Food and Agriculture Organization of the United Nations

Food fraud

Intention, detection and management

5

FOOD SAFETY
TECHNICAL TOOLKIT FOR ASIA AND THE PACIFIC

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Food and Agriculture Organization of the United Nations
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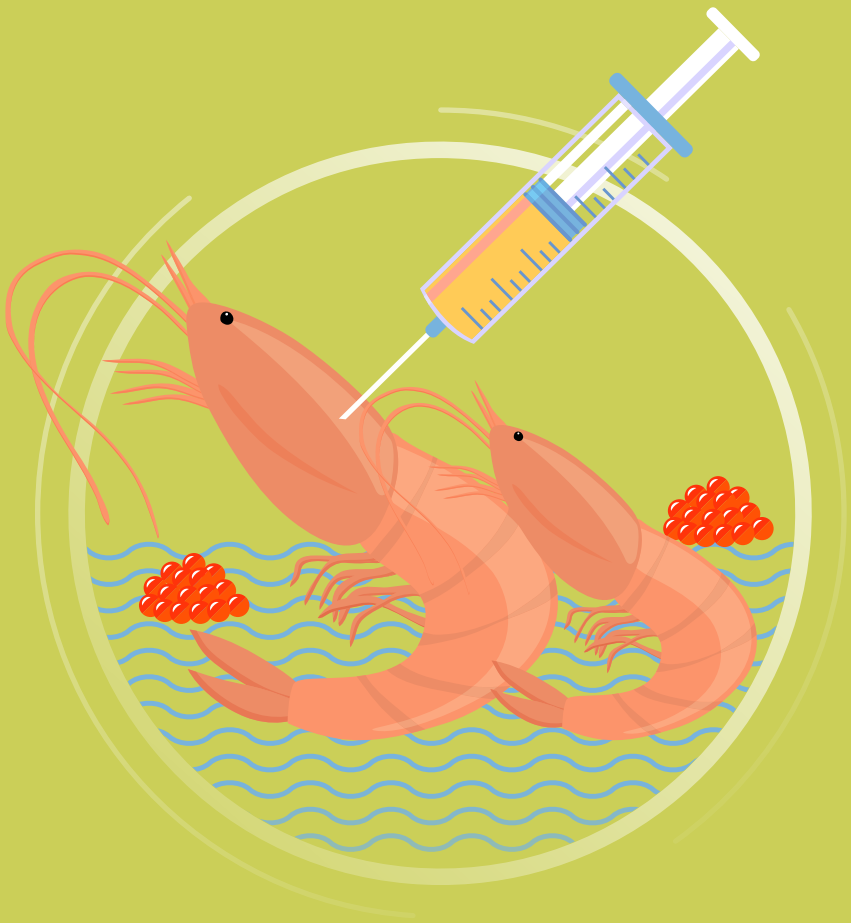
Abstract

Food fraud occurs when a food supplier intentionally deceive its customer about the quality and contents of the foods they are purchasing. While food fraud is often motivated by profit, some forms of food fraud can also pose a direct threat to the health of customers and consumers. Detecting food fraud is a challenge because consumers alone cannot detect them, and food fraudsters are usually innovative in the ways they avoid detection. In Asia and the Pacific, the risk of food fraud is estimated to be high, due to the high demand for premium quality food combined with an increasingly globalised food supply chain. This document describes the key aspects of food fraud, and discusses a set of measures that food safety authorities can take in order to stop the persistent problem of food fraud. Among these, legal interventions combined with the use of technological tools seem to be promising tools in combatting the phenomenon. The adoption of a definition of food fraud at the national level could support the identification of targeted actions, and the tools which help the alignment of national legislations and measures with Codex Alimentarius food standards support national food safety authorities in addressing the problem.

Keywords

Food fraud, food safety, food quality, food adulteration, food standards, food legislation, consumer protection, Codex Alimentarius, Food and Agriculture Organization of the United Nations (FAO), Asia and the Pacific.



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Acknowledgements

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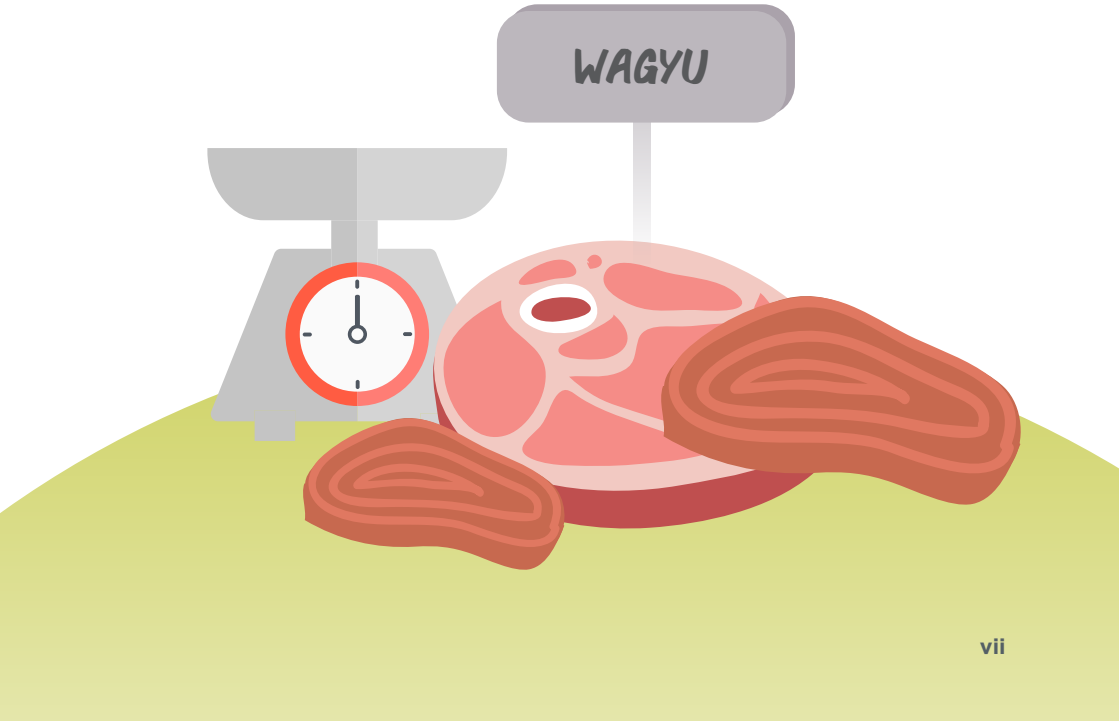
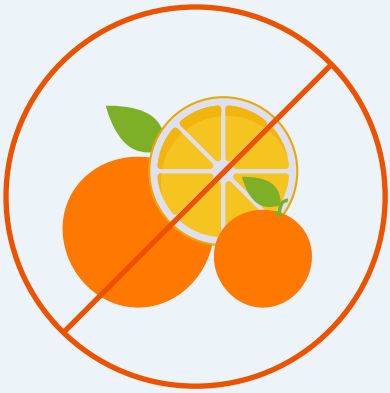




1 Introduction

Food fraud occurs when customers are deceived about the quality and/or content of the food they are purchasing, and is often motivated by an undue advantage for those who are selling the food. A 2016 study conducted on food fraud in Canada showed that more than 75 percent of respondents reported that they would pay an extra one to five percent more for zero food fraud certified products; 24 percent perceived food fraud as a high risk to their health (Statista, 2020). Economically motivated adulteration of food and food fraud can be a serious issue for food safety: the case of melamine in milk led to over 300 000 people becoming ill (BCC, 2010), while the toxic olive oil syndrome resulting from aniline in olive oil led to approximately 300 deaths shortly after the onset of the disease and to a larger number developed chronic disease (Gelpi, 2002).

Apart from the adverse public health impact, food fraud plays a major role in negatively impacting consumers' trust in food industries and government agencies. Food safety professionals around the world are dedicated to ensuring that food is safe, but blind spots in food supply chains can provide opportunities for individuals and business to conduct food fraud. It is extremely costly to respond to food fraud: it is estimated that the cost of food fraud for the global food industry is approximately EUR 30 billion every year (European Commission, 2018).

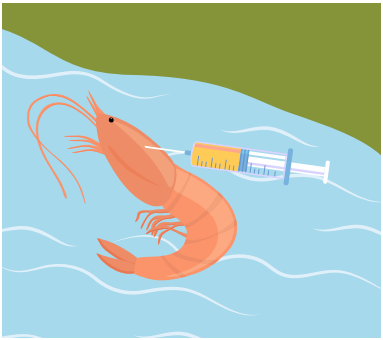
2 Food fraud and food safety

2.1. Background

Food fraud is commonly described as any suspected intentional action committed when a food business operator intentionally decides to deceive customers about the quality and/or content of the food they are purchasing in order to gain an undue advantage, usually economic, for themselves. While this is a common description, many others also exist. Examples of food frauds include adding sugar to honey, selling regular beef as Wagyu beef, or injecting shrimp with gel to make them look larger and weigh more (see Box 1).

While these examples of food fraud mostly harm the wallet and trust of the customer – which alone should call for government action – other forms of food fraud can pose a direct threat to the health of customers and consumers; such as adding melamine to infant formula (Hilts and Pelletier, 2009), lead to powdered turmeric (American Spice Trade Association, 2013), and dangerous chemicals to milk (The News, 2020). Finally, the health threat can be indirect, such as when the nutritional quality of the food is not what is promised because of lower-quality ingredients, which robs the consumer of the health benefits for which they paid. As such, food fraud always concerns *the quality of food,* and it can be related to either the product (e.g. wood dust in coriander; see Hindustan Times, 2019) or the process (e.g. selling non-halal products as halal (Ahmad *et al.,* 2018) without intentionally affecting food safety. However, food fraud can pose a risk food safety as a secondary effect, and it can result in the product being harmful to consumers, such as formaldehyde in fish (Agriculture Times, 2018) and undeclared allergens added to food products (FAO and WHO, 2017) (see Table 1).

Box 1. Gel-injected shrimp



A growing problem in some countries in Asia and the Pacific is the injection of gel into shrimp to increase their weight and make them look more appealing. The health consequences of such practices are unknown, but because the products with which shrimp are injected are not designed for food use, they are likely to be dangerous.

At the national level, widely published food fraud cases can decrease the trust and confidence of consumers in the country's food supply, even in cases where such systems are safe and becoming safer (Barnett *et al.,* 2016). Successful food fraud can also make it more likely that fraudsters take further risks with food, thereby placing the safety and integrity of food supply chains in danger.

Several key challenges make detection and prevention of food fraud difficult. First, it is not always clear what is meant by food fraud and where the line between food fraud and marketing lies. This requires a clear understanding, and potentially a legal definition, of food fraud that does not slow innovation but which protects the health and trust of customers and consumers. Second, without specialized instruments and knowledge, it may be difficult or impossible for consumers to detect food fraud at supermarkets or market stalls. Unless the product poses an immediate health hazard, consumers may not necessarily know, even after consuming the product, that they were victims of food fraud. This means that the fight against food fraud cannot be left

to consumers, but instead must be taken up by governments and the food industry. Third, food fraudsters actively avoid detection and once one method of fraud has been discovered, they move on to a different method, potentially avoiding detection for a long time. This third problem is made worse by the fact that the kinds of products used to adulterate food, such as melamine and other chemicals, are not easily detected through regular food safety and quality tests used by food safety authorities and law enforcement around the world. This requires innovation both in preventing and detecting food fraud, such as the adoption of new technologies and digital innovations on traceability.

Table 1. Types of food fraud

Term	Definition	Example	Potential public health threat that may lead to illness or death
Adulterate	A component of the finished product is fraudulent	Melamine added to milk	Fraudulent component
Tampering and mislabelling	Legitimate products and packaging are used in a fraudulent way	Changed expiry information; fraudulent description of production method or origin	Fraudulent packaging information
Over-run	The legitimate product is made in excess of production agreements	Under-reporting of production	Fraudulent product is distributed outside of regulated or controlled supply chain
Theft	Legitimate product is stolen and passed off as legitimately procured	Stolen products are mixed with legitimate products	Fraudulent product is distributed outside of regulated or controlled supply chain

Term	Definition	Example	Potential public health threat that may lead to illness or death
Diversion	The sale or distribution of legitimate products outside of intended markets	Relief food redirected to markets where aid is not required	Shortages or delays of relief food to needy populations
Simulation	Illegitimate product is designed to look like but not exactly copy the legitimate product	"Knock-offs" of popular foods not produced with same food safety guarantees	Fraudulent product of lesser quality
Counterfeit	All aspects of the fraudulent product and packaging are fully replicated	Copies of popular foods not produced with same food safety guarantees	Fraudulent product

Adapted from Spink and Moyer, 2011.

2.2. Food fraud in Asia and the Pacific

Asia and Pacfic suffer from a lack of accurate data on food fraud, but are still considered to be at risk from this practice (Reilly, 2018). Further, the **globalization of food supply**, with long, complex and often difficult-to-trace chains, and the related lack of transparency and traceability, **creates new opportunities for food fraud**, and potential safety and health threats as a result.

A brief overview of some reported food fraud cases from Asia and the Pacific in the past three years, as found in the European Commission's monthly Food Fraud Summary Reports (2020),[1] provides a wealth of examples of "traditional" food fraud – those types of **fraud that target the same products and channels of commerce as has been practiced for millennia.**

[1] These monthly reports can be found at: https://ec.europa.eu/knowledge4policy/food-fraud-quality/food-fraud-summary-reports_en

Table 2. Overview of some reported food fraud cases from Asia and the Pacific in the past five years

Australia Almost 20 percent of honey on the Australian market is adulterated with substances such as cane sugar or corn syrup. The rate of adulterated samples went up to 50 percent for imports from Asia (Zhou *et al.,* 2018).

Bangladesh National authorities were forced to shut down a synthetic fruit juice manufacturing plant for producing juices that did not contain any fruit but were instead manufactured using hazardous chemical substances (Daily Sun, 2018).

Pakistan The country is the world's fifth largest milk producer, authorities commonly confiscate milk adulterated with urea and contaminated water (The News, 2019; Daily Times, 2019).

China A collaboration between Chinese and Italian scientists carried out DNA tests on 153 samples from 30 different brands of roasted Xue Yu (a kind of cod) fillet and found that 58 percent of the samples were substituted with other fish species (Xiong *et al.,* 2017).

Taiwan Province of China The chair of a food processing company was convicted of mixing low-grade palm oil and other cheap oils and labelling them as high-grade olive oil. Beyond the fact that lower-quality oils were used, the blend also contained artificial colourants that were harmful to human health (Logan, 2016).

Source: European Commission, 2020.

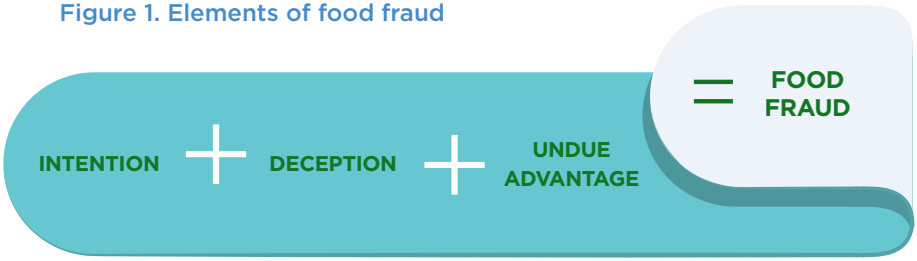
New challenges with regard to addressing food fraud are related to the fast growth of e-commerce of food in the Asia-Pacific area. Countries such as Australia, China, Indonesia, Japan and South Korea are experiencing a boom in e-commerce in general, and increasingly in food e-commerce. Three of the top ten online grocery markets in the world are in Asia, with the majority being in China followed by Japan and South Korea (Food Industry Asia, 2018).

There are several problems associated with food e-commerce, particularly between businesses and consumers, which make e-commerce more vulnerable to food fraud. These result from the fact that consumers have no face-to-face contact with the traders, no real opportunity to inspect food items before purchase, and are (typically) required to pay in advance of delivery. Essentially, consumers must fulfil their contractual obligations at the beginning of the transaction, while trusting the trader, who may be in another jurisdiction, to fulfil theirs at the end (Hunter and Riefa, 2017). Furthermore, even legitimate food business operators who operate online may not be able to control the final delivery of the products (Comans, 2019), which are often posted to the final consumer or delivered via couriers. Due to these vulnerabilities, a recent investigation using DNA barcoding of fishery products sold online in China found that 85 percent of the samples identified by DNA barcoding were mislabelled (Xiong *et al.* 2016)

2.3. Key legal aspects that determine food fraud

The previous section showcased a variety of examples of food fraud in Asia and the Pacific. To better identify legal interventions and new technologies to reduce food fraud, it is important to go beyond examples and try to better understand what food fraud is. FAO has been active in this area, and in 2019, it convened an expert meeting to discuss food fraud.

Figure 1. Elements of food fraud



Source: FAO, 2020

From four days of discussion and debate, the expert meeting identified three elements underlying all cases of food fraud, informed both by international instruments[2] and existing national examples:[3]

1) intentionality,
2) deception and the motivation of
3) undue advantage (Figure 1).

Intention separates food fraud from mistakes and errors. Deception may be through any means, such as labels or advertisements, and at any stage of the supply chain, to mislead a buyer, customer or consumer as to the integrity or value of the food. Food fraud is different from other offences because of the presence of an undue advantage, or unfair advantage, which most often takes the form of economic gain. Of course, if injury is caused, in particular to human health, or if death is caused, such effect should attract a penalty that matches or reflects the level of injury. As such, food fraud could be understood as the intentional deception of a customer or a consumer for an undue advantage, economic or not (FAO, 2020).

[2] Such as: Codex Alimentarius Commission, Discussion Paper on Food Integrity and Food Authenticity, CX/FICS 18/24/7, August 2018; BRC Global Standards. 2018. Global Standard Food Safety. Issue 8; International Featured Standards. 2018. IFS Standards Product Fraud – Guidelines for Implementation; Global Food Safety Initiative. 2018. Tackling Food Fraud Through Food Safety Management Systems.

[3] Such as: China, Draft Measure to Handle Acts of Food Safety Fraud; EU, EU Food Fraud Network key operative criteria for food fraud; USA, FDA Notice on Public Meeting on Economically Motivated Adulteration, 74 Fed. Reg. 15,497; British Standards Institution PAS 96: 2017.

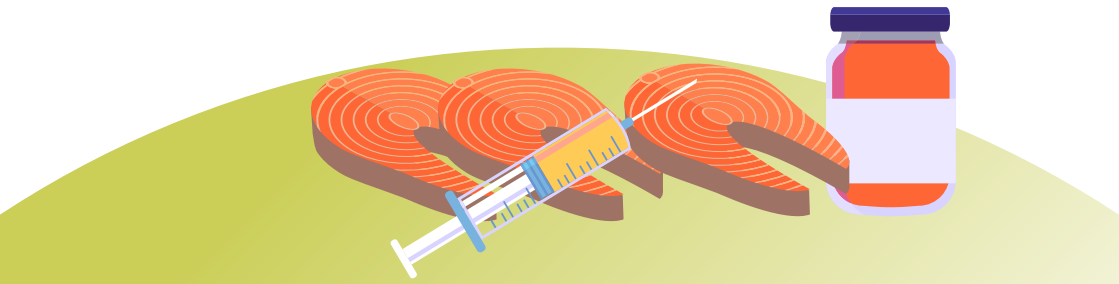
What is clear from these elements, is that **any act that would be categorized as food fraud would already most likely be prohibited** in the national legal frameworks of jurisdictions in the Asia-Pacific region. This should not lead to a sense of security, however, as the rising number of food fraud cases in the region, and in the world in general, suggest that a generic approach is not necessarily enough. The question then is, what would be the legal interventions, as well as potential technical innovations, needed to reduce food fraud?

2.4. Legal interventions and new technologies to reduce food fraud

2.4.1. Legal interventions

Even in jurisdictions where food fraud cases are already be prohibited, it is still **valuable for governments to adopt a definition of food fraud.** A well-defined concept of food fraud may bring focus and offer more targeted solutions to pre-existing prohibitions, as well as highlight the seriousness of food fraud, which poses risks not only to economies but also people's health. Few countries have laws that define food fraud in all jurisdictions, including those in the Asia-Pacific region.

Preventing food fraud from happening in the first place is safer and more cost-efficient than trying to detect it after the fact. Legal frameworks can, and often do, place the primary responsibility to prevent fraud on food business operators, such as through traceability requirements and requirements to adhere to good agricultural practices and good manufacturing practices. One way to improve the private sector's capability to prevent food fraud is the adoption of **food fraud vulnerability assessments** in both private and public regulatory frameworks (see Box 2).



Box 2. The Vulnerability Analysis and Critical Control Point (VACCP) system

Food safety has significantly benefited from the adoption of the Hazard Analysis and Critical Control Point (HACCP) principles. Similar gains in the fight against food fraud could be achieved by the adoption of the Vulnerability Analysis and Critical Control Point (VACCP) system. Following the VACCP principles, a food business can develop documented procedures to identify and mitigate the risks of food fraud in their supply chains. (Reilly, 2018a)

A VACCP system would typically consist of:

- drawing up a list of all ingredients and materials used in the manufacturing process;
- identifying potential forms of fraud they may be subject to;
- evaluating the risk of fraudulent practices;
- identifying and implementing control measures; and
- recording and reviewing findings.

Adulteration is a well-known form of food fraud, which can pose direct health risks to consumers. Many of the examples in earlier sections of this paper – contaminated water in milk, dangerous chemicals in spices, formaldehyde in fish, melamine in infant powder – pose direct risks to anyone unlucky enough to have consumed such fraudulent products. Due to adulteration's direct health risk, national food safety frameworks, and occasionally their criminal laws, commonly prohibit or criminalize this practice. One example comes from Thailand, where the Food Act (B.E. 2522) Section 27 prohibits adulteration, substitution and mislabelling, which includes many forms of typical food fraud (see Box 3).

Box 3. Thailand's Food Act Section 27

Food of the following descriptions shall be deemed adulterated:

1) Food for which other substances are partly substituted, or in which valuable substances are wholly or partly removed and which is sold as or under the name of the genuine food.
2) Substances or food produced as substitutes for any food and distributed as being genuine food.
3) Food that is mixed or prepared in any way to conceal defects or inferior quality of the food.
4) Foods labelled in order to deceive or try to deceive purchasers in matters of quality, quantity, usefulness or special nature or place or country or production.
5) Food not up to the quality or standard prescribed by the Minister of Public Health, and the quality or standard of that food deviates from the upper or lower specified limit by more than thirty percent, or its deviation may be harmful to the consumer.

One way to provide an objective background against which cases of suspected food fraud can be measured, is to adopt food standards for specific products and commodities. To ensure that these standards reflect international best practices, the use of standards adopted by the Codex Alimentarius Commission is highly recommended.[4] As an example, if a seller was offering a product labelled "edible sago flour" in a jurisdiction that has a food standard for it that is compliant with the Codex Alimentarius Regional Standard for Edible Sago Flour (Asia) CXS 301R-2011, and the offered product did not comply with such standards, the second element – deception – would be easy to prove.

[4] These standards are available online at: http://www.fao.org/fao-who-codexalimentarius/codex-texts/list-standards/

Particularly when combined with food standards, food labelling rules can be effective in preventing food fraud. Simply put, if the information required and provided for a food item is true, lawful and clear, there is no room for food fraud. As with food standards, matching a country's labelling requirements with those proposed by the Codex Alimentarius Commission would ensure the use of international best practices. For example, in Japan, the Food Labelling Act (Act no. 70 of 2013) creates standards for food labelling following the fundamental principles of securing the safety and opportunity of consumers to make autonomous and rational choices. In South Korea, the Food Sanitation Act (Article 13) creates a prohibition against false and unrealistic labelling and advertisement of food items, as well as the use of labels or advertisements that are likely to deceive or mislead consumers.

Outside the scope of food safety legislation, consumer protection legislation can also offer protection against food fraud. These types of legislation protect consumers' right to not be harmed by unsafe and hazardous goods and services, and to be informed about issues such as quality, quantity and price and to seek redress against fraud (Vapnek and Melvin, 2005). India's Consumer Protection Act of 1986 contains provisions for the protection of consumers against unfair trade practices, defined as: "trade practices, which, for the purpose of promoting the sale use or supply of any goods [including food] or for the provision of any service, adopts any unfair method or unfair or deceptive practice".

Examples given in the same article include falsely stating that goods are of a particular standard, quality, quantity, grade, composition, style or model; or making false or misleading statements concerning the need for, or the usefulness of, any goods or services.

Finally, food e-commerce should be subject to the same requirements as traditional retail market requirements, and could benefit from specific legal interventions. More careful attention may need to be paid to aspects such as record-keeping and transparency, traceability of food, and controls and import formalities. A difficult topic in food e-commerce is the question of liability of different stakeholders for cases of food fraud. While the primary responsibility for food fraud is with the food business operators who committed the act, regulators may need to decide on the limits of liability for the providers of online

platforms where these foods are traded (see Box 4). Other possible issues can arise, such as when food offered for sale online is produced following the food safety standards of the producing country, which may differ from those of the importing country (see Box 5).

Box 4. Liability in food e-commerce in China

Internet platforms in China are both regulators and regulated under China's Food Safety Law. They are obligated to register the legal names of food retailers admitted to their platform, define their food safety management responsibilities, and verify that those who are required to obtain permits have their permits. If the platform becomes aware of food safety violations, which could include food fraud, the platform must stop the trader from continuing irregular activities and report them to the local food and drug authority. For serious offences, the provider must stop providing the internet platform services. Failing to comply with these obligations can lead to fines or closure of operations for the e-commerce platform.

Any of these legal interventions are unlikely to succeed without efficient control and enforcement. Governments need to be able to detect the occurrence of food fraud, including through import controls at their borders. This requires creating a legal basis to control and inspect food products at various stages of the food chain. Beyond a legal basis, government officials undertaking food inspections must have the technical capacity to physically detect when a product is fraudulent. For this exercise, the technological innovations of the next section can help.

Box 5. Professional counterfeit hunters

In the early stages of cross-border food e-commerce in China, a unique mode of private enforcement emerged in the form of professional counterfeit hunters – groups of private professionals aiming to intentionally purchase substandard goods to seek punitive compensations under China's consumer protection and food safety laws. These counterfeit hunters intentionally purchase food items in cross-border e-commerce that they suspect to be in violation of Chinese food and safety standards. They then file lawsuits against the online food business operators and platform service providers, claiming that it is a fraudulent practice for them to sell those foods. If hunters are successful in the courts (i.e. the food item did not follow the Chinese standards, whether or not it followed the domestic standards of the country-of-origin), they would be rewarded compensations of ten times the value of the food purchased. (Pinghui, Xiao, pers. comm., 2019; Global Times, 2018).

2.4.2. Innovative technologies

Food fraud is a continuous race between food fraudsters who devise new ways to defraud their customers, and officials and careful buyers who try to catch them. Fraudsters hold an unfortunate edge in this race, as they are free to innovate any possible ways to increase their profit, with no concern for the well-being of consumers. To deal with this, legal interventions alone are not enough, and innovative technologies can go a long way to breach the gap.

Traditionally, access to laboratories has been a requirement to detect whether some food products have been adulterated and are fraudulent. This is costly both monetarily and time wise. The recent development of portable testing devices, through funding from both the private sector and governments, may reduce both costs. Thanks to recent developments in miniaturisation technologies, AI-driven machine learning and general increases in computing power, it is now possible to build portable devices utilizing infrared, ultraviolet and visible light, or Surface Enhanced Raman Spectroscopy sensors. Use of such relatively cheap portable devices would move testing from the laboratory to the field and enable risk-based sampling. Using a variety of detection technologies, with different sensory capabilities in changing combinations, would make food fraudsters' jobs of finding weaknesses in any individual method more challenging (Popping, 2019).

The real functionality of the portable devices would be dependent on the reference database against which they would reference the results from analysing the samples. To be as effective as possible, and accessible to officials and private parties alike, such reference databases could be centrally held by an independent institution or organization. This naturally carries rather significant costs. Secondly, the quality of the data, both from authentic products and from adulterated ones, fed into such reference databases, may be the reason for the database's failure or success. With good data, these databases and devices can create accurate profiles of authentic products, against which samples can be compared (Popping, 2019). Conversely, low-quality data results in overall inefficiency of the database.

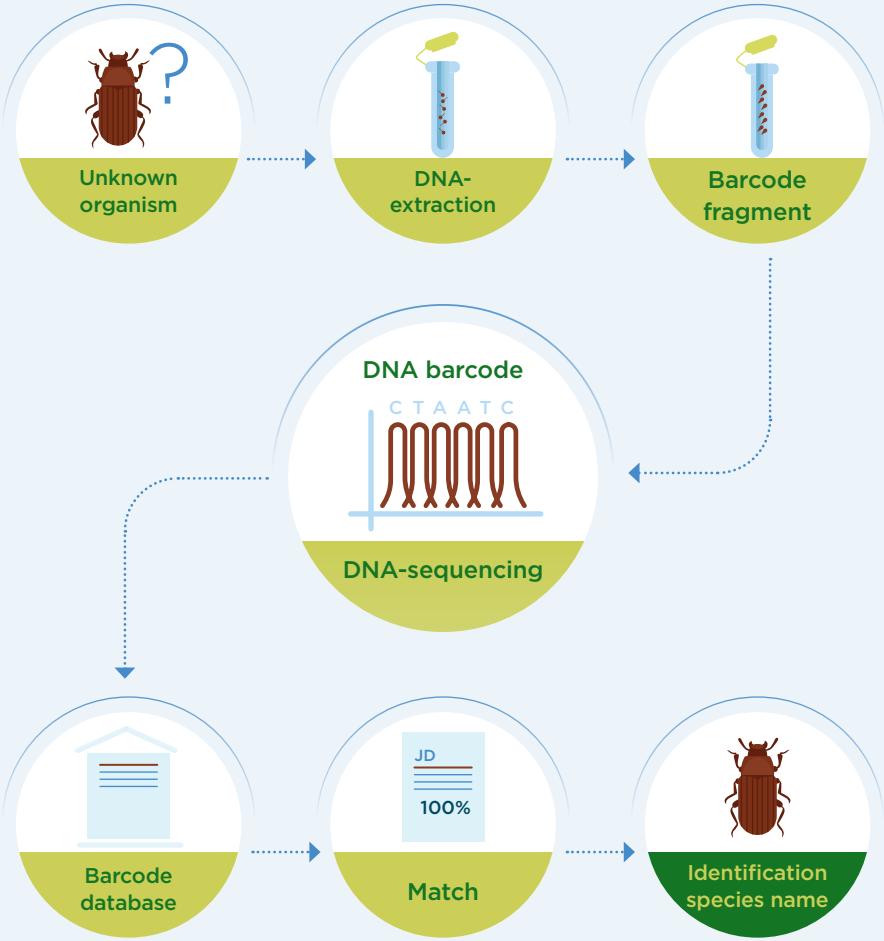
DNA barcoding, which has seen success when used to identify fish (see Box 6), is a promising and potentially very accurate method of identifying the species and detecting cases of food fraud by substitution. For fish identification, DNA barcoding works by using a short genetic sequence of mitochondrial DNA to identify the fish as belonging to a particular species. This very useful method can be used on both raw and cooked products (Reilly, 2018b).

Box 6. DNA barcoding to detect fish fraud in Asia (Reilly, 2018b)

Investigations in Asia using DNA barcoding have reported cases of mislabeling of fish. In a forensic fish survey conducted in Malaysia in 2016, 16 percent of raw, frozen or commercially processed fish were found to be mislabeled (Chin Chin *et al.,* 2016). Studies in China using DNA barcoding have also revealed widespread mislabeling of fish on the national market (Xiong *et al.,* 2016a, b). A study on the authenticity of fish maws (dried, salted swim bladders) on the Chinese market found that 53.2 percent were mislabeled, and commercial species substituted with low-value species (Wen *et al.,* 2015). Similarly, an investigation into the authenticity of fish imported into Taiwan Province of China showed that 70 percent of samples were mislabeled (Chang *et al.,* 2016).

An Indian survey of the authenticity of fresh and processed fish from the domestic market also used DNA barcoding (Nagalakshmi *et al.,* 2016). Its results showed that 22 percent of samples were mislabeled. Another study used DNA barcoding to identify shark species from dried fins, confiscated from a vessel fishing illegally in Australian waters (Holmes, Steinke and Ward, 2009). It found that the fins were from 27 different shark and ray species, some belonging to endangered species. A DNA analysis of fish in retail markets and fish ports in Indonesia utilizing both the CO1 and the nuclear rhodopsin gene fragment revealed mislabeling of some species and substitution with endangered species (Abdullah and Rehbein, 2017).

Figure 2. Simplified steps for DNA barcoding



Another technically advanced method for establishing food authenticity is the variety of techniques under the umbrella of nuclear techniques, including the analysis of stable isotopes and trace elements, and profiling volatile organic compounds. Stable isotope analysis combined with trace element analysis can be a very accurate way to link a food product to the environment or location where it was produced and the agricultural methods that were used during its production.

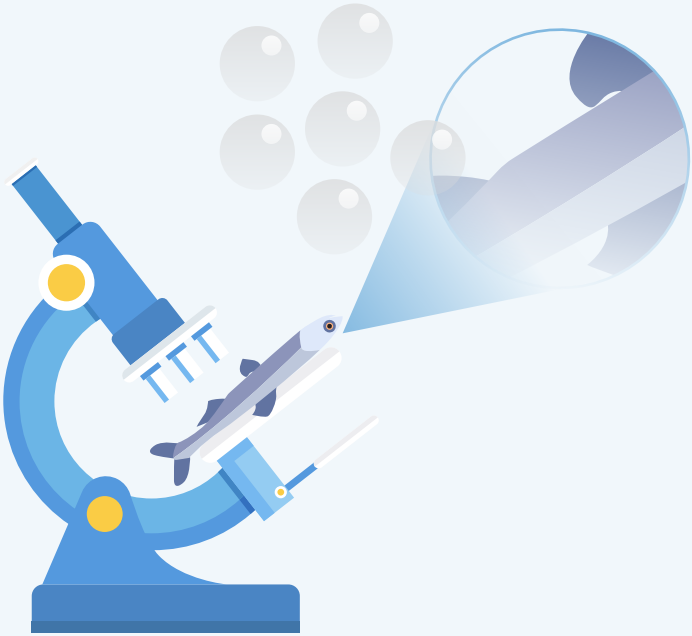
While this method can be very accurate, it is both costly and requires a high level of expertise to undertake. As with the simpler portable devices, the results are only as good as the comparison data available in reference databases (Kelly *et al.,* 2019). Another robust method that provides ideal application to detect food frauds is Nuclear Magnetic Resonance spectroscopy, which can rapidly analyse mixtures at the molecular level without requiring separation and or purification steps (Hatzakis, 2018). The fact that a broad spectrum of ingredients can be tested at once allows for both on-targeted detection and for quantification of dozens of substances in a few minutes. The result of the test is a pattern of substances that can be easily compared to other reference spectrums of authentic foods through automatic methods. The success of the application of this techniques largely relies on the availability of sufficiently populated databases (Sobolev, 2019).

Blockchain technology shows early promise in improving traceability and transparency of food supply chains (see Box 7). Blockchains can assist in providing an unchangeable record from the creation to the retail store of a product (FAO and ITU, 2019). As such it could be efficient in preventing operators in the middle of the supply chain from changing the description of a food product, such as mislabelling horse meat as beef, but it would not prevent the first person inputting the original data into the blockchain from fraudulently defining the product at the start. Blockchains can also be expensive to operate, and for full traceability, require the different blockchains of different companies to work together (Kim and Laskowski, 2017). As such, blockchains do not offer a silver bullet to combat food fraud and more general issues of traceability, but when applied carefully and combined with inspections to verify the quality of original information, can increase the transparency of supply chains and consumer trust.

Box 7. What is blockchain?

Distributed ledged technology (DLT) is a decentralized system for recording transactions with mechanisms for processing, validating and authorizing transactions that are then recorded on an unchangeable ledger.

Blockchain is an implementation of DLT. In the simplest terms, a blockchain consists of a linked chain that stores auditable and unchangeable data in units called blocks.



Conclusions

Food fraud is an age-old problem that has gained more recognition in the policy agendas in the Asia and Pacific region in recent years because of highly publicized cases of very serious health repercussions. Because of rapidly rising living standards, and the related demand for premium quality food, as well as the explosive growth of food e-commerce, the region is considered to be at particular risk for food fraud. This fact requires action from governments to ensure consumers' trust in the safety and function of their food supply chains.

Two connected avenues for preventing and controlling food fraud were considered in this paper: legal interventions and technological innovations. Legal interventions, which should closely match the individual country context, could benefit from a definition of food fraud in a statutory instrument. Such a definition could bring clarity and focus on the fight against food fraud. Other key interventions could include the use of VACCP principles, creating and updating food standards and labelling rules compliant with the Codex Alimentarius standards, and the application of consumer protection legislation to cases of food fraud, when food safety systems are not more suitable. Importantly, the rapidly expanding food e-commerce sector requires specific legal interventions to make it safer, more transparent and reliable, such as by clearly designating the roles and liabilities of the different operators, including internet service providers, in the field of online food trade. These interventions must be accompanied by effective control and monitoring mechanisms.

To assist in catching technologically advanced food fraudsters, this paper showcased some recent technological innovations. Handheld portable devices can take testing from the laboratory to the field. Nuclear techniques, such as stable isotope analysis, while difficult in terms of cost and high-levels of expertise required, can be very accurate in detecting various kinds of fraud, including mislabelling of origin and production process. Both of these require comprehensive reference databases in order to fully function. DNA barcoding can be very effective in identifying species substitution, and has seen great success when used on difficult-to-identify fishes. Finally, blockchain and other digital traceability solutions, when appropriately applied, can increase the transparency of food supply chains, thus making fraud more difficult and increasing consumer trust.

4 Recommendations for food safety authorities

Below is a set of practical recommendations that national food safety competent authorities might like to consider:

1. Include the topic of food fraud when discussing emerging issues regarding food safety. In order to preserve consumers' trust and the safety of food supply chains, governments need to manage food fraud, especially when it jeopardizes the safety of food.

2. Adopt a definition of food fraud at the national level.

3. Review national food safety and quality legislation so that they are aligned with Codex Alimentarius, which provides a solid basis to counter food fraud.

4. Develop a framework to respond to challenges related to food fraud in e-commerce.

5. Keep up to date with and invest in new technologies to counter food fraudsters.

5 Resources

5.1. FAO Resources

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5.2. Other readings

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Food fraud

Intention, detection and management

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