



The Food and Environment
Research Agency

Lost without Trace: new approaches to tracing the origin of food

Paul Brereton (and many others)

Food and Environment Research Agency

Sand Hutton, York, UK



Adulterated olive oil ?

- Falsification of Italian olive oil with products made from wood leaves and berries of trees



- Reported in Rome 1st century AD

-History of the Food Quality Standards –

Radomir Lasztity, Marta Petro-Turza and Tamas Foldesi

<http://www.eolss.net/ebooks/Sample%20Chapters/C10/E5-08-01-01.pdf>

To be discussed

- Rationale & overview of TRACE
- Food mapping –use of predictive isoscapes
- Fingerprinting methods
- Molecular biological methods
- Conclusions

Rationale for TRACE: 2003/4

- Drivers for food traceability
 - Consumer food safety and socio-economic concerns
 - BSE,
 - Foot and mouth
 - dioxins
 - Sudan red
 - One step up one step down legislation introduced primarily to enhance risk management in terms of selectivity of recall
 - Reg (EC) 178/2002 General food Law
 - » One step up one step down traceability implemented 2005
- Consumer preference for products of defined origin
 - Provenance of foods, organic, sustainability, biofuels,
 - How to verify?

Traceability is a tool

- Traceability does not make food safe or assure product integrity
- Traceability systems track and trace food packaging
- Need methods for verifying the contents

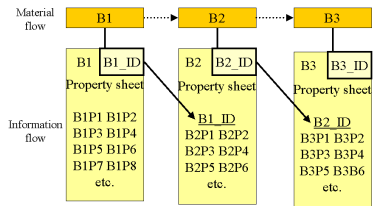


www.trace.org



- To develop traceability methods and systems that will provide consumers with added confidence in the authenticity of European food.
- €12M EU (€19M Total)
- 50+ participants, multi-disciplinary, 150
- Industry, academia, 150 researchers
- Europe, Argentina, China (+ US, NZ, AUS)
- 5 yrs 2005-2009

TRACE Overview



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.



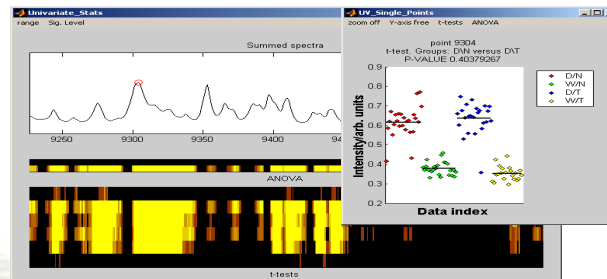
Traceability systems

Demonstration activities

Consumer studies



Training



Analytical tools

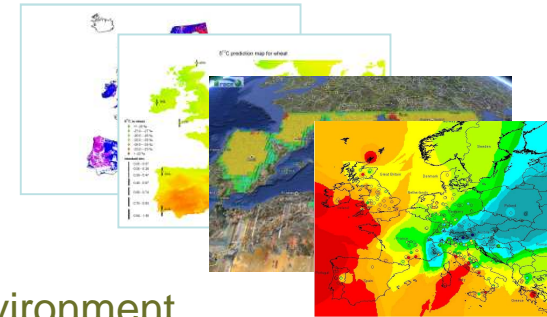


Dissemination

TRACE key outputs: verifying origin

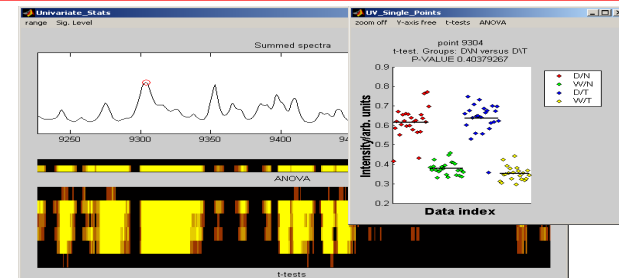
- Determining geographical origin

–investigating tracers in food and linking to the local environment



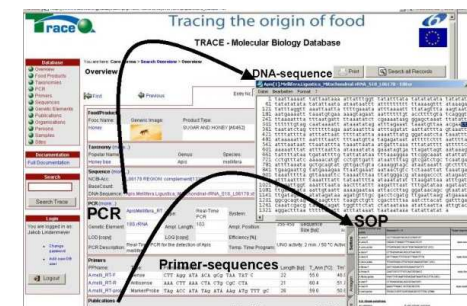
- Food assurance systems

– Characterising foods through spectroscopic fingerprinting



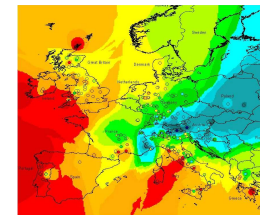
- Methods for species/variety id

– Molecular methods for Honey, cereal, meat
 – Generic methods for plant species
 – Molecular database of methods and sequences
<http://www.trace.eu.org/mbdb>



Production of predictive isoscapes

- Can components (stable isotopes and TE) in a food and its environment be linked?
 $\delta^{18}\text{O}$, $\delta^2\text{H}$, $\delta^{13}\text{C}$, $\delta^{87}\text{Sr}$
- If so can we predict the levels of certain components in a food of declared provenance ?
- Can the predicted levels (specifications) be used as an objective means of verifying geographical origin ?



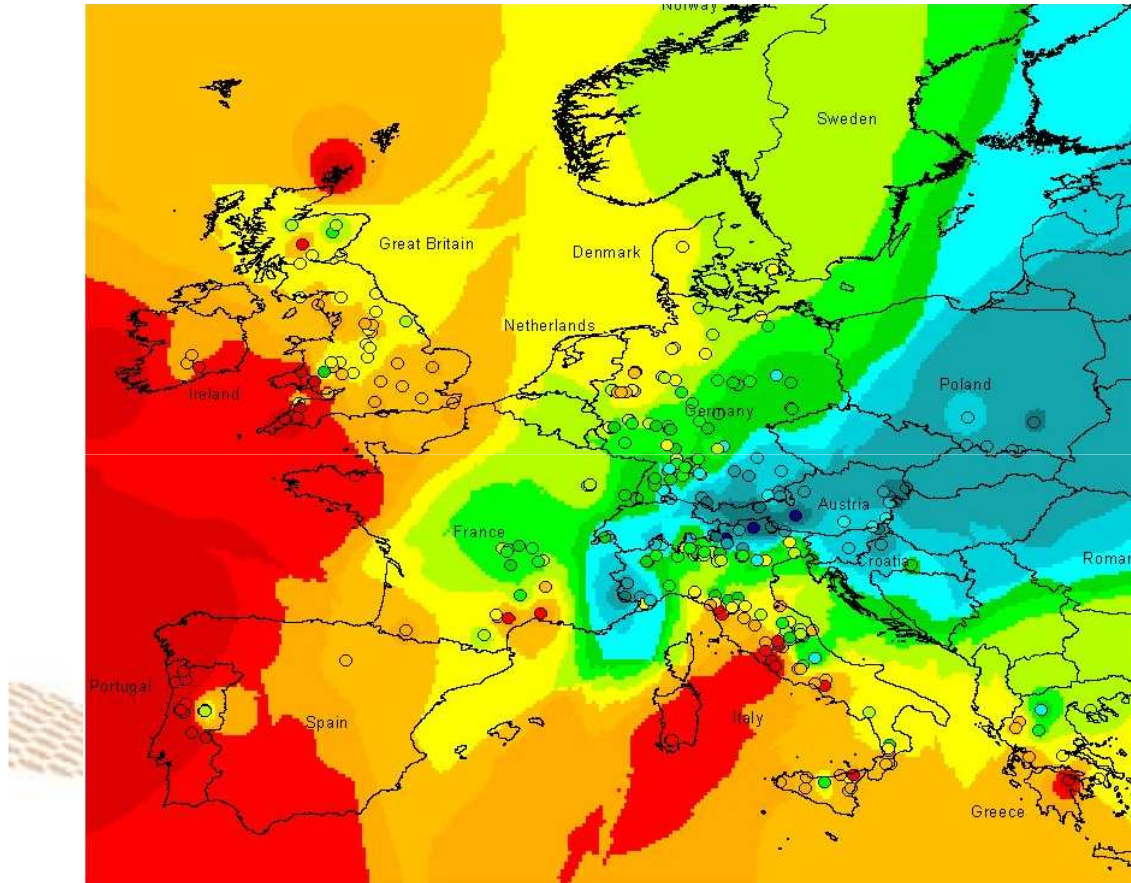
Experimental Design

- 21 Model sampling sites
 - Climate
 - Geography
 - Geology
- ~12,000 groundwater, soil and food samples analysed
 - $\delta^2\text{H}$, $\delta^{18}\text{O}$, $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{34}\text{S}$, $\delta^{87}\text{Sr}$ and trace elements
 - >~600,000 analytical data points to be produced
 - Statistical analysis
- Geo-climatic modelling (isotopes only) to produce Specification Prediction Models

$\delta^{18}\text{O}$ in water isoscape*



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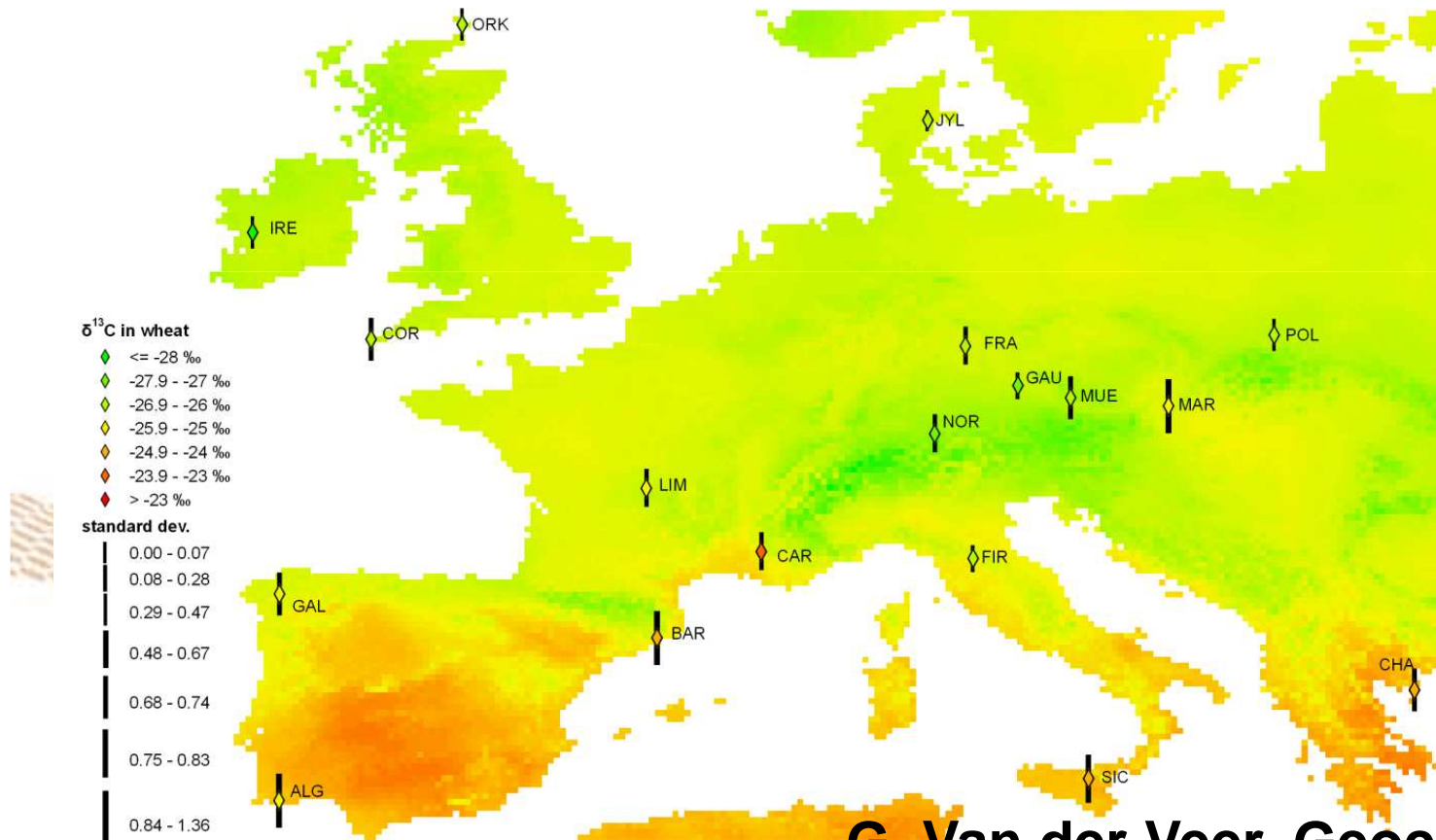
*Dr. S. Voerkelius, Hydroisotop GmbH

$\delta^2\text{H}$, $\delta^{18}\text{O}$ related to
climate

Van der Veer, G., Voerkelius, S., Lorentz, G., Heiss, G., J.A. Hoogewerff, J.A., 2009. Spatial interpolation of the deuterium and oxygen-18 composition of global precipitation using temperature as ancillary variable. *Journal of Geochemical Exploration*, 101 (2) 174-184.

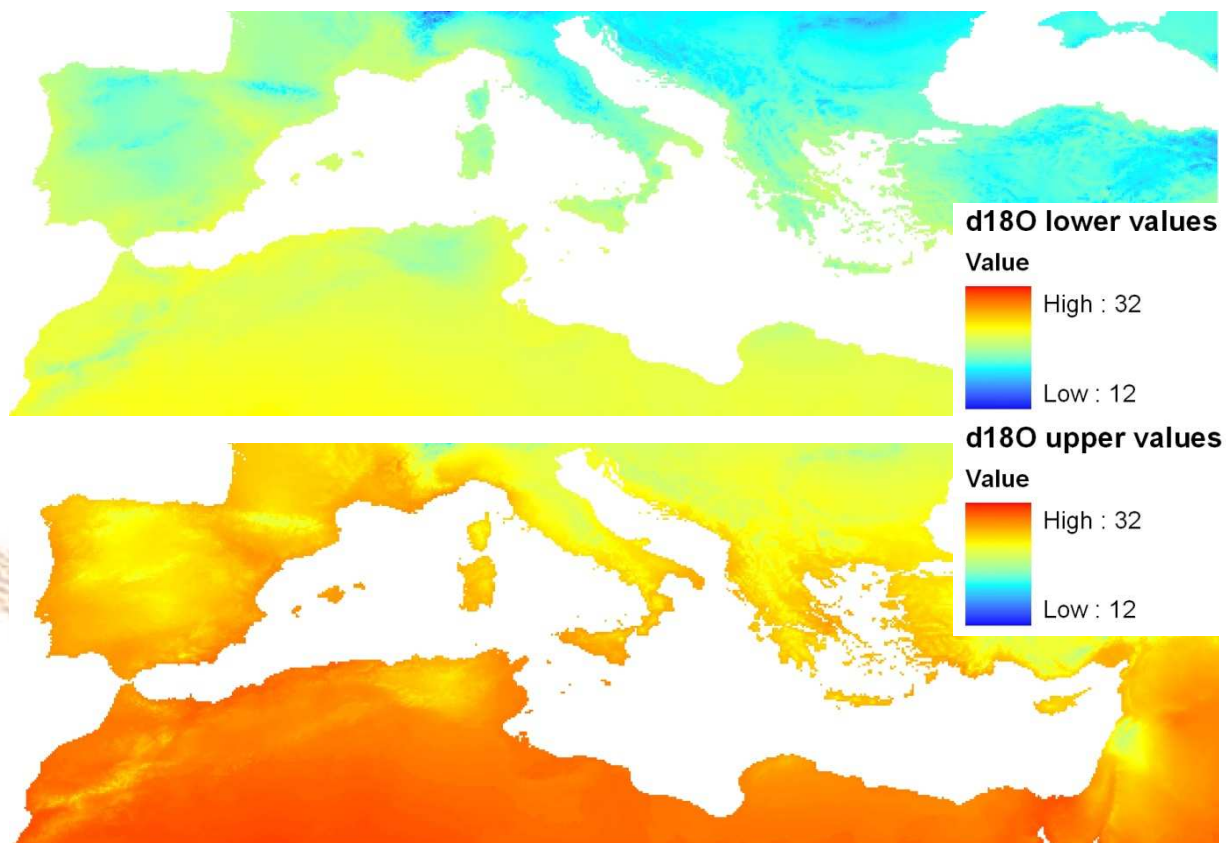
$\delta^{13}\text{C}$ in wheat based on relative humidity and altitude

$\delta^{13}\text{C}$ prediction map for wheat

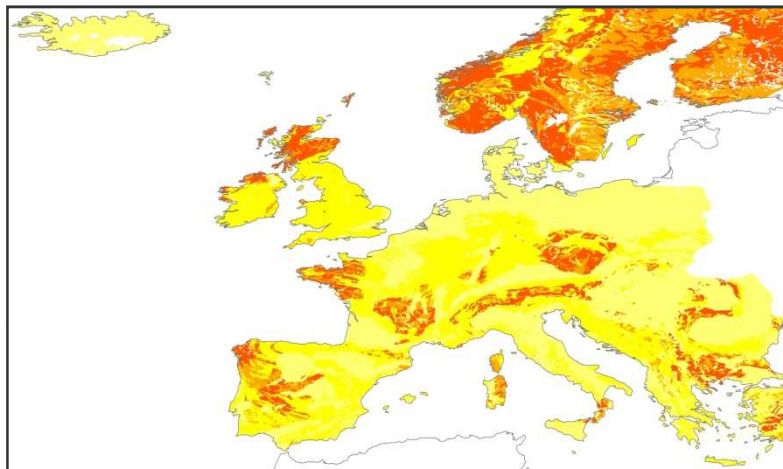


G. Van der Veer, Geochem Research

$\delta^{18}\text{O}$ isoscape for olive oil



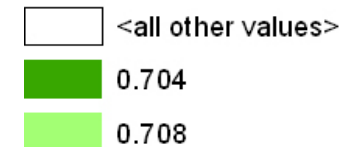
$^{87}\text{Sr}/^{86}\text{Sr}$ isoscape (mineral water)



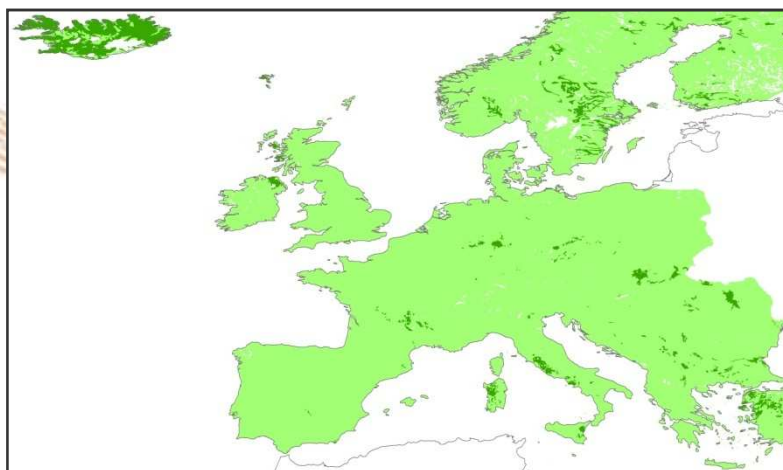
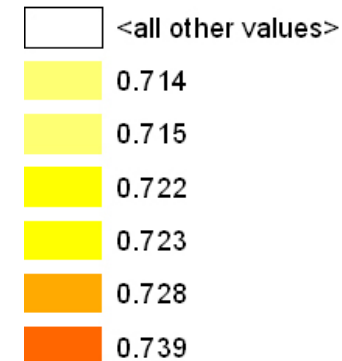
Predicted specifications (2.5 and 97.5 percentile) of $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in European mineral water.

$^{87}\text{Sr}/^{86}\text{Sr}$

lower values



upper values



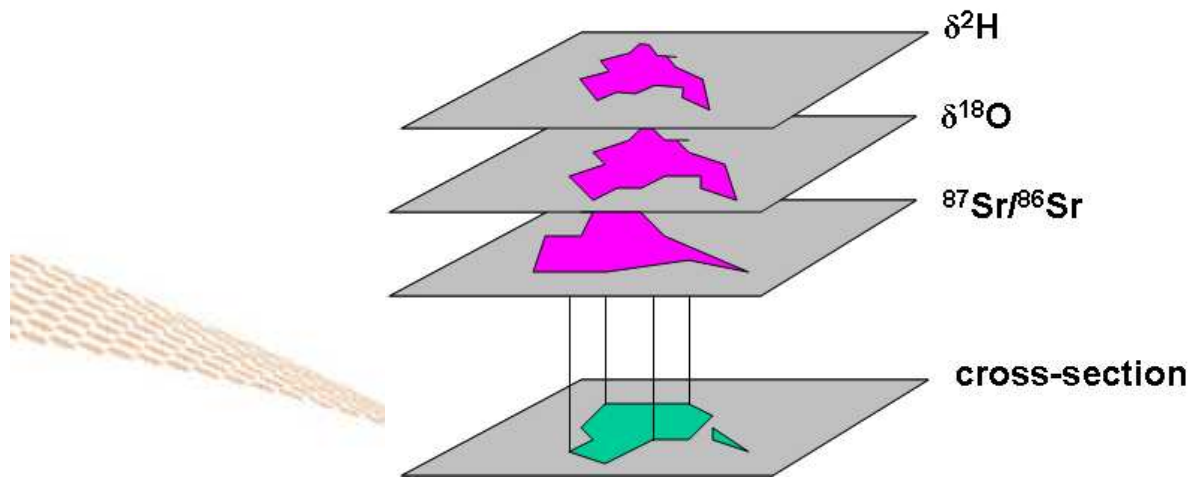
Specifications for geographical origin

$$S_A(x, y) = cl_{P_1}^- < P_1(x, y) < cl_{P_1}^+ \ \& \ cl_{P_2}^- < P_2(x, y) < cl_{P_2}^+ \ \& \dots \ cl_{P_N}^- < P_N(x, y) < cl_{P_N}^+$$



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Combination of ranges applies to an area, which is the cross-section specification areas:



Grishja van der Veer (Geochem)

Predicting geographical origin



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The screenshot displays the TraceTool software interface. The main window is titled "TraceTool - by Maritech" and contains a control panel on the left and a map of Europe on the right. The control panel has two tabs: "Heat maps" and "Cross-sections". Under "Heat maps", the "Commodity" is set to "Mineral water". There are four checked items with numerical values: d2H: -80.0, d18O: -7.0, 87Sr/86Sr: 0.715, and d13C: -30.0. Below these are buttons for "Area" (highlighted in red) and "Lines". There are also two unchecked checkboxes: "Elevate polygons by number of hits" and "Color polygons by number of hits", and a "Show on map" button. The "Cross sections" section has three items: "Mineral water | d2H: = -80" (unchecked), "Mineral water | d2H: = -80 | d18O: = -7" (unchecked), and "Mineral water | d2H: = -80 | d18O: = -7" (checked). The map shows a satellite view of Europe with a grid overlay. Large areas in the north and east of Europe are highlighted in red, indicating the predicted geographical origin for the selected commodity and parameters. The interface includes a "maritech" logo at the bottom left, a "Plugin Ready" status bar, and copyright information at the bottom of the map: "© 2010 Google", "© 2010 Tele Atlas", "© 2010 Europa Technologies", and "US Dept of State Geographer". A "6 Trace" logo is visible in the bottom right corner of the screenshot.

Exploitation of TRACE

Industry implementation of isotopic methods for determining geographical origin

- Parmigiano Reggiano PDO cheese consortium (IT)
- Grana Padano PDO cheese consortium (IT)
- Granja Pocitana S.R.L. olive oil (AR)
- Bodega Augusto Pulenta winery (AR)
- Carton Group chicken producer (IE)
- EBLEX (and consortium) beef (UK)
- BPEX implementing isotopic techniques in the pork industry (UK)
- Australian pork industry

Fingerprinting

- Methods developed for verifying:
 - Honey
 - Chicken origin
 - Aging of meat
 - Beer production

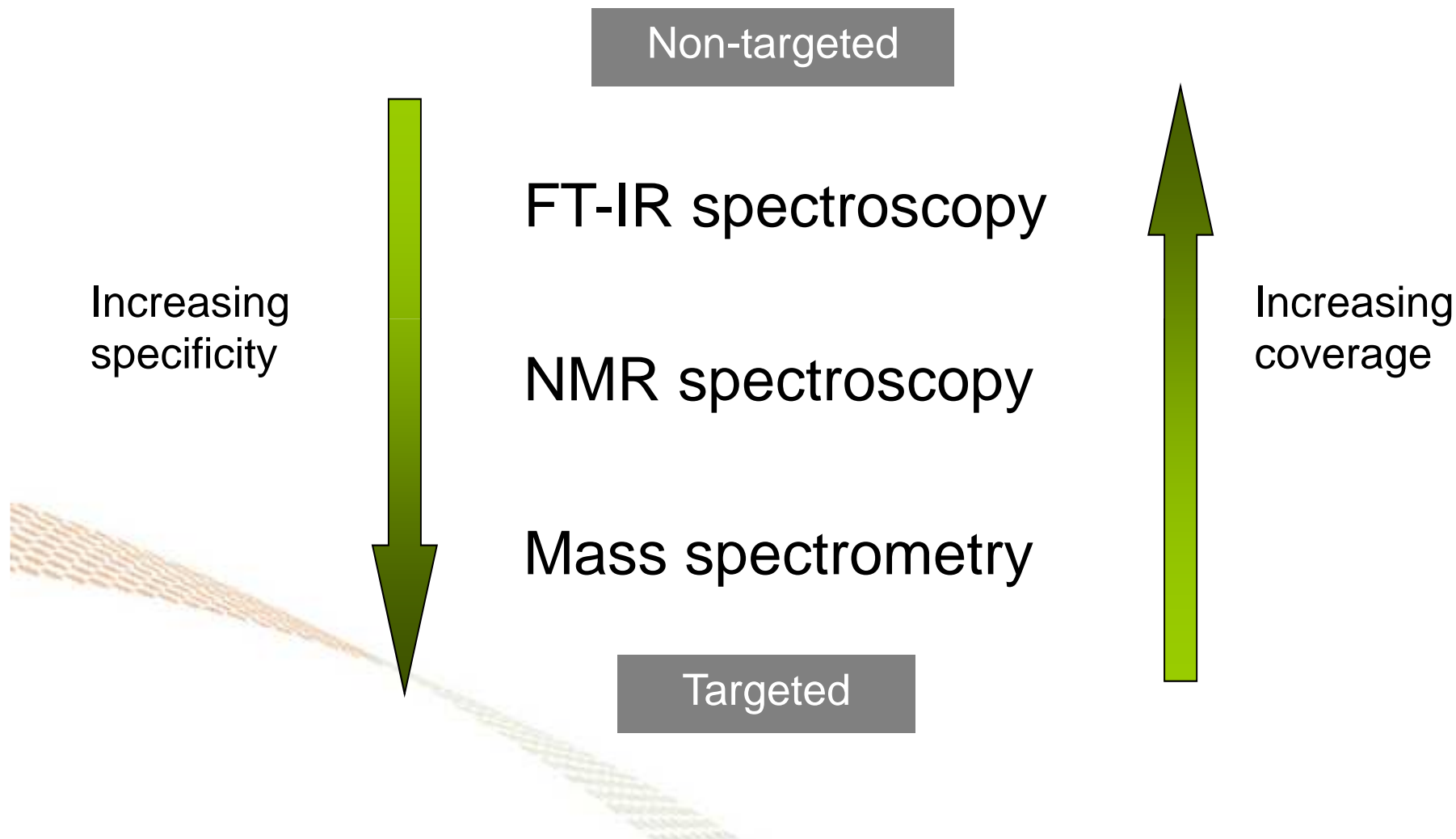


- NIR, FT-IR, H-NMR, DART-MS, LC-MS

Food verification methodology



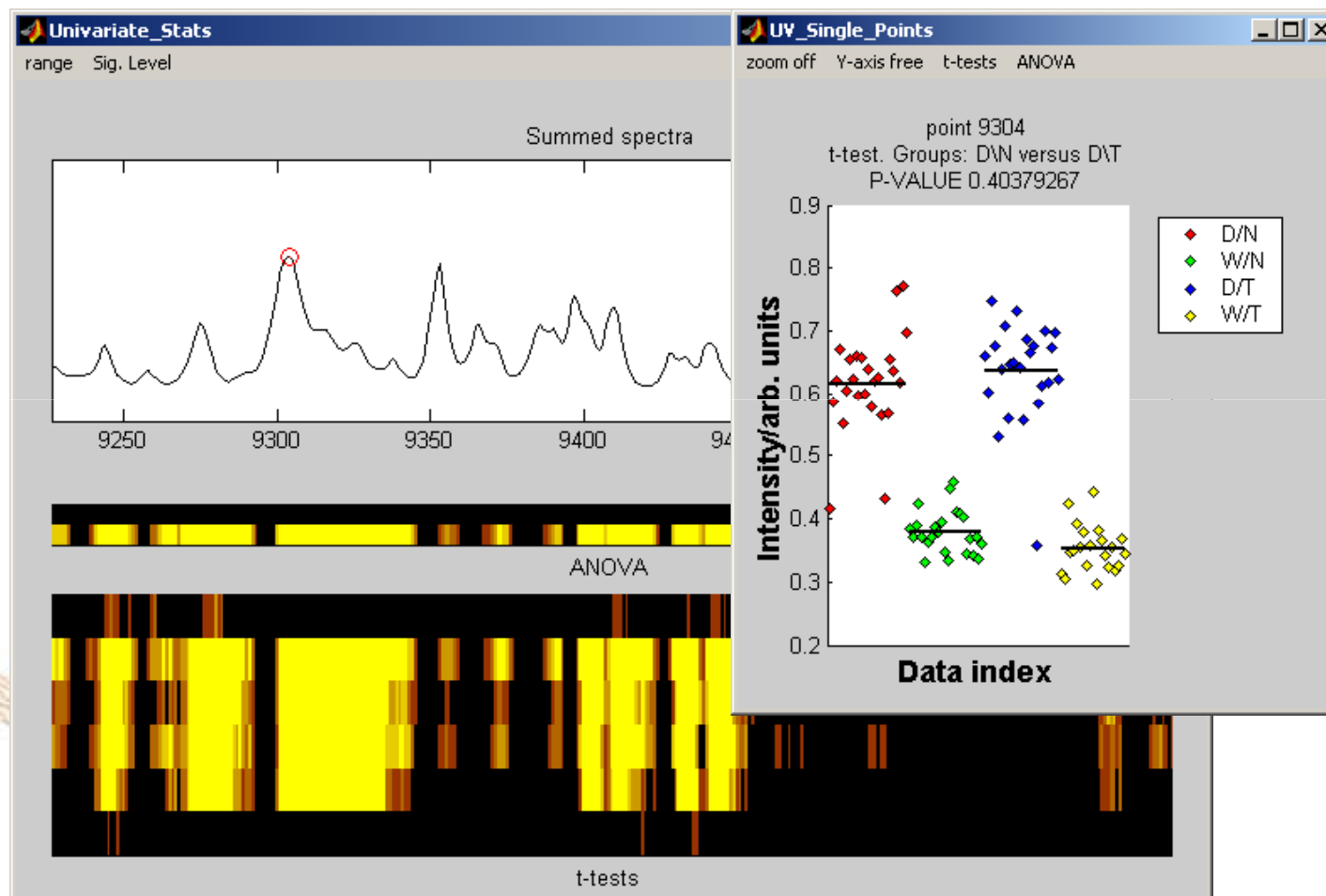
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Data capture/interpretation



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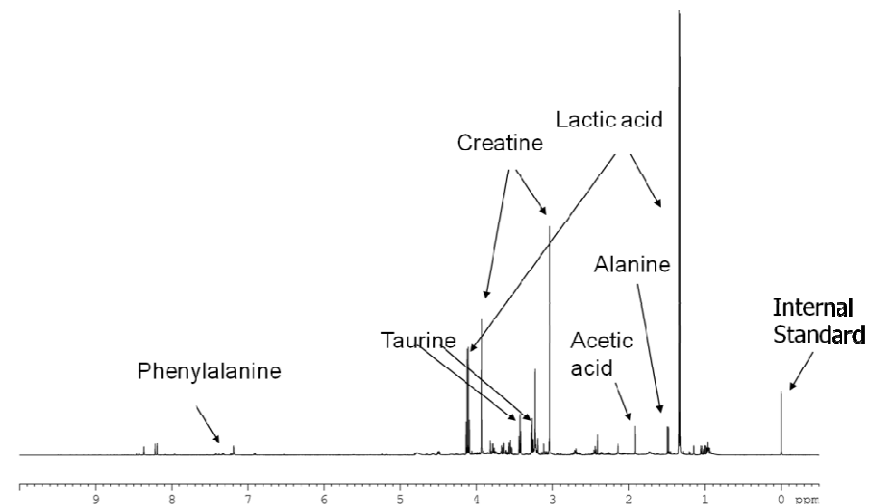


^1H NMR fingerprinting: Meat Aging



- Irish beef labelled as aged for 21 days
- Used as a marketing tool to promote quality of beef.

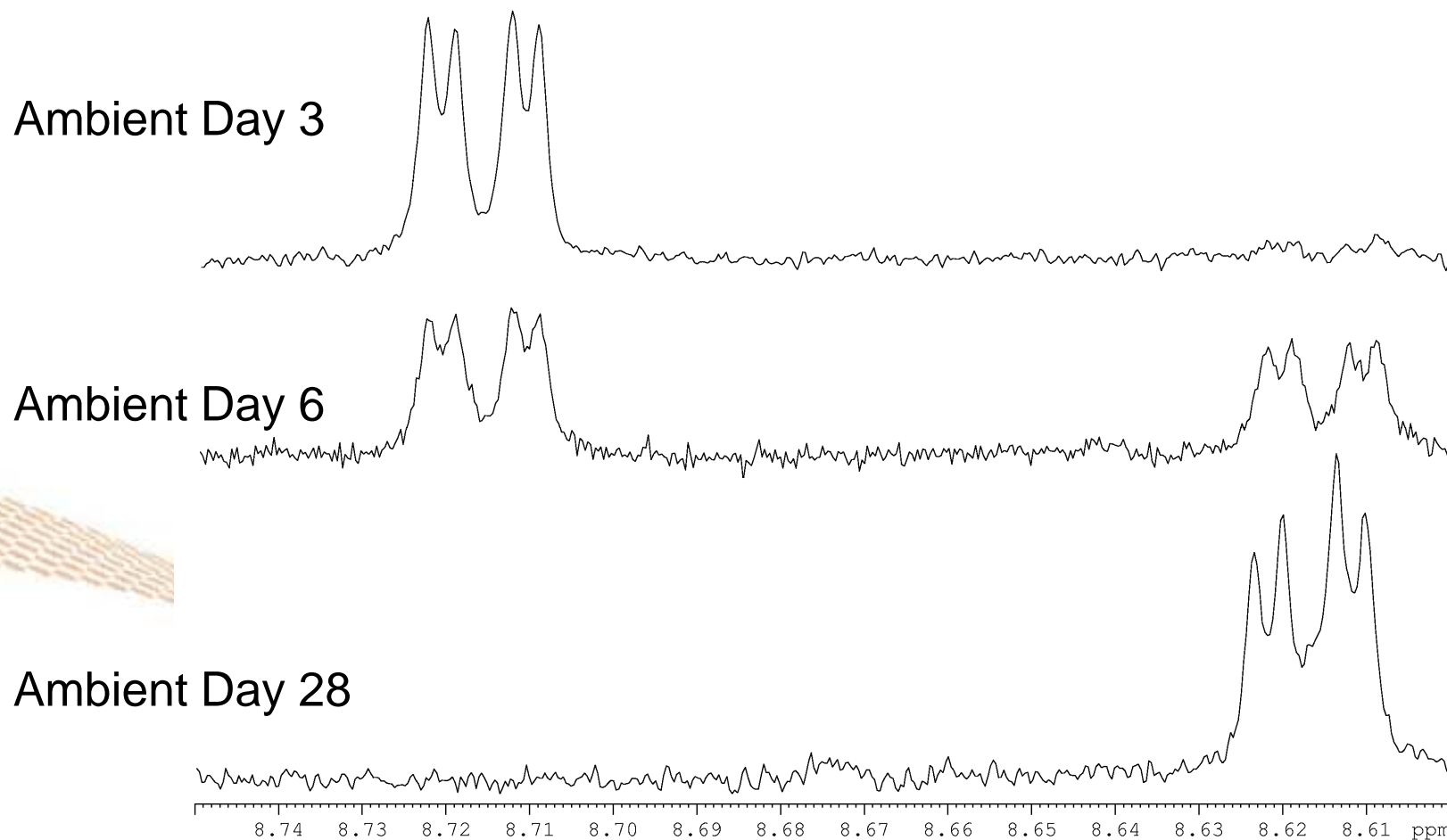
- NMR metabolite profile of meat extract used to determine age and storage conditions



Changes in ^1H NMR spectrum during storage of meat

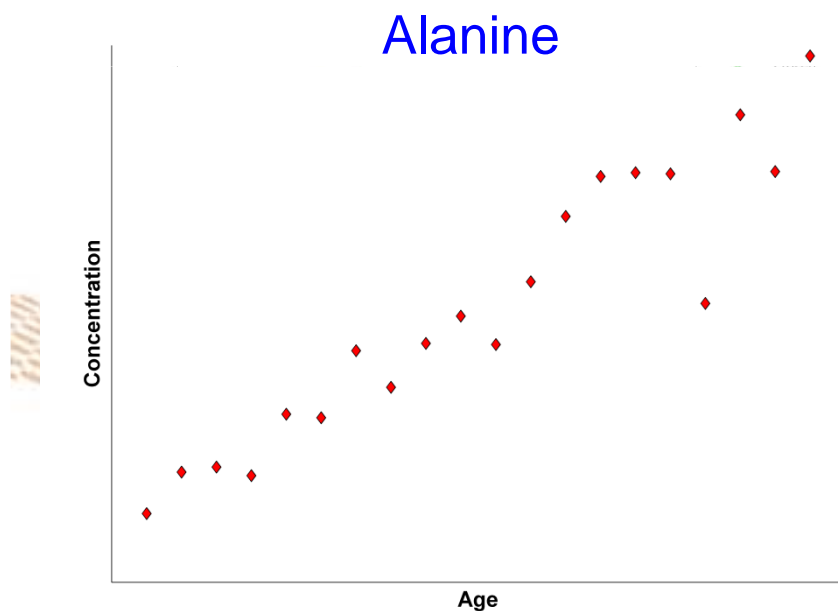


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Metabolic biomarkers.

- Non-targeted profiling of steak extracts using HR ^1H NMR spectroscopy.
- Wet aged meat stored at 4°C studied over 28 days.



- Systematic changes in metabolite concentrations with meat age.
- Rates of change are dependant on storage conditions and specific markers of poor storage were detected.

Molecular biological methods



- Cereals- species-specific padlock ligation probes developed
- Microsatellite approach to cattle breed i.d.
- 16 different real time PCR methods for honey foral type
- Data base of methods, sequences, samples

Molecular biology database

www.trace.eu.org/mbdb



Tracing the origin of food

TRACE - Molecular Biology Database

Overview

Food/Product: Honey

Taxonomy (more...)

Sequence (more...)

PCR (more...)

Primer-sequences

DNA-sequence

SOP

Genetic Element: 18S rRNA

Ampl. Length: 103

Ampl. Position: 700-800

System: Real-Time PCR

PCR Description: Real-Time PCR for the detection of Apis

Temp. Time Program: 10 min / 95 °C Active

Primer-sequences

Primer Name	Type	Sequence	Length [bp]	T _{Ann} [°C]	T _m
ApisRT-F	Sense	CTC Aag ATA ACA gCg TAA TAT C	32	55.8	48.1
ApisRT-R	Antisense	AAA CTT AAA CTA CTg CgC CTA	21	60.4	51.3
ApisRT-prob	Marker/Probe	TAg ACC ATA TAg ATA AAg ATg TTT gC	26	59.6	50.5

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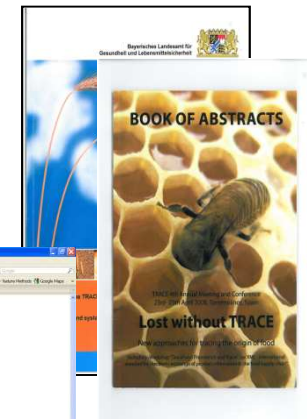
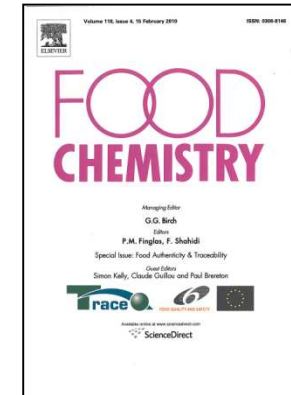
Publications (www.trace.eu.org)



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- 60 peer reviewed papers
- Special TRACE edition of Food Chemistry
- 12 Newsletters
- 2 DVD/videos
- > 200 TRACE presentations
- Fingerprinting booklet

Food Chemistry Special
Edition - Volume 118, Issue 4
– 15 February 2010



Summary

- TRACE has played the lead role in progressing the state of the art for tracing and assuring the provenance of food
- TRACE outputs are being implemented within the food industry and control agencies to enhance consumer confidence and to assure added value to the food sector

Acknowledgements

- Adrian Charlton (Fera)
- Paul Reece (Fera)
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Acknowledgements to the TRACE consortium.....:

