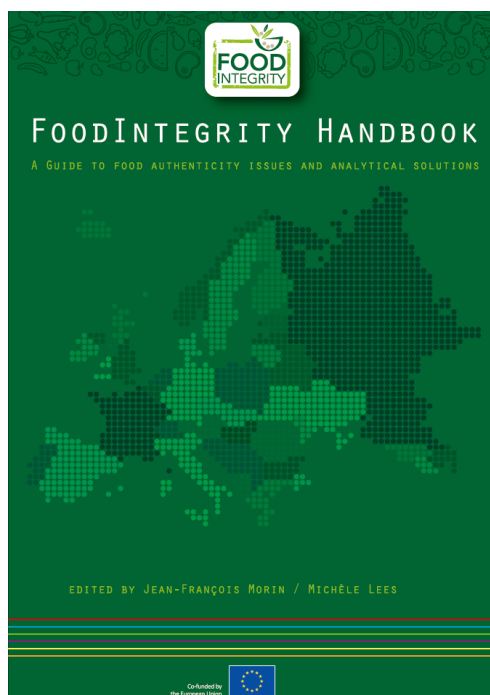


# FOODINTEGRITY HANDBOOK

## *A GUIDE TO FOOD AUTHENTICITY ISSUES AND ANALYTICAL SOLUTIONS*

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ISBN      *print version*                      978-2-9566303-0-2  
              *electronic version*                978-2-9566303-1-9

<https://doi.org/10.32741/fihb>

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## **Foreword by Mr. Van Goethem**

**Director DG Health and Food Safety, European Commission**

The past half a century has seen a revolution in the way that food is produced, processed and marketed. Today, EU citizens are accustomed to choice, convenience, quality, and competitive prices when it comes to the food they buy.

The complex nature of our globalized food supply chains and the economic motivation to provide cheaper food products have contributed to the growing problem of food fraud, with recent scandals such as horse meat in beef products drawing worldwide attention. Fraudsters are becoming increasingly inventive in the deceptive tactics they are deploying to take advantage of the sophisticated nature of food supply chain. Because of its complexity and worldwide reach, reining in food fraud requires a collaborative effort between industry and government agencies. Preventive systems identifying problems at an early stage, preparedness at all levels and coordination are essential.



In this respect, the European Commission has taken action in creating the EU Food Fraud Network. EU Member States, supported by a dedicated IT system, can now rapidly exchange information on potential cross-border fraud. The Knowledge Centre for Food Fraud and Quality created on 13 March 2018 and operated by the Commission's Joint Research Centre complements the EU Food Fraud Network by providing an interface between science and policy-making.

At industry level, many companies have already implemented ways to counter global fraud threats, but more needs to be done. Industry alarms should go off whenever a commodity suddenly floods the market at a too-good-to-be-true price. New analysis tools are appearing to help alert industry and regulators in real time to potential problems. Some of the responsibility also falls upon consumers to remain vigilant and speak up when they witness what they believe to be fraudulent practices. Manufacturers can support this effort by helping consumers identify issues, giving them the resources to identify fraudulent products so that they know what to look for to avoid these products. Transparency and data-sharing between national governments, agencies and industry is key to detect and prevent fraudulent practices. The Food Integrity Project contributes to this goal by gathering experts from industry, academia, research institutes, technology providers and a global network of stakeholders. It is an international focal point for harmonisation and exploitation of research and technology for insuring the integrity of European food.

Thanks to thorough and detailed guidance, this Food Integrity Handbook will be an important resource to all of us when looking for information on food authenticity issues and will help to create a trusted food sector. The authors and all those who contributed to the handbook deserve special recognition for their work.

# **Foreword by Pr. Christopher Elliott OBE**

## **Founder of the Institute for Global Food Safety Queen's University of Belfast**

The first handbook on food authenticity was published 20 years ago and it is quite remarkable to track the events that have unfolded over this period of time. Food authenticity or food fraud or as sometimes referred as food crime has become a widely discussed issue in many parts of the world. The melamine scandal in China dating back a decade now seems to have been the trigger to alert many stakeholders in governments, food industries and more importantly the general public of the impact cheating in the global food supply system can have.



The new edition of the handbook has sought to address the growing complexities of food and drink authenticity. It seems the ingenuity of those who set out to cheat us all knows no bounds. It also seems that virtually everything we eat and drink has some vulnerability to fraud and that individuals and potentially organised crime gangs will try to exploit these.

A major element in the fight against fraud is the development, validation and implementation of novel methodologies that can detect and often quantify the level of cheating that has occurred. There have been many innovations in analysis over the past two decades and the handbook gives some excellent examples of these and how they can be applied.

Another interesting and very worthwhile addition to this handbook is the horizon scanning which the authors have conducted. What will be the major challenges over the next 20 years and how will analytical science provide some of the solutions.

# Introduction

The first “handbook” of this type dealing with food authenticity was published in 1998, the result of European collaboration through the EU-funded Concerted Action FAIM<sup>1</sup> which brought together over fifty scientists from food research institutes, from industry, from regulation authorities and from private laboratories. Their aim was to review the authenticity issues current at that time and to investigate the availability of analytical methods to address those concerns. The FAIM handbook contributors are given a special mention in the Acknowledgements section at the end of this book.

Twenty years on, through another, albeit much larger, European funded project, Food Integrity<sup>2</sup>, a similar group of scientists have collaborated to produce an updated handbook on food authenticity issues and related analytical methods. A lot has changed in twenty years. The Food Integrity Handbook is not simply a revised version of the earlier FAIM book but does complement it in several ways. It has retained a very similar structure, which is repeated throughout the different chapters. On the other hand, it deals with a wider range of food products; it includes chapters on eggs and egg products, nuts, nut products and seeds, plant-derived sweeteners, spices, wines, spirit drinks, tea, flavourings and gelatine, in addition to the main food commodities - cereals, coffee, dairy products, fish and meat products, fruit juices, honey, oils and fats – dealt with in the FAIM Handbook. In addition this new Handbook does not have a separate chapter on the use of Chemometrics in food authenticity studies, which in the FAIM book reviewed some of the most important and useful concepts in multivariate chemometric/statistical methods. Two decades ago such concepts were still fairly new in food science whereas today they are widely used in the analytical field.

The Food Integrity Handbook has been written for food business operators and is primarily aimed at quality control managers working in food production and to those actors involved in the food supply chain. It may also be useful to young scientists starting their career in food science and to students and researchers with little prior knowledge of the area. The first section of this book provides the definitions of Food Authenticity and the different concerns that constitute Food Fraud, compiled in connexion with the work being undertaken in the Authent-Net project<sup>3</sup> to establish a European voluntary standard (a CEN Workshop Agreement, or CWA) entitled "Authenticity in the feed and the food chain - General principles and basic requirements".

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<sup>1</sup> FAIM : Food Authenticity – Issues and Methodologies. Funded by the European Commission’s Agro-Industrial Research Programme under project No AIR2-CT94-2452. 1994-1998.

<sup>2</sup> Food Integrity - Assuring quality and authenticity in the food chain. Funded by the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement No 613688. 2014-2018.

<sup>3</sup> Authent-Net – Food Authenticity Research Network. Funded under the European Union’s Horizon 2020 research and innovation programme under grant agreement No 696371.

Since this Handbook is intended as a simple, searchable guide to food fraud / food authenticity issues organised by product type, each of the food group chapters follows a similar structure, making it easier for the reader to find the information they are looking for. The format starts with a general overview of the product, with a short introduction to the industry sector, its importance in the global market, and how it may have changed in recent times as a result of consumer pressure or the implementation of new technology. Food products may be marketed in different forms, some of which may be linked to a specific manufacturing process or method of agricultural production. This type of knowledge is important in order to explain certain fraudulent practices, and essential when interpreting data from analytical tests.

Most food products are defined by a set of specifications, or “standard of identity”, whether in legislation or in industry sector guidelines. These specifications, which often include specific compositional characteristics, form the basis for describing a foodstuff and for highlighting any deviations from this composition that could be due to mislabelling and/or economic adulteration. Current standards of identity or related legislation, both in the European Union and on the international level are provided for the different food commodities where available.

The prime focus of this Handbook is of course food authenticity and the analytical solutions available to address existing concerns. These are described in detail for each food product, starting with food fraud problems that are currently facing the food industry or have occurred in the past. Although the main motivation for food fraud is economic, there is increasing concern among both regulatory authorities and consumers about the potential health risk of a fraudulent practice. For example a cheap extender might be used that is allergenic, as in the case of nut protein in cumin spice. Where relevant, examples of the potential threat to human health are provided.

Then follows a review of the analytical methods used to test for authenticity. In this section care has been taken to highlight those methods that are most commonly used, and in particular, those that are officially recognised. In recent years, increasingly sophisticated techniques and instrumentation have been developed to detect adulteration and misrepresentation. These latest methods are included where they are accessible to routine use. When comparing the original FAIM Handbook and this present one, two major areas of analytical investigation stand out as different. One of these is the use of DNA techniques which, for a majority of the food products dealt with in the FAIM handbook, were only mentioned under the section on “potential methodologies” as techniques requiring further efforts before being accepted as routine procedures. As can be seen in this book, DNA techniques are now routinely and officially used for authentication purposes. One example is the verification of specific Basmati rice varieties from India and Pakistan that, under EU Regulations, are granted a zero rate of import duty on presentation of an authenticity certificate based on DNA analysis. The other major difference is the breakthrough in untargeted methods. These approaches employ various spectroscopic and/or chromatographic techniques, which can provide an entire analytical profile of a food product which can then be used to judge its authenticity. The most established in this area is based on NIR (Near Infrared) spectroscopy which is now widely used in various sectors and is particularly suitable as a rapid method for the at-line and on-line use (see for example the chapter on Cereals). A further example employs <sup>1</sup>H-NMR (Nuclear Magnetic Resonance) screening which, provided that appropriate statistical models have been established from authentic material beforehand, can evaluate a large number of analytical parameters related to quality and authenticity, simultaneously and in a few minutes (see the example given in the chapter on fruit juices).

One of the purposes of this Handbook is to help small and medium companies with setting up food fraud mitigation plans and therefore a section on additional tools for mitigating food fraud risk has been included towards the end of the document. This section provides information on the

different approaches to evaluate food fraud vulnerability, the importance of traceability in the food supply chain, and a “best practice” example of sector specific food fraud mitigation.

But what will the future look like in the next twenty years? The authors of each of the food product chapters have been asked to give their expert opinion on potential authenticity issues to look out for in the future, such as those that may not be economically viable now but may become so due to changing geopolitical situations, the effects of climate change and so on. They also provide an insight into where current research on authenticity techniques is heading and which analytical methods are on the horizon.

Food Fraud has been around a long time but following several highly mediatised incidents such as the milk and infant formula contaminated with melamine in 2008 and the horsemeat scandal in 2013, all authenticity issues have become big news. Regulators and customers now require food operators to keep abreast of any potential risks and to regularly assess their raw material and ingredient supply chains for vulnerability to food fraud. It is hoped that this Food Integrity Handbook will be a useful companion to help the food industry achieve this aim.

# Definition of food fraud and food authenticity

The notion of food fraud and food authenticity received increased focus as a field of investigation by the research community and the food industry in the late 2000s, following highly mediatised crises such as the melamine scandal in China in 2007 and Horsegate in 2013, with adverse impact on vulnerable consumers for the former. These incidents led stakeholders to request a clear definition of food fraud including the identification of the different types of fraud as a first step toward combatting these practices.

Some early work was carried out in the United States by the Grocery Manufacturers Association [1], Michigan State University [2] and the US Pharmacopeial Convention (USP) [3]. After the horsemeat scandal, a series of high level reports was published by some national health authorities [4–6]. They all highlighted the importance of the standardisation of the terms related to food fraud.

In 2012, a 'Food Fraud Think Tank' was set up with the support of the Global Food Safety Initiative (GFSI), an public-private initiative, to explore food fraud issues. It published a document on food fraud mitigation in which it provided some definitions of the different types of fraud [7]. This collaborative work, some members of which took part in the FoodIntegrity project over the following years, is the basis of this chapter. Most of the definitions used in the following pages refer to it.

During another European research project named Authent-Net [8], a standardisation initiative within the framework of a "CEN/CENELEC Workshop Agreement" (CWA) has been launched in order to set up a first consensus-based terminology of authenticity and food fraud [9]. This working group has received input from scientists, industry organisations and other ongoing research projects, and in particular from FoodIntegrity. It has made terms and concepts related to food fraud clearer and more accurate, thus enriching the GFSI definitions. It is expected that this work will lay down the basis for future internationally standardised definitions.

The Codex Alimentarius Commission has established an electronic working group (eWG), chaired by the Islamic Republic of Iran and co-chaired by Canada and the European Union, whose mission has included the clarification of the definitions of food integrity, food authenticity, food fraud and economically motivated adulteration (EMA) in relation to Codex Committee on Food Import and Export Inspection and Certification Systems (CCFICS) texts. They have published a position paper [10] where key elements identified underlying these notions have been identified and definitions developed. This position paper will be used as a basis for initiating new work in this area, so as to provide guidance on how to assure the authenticity of food by minimising vulnerability to fraud and mitigating the consequences of food fraud.

## Food fraud definition

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In the vast array of issues which can be faced in the whole food supply chain, the GFSI Food Fraud Think Tank considered four categories related to food integrity (cf. Figure 1). Distinguishing between these categories requires putting oneself in the place of the person at the source of the issue. Is the action deliberate or unintentional? If unintentional, it is a food safety issue, when consumer health can be harmed, or simply a food quality issue.

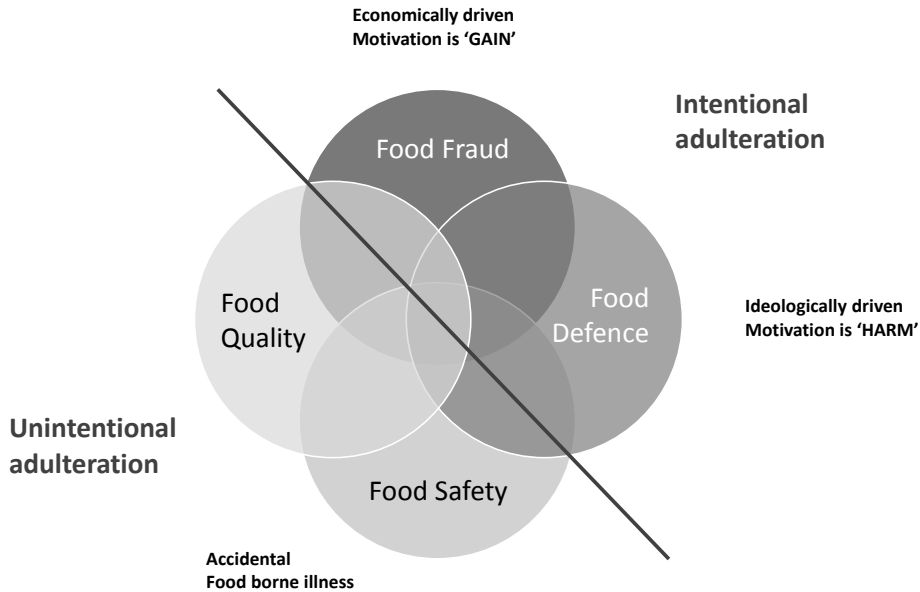


Figure 1: Difference between food fraud, food defence, food safety and food quality. Food fraud.  
Adapted from Food Fraud Think Tank [7]

But when the action is intentional, then the behaviour can be considered a crime. When the motivation of the criminal is to harm people, the type of action falls in the field of "Food defence" according to the GFSI Food Fraud Think Tank. It can be even qualified as terrorism when the action aims at gravely disturbing public order. When the intention is only economical, the action can be considered as food fraud.

The notion of economic gain has been endorsed in the CWA: it is stated that "financial gain is the most common motivation for food fraud", as well as the intentional factor. The definition of food fraud that has been agreed on in this document is:

**Food fraud:** an action *"intentionally causing a mismatch between food product claims and actual food product characteristics, either by deliberately making claims known to be false or by deliberately omitting to make claims that should have been made."*

As most food products are produced and sold according to relevant regulations and requirements, food fraud also occurs when some aspect of the production violates these requirements or regulations.



In the same way, the definition of an "Authentic food product" given by the CWA is very close to that of food fraud:

**An authentic food product** is *"a food product where there is a match between the actual food product characteristics and the corresponding food product claims; when the food product actually is what the claim says that it is."*

It should be noted that the definition of food fraud developed by Codex Alimentarius position paper identified as key elements: deliberate intent, deception, financial gain and misrepresentation. The document provided by the eWG considers food fraud as being intimately linked to food integrity: food fraud is *'any deliberate action of businesses or individuals to deceive others in regards to the integrity of food to gain undue advantage'*.

The document also distinguishes 'food authenticity' and 'food integrity': both are a status of a food product, but the former is the state of being *'not altered or modified with respect to expected characteristics including, safety, quality, and nutrition'*, while the latter is the state of being *'genuine and undisputed in its nature, origin, identity, and claims, and to meet expected properties'*.

## The different types of food fraud

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Based on the definition of food fraud the GFSI Food Fraud Think Tank developed, it identified a series of seven different types of frauds, as shown in Figure 2. Some of these terms have been defined in the CEN Workshop Agreement.

One of the most common frauds is **adulteration**. According to the CWA, it is:

*"A type of food fraud which includes the intentional addition of a foreign or inferior substance or element; especially to prepare for sale by replacing more valuable with less valuable or inert ingredients."*

This practice is sometimes referred to as Economically Motivated Adulteration (EMA). This term is defined in the Codex Alimentarius position paper. It is recognised as *'a subset of food fraud'*.

Different types of adulteration can occur in food products. Their definition is given below in italic.

**Substitution** is the *"process of replacing a nutrient, an ingredient or part of a food (often one with high value), with another nutrient, ingredient or part of food (often one with lower value)."* Examples of substitutions are substituting low value fish species for high value fish species when selling processed products (fillets, fish pies, etc.), substituting milk protein with hydrolysed leather protein or sunflower oil partially substituted with mineral oil.

**Dilution** is *'the process of mixing a liquid ingredient (solute) with high value with a liquid of lower value'*. The action addition of water to Not-from-concentrate (NFC) fruit juice or to milk is an example of this.

**Unapproved enhancement** is the *"process of adding unknown and undeclared compounds to food products in order to enhance their quality attributes"*. The melamine in milk falls under this category, as adulteration with melamine in milk products aimed at enhancing nitrogen content in

already diluted milk. Use of unauthorised additives, such as Sudan dyes in spices, is another example of unauthorised enhancement.

**Concealment** is the *"process of hiding the low quality of food ingredients or products"*. Injecting poultry with hormones to conceal disease is an example of this, as well as meat treated with carbon monoxide.

The other types of food frauds identified by the GFSI Food fraud Think Tank have not been specifically defined in the CWA. However, they are commonly used in a number of scientific publications, including this book. A definition of these terms was drafted by the FoodIntegrity experts when they designed the FoodIntegrity Knowledge Base (see the dedicated chapter of this book).

**Grey market:** this term includes production, theft, and diversion involving unauthorised sales channels for products. An example of this is the sale of excess unreported product when there are production agreements or quotas for the product and the product in question is deliberately produced in excess of these. A fish product originating from illegal, unreported, and unregulated (IUU) fishing is another example. This term also applies when there is a geographical restriction on the sale and distribution of the product, and the product in question is deliberately sold or distributed in other areas; this is often referred to as "grey market" sales.

**Counterfeit** is a case when where Intellectual Property Rights (IPR) infringement is in effect. This could include any or all aspects of the other product or packaging being fully replicated, for instance the process of copying the brand name, packaging concept or processing method for economic gain. Imitation wines and spirits with fake labels of a popular brand is a classical example (see the chapter on Spirits).

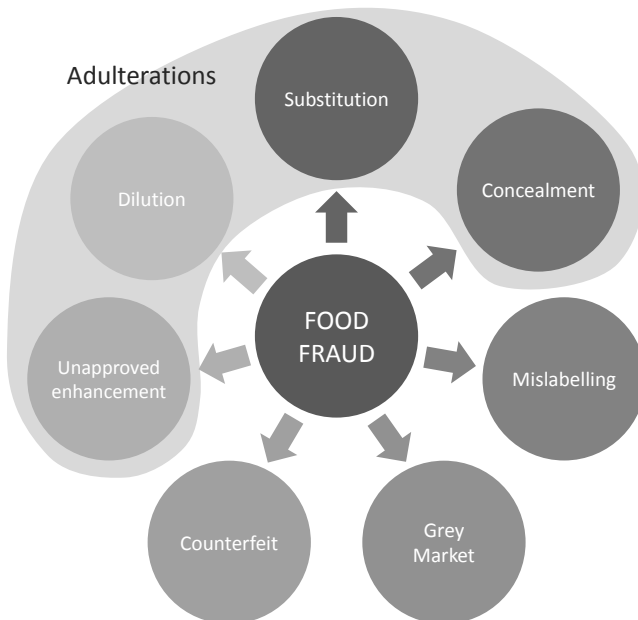


Figure 2: Terminology of food frauds. Adapted from Food Fraud Think Tank [7]

**Mislabelling** is a special case of food fraud. It concerns the process of putting false claims on packaging for economic gain. Selling farmed salmon as wild salmon, or conventional fresh produce as organic are examples of this fraud. Expiry date modifications fall under this category. However, mislabelling may apply to all forms of food fraud: to be efficient, a fraudulent product must indeed be "mislabelled" to be purchased by a buyer. But the expression is mainly used to indicate distortion of the information provided on the label.

The Codex Alimentarius position paper has also identified seven different types of food fraud. Although their designations are slightly different ('*simulation*' is used instead of '*concealment*', for instance), they overlap and are consistent with the definition of the GFSI and CEN Workshop Agreement.

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