

SmartNotes

QA

How can stable isotopes be used to determine origin and authenticity of food and beverage products?

Food and beverage products have a fingerprint, a unique chemical signature that allows the product to be identified. To visualize this fingerprint, Isotope Ratio Mass Spectrometry (IRMS) can be used, identifying the isotope fingerprint of the product. The **isotope fingerprint** in food and beverage products is region or process specific (Table 1), 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). These processes can be traced using **carbon, nitrogen, sulfur, oxygen and hydrogen** isotopes, with their variations indicating the origin and history of food and beverage products.



Table 1. Isotope fingerprints in food and beverage products.

Isotope fingerprint	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	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

Production through to consumer: the spectre of economically motivated fraud

Complexities in the food and beverage supply chain from the production site through to the consumer have presented significant, and at times relatively easy, opportunity for economically motivated fraudulent activities to occur and be undetected. This means product adulteration, replacing a higher quality, original material with one of lesser quality, or extending a product by adding an adulterant and product mislabelling, including misrepresenting product origin and ingredients. Collectively, this affects consumer confidence, product brand reputation and may have a positive, or negative, impact on manufacturer revenue, depending on the source of adulteration. Consequently, there is an increase in retailer and consumer demand to see proof that food and beverage products are what the label claims them to be, including origin, authenticity and ingredient verification.

Legislation has been enacted globally to protect food and beverage products with respect to production processes and product labelling, either at the country level or cross-country level, such as in the European Union. For example, certifications on production practice and geographical origin add value to products, such as Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Specialty Designation (TSG). The combination of legislation and food fraud practices demands a reliable analytical technique that can verify the origin, authenticity and label claims of food and beverage products.



Analytical solution: detecting isotope fingerprints

Using **isotope fingerprints**, food and beverage origin, authenticity and product label claims can be verified in a unique way. Isotope Ratio Mass Spectrometry (IRMS) works by detecting the “isotope fingerprint” of a sample, a unique chemical signature that changes from sample to sample. There are a number of approaches to preparing food samples for isotope analysis, however, the fundamental process for IRMS is the conversion of a solid or liquid sample to a gas under high temperature. In the case of EA-IRMS and GC-IRMS the conversion of the sample to a gas is performed by two processes: combustion and pyrolysis. Combustion, burning the sample at around 1000 °C with oxygen, is used to evolve carbon, nitrogen and sulfur from the sample in the form of N₂, CO₂ and SO₂. Pyrolysis, breaking down the sample at 1400 °C in a reductive environment, is used to evolve hydrogen and oxygen from the sample, in the form of H₂ and CO. After the gases are produced, they are separated from one another using gas chromatography and then transferred in a continuous gas flow to a detector that measures the isotope fingerprint of the sample.

Food and beverage samples can be introduced into the Isotope Ratio Mass Spectrometer and analyzed for their isotope fingerprint via various analytical peripherals, for example an elemental analyzer or using a gas or a liquid chromatography interface.

The dedicated solutions of the Thermo Fisher Scientific™ stable isotope portfolio are designed to offer different capabilities and performances, with dedicated features for the coupling to the Thermo Scientific™ IRMS Systems, according to the varying analytical needs of modern laboratories working for routine and research applications:

- the Thermo Scientific™ EA IsoLink™ IRMS System, for analysis of bulk samples
- the Thermo Scientific™ GC IsoLink II™ Interface for GC-IRMS, for analyzing specific compounds from a bulk sample
- the Thermo Scientific™ LC IsoLink™ Interface for IRM-LC/MS, for analyzing specific compounds from a bulk sample in liquid form
- the Thermo Scientific™ GasBench II System, for the analysis of gas samples from beverages



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