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Biomarkers to authenticate Irish grass-fed beef



Key external stakeholders:

Regulatory agencies, Bord Bia, beef producers/processors

Practical implications for stakeholders:

- Biomarkers to authenticate Irish grass-fed beef have not been identified and, therefore, the marketing advantage that should accrue by being able to prove unequivocally that beef is Irish and grass-fed has not been exploited.
- This project produced a unique and extensive dataset consisting of marker elemental isotopes, molecules, and differentially expressed genes characterising (i) Irish beef produced solely off grass or off concentrates or off silage/grass/concentrate combinations and (ii) non-Irish beef.
- The approach taken will be useful for individual producers seeking to market beef produced to a unique and defined regional production system.

Main results:

- Stable isotope analysis and fatty acid analysis permitted 100 % correct classification of grass-fed beef from concentrate-fed beef and from beef from animals fed a 50:50 combination of grass and concentrates.
- Discriminant analysis of stable isotope data from 146 international samples showed that 84.9% were correctly assigned to their country of origin.
- Stable isotope analysis of bovine tail hair provided an archival record of the pre-slaughter diet of beef cattle and, importantly, of changes (e.g. grass to concentrates) to the pre-slaughter diet.

Opportunity / Benefit:

Commercialisation of this research could involve the setting up of a food authentication testing facility involving the establishment and maintenance of databases against which routine or suspect samples would be tested.

Collaborating Institutions:

UCD

Teagasc project team:	Dr. Aidan Moloney (PI) Dr. Gerry Downey Dr. Alistair Black Dr. Bernadette Earley
External collaborators:	Prof. Frank Monahan (UCD) Dr. Olaf Schmidt (UCD) Prof. Torres Sweeney (UCD) Dr. Lorraine Brennan (UCD)

1. Project background:

Grass-fed beef:

- contains elevated levels of nutritionally-beneficial nutrients (e.g. omega 3 fatty acids, conjugated linoleic acid);
- can be produced in low input, environmentally-sustainable farming systems;
- is attractive to consumers who are increasingly aware of the origin of their food and the manner in which it has been produced,

Biomarkers to authenticate Irish grass-fed beef have not been identified and, therefore, the marketing advantage that should accrue by being able to prove unequivocally that beef is Irish and grass-fed has not been exploited. There is a requirement for analytical methods to provide independent and objective confirmation of identity.

2. Questions addressed by the project:

Could a set of novel biomarkers be identified by which Irish grass-fed beef could be authenticated and distinguished from concentrate-fed beef and non-Irish beef?

Would it be possible to authenticate Irish grass-fed beeds with a high degree of confidence by measuring several components at once and using multivariate statistical analysis?

3. The experimental studies:

The following beef sources were used in the study:

- Irish beef produced under a fully pasture-fed (12 months at pasture) beef production system at Teagasc Grange Research Centre.
- Irish beef produced under a fully concentrate (cereal)-fed (12 months housed) beef production system at Teagasc Grange Research Centre.
- Irish beef produced under a fully grass-fed (6 months grass silage, while housed, followed by 6 months at pasture) beef production system at Teagasc Grange Research Centre.
- Irish beef produced under a mixed grass-concentrate beef production system (6 months grass silage while housed followed by 6 months at pasture with a concentrate supplement) at Teagasc Grange Research Centre.
- Beef (of unknown dietary background but including some reputedly grass-fed beef) from EU and non-EU sources.

The beef was subjected to the following suite of measurements:

- Stable isotope analysis of Carbon, Nitrogen, Hydrogen, Oxygen, Sulphur.
- Fatty acid analysis – including determination of conjugated linoleic acid, linoleic/linolenic acid and omega-6/omega-3 ratios.
- Carotenoid analysis – β -carotene and lutein.
- Vitamin E (α -tocopherol) analysis.
- Volatile (terpene) analysis.
- Gene expression using transcriptomic techniques.
- DNA analysis for Zebu genes.

Comprehensive statistical analysis was carried out on the data from each task and on the combined data.

4. Main results:

A unique and extensive data set consisting of marker elemental isotopes, molecules, and differentially

expressed genes characterising (i) Irish beef produced solely off grass or off concentrates or off silage/grass/concentrate combinations and (ii) non-Irish beef, has been collected.

Analysis of the data sets showed that

- Stable isotope analysis and fatty acid analysis permitted 100 % correct classification of grass-fed beef from concentrate-fed beef and from beef from animals fed a 50:50 combination of grass and concentrates.
- Stable isotope analysis of bovine tail hair provided an archival record of the pre-slaughter diet of beef cattle and, importantly, of changes (e.g. grass to concentrates) to the pre-slaughter diet.
- Light reflectance and carotenoid data from subcutaneous fat of beef could be used to distinguish between beef from animals fed a barley-based concentrate diet and beef from animals fed pasture-based diets, but not between different pasture-based diets.
- Analysis of flavour volatiles made it possible to distinguish between 4 different Irish beef production systems including pasture-fed, concentrate-fed and mixed silage/grass/concentrate production systems. It was possible, using analysis of stereoisomers of vitamin E in muscle, to distinguish between beef from animals fed synthetic supplements (commonly used in vitamin/mineral supplements included in beef concentrate rations) and beef from animals raised on pasture without a synthetic vitamin E supplement. Irish grass-fed beef differed from U.S. grass-fed beef on the basis of evidence of feeding, in the U.S., of a synthetic vitamin E supplement.
- NMR analysis of urine taken at slaughter from beef cattle permitted discrimination between grass-fed beef, concentrate-fed beef and beef from animals fed a 50:50 combination of grass and concentrates.
- Discriminant analysis of stable isotope data from 146 international samples showed that 84.9% were correctly assigned to their country of origin (82.2% when cross-validated). All of the Irish beef samples verifiable as pasture fed beef were correctly classified as pasture-fed and then cross-validated.
- Differential expression of genes in muscle occurs when beef cattle are fed contrasting diets – grass at pasture vs concentrates while housed. There are no other published papers (from Ireland or elsewhere) in which such an analysis of gene expression in beef from contrasting production systems (including specifically grass-fed) was carried out.

5. Opportunity/Benefit:

The research is applicable to producers of beef who adopt a controlled feeding regime and thereby may have a defined molecular marker signature (in meat, urine and tail hair) that makes their product clearly identifiable. Commercialisation of this research could involve the setting up of a food authentication testing facility involving the establishment and maintenance of databases against which routine or suspect samples would be tested. In a broader context the research is applicable to country of origin labelling for Irish beef.

6. Dissemination:

Main publications:

- Röhrle, F.T., Moloney, A.P., Osorio, M.T., Luciano, G., Priolo, A., Caplan, P., and Monahan, F.J. (2011) 'Carotenoid, colour and reflectance measurements in bovine adipose tissue to discriminate between beef from different feeding systems.' *Meat Science* 88, 347–353.
- Osorio, M.T, Moloney, A.P., Schmidt, O. and Monahan, F.J. (2011) 'Beef authentication and retrospective dietary verification using stable isotope ratio analysis of bovine muscle and tail hair'. *Journal of Agricultural and Food Chemistry*, 59 (7), 3295–3305.
- Osorio, M.T, Moloney, A.P., Schmidt, O. and Monahan, F.J. (2011) 'Multielement isotope analysis of bovine muscle for determination of international geographical origin of meat'. *Journal of Agricultural and Food Chemistry*, 59 (7), 3285–3294.

Popular publications:

- UCD Press release: Tail hair tells tale of cattle's diet – Scientists trace grassland production. <http://www.ucd.ie/news/2011/04APR11/270411-Tail-hair-tells-tale-of-cattles-diet-Scientists-trace-grassland-production.html>
- The Irish Times, Friday May 20, 2011 "New test of tail hair can reveal cattle's diet".
- The Irish Farmer's Journal, May 21, 2011 "New test for grass-fed beef".

Workshops:

Relay workshop – “Meat matters – quality, health, innovation and exploitation of new technologies” Thursday 22nd October 2009, Ashtown Food Research Centre, Teagasc, Dublin 15. “Meat Authentication – determination of the dietary background and geographical origin of meat”.

7. Compiled by: Dr. Aidan Moloney and Prof. Frank Monahan (UCD)
