Tracing the origin of food

Paul Brereton
Food and Environment Research Agency, Sand Hutton, York, UK
paul.brereton@fera.gsi.gov.uk
To be discussed

• Introduction to Fera

• Importance of origin

• Verification procedures

• Food Integrity
Fera

• Government Research Agency ~900 staff

• Translational science solutions to Industry, Gov, NGO’s

• Wildlife, Plant protection, incident response

• (Bio) analytical chemistry, modelling, risk analysis, omics
Non targeted analysis: discovery, characterisation & interpretation

Non-targeted

Increasing specificity

FT-IR spectroscopy

NMR spectroscopy

Mass spectrometry

Targeted

Increasing coverage

Food Science & Nutrition Industry Day, 14 January 2013
Working with industry –

- LINK - Identifying chemical migration hazards, new can coatings
- EU FACET - integrated risk assessment
- Valspar-Fera - risk mitigation for new product development
- Non targeted analysis - TOF-MS

- 8 papers, 2 PhDs, 3 MScs, 3 appl notes, 7 ind articles > £2M R&D
- Partnership with Valspar

Product discovery & human health

- Manuka Honey
  - Anti-microbial efficacy studies
  - Active component identified

Industry feedback

“Working with Fera has enabled us to identify many potential opportunities throughout different strands of our business. Fera is now a trusted partner who we involve in our innovation processes and who helps us take new ideas to market.” Walter Sommerville, Nestlé.

“Working with Fera gives us access to a range of high-quality online regulatory and contamination tools which provide us with essential data quickly and easily. We are always impressed with the quality and high level of analytical service and scientific research capabilities provided by Fera.” Dave Wroe, Princes Foods (GB) Ltd.

“Fera’s knowledge and expertise provides us with commercial solutions backed by government impartiality. One of the important factors in our decision to work with Fera was their history of successfully delivering public-private partnership projects, from scoping and planning the project through to implementation and delivering results.” Peter Oldring, Valspar Corporation
Why are we interested in the origin of our food?

- Specific legislation [(EC) No 2772/1999]
- PDO/PGI legislation [(EC) No 510/2006]
- Consumer preference
- Consumer confidence
- Ethical production
- Patriotism (Ethnocentrism)
- Food miles

Food Information for Consumers Regulation (EU) No 1169/2011

Food Science & Nutrition Industry Day, 14 January 2013
Traceability systems

Tracking and tracing food

Property sheets (manual or electronic) are keyed to globally unique batch (trade unit) ID which in turn reference previous property sheets through their unique ID. The reference link can be passive (only used in exceptional circumstances, i.e. recall) or it can be active and involve a request-response scheme where B2 can ask B1 for more information about a certain B1_ID, and get a (standardized, electronic) reply.

Courtesy of Petter Olsen Nofima (No)
Traceability vs verification systems

• Traceability does not make food safe or assure product integrity

• Traceability systems track and trace food packaging

• Need verification methods as well
Verifying origin

• Geographical origin
  – stable isotopes

• Species/varietal
  – genomics, proteomics

• Product, production
  – Spectroscopy, mass spectrometry
Species origin: Gelatine

Enzyme digestion → LC separation

Fragmentation of tryptic peptides in MSMS mode

MSMS analysis
Product discovery/characterisation

- Manuka Honey
  - Anti-microbial efficacy studies
  - Active component identified
  - Working with industry to exploit

Verifying geographical origin

ISOSCAPES
What is an ISOSCAPE?

ISOTOPE LANDSCAPE

A map that represents the geographical distribution of stable isotopes in precipitation, ground water, soil, or a biological system...

but remember isotopes do not respect political boundaries!
What is an Isotope?

**ISOTOPE**

**“EQUAL”**

**“PLACE”**

Isotopes of an element occupy “equal” (the same) “place” in the periodic table. They have the same atomic number.
What is an Isotope?

Different atomic mass
The same atomic number

14N

Abundance 99.63 %

15N

Abundance 0.37 %
Bio-element stable isotopes of interest

- $^{13}\text{C}$
- $^{12}\text{C}$
- $^{15}\text{N}$
- $^{14}\text{N}$
- $^{18}\text{O}$
- $^{16}\text{O}$
- $^{34}\text{S}$
- $^{32}\text{S}$

- $^{2}\text{H}$
- $^{1}\text{H}$
- $^{87}\text{Sr}$
- $^{86}\text{Sr}$

Meteorological variation

Fertiliser

Photosynthesis

Sea-spray

Metabolic variation

Sandstone

Mudstone

Geological variation
Rationale for deuterium ($^{2}$H) geographic tracer

Two complementary approaches for the verification of food geographical origin:

1. Database approach

Origin determined from a dedicated database

* Requires data/specs from all producers
* Reliable but can be expensive
* Not necessarily the result of local factors;
* Needs regular update

Works best for limited number of well defined producers e.g. PDO

2. ISOSCAPE approach

Origin based on interpolation or relationship between geo-climatic factors and food isotopic composition

* Predicts isotopes for unsampled areas
* Potentially highly cost effective
* Based on “static” local factors

Works also for many ‘unsampled’ LOCAL producers

Why use an ISOSCAPE??
Combined areas of possible origin for $\delta^2H$, $\delta^{34}S$ and $^{87}Sr/^{86}Sr$

The combined area of possible origin (in green) applies to a intersection which is smaller than the individual specification areas.

Courtesy of Grishja van der Veer (Rikilt)
**Question?**

- Given a beef sample of unknown provenance with a measured isotope fingerprint; from which region(s) of UK is it likely to have come?
How is the ISOSCAPE created?

- HCNS and Sr isotope ratios measured in authentic beef samples of known origin
- Bayesian statistics applied to decide which krigging model should be used
- Isotope data is loaded into ArcGIS and a semivariogram created and metrics validated, create interpolated map layer
- The online tool then takes these layers and samples from them
- [http://isoscapes.fera.defra.gov.uk](http://isoscapes.fera.defra.gov.uk)
Constructing a Bayesian predictive distribution

- The probability that an unknown sample came from a specific region in the British Isles lends itself to a **Bayesian approach**
- Predictions were made at two-letter postcode spatial resolution
- (Predictions at farm-level may be inaccurate due to small number of observations at each sampling location)
Observations per sampling location

Only skewed sampling data available how to interpolate for unsampled areas?
Differences in observed isotope measurements within GB

- $d^{13}C$ ‰
- $d^{2}H$ ‰
- $d^{15}N$ ‰
- $d^{34}S$ ‰

England
Scotland
Wales

87/86Sr ‰
Constructing a Bayesian predictive distribution

1. Distributions were fitted to the observations in each two-letter postcode region (for which data are available)

Example – distribution of observed $\delta^{13}C\%o$ from KW (Kirkwall, Orkney)
Constructing a Bayesian predictive distribution

1. The parameter estimates of the distributions were spatially interpolated (kriging) to obtain parameter estimates for all regions in GB.

2. Covariates, such as environmental variables, were used in the kriging model (cokriging) to improve the kriging predictions of the parameter estimates.
Example – environmental variables used in cokriging
http://isoscapes.fera.defra.gov.uk/

ISOSCAPE Challenge
Search
Currently there is no input validation to check for acceptable input ranges, neither do the radio buttons do anything. Also, please do be aware that returning search results can take 10-30 seconds and drawing each individual map can take well over a minute!

C -25
Bio1  Bio12

H -91
Bio1  Bio12

N 6.5

S 8

SR 0.71

Run a probability model for these values

C  

N  

SR  

H  

combined  

S  
Search
Currently there is no input validation to check for acceptable input ranges, neither do the radio buttons do anything. Also, please do be aware that returning search results can take 10-30 seconds and drawing each individual map can take well over a minute!

C -25
Bio1  Bio12

H -91
Bio1  Bio12

N 8.5

S 8

SR 0.71

Run a probability model for these values
Currently there is no input validation to check for acceptable input ranges, neither do the radio buttons do anything. Also, please do be aware that returning search results can take 10-30 seconds and drawing each individual map can take well over a minute!
ISOSCAPES in the pipeline?

• TSB Authentick ✔ project – Isotopic variation
  – Whisky
  – Pork
  – Lamb
  – Chicken
  – Venison
  – Beef
  – Tomatoes
  – Eggs

• Timber origin – Isotopic and genetic variation
Food Integrity

• Food Integrity = safe & authentic food

• EU sponsored strategy to enhance European Agri-food economy in the face of food security pressures

• Global consumers assured about the integrity of European food.

• Fera leading an international consortium €12M “Food Integrity”- please join us
Summary

• Food provenance is becoming of increasing importance

• Analytical methods, systems and legislation are in development to assure the integrity of our food.

• Fera is at the forefront of methodology and is working with industry to develop transparent systems that demonstrate the integrity of the food we eat.
Acknowledgements

- Simon Kelly (Fera)
- Helen Grundy
- Adrian Charlton
- Malcolm Baxter (Fera)
- Helen Owen (Fera)
- Sarah Knight (Fera)
- Dav Thomas (Fera)

Thank you

paul.brereton@fera.gsi.gov.uk