Chapter 2
Introduction (Part 2 of 2): Basic Prevention Concepts

Summary

This chapter presents the introduction to the fundamentals of product fraud prevention and the application to food fraud. To start, the basic concepts are reviewed, then the risks or vulnerabilities, and finally the difficulties and issues that have hindered the focus on prevention. The interdisciplinary nature of prevention is reviewed by considering how the fraud opportunity is created and the many academic disciplines that help understand the optimal countermeasures and control systems.

The Key Learning Objectives of this chapter are

- (1) **Product Fraud Attributes:** This section will present the basic details that define the fraud opportunity as well as the key focus areas for prevention.
- (2) **Types of Harms and Identifying the Root Cause or Types of Food Risks and Vulnerability:** To identify these concepts, there is a need to step back and review the terms and how they relate to each other.
- (3) **Prevention and Problem-Focused Research:** After holistically reviewing the reaction or tactical responses through reducing the fraud opportunity, there is an obvious need to focus on and prioritize multidisciplinary-based prevention countermeasures.

This chapter reviews the "(0) Fundamental Concepts" and "(A) Academic Disciplines" in the Food Fraud Prevention Cycle (Fig. 2.1).

Introduction

Beyond definitions of terms, there are some key concepts that provide insight to address food fraud prevention. The concepts are both about the fraud opportunity and also about how to think to address the problem. This chapter addresses a wide range of topics that are fundamental concepts.

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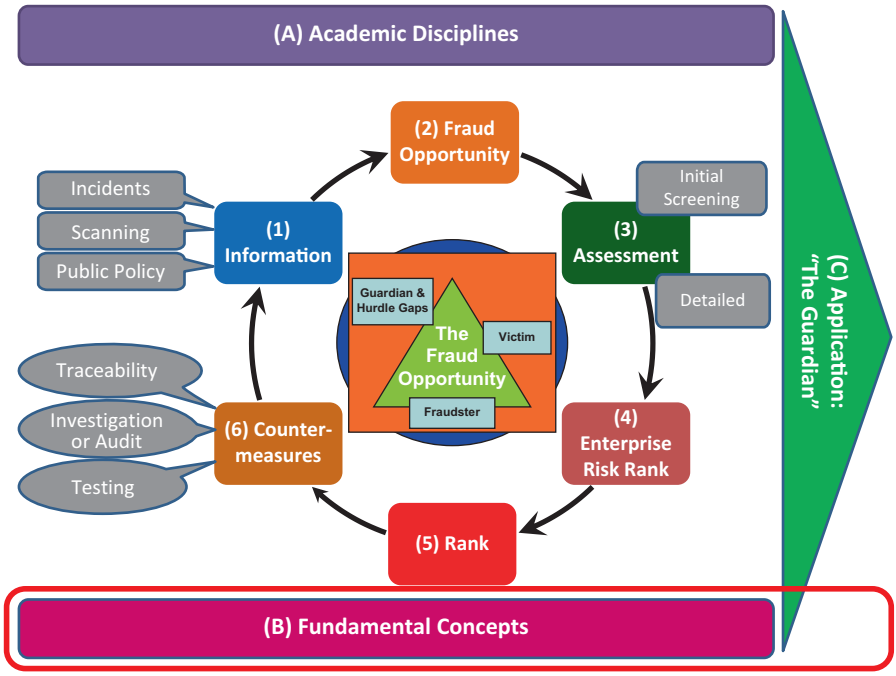

Fig. 2.1 Food Fraud Prevention Cycle—where this chapter applies to the overall concept: "(B) Fundamental Concepts" (Copyright Permission Granted) (Spink 2014; Spink et al. 2019)

Key Learning Objective 1: Product Fraud Attributes

This section reviews the basic details that define the fraud opportunity as well as the key focus area for prevention. This expands from the basic attributes of the product fraud risk to the beginning of organizing the response plan.

The Key Learning Objectives of this section are

- (1) The types of food fraud risks
- (2) The types of deceptive and non-deceptive counterfeits
- (3) The goals of the countermeasures and control systems

Types of Food Fraud Risks: Direct, Indirect, and Technical

A consideration when classifying food fraud incidents is the type of risk that occurs. From "Introducing the Public Health Threat of Food fraud," there are three basic types of food risks including direct or acute, indirect or chronic, and then technical or nonmaterial (Spink and Moyer 2011).

"This research identified three types of food fraud risks for public health: direct, indirect, and technical. It is important to note that for all three types, these are the effects, not the fraudster motivation.

- ***Direct food fraud risk*** occurs when the consumer is put at immediate or imminent risk, such as the inclusion of an acutely toxic or lethal contaminant; that is, one exposure can cause adverse effects in the whole or a smaller at-risk population.
- ***Indirect food fraud risk*** occurs when the consumer is put at risk through long-term exposure, such as the buildup of a chronically toxic contaminant in the body, through the ingestion of low doses. Indirect risk also includes the omission of beneficial ingredients, such as preservatives or vitamins.
- ***Technical food fraud risk*** is nonmaterial in nature. For example, food documentation fraud occurs when product content or country-of-origin information is deliberately misrepresented."

In reality, a food fraud incident probably has aspects that are in each category. For example, melamine in infant formula did include direct food fraud risk from the lethal response in some infants, an indirect food fraud risk due to lower nutritional content, and also a technical food fraud risk of the mislabeling. On the other hand, a genuine, food product that was manufactured under confirmed Good Manufacturing Practices in an authorized facility that has a fraudulent country of origin to avoid a high tariff would be only a technical food fraud risk (as long as there was still supply chain traceability).

Types of Fraudulent Deception: Deceptive Versus Non-deceptive Product and Primary and Secondary Markets

While it is not usually a debate for food products, generally product fraud includes deceptive and non-deceptive products (OECD 2008; Moyer et al. 2017):

- ***Deceptive Products*** *(*counterfeits) are products that are placed into supply chains with the intent to deceive the consumer into believing that the product is genuine in every way.
- ***Non-deceptive Products*** (counterfeits) are products that do not position to deceive the consumer into believing the products are genuine by their positioning in the market whether through the type of retail outlet in which they are sold (flea market, etc.), the price (exponentially low), or the quality (poor).

In addition to the deceptive and non-deceptive description, another consideration is the type of market including primary and secondary markets. While there is an academic definition of two extremes, the actual marketplace includes variations along a continuum.

- **Primary market** is through authorized resellers which are for "Consumers who demand goods of genuine, non-infringing origin establish a market that is referred to in this report as the primary market (Spink 2019). For a fraudster to penetrate this market, to maintain the price and continued sales, the product must be able to deceive consumers into thinking they are buying genuine products (deceptive counterfeits)" (Spink 2019).
- **Secondary market** (possibly to the clearly illegal and clandestine black market): "Under certain conditions, consumers are often willing to purchase products they know are not legitimate" (Spink 2019). In this situation, the consumers usually understand something is not right or proper about the product whether it is stolen, counterfeit, or otherwise substandard (non-deceptive counterfeits). "There are other markets in between such as products not sold through authorized resellers, legal diverted product, or other types of 'gray markets'"(Spink 2019).

There are many important considerations both for how consumers are deceived (or not) and how to successfully implement risk treatments (from (Moyer et al. 2017):

> Food fraud can usually be categorized as a deceptive product since consumers generally would not purposefully choose to purchase a counterfeit food. Consumers might seek lower prices, a generic version, or discounted sale products, but they would not purchase an outright fake food. This distinction actually aids in combatting food fraud as it deemphasizes non-deceptive fraudsters who do not have access to food value chains including retailers. (Moyer et al. 2017)

Also,

> When considering all product fraud, there are deceptive products designed to convince the victim that the product is genuine in every way (e.g., branded food, pharmaceuticals, and products sold at traditional retail outlets, etc.) (OECD 2008). Conversely there are non-deceptive products that do not try to hide the fact that they are counterfeit or fraudulent (e.g., luxury goods offered at a fraction of typical market price and sold at non-traditional outlets such as flea markets, products that are insinuated to be stolen goods that could be counterfeits, etc.). (Spink et al. 2013)

This classification is an important insight when selecting countermeasures:

> When selecting countermeasures, it is important to understand the difference and to know whether consumers are seeking genuine or counterfeit product since this will affect the countermeasures chosen. With deceptive counterfeits, the consumer may not be aware there are counterfeit products in the marketplace; increasing awareness through publicity may lead the consumer not to buy the genuine brand or product which would not satisfy the brand owner. With non-deceptive counterfeits, the consumer is seeking illegal product, so identifying a product as 'fake' would not deter the sale. (Spink et al. 2013)

Thus, it is important to understand whether the customer is seeking a counterfeit product or if they are even aware that there may be fraudulent products in the marketplace.

Countermeasures and Control Systems: Detect, Deter, and Prevent

Based on criminology theory, there are three goals of countermeasures and control systems including detect, deter, and prevent. The prevent concept is admittedly aspirational, but the ultimate goal is not only to reduce the criminal act but eliminate it from even occurring at all (Spink et al. 2016a, b):

- "***Detection (detect)*** is finding a specific adulterant-substance or product anomaly."
- "***Deterrence (deter)*** is a targeted countermeasure to stop one specific type of food fraud or fraudster."
- "***Prevention (prevent)*** is the application of countermeasures that reduce the fraud opportunity."

Also:

> Food fraud is opportunistic in nature and represents a significant challenge to both industry and government (Spink 2011). Detection and intervention become more complex when incidences of food fraud seem to be random, isolated, or small. Food fraud incidents do not fall into a statistically normal distribution, based on the widespread prevalence of the same type of fraud. Food fraud risk analysis is further complicated by the fraudsters being intelligent, resilient, clandestine, and good at stealthily avoiding detection. Prevention, through deterrence of *the chemistry of the crime*, is critical because we cannot incarcerate our way to safety. (Spink and Moyer 2011)

Sidebar: Home Burglary Analogy for Detect, Deter, and Prevent

In relation to food fraud prevention, the concepts of detect, deter, and prevent are difficult to understand in relation to the actual application to food fraud prevention. Different stakeholders have different ideas of what the terms mean. A food authenticity scientist understands that a species test does "detect" an incorrect species. That logically does "deter" and thus "prevent." While this is generally true—of course—there is more to prevention than a general theory. "*General* theories *generally* apply, and *specific* theories *specifically* apply." We find that using everyday examples helps to explain the topics. For "deter"—and as it is presented in the fraud opportunity—two actions are hurdles that make an act more difficult to conduct and guardians who catch the crime.

To use an everyday example, we refer to protecting a home from a specific act such as a break-in burglary or generally of any type of attack.

For a specific act such as a burglary, we will present how the topics apply:

- ***Detect:*** The goal is to monitor any bad guys *in* your house. "Beep-Beep" the motion detector alarm is sounded since a burglar is in your kitchen and then flees. You are in your bedroom, so it is good that the burglar did not get to you, but it would have been better if they didn't get into your house at all.

(continued)

  - ***For food fraud prevention*****,** an example is conducting a species test on incoming raw materials and therefore removing illegal horsemeat before it gets into your production. If you catch it, it is fortunate that the fraudulent material did not get into your finished product, but it would have been better if you were never even shipped the fraudulent goods. The higher objective is to deter the fraudster.

- ***Deter:*** The goal is to combat—or deter—a specific type of activity which is entering the house through a window. Considering a "guardian," "crash" a burglar breaks your kitchen window, but a nearby security office hears the noise and stops the burglar. It is an improvement that the burglar did not get into your kitchen but you'd really rather they didn't even try to break your window. Considering a "hurdle"—"crash" a burglar breaks your kitchen window but hits security bars that you have put on the window, and they flee—it is an improvement that the burglar did not get into your kitchen but you'd really rather they didn't even try to break your window.

  - ***For food fraud prevention*****,** this is either a very alert incoming goods quality control person noticing a difference in a product or conducting a specific type of authenticity test to reject the product before it is taken into inventory. The higher objective is to prevent, the fraudster from ever even trying to attack you.

- ***Prevent:*** The goal is to dissuade any burglar from even trying to break into your house. For the general burglar, your home defense does not need to be perfect but just a less attractive target. If your house is locked, lights on, dog barking, alarm on with active blinking, and your neighbor's house is dark with a window open, then unless there is something very attractive about your house, the bad guy will not rob you.

  - ***For food fraud prevention*****,** this is a potential fraudster (a motivated offender who is looking for a victim, see criminology theory chapter below) who does not consider you as a target.

Expanding this home protection from burglary to all fraud, you are concerned about *all* types of attacks on your house, not just break-ins. If you conduct a vulnerability assessment for all crime issues, you might find sometime link cybercrime through Wi-Fi-enabled systems or malware through email. Those are very different from combating a burglar but no less concerning or dangerous. From this perspective, it's obvious that a different scientific discipline is needed to combat that vulnerability.

Now, to take a strategic approach to reduce the overall home fraud opportunity, once you identify vulnerabilities, you continue to examine the risk. Vulnerabilities are system weaknesses that could be compromised. For example, a window is left unlocked. A risk is the consideration of the vulnerability

in relation to other factors that define likelihood and consequence, for example, the unlocked window after considering how many houses have been burgled in your neighborhood in the last year (likelihood) and how bad it would be for you if you had items stolen (consequence). If there have been many burglaries nearby and you have valuable products, then your "risk treatment" could justify a large investment. In part, you may review what other neighbors have implemented, so you at least have a system in place that is as good as theirs.

In many cases, the food fraud vulnerability assessments identify simple vulnerabilities (such as that window left open) and very easy countermeasures and control systems (make sure to close and lock the window when you leave your house). Closing the window vastly reduces the fraud opportunity regardless of the risk. If there are few burglaries in your neighborhood, your vulnerability would vastly be reduced, but the statistical probability would hardly be reduced at all. From a "risk-based approach," it would not be warranted to close the window. From a "vulnerability reduction approach," it is efficient and logical to get into the habit of committing those extra couple seconds always to close the window.

It is important to note that if someone really wants to get into your specific house, it will probably happen. High-security art museums and banks are successfully attacked and robbed. The countermeasures and control systems do not need to be perfect or impenetrable just "unattractive enough" to reduce your fraud opportunity to within your "risk tolerance" (note: "risk appetite" and "risk tolerance" are terms that are formally defined in standards and will be addressed more thoroughly in a later chapter). There is a saying of "how fast do you need to be to outrun a bear? Faster than the person you are running with" (insinuating that the bear will stop and eat your colleague)! For food fraud prevention, there is a sharing of best practices, so everyone is not getting faster but all carrying bear repellant systems. The bear doesn't try to attack any of you.

Addressing an Incident: Prevention, Intervention, and Response

The Food Protection Plan of prevention, intervention, and response will be reviewed in more detail in later chapters on risk assessment, but here it is important to include with the other basic terms. Based on the FDA Food Protection Plan concept, the series of activities to address an incident are presented here (Fig. 2.2) (FDA 2007):

- **Prevention:** to implement risk treatments or change behaviors in a way that reduces the likelihood of the event occurring again
- **Intervention:** to identify the hazard and find a detection method focusing on an immediate, direct, and tactical response to "intervention" that is absolutely critical and proper during a crisis
- **Response:** to find ways to remove the hazard from the supply chain quickly

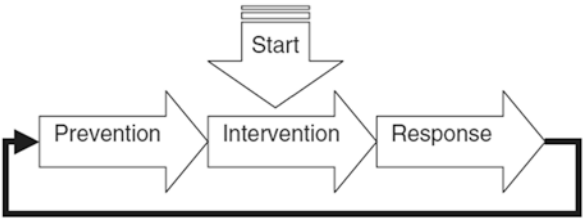

Fig. 2.2 Food Protection Plan series of activities: Prevention-Intervention-Response (PIR) with the starting point after an incident at intervention (Copyright Permission Granted) (Spink and Moyer 2011)

The figure identified that the process starts at intervention because there needs to be awareness and priority-setting before the process starts. A saying is that "We do not prevent everything."

The Focus on Countermeasures and Control Systems

Throughout this book, the prevention strategies and risk treatment tactics are referred to as ***countermeasures and control systems***. A **countermeasure** is a risk treatment such as an authenticity test or using an authentication code. A **control system** is a monitoring or process control that reduces the fraud opportunity by either seeking anomalies or increasing the transparency of the supply chain through traceability. The term "control system" was carefully selected after starting with "control plans" and also considering a more proactive statement of a "control strategy." First, a system seems to be more all-encompassing than a plan. "System" was used to make sure to not confuse with other concepts, for example, HACCP is often referred to as a "plan." "Control plan" was avoided not to confuse the activity with the US FDA-defined regulatory compliance use of the phrase (FDA 2011). For example, "in-process control plan" is a specific focus in the FDCA specifically here referring to 21 CFR 106 D conduct of audits) (FDA 2015a, b; 21CFR106D 2018). The focus of a Food Fraud Prevention Strategy is to create an overall management system that could end up meeting regulatory compliance but only after further review and adjustment. "Control strategy" was not used not to confuse the activity with the CODEX defined the concept of a "National Food Control Strategy" (WHO 2003). For example, that CODEX report states "The attainment of food control system objectives requires knowledge of the current situation and the development of a national food control strategy" (WHO 2003). The Codex use of the term "strategy" is consistent with the Food Fraud Prevention Strategy definition and scope.

Key Learning Objective 2: Types of Harms and Identifying the Root Cause

This section reviews the food risks and vulnerability which provides a foundation for classifying and organizing a response.

The Key Learning Objectives for this section are

- (1) The Food Risk Matrix and relationship between concepts of food quality, food safety, food fraud, food defense, and food security
- (2) The supply chain vulnerabilities by identifying each node whether within or outside the proprietary or legitimate supply chain
- (3) The root cause of the vulnerability which is an economic gain

Food Risk Matrix: Connection of Concepts

Expanding on the brief introduction to the Food Risk Matrix above, before reviewing the types of harms and the root causes, it is important to expand the understanding of the problem, itself further. An important concept is how food fraud connects to other types of food risks—this helps define what is and what is *not* food fraud.

Food fraud risks are already present whether explicitly known or not. A company is accountable and responsible for all food risks. The CEO holds the President accountable who holds the General Manager accountable who holds the VP of Quality Assurance accountable. The VP of Quality Assurance is possibly your boss. If you are assigned the responsibility for addressing food fraud, then you are doing them a disservice if you do not cover all types of fraud and for all products. You could say "that wasn't my assignment," but "not my job" is not a wise career move. Of course, scope creep and lack of resources are a challenge, but it is recommended that you *at least* define what you do and don't cover in your project.

Especially when reviewing food fraud prevention for the first time—whether for GFSI, the Food Safety Modernization Act Preventive Controls Rule, Sarbanes-Oxley Act,[1] or others—it is most efficient, and not that much more work, to address *all* types of fraud and for *all* products. This is also efficient because at some point in the future you—or someone else—will be given this task.

One way to review and organize all food risks is by using the Food Risk Matrix (Fig. 1.4 from above) (Spink and Moyer 2011). The Food Risk Matrix was developed to focus on prevention which is the cause—not the effect—of an incident.

In the past, food agencies such as the US FDA categorized health hazards as (1) unintentional (Food Safety) or (2) intentional (food defense). With these two

[1] Throughout this book the US Sarbanes-Oxley Act of 2002 (SOX or Sarbox) is referred to as a primary compliance requirement for implementing Enterprise Risk Management. While SOX is a compliance requirement in the USA for public companies, the basic "ERM" or "ERM-like" systems are a regulatory or general management requirements for virtually all companies. The owners of the company, through the board of directors, require this type of oversight.

categories, of course, food fraud would be classified under food defense. Before the FSMA Intentional Adulteration Rule, the US FDA included food fraud under food defense. In the rule development process and public comment responses, EMA/FF was most efficiently addressed by preventive controls and thus was switched to the FSMA Preventive Controls rule (FSMA-PC).

While reviewing how an agency addresses unintentional or intentional acts, it is opportune to review details of how the FDA addressed the subject. While all hazards are a concern and focus for a public health agency such as the FDA, there was a need to define the scope of final rules to address the overall law.

Before the FSMA final rules, the FSMA law (US Code) included clear and direct compliance requirements that technically required a food fraud vulnerability assessment for all types of fraud and for all products—specifically there is a requirement to assess *all* hazards, of which acts for economic gain are listed (emphasis added) (21CFR117.130 2018):

> **§ 117.130 - Hazard analysis & Sec. 507.33 Hazard analysis.**
>
> ‘(1) You must conduct a hazard analysis to identify and evaluate, based on experience, illness data, scientific reports, and other information, known or reasonably foreseeable hazards for each type of animal food manufactured, processed, packed, or held at your facility to determine whether there are any hazards requiring a preventive control; and
>
> ‘(2) The hazard analysis must be written regardless of its outcome.
>
> b) Hazard identification. The hazard identification must consider:
>
> ‘(1) Known or reasonably foreseeable hazards that include:
>
> ‘(i) Biological hazards, including microbiological hazards such as parasites, environmental pathogens, and other pathogens;
>
> ‘(ii) Chemical hazards, including radiological hazards, substances such as pesticide and drug residues, natural toxins, decomposition, unapproved food or color additives, and food allergens; and
>
> ‘(iii) Physical hazards (such as stones, glass, and metal fragments); and
>
> ‘(2) Known or reasonably foreseeable hazards that may be present in the food for any of the following reasons:
>
> ‘(i) The hazard occurs naturally;
>
> ‘(ii) The hazard may be unintentionally introduced; or
>
> ‘(iii) The hazard may be intentionally introduced for purposes of economic gain.

In FSMA-IA, the FDA defined the “intentional adulteration” section scope to be “wide-scale health harms.”

The FSMA Draft Rule provides a table that explained exactly why certain intentional acts were outside the scope including disgruntled employees and economically motivated adulteration (other issues not mentioned are tampering/ malicious tampering, smuggling, stolen goods, port shopping, and others) (Table 2.1) (FDA 2016).

The FSMA-IA Final Rule stated:

> We further explained that attacks by disgruntled employees, consumers, or competitors would be consistently ranked as relatively low risk mainly because their public health and economic impact would generally be quite small. We further stated that disgruntled employees are generally understood to be interested primarily in attacking the reputation of the company and otherwise have little interest in public health harm. Typically, acts of disgruntled employees, consumers, or competitors target food and the point(s) in its production

Table 2.1 "Scope of intentional adulteration and proposed exclusions and exemptions (table from the draft rule but confirmed in the final rule)

Type of intentional adulteration	Coverage within the scope of proposed 21 CFR 121	Brief rationale and the relevant corresponding section of the rule
Acts of disgruntled employees, consumers, or competitors intended to attack the reputation of a company, and not to cause public health harm, although public health harm may occur	Not within the scope of intentional adulteration covered under proposed 21 CFR 121	Not considered "high risk" because not intended to cause widespread, significant public health harm. See section IV.E of this document
Economically motivated adulteration (EMA) intended to obtain economic gain, and not to cause public health harm, although public health harm may occur	Not within the scope of intentional adulteration covered under proposed 21 CFR 121	Considering addressing as part of hazard analysis in a preventive controls framework where EMA is "reasonably likely to occur." See section IV.F of this document
Acts intended to cause massive public health harm, including acts of terrorism	Covered within scope and is the focus of proposed 21 CFR 121	Considered "high risk" because the intent of the act is to cause widespread, significant public health harm

> that are convenient (i.e., a point at which they can easily access the food and contaminate it). To minimize or prevent this type of adulteration would require restricting access to nearly all points in the food system. Instead, we proposed to focus on those points in the food system where an attack would be expected to cause massive adverse public health impact. (FDA 2016)

In the absence of a clear FSMA law definition of "adulteration," this was the FDA interpreted the FSMA law statement of "intentional adulteration, including by acts of terrorism" and "intentionally introduced, including by acts of terrorism" (FDA 2011).

Sidebar: FSMA Regarding Smuggling and also Port Shopping

The FDA Final Rules constantly emphasize they apply to the final rule and not the overall FSMA or US legal compliance requirements. There are some FSMA law requirements topics that are not explicitly addressed in a final rule. The final rules also continue to emphasize that the overarching statutory requirement is still the Food, Drug & Cosmetics Act of 1938. For food fraud prevention, two topics include:

- **Smuggling:** product that is imported into the U.S. through an act of deception. FSMA and Smuggled Foods is illegal under 21 USC 2243 and 21 CFR Sect. 309. Product that has been smuggled would be illegal under various laws including the FDCA Adulterated Foods section.
  - "SEC. 309. <<NOTE: 21 USC 2243.> > SMUGGLED FOOD (a) In General. <<NOTE: Deadline. Strategy.> > --Not later than 180 days

(continued)

after the enactment of this Act, the Secretary shall, in coordination with the Secretary of Homeland Security, develop and implement a strategy to better identify smuggled food and prevent entry of such food into the United States.
- (b) Notification to Homeland Security. <<NOTE: Deadline.> > --Not later than 10 days after the Secretary identifies a smuggled food that the Secretary believes would cause serious adverse health consequences [[Page 124 STAT. 3967]] or death to humans or animals, the Secretary shall provide to the Secretary of Homeland Security a notification under section 417(n) of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 350f(k)) describing the smuggled food and, if available, the names of the individuals or entities that attempted to import such food into the United States.
- (c) Public Notification.--If the Secretary--
- (1) identifies a smuggled food;
- (2) reasonably believes exposure to the food would cause serious adverse health consequences or death to humans or animals; and
- (3) reasonably believes that the food has entered domestic commerce and is likely to be consumed, the Secretary shall promptly issue a press release describing that food and shall use other emergency communication or recall networks, as appropriate, to warn consumers and vendors about the potential threat.
- (d) Effect of Section.--Nothing in this section shall affect the authority of the Secretary to issue public notifications under other circumstances.
- (e) Definition.--In this subsection, the term "smuggled food" means any food that a person introduces into the United States through fraudulent means or with the intent to defraud or mislead."

- **Port Shopping**: attempting to import products into a US port after had been rejected at another US port. Port shopping is illegal under FSMA 21 USC 381 and 21 CFR Sec. 115 (FDA 2011). Product that has been smuggled would be illegal under various laws including the FDCA Adulterated Foods section.

  - SEC. 115. [NOTE: 21 USC 381 note] PORT SHOPPING.
  - "[NOTE: Notification.] Until the date on which the Secretary promulgates a final rule that implements the amendments made by section 308 of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, (Public Law 107-188), the Secretary shall notify the Secretary of Homeland Security of all instances in which the Secretary refuses to admit a food into the United States under section 801(a) of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 381(a))

> so that the Secretary of Homeland Security, acting through the Commissioner of Customs and Border Protection, may prevent food refused admittance into the United States by a United States port of entry from being admitted by another United States port of entry, through the notification of other such United States ports of entry."

Sidebar: Applying the Food Risk Matrix to Key Job Responsibilities

Considering the vertical columns in the Food Risk Matrix, food quality and food safety are both "unintentional" acts—there is no intent to create these problems. Then, food fraud and food defense are both "intentional" acts—the actors know what they are doing.

Food fraud is an emerging and often odd type of problem. Melamine in infant formula created a health hazard, so it was initially addressed by the food safety product recall team. The food safety countermeasure and controls were put in place. Once melamine was not found in the product, the problem was considered "resolved" or at least "not a problem anymore." The food safety team would logically *not* prioritize any further focus on melamine. The food safety team would definitely not expand to consider other types of protein fraud.

For this melamine example, the "effect"—the incident—did have a health hazard and so logically would be addressed by the food safety system. The challenging issue is that the "cause"—or the root-cause motivation—was nothing like any other food safety issue. The problem was not a microbe but a human adversary. The human adversary is intelligent, learns, and can actively seek to avoid detection. Traditional food safety countermeasures and control systems are at best "ill-fitting tools." Of course, testing for melamine is good and will catch melamine, but "the goal is not to catch bad product but stop fraud from occurring in the first place."

Once the effect—the incident—is under control, then preventive measures can be considered within the "Food Fraud Cell" of the Food Risk Matrix. To effectively and efficiently protect consumers and the company, there are several important best practices:

1. Each new incident must be assigned to a specific cell.
2. Someone must be clearly defined and recognized as accountable for the management of each cell.
3. A new incident cannot be a switch to another cell until the owner of that other cell accepted the switch.

Food Supply Chain Vulnerabilities

The food risks are present throughout the Food Supply Chain whether within or outside the proprietary channels. To consider the scope of food fraud prevention, the extent of the supply chain risks should be reviewed (Fig. 2.3). The most impactful problems have been adulterant-substances added to the raw materials and mislabeling such as origin or type of processing. Considering these food safety issues, the focus on ingredients is logical. Most of the food fraud incidents are categorized as a food safety hazard and, thus, usually first managed by a food safety workgroup (Moore et al. 2012; Everstine et al. 2013; Strayer et al. 2014; Everstine et al. 2017). The food safety group is focused on their highest risk products and activities that are incoming raw materials. The food safety group is often closely connected to Supplier Quality Assurance. This type of workgroup does not have responsibility for a product after it enters manufacturing—thus, the focus on food fraud prevention often does not expand past the (1) incoming goods and (2) manufacturing steps in the supply chain.

While fraud does occur on the Food Fraud Prevention Cycle at location "(2) Manufacturing," the controls here are usually a combination of HACCP as well as Corporate Security such as employee theft.

Purchasing, Supplier Quality Control, and Operations usually end their focus after the product leaves the production facility to "(3) Finished Goods." The control of the supply chain is often the role of a Traffic or Logistics Group.

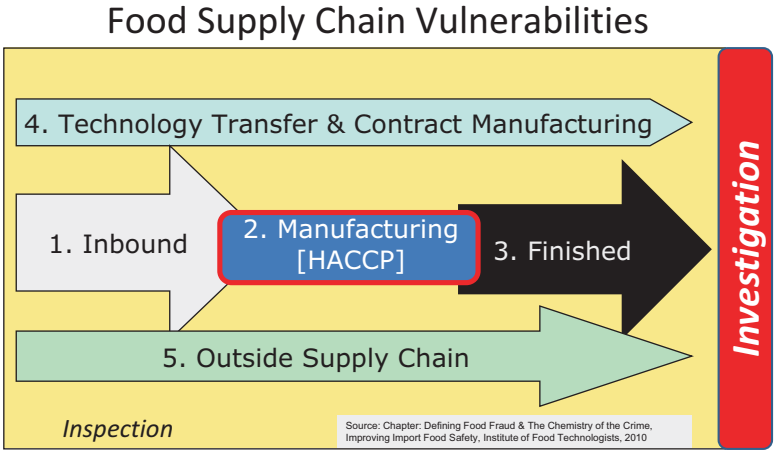

Fig. 2.3 The food supply chain with a focus on vulnerabilities that are identified by either inspection or investigation. (Copyright Permission Granted) (Spink 2012)

There is a fraud opportunity between "(2) Manufacturing" and "(3) Finished Goods" that could be employee theft, reselling of product that was sent for destruction, downgrading "first quality" product to "substandard" in a criminal scheme, or other weights or document fraud.

Of the two segments that are outside the normal operation the first is "(4) Technology Transfer & Contract Manufacturing." The contract manufacturers are usually more under the control of the usual product quality but not always. The contract manufacturers are outside the day-to-day monitoring, so there is a unique "fraud opportunity." Another segment is technology transfer where a brand may be licensed by a company in another country or region. This segment is usually administered by a legal group managing the legal contract.

There are other incidents that are also found and assigned to other parts of the corporation. For example, a counterfeit or diverted product that is found in a marketplace are often found during global brand protection audits by Corporate Security located at "(5) Outside the Supply Chain" and more generally "(6) Marketplace."

When a problem is identified, it is assigned to the most common or convenient business function. If you find the counterfeit product in a far-away country, it is best to have Corporate Security engage criminal investigators in those countries (MSU-FFI 2018). A food science inspector in your home country would not have the skills or capabilities to conduct the criminal investigation, and they probably aren't trained to avoid violence and personal security such as avoiding kidnapping. For this situation, the intervention is best led or at least coordinated by the Corporate Security function.

Personal Insight: Technology Transfer and Patent Royalty Payments

I presented at an academic Law School conference where several professors were getting great accolades for their patented crops. They were talking about patent negotiations and writing licensing contracts. It was a very exciting presentation because they were discussing the great financial payments for agricultural production based on the number of plants or trees in use. There was a royalty paid for each plant or tree used.

Considering product fraud, I asked how they monitored the use of their patents. There seemed to be a very high fraud opportunity if the patent buyer was providing the data for defining the amount of the payments.

I got blank stares.

I never got invited back to that conference speaker.

Root-Cause Analysis: Cause and Effect

Now that the type of food risks and the food supply locations of vulnerabilities have been presented, it is important to shift to focus on the root causes. The "cause" aspect is important to consider separately from the "effect." The "cause"

is the reason why an incident could occur which would have a result of an "effect." For food safety, there is HACCP to focus on the food safety "cause" and a very active and extensive system to deal with incidents or the "effect" of those potential public health harms. For food defense, there is also a threat assessment and control system methods to deal with contaminated products. For food quality, there are total quality management systems that extensively assess the root cause of possible anomalies. For food fraud, the vast majority of incidents do *not* have a public health harm so they do not trigger the food safety or food defense response systems. Also, the food fraud vulnerabilities would rank very low on a food safety or food defense risk assessment. Likewise, food fraud would be difficult to truly consider in a food quality system since there are so few incidents and usually so little of an economic impact. For all the traditional food risk responses, addressing and prevention of food fraud are just so complex, interdisciplinary, and fundamentally different.

For food safety incidents, there is a focus on the "effect" from "public health harm."

The food safety vulnerabilities and risks are inherent in the nature of the food production (e.g., vegetables are grown in dirt, animals have produce feces in their bodies, and the food manufacturing operations constantly address these non-sterile challenges).

Based on the food safety paradigm, there is a belief that current control systems or HACCP plans are holistic and all-encompassing for all public health-related food risks. Food safety issues are not the root cause of all food public health hazards. When melamine was detected in infant formula and powdered milk, there seemed to be a food safety industry impression that the early warning systems worked since they detected the product. In reality, melamine was not a substance on the early warning system radar, and the "early warning" was the public health incidents—the detection was a response to human illness and death. Waiting for illness or death is not proactive and not the intent of an early warning system; rather, monitoring for illnesses is an outbreak rapid alert system.

The application to food fraud and prevention is that there is often a belief that the current food safety response systems and HACCP plans already are competently addressing the—and assumed all—food public health hazards.

The root cause of the food fraud incident is fundamentally different than for food quality, food safety, or food defense. Thus, a separate root cause analysis for food fraud would focus on the unique "cause" which is an intelligent, human, criminal adversary who is actively seeking to avoid detection.

For food fraud prevention, really the only practical approach is to consider vulnerabilities and address the root cause. When this focus is implemented, there can be simple and usually cost-effective risk treatment that vastly reduces or eliminate the fraud opportunity and the subsequent costs or illnesses.

Examples of Incident Impacts

To continue to focus on the root causes and to understand the complex challenge, it is important to review incidents. Food fraud incidents are not new, but there is a recent focus on clustering these types of activities and considering holistic, all-encompassing risk treatments.

It is widely documented that food fraud was present in the UK back to the 1800s by Accum, to ancient times by Pliny the Elder in his book Natural History (***Naturalis Hist****oria*, which was actually not completed at the time of his death in AD 79 during the eruption of Mount Vesuvius), and recorded even back as far as 1046 BCE in the writings of Zhou Dynasty in China (Wu et al. 2017). The first US food laws in 1906 and 1938 mentioned "fraud jokesters" and diethylene-glycol which also was cited as a danger in the US Food Safety Modernization Act of 2011. The same types of food fraud—actually the exact same fraud acts and substances—have continued to be a problem.

Several modern food fraud incidents occurred that escalated the danger and risks for companies, markets, and even countries. Several of the most impactful modern food fraud incidents include (Moore et al. 2012; Everstine et al. 2013; Strayer et al. 2014; Spink et al. 2016a):

- ~2004—Sudan Red carcinogen colorant in paprika and other spices (adulterant-substance)
- 2007—melamine in infant formula and pet food (adulterant-substance)
- 2012—horsemeat in beef (adulterant-substance)
- Continued announcements such as:
  - Peanut Corporation of America selling the product with known bacterial contamination (tampering)
  - Smuggled honey and origin laundering for tax avoidance (diversion)
  - Stolen raw poultry re-introduced to the supply chain (theft)
  - Ground peanut shells used to extend cumin (adulterant-substance)

The seemingly never-ending string of incidents has become more defined and catastrophic as an issue for several reasons including more product traveling farther and faster around the world, that global reach increasing the minimum efficient scale of production (larger manufacturing plants produce more product), a consumer preference for less processed or raw foods, and an increase in both the test precision and the availability of more tests being conducted, plus the more rapid communication of problems once they do occur.

The Economic Impact of a Food Fraud Incident

The economic impact of an incident can be very significant or catastrophic. Beyond the cost of a product recall or regulatory penalty is a possibly bigger loss of sales or loss of market capitalization (the value of a company based do its stock price).

It is estimated by Forbes magazine that McDonald's restaurants lost 0.8% in stock price due to an alleged date code tampering fraud in China. The 0.8% drop for a $90 billion market capitalization is almost a $900 million drop in the stock price. While stock prices fluctuate up and down, there is a problem when the fluctuation is based on a specific single incident or vulnerability. While not food fraud, another example is the impact on the entire New Zealand economy when the Fonterra Corporation has a suspected food safety incident. This led to a block of imports of some of their perishable dairy products. Fonterra is a co-op that represents New Zealand dairies and is a major part of the entire economy. It is reported that the New Zealand currency devalued during this crisis.

While in Macro, or enterprise-wide, the impact of the incidents is a result of micro- or fraudster-specific opportunities. The risks can be summarized to an overall impact, but the derivation of the estimates and the understanding of the fraud opportunity are specific to the individual actors. For example, the food fraud profit per truckload can be very high and even more humongous when considering one deal could be many truckloads (Table 2.2) (Moyer et al. 2017).

For more detail on how quickly the food fraud profits can accrue, it is helpful to review the details of an incident (Table 2.3) (Moyer et al. 2017).

Key Learning Objective 3: Prevention and Problem-Oriented Research

This section reviews the root cause of the fraud opportunity which leads to a strategy based on an understanding of the root cause to create prevention focused efforts.

The Key Learning Objectives of this section are to review

- (1) Why prevention is the primary and most efficient and effective response
- (2) Working from identification of the problem to seek solutions (and Envisioning food fraud prevention as similar to managing diabetes not fixing a broken leg)
- (3) Why an interdisciplinary approach is critical and most effecient

Table 2.2 Review of food ingredients, adulterants, estimated economic gain, and the units of one fraud incident

Food ingredient	Adulterant	Economic gain	Units
Wheat gluten	Melamine	$31,000	Truckload (50k lbs.)
Wheat	Urea	$11,000	Bin (10k bushels)
Apple juice	High-fructose corn syrup or hydrolyzed chicory syrup	$18,000	Truckload (50k lbs.)
Tomatoes	Maltodextrin	$12,000	Truckload (50k lbs.)
Spices (e.g., paprika, curry, chili powder, etc.)	Sudan dyes	Undefined	$0.06 of dye probably increases profit by $1+/lb

Adapted from DeVries (2013)

Table 2.3 Ingredient-level review of adulterated melamine in a hypothetical protein bar

Food ingredient	Percent content per bar	Cost per pound (of the raw material)	Genuine product: ingredient coast per 1 lb. bar[a]	Fraudulent ingredient cost in the finished good[b]
Peanuts	30%	$1.00	$0.30	$0.30
Almonds	25%	$2.40	$0.60	$0.60
Wheat gluten	20%	$1.25	$0.25	$0.126 ($0.25/2+ $0.001)
Sugars	10%	$0.20	$0.02	$0.02
Vegetable oil	10%	$0.50	$0.05	$0.05
Salt/soda/misc.	5%	$1.00	$0.05	
Ingredient total	**100%**		**$1.27**	**$1.146**
Processing and packaging		50% of the total cost of goods sold (COGS)	$0.64	$0.64
Total cost (per bar)			**$1.91**	**$1.786**
Food fraud profit (per bar)				**$1.124**
Pounds per truckload	50k pounds			
Total profit (per truckload; authentic vs. non-fraudulent)				**$6200**
Truckloads per sale	10 truckloads			
Total food fraud profit				**$62,000**

Adapted from Moyer et al. (2017)
Note [a]for simplicity, a 1 pound single serve bar was used]
Note [b]10% melamine at $0.01 per pound

The Efficiency of Prevention: The Only Really Logical Strategy

While it may seem completely logical to state the efficiency of prevention, there are often proposed countermeasures or control systems that do not address the overall concept. When considering the overall food risk focus, the food fraud problem is to address all types of fraud for all products and a proactive, strategic approach. The fraudsters are focused on any criminal act that allows them a high probability of achieving their highest available economic gain, so the response is likewise aligned. Once the assessment of the overall problem and the prevention strategy is in place, only then can detection and deterrence countermeasures and control systems be considered and assessed. The chapter on Risk Analysis and the other on Risk Assessment Application will cover this concept in more detail and with examples.

Shifting to Prevention: Why Hasn't This Been Addressed Proactively Before?

An occasional question is that if food fraud has been around since the beginning of recorded history, then why has it not been directly addressed? There is a question of why a government would "allow" this to continue not to be directly addressed? Also, if there are so many economic harms to a company, why haven't they addressed this sooner? The answer is based on the complexity of the crime and the extremely interdisciplinary strategy.

Also, later in the Criminology Chapter, there will be a more detailed discussion about the complexity even of classifying product fraud as a "traditional crime" or a "white collar crime." The research led product fraud identified as a hybrid crime where the preparation is more of a typical "white collar crime" and the activity is more of a typical "traditional crime." Anytime a problem falls outside of normal and simple categories, there are additional challenges regarding accountability and responsibility.

Regarding the complexity of the detection of the fraud act, to begin there are two parts to the response to the incidents which are detecting the fraud and then prevention countermeasures and control systems. First, there is detecting the food fraud act. Industry and agencies already have systems in place to detect contaminants (regularly occurring, expected "things"). When an incident like melamine occurs, it becomes known, and, if it seems to have a chance of occurring again or in a more harmful, the adulterant could be categorized in an Early Warning System as a "contaminant." The *reactive* systems start to look for that contaminant.

This is applicable to those contaminants that are known and can be expected to recur under the same general conditions and in the same way. For food fraud, there are a nearly infinite number of adulterants. Also, just because there is a fraud opportunity (e.g., the price of a commodity sky-rocket), this does not mean there is always an incident.

The human fraudster may be a biological organism that does respond to opportunities. But unlike a microorganism, the human fraudster will not always respond the same way each time to the same stimuli or conditions. The human fraudster is often intelligent, creative, resilient, patient, and often very well-funded. Also, the human fraudster may decide for some reason *not* to act. Beyond this generalization, the macroeconomic conditions do not always apply to an individual human fraudster. Each human fraudster is like a separate species of microorganism—or at least a single species that has exhibited a nearly infinite number of mutations or adaptations. Each human fraudster has an extremely varied set of characteristics and motivations.

To explain this analogy, consider that *E. coli*, *Salmonella*, and *Listeria* are three microorganisms. While most *E. coli* (the general genus *Escherichia*) are not only harmless to humans but actually play an important role in gut health, there are pathogenic strains such as *E. coli* H1N1 that pose a very serious public health threat (CDC 2018). That said, all *E. coli* will respond to environmental conditions, in the same way, every time (admittedly, there may be some mutations or abnormal

individual organisms). With the human fraudster, the response to the condition is much more individual. For example, the global change in cocoa pricing will have no effect on a fraudster dealing with tea. Also, that global change in cocoa pricing may have no effect on a fraudster selling hot chocolate to a company that has very strong incoming goods quality control tests—the fraudster may decide it is a "rational choice" *not* to try to commit the fraud act (for more, see the Criminology chapters).

To review the question of whether there is a practical and pragmatic response to address food fraud prevention, in response to that, the blame is on academia (including the authors of this book) for not more fully grappling with the challenge sooner. While the academics have been improving detection, and separately growing criminology concepts such as Situational Crime Prevention, there has been a challenge to develop a paradigm-shifting theory that addresses the challenge of integrating a multiple of disciplines. It is very difficult to apply a complex web of disciplines to respond to a complex problem such as food fraud. The food fraud opportunity has continued to grow because of the very nature of the complexity. The bad guys have been able to evolve to exploit even minuscule new guardian and hurdle gaps—there are capable guardians and hurdles but an even more nimble criminal response.

These all are factors that have led to challenges when focusing on the overall Food Fraud Prevention Strategy.

Food Fraud as a Disease: Managing Diabetes Rather than Fixing a Broken Leg

There is a saying:

> ***Food fraud prevention is like managing diabetes not fixing a broken leg -- for diabetes, the patient may look fine today but without monitoring and treatments but danger could be close at hand.***

Another challenge when considering prevention has been the lack of information on the incidents and the general lack of incidents. Let's consider food fraud to be a new disease. We don't wake up one day and figure a way to cure or manage a disease. There are many years of patients showing up sick at the hospital. This is the effect, and we don't yet understand the cause… we don't even know that it's a new disease. Along the way—or over possibly the 100s of years—we start to see a pattern, but it is faint. Each doctor, hospital, or country just doesn't see that many of these specific rare cases. As more information is stored and more readily accessible, and as we have more and better testing, we can learn more about the illness. At some point, we have a lucky break—usually an outbreak or a cluster of incidents—that lead us to identify it is really a new disease.

This is the "eureka" moment when we shift from intervention through response to prevention (Fig. 2.2). We don't start with prevention, and we don't even start with a response. Only after those two can we cycle back up to prevention.

For example, in the USA, there was an incident where we started to see many pets dying. We had no idea why they were dying, but we did the best we could to treat them (intervention: the public health system and their healthcare professionals). At some point, we figured the root cause was melamine, found it in the pet food and the pet food was recalled from the marketplace (response: the marketplace and the industry recalling product). Then to focus on prevention, we began to implement testing for melamine in raw ingredients and finished goods (prevention and the industry conducting tests).

So while the system evolved to address melamine, we were aware that the problem wasn't just melamine. The fraud opportunity was not just for melamine but for all types of protein fraud. The food industry, agencies, academics, and others began working together to understand the fraud opportunity better and to implement holistic, all-encompassing countermeasures. This activity is underway, and a first step is improved intervention and detection methods and also establishing a common frame of definitions and a prevention focus.

Personal Insight: Food Fraud Prevention into Action

So, food fraud was known, but there was not enough information to really establish a common, effective, holistic, all-encompassing, preventative approach. I stated in a public forum meeting in 2010 when asked if I thought "industry was doing enough to address food fraud" I responded with "based on the way we academics – and the laws – have defined food fraud and prevention… I think industry – and agencies – are doing a fine job." The key is how food fraud is defined and addressed in the laws. There are great strides being made considering how little is really known about food fraud prevention.

I was told that is it usually at least 5–10 years between an article published in a scholarly article makes an impact in the real world. While I continue to emphasize that there was excellent work in food fraud before our article, our article was the first scholarly article with research focused on the definition of food fraud. So the term was defined in November 2011. Just about 2 years later, food fraud had just entered the mainstream. Several key dates and milestones include:

- February 2017: The GFSI Guidance Document version 7 was published that included food fraud requirements as of January 2018.
- May 2016: The FSMA Intentional Adulteration Final Rule was published with a full implementation date in "three years after the publication of the final rule" (FDA 2016).
- September 2015: The FSMA Preventive Controls Final Rule was published with a full implementation date for large companies "required to be in compliance on September 19, 2016 (two-thousand and sixteen)" (FDA 2015a, b). The term economically motivated adulteration was included and the term "defraud" and "fraudulent" but not specifically "food fraud." This includes addressing any hazard from any source including the act that is for "economic gain" and for any

product—thus, FSMA has essentially required a full Food Fraud Vulnerability Assessment and Food Fraud Prevention Strategy since at least September 2016. The publication date of the final rule was forced by lawsuits to be published by August 31, 2016, so additional changes—such as further addressing EMA or possibly expanding to use the term "food fraud"—was not possible due since new addition edits would require an additional open comment period (Case4:12-cv-04529-PJH 2012; CRS 2016; Case No.: 3:18-cv-06299 2018).

- July 2014: The GFSI board of directors published the "GFSI Position Paper on Mitigating the Public Health Risk of Food Fraud" (GFSI 2014).
- February 2014: The GFSI Food Fraud Think Tank presented their recommendation to include food fraud in their Food Safety Management System (a final report but not a public document)
- February 2014: The GMA published their Brand Protection report (GMA 2014).
- January 2014: The US Congressional Research Service published their report on food fraud which is a demonstration of congressional interest in a subject (CRS 2014).
- December 2013: The first draft of the FSMA Intentional Adulteration draft rule was posted on the Federal Register with a request for comments, and it mentioned a shift from economically motivated adulteration to the preventive controls rule. This was a significant shift in focus from a local threat or target-specific food defense-type countermeasures to more preventive controls (FDA 2013a, b).
- October 2013: The EU proposed a draft referendum on food fraud which proposed a common definition of food fraud (CRS 2014).
- July 2012: The GFSI convened a Food Fraud Think Tank to review the subject.
- November 2011: Peer-reviewed journal publication of "Defining the Public Health Threat of Food Fraud" (Spink and Moyer 2011).

Before that publication in November 2011, there was momentum starting on the related topics:

- October 2011: The GMA published their Capturing Recall Costs report (that included fraudulent and criminal acts) (GMA 2011).
- April 2011: The first draft of the FSMA Preventive Controls draft rule was published on the Federal Register with a request for comments, and it had no mention of economically motivated adulteration or fraud (FDA 2013a, b). Later, EMA was added to this rule after the Intentional Adulteration draft rule directed the change (FDA 2013a, b).
- January 2011: The US Food Safety Modernization Act (FSMA) was signed in to law and identified actions for "economic gain" but did not mention fraud.
- November 2010: The GMA published their report on Consumer Product Fraud (which featured food fraud) (GMA 2010).
- May 2009: FDA public meeting on Economically Motivated Adulteration where the "FDA working definition" of that term was first published (FDA 2009).

So, food fraud prevention is being addressed and implemented. There has been quite a bit of focus on reactive and responsive actions. This seems to be common for

analytical science and also for enforcement organizations. These might seem like two very different types of groups, but the core theory is that when faced with challenges, we, as humans, respond with our current resources, what we know, and what we can implement right away.

So, analytical chemists, faced with the melamine adulteration, naturally approach the problem from their world view—a natural first step is to increase the focus on food authenticity detection. Their focus increases the ability to "detect" fraudulent product.

Also, enforcement organizations, faced with melamine adulteration, naturally approach those problems from their world view—a natural first step is to find, arrest, and prosecute the food fraudsters. Their focus increases the ability to "deter" the fraudsters (at least to some degree, for those who are currently committing fraud, get caught, and are persuaded not to continue committing fraud -- that will be discussed further later).

These linear solutions fit for a linear problem. With food fraud, there are a nearly infinite number of adulterants, and there are a seemingly near an infinite number of fraudsters. (When considering the adulterants, there are also ways to commit fraud that do not include an adulterant at all… such as for genuine but stolen products.) There is a saying that "for food safety that we will not test our way to safety." Also, we're not trying to make "food, safe" we're trying to make "safe food." For food fraud prevention, we're not going to arrest our way to safety. We're not trying to catch food fraud we're trying to prevent the fraud opportunity in the first place.

Prevention Addresses Problems: "Problem Looking for a Solution" or "Solution Looking for a Problem"

Since food fraud prevention is focused on the fraud opportunity and a strategic prevention approach, to reduce vulnerabilities, there is an obvious need for countermeasures and control systems. The risk manager—brand owner or manufacturer—addresses the overall, enterprise-wide, holistic, and all-encompassing strategic problem and then to tactically address a specific incident. The specific incident is straightforward and a very finite problem and response. On the other hand, the suppliers of the countermeasures and control systems are of course trying to apply their product to the user need. The implementation of the overall Food Fraud Prevention Strategy compliance requirements will help with this conundrum. The more harmonized and standardized the strategy, the more clearly both sides will understand the problem (diagnosis or root cause), optimal countermeasures, and control systems (risk treatment) and understand then "how much is enough" (prognosis that results in decision) (see the section on Diagnosis, Treatment, Prognosis, and Decision).

In the absence of a harmonized and standardized food fraud prevention approach, it was most simple to take a direct, tactical approach to start by considering solutions before there was even the creation of an overall strategic vision. At that point, the strategic problem was not yet clarified which has been a constant challenge for anti-counterfeiting and security products suppliers across all industries.

Product and service providers—admittedly, including academics seeking funding for research or tuition dollars from students—are usually a "solution" looking for a "problem." Suppliers often present only a factual statement about the new technology or service "feature" and let the customer figure the actual application "benefit" of how it resolves a problem. The problem is that the "features" of the product are usually presented without a clear explanation of the specific "benefit" for the customer. To be fair, it is the job of the supplier to sell their products not to solve the world's problems.

Sidebar: A Solution Looking for a Problem or a Problem looking for a Solution?

The concept of a "solution looking for a problem" may seem abstract or confusing, so an example will be provided.

During the Silicon Valley Dot-Com era, there were massive innovations in computer technology and online applications. It was referred to as the "dot-com" era because of the Internet websites that ended in ".com" (though later referred to sometimes as "dot-bomb" after many of the companies went out of business). During that time there was the development of technology "solutions" for "problems" that had not actually been specifically identified. The computer science sometimes expanded for technology sake, not for an actual market need. There was a saying that it "was a solution in search of a problem." In the information technology field, there is often a strategy from the venture capitalists to invest in many start-up companies to hedge their bets that one will be a low-probability/ high-return investment. It was seemingly lucky if a technology innovation efficiently met a market need or "problem." Some of those "lucky" products received big financial gains during their exit strategy of selling to a bigger company while some even stayed in business and succeeded.

A "solution looking for a problem" is the process to first create a unique, patentable, defensible technology and then try to sell it by identifying problems where it might fit. The opposite approach is to clearly identify and research a problem and then consider theoretically the perfect response. After clearly identifying the problem, then a targeted solution is sought or developed.

In the discipline of Criminology, when addressing a new "problem," there is a focus on "environmental criminology" or the physical space of crime (for more, see Criminology chapter) (Beirne and Messerschmidt 2005). The focus is also on the human adversaries through concepts such as "rational choice theory" and "routine activities theory" (Cohen and Felson 1979; Felson and Clarke 1998; Clarke and Eck 2005). The criminologists focus on the root cause of the problem. An example is the influential publication

(continued)

"Crime Prevention in 60-Easy Steps" (Clarke and Eck 2005). This essentially explores the details of the "crime opportunity" and then considers countermeasures and control systems. Essentially this focuses from the "problem outwards" to only then consider countermeasures or "solutions."

Food fraud prevention research began with that focus on the center or the "fraud opportunity." Once that was understood, then it became clearer on how to prevent food fraud.

Without a focus on the overall fraud opportunity—or a vulnerability assessment for the entire system—then picking countermeasures and control systems is a guess at best. Without that enterprise-wide assessment, then stakeholders often hear of a new technology (solution) and try to apply it to the problem ("a solution looking for a problem").

The application to food fraud prevention is that it is most efficient—critical—to focus on the fraud opportunity and then apply that insight to understanding what might contribute to detect, deter, and prevent.

Personal Insight: The Positioning of Food Fraud Prevention

After reviewing the challenge of considering and selecting countermeasures and control system, a more basic question is about what is the science and sciences of food fraud prevention?

For our MSU research, the first academic home was in food safety where there was engagement in graduate course development, teaching, and research (see point A in the figure below) (Fig. 2.4). Next, the packaging science familiarity led to a natural consideration of packaging countermeasures and control systems such as traceability and anti-counterfeit security features (see point B, in Fig. 2.4). When including these two disciplines, the activity was still reactive—catching fraudsters by authenticity tests or counterfeit packaging or labels. The next innovation was including Supply Chain Management (SCM) (see point C). Supply Chain Management focus is on optimizing the transit of genuine products, so there was no a clear academic resources yet. The next important step was digging deeper to the root cause which was the human adversary which led us to Criminology (see point D). The first person to bring Criminology theory of Situational Crime Prevention to food fraud research the MSU School of Criminal Justice colleague Dr. Robyn Mace. Later, another MSU School of Criminal Justice colleague Dr. Justin Heinonen helped refine that focus into the SARA method and from a Victimology perspective. Our first immersion in Criminology was through the book *Crime in Everyday Life* by Felson (Felson 2002). This book introduced the crime triangle which has been a—or the—foundation of food fraud prevention.

Since the fraud prevention research was "from the problem outward"—rather than trying to apply one academic discipline to the new problem—there were constantly new disciplines that provided incredibly efficient contributions to prevention (next Fig. 1.1).

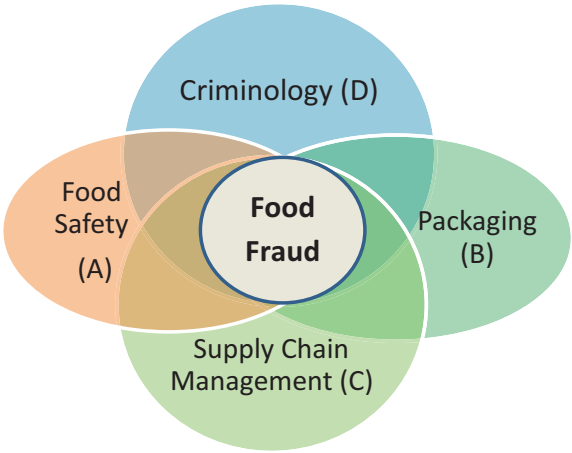

Fig. 2.4 The first disciplines considered to address Food Fraud Prevention: single or dual discipline "interdisciplinary research" then evolving to "multidisciplinary" researchers, education, and outreach. (Copyright Permission Granted) (Spink 2009)

Every time we gave a presentation we seemed to identify another discipline that adds to the science. As recently as late 2017, we were researching news media responses to suspected food fraud activity. This led—obvious in hindsight—to seek out journalism scholars. Michigan State University has a top Journalism Department in our College of Communications Arts and Sciences. Eventually, we found a scholar colleague Dr. Eric Freedman (Knight Chair in Environmental Journalism, director of the Knight Center for Environmental Journalism and a professor in the School of Journalism), who had research expertise in a similar area of science journalism. This collaboration led to a research project and journal article submission on investigating food fraud suspicious activity.

Earlier, when the political science and social anthropology were presented, first, the basic concepts were identified as critical but foreign to the current researchers. To step back, when hearing "social anthropology," the thought came to mind of the movie character Indiana Jones digging up ancient artifacts. That is "archeology" the study of humans through their artifacts where "social anthropology" is the study of how and why humans interact in their culture. When this concept was presented to several senior anti-counterfeiting industry leaders, they were very interested. The encouragement led to even more of the research study of the motivation of the fraudsters. Not considering social anthropology is inefficient or even dangerous if the researchers or practitioners do not understand how and why people interact with each other and outsiders they cannot understand how to influence them.

These are all examples of the interdisciplinary nature of food fraud prevention. These disciplines have been considered in the development of food fraud prevention (Spink 2009).

The Disciplines of Food Fraud Prevention

Beyond the core disciplines of food safety, packaging science, supply chain management, and criminology, there are many others that contribute to understanding and controlling the problem (Fig. 2.5).

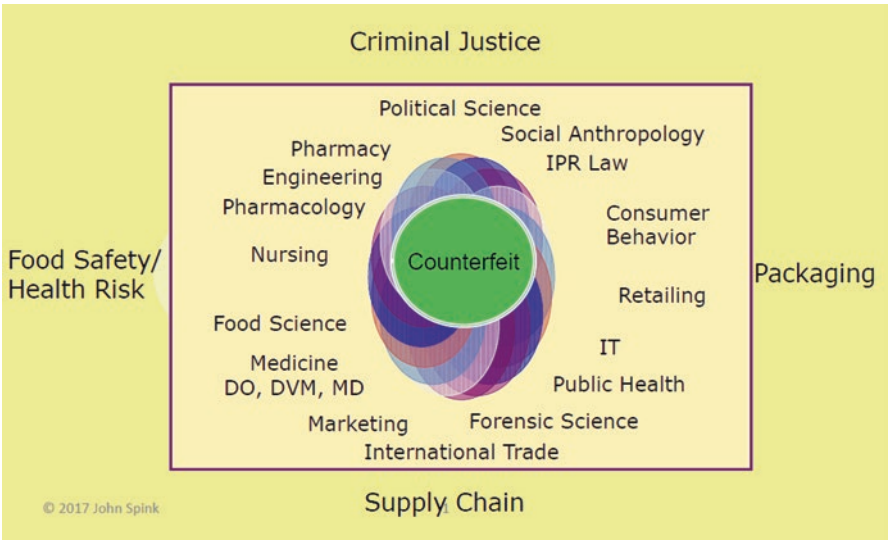

Fig. 2.5 Presentation of the extremely interdisciplinary nature of product fraud prevention. (Copyright Permission Granted) (FDA 2009; Spink 2009)

It became evident that almost any and every discipline has a contribution to helping understand the fraud opportunity, the role of the bad guy or consumer, or even the overall concept of prevention. This growing list of disciplines led to a focus on "food fraud" as a separate discipline.

Later, the science and sciences of food fraud prevention was organized in a honeycomb network of interrelated activities (Fig. 2.6) (Spink 2017).

Research Approach: Interdisciplinary Versus Multidisciplinary

Food fraud prevention is so challenging because it requires an ***interdisciplinary approach*** (Gray 2011). Traditionally an event that had a food safety hazard was assigned to a food safety group, and—logically—food safety countermeasures and control systems were applied. The problem is that "if the biological organism in question was a micro then we would use the discipline of microbiology; since the biological organism in question is a human we obviously must use the discipline of social science and criminology" (Wu et al. 2017). When the starting point is in one discipline, it is a challenge to expand to interdisciplinary—especially with such a leap such as from microbiology to criminology…let alone adding social anthropology, public policy, or political science. What is required is to step back and consider the root cause and only then consider the ultimate objective and then seek out the disciplines that help. The root cause is a human adversary perceiving a fraud opportunity and then having the opportunity and motivation to act. The ultimate objective is to put countermeasures and control systems in place that dissuade the human adversary from acting. Finally, the disciplines that most directly apply are

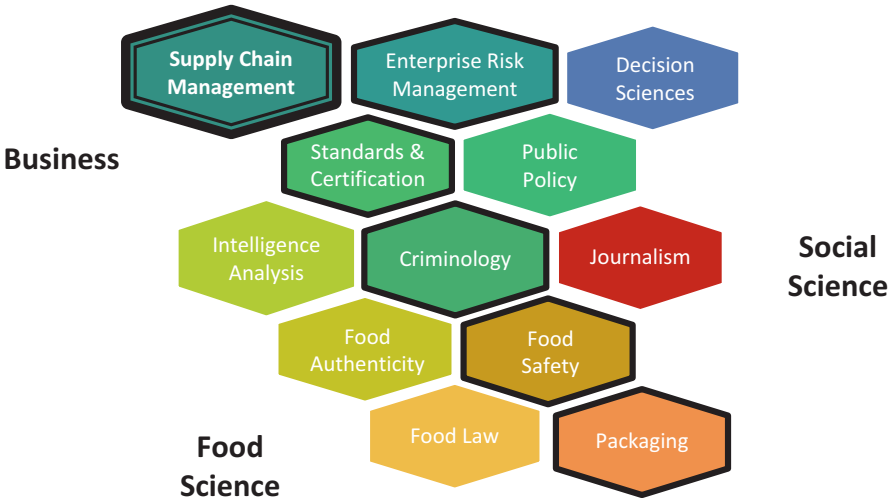

Fig. 2.6 The science and sciences of food fraud prevention. (Copyright Permission Granted) (Spink 2017)

criminology, supply chain management, business (including considering the criminal enterprise having business characteristics) decision-making, and then science and technology to detect the fraud act.

Multidisciplinary Versus Interdisciplinary Approach

Beyond just the interdisciplinary group, there is a need for multidisciplinary researchers. The food fraud problem is very complex, and the fraud opportunity is created due to many complex supply chain networks combined with a patchwork of laws, regulations, standards, and certifications. Food fraud has not been defined as a specific area of study or as a particular responsibility of one group. The complexity of addressing food fraud is based in part on the need for an interdisciplinary or multidisciplinary understanding of the problem. In 2011, Dr. J. Ian Gray, MSU Vice President of Research and Graduate Studies, presented some insights ((Gray 2011) referring to (Pain 2003)). He stated that: "Multi-(or plural-) and interdisciplinary research – often used interchangeably, but originally referred to different approaches."

- ***Interdisciplinary***: "When experts from different fields work together on a common subject within the boundaries of their own disciplines, they are said to adopt a multidisciplinary approach. […] If the experts stick to these boundaries of their own discipline, they may reach a point where the project cannot progress any further. They will then have to bring themselves to the fringes of their own fields to form new concepts and ideas – and create a whole new, interdisciplinary field."
- ***Multidisciplinary***: "A transdisciplinary team is an interdisciplinary team whose members have developed sufficient trust and mutual confidence to transcend disciplinary boundaries and adopt a more holistic approach."

As food fraud is researched, it becomes clear that many disciplines contribute to the understanding and holistic perspective on the "fraud opportunity." Food fraud is not only a problem of crime, food, business, food authenticity, packaging, traceability, supply chain management, social anthropology, political science, enhanced traceability transaction security, a customer problem, or a legal problem.

Dr. Gray also discuss *The Third Revolution* which is the convergence of the life sciences, physical sciences, and engineering (Sharp et al. 2011):

- "Convergence is a new paradigm that can yield critical advances in a broad array of sectors, from health care to energy, food, climate, and water."
- "Convergence is the result of true intellectual cross-pollination."

Not to get too philosophical, but the Science Fiction writer Isaac Asimov identified some of the future problems regarding researcher over-specialization (Asimov 1989):

1. "Could someone be a truly great mathematician if math was all they knew?"
2. "Specialists doing to their specialty to avoid thinking about anything else."
3. "Over-specialization … it cuts knowledge, and it leaves it bleeding."

While this multidisciplinary and third revolution convergence may be the future, there is usually little funding or resources for this new type of research. While there is an effort to support the interdisciplinary research activities of bringing experts in disciplines together, University Departments are organized by unique disciplines, judged on funding, publications, and thought leadership in their specific field. The multidisciplinary researchers are often some of the most productive on campus (e.g., at one University the fixed-term versus tenured faculty-led more of the $1 million+ funded projects); they are often considered extension, practitioners, or outreach functions. So, while food fraud prevention is developing based on a marketplace need, due to the slow new funding, the research and multidisciplinary teams are slowly organically growing.

Management Structure: "Who 'Owns'" It?

The multidisciplinary conundrum is also present in corporate accountability or governance with the question "who owns it?"

Another complexity to addressing food fraud prevention is even within a company and the role of assigning accountability. Before reviewing how to assess the problem, there is an important question of "who owns it" or basically what job function should address food fraud.

There is a complexity to food fraud that has led to inefficient strategies. A challenge is that the problem and controls are spread across the functions of a company. Using Michael Porter's Categories of Tangible Interrelationships (defines a company's job functions as primary and support activities) (Porter 1985), the concepts are plotted for identifying what function "creates" the problem, who "cleans" the problem, and finally who best can manage to "deter" the problem (Fig. 2.7).

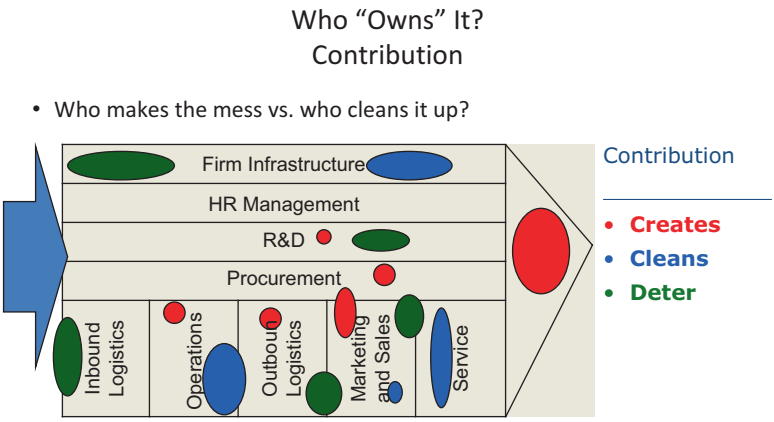

Fig. 2.7 Adaptation of Porter's corporate structure to show where product fraud problems are created, who responds, and where is the most efficient and effective deterrence or prevention. (Copyright Permission Granted) (Spink 2011)

An old story helps present insight into the complexity of the problem of implementing countermeasures and control systems. Product counterfeiting was a problem for a company. Corporate security conducted a major investigation and raid that resulted in the prosecution of a counterfeiter and the seizure of millions of dollars in counterfeit parts. These were "deceptive" counterfeits sold as "genuine," so each part seized directly added to sales. The "ROI" on the seizure was very clear and realized by the Sales Department in the next sales cycle (Fig. 2.8). The Packaging Department was tasked with identifying and proposing new anti-counterfeit packaging components. When the packaging group sent the decision to the Purchasing Department the question was "ok, we'll purchase the new packaging components but whose budget do we charge?" In this case, the Operations Department didn't yet know they would have an additional operations cost!

At this point, the Purchasing Department was not provided additional budget dollars to cover the new products. The Sales Department wasn't interested in volunteering the transfer of budget funds because the revenue was the avoidance of loss or future gains.

The application to food fraud prevention is that this was a case study the helped define the need for an overarching corporate policy as well as engaging enterprise risk management to more clearly define what the risk was outside the "risk tolerance." A clearly defined corporate policy cannot be ignored. A risk that is clearly defined as outside the "risk tolerance" must be addressed or now disclosed—corporations don't want to provide new disclosures of risks…especially inherent risks that have been present but unknown…what other risks might be unknown?

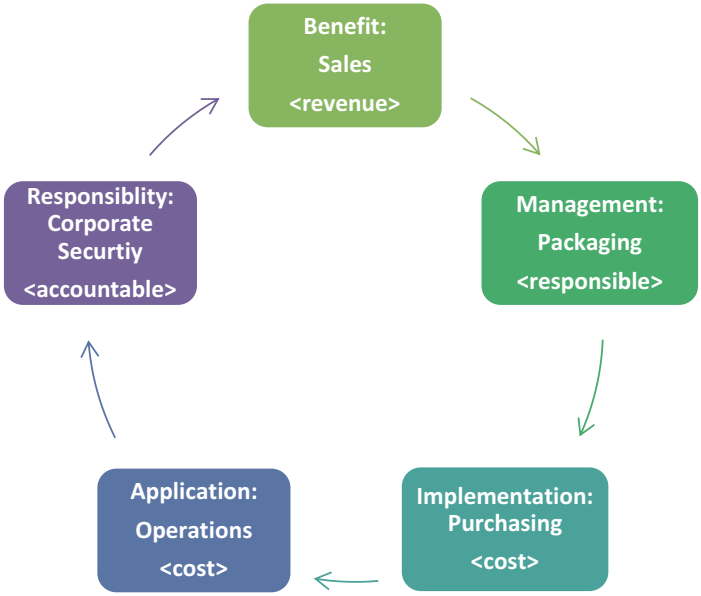

Fig. 2.8 Relationship cycle within and enterprise of benefit, management, implementation, application, corporate benefits and then back to the start. (Adapted from (Porter 1985))

Sidebar: Fire Prevention and Ben Franklin

Food fraud prevention is not exciting, and if done right, then it is intentionally monotonous and boring. It is exciting and newsworthy when a fireman runs out of a burning building rescuing a baby. On the other end of the spectrum, watching a fire inspector makes sure that the smoke detectors are working and the fire exits are well marked is about as exciting as "watching paint dry" (which is not very exciting). Listening to a building code review of fire resistance structural features is literally reading an engineering textbook (also, even less exciting than watching paint dry). *But* the most efficient and effective way to reduce the "fraud opportunity" is the prevention details. It may be exciting to purchase new and faster fire engines to put out fires faster, but it's much more efficient to try to prevent the fires from starting in the first place (Fig. 2.9):

- For every 1000 firefighters who are trained in fire intervention, there might need to be 1 fire inspector.
- For every 1000 fire inspectors who are trained in the detection of vulnerabilities of fires, there might need to be 1 fire prevention engineer.
- For every 1000 fire prevention engineers who are trained in prevention science, there may need to be 1 engineer studying fire incidents for new root causes.
- *And* each person and job is critical to protecting society from injury from fires. Some of the actors are focused and trained on a different topic.

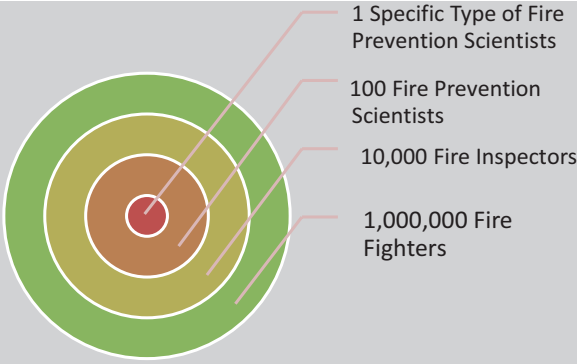

Fig. 2.9 Fire prevention human resource allocation example of fire fighters, fire inspectors, fire prevention scientists, and specific type of fire prevention scientist

- A complex and complicated follow-up assessment is how much is invested in each type of job.

Questions to start addressing the question could include the following: Are the firemen equipped or trained to conduct fire inspections? Are they educated on civil engineering theories about how to reduce the spread of chemical fires? No. Should they? No. *But* the people "accountable" for protecting public safety *are* "accountable" for addressing this root cause or vulnerability.

The famous Ben Franklin quote of "an ounce of prevention is worth a pound of cure" was reportedly based on is work during the creation of first the Philadelphia Fire Department (Franklin 1735). When addressing fire prevention, he is reported to actually have said: "an ounce of prevention is worth *ten* pounds of cure."

The application to food fraud prevention is that the same holds true for food fraud prevention. There is a need to step back and consider the root cause as well as the most efficient and effective ways to address the prevention actions… regardless of your current experience or education. This is consistent with many other concepts that will be covered later including ISO 31000 Risk Management that begins with "establishing the context." For every 1000,000 food investigators, there only need to be a handful of food fraud prevention scientists.

Conclusion

This second Introduction chapter expanded on the definitions and scope of food fraud to the critical foundational or organizational subjects such as the food risks, the types of harm including why there is a fraud opportunity. In combination these two Introduction chapters present that for efficiently and effectively reduce the fraud opportunity—the goal is not to catch bad product but to prevent the food fraud act from occurring in the first place—addressing all types of fraud is critical as is a primary and holistic focus on reducing the fraud opportunity through prevention. The nature of the fraudsters is to attack any and all vulnerabilities, so an equally interdisciplinary approach is needed to understand and respond to that fraud

opportunity. ***The first conclusion is*** that there are a wide range of food fraud attributes that expand the vulnerability beyond public health harm and traditional detection and enforcement responses. ***The second conclusion is*** that the nature of the fraud act and the fraudster leads to vulnerabilities that are outside the usual focus areas of the proprietary, authorized, and legitimate supply chain. This recognized to also be outside the traditional HACCP programs or scope. ***The final conclusion is*** that there are many reasons why there has not been a coordinated, strategic, and interdisciplinary focus on the fraud opportunity. As with historical innovations such as the implementation of quality management or environmental sustainability programs, there is an unmet need that becomes so extreme that a paradigm shift is necessary and then the methods are developed. For food fraud prevention, that paradigm shift is underway which includes broadening the focus to all types of fraud, to all products wherever they are in the supply chain, and then a shift from response to prevention through criminology and business management focused efforts to reduce the vulnerability or fraud opportunity. If there's no fraud opportunity, then there's no fraud opportunity. There is a saying:

> ***If there is no fraud opportunity, then you could be buying from the famous criminal Al Capone, and he wouldn't commit a crime against you… if there is no fraud opportunity, then he would not find a crime to commit (Of course you'd rather not buy from a known criminal).***

Appendix: WIIFM Chapter on Introduction to the Concepts

This "What's In It For Me" (WIFFM) section explains why this chapter is important to you.

Business Functional Group	Application of This Chapter
WIIFM all	Due to the complex nature of the risk, expand the focus from just addressing a problem or corrective action to the calibration of the overall vulnerabilities of the enterprise.
Quality Team	Food fraud is very different non-traditional food safety hazard that requires a unique shift to prevention, and that has a focus on new and unique vulnerabilities.
Auditors	The assessments and strategies you see will be very different from health hazard assessment and based more on business decision risk assessment.
Management	There is a solid foundation of scholarly literature, and there may be a need for additional training and education— – but your implementation does not need to be costly since there are many synthesized and refined resources.
Corp. Decision-Makers	While this may seem like a very odd and abstract risk, there are work processes that are very strategically based and integrated with all other enterprise-wide risks.

Appendix: Study Questions

This section includes study questions based on the Key Learning Objectives in this chapter:

1. Discussion Question
   (a) Why does FF require a fundamentally different approach than addressing other types of food risks?
   (b) What are the most dangerous aspects of a FF incident (define "dangerous")?
   (c) Does the type of food fraud change the concern for potential health harms?
2. Key Learning Objective1
   (a) What is "Product Fraud" and the relationship to "Food Fraud"?
   (b) What are the "Product Fraud" attributes?
   (c) What is the different enterprise risk of a product in a "Primary" or "Secondary" market?
3. Key Learning Objective2
   (a) What is a Food Fraud "Indirect Risk"?
   (b) What is the difference between "Detect" and "Deter"?
   (c) Is Food Fraud a non-deceptive counterfeit product?
4. Key Learning Objective3
   (a) What is "Smuggling" and in relation to "Diversion"?
   (b) Is "Port Shopping" a type of Food Fraud and if so, then why—or why not?
   (c) Explain why all types of Food Fraud are a compliance requirement of FSMA 21CFR117?

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