

Defining the Public Health Threat of Food Fraud

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Abstract: Food fraud, including the more defined subcategory of economically motivated adulteration, is a food risk that is gaining recognition and concern. Regardless of the cause of the food risk, adulteration of food is both an industry and a government responsibility. Food safety, food fraud, and food defense incidents can create adulteration of food with public health threats. Food fraud is an intentional act for economic gain, whereas a food safety incident is an unintentional act with unintentional harm, and a food defense incident is an intentional act with intentional harm. Economically motivated adulteration may be just that—economically motivated—but the food-related public health risks are often more risky than traditional food safety threats because the contaminants are unconventional. Current intervention systems are not designed to look for a near infinite number of potential contaminants. The authors developed the core concepts reported here following comprehensive research of articles and reports, expert elicitation, and an extensive peer review. The intent of this research paper is to provide a base reference document for defining food fraud—it focuses specifically on the public health threat—and to facilitate a shift in focus from intervention to prevention. This will subsequently provide a framework for future quantitative or innovative research. The fraud opportunity is deconstructed using the criminology and behavioral science applications of *the crime triangle* and *the chemistry of the crime*. The research provides a *food risk matrix* and identifies food fraud incident types. This project provides a starting point for future food science, food safety, and food defense research.

Keywords: counterfeiting, economically motivated adulteration, food fraud, food safety, public health

Practical Application: Food fraud, including the more defined subcategory of economically motivated adulteration, is a food protection threat that has not been defined or holistically addressed. The terrorist attacks of September 11, 2001, led to the development of food defense as an autonomous area of study and a new food protection discipline. As economically motivated adulteration grows in scope, scale, and awareness, it is conceivable that food fraud will achieve the same status as an autonomous concept, between food safety and food defense. This research establishes a starting point for defining food fraud and identifying the public health risks.

Introduction

Food fraud, including the more defined subcategory of economically motivated adulteration, is a public-health food risk that is growing in awareness, concern, and danger (Elliott 2009; Alford 2010; Anonymous 2010; Bo 2010; Chui 2010; GMA 2010; Huffstutter 2010; Interlandi 2010; Layton 2010; Paddenburg 2010). Primarily the regulatory domain of FDA, but often overlapping with USDA, Food Fraud is an intentional act for economic gain, whereas a food safety incident is an unintentional act with unintentional harm, and a food defense incident is an intentional act with intentional harm. Food fraud is a broader term than either the Food and Drug Administration (FDA) definition of economically motivated adulteration (EMA) or the more specific general concept of food counterfeiting. Food fraud often leads to adulterated food products. Food fraud is, indeed, a food-industry issue. It is important to emphasize that although the *cause* or *motivation* is economic or financial, the *effect* is often a public health

threat. Through the evolution of industry research and this study, it became clear that there was a lack of understanding of clear statements about the associated public-health food risk. Therefore, it is important to review the nature of the risk and its history before developing prevention, intervention, and response plans (WHO 2003; Closs and McGarrell 2004; deKieffer 2006; DHS 2007; FDA 2007b; PriceWaterhouseCooper 2007; CFSAN/FDA 2009). While there has been a tremendous amount of work done in the broader area of food adulteration, the long-term commitments to researching food fraud have been minimal. Through a literature review and peer consultation, this report was created as a “backgrounder” on the topic. The intent of this research paper is to provide a base reference document for defining food fraud—it focuses specifically on the public health threat—and to facilitate a shift in focus from intervention to prevention.

Economically Motivated Adulteration

Economically Motivated Adulteration (EMA), a subcategory of food fraud, is a root cause of public health food risks (Spink and Harte 2008; FDA 2009; Spink 2009a). EMA was defined in the May 2009 FDA Open Meeting on Economically Motivated Adulteration as: “. . . the fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production.” This meeting also noted, “EMA includes dilution

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of products with increased quantities of an already-present substance to the extent that such dilution poses a known or possible health risk to consumers, as well as the addition or substitution of substances in order to mask dilution.”

Food fraud

Food fraud has been conducted since antiquity; evidence has been found of counterfeit Roman seals on amphorae containing fraudulent olive oil and wine (Mello and others 1982; Purcell 1985; Armstrong 2009). While the basic fraud actions are similar to those occurring in modern times, the scale then was limited and covered a small geographic area. Because modern food supply chains have been lengthened, complicated, and accelerated, the risk of food fraud has broadened to include entire global populations (Spink and others 2010). While the scope of food fraud may have remained the same over time, modern food supply chains and manufacturing infrastructure have vastly expanded its scale and potential impact. By leveraging existing research on product fraud and counterfeiting, more specific definitions for food fraud have been developed:

Food fraud is a collective term used to encompass the deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging; or false or misleading statements made about a product, for economic gain. Food fraud is a broader term than either the economically motivated adulteration (EMA) defined by the Food and Drug Administration (FDA) or the more specific general concept of food counterfeiting. Food fraud may not include “adulteration” or “misbranding,” as defined in the Food, Drug, and Cosmetic Act (FD&C Act), when it involves acts such as tax-avoidance and smuggling. (Spink and Moyer 2011, p. 1)

The motivation for food fraud is economic or financial, but the result or impact is a real public health vulnerability—whether a public health incident ensues, the adulteration or misbranding creates the potential for harm. In some ways, food fraud threats could be considered more risky than traditional food safety threats since the contaminants are unconventional. Traditional food safety intervention focuses on a set of bad bugs (referring to the FDA’s Center for Food Safety and Applied Nutrition [CFSAN] “Bad Bug Book”), on known harmful chemicals, and on commonly present physical hazards, but fraudsters may use adulterants that are not listed among those conventional food safety contaminants (Fortin 2006; CFSAN/FDA 2009; WHO 2009). For example, melamine was an unexpected food adulterant since it is a plasticizer used in forming plastic products—it was used by fraudsters since it ingeniously mimicked high quality protein in common protein content quality control tests (Roth and others 2008).

Government agencies tasked with mitigating food-related public health risks are gaining efficiencies through public-private partnerships and interagency collaborations. While there is a long history of food safety improvements, evolving risks and the lack of a clear definition have hampered progress in addressing food fraud. The FDA’s 2007 Food Protection Plan “builds in prevention first, then intervention, and finally, response” (Figure 1) (FDA 2007b). The concept of food protection covers all public health threats related to food, regardless of the source, and traditionally focuses on prevention and countermeasures for food safety and food defense.

While this is the logical progression for a concept as well researched and well known as food safety, the food fraud response currently begins at the intervention stage (that is, learning about

the risks) then moves to the response stage (that is, public-private partnership coordination). As the response stage becomes better known, food fraud focus will naturally evolve to include the prevention stage.

In May 2009, the FDA held a public meeting on EMA (FDA 2009). Its stated purpose was to “better predict and prevent EMA with a focus on situations that pose the greatest public health risk.” All FDA regulated products—food, drugs, biologics, medical devices, and animal feed—were considered. A broad range of stakeholders were engaged, including academia, industry, trade groups, associations, and consumer groups. The intended direction was to encourage ways to “predict” the types of attacks and then shift to “prevention” countermeasures. This concept is emphasized repeatedly in many FDA documents, due to the importance of focusing resources on maximizing the reduction of the greatest public health risks. This meeting was a significant advancement toward reducing food fraud for several reasons: the FDA officially recognized this emerging risk as an autonomous concept; the FDA addressed EMA across all products; and, finally, the FDA assigned policy monitors and researchers for both public and private stakeholders. The meeting was a catalyst for trade and nongovernmental organizations to formalize their work in this area. Examples include the Grocery Manufacturers Association’s (GMA’s) Consumer Product Fraud Report (January 2010), the U.S. Pharmacopeia (USP) Food Protein Workshop: Developing a Toolbox of Analytical Solutions to Address Adulteration (June 2009), and the USP creating the Expert Panel on Food Ingredient Intentional Adulteration (August 2010) (USP 2009; GMA 2010).

Another example of food fraud’s increased recognition is the February 2009 U.S. Government Accountability Office (GAO) report on seafood fraud. Among the recommended strategies, the GAO suggested that the Dept. of Homeland Security’s Customs and Border Protection (CBP), the Dept. of Commerce’s National Marine Fisheries Service (NMFS), and the Dept. of Health and Human Services’ FDA collaborate to “develop goals, strategies, and mechanisms to efficiently and effectively share information and resources related to seafood fraud detection and prevention across agency boundaries” (GAO 2009). This GAO report was intended to focus on economic risks, however, and only briefly mentioned 2 possible public health risks (a toxic pufferfish incident, in which it was mislabeled as monkfish, and allergen risks due to mislabeling) (see Table 1). This study expands on the GAO Seafood Fraud Report by exploring more of the potential EMA, food-related public health risks, and includes additional comments in the right hand column.

Food Fraud and the Food Protection Risk Matrix

The concept of distinguishing between cause and effect is critical to shifting the focus from a reactive to a proactive strategy.

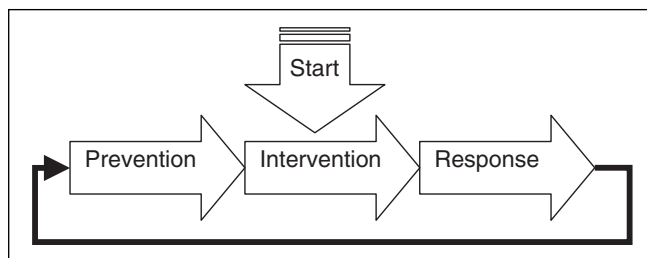


Figure 1—Food protection plan progression.

While classic intervention and response tactics have value whenever public health is threatened, proactive prevention is the logical progression. This has been the natural evolution in many aspects of the food protection disciplines of food safety and food defense: a better understanding of emerging risks, based on intervention and response experiences, as well as understanding the science behind situations.

Traditional food safety approaches may not be the most effective option for detecting or deterring food fraud. Food fraud risk is based on a completely different set of motivations, so prevention is different from programs to improve food safety, food defense, and food quality. To facilitate the shift toward prevention, it is important to understand that the root cause of food fraud has fundamentally different properties than food safety's traditional bad bugs, bad chemicals, and physical hazards. Reducing food fraud opportunities requires a deeper understanding of the public health risk in order to consider the specific types of food fraud risks.

This research identified 3 types of food fraud risks for public health: direct, indirect, and technical. It is important to note that for all 3 types, this is the effect, not the fraudster's 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.

The food protection concept includes food quality, food safety, food fraud, and food defense. A food defense risk is a public health threat that is intentional, such as malicious tampering or terrorism. A food quality risk is an economic threat that is unintentional. A food fraud risk is economically motivated and intentional, but is not intended to be a public health food threat. For example, fraudsters have added melamine to milk to boost the apparent protein content for economic gain, but in some situations the

amount was so great that a public health incident ensued. The *motivation and cause* for the melamine incident clearly make this food fraud, even though the *result and effect* are an adulteration that caused a food safety risk.

In order to better understand how food fraud differs from other food concerns, such as food safety, the food protection concepts were incorporated into the *Food Risk Matrix* was developed (Figure 2) (Spink 2007, 2009b). It is important to emphasize that the matrix addresses the cause of the risk and the motivation of the fraudster, but not the effect. If a food quality event leads to the effect of a food safety risk, there is still a food quality root cause. For example, salvaging dropped fruit that is bruised and subsequently contaminated with *E. coli* O157:H7. The 4 disciplines food safety, food defense, food quality, and food fraud are arranged in quadrants. The *x*-axis represents the variable of intent and includes the 2 scenarios of intentional and unintentional. The *y*-axis represents the threat variable and includes economic and public health. A food safety risk is a public health threat that is unintentional, such as lettuce contaminated with *E. coli* O157:H7.

The 4 disciplines in the *Food Risk Matrix* are further distinguished by exploring specific motivations or causes, and the effects of each type (Table 2).

Measuring the successful shift from reactive tactics, such as detection and intervention, to a proactive preventative strategy is challenging because existing metrics were established to quantify intervention and estimate the effectiveness of response actions. Food safety has followed a historical pattern of detection of incidences, followed by the adoption of new preventative measures such as the Good Manufacturing Practices (GMPs) regulations, the Hazard Analysis Critical Control Points (HACCP), and Good Hygienic Practices (GHPs), including targeted hand washing programs. Since food safety incidents are more frequent and occur in a broader, statistically "normal distribution," and there is a national, state, and local investigative system in place, statistical data are effective proof of the success of these approaches (for example, CDC annual reports and FoodNet surveys). Food defense also relies on detection and intervention, but it is harder to quantify, due to a lack of events with risk-based assessments, in order to define success in the best way possible. Such tactics and metrics are also very challenging to apply to food fraud; the incidents

Table 1—GAO seafood fraud report: types of food fraud and potential public health risk (GAO 2009).

GAO seafood fraud report detail (1)			New comment (2) potential public health food risk
Fraud type	Description	Cause and motivation	
Transshipment	Transferring cargo among different transports and countries	Avoid tariffs or anti-dumping duties	Compromised storage, handling, and traceability (in the event of a recall)
Over-treating	Adding more ice or water than allowed by regulation	Increase profits by including more weight for ice than fish	Water may include pathogens or chemicals (for example, if ice was made from pond water)
Species substitution	Substituting less costly species and misrepresenting them as more expensive species	Increase profits due to cost differential	Misrepresented species may be toxic or cause allergic reactions
Short-weighting	Package labels state weights higher than packaged contents	Increase profits due to weight differential	None
Other mislabeling or misrepresentation	Misrepresenting country of origin, ingredients, so on	Generally avoid costs and maximize profits	Undeclared allergens, toxins from banned locals (for example, ciguatoxin-prone reefs), weight increased added through other unknown materials, so on

In each case, fraudsters may not be following Good Manufacturing Practices (GMPs), Good Agricultural Practices (GAPs), or Good Hygiene Practices (GHPs).

(1) These columns are directly from the GAO Seafood Fraud Report.

(2) This column was not included in the GAO Seafood Fraud Report and was developed for this report.

are diverse in nature with an uncertain distribution. For example, analyzing products at one port of entry does not represent the distribution of risk across all ports. The current intervention metrics, such as the number of seizures or arrests, do not measure prevention. Even risk assessment tools like CARVER+Shock do not directly apply to assessing food fraud risk because food fraud does not have a traditional terrorist “shock” value. A key precept is that food fraudsters do not intend to pose a public health threat. This risk only exists through the fraudsters’ negligence. The intent to do harm through food products would be classified as a food defense event. It is likely that far more food fraud incidents occur, which are not detected. One other difference between food fraud and food defense is that a food defense incident is likely to be a one-time act (for example, a dramatic injury or death impact), whereas food fraud issues can continue almost indefinitely, unless they are exposed—whether through the carelessness of the perpetrators, reported adverse effects on consumption of the product, or deliberate disclosures by one or more players involved for either revenge or economic gain.

Criminology

Criminology and behavioral science theories offer human behavioral insights into food fraud criminals and the underlying fraud opportunity. Food fraud is a deliberate act, carried out by those people in charge of the operation. By its very nature, this suggests

that the behavioral sciences can provide a greater understanding of the problem. The proactive prevention of food fraud requires a fundamental shift from the reactive detection and intervention perspectives. This shift is efficiently explained through 2 basic criminology theories. *Traditional criminology* focuses on reducing crime by understanding the motivations of the human actors (Beirne and Messerschmitt 2006). *Environmental criminology* seeks to reduce the crime opportunity by reducing the physical attributes of time and space from the environment (Beirne and Messerschmitt 2006). Two key criminology applications also apply here: the *crime triangle* and the related concept of the *chemistry of the crime* (Clarke 1997; Felson 1998).

Before addressing the basic criminology theories, it is helpful to classify the criminal types, which in turn enables the categorization of motivations, the nature of the fraud, the capabilities and resources of the fraudster, risk assessment, and risk mitigations such as detection, intervention, and deterrence (Table 3).

The mention of the term “organized crime” readily conjures images of hierarchical organizations such as La Cosa Nostra, Mafia, Russian mobs, Chinese Triads, or South American drug cartels. There are legal and technical differences between organized crime and criminals that are organized (Chow 2003). Since the opportunity exists for a small fraud event to be distributed across a wide population, less sophisticated criminals who are organized cannot be ignored. Criminals form a network to perpetrate a crime,

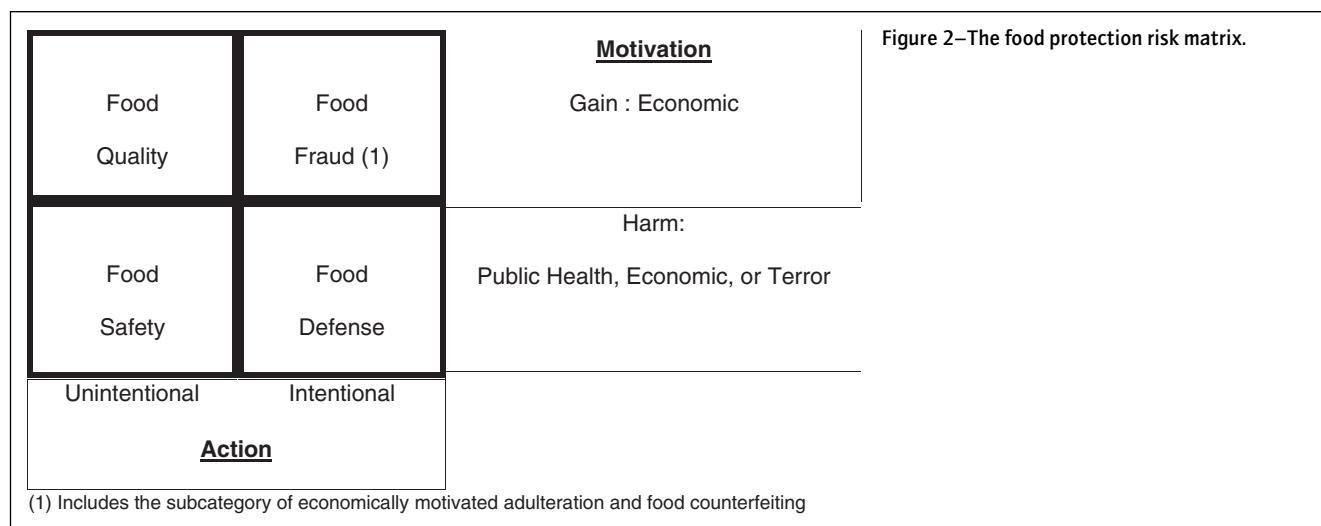


Table 2—Risk cause and effects for the food disciplines.

Discipline risk type	Example	Cause and motivation	Effect	Public health risk type	Secondary effect
Food quality	Accidental bruising of fruit	Mishandling	Unsalable product or possible additional contamination with <i>E. coli</i> O157:H7	None or Food Safety	Reduced brand equity or Food Safety incident
Food fraud	Intentional adulteration of milk with melamine	Increased margin	Toxic poisonings	Food Safety	Public fear and possible lower prices industry-wide
Food safety	Unintentional contamination of raw vegetables with <i>E. coli</i> O157:H7	Limited field protection and control during harvesting and processing	Illnesses and/or deaths	Food Safety	Damaged industry, recall expense, and public fear
Food defense	Intentional contamination of ground beef with nicotine	Revenge intent against the store/manager through injury to consumers	Nonlethal poisonings	Food Defense	Adulterated product, damaged industry, recall expense, and public fear

disband when the action is completed, returning to their normal, sometimes legitimate, operations and then re-form into a new criminal network, with the intent and capability of perpetrating a new fraud. Unlike traditional organized crime, these are often swarms or networks. Disrupting any single link in the chain will not necessarily cripple the network or the ability for new fraudsters to reconnect (Spink 2011).

To further understand the nature of food fraud, several criminology applications provide insight. First is the crime triangle. There are 3 elements of crime opportunity or the more general term of fraud opportunity, as illustrated by the crime triangle: victim, fraudster or referenced in criminology research as the “criminal,” and guardian including hurdle gaps (Figure 3) (Felson 1998). It is important to emphasize that there may be very capable guardians and hurdles in place, but the nature of an evolving, emerging threat is that new gaps always occur. The term fraudsters is used since in many incidents, the food fraud is not criminal or even a civil law violations, and may not be considered unethical in many cultures (this last point is a behavioral sciences and social anthropology phenomenon). To adapt the concept, note that as the legs increase in length, the area of the triangle increases, which represents an increase in the crime opportunity. Manipulating any leg of the triangle affects the area of the triangle and the crime opportunity.

It is rare, and usually not economically feasible, to completely eliminate an element of the crime triangle. There are a nearly infinite number of fraudsters. Brand growth and increased brand recognition of a product actually increases the fraud opportunity (that is, more victims, spending and brand equity). Finally,

the guardian or hurdle gaps lead to a greater fraud opportunity. Guardians include entities that monitor or protect the product and could include customs, federal or local law enforcement, trade associations, nongovernmental organizations, or individual companies themselves. Hurdles include components or systems that exist (or are put in place) to reduce the fraud opportunity by assisting in detection or providing a deterrence.

Fraud opportunities could be reduced by increasing the risk of detection, or increasing the costs of the necessary technology to commit the fraud and/or of developing quality levels that would attract consumers. Countermeasures are intended to reduce the fraud opportunity, but a refinement to a process or a narrowing of focus in detection could inadvertently create new gaps that could be exploited by fraudsters. An example of this uncertain nature is that fraudsters may shift ports of entry by conducting strategic “port shopping” and by shipping fraudulent product through less-monitored entry points.

In addition to the crime triangle, there are other applied criminology theories that provide insights on fraud. *The chemistry of the crime* concept is related. Here there are a set of elements, under certain conditions, which combine to produce the opportunity for a crime. Manipulating the number of elements or their time and spatial relationships can disrupt the crime opportunity. Other criminology applications that are important and apply, but are beyond the scope of this research, are the study of criminal motivation and crime components. These are further explored within the situational crime prevention and rational choice theory (Clarke 1997; Felson and Clarke 1998).

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.

Table 3—Criminal types and attributes applicable to food fraud (Spink [2011]; adapted from Hagan [2010]).

Types criminals	Definition
Recreational	Action for entertainment or amusement
Occasional	Infrequent, opportunistic
Occupational	Incidents at their place of employment either as an individual act or in cahoots with the company
Professional	Crime fully finances their lifestyle
Ideological	Domestic or international terrorist who commits this act to make an ideological statement or to economically harm an entity

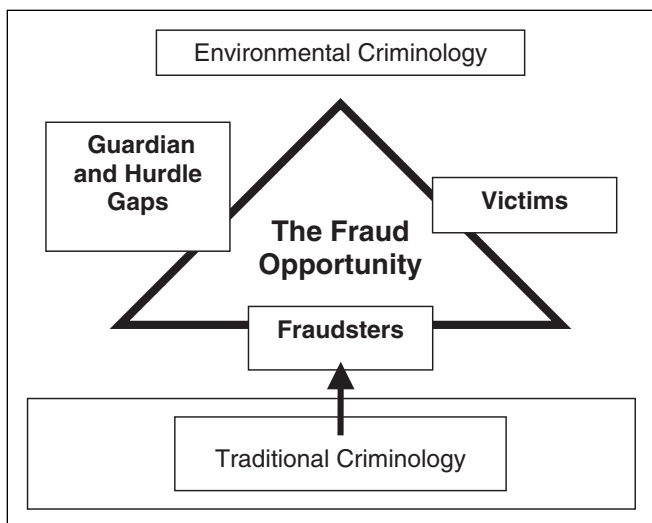


Figure 3—The crime triangle (Spink [2007]; adapted from Felson [1998]).

Laws, Regulations, and Standards

The current era of food regulations began with the U.S. Federal Food, Drug, and Cosmetic (FD&C) Act of 1938 (Fortin 2009). The Act was initiated after the mass poisoning of patients by medicine that contained diethylene glycol (DEG). The FDA was given the direct responsibility for these products and for protecting the public’s health though it should be emphasized that many of the issues and threats overlap with USDA products. DEG has continued to be a lethal adulterant, globally, and was found in the U.S. as recently as 2007, in counterfeit, branded toothpaste (Bogdanich 2007; FDA 2007a). While there have been tremendous efforts and accomplishments made in protecting the food supply, security gaps have been identified in the U.S. Government Accountability Office (GAO) reports in 1997, 1999, 2008, and 2010, for example (GAO 1997, 1999, 2008a, 2008b, 2010). The 1997 report stated: “the existing federal system to ensure a safe food supply is fragmented, characterized by a complex maze of often inconsistent legal and regulatory requirements implemented by 12 different federal agencies, of which 6 have major roles in carrying out food safety and quality activities.” While the FD&C Act defines basic terms such as “adulterated food,” “misbranded food,” and “counterfeit drug,” food fraud and economically motivated adulteration remain undefined in the laws and regulations.

Table 4—Food fraud incident types (Spink 2007, 2009b).

Term	Definition	Example	Potential public health threat that may lead to illness or death
Adulterate	A component of the finished product is fraudulent	Melamine added to milk	Fraudulent component
Tamper	Legitimate product and packaging are used in a fraudulent way	Changed expiry information, product up-labeling, so on	Fraudulent packaging information
Over-run	Legitimate product is made in excess of production agreements	Under-reporting of production	Fraudulent product is distributed outside of regulated or controlled supply chain
Theft	Legitimate product is stolen and passed off as legitimately procured	Stolen products are co-mingled with legitimate products.	Fraudulent product is distributed outside of regulated or controlled supply chain
Diversion	The sale or distribution of legitimate products outside of intended markets	Relief food redirected to markets where aid is not required	Shortages or delays of relief food to needy populations
Simulation	Illegitimate product is designed to look like but not exactly copy the legitimate product	“Knock-offs” of popular foods not produced with same food safety assurances	Fraudulent product of lesser quality
Counterfeit	All aspects of the fraudulent product and packaging are fully replicated	Copies of popular foods not produced with same food safety assurances	Fraudulent product

In each case, fraudsters may not be following Good Manufacturing Practices (GMPs), Good Agricultural Practices (GAPs), or Good Hygiene Practices (GHPs).

From a non-food-centric perspective, product counterfeiting has been defined in a macro sense as deceptive misrepresentation of a product, while in the micro sense it is defined as an intellectual property violation of trademark, patent, or copyright. The macro definition is consistent with the traditional global definition used by the World Health Organization (WHO) (WHO 2007). Seven different types of counterfeiting have been identified, with respect to economic and public health threats due to food fraud (Table 4) (Spink 2007, 2009b).

While the FD&C Act is the tool used to address food fraud, there are other applicable regulations that cover such areas as intellectual property rights, fair labeling, tampering, theft, consumer product safety, and product importation (Spink and others 2011). The laws and regulations covering food fraud and consumer product counterfeiting are diverse because they were developed from regulatory or statutory responsibilities outward, specific to the known fraud types and the criminals—this inherent complexity creates both coverage gaps and overlaps that impede food fraud enforcement efforts. Fraudsters seek gaps in monitoring and control systems. Process refinements can actually create new gaps for fraudsters, when industry-wide process improvements or refinements focus detection on risk factors from a range of known incidents such as *Salmonella*, diethylene glycol, anthrax, or cyanide. Fraudsters ferret out and exploit gaps created by the general efficiency of narrowing the inspection or monitoring focus. Preventing food fraud risk requires an interdisciplinary and holistic approach to ensure full coverage.

Sound laws and regulations are the foundation of law enforcement and the criminal justice system. At the Federal level, food protection laws, statutes, and regulations are created within the U.S. Code (USC); how laws are to be carried out is defined in the Code of Federal Regulations (CFR). In short, the USC defines laws and the CFR defines their implementation (USPTO 2008).

Effective enforcement is a challenge because the food fraud risk is emerging, evolving and extremely complex. For example, the deliberate misidentification of packaged food potentially involves a variety of regulatory violations under the jurisdiction of various regulatory and enforcement agencies (Spink and others 2011). Food ingredient statements are the regulatory and statutory domain of the FDA. Country-of-origin statements involve both Customs and Border Protection (CBP), and Immigration and Customs Enforcement (ICE). Fair labeling laws are enforced

by the Federal Trade Commission (FTC). Intellectual property (IP) laws cover trademark infringements, and can involve the U.S. Patent and Trademark Office (USPTO), and the FBI. The nature of the food fraud risk, with its complexity, inherent regulation gaps, and overlapping enforcement agencies, requires both a holistic awareness and approach.

In 2010, standards organizations were just beginning to expand the “intentional adulteration” focus to include a focus on consumer product fraud and, specifically, economically motivated adulteration. For example, the International Standards Organization *Technical Committee 247 Fraud Countermeasures and Controls* has a defined scope to support other current standards such as ISO 22000 Food Safety and ISO 28000 Supply Chain Security. Also, as mentioned above, the U.S. Pharmacopeia/Food Chemicals Codex is also expanding to include this specific type of food risk. Each initiative faces the same challenges of an emerging, interdisciplinary threat that requires nontraditional disciplines to address the root motivation and develop preventative measures.

Conclusion

While humans must consume food, how and where they acquire it and, by contrast, the pervasiveness of the food fraud that can be perpetrated, are almost infinite. Deterring food fraud requires interdisciplinary research combining criminology with other fields, such as food safety, public health, packaging, food science, food law, supply chain management, consumer behavior, social anthropology, and political science. Focusing on the criminal component of the *crime triangle* provides insights to the motivations for seeking food fraud opportunities.

This research on food fraud has outlined the history, the core public-health food risk, the risk assessment methods, the basic application of the criminology and behavioral sciences, the core fraud opportunity, and the applicable laws and regulations. The major outcome of this study was to clarify that while the motivation may be economic, the public health vulnerability is real. In some cases, food fraud is more dangerous than traditional food safety risks, since potential adulterants are unconventional, and the current intervention and response systems are not looking for these contaminants. Defining the problem and understanding the nature of the risk are the first steps in transitioning through the natural evolution of intervention and response to prevention. This research provides an overview of the topic, to help determine

the optimal interagency enforcement tactics and metrics, as well as to emphasize the need to support a continued public–private partnership approach.

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