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# Food authenticity assessment: ensuring compliance with food legislation and traceability requirements

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## Abstract

*Introduction* The globalisation of food markets implies that consumers come into contact with a great variety of foods, therefore European and worldwide consumers are very concerned about the origin of the food they eat. Moreover, recent food scares have added to public sensitivity regarding the origin of food and its authenticity. The objective assessment of food authenticity has thus become of paramount importance. *Methods* The MoniQA Network of Excellence has set up a working group on food authenticity which gathers experts from different backgrounds to address this topic, to identify any gaps and needs, and to offer legislators, control authorities and all interested parties objective, validated and harmonised means to measure food authenticity attributes. *Results and conclusions* In this paper, an overview of all the work done by the Food Authenticity working group during the first year of the activities of the NoE is presented. It has emerged that there are already rapid chemical and biochemical techniques that, when combined with statistical treatment of the data, have shown a degree of success. However, some basic problems remain, which need to be addressed for the successful determination of food authenticity such as sampling, method performance and uncertainty. The MoniQA Food Authenticity Working Group is working at the development of methods to authenticate foods taking into account the need of robust markers, rapid and reliable validated methods, appropriate statistical treatment of analytical data, as well as comprehensive and up-to-date databases of authenticity markers.

## Introduction

Consumers worldwide, and European ones in particular, are showing an increasing interest in issues related to food, diet and nutrition. The globalization of food markets implies, in fact, that consumers come into contact with a great variety of foods and that they are more and more concerned about the origin of the food they eat.

In many countries, ideas and beliefs about the properties of foods also embody social values that in several cases have to do with the concepts of trust, fairness and care.

Kelly *et al.* report (2005) that there is a growing enthusiasm among consumers for high quality food with a clear regional identity as a consequence of (a) patriotism; (b) specific culinary, organoleptic qualities or purported health benefits associated with regional products; (c) a decreased

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confidence in the quality and safety of foods produced outside their local region, country or the EU or (d) concern about animal welfare and 'environmentally friendly' production methods. Moreover, recent food scares such as the BSE, the foot and mouth disease, the avian flu and the malpractices of some food producers have added to public sensitivity regarding the origin of food or, in other words, food authenticity. The adulteration of milk with melamine, which happened in China, has also contributed to bring the attention of the whole world towards the origin, safety and quality of our food.

The determination of food authenticity is, therefore, of paramount importance in food quality control and safety. In general, food authenticity issues fall into one of the following categories: (1) economic adulteration of high value foods; (2) misdescription of the geographical, botanical or species origin; (3) non-compliance with the established legislative standards and (4) implementation of non-acceptable process practices. The above-mentioned food authenticity issues are also covered by a European legislative framework as regards: (1) the misdescription of name of food and non-compliance with requirements of legal name (e.g. virgin olive oil, chocolate, jam, etc.); (2) the adulteration of foods or substitution with lower value ingredients; (3) the misdescription of geographical species, variety and production origin; (4) the non-declaring of certain processes in the ingredients or preparation of food; and (5) incorrect quantitative ingredient declarations. However, the globalization of food supply has lately implied longer supply chains potentially more difficult to be controlled and traced that have to rely on producer country inspection and control. The objective assessment of food authenticity is therefore important in food quality control and safety.

Apart from using traceability systems, applying objective authenticity techniques to verify the origin description of foods is a challenging exercise. This paper assesses the state of the art of all possible issues having to do with the determination of food authenticity from the legislative frame to the analytical one, and aims at identifying topics that need to be addressed in the future. It represents a review of the issues that have been dealt with within the Food Authenticity Working Group of the European Union Network of Excellence 'MoniQA' during its first year of work (MoniQA, 2007).

## The regulatory environment within the EU

### Legislative framework

Most food legislation is harmonized throughout the European Union through a number of European Commission (EC) Directives and Regulations. Those pertinent to food authenticity can be listed as follows.

The labelling of food is subject to the general rules laid down in Council Directive 2000/13/EC. This is a consolidated version of the original Council Labelling Directive 79/112/EEC and all the subsequent amendments. The prime consideration of this legislation is the need to inform and protect the consumer. The main provision of Directive 2000/13/EC is to require the following particulars in the labelling of food: (1) the name under which a product is sold; (2) the list of ingredients; (3) the quantity of certain ingredients or categories of ingredients; (4) the net weight, and for alcoholic drinks with more than 1.2% alcohol by volume, the alcoholic strength by volume; (5) the date of minimum durability i.e. 'use by' for those highly perishable foods from a microbiological point of view, or 'best before'; (6) any special storage conditions of use; (7) the name of business name and address of the manufacturer, packager, or seller established within the EU; and (8) instructions for use.

Other particulars need to be given where to omit them would be misleading to the consumer. These include any physical process such as freezing, drying or irradiation of ingredients, and the geographical origin of the food. There is also a requirement to declare the presence of any approved GM ingredients above 0.9% (non-approved are prohibited), and warn consumers of certain allergens not named in the list of ingredients. A quantitative ingredient declaration is also required for those ingredients highlighted in the name of the food or which consumers would associate with the food. By means of this Directive, the EC aims at defining an approach that will certainly provide consumers with information to facilitate safer, healthier and sustainable choices, and that will also create a competitive market, dynamic, efficient, innovative, and making full use of the power of labelling to sell products. In 2004, the EC announced review of all EU Food Labelling Legislation and in February 2006, a Commission Consultative document was published. The Food Labelling Directive will be replaced in the future by a Regulation on Food Information, which is under discussion, and will probably be agreed in 2010. The main provisions on labelling will remain, but there may be stronger requirements for origin labelling.

The EC also adopted special provisions as regards the protection of geographical indications and designations of origin for agricultural products and foodstuffs. The Council Regulation (EC) 510/2006 of 20 March 2006 establishes, in fact, the rules for protecting designations of origin and


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geographical indications for agricultural products and foodstuffs intended for human consumption. This is a consolidated version of the original Regulation EEC 2081/92 and all subsequent amendments. The main provision of Council Regulation (EC) 510/2006 is (1) to ensure that only products genuinely originating in a specific region are allowed in commerce as such; (2) to make Protected Designation of Origin and Protected Geographical Indication symbols or indications obligatory; and (3) to enable an easier identification of these products on the market so as to facilitate controls. The Council Regulation 510/2006 lays down the rules on the protection of designations of origin and geographical indications for agricultural products intended for human consumption except the wine sector products which are regulated by special regulations (Regulation EEC 823/87 and Regulation EC 479/2008 amending and repealing previous regulations of 1986, 1999, 2003 and 2005).

On the other hand, agricultural products and foodstuffs guaranteed as Traditional Specialities (TSG) are regulated by the Council Regulation 509/2006 of 20 March 2006 that lays down the diversification of agricultural production as well as the promotion of traditional products with specific characteristics should be encouraged. It is a consolidated version of the original Regulation EEC 2082/92 on certificates of specific character for agricultural products and foodstuffs. The main provision of Council Regulation 509/2006 is (1) the encouragement of the diversification of agricultural production and the promotion of traditional products with traditional products with specific characteristics; (2) the provision for economic operators of instruments allowing them to enhance the market value of their products while protecting consumers against improper practices; and (3) the introduction of the certification of 'Traditional Speciality Guaranteed' that meets the consumer demand for traditional products with specific characteristics.

As regards another topic of interest for the food authenticity, i.e. traceability, in January 2002 the EU adopted the framework regulation EC/178/2002 laying down the general principles and requirements of EU food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. This Regulation mainly aims at preventing fraudulent or deceptive practices, adulteration of food, and any practice that may mislead the consumer. It provides, in fact, basis for consumers to make informed choices about the food they consume, as stated in article 8 on the 'protection of consumers' interests'. Moreover, this Regulation takes account of the 'precautionary principle' and sets out general provisions for imposing traceability of food and feed. In particular, it requires traceability records – 'one up and one down', i.e. from where a business purchased its raw materials or products and whom it sold them to. But, it does not cover the whole food chain from farm to fork.

As regards the protection of consumers, the EC also adopted special provisions on 'names' which have become 'names' prescribed by law – see all the 'Breakfast Directives' on sugars, honey, preserved milk, jams, chocolate and fruit juice. Council Directive 2001/110/EC, Council Directive 2001/111/EC, Council Directive 2001/112/EC, Council Directive 2001/113/EC, and Council Directive 2001/114/EC define, in fact, respectively the terms 'honey', 'sugars', 'fruit juices', 'jams, jellies, and marmalades and sweetened chestnut purée', 'partly or wholly dehydrated preserved milk', so that these names are used in trade to designate them. Other legal names also protect consumers but were drawn up principally to lay down minimum standards for marketing support, which includes the main agricultural products – poultry meat, olive oil, spirit drinks, wines (now Regulation 1234/2007 on common organization of agricultural markets), and also canned sardines and canned tuna.

## Consequences for the agrifood business

Relevant authorities within Member States have the duty to enforce food law that requires food to be safe – in terms of microbiological safety, contaminants, etc.– and to be described correctly in terms of its nature, composition, ingredients, origin, etc. Food businesses, in turn, have the duty to ensure that their products comply with food law and all its prescriptions. In other words, the food they sell must be 'safe' and it must correspond exactly to its description both in terms of any direct effect on consumer health and legal requirements regarding permitted maximum levels of contaminants, etc., but also with regard to food price. Besides paper documents for both groups of stakeholders, analytical tests are an essential tool in validating both enforcement systems and commercial operations and transactions.

On the basis of a survey of available methodologies to check quality parameters connected with food authenticity in different foodstuffs that was performed within the MoniQA project, we can say that there is still considerable room for improvement in both sampling and analytical methodology. In particular, there is a need to ensure that:

- Procedures used by exporting countries are in harmony with those used by the competent authorities in Member

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States as provided under the Regulation (EC) 882/2004, on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules,

- Attributes of food authenticity are clearly identifiable, describable and/or measurable by all involved parties,
- The limitations inherent in analytical data in particular concepts such as uncertainty and limits of quantification are understood by all concerned,
- Development of mechanisms to assist in the preparation of appropriate commercial specifications as well as making certain that sampling and analytical methods used 'in house' (usually rapid methods) are fit for purpose. This involves taking into account not only the analyte but also the food matrix in which it is analysed.

## The objective measurement of authenticity attributes and the determination of food authenticity

Food authenticity, in general terms, is perceived as an important aspect by consumers at an emotional level because it involves their trust in what they buy. As a consequence it is well looked after by food manufacturers and legislators.

Some possible attributes of food authenticity come from the following fields: (a) genetics; (b) territory (soil, climate, degree of pollution, etc.); (c) harvesting and post-harvesting treatments; (d) processing conditions; (e) other ingredients which are functional to the quality of a certain food. The whole picture becomes more and more complex if one moves to a level beyond the producer/manufacturer. The GMO issue can fall within problems related to genetics.

Issues such as tradition and identity play an important role in the perception of food authenticity, and the paradox might occur that a food might be safer if produced with more modern methods although the traditional method of producing the food is what makes it authentic. The consumer thinks of authentic food as being safe, and food safety and authenticity are undoubtedly linked. In this respect we have a record of various incidents when attempts to adulterate food for financial gain have actually led to serious food safety incidents. For example, the attempts made in Austria in 1985 to improve mouth-feel and sweetness of wine by adding glycerol unfortunately resulted in the addition of ethylene glycol and the potential for brain and kidney damage. Recently, attempts made by Chinese milk processors to increase the measured nitrogen (protein) content of powdered milk to increase its value by adding melamine resulted in a major food safety incident in China with global repercussions. Whether these adulterations were intentional or arose through lack of knowledge of the chemicals involved, they produced serious and widespread effects in several sectors. Consequently, the eradication of even innocuous adulteration of food will reduce the risk of such incidents by deterring those who may consider it.

Also, food authenticity is often synonym of a positive quality even if people in general are able to recognize that non-traditional high quality foods exist as well (e.g. probiotic yoghurts, functional foods, etc.).

As we have seen, adulteration and food fraud are without any doubt interconnected with the concept of food authenticity. In this paper the authors define food fraud as 'the deliberate and illegal mislabelling of food for economic gain'.

To remain within Europe, we can say that fraud is not a new issue, with cases of adulteration being reported in Roman times. What has changed considerably over the last 20 years is the main target of the fraud. Until the demise of the Common Agriculture Policy (CAP), the primary focus of European anti-fraud resources was on protecting the EC and Member States from frauds that exploited the complexities of subsidy and tariffs that existed within the CAP. Recently there has been an increased emphasis from the food industry on marketing of foods with perceived food quality attributes to an ever more discerning European consumer. Many of these perceived quality attributes cannot easily be verified using current analytical methods. As a result, food control authorities face considerable challenges in verifying labelling descriptions that relate to: provenance, organic, fair trade, food miles, sustainability. This is to the detriment of the consumer but also the food industry, as the honest producer is not protected nor the purchasers of such products in the food chain.

Analytical methods for use in detecting food fraud usually rely on detecting/quantifying marker(s) of the authentic product or more commonly detecting/quantifying markers of the adulterant. The complexity of the methodology usually depends on the nature of the difference between the authentic product and the adulterant as well as whether the product has been completely replaced or extended. Determining geographical origin requires sophisticated methodology to identify and measure markers in the food that can be related to the foods local environment. The markers are often complex and rely on chemometrics to provide interpretation.


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Multi-element and isotopic analyses have been applied to several foodstuffs to develop methods that will permit their geographical origins to be determined with varying degrees of certainty. The natural variation or fractionation that occurs in the isotopic content of the bio-elements, hydrogen, carbon, nitrogen and oxygen and the heavy element strontium can be exploited to determine the geographical origin of foods (Kelly *et al*., 2005). In addition multi-element screening is used to identify macro-, micro- or trace-elements that indicate provenance. The combination of these techniques with multivariate statistics to determine the geographical origin of food is a growing area of research and the techniques are established in criminal forensic science (Idoine *et al*., 2005), ecology (Hobson, 1999) and forensic archaeology (Hedges *et al*., 2005).

Other analytical techniques and parameters have been studied to verify the origin of regional foods such as aroma, sugar, phenolic and flavour compound profiling by gas and liquid chromatography; 'fingerprinting' or chemical profiling by $^{1}$H NMR, near Infra-Red and Fluorescence spectroscopy (Charlton *et al*., 2002; Kelly *et al*., 2005; Reid *et al*., 2006).

Differences in the nitrogen isotope compositions of the organic and conventionally grown crops have been studied in order to devise a mean to detect fraud in the organic sector. Increasing consumer demand for organic products has meant rapid expansion worldwide of the organic retail sector. While the founders of the organic farming movement placed considerable value on close links between producers and consumers, the demand for organic produce has widened this gap and the globalization of organic markets will inevitably place an increased burden on certification/inspection bodies and traceability systems on which the authenticity of the organic produce depends. Results demonstrated that the nitrogen isotope approach is capable of providing intelligence on whether synthetic nitrogen fertilizers are likely to have been applied to certain crop types (Bateman *et al*., 2005; Bateman & Kelly, 2007; Bateman *et al*., 2007). The trace metal analysis to establish markers for mineral supplementation or the possible effects of arbuscular mycorrhizal fungi association in organic soils is another analytical approach that has been advocated as having the potential to discriminate between organic and conventional agriculture (Gosling *et al*., 2006).

Recently DNA and metabolomics studies have come to play their role in authentication studies. DNA-based methods offer, in fact, a number of advantages over traditional approaches as (1) DNA or fragments of DNA can survive a high degree of processing/heat treatment (up to 120 °C); (2) DNA is an excellent marker for biological material because there are unique sequences for each individual organism; (3) the measurement of DNA fragments has allowed DNA-based methods to become quantitative as opposed to only qualitative (Burns *et al*., 2004; Woolfe, 2007).

Within the EU funded project Oliv-Track the analysis of residual DNA present in olive oil samples was utilized as a useful support to metabolomics methods and molecular markers have been used to prove their applicability in the authentication of certain olive oils (Rallo *et al*., 2000; Testolin & Lain, 2005; Doveri *et al*., 2006; Doveri *et al*., 2008). The intrinsic correlation between the quality of the extracted DNA and the reliability of the fingerprinting obtained with a molecular marker was also related with the possible applicability in platform of array and real-Time PCR (Busconi *et al*., 2006; Pafundo *et al*., 2007; Consolandi *et al*., 2008).

Since 1999, many species-specific methods have also been developed for the detection of beef, lamb, pork, chicken and turkey, after that a UK Ministry of Agriculture, Fisheries and Food meat speciation survey found that about 15% of the meat samples tested contained meat species not declared on the label. These methods need, however, to be improved, as the employment of DNA methods did not enable a firm conclusion as to whether the undeclared species were present as a result of deliberate adulteration or accidental cross-contamination (Burns *et al*., 2004). DNA analysis has also been used to check potato samples which were labelled either with no or insufficient varietal information or with the wrong variety, to estimate adulteration of Basmati rice with non-Basmati rice (Burns *et al*., 2004; Woolfe & Primrose, 2004), to identify commercial fish and seafood species (Rasmussen & Mornssey, 2008) and to identify and quantify small grain cereal mixtures (Terzi *et al*., 2005).

The rapid advances of molecular biology and genetics have led to the development of simplified, rapid and automated methods and analytical kits. Thus the application of the former backed by sophisticated analytical techniques could lead to the rapid and foolproof identification of species, varieties, geographical origin, admixtures and adulterations of a great number of foodstuffs. Rapid and inexpensive methods are particularly interesting for screening purposes and routine checks.

New approaches developed within the European Trace project such as metabolite profiling methods and isotopic food maps also represent recent developments in the determination of food authenticity.

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## Conclusions

Besides other reasons, the European Food Legislation by granting Denominations of Origin at several levels to different food products has posed the question of food authenticity. Just admitting that we are able to identify and describe the main attributes of authenticity, i.e., which are the special qualities of a given product to be considered authentic, a major question arises which requires an answer if we want to distinguish between an authentic food from a non-authentic food: how can authenticity be measured? It is a challenge to come up with describable and most of all measurable characteristics and markers of authenticity for different food products. As we have seen in Chapter 3, several traditional and rapid chemical and biochemical analytical techniques have been experimented with a certain degree of success together with different ways of statistically processing the analytical data.

However, some basic problems that are common to other fields, can be of interest also in the determination of food authenticity parameters such as sampling, method performance and measurement uncertainty. Without knowing the above mentioned parameters it is difficult to obtain reliable analytical data to be used in legal or commercial decisions. Surely in this respect there is room for research and harmonization.

It is also auspicable that European databases for the different food products are built that can be used to compare results in case of dispute. For example, within the European OLIV-TRACK Project a database of olive cultivars was produced in order to make the results of the identified and measured markers available to all researchers (http://biowe-b.ensam.inra.fr/multicrop/). Comparative databases are essential for authenticity work and a common theme of food authentication studies is the requirement for a database of genuine samples of sufficient amplitude to which the 'suspect' test sample can be compared with establish its authenticity.

Also in the field of food authenticity, besides reliable but time consuming analytical methods, there is a great need for the development of fast methods of proven efficacy and reliability.

The MoniQA Food Authenticity Working Group seeks to establish a forum where discussions are allowed among the interested parties, solutions to the above mentioned problems are elaborated and proposed, possible methods are tested, and common documents are issued for a harmonized strategy of food authenticity management.

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