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AN028

Easy-to-Use Combustion Module-CRDS System for Rapid Verification of Delta ^{13}C Ratios in Beef Labeled Grass-Fed

A fast screening method for supply chain quality control and truth-in-labeling verification of beef products.

Summary and Relevance:

In the later stages of their life, beef cattle in the U.S. are typically confined to feedlots. Feedlot cattle can be fed a wide range of diet mixtures including corn, soy, or grain by-products, as well as some grass. Corn silage is commonly used in the U.S feedlot system due to the relatively low costs of this food and to the high energy content which allows the animals to gain weight quickly. In recent years, demand has risen for"grass-fed" beef driven by consumer concerns over animal welfare and belief that beef raised on grass confers health benefits on consumers due to its lower saturated fat content and due to higher concentrations of conjugated linoleic acid (CLA) which some research has found to inhibit growth of cancer cellsi.

The USDA issued a voluntary standard for the marketing of grass-fed beef in 2007 stating that "grass and/or forage shall be the feed source consumed for the lifetime of the ruminant animal, with the exception of milk consumed prior to weaning. The diet shall be derived solely from forage and animals cannot be fed grain or grain by-products and must have continuous access to pasture during the growing season"[2]. Some producers market beef as "grass-fed" while openly admitting that the animals are feed a grain-based diet in their last weeks of life. Other producers state that their beef is "pasture-finished" and therefore feed grass throughout the life of the cow.

Corn and grass are chemically distinguishable by the ratio of the stable isotopes of carbon ^{13}C and ^{12}C, measured as the parameter $\delta^{13}C$ within them relative to VPDB, an internationally agreed upon standard . Corn is a member of a group of so-called C4 plants that photosynthesizes $^{13}CO_2$, more readily than the so-called C3 plants (which include soy, alfalfa and wheat). C4 plants exhibit between 1 and 1.4% less ^{13}C relative to the VPDB international standard. This differential is denoted on the per mil scale or parts per thousand, -10 to -14‰. C3 plants typically contain 2.5 to 2.9% less 13C than the same standard and their values fall in the $\delta^{13}C$ ratio range from -25 to -29‰.

Meat tested from animals fed diets of varying percentages of corn and grass has been shown to reflect the animal's diet in the corresponding $\delta^{13}C$ value of the meat. ii In fact, researchers have measured significant variability in $\delta^{13}C$ values of cooked meat and other foods from major U.S. fast food chains, evidence that stable isotope values persist from feedlot to table. iii Because animals take up the carbon isotopes of their food into their own tissues, these tissues reflect the $\delta^{13}C$ value

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of their diet. In the case of beef, a $\delta^{13}C$ value of lower than -21‰ indicates that at least some C3 grass was consumed during the finishing process.

In this application note we tabulate the $\delta^{13}C$ values of store-bought ground beef bearing the grass-fed label and compared them against $\delta^{13}C$ values of beef not labeled as grass-fed which we assumed to have consumed corn in significant amounts during the period it spent in a feedlot during the last months of its life. The values indicate (assuming accurate product labeling and disclosure) that beef raised on a strict grass diet has $\delta^{13}C$ values that appear to be clearly distinguished from beef from corn-fed/corn-finished cattle and from beef that is grass-fed for much of its life but then grain-finished (or fed a grain diet) for the last few weeks of its life.

Process:

Five brands of ground beef were purchased from local supermarkets, including an upscale grocery store. Of the five beef brands, two were labeled as grass-fed, one was labeled as pasture-raised, one was labeled "vegetarian" diet and one was an inexpensive brand that made no dietary claims. For each of the meats, two pinhead-size samples (ca. 1 µg) were combusted. The CO_2 gas evolved from each sample was collected and analyzed in Picarro's Combustion Module-Cavity Ring-Down Spectrometer (CRDS) system.

Results:

Table 1 (below) shows the $\delta^{13}C$ values obtained for the six samples. Only one of the four brands labeled grass fed (Brand B) shows a value totally consistent with a C3 diet. Brand D notes on their web site that their beef is corn-finished for corn-fed flavor. The isotopic values of Brand D beef appears to be consistent with their statement. The supermarket brand (Brand E) beef shows evidence of a mixed C3 and C4 diet, indicating that a mix of corn and grass may have both been present during finishing. Alternatively, their meat contains a mixture of meat from animal finished on corn and finished on grass.

Sample Description	$\delta^{13}C$ (permil)
Brand A Beef Pasture Raised	-18.65
Brand B Organic Grass Fed	-28.00
Brand C Organic 100% Grass Fed	-18.33
Brand D Natural Beef Vegetarian Diet	-15.21
Brand E supermarket brand ground beef	-22.22

Comments:

As the findings of this test illustrate, Picarro's CM-CRDS system can be used to quickly measure beef and other food samples. Data from such measurements can be used as a fast and effective screen of product labeling. The method is quick and easy to use and can process samples for as little as 30 to 40 cents each. However, it is important to note, also, that certain pasture grasses

may be C4 and therefore may impart $\delta^{13}C$ values closer to those of corn than those of C3 plants. That said, C4 pasture grasses are very localized and uncommon in the U.S. In conclusion, Picarro's CM-CRDS system can provide a viable technology to test consistency of claims of grass-fed and corn-fed beef in production settings. Dramatic changes of the $\delta^{13}C$ value can indicate changes in feeding processes that can become important to the value of products and the verification of labeling claims.

References:

i De Smet S, et al..Stable carbon isotope analysis of different tissues of beef animals in relation to their diet. Rapid Commun Mass Spectrom. 2004;18(11):1227-32
ii Bahar B, et al. (2005) Alteration of the carbon and nitrogen stable isotope composition of beef by substitution of grass silagewithmaize silage. Rapid CommunMass Spectrom 19:1937–194
iii Jahren, A. Hope and Rebecca A. Kraft. "Carbon and nitrogen stable isotopes in fast food: Signatures of corn and confinement." Proceedings of the National Academy of Sciences USA. 105; 46 (2008).