Food Fraud – A Global Challenge

Prevention and mitigation of the risk of food adulteration

Foods of a certain origin or production method are becoming increasingly popular. Extra virgin olive oil, beef from Argentina, Parmigiano Reggiano, Jamaican Blue Mountain coffee, Manuka honey from New Zealand or Cabernet Sauvignon from South Africa are some of these examples. With an organic seal on the label, consumers pay a premium.

International operations such as OPSON have repeatedly demonstrated that premium and even mass products are being counterfeited and marketed on a large scale. Counterfeiters often take advantage of the complex international supply networks, as was shown in the horse meat scandal in 2013.

Adulteration can have many different manifestations.

What is food fraud?

Food fraud is a deliberate violation of European food law, whereby an economic gain is achieved by deceiving consumers. Four key criteria must be met:

- Infringement of EU law
- Intent
- Economic advantage
- Consumer deception

Opportunity lies in the heart of food fraud. A fraudster recognizes the opportunity, evaluates potential obstacles, for example, in the form of laws, controls (probability of detection) and possible penalties and maximizes his own advantage, which ultimately leads to the victim's disadvantage. A fraudster does not necessarily have to be an individual; the past has shown that the actors behind food fraud are often many, organized in crime networks. The victim does not necessarily have to be an individual either.

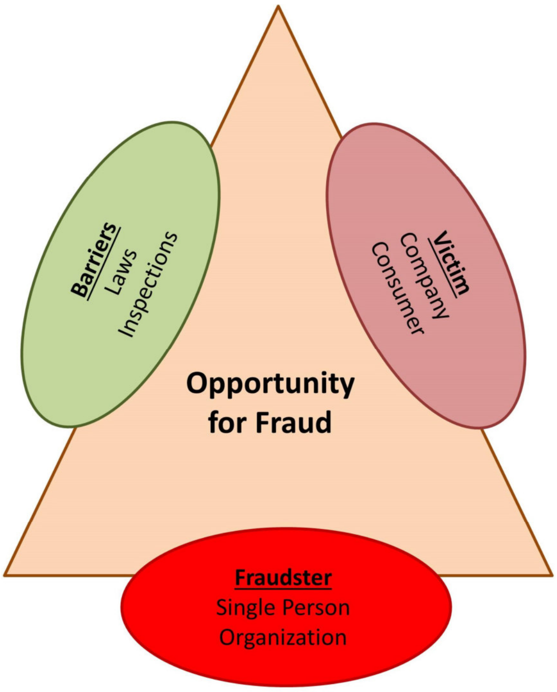

fig. 1: Food Fraud is influenced by several factors.

A company can become a victim if it unintentionally buys counterfeit goods and processes them into its products. Figure 1 illustrates the interrelationships.

At international level the terms differ to a certain extent. What is understood in Europe as "Food Fraud" is called "Economically Motivated Adulteration (EMA)" in the USA and needs to be distinguished from "Intentional Adulteration (IA)". The latter includes, for example, antibiotic residues (→ food safety), as these were administered to the animal intentionally. So there is plenty of potential for confusion in communication across the Atlantic Ocean that you need to be aware of.

For a better comprehension of the facts of the case, it is also useful to distinguish the term food fraud from other infringements of food law. These can be divided into the four categories Food Quality, Food Defense, Food Safety and Food Fraud (Food Risk Matrix, Spink, et al., 2011). Infringements in the various categories differ in terms of the motivation of the actor and his intention.

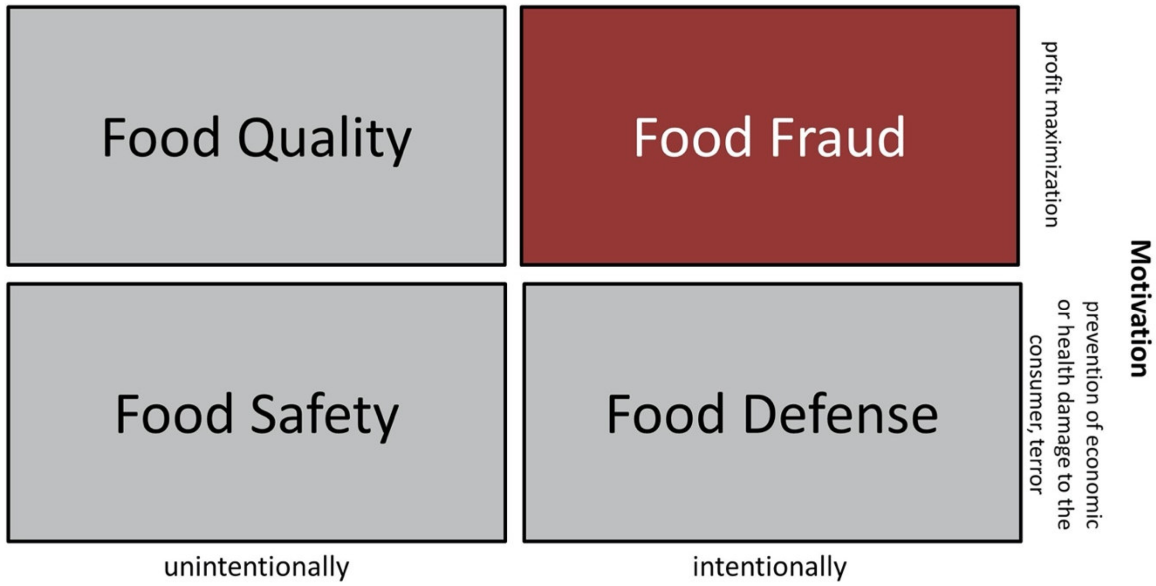

fig. 2: Food Risk Matrix according to Spink et al., 2011.

Food quality: **Maximization of profit is the motivation to achieve high food quality - infringements in this area are accordingly unintentional.**

Food safety: **In this case, the motivation is to avoid any damage to the health of the consumer. Since infringements represent an economic loss for the person placing the product on the market, cases in this category are also unintentional.**

Food Defense: **Food Defense is concerned, among other things, with protection against damage to health and economic interests. In contrast to food safety, however, it is based on an intentional act, such as that underlying blackmailing or terrorist acts.**

Food Fraud: **Here the motivation is to maximize profit, but not by maximizing product quality at the same time, but by dishonest means. Thus, there is an intentional act that results in financial damage to the defrauded. Most cases result only in financial damage, but in some cases, food safety may well become an issue, such as the adulteration of baby food with melamine that occurred in China a few years ago.**

Which matrices are affected?

Wherever there is an opportunity to increase profits while the probability of being caught is low, adulteration in one form or another is to be expected. Available “fraud hit lists" differ slightly depending on the database used. Mostly, however, the same foods are found in the top ten, although occasionally in a slightly different order. Figure 3 is based on data from the USP Food Fraud Database (now Decernis).

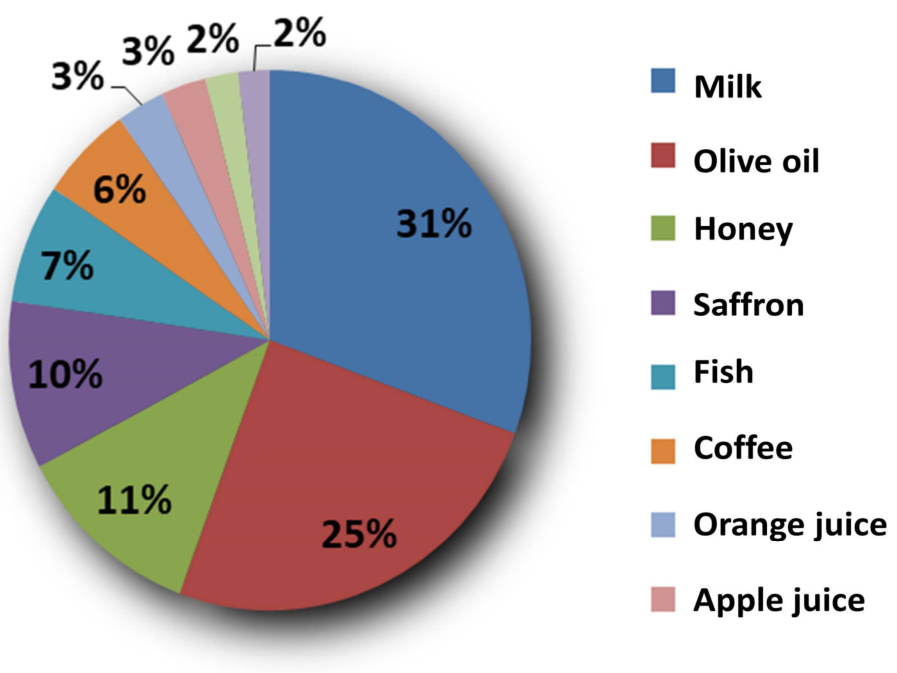

fig. 3: Food Fraud Hit list of the most frequently adulterated food.

The most common adulteration is the replacement of a valuable ingredient. Examples are syrup in honey or foreign oils in olive oil. Another type of adulteration is masking of defects on fresh fruit by means of (possibly harmful) dyes.

Other examples of adulterations are:

- intentional mislabeling, such as changing the best-before date or even organic labelling on conventionally produced products
- the sale of overproduced goods through unauthorized methods (e.g. when a fishing quota is exceeded)
- Artificial modification of quality-determining parameters with harmful substances, as in the melamine scandal some years ago
- Counterfeiting of a well-known premium product, often with protected designation of origin or indication of geographical origin, with low-quality raw materials or raw materials of other origins

A comprehensive overview of food fraud and definitions in this area is provided by the CEN Workshop Agreement (CWA) 17369:2019.

How can I protect myself?

The range of adulterated products is very broad. Often comparatively high-priced products are affected, but nevertheless products from large-scale production should not be disregarded.

First of all, it is necessary to be aware of the current situation in an objective manner. This is best done through a vulnerability assessment (VACCP, Vulnerability Assessment Critical Control Point). Companies that are certified according to IFS, BRC or comparable standards have to do this anyway, as it is required by the food standards.

In the vulnerability assessment, various steps of the supply chain and also internal processes are examined and evaluated with regard to the probability of an adulteration occurring. In this way, vulnerable points can be identified, for which a mitigation strategy is then developed and implemented. This strategy can include, for example, an increased number of audits of suppliers or the testing of products by laboratory analysis.

Within the scope of VACCP, products are evaluated with regard to a possible probability of adulteration. Use of databases which contain data on known cases of food fraud and also other information facilitates VACCP. Some of these databases are, however, subject to a fee (e.g. Decernis Food Fraud Database, HorizonScan). There are also freely available sources (RASFF, monthly published JRC Food Fraud Reports, Food Fraud Risk Information foodfraudadvisors.com).

It is important to note that vulnerability assessments are not single events, they rather have to be carried out on a regular basis.

How do laboratory analytics support?

The analytical proof of authenticity or adulteration is usually very demanding, as in many cases it is not known how and with what the product has been adulterated. More obvious adulterations can even be detected by sensory means, e.g. smell and taste.

But usually this is much more complex.

The TCF² has a global network of Tentamus laboratories, which employ the latest technology and necessary know-how to answer questions in the field of food fraud by means of state-of-the-art analysis. Various techniques are used for this purpose:

Isotope ratio mass spectrometry (IRMS): This technique is used to determine the ratios of different isotopes. Commonly the isotopes of carbon ($^{13}C/^{12}C$), hydrogen ($^{2}H/^{1}H$), nitrogen ($^{15}N/^{14}N$), oxygen ($^{18}O/^{16}O$) and Sulphur ($^{34}S/^{32}S$) are used for this purpose. Comparison with reference samples makes allows for differentiation of geographical origins, for example for vegetables. It is also possible to distinguish organic products from conventionally produced products (e.g. pork, beef, vegetables). The carbon isotope ratio allows conclusions about adulteration of honey with corn or sugar cane syrup. It is also possible to distinguish natural vanillin from the vanilla pod from biotechnologically or synthetically produced vanillin.

High resolution mass spectrometry (HRMS): **High-resolution mass spectrometry, usually coupled with liquid chromatography, also allows the analysis of a large number of different substances that provide a sample "fingerprint". Comparison with reference samples provides insight in possible adulteration of the product. In addition, it is possible to identify adulteration markers using HRMS, which can then be transferred to classical triple quadrupole mass spectrometry (LC-MS/MS). At the moment HRMS is primarily used for honey, but could be used for fruits and oils aswell.**

Fourier-transform infrared spectroscopy (FT-IR): **This technique can also be used to create a "fingerprint". A database of different authentic reference samples is used for comparison. Deviations from the reference samples indicate an adulteration. It is also possible to quantify identified substances. FT-IR is used e.g. in the analysis of milk.**

Next Generation Sequencing (NGS): **This molecular biological method makes it possible to analyze the DNA present in mixtures and, by comparing it with a database, to determine the genus or even species from which the DNA originates. This works for products of vertebrates as well as for land living plants. An application would be testing of oregano for adulteration with foreign plants (olive leaves, sumac, etc.). It can be also used for more complex matrices such as condiments, mixed tea and convenience food.**

Nuclear magnetic resonance spectroscopy (NMR): **Initially used primarily for structure elucidation of pure chemical substances, this technique found its way into food analysis a few years ago. A large number of different substances are detected simultaneously, resulting in a comprehensive "fingerprint" of the sample. By comparison with reference samples, deviations can be detected which can be used to detect adulteration or the geographical or botanical origin. Honey-Profiling™, which was mainly developed by QSI GmbH, Bremen, in cooperation with the equipment manufacturer Bruker GmbH, Rheinstetten, uses NMR technology and enables the detection of adulteration of honey with sugar syrups and also provides information on the geographical and botanical origin of honey.**

NMR is also suitable for comparing different batches of the same product or for comparing a sample from the country of origin of a product with the delivered product at the destination.

„Classic" Mass spectrometry (GC-MS, LC-MS): **This technique is already established in the analysis of residues and contaminants, such as pesticides, antibiotics and pyrrolizidine alkaloids. Among other things, it is ideally suited for the detection of adulteration markers that have previously been identified using a non-targeted approach, such as HRMS, with high sensitivity at high sample throughput. Thus, there are various parameters that can be measured, e.g. in olive oil, with this technique with targeted analysis. Presence or exceedance of a defined value indicates adulteration. For example for cinnamon the parameter coumarin provides an indication of the origin. Furthermore, markers for sugar syrup admixtures to honey, which are characteristic for e.g. rice or beet sugar syrup, are also analyzed.**

This list is of course not complete. Depending on the product, other methods are used. Many different other technologies are used.

Block chain

The term "block chain" is also often used in connection with food fraud. First of all: this is NOT the ultimate solution to the problem of Food Fraud. A block chain is a chain of several transactions and used as a digital register which records transactions between two parties.

The advantage of block chain lies in its extremely strong protection against manipulation. Every modification to the block chain is traceable. However, a block chain alone cannot guarantee the integrity of data it contains. This is still the responsibility of the person who must ensure that all data stored in the block chain is correct and authentic. If this is the case, however, the data is safe from manipulation. Currently, an increasing number of food companies are starting block chain projects. Walmart was a pioneer with a block chain for mangos. In this pilot project, consumers were able to gain insight into the supply chain all the way to the producer by reading a QR code printed on the product label with their mobile phone. The possibilities here are (nearly) unlimited. Anyone who deals more intensively with block chain technology will sooner or later come across the term "smart contract". Smart contracts automatically check if certain conditions are met that parties negotiated and agreed on before. They can be organized in a legally binding way. For example, upon delivery a product is automatically prepared for lab testing. Results are then automatically compared to contractually agreed specifications. Finally, the delivery is automatically released and payment for the delivery is automatically initiated. In the light of advancing automation and internet-of-things, it is recommended to keep an eye on this topic.

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TCF² = Tentamus Center for Food Fraud

The TCF² serves as a hub for inquiries in connection with food fraud.

It combines analytical resources of the Tentamus laboratories and offers additional services such as consulting, sampling including sealing, e.g. of containers in the port prior to international shipment and support around certification systems, e.g. in the context of VACCP.