



# Food Integrity with New Analytical Technologies: unlocking the truth

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# The World Leader in Serving Science

**Mission:** We enable our customers to make the world healthier, cleaner and safer.

**\$20B**  
in revenues

**50**  
countries

**>\$900M**  
R&D investment

**>65,000**  
employees

## Our Customer Focus:

We help accelerate innovation and enhance productivity for our customers.

**ThermoFisher**  
SCIENTIFIC

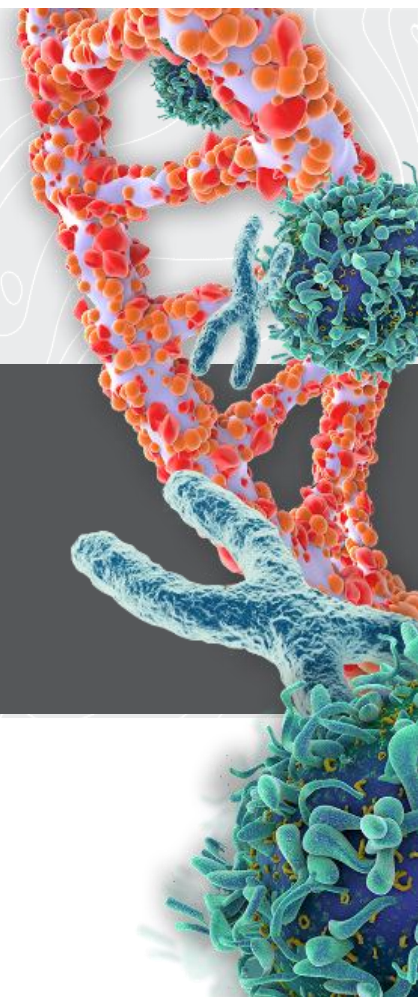
thermo  
scientific

applied  
biosystems

invitrogen

 fisher  
scientific

unity  
lab services



# Fulfilling our mission



Enabling our customers to make the world healthier, cleaner and safer



# Current Topic

Foods prone to fraud

USP  
FOOD FRAUD  
DATABASE



## USP Adds 800 New Records to Food Fraud Database



### 40% of oregano tested was adulterated - Forbrugerrådet Ta

By Joseph James Whitworth

19-Oct-2017 - Last updated on 19-Oct-2017 at 10:15 GMT



- Olive oil, milk, honey, saffron (picture and apple and orange juices most commonly reported to have been fraudulently adulterated)
- May be diluted with cheaper or potent substitute
- Or cheap alternative deliberately mislabeled as luxury ingredient

(\*study didn't examine processed food: breakfast cereals and ready meals)

Source: Global study in Journal of Science



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11 February 2013 Last updated at 12:35

### Horsemeat scandal: How often does food fraud happen?

By Tom de Castella and Brian Wheeler  
BBC News Magazine



# Food Integrity: where fingerprints are strong



## Mislabeled

Mislabelling of fish, meat, fruit and vegetable products is common:

- Wild ↔ farmed
- Origin and feeding diet
- Organic versus inorganic



## Adulteration/Food Fraud

We need to confirm whether a species is present in sample (e.g. *allergies*, *religious taboos*, *lower cost substance*)

- Meat
- Halal Foods
- Plants, Spices
- GMO

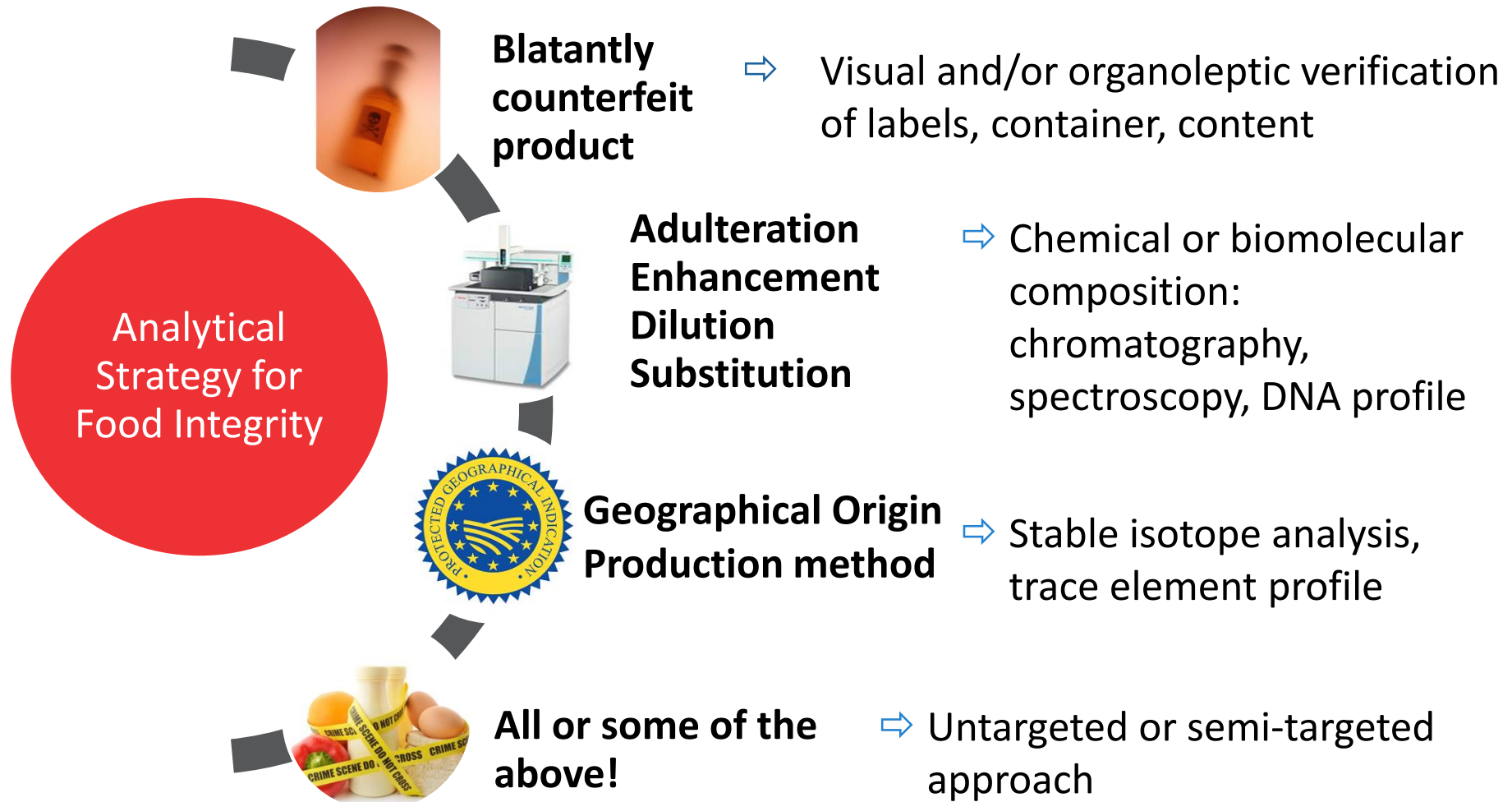


## Authenticity, Origin

We need to confirm the place of origin of a product, label declaration.

- Dairy
- Cheeses
- Plants, Spices

# Choosing the right analytical strategy to reduce the food fraud risk



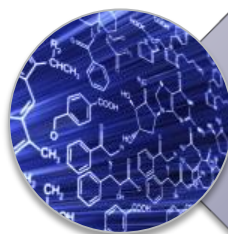


# Food Integrity: where fingerprints are strong

- Food and beverage products have a fingerprint, a unique signature that allows the product to be identified.



**Fraud by addition,  
removal, modification of  
chemical component**



Chemical profiling - spectroscopic techniques IR, NMR, Isotope Ratio Mass Spectrometry (IRMS)



Biomolecular profiling - DNA analyses, NGS (Next Generation Sequencing)

**Fraud by mislabelling,  
substitution of a species**

# DNA Fingerprints for Multi Species ID and Authenticity

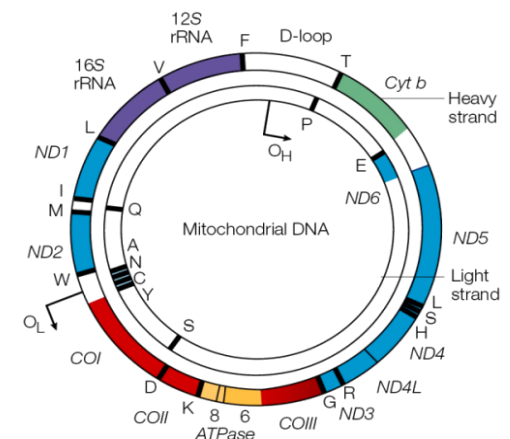
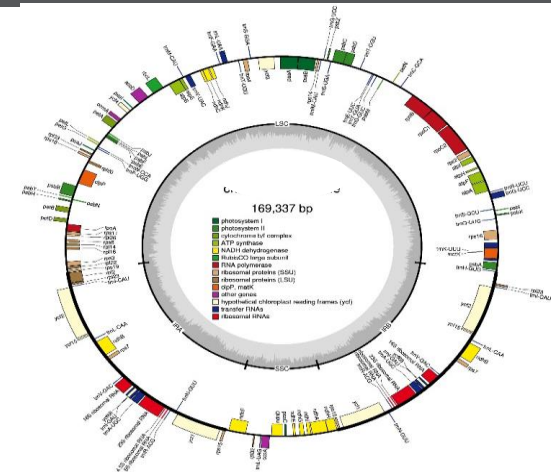
- To visualize this fingerprint, Next Generation Sequencing(NGS) can be used, identifying the DNA fingerprint of the product(s)
- The Genome Is The Fingerprint





# Food Traceability by Ion Torrent™ sequencing

- Ion Torrent™ next generation sequencing can provide
  - Accurate species ID by sequencing of *cytochrome* subunits and other genes (“barcodes”) even in mixed samples
  - Sequencing results show the percentage composition of different species in a sample
- Next generation sequencing can also associate geographic origins of the food
  - Determination of SNP frequencies by GBS of high diversity genes
- NGS can identify the presence of pathogens in a sample
  - 16S gene sequencing for identification of bacterial organisms
  - 18S/ITS gene sequencing for identification of fungal organisms
  - Metagenomics
  - Whole genome sequencing



# Thermo Scientific solutions for Food Industry

## Thermo Scientific™ NGS solutions for Food Integrity:



### Simple

Simple and complete workflows  
for your applications



### Accurate

Reliable accuracy



### Fast

Rapid turnaround times



### Supported

Strong global service  
and support

**Team of 1,300+**

Services and support members

# Thermo Scientific™ NGS solutions for Food Integrity:

- The new **Thermo Scientific™ Multi Species ID System** is a complete, automated, next generation sequencing workflow and software database for multi-species ID to ensure confidence and consumer trust.

## The NGS Food Integrity System includes:



**SGS™ ALL Species  
ID DNA Analyser  
Kits**



**Thermo Scientific™  
Ion Chef™ System**



**Ion GeneStudio™  
S5 System  
Next Generation  
Sequencer**



**Torrent Suite™ and  
SGS™ ALL Species  
ID Analyses  
Software**



# ~45 Minutes Hands-On Time from DNA to Data | Only 2 Pipetting Steps Per Sample



## Automated library construction

### Pipet

sample and primer pools into Ion Chef System for library prep

### Load cartridge

into Ion Chef System

### Pipet

library into Ion Chef System for templating and chip loading

## Automated template preparation

### Load cartridge

into Ion Chef System

## Sequencing

### Transfer chip

to Ion GeneStudio S5 System for sequencing



15 min  
hands-on time



15 min  
hands-on time



15 min  
hands-on time

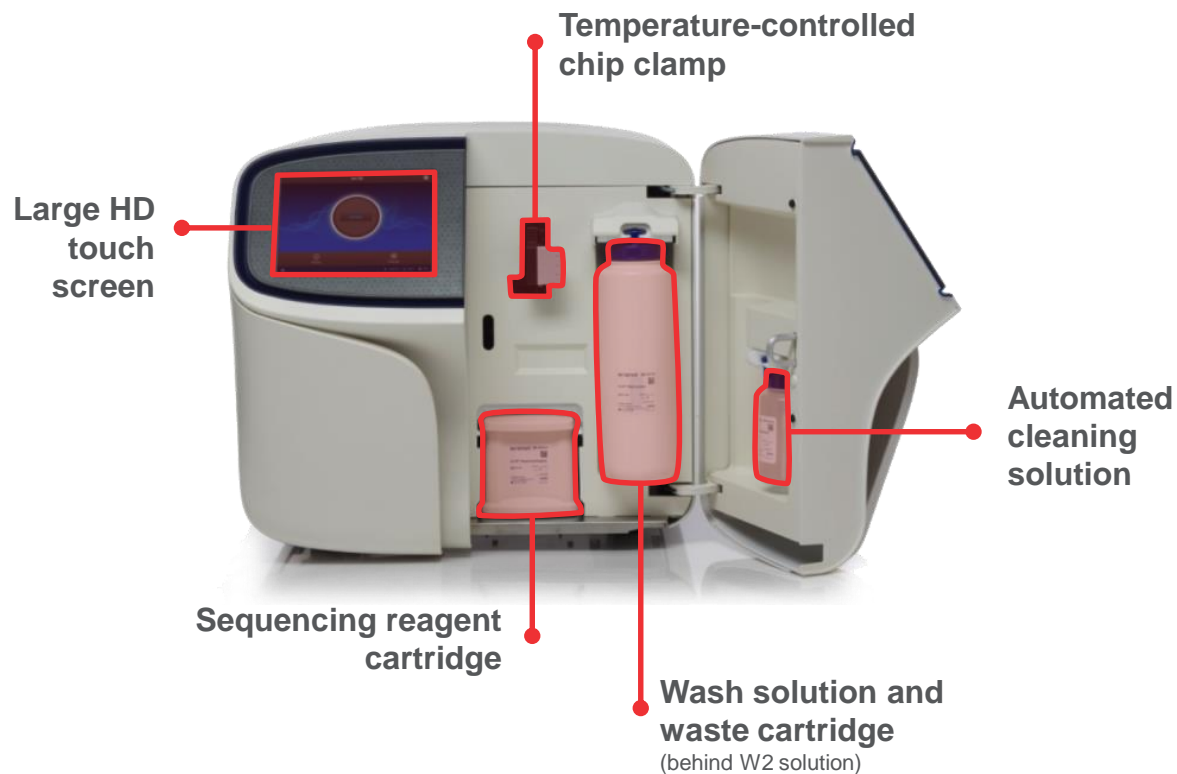
# Plug-and-Play Reagents on Ion GeneStudio S5 Series Systems



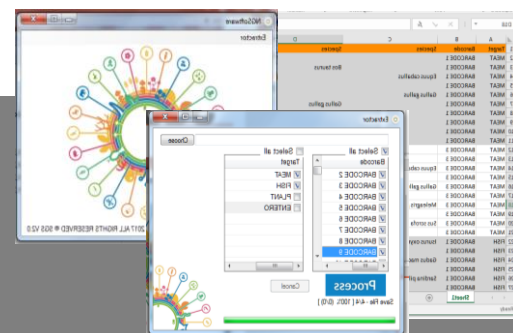
Standard power

~~Gas~~

~~Water~~



# Complete workflow from design to interpretation and confirmation



## Torrent Suite Software

Perform basecalling and alignment for single samples

## Torrent Suite Software

Identify and annotate your variants of interest with public or private databases, and perform multi-sample comparisons

## SGS ALL SpeciesID software

Private databases, and perform multi-sample comparisons on almost any kind of sample



# What is in my Curry powder seasoning?



## SITUATION

- Retailer asked for NGS spices in Curry mixture (containing more than 10 spices according to label)



## RESPONSE

- All the spices except laurel (scientific name *Laurus nobilis*) could be detected
- NGS spices was performed and the majority of the sample (> 90%) was composed by a very similar plant of the laurel family but not *Laurus nobilis* (laurel) - potentially a toxic plant
- The supplier was mixing in the curry preparation not Laurel but something else similar to Laurel but with less than 10% of true laurel

## VALUE DELIVERED



### Rapid Response

Hours to days to sequence sample, and provide accurate analysis back



### Customer Solution

Specific for *Plant Species ID* testing in food



### Increased profitability

Fast and accurate analysis for prevention of intentional adulteration of food supply

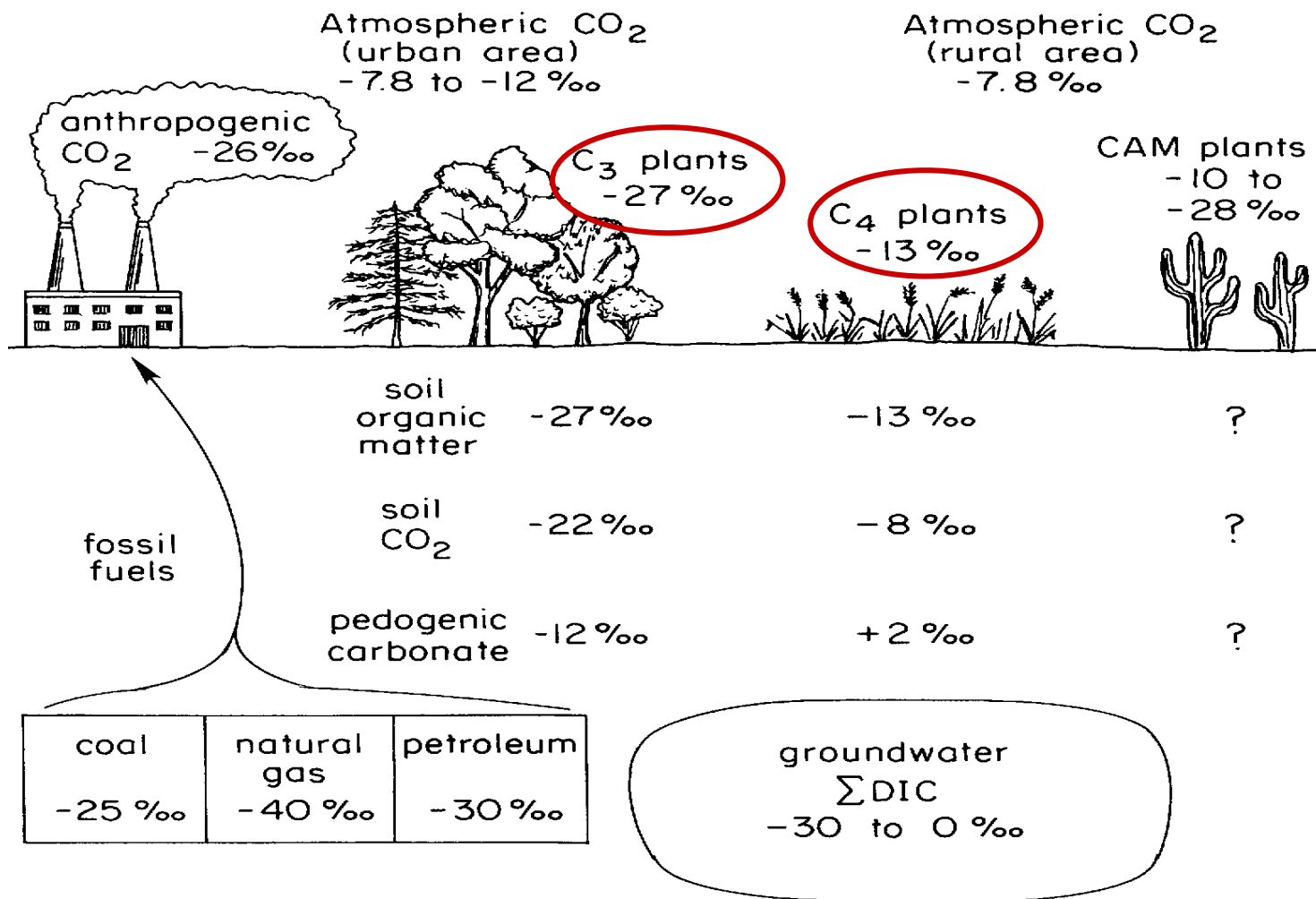
# Isotope Fingerprints for Origin and Authenticity

- To visualize this fingerprint, Isotope Ratio Mass Spectrometry (IRMS) can be used, identifying the isotope fingerprint of the product.
- The isotope fingerprint is region or process specific, which means that products can be **differentiated based on geographical region** (cheese, coffee, sugar, fish and animal feeding areas), **botanical processes** (beans, seeds, olive oil, vanilla), **soil and fertilization processes** (fruits and vegetables) and **fraudulent practices** (sugar addition to honey, watering of wines and spirits).



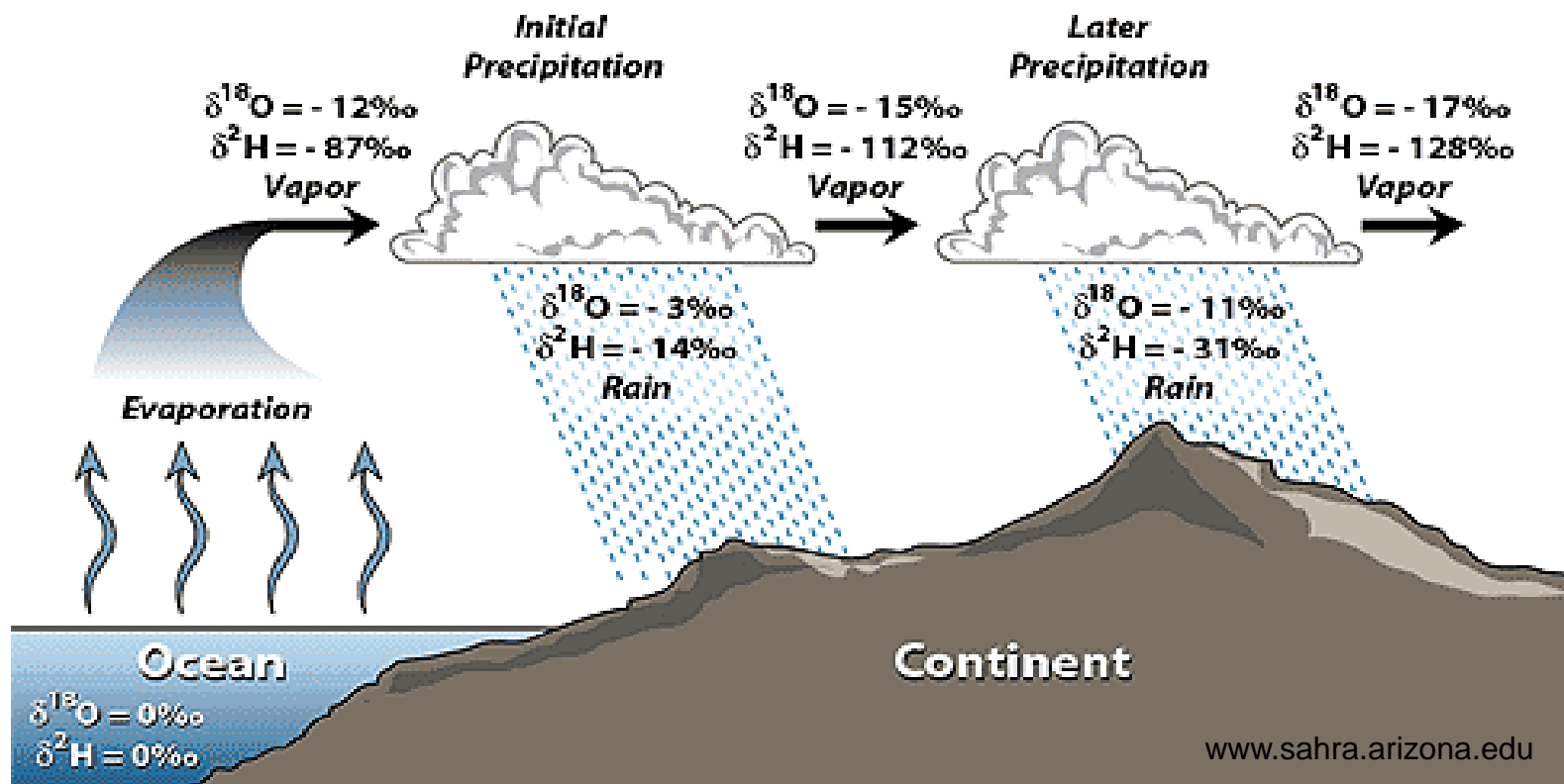


# What can $\delta^{13}\text{C}$ tell us?



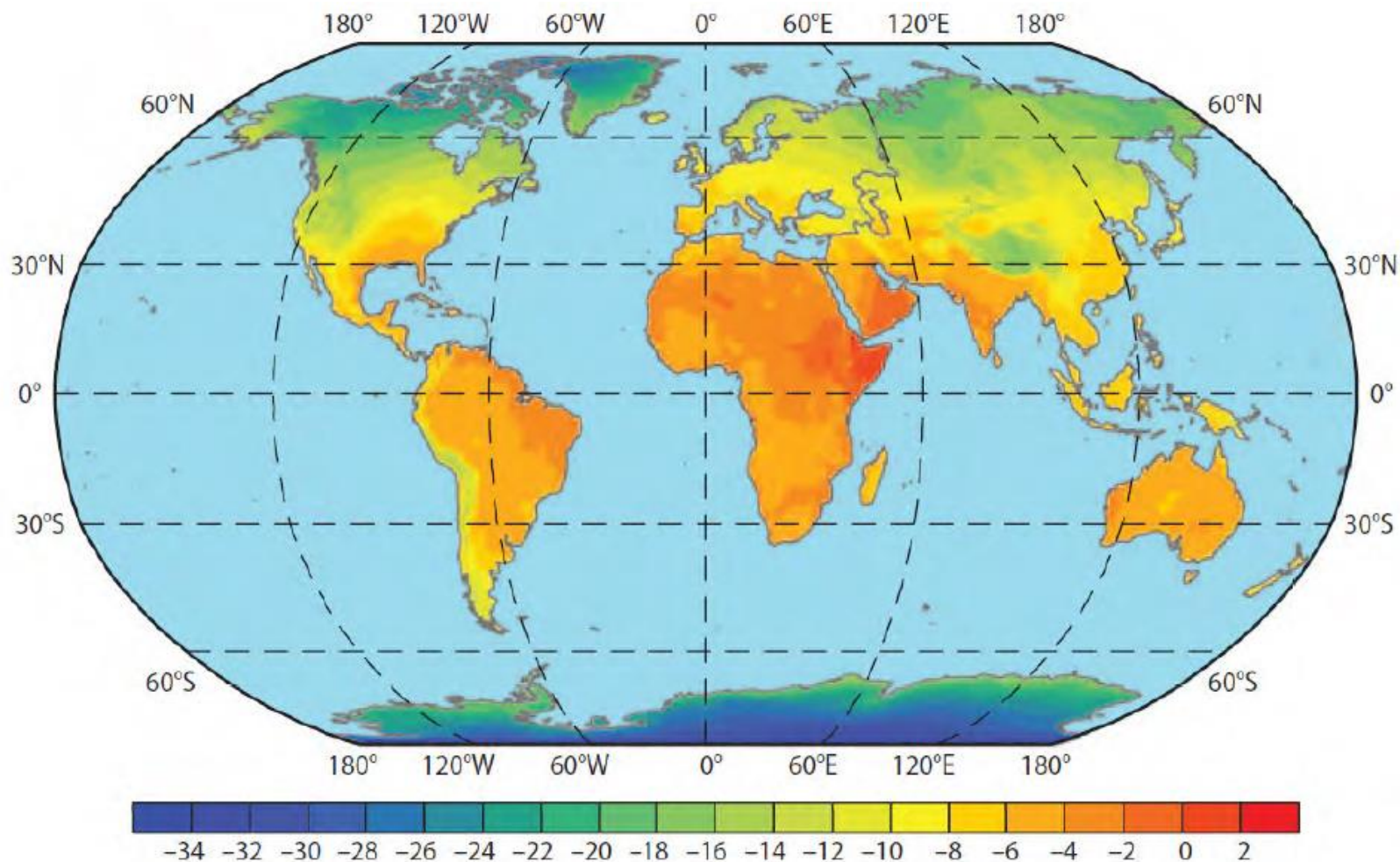
- $\delta^{13}\text{C}$  values differ due to photosynthesis
  - This can differentiate products derived from  $\text{C}_3$  and  $\text{C}_4$  plants

# What can $\delta^2\text{H}$ and $\delta^{18}\text{O}$ tell us?



- Hydrogen and oxygen isotopes change in the water cycle through evaporation, transpiration, sublimation, condensation and precipitation processes, giving rise to unique local – regional signatures, which transfer to biological material during their growth period

# What can $\delta^2\text{H}$ and $\delta^{18}\text{O}$ tell us?





# EA IsoLink IRMS System

- The new **Thermo Scientific™ EA IsoLink™ IRMS System** is an all-in-one fully automated, modular EA–IRMS solution for all CNSOH applications.

*A modular EA-IRMS System fully software supported for CNSOH analyses*

**The EA IsoLink IRMS System includes:**

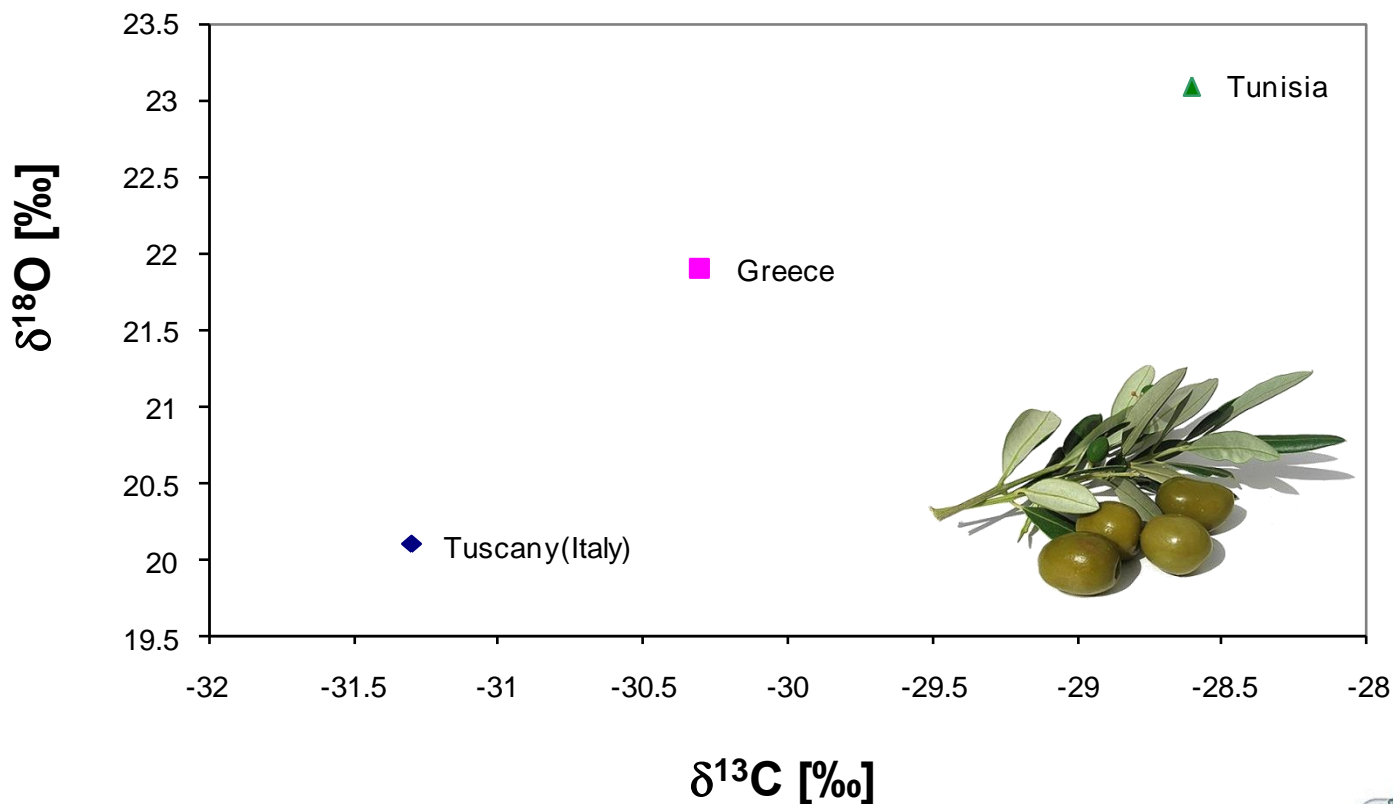
**Thermo Scientific™ Flash IRMS™  
Elemental Analyzer**

**Thermo Scientific™ ConFlo IV™  
Universal Interface**

**Thermo Scientific™ Isotope Ratio  
Mass Spectrometer**

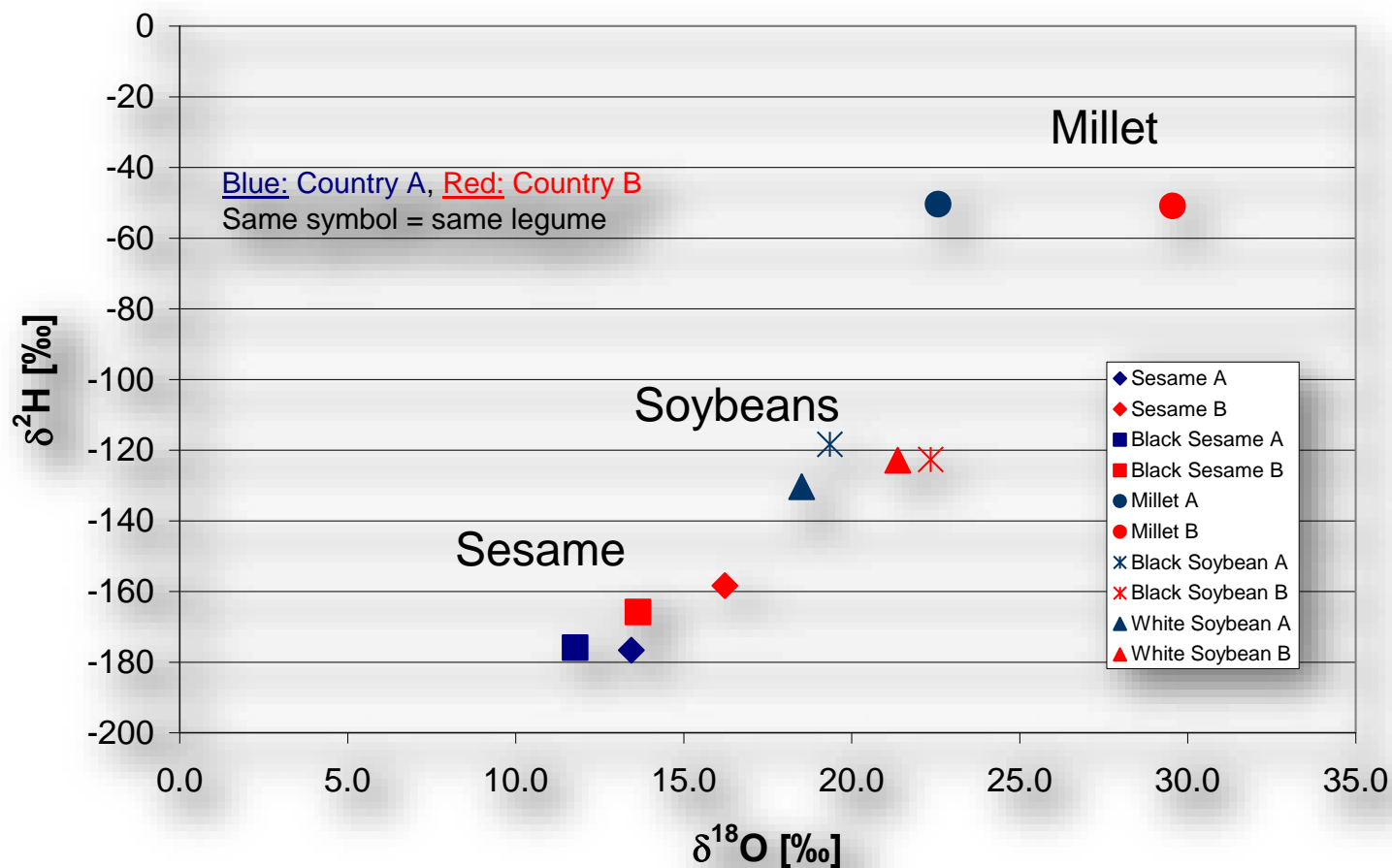


## Where does your olive oil come from?



Data taken from: Giovanni Fronza, et al.  
Rapid Commun. Mass Spectrom. 2001; 15: 763-766

## Agricultural products from Korea (Blue) and China (Red)



# Isotope fingerprints in food and beverage products

## What is the biogeochemical interpretation

## What is an example of food fraud interpretation?

## What products can be affected?

Carbon

Botanical origin (C3, C4 and CAM photosynthesis)

Adulteration (e.g. sweetening with cheap sugar)

Honey, liquor, wine, olive oil, butter, flavors

Nitrogen

Soil processes, plant fertilizer processes

Mislabeling (Differentiate organic and non-organic)

Fruits and vegetables, animal meat

Sulfur

Local soil conditions, proximity to shoreline

Origin of product; Fertilization

Fruits and vegetables, animal meat, honey

Oxygen

Principally related to local-regional rainfall and hence geographical area

Watering of beverages, place of origin of product

Coffee, wine, liquor, water, sugar, animal meat, flavors

Hydrogen

Related to local-regional rainfall and hence geographical area

Watering of beverages, origin of product

Coffee, wine, liquor, water, sugar, animal meat, flavors



## Thermo Scientific™ Isotope Ratio solutions for Food Integrity:

**EA IsoLink™ IRMS System**



**GC IsoLink II™ IRMS System**



**LC IsoLink™ IRMS System**



**GasBench II System**



# Official methods using Isotope Fingerprints

| Product   | Official method     | Isotope fingerprint                          | Sample                                | What does it address?  | Analytical solution   |
|---|---------------------|--|---------------------------------------|--|---|
| <b>Wine</b>   |                     |  |                                       |  |   |
|    | OIV-MA-AS2-12       | $\delta^{18}\text{O}$                        | Water                                 | Adulteration, Geographical origin, Year of vintage                   | Thermo Scientific™ GasBench II System, Thermo Scientific™ Dual Inlet                                |
|   | OIV-MA-AS312-06     | $\delta^{13}\text{C}$                        | Ethanol, Wine must, Grape sugar       | Adulteration, origin   | Thermo Scientific™ EA IsoLink™ IRMS System, Thermo Scientific™ GC IsoLink II™ Interface for GC-IRMS |
|   | OIV-AS312-07        | $\delta^{13}\text{C}$                        | Glycerol in wines                     | Adulteration by addition of glycerol from C4 maize or Fossil sources | GC IsoLink II Interface for GC-IRMS, Thermo Scientific™ LC IsoLink™ Interface for IRM-LC/MS         |
|   | OIV-OENO 510-2013   | $\delta^{13}\text{C}$                        | Acetic acid in wine, vinegar          |  | GC IsoLink II Interface for GC-IRMS, EA IsoLink IRMS System   |
|   | OIV-OENO 510-2013   | $\delta^{18}\text{O}$                        | Water in wine, vinegar                | Adulteration, Geographical Origin, Year of Vintage                   | Thermo Scientific™ GasBench II System, Dual Inlet   |
| <b>Sparkling wine</b>   |                     |  |                                       |  |   |
|    | OIV-MA-AS314-03     | $\delta^{13}\text{C}$                        | CO <sub>2</sub> in sparkling wine     | Origin and authenticity of sparkling wine                            | GasBench II System, EA IsoLink IRMS System, GC IsoLink, Dual Inlet                                  |
| <b>Spirits</b>  |                     |  |                                       |  |   |
|    | OIV-AS312-07        | $\delta^{13}\text{C}$                        | Glycerol in spirits                   | Adulteration by addition of glycerol from C4 maize or Fossil sources | GC IsoLink II Interface for GC-IRMS, LC IsoLink Interface for IRM-LC/MS                             |
| <b>Fruit Juice</b>  |                     |  |                                       |  |   |
|    | EU – CEN 1995       | $\delta^{13}\text{C}$                        | Sugars                                | Adulteration   | GasBench II System, LC IsoLink Interface for IRM-LC/MS, GC IsoLink II Interface                     |
|   | USA – AOAC 1981     | $\delta^{13}\text{C}$                        | Sugars                                | Adulteration   | GasBench II System, LC IsoLink Interface for IRM-LC/MS, GC IsoLink II Interface                     |
|   | EU – CEN 1998       | $\delta^{13}\text{C}$                        | Sugars and pulp                       | Adulteration   | GasBench II System, LC IsoLink Interface for IRM-LC/MS, GC IsoLink II Interface                     |
|   | EU – CEN 1995       | $\delta^2\text{H}$ and $\delta^{18}\text{O}$ | Water                                 | Adulteration   | GasBench II System, LC IsoLink Interface for IRM-LC/MS, GC IsoLink II Interface                     |
|   | AOAC method 2004.01 | $\delta^{13}\text{C}$                        | Ethanol (From Fermentation)           | Adulteration   | GasBench II System, LC IsoLink Interface for IRM-LC/MS, GC IsoLink II Interface                     |
| <b>Fruit Juice (Concentrate)</b>  |                     |  |                                       |  |   |
|  | AOAC 1992           | $\delta^{18}\text{O}$                        | Water                                 | Adulteration   | GasBench II System, LC IsoLink Interface for IRM-LC/MS, EA IsoLink IRMS System                      |
| <b>Honey</b>  |                     |  |                                       |  |   |
|  | AOAC method 991.41  | $\delta^{13}\text{C}$                        | C-4 plant sugars at concentration >7% | Adulteration of honey  | EA IsoLink IRMS System  |
|   | AOAC method 998.12  | $\delta^{13}\text{C}$                        | C-4 plant sugars at concentration >7% | Adulteration of honey  | EA IsoLink IRMS System  |
| <b>Cheese</b>   |                     |  |                                       |  |   |
|  | EU Reg 548/2011     | $\delta^{13}\text{C}$                        | PDO                                   | PDO Grana Padano   | EA IsoLink IRMS System  |

## A Mission We are Proud Of



We enable our customers to make the world healthier, cleaner and safer.



Investigate more....

[thermofisher.com/foodintegrity](http://thermofisher.com/foodintegrity)



**TRUST**

your foods are all they should be.

Food adulteration and authenticity testing brochure