DIFFERENTATION OF BEEF ACCORDING TO THE PRE-SLAUGHTER DIET OF CATTLE USING THE STABLE ISOTOPE RATIOS OF CARBON AND NITROGEN

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Introduction

Consumers demand reliable information about the food they buy. In particular, guarantees concerning the authenticity of meats are deemed fundamental to the assurance of food safety, quality and animal welfare (Verbeke and Viaene, 1999). Existing livestock traceability schemes depend ultimately on a paper trail and there is a need for scientific technologies for meat authentication to reassure consumers and to protect regional designations.

Stable isotope (SI) ratio analysis (SIRA) is one potentially useful technique for testing food authenticity. Since dietary C and N stable isotope (SI) compositions (expressed as $\delta^{13}C$ and $\delta^{15}N$) influence the isotope compositions of these elements in animal tissues, $\delta^{13}C$ and $\delta^{15}N$ of animal tissues are useful isotopic markers of diet. The $\delta^{13}C$ in livestock animal tissue primarily depends on the proportion of C_3 and C_4 photosynthetic plants consumed. The $\delta^{15}N$ in such animal tissue is usually less specific for particular dietary inputs but can reflect, among other husbandry practices, the presence of leguminous plants in the diet and also the intensity of agricultural land use in raising the feed crops. Recently, we have shown SIRA to have potential for the authentication of the geographic origin of beef and the proportion of C_3 and C_4 plant material in cattle diets and to distinguish between beef from organic or conventional production systems (Schmidt *et al.*, 2004; Bahar *et al.*, 2005). The objective of this study was to determine the potential of SIRA to distinguish between beef from cattle that consumed, during the finishing phase, a range of feedstuffs commonly available in Ireland.

Materials and Methods

In an indoor study, continental cross-bred beef steers (n=14/feedstuff) were offered grass silage, maize silage (cv. Benecia), fermented whole-crop wheat (cv. Soissons), alkalage whole-crop wheat (cv. Soissons) and *ad libitum* concentrates (83% rolled barley). The alkalage was ensiled with 45 kg Home 'N' Dry (Volac International Ltd.)/t dry matter. Forages were offered *ad libitum* through individual Calan gates and supplemented with 3kg concentrates/head/day. In a grazing study, continental cross-bred steers (n=14/feedstuff) were finished on either a conventionally managed sward i.e. the grass sward received approximately 200kg N ha^{-1}, or an optimally managed grass-clover sward that received 50kg N ha^{-1} in early spring. Animals were slaughtered after approximately 5 months of treatment. After cooling the carcasses for 24 h, *longissimus* muscle was sampled, vacuum packed and stored at -18°C until analysis. Natural abundance isotope ratios of carbon ($^{13}C/^{12}C$), and nitrogen ($^{15}N/^{14}N$) were measured on de-fatted muscle tissue by continuous flow isotope ratio mass spectrometry using a Europa Scientific ANCA-NT 20-20 Stable Isotope Analyser and are expressed in delta (δ) notation in parts per thousand. Data were analysed by (Multivariate) Analysis of Variance.

Results and Discussion

The stable isotope composition of the feeds is shown in Table 1. As expected, the $\delta^{13}C$ of maize silage was less negative than the other feeds. The $\delta^{15}N$ was highest for grass silage and lowest for the concentrate. Muscle SI composition is summarised in Table 2. Feed and muscle $\delta^{13}C$ were linearly related: Muscle = 0.41 (feed) – 14.02, se = 0.59, $P<0.05$, $R^2 = 0.95$. Beef from maize silage-fed cattle had the least negative $\delta^{13}C$ reflecting the SI composition of the feed, as previously observed (Bahar *et al.*, 2005). The $\delta^{13}C$ value distinguished ($P<0.05$) between beef from concentrate/wheat silage, grass silage, grazed grass and grazed grass/clover-fed cattle, but not between beef from alkalage and wheat silage-fed cattle or between beef from alkalage and concentrate-fed cattle. The relationship for $\delta^{15}N$ was: Muscle = 0.29 (feed) + 6.36, se = 0.61, $P = 0.05$, $R^2 = 0.47$. Using the $\delta^{15}N$ value resulted in a poorer discrimination of beef samples compared to using the $\delta^{13}C$ value.

A scatter plot of the individual data is shown in Figure 1. As before, beef from maize-silage fed cattle was clearly distinguished from other samples. The combined isotopic composition of carbon and nitrogen did not improve the discrimination of beef from wheat silage or concentrate-fed cattle beyond that achieved by considering only $\delta^{13}C$.

Table 1: Carbon and nitrogen stable isotope composition of feed ingredients.

Ration	Delta ^{13}C	sd	Delta ^{15}N	sd
Alkalage	-28.20	0.10	4.37	0.73
Concentrate	-27.48	0.30	2.95	0.36
Grass silage	-30.65	0.11	9.31	0.73
Maize silage	-12.74	0.30	6.32	0.26
Wheat silage	-28.02	0.25	3.11	0.36
Grass	-30.37	0.56	5.88	1.14
Grass/clover	-30.24	0.64	4.88	0.97

Table 2: Carbon and nitrogen stable isotope composition of *Longissimus* muscle from cattle fed various diets pre-slaughter[1]

Ration	Delta ^{13}C	Delta ^{15}N
Alkalage	$-25.36^{b,c}$	6.93^{a}
Concentrate	-25.65^{c}	7.16^{a}
Grass silage	-26.18^{d}	8.82^{d}
Maize silage	-19.42^{a}	7.76^{b}
Wheat silage	-25.28^{b}	7.19^{a}
Grass	-27.51^{e}	9.05^{d}
Grass/clover	-27.19^{f}	8.17^{c}
Sed	0.145	0.167
Significance	P<0.001	P<0.001

[1]Within a column means with different superscripts differ (P<0.05)

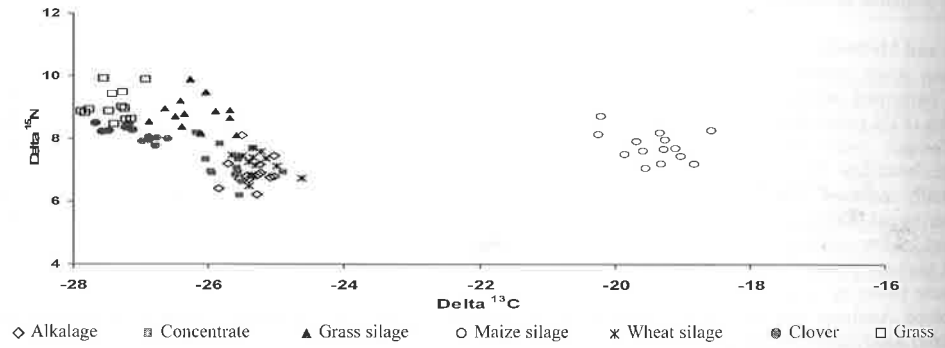

Figure 1: Carbon and nitrogen SI ratios in beef from cattle fed different diets.

Conclusions

Differences in the carbon and nitrogen stable isotope composition of the feeds examined were reflected in the muscle of cattle thereby allowing SIRA to be used as a component, at least, of a scheme to authenticate the dietary history of beef from cattle consuming these feeds.

References

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