

IUFOST Scientific Information Bulletin (SIB)
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FOOD FRAUD PREVENTION

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Summary

Food Fraud – and the focus on prevention – is an important and evolving food industry focus. Even though the vast majority of these incidents do not have a health hazard in some ways they are more dangerous because the substances and actions are unknown and untraceable. The types of food fraud stretch the traditional role of food science and technology to include criminology, supply chain traceability and other control systems. The food authenticity and integrity testing will be the most complex actions and their value should be assessed in terms of the contribution to prevention. This Scientific Information Bulletin (SIB) presents an introduction, review of incidents, the fundamentals of prevention which then provide insight on the optimal role of Food Science and Technology.

Introduction

Food Fraud – including the US-centric sub-category of “economically motivated adulteration” or “EMA” – globally is one of the most active food industry and regulatory issues. Food companies and agencies – regardless of a traditional focus on public health risks – are being held accountable by consumers and agencies for food fraud prevention. This has been a major government focus in the European Union, United Kingdom, China and – while there has been focus on food safety issues within the Food Safety Modernization Act there are clear food fraud compliance requirements – the USA. Beyond the potentially catastrophic economic impact of a recall or manufacturing shut-down, corporate officials are being held personally criminally liable for incidents. The prosecution has shifted from liability for the corporation to criminal incarceration for corporate leaders such as for Peanut Corporation of America and Jenson Brothers. [1, 2] For these and many reasons discussed below there has been an intense focus on food fraud research and specifically on prevention.

For Food Scientists and Technologists, the most applicable and complex aspect of food fraud is product authentication and integrity testing.[3-6] The value of those tests and methods should be judged by the contribution to reducing the *fraud opportunity*, *i.e.*, the overall *food fraud prevention*. It is said that we will not test our way to safety and we will not arrest our way to prevention.

The *research justification* for this Scientific Information Bulletin (SIB) is to provide an overview of food fraud vulnerability and prevention so Food Science and Technology can be most efficiently and effectively applied.

Food Fraud Overview

Definitions and Types

Food fraud is illegal deception for economic gain using food.[7-11] The broad types of incidents include adulterant-substances (including dilution, substitution, concealment, etc.), tampering, theft, diversion or gray market, over-runs or unauthorized production, simulations and intellectual property rights counterfeiting (Table 1).[7] A 2016 Michigan State University survey reinforced the broad scope of food fraud when over 50% of survey respondents prioritized adulterant-substances, tampering, theft, *and* counterfeiting.[12] A challenge is that other than adulterant-substances the countermeasure and control systems are outside of food science authenticity or integrity testing.

While the greatest health hazard is usually from adulterant-substances and counterfeits, to prevent the fraud act by a human actor, the most efficient focus is on reducing the *fraud opportunity*. Food Fraud (intentional, no harm) is one type of food risk along with Food Quality (unintentional, no harm), Food Safety (unintentional, harm), and Food Defense (intentional, harm). The interrelation can be explained using the Food Risk Matrix (

Figure 1). To be most efficient from a business process standpoint – to thoroughly manage and counter all types of risks – it is most efficient to assign an *accountable person* to each cell in the matrix and to assign each incident to a specific cell. This may seem intuitive but this process is only recently being researched and implemented.

Food Quality	Food Fraud	Motivation: Economic Gain
Food Safety	Food Defense	Harm including health, economic, terror
Unintentional	Intentional	Food Risk Matrix

Figure 1: Food Risk Matrix used to differentiate Food Quality, Food Safety, Food Fraud and Food Defense [13]

A 2007 SIB addressed the food defense aspects in [Short Summary on Food Defense](#). The SIB focus was consistent with the definitions and scope listed here. Also, the recommendations built upon the traditional food safety Hazard Analysis and Critical Control Point (HACCP) concepts and methods that are also consistent with the direction of food fraud prevention.

A 2015 SIB on [Whistleblowing and the Food Industry](#) mentioned food fraud and one of the actions that is very hard to detect. This SIB mentions the Sarbanes-Oxley Act of 2002 in relation to the whistleblower provisions.

There is a seemingly limitless list of types of adulterant-substances but they are all used to exploit essentially a basic *fraud opportunity*. The *fraud opportunity* exists for adulterant-substances since there is the ability to deceive authentication or integrity tests. The fraudsters have exhibited tremendous ingenuity and efforts to avoid detection. Also, if the risk of getting caught or the cost of

conducting the crime is too high, the fraudsters innovate. For example, rather than utilizing complex and covert manufacturing operations, many fraudsters have switched from counterfeiting to stolen goods. Food is now the largest dollar value of cargo theft in the USA “food and drink is the most stolen type of freight since 2008.”[14] The adaptation to stolen goods creates a problem for authenticity and integrity tests because the products are defined by the US Food, Drug & Cosmetics Act as ‘Adulterated Foods’ -- unfit for commerce -- and subject to a recall. The stolen goods are 100% genuine. Authenticity tests could **not** identify the stolen goods.

Table 1: Food Fraud Types, Definitions, and Examples [7]

Term	Definition	Example
Adulteration (adulterant-substance)	A component of the finished product is fraudulent; substance or an impurity	Melamine added to milk
Tampering	Legitimate product and packaging are used in a fraudulent way. Includes mislabeling.	Changed expiry information, product up-labeling, religious designation, etc.
Over-run and Unauthorized Production	Legitimate product is made in excess of production agreements	Under-reporting of production
Theft	Legitimate product is stolen and passed off as legitimately procured	Stolen products are co-mingled with legitimate products.
Diversion or Gray Market	The sale or distribution of legitimate products outside of intended markets. Includes smuggling	Relief food redirected to markets where aid is not required
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 assurances
Counterfeiting	Intellectual Property Rights (IPR) infringement, that could include all aspects of the fraudulent product and packaging being fully replicated	Copies of popular foods not produced with same food safety assurances

Review of Incidents

While food fraud has been recorded since the Chinese Zhou Dynasty (1046 to 256 BC) [15], there has been a lack of strategic or holistic approach to prevention. Throughout history there has been a priority on public health risks such as foodborne illness and deaths. When an agency such as the US Food and Drug Administration takes a ‘public health, risk-based approach’ traditional food safety incidents would be a much more dangerous threat than from food fraud. The vast majority of food fraud incidents do **not** have a public health threat. Food safety incidents are a much bigger health hazard for societies.

Several megatrends have led to food fraud becoming more of a recognized threat. *Globalization* has led to more products moving faster around the world. Globalization has enabled the *economically viable manufacturing scale* to increase so some facilities make more and more product. At the same time, *traceability* allows more *transparency* of the provenance or source of the product. This combined with the *advanced detection* technology – and *dissemination of higher powered testing equipment* – has led to the more accurate identification of the source of anomalies.

Before reviewing food fraud incidents, it is important to review how food is determined to be ‘safe.’ The 2013 SIB on [Safety, Risk, and the Precautionary Principle](#) provided several key concepts that apply to food fraud prevention and vulnerability. Quotes from that SIB include:

- “‘Safety’ literally means complete absence of risk. Nothing in life is entirely risk-free, and indeed science cannot demonstrate freedom from risk, particularly from as yet unknown risks, because ‘absence of evidence’ is not ‘evidence of absence.’ Science cannot know, and can never know; all there is to know about any topic.”
- “So any policy purportedly based on requiring science to prove safety is unrealistic. In practice, therefore the purpose must be to achieve absence of unacceptable risk or, to use a term borrowed from the World Trade Organisation “an appropriate level of protection” (ALOP).”
- “What constitutes ALOP is determined by legislators in the form of laws and regulations, although a manufacturer may choose to operate stricter standards than the law requires.”
- “For practical purposes, references to ‘safety’ and ‘safe’ in this Bulletin should be interpreted as meaning achieving ALOP.”

Essentially for food safety, finished products and ingredients are tested for the biological, chemical, and physical agents that most often lead to unsafe foods. Food is not tested to be ‘safe’ it is tested to make sure it does not contain agents at levels that most often lead to *unsafe* food or that do not meet the ALOP. Considering that, it is not surprising that a focus on identifying or avoiding specific unacceptable adulterant-substances does not stop food fraud. If the fraudsters do not know detection tests are being conducted then these countermeasures may not lead to prevention. The goal is to prevent -- not catch -- food fraud.

It is important to note that other industries have also not had success in preventing a wide-range of product fraud. There are no magic processes or test methods that have solved this problem for other industries. As will be covered later, the food industry efforts from 2012-2016 are actually much more efficient and effective than for other industries.

Several of the most influential food fraud incidents are reviewed here:

- **Sudan Red colorant:** It was generally around 2003 that this became a food fraud concern. [16] The colorant is illegally used to brighten spices and sauces, which is more appealing to consumers. This was a global incident that raised the awareness that food fraud could be a wide-spread public health and economic incident.
- **Melamine in Infant Formula and Skim Milk powder:** Melamine had occasionally been found in foods but there was a low public health concern until this outbreak generally around 2007. The

US Pharmacopeia *Food Fraud Database* reported melamine adulterant-substances as early as 1980.[17] Melamine, when combined with other contaminants, created the health hazard. Once melamine was identified – and tested – there was a realization of a very wide-scale threat that was throughout Asia. Melamine is a plasticizer used in plastics production and there should not be any appreciable or dangerous amount in foods. The amount of melamine that would migrate or leach from plastic packaging would not create the contaminant levels for this type of illness.

- **Melamine in Pet Food:** Also generally in 2007-2008, melamine and the contaminants were found in wheat gluten used in pet foods.[18] At the start of the intervention, the challenge was to even just figure the root cause of the illnesses and deaths. As with infant formula and milk powder, melamine was never expected to be in the foods at elevated levels.
- **Horsemeat in Beef:** Generally in 2012, horsemeat was found to have been illegally substituted in beef.[19] A routine quality control test in Ireland found horsemeat that led to world-wide testing and recalls. Horsemeat was found to be substituted in a wide-range of products. While there was considered to generally be no public health threat the consumer and recall impacts on the industry were near economically catastrophic for the company, meat industry, food industry, and the UK economy. Some species – or process – substitution also has religious concerns regarding the preparation or handling.
- **New incident reports:** Over time, more incidents have just reinforced that food fraud is a constant issue that must be addressed. The range of issues include: peanut husk filler in cumin, species swapping in fish, fillers in oregano, extra virgin olive oil fraud, and others.[20-23] In certain cases such food fraud could be catastrophic, for example, where a substituted ingredient results in a severe allergic reaction.

The horsemeat scandal was the incident that led to the UK/DEFRA funded Elliott Review which recommended the creation of the UK National Food Crime Unit.[24] Also, this incident accelerated the activity of the Global Food Safety Initiative (GFSI) to expand their Food Safety Management System to specifically – and uniquely – cover food fraud (GFSI is a consortium of food companies focused on creating a harmonized Food Safety Management System and certification which followed the recommendation of their Food Fraud Think Tank).[11, 25]

Interdisciplinary approach

An interdisciplinary approach is recommended by the likes of the UK Elliott Review, EU, China, the USA, and the GFSI.[8, 11, 21, 26, 27] It has been said that “if the biological organism in question is a microbe it is most efficient to engage the field of microbiology; since the biological organism in question is a human, and therefore, it is most logical to engage the field of Social Science and specifically Criminology.”[15]

Criminology theory helps to understand the root case and how to focus preventing the crime. A wide range of other disciplines must be engaged to understand the *fraud opportunity* including supply chain management, food science authenticity testing, countermeasures such as from packaging science,

information technology for traceability, decision-sciences and risk analysis to assess the vulnerability, and then business decision-making such as Enterprise Risk Management (ERM).[28]

Food Fraud Prevention

Food fraud prevention starts with criminology and the motivation of the human actor. Criminology prevention considers broad system that covers the entire market or physical environment. The Criminology theories are Situational Crime Prevention (the space of crime), Routine Activities Theory (what other actions are criminals conducting), and Rational Choice Theory (why do the criminals think they can get away with this crime). Environmental Criminology considers the space of crime whereas Traditional Criminology considers the psychology of the criminal.

Another set of theories approaches food fraud not from a Criminology standpoint but from Business Fraud. It is sometimes confusing that both theories include a triangle: the Crime Triangle and the Fraud Triangle. Also, over time, each of these theories has evolved to more complex triangles.

The Association of Certified Fraud Examiners defines the Fraud Triangle with the three legs to be: (1) pressure (on the individual), (2) opportunity, and (3) rationalization. [29] This is sometimes expanded to a diamond adding a component of (4) capability of the fraudster. [30]

The original and basic Crime Triangle is based on Situational Crime Prevention and Routine Activities Theory. This considers that the 'crime opportunity' is defined by: (1) victim, (2) criminal, and (3) absence of a capable guardian.[31, 32] Adapted to food fraud, the *fraud opportunity* is determined by: (1) victim, (2) fraudster, and (3) guardian and hurdle gap (Figure 2).

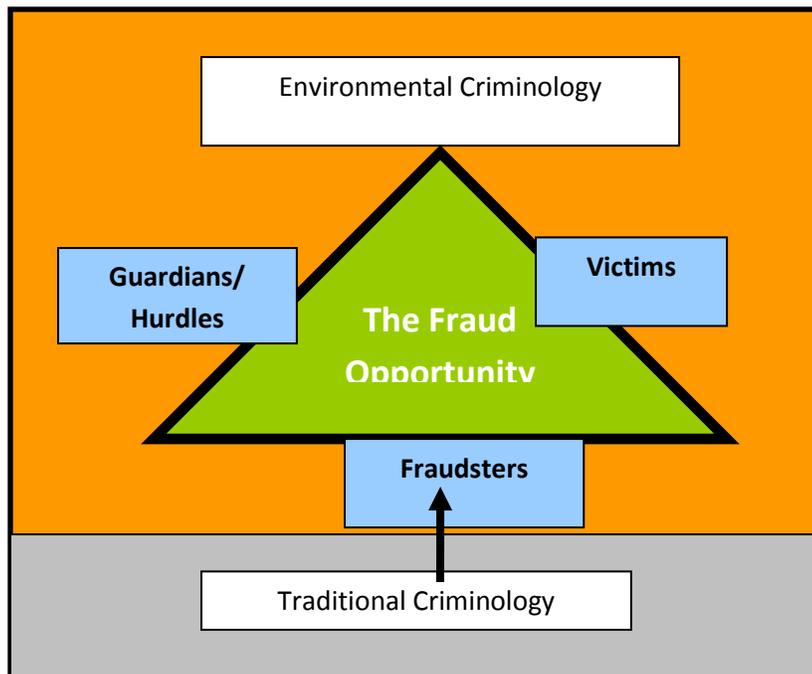


Figure 2: Situational Crime Prevention applied to Food Fraud in the Crime Triangle [7]

The movement of so many products so far around the world also creates a new and expanding *fraud opportunity*. As the melamine in pet food incident demonstrated, one incident can very quickly impact product around the world. As the horsemeat in beef scandal demonstrated, one rogue supplier can cripple an entire industry.

Food Fraud Prevention Strategy

Many governments are requiring that food fraud hazards be (1) assessed and (2) control plans be put in place to manage those hazards. Specifically addressing food fraud is new so there naturally are not too many details or prescribed regulatory compliance requirements.

Beyond the massive economic loss to industry for incidents such as melamine or horsemeat, individuals are being held criminally liable. While there may be few compliance requirements, companies – and their individual leaders – are being held criminally liable for incidents. For example, the CEO of Peanut Corporation of America was sentenced to over 30 years in US Federal prison for his role in a food fraud incident.[1] Also, five other company employees received US Federal prison sentences of at least five years.

Regardless of the current or future regulatory compliance requirements, to maintain a viable business companies must reduce their *fraud opportunity*. The increase in the awareness of the economic impact of food fraud coincided with the advancing academic focus on *proactive prevention*. Taken together, the food industry has taken a very proactive and active approach to address food fraud.

Conclusion: The Role of Food Science and Technology in Food Fraud Prevention

Food Fraud Prevention is complex not only in the analytical methods of detection but in the interdisciplinary applicable theory. Because there is usually no health hazard, the traditional detection and alert systems often do not detect food fraud. The key actions in reducing the fraud opportunity are to detect, deter, and prevent.[7, 33] The effort to detect – or authenticate -- will always be the most scientifically complex and challenging. Although *detect* is the most complex the first step should be consider how to *prevent*, and how to reduce the *fraud opportunity*. Once the specific human criminal acts and methods are understood, efficient and effective countermeasures and control systems can be defined.

The role of food science and technology will be in developing the specific tests and methods that *prevent*. In some cases, more technology is not needed. In other instances the authentication challenges will be so great or costly that the solution is that other countermeasures or control systems will need to be employed. The most important role for Food Science and Technology is to take a holistic, all-encompassing view of food fraud prevention.

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Websites

The US Pharmacopeia has a Food Fraud Database that provides incidents and other tools to evaluate the fraud opportunity. <https://www.foodfraud.org/>

The US Pharmacopeia also has created a Food Fraud Mitigation Guidance document that addresses adulterant-substances in food ingredients. <http://www.usp.org/food/food-fraud-mitigation-guidance>

The Food Protection and Defense Institute (formerly the National Center for Food Protection and Defense) has created an incident database. <https://www.ncfpd.umn.edu/innovations/food-fraudema/incidents-database>

The EU the Rapid Alert System for Food and Feed system (RASFF) includes search criteria for “adulteration and fraud” that includes both intentional and unintentional fraud. An example of unintentional fraud could be an error on a shipping document or label. <https://webgate.ec.europa.eu/rasff-window/portal/?event=searchForm#>

The Michigan State University Food Fraud Initiative provides a wide range of resources and programs that focus on food fraud prevention. www.FoodFraud.msu.edu

The Global Food Safety Initiative (GFSI) created a Food Fraud Position Paper that defines the future direction of their compliance requirements. http://www.mygfsi.com/images/mygfsi/gfsifiles/July_2014_-_GFSI_Position_Paper_-_Mitigating_the_Impact_of_Food_Fraud.pdf

The Global Food Safety Initiative (GFSI) guidance document Issue 6 includes food defense requirements and the new Issue 7 will expand to include food fraud. <http://www.mygfsi.com/schemes-certification/benchmarking/gfsi-guidance-document.html>

The SSAFE organization has created Food Fraud Guidance. The GFSI Food Fraud Position Paper stated “The GFSI Board will support SSAFE’s initiative which aims to develop and publish practical guidelines for companies on ‘how’ to assess and control food fraud vulnerabilities.” The SSAFE guidance includes a Food Fraud Vulnerability Assessment. This FFVA has a focus on ingredients and covers most, but not all, of the types of Food Fraud. The January 2015 draft stated “grey market production/theft/diversion are out of the scope of this guideline” <http://www.ssafe-food.org/our-projects/>

The SSAFE food fraud tool is made available online and automated by PWC (PriceWaterhouseCoopers). <https://www.pwc.com/foodfraud>

The Chinese National Center for Food Safety Risk Assessment (CFSA) is the lead agency in China addressing food fraud prevention. “Food fraud is gaining interest as an emerging risk given the increasingly global and complex nature of food supply chains. Food Fraud incidents have become a major concern for countries around the world. The nature of the global food supply chain leads one local incident to possibly impact trade around the world. To clarify, Food Fraud” is deception for economic gain using food, “Economically Motivated Adulteration” or “EMA” is a “substance” for “economic gain,” and “intentional adulteration” (or “Food Defense”) covers both those topics but also includes acts that intend to cause harm.”

<http://www.chinafoodsafety.net/detail.aspx?id=029144623B8D0B9303847BA7614AA271E7D543566CB94072>

Queen’s University Belfast is focused on food fraud prevention in their Food Safety and Food Integrity research with in the Institute for Food Security. This is led by Professor Christopher Elliott who also is the lead author of the UK Elliott Review. <http://qub.ac.uk/research-centres/InstituteforGlobalFoodSecurity/Research/FoodSafetyandFoodIntegrity/>

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The International Union of Food Science and Technology (IUFOST) is the global scientific organisation representing more than 300,000 food scientists and technologists from over 75 countries. IUFOST is a full scientific member of ICSU (International Council for Science) and it represents food science and technology to international organizations such as WHO, FAO, UNDP and others.

IUFOST organises world food congresses, among many other activities, to stimulate the ongoing exchange of knowledge and to develop strategies in those scientific disciplines and technologies relating to the expansion, improvement, distribution and conservation of the world's food supply.

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