupling nature. The slow turnover rates of C and N indicated that the dietary information in bovine *L. dorsi* and *P. major* muscle tissues is integrated over several months.

CONCLUSIONS

- The turnover of the C and N in bovine skeletal muscles is relatively a slow process and therefore SIA of skeletal muscles can be used to predict the diet only when the cattle consume isotopically distinct diet for several months
- Since both the *L. dorsi* and *P. major* tissues have very similar turnover rates of C and N, analysis of either tissue would provide similar results.

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