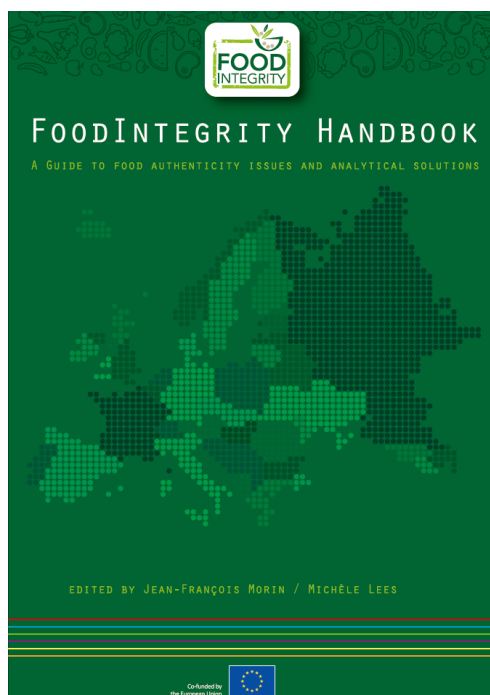


FOODINTEGRITY HANDBOOK

A GUIDE TO FOOD AUTHENTICITY ISSUES AND ANALYTICAL SOLUTIONS

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Further reading

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The FoodIntegrity Network, a group that had members representing the key stakeholders impacted by food fraud (regulators, industry, academics, research providers and customers) was used to identify key areas where scientific guidance was required. The output from this was the production of several opinion papers. The aim of the scientific opinions produced as part of the FoodIntegrity project was to provide independent scientific advice and communicate to all interested parties on topical issues concerning food integrity. The scientific opinions provide objective, science-based advice, and clear and coherent communication, grounded in the most up-to-date scientific knowledge and data. These opinions are recommended as further reading. The titles, an abridged abstract and the corresponding author are contained below. At the time of writing, several of these papers are under peer review and it is expected that these will be available in open access journals at the time of reading.

Stable isotope techniques for verifying the declared geographical origin of food in legal cases

Corresponding Author: Federica Camin (Department of Food Quality and Nutrition, Research and Innovation Centre, Fondazione Edmund Mach (FEM))

Consumers are increasingly interested in the provenance of the foods and European laws require protection against the mislabelling of premium foods. Methods for testing authenticity require robust analytical techniques that can be utilised by the various regulatory authorities. Of the many techniques, the most widely-used method is stable isotope ratio analysis. Scope and approach: Focus is on the use of stable isotope ratios of H, C, N, O, S and Sr for verifying the geographical origin of food, cross-referencing it with examples of legal cases. State of the art including rules for building an authentic sample reference database (commonly called databank) and for interpreting the results obtained in actual cases is described. The overall objective is to provide stakeholders and competent authorities dealing with fraud, with a best-practice guide for its use. Key findings and conclusions: Stable isotope ratios can differentiate foods on the basis of their geographical origin and, especially for light elements, can be measured reliably in routine work in different matrices and compared successfully between different laboratories. Examples of legal applications are grape products, orange juices, olive oil, cheese, butter, caviar. Sometimes, the cases are not brought directly to the court, but before further verifications (e.g. paper traceability, forensic accounting) are conducted. The system can satisfy the court when a robust databank of authentic samples exists, the methods used are officially recognized, validated and accredited, and the expert demonstrates that the conclusions are sufficiently robust and reliable to stand up to the required level of proof.

Role of analytical testing for food fraud risk mitigation – principles of cost-benefit determination for analytical fraud testing

Corresponding Author: Francis Butler (University College Dublin)

Food fraud is of high concern to the food industry. A multitude of analytical technologies exist to detect fraud. However, this testing is often expensive. Available databases detailing fraud occurrences were systematically examined to determine how frequently analytical testing triggered fraud detection. A framework was developed for deciding when to implement analytical testing programmes for fraud and a framework to consider the economic costs of fraud and the benefits of its early detection. Current regulatory issues relating to food fraud detection are explored as well as some of the main factors associated with statistical sampling for fraud detection.

What are the scientific challenges in moving from targeted to non-targeted methods for food fraud testing and how can they be addressed? – Spectroscopy case study

Corresponding Author: Terry F. McGrath (Institute for Global Food Security, ASSET Technology Centre, School of Biological Sciences, Queen's University Belfast, Northern Ireland, United Kingdom)

Background: The authenticity of foodstuffs and associated fraud has become an important area. It is estimated that global food fraud costs approximately \$US49b annually. In relation to testing for this malpractice, analytical technologies exist to detect fraud but are usually expensive and lab based. However, recently there has been a move towards non-targeted methods as means for detecting food fraud but the question arises if these techniques will ever be accepted as routine.

Scope and approach: In this opinion paper, many aspects relating to the role of non-targeted spectroscopy based methods for food fraud detection are considered: (i) a review of the current non-targeted spectroscopic methods to include the general differences with targeted techniques; (ii) overview of in-house validation procedures including samples, data processing and chemometric techniques with a view to recommending a harmonized procedure; (iii) quality assessments including QC samples, ring trials and reference materials; (iv) use of “big data” including recording, validation, sharing and joint usage of databases.

Key findings and conclusions: In order to keep pace with those who perpetrate food fraud there is clearly a need for robust and reliable non-targeted methods that are available to many stakeholders. Key challenges faced by the research and routine testing communities include: a lack of guidelines and legislation governing both the development and validation of non-targeted methodologies, no common definition of terms, difficulty in obtaining authentic samples with full traceability for model building; the lack of a single chemometric modelling software that offers all the algorithms required by developers.

The scientific challenges in moving from targeted to non-targeted mass spectrometric methods for food fraud analysis: A proposed validation workflow to bring about a harmonized approach

Corresponding Author: Michele Suman (Barilla Advanced Laboratory Research Parma, Italy)

Background: Detecting and measuring food fraud is a challenging analytical task since a very wide range of food ingredients and types may be adulterated by numerous potential adulterants, many of which are yet unknown. To date most of the methods applied for the control of food fraud are targeted methods, which are focused on the detection of one or a few classes of known compounds.

Scope and approach: There is an increasing availability of solutions and applications based on high resolution mass spectrometry (HRMS), allowing parallel non-targeted approaches, novel compound identification and retrospective data analysis. For these types of methods sample-handling must be minimal to allow the inclusion of as many as possible chemical categories. However data-handling of such methods is much more demanding, together with the potential requirement to integrate multiplatform data as well as conducting data fusion. To allow the processing of massive amounts of information based on the separation techniques and mass spectrometry approaches employed, effective software tools capable of rapid data mining procedures must be employed and metabolomics based approaches does appear to be the correct way forward. To verify the relevance of modelling results, appropriate model validation is essential for non-targeted approaches, confirming the significance of the chemical markers identified.

Key findings and conclusions: The present paper is devoted to review and assess the current state of the art with regards non-targeted mass spectrometry in food fraud detection within many food matrices and to propose a harmonized workflow for all such applications.

Sampling guidelines for building and curating food authenticity databases

Corresponding Author: James Donarski (Fera Science Ltd, York, UK)

Background: Food fraud is a global issue and one that can often be detected through the use of analytical testing. Analysis of suspect foodstuffs and comparison of their results to those contained within a food authenticity database is a typical approach. This scientific opinion was commissioned as part of the FoodIntegrity EU project to provide guidance for the creation of these food authenticity databases.

Scope and Approach: This opinion paper provides what the authors believe are the most important considerations which must be addressed, when creating a food authenticity database. It covers three broad sections, relating to aspects that need to be considered before, during and after the analytical data has been collected. Specifically, the areas of database scope, analytical methodology, sampling, collection and storage of data, validation and curation are discussed.

Key Findings and Conclusions: The globalisation of foodstuffs brings new and novel commodities to consumers throughout the world. When foodstuffs are new to a specific population, it can be the case that consumers or even inspection laboratories cannot easily recognise when a fraud has taken place. The provision of available, reliable and robust food authenticity databases is a tool in preventing such fraud. This opinion was produced to facilitate the sharing of these databases.

Use of NMR applications to tackle future food fraud issues

Corresponding Author: Luisa Mannina (Institution Dipartimento di Chimica e Tecnologie del Farmaco, Sapienza Università di Roma)

Background. NMR targeted and untargeted methodologies are widely recognized as important tools for food authentication and the detection of counterfeit products. Targeted approaches allow the identification of specific markers of identity/adulteration for a given foodstuff. In the untargeted approach, the chemical profile of the whole foodstuff is used to create a unique fingerprint as a reference for suspect samples. The untargeted analysis methodology typically follows the metabolomics approach.

Scope and Approach. In this manuscript we discuss how both targeted and untargeted NMR methodologies are applied in routine use for food fraud monitoring. The cost effective approaches for routine application are discussed using examples of Food Screener™ and benchtop low-field instruments. Key Findings and Conclusions. Several examples of routine consolidated NMR targeted and untargeted applications are reported and the food matrices that are problematic for the NMR application are discussed. The future NMR implementation into routine practice will rely on the further exploration of FoodScreener™ like platforms for simultaneous targeted and untargeted applications and the continued development of applications for low-field benchtop instrumentation.

The future of NGS (next generation sequencing) analysis in testing food authenticity

Corresponding Author: Edward Haynes (Fera Science Ltd, York, UK)

Food authenticity is a big concern for consumers, food authorities and food producers and processors, since incorrect food labelling and other types of fraudulent practices have been demonstrated to negatively affect the confidence and even the safety of the final consumer. European Union regulation (EU) No. 1169/2011 requires that consumers should be appropriately informed regarding the food they consume. This is vital in order to achieve a high level of health protection and to guarantee their right to information, as well as to protect the businesses of scrupulous producers from unfair competition. Consumers' choices can be influenced by health, economic, environmental, social and ethical considerations. In fact, the general dictionary definition of "authenticity" is "the quality of being authentic, trustworthy, or genuine", and the relevant dictionary definitions of "authentic" include "not false or copied; genuine; real" and "having an origin supported by unquestionable evidence; authenticated; verified". More specifically regarding food authenticity, a recently produced CEN standard defines authenticity in a food and feed context as the match between the *food product characteristics and the corresponding food product claims* (CEN WS86). These labelling requirements, which are legally specified and differ depending on the product, may include the scientific name or breed, and production method (e.g. organic, free-range, wild-caught etc.). However, other features of the product can also be included by producers to inform the consumer, including (i) ethical issues (halal, vegetarian, etc.), (ii) nutritional composition (vitamins, omega 3, etc.), (iii) the area where the product was caught or farmed (for sustainability reasons, or with particular regard to EU legislation regarding protected designation of origin (PDO), protected geographical indication (PGI), traditional specialities guaranteed (TSG) etc.), (iv) status of the product (such as whether the product has been previously frozen and defrosted) and (v) the presence of undeclared ingredients that can also represent a health risk for the consumer (allergens such as gluten, nuts, etc.).