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Food Safety, Food Fraud, and Food Defense: A Fast Evolving Literature

Louise Manning and Jan Mei Soon

Abstract: Intentional food crime is plural in nature in terms of the types of crime and the differing levels of financial gain. Successful models of food crime are dependent on how well the crime has been executed and at what point, or even if, detection actually occurs. The aim of this paper is to undertake a literature review and critique the often contradictory definitions that can be found in the literature in order to compare and contrast existing food crime risk assessment tools and their application. Food safety, food defense, and food fraud risk assessments consider different criteria in order to determine the degree of situational risk for each criteria and the measures that need to be implemented to mitigate that risk. Further research is required to support the development of global countermeasures, that are of value in reducing overall risk even when the potential hazards may be largely unknown, and specific countermeasures that can act against unique risks.

Keywords: adulteration, fraud, holistic, risk mitigation

Introduction

Contamination in the context of food can be described as "the introduction or occurrence of an unwanted organism, taint or substance to packaging, food, or the food environment" (BRC 2015). Food safety hazards have been defined as "a biological, chemical, or physical agent in, or condition of, food with the potential to cause an adverse health effect" (CAC 2003; BS EN ISO 22000; 2005; Wallace and others 2011). Codex Alimentarius defines a contaminant as: "any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry, and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport, or holding of such food or as a result of environmental contamination. The term does not include insect fragments, rodent hairs, and other extraneous matter" (CAC 1995:1).

The U.S. Federal Food, Drug, and Cosmetic Act Section 342 defines adulterated food principally as food that bears or contains: "any poisonous or deleterious substance which may render it injurious to health; but in case the substance is not an added substance such food shall not be considered adulterated under this clause if the quantity of such substance in such food does not ordinarily render it injurious to health." Thus, an adulterant can be deemed to be any poisonous or deleterious substance. Section 343 of the same legislation defines misbranded food as food that is falsely or misleadingly labeled, offered for sale under another name, is an imitation of another food, where a container is misleading as to the contents. The term adulterated food as described above does not distinguish explicitly between intentional or unintentional addition of an adulterant. Lipp (2011) stated that to differentiate between the terms contamination and adulteration, and by inference contaminant and adulterant, the former should be considered in terms of unintentional activity and being technically unavoidable, whereas adulteration is intentional replacement of an ingredient that is specifically motivated, for example economic or ideological gain.

It should be considered that although the terms contamination and malicious contamination have been used widely in the literature, some U.S. literature distinguishes between contamination and adulteration in that the former is used to describe instances of unintentional contamination whereas the latter term is used to define all intentional activities whether motivated for economic gain (EMA) or not. In this paper, if literature is quoted that has described an event as contamination, whereas the U.S. definition would define it as adulteration, for purposes of accuracy to the original source that term has remained in the text. However, consideration should be given going forward when developing supply chain standards and regulations to ensure common terminology use as this would be of value.

Although historically food safety was described as the concept that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (BS EN ISO 22000 2005), that is, a term encompassing both (a) intentional acts and (b) unintentional contamination, more recent literature seeks to differentiate between the two. PAS 96 (2014) defines a hazard as something that can cause loss or harm which arises from a naturally occurring or accidental event or results from incompetence or ignorance of the people involved compared to a threat being something that can cause loss or harm which arises from the ill-intent of people. FSIS (2014) characterizes food safety and food defense as being distinct issues that need to be addressed, namely that food safety refers to protecting the food supply from unintentional contamination, whereas food defense refers to protecting the food supply from intentional adulteration with a motive to cause harm. Alternatively, the Global Food Safety Initiative (GFSI 2013) suggests that food defense is a subset of food safety issues (where the adulterant has the potential to cause harm and separate where the agent is nonharmful rather than the FSIS definition of them being a separate set of issues.

The potential for food crime is often influenced by a difference between availability and demand, creating an opportunity for criminals or fraudsters to financially benefit from the shortfall. The World Food Summit of 1996 defined food security as existing

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doi: 10.1111/1750-3841.13256

Journal of Food Science A Publication of the Institute of Food Technologists

"when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy, and active life" (WHO nd). Defra (2006) goes further and defines levels of food security as: individual or household food security relating to purchasing power, which is determined by income, access to resources, and affordability of food; regional food security where regions are dependent on key distribution routes for food; national/trading block food security relates to the ability of a country or trading block to assess sufficient foodstuffs, even in the face of severe disruptions to the supply chain; and global food security, that is, the ability of the world's food producers to meet global demand, and ensure the efficiency and effectiveness of global trading and distribution systems. The interconnecting factors that frame food security also influence the opportunities for food crime.

Crime is defined as an offence or illegal acts punishable by law. The term "illegal" can be considered as being unlawful, contrary to law, or an activity that the law directly forbids (Rapalje and Lawrence 1997). Food crime can be described as an activity organized by individuals or groups who knowingly set out to deceive, and or injure, those purchasing and consuming food (adapted from Elliott Review 2014). This rationale would suggest that food crime occurs when food is intentionally modified in order to bring harm to individuals or for purposes of economic gain and both situations may lead to issues of food safety or food quality. Two brothers who owned and operated Jensen Farms in Colorado pled guilty to charges associated with the introduction of cantaloupe into interstate commerce that was adulterated with *Listeria monocytogenes* (FDA 2013). Thus, it was determined that the cantaloupe bore a poisonous substance that rendered them injurious to health. In May 2011, the cantaloupe cleaning system was allegedly changed. The new system, built to clean potatoes, was installed, and was to include a catch pan to which a chlorine spray could be used to clean the fruit of bacteria. The chlorine spray, however, was never used. In this example, the use of the term "adulteration" suggests that by failing to implement a process that is specifically designed to minimize the risk of harm to consumers then, even where there was no specific intent to cause harm, a criminal act can be deemed to have taken place.

Fraud can simply be described as: a type of criminal activity that can be an abuse of position, or false representation, or prejudicing someone's rights for personal gain (SFO nd). Food fraud is defined by the Food Standards Agency (FSA) as: "deliberately placing food on the market, for financial gain, with the intention of deceiving the consumer" (Elliott Review 2014). The Elliott Review (2014:6) states that "food fraud becomes food crime when it no longer involves random acts by 'rogues' within the food industry but becomes an organized activity by groups which knowingly set out to deceive, and or injure, those purchasing food"; thus, building on the FSA definition.

The U.S. Food and Drug Administration (FDA) determine economically motivated adulteration (EMA) 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," that is, for economic gain (Lutter 2009). EMA is therefore only one example of the types of fraudulent activity that can occur in the food supply chain and EMA as a definition should not be used when considering other types of fraudulent activity. This is discussed more fully later in the paper. The aim of this research is to undertake a literature review and critique the often contradictory definitions that can be found in the literature in order to compare and contrast existing food crime risk assessment (FCRA) tools and their use. The use of the term FCRA is novel and not currently used in the literature, and as such is an evolving concept. Although Elliott (2014) proposed the use of food crime prevention networks FCRA build on this as they contain 2 distinct elements as is described in this paper. First, there is the risk assessment process itself and then the development of a series of countermeasures that are embedded in a food control system at organizational or national levels. Thus, adopting Felson's approach (2006) of identifying events, sequences, and settings is helpful in developing food crime risk assessment models.The methodological approach that has been used in terms of critiquing existing academic and gray literature is of value to academics and practitioners to clarify the current contradictions in the literature and to develop a common, accepted vocabulary that is then utilized going forward in the food industry. This element of redefinition will also inform future reviews of regulatory standards and also global standards such as those developed through Codex Alimentarius and the International Standards Organization (ISO).

Table 1–Factors that can be used to assess natl. food system vulnerability (Source: Manning and others 2005).

Factors that can be used to assess national food system vulnerability
• The effectiveness of the countries food safety management infrastructure and current surveillance mechanisms.
• Availability of potential food contamination agents.
• Motivation for perpetrators of food terrorism.
• Potential for the agent to contaminate mass produced food and gain widespread distribution.
• Potential of human-to-human transmission of the agent.
• Capability for an effective emergency response.
• Potential size of the threat to the food supply chain, animal health and welfare, export food trade, tourism, and public health.

Food Defense

Food defense is the collective term used to describe activities associated with protecting the nation's food supply from deliberate or intentional acts of contamination or tampering (FDA 2014). Food defense therefore encompasses intentional contamination (perhaps better phrased as adulteration) of the food supply contrasting with the unintentional contamination that is the focus of established food safety measures (Mitenius and others 2014). The authors suggest that the concept of intentional adulteration as being separate from unintentional contamination introduces the notion of a different set of vocabulary such as perpetrator, malicious intent, and capabilities. Further, food defense has been described as the process to ensure the security of food and drink and their supply chains from all forms of intentional malicious attack including ideologically motivated attack leading to contamination or supply failure (GFSI 2013). This definition suggests that the term food defense is not only used to define national strategy toward intentional food adulteration, but also can be used at the supply chain and organizational level. Indeed, BRC (2015) considers food defense as the procedures adopted to assure the safety of raw materials and products from malicious contamination or theft. Therefore, food defense has been said to reflect the protection activities, and/or the security assurance process or procedures that deliver product safety with regard to intentional acts of adulteration. These policies, processes, and procedures will be defined in this paper as countermeasures (see the section "Food Fraud and Wider Food Crime"). Countermeasures are the means and mechanisms implemented to mitigate risk and as a phrase widely used in criminology literature.

Table 2–Types of food crime.

Type[a]	Definition[b]	Definition[a]	Definition[c]
Adulteration	The addition of an undeclared material into a food item for economic gain.	A component of the finished product is fraudulent	Product adulteration
Counterfeit		All aspects of the fraudulent product and packaging are fully replicated	
Diversion		The sale or distribution of legitimate products outside of intended markets	
Over-run		Legitimate product is made in excess of production agreements	
Simulation		Illegitimate product is designed to look like but does not exactly copy the legitimate product	
Tampering		Legitimate product and packaging are used in a fraudulent way	
Theft		Legitimate product is stolen and passed off as legitimately procured	
Malicious poisoning, bioterrorism, or sabotage		Intentional adulteration with a view to cause harm, fear, or dread using other types of food crime identified by Spink and Moyer (2013).	Food poisoning.
Misleading indications (words/pictures)[a]			Use of words such as "natural," "traditional." Use of pictures for example, depictions on packaging that do not reflect the nature of the product inside, or the methods of production.
Packaging size[a]			Use of overlarge packaging.

[a]Spink and Moyer (2013).
[b]Adapted from BRC (2015)
[c]Croall (2009)

Food defense strategies can therefore be implemented at national and local levels. The FDA (2015) has differentiated between national risk assessment models and supply chain or organizational food defense models. At national strategy level, in the United States, the CARVER+ Shock method has been adopted, where the acronym CARVER stands for: Criticality—a measure of the public health and economic impacts of an attack as a result of the batch size or network of distribution; Accessibility—the ability to gain physically access and egress where this can change over time and also as a result of the use of counter-measures; Recuperability—the ability of food system to recover from an attack; Vulnerability—the ease of accomplishing the attack. This too can change over time and as a result of the use of countermeasures; Effect—the amount of direct loss from an attack as measured by loss in production; Recognizability—the ease of identifying the target, with Shock a combined measure of the health, psychological, and collateral national economic impacts of a successful attack on the target system being the final element (FDA nd).

A vulnerability assessment (VA) tool can be developed to operate at the food facility or individual food process level. The VA tool specifically focuses on 3 elements that reflect the vulnerabilities that exist and the means for their mitigation for an organization that could potentially be under threat, namely the attributes: Criticality, Accessibility, and Vulnerability. This approach is sometimes referred to as Vulnerability Analysis Critical Control Point or VACCP. The FDA and the U.S. Dept. of Agriculture adapted CARVER+ Shock to also develop a VA software (VAS) tool that can be used at food facility or process level in order to build a food defense plan (FDA 2015). The food defense plan approach supports food business operators to develop personalized food defense plans by integrating existing FDA tools, guidance, and resources into 1 single application (FDA 2015). Therefore, a situational and premises focused food defense plan can be established to address the risk of intentional food adulteration.

Situational risk has been explored within criminology literature (Perline and Goldschmidt 2004; McGloin and others 2011). Situational risk factors, are often predictive, lie outside of the individual and include environmental factors such as corporate culture, work environment and can have a multiple compounding impact (Carson and Bull 2003; Perlite and Goldschmidt 2004) and such risk can be reduced by strengthening environmental resilience to mitigate such risk (Clapton 2014). Therefore, situational crime prevention seeks to reduce opportunities for specific categories of crime by increasing the associated risks and difficulties and reducing the rewards (Clarke 1995), so situational crime prevention in terms of deterrence of food crime and reduction of crime risk is an important consideration (Spink and Moyer 2011).

Crime vulnerability can be defined as the extent to which an individual, organization, supply chain or national food system is at risk from, or susceptible to, attack, emotional injury or physical harm, or damage from an intentional act. The WHO (2002) suggested that vulnerability should be assessed on the basis of the scientific, economic, political, and social circumstances of a country to measure the extent of the threat and to set priorities for resources. The WHO further note that vulnerability should be assessed as a multidisciplinary activity, with input from legal, intelligence, medical, scientific, economic, and political sectors (Manning and others 2005). On a national level, vulnerability may be assessed on the basis of a number of factors (Table 1). Further, the determined level of vulnerability needs to be routinely reassessed to ensure that the ranking and prioritization of risk remains appropriate and that suitable countermeasure(s) continue to be in place.

Independently, PAS 96 (2014) has been developed as a standard to underpin the threat analysis critical control point (TACCP)

Table 3–Motivation behind food fraud and food defense activities.

Types of food crime	Rational Choice Theory (Pease 2006)	Routine Activity Approach (Cohen and Felson 1979)	Social Control Theory (Hirschi 1969)	Relative Deprivation (Walklate 2007)	Game-theoretic approach (Hirschauer and Zwoll 2008)	Common sense (Walklate 2007)
Food fraud	Perpetrator weighs the costs and benefits of committing a crime and makes his or her choice. In this context, choice is governed by time, ability, and access to relevant information.Economic incentive as pull factor.	Offenders decided to commit crime according to a particular time, targeted victims, and place. Categorized into a triangular relation—a motivated offender, potential victim, and the presence or absence of a guardian. It is important in this scenario for the offender to be aware of the victim's routine.	Bound by fear of consequences. Social controls exerted by 4 types of bonds. *Attachment* level of strength or weakness of relationships between an individual and others as via relationships. The stronger the social expectation, the stronger the attachment, the more likely the individual will conform. *Commitment* that is, conformity to a particular lifestyle. The higher the level of commitment, the less likely the individual will deviate from it. *Involvement*—the time spent in conventional behavior or law abiding practices. The longer the time spent in engaging in these activities, the less time the individuals will have for other things. The final bond explains that if an individual had been brought up with the *belief* that they are law abiding citizens, the less likely they are to break the law.	Occurs when an individual feels deprived or perceive themselves as deprived. The sense of deprivation is commonly (but not exclusively) connected to material circumstances Economics/incentives as pull factor.	Reconstructs the monetary incentives of profit-oriented actors. The likelihood for these economic actors to break rules increase with the probability of profits they expect to earn and reduces if losses are anticipated due to risk of detection. At the same time, fraud activities will decrease with an increase in social factors that could "protect" or "shield" the profit-oriented actors from yielding to the economic temptation.Estimates the incentives of actors in farm or food industries. Helps to identify or expose critical settings where economic temptations may arise.	Food fraud is driven by monetary needs or gains and / or greed.
Food defense	Time, ability, and information. Motivation to do harm.	Motivated offender with a clear potential victim.	No fear of consequences.	Impact oriented.	Impact oriented.	Sadist, enjoy thrill of 'excitement' caused by the harm, revenge, envy.

approach to assessing the risk associated with such threats. PAS 96 (2014) describes TACCP as the systematic management of risk through the evaluation of threats, identification of vulnerabilities, and implementation of controls to materials and products, purchasing, processes, premises, distribution networks, and business systems by a knowledgeable and trusted team with the authority to implement changes to procedures. TACCP has been designed to interface with and build upon food safety risk management methodology such as hazard analysis critical control point (HACCP), as many precautions taken to assure the safety of food are likely to also deter or detect deliberate acts of contamination (PAS 96 2014). TACCP uses a matrix type approach to identify the likelihood of an incident occurring and how it might be mitigated through the use of appropriate countermeasures. This approach is only of value where potential threats and the risk associated with them can be assessed, so it is of little value in mitigating against emerging issues when as previously outlined the modus operandi is for the crime to continue undetected.

Food Fraud and Wider Food Crime

Most food fraud cases are not harmful, but notable exceptions include the melamine in Chinese skimmed milk powder (Gossner and others 2009), sudan dyes in spices (Stiborova and others 2002), false labeling of puffer fish as monkfish (Cohen and others 2009), and the plasticizer di(2-ethylhexyl)phthalate (DEHP) being used as a cheaper substitute of clouding agents in food and beverages (Yang and others 2013). Different types of food fraud generate various levels of monetary gains, dependent on how well the "fraud" has been carried out, and if detection occurs and form an element of wider food crime. Spink and Moyer (2011) proposed 7 types of food fraud, namely adulteration, counterfeit product, diversion of products outside of intended markets, over-run, simulation, tampering, and theft (Table 2).

Criminal attributes can also be characterized into ideological, occasional, occupational, professional, and recreational types (Spink and others 2013). PAS 96 (2014) using a different approach identifies a number of threats that need to be considered when undertaking TACCP, namely: EMA, malicious contamination, extortion, espionage, counterfeiting, and cybercrime with an associated typology for individuals that pose a threat:

(1) The extortionist.
(2) The opportunist.
(3) The extremist.
(4) The irrational individual.
(5) The disgruntled individual.

Table 4–Criminal types and attributes, risk, and typical countermeasures (adapted from Spink and others 2013).

Types of criminals	Definition	Magnitude of risk (likelihood/severity)	Typical countermeasures and controls in the food supply chain to mitigate risk
Ideological poisoning (usually single motive group or individual)	Domestic or international terrorist who commits the criminal act to make an ideological statement or to economically harm an entity, or to create panic and fear in the target population.	Magnitude will depend on the nature of the product, organization, supply chain, and/or the population targeted.	Currently the use of risk assessment by organizations to identify appropriate controls, for example, security, tamper evidence, supplier assurance.
Recreational tampering and or theft.	Undertakes crime for entertainment or amusement.	Low risk potentially mitigated by implementing appropriate countermeasures.	Traditional technical risk assessment to implement supply chain and onsite security, for example, enclosed containers, secure vehicles and containers, tamper evident seals, and so on.
Occasional diversion, tampering or theft	Infrequent, opportunistic individual.	Low risk potentially mitigated by implementing appropriate countermeasures.	Traditional technical risk assessment to implement supply chain and onsite security, for example, enclosed containers, secure vehicles and containers, tamper evident seals, and so on.
Occasional over-run	Infrequent, opportunistic individual.	Low risk potentially mitigated by implementing appropriate countermeasures.	Stock control measures and mass balance exercises to ensure that resources utilized equate to product sold legitimately on invoices, dispatch notes, etc.
Occasional adulteration (substitution), for example, product with different provenance or method of production, that is, conventional product sold as organic, different ingredients, and so on.	Infrequent, opportunistic individual.	Low risk potentially mitigated by implementing appropriate countermeasures.	This activity would be reactive and not systemic within the organization or the food supply network. Controls will be different depending on whether perpetrators are inside or outside the business and whether there is internal pressure to substitute to meet supply chain requirements, foe example order size. Measures such as stock control, mass balance exercises, internal audits, CCTV cameras may identify but risk level increases especially if adulteration cannot be identified readily by laboratory or visual analysis.
Occupational	Crime occurs at the place of employment, either as an individual acting alone or in collaboration with the modus operandi of the organization.	Magnitude of risk increases especially if individual can operate unnoticed in an organization or operates in collaboration with the organization. Potentially a degree of mitigation by implementing appropriate countermeasures unless the activity is deliberately ignored or encouraged by management.	Crime occurs at the place of employment, either lone individuals or through collaboration with the modus operandi of the organization. Perpetrators understand the controls and countermeasures in place and are able to work around them falsifying documentation if necessary.
Professional	Criminal activity fully finances their lifestyle.	Magnitude of risk increases and will depend on the nature of the product, organization, supply chain, and/or the population targeted.	Existing measures and controls in place can be vulnerable to professional criminals and their networks.

(6) The hacktivist and other cyber criminals.
(7) The professional criminal.

This extends beyond the product-orientated types of food fraud to consider wider organizational fraud associated with accounting, organizational "secrets," for example recipes, unique processing standards, and so on. When seeking to mitigate supply chain fraud, assessment activities must consider countermeasures that are implemented at the supply chain level not just at the facility level. This parallels with the procurement requirement for the adoption of prerequisite programs such as good agricultural practice by suppliers that are designed to prevent food safety issues from occurring in the 1st place rather than focusing on activities within a site-HACCP plan for detection at facility level as the predominant level of control.

Criminology and understanding of behavioral science provides a wider insight into the motivation and causation behind food crime. This research has considered the extent to which food fraud and food defense fit into these theoretical criminological frameworks (Table 3). Table 3 considers 6 crime motivation theories and shows the difference between traditional HACCP style risk assessment and the type of assessment that needs to be included in approaches such as TACCP and VACCP. Using HACCP although the cause of a food safety hazard is considered in terms how the hazard can arise in order to implement an appropriate preventive measure, the mindset of the perpetrator or the incentives to intentionally contaminate have not been explicitly addressed. Furthermore, if there is an argument that food safety, food fraud, and food defense need to be risk assessed separately, there is no requirement to include intentional food adulteration during the HACCP process. Food defense needs to consider the perpetrator, the relevance of impact, and their motivation to cause harm. Food fraud is driven by singular motivation, that is, the desire for gain, and in order to implement appropriate

Table 5–Root cause analysis of intentional food adulteration (adapted from Motarjemi and Wallace 2014).

	Food fraud	Food defense (internal employee)	Food defense (external agent)
1	Why was the fraud committed?	Why did the employee deliberately adulterate the product?	Why did the agent deliberately adulterate the product?
	Motivated for monetary gain. Deliberately modifying the food to achieve more $.	Motivated to harm or insinuate harm had been caused.	Motivated to harm, publicity, other motive
2	Why did the agent want monetary gain?	Why did the employee want to bring harm?	Why did the agent want to bring harm?
	Motivation to access money especially if perpetrator can identify a vulnerability.	Revenge, dissatisfaction, excitement in causing chaos, financial gain for example, blackmail.	Revenge, dissatisfaction, envy (competitor), excitement in causing chaos, financial gain, for example blackmail.
3	Why did the agent target this organization?	Why did the employee feel dissatisfy or resentful?	Why did the agent target this organization?
	Ability to perpetrate the crime without discovery, magnitude of financial gain compared to risk.	Unjust work-related practices, termination, and personal grudge.	Unjust business-related practices, personal grudge, ability to gain publicity due to organization's profile.
4	Why did illicit business related practices arise? What is it about the organization's profile that draws attention?	Why was the employee terminated? Why did unjust work-related practices arise in the company?	Why did unjust business-related practices arise with the company? What is it about the organization's profile that draws attention?
	In order to answer the above specific questions, the respective organization can investigate reasons for example, vulnerability to fraud, networks in which the business operates and so on.	In order to answer the above specific questions, the respective organization can investigate if the above claims are true and find ways to resolve unjust work-related practices.	In order to answer the above specific questions, the respective organization can investigate reasons, for example country of origin of organization, religious or ideological background, previous business practice that could warrant organization being seen as unjust.
5	How should the company react?	How should the company react?	How should the company react?
	Investigate the incident and identify vulnerabilities through the use of an appropriate analysis tool.	Change of keys/access number to reduce accessibility, security, and utilization of threat analysis tool.	Change of keys /access number to reduce accessibility, security and utilization of CARVER + Shock tool
6	How proactive should the company be to reduce future risk of threats.	How proactive should the company be to reduce future internal food threats?	How proactive should the company be to reduce future external food threats?
	Adopt proactive approach to improve work related practices and conditions and utilization of appropriate analysis tool.	Adopt proactive approach to improve work related practices and conditions and utilization of threat analysis tool.	Adopt proactive approach to improve work and supply chain related practices and conditions and utilization of threat analysis tool.

countermeasures, the motivational element of food fraud needs to be fully understood.

The magnitude of harm caused by intentional adulteration in terms of likelihood and severity will increase according not only to the agent used, but also if an individual can operate unnoticed in an organization or operates in collaboration with the organization. The degree of mitigation achieved by implementing appropriate countermeasures will vary by type of crime and by the commitment of the management of the organization to minimize vulnerability to crime (Table 4). Seven types of criminal are outlined in Table 4 from the ideologically motivated individual to those who see crime as a recreational activity for entertainment and amusement, occasional criminals who are opportunist and commit crime infrequently, occupational criminals who are active within their place of employment, and professional criminals who fund their lifestyle completely from criminal activity. The magnitude of risk (in terms of likelihood and severity) is considered in Table 4 and will be unique to the situation that arises. Typical

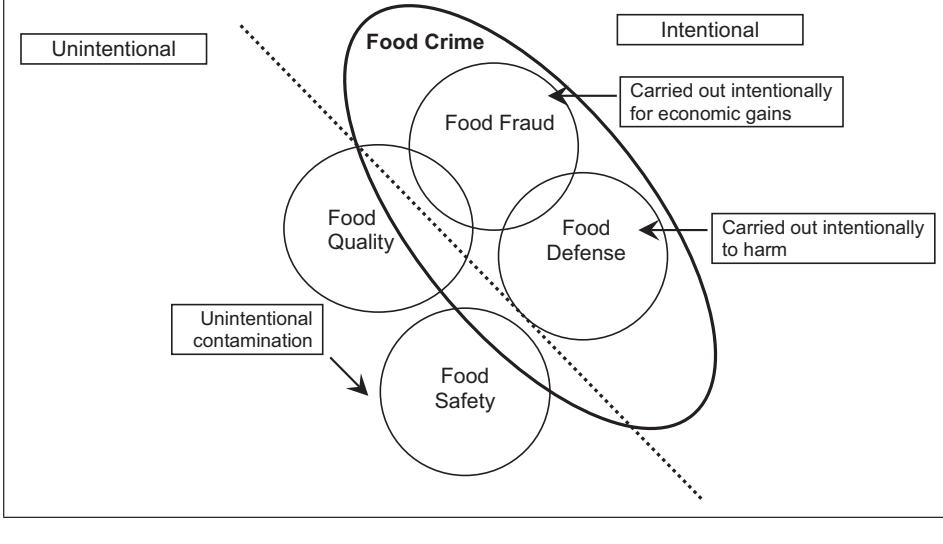

Figure 1–Intentional and unintentional modifications of food (food fraud, defense, safety, and quality) that need to be addressed in a food control system (adapted from Moyer 2011; GFSI, 2014; FSIS 2014; Leathers 2014; Spink and Moyer 2011).

countermeasures have been described for different types of criminal that need to be considered within an effective food control program.

This complexity is shown further in Table 5, and by using a slight modification of the questioning (5 Whys see Motarjemi and Wallace 2014) technique of root causes analysis, first food fraud and then food defense with regard to both internal employees and external agents and the risk of intentional food adulteration is considered. The root cause analysis demonstrates that a proactive approach to improving work and supply chain related practices and that focus on intentional adulteration, that is, countermeasures and the utilization of FCRA tools to determine vulnerability is essential in order to mitigate risk.

This argument extends as shown in Table 4 and 5 to the development of measures to mitigate risk developed as a result of using threat or vulnerability analysis tools. Mitigation measures or countermeasures are designed not only to lessen the impact, but also to make intentional contamination less likely in the 1st place (Mitenius and others 2014). Countermeasures developed to minimize food crime risk can include: the use of unique serial numbers at batch, product, or lot level; traceability through measures such as radio frequency identification devices (RFID); and features on the packaging of individual items such as special inks, holograms, and so on, in cases of product or on each pallet (Spink and others 2010). HACCP as a risk assessment tool was developed initially to consider contamination in its entirety both intentional and unintentional, a differentiation between the terms food safety and food defense would mean that this may have to be revisited especially in light of an organization using a combination of HACCP, VACCP, and TACCP as risk assessment tools. A HACCP approach considers the development of an operational prerequisite program (OPRP). An OPRP is identified within hazard analysis approaches as essential in order to control the likelihood of introducing food safety hazards and/or the contamination or proliferation of food safety hazards in the product(s) or in the processing environment (BS EN ISO 22000: 2005). Furthermore, the development of an OPRP alongside the integration within an organizational management systems of an effective portfolio of food crime countermeasures is of great importance when considering the degree of risk associated with both adulteration and unintentional contamination in a given operational situation.

The global food safety initiative (GFSI) position paper on mitigating the public health risk of food fraud (July 2014) considers the interaction of food defense, food fraud, food safety, and food quality. This approach does not clearly separate food safety, food quality, food defense, and food fraud, but this may simply be a causal result of using a Venn diagram to pictorially describe the interaction. This overlapping representation is in contrast to FSIS (2014) and the FAO Assuring Food Safety and Quality: Guidelines for Strengthening National Food Control Systems publication (2003:3), which states that:

"Food safety refers to all those hazards, whether chronic or acute, that may make food injurious to the health of the consumer. It is not negotiable. Quality includes all other attributes that influence a product's value to the consumer."

The FAO (2003) publication places particular importance on the fact that the clear distinction between food safety and food quality and that this has public policy implications and also implications for the development of organizational management systems. Thus, this separating of terminology can be extended to the organizational development of food safety, food defense, and food quality plans, and determining their purpose in terms of what factors they are seeking to control. Therefore, the 4 elements of a food control system, otherwise determined as the 4 elements of food protection (see Spink and Moyer 2011), can be described as follows:

(1) Food defense—ideologically motivated intentional adulteration that makes the food injurious to health.
(2) Food fraud—economically motivated intentional adulteration that may or may not make the food injurious to health. Thus, some food fraud issues may overlap with the definition of food defense whilst others may be a food quality issue.

Unintentional	Intentional	Motivation
Food Quality	**Food Fraud**	**Economic gain**
Food Safety	**Food Defense**	**Harm**

Figure 2–The food protection risk matrix (adapted from Spink and Moyer 2011).

High profit: high likelihood of detection Medium food fraud risk	**High profit: low likelihood of detection High food fraud risk**
Low profit: high likelihood of detection Low food fraud risk	**Low profit: low likelihood of detection Low food fraud risk**

Figure 3–Food fraud quadrant model (adapted from NSF 2015).

(3) Food safety—unintentional contamination of food that makes the food injurious to health.
(4) Food quality—delivery of attributes that influence a product's value to consumers.

These definitions have been drawn together visually (Figure 1). This approach differs from (i) that of Spink and Moyer (2011), where they identified the 4 elements described above as being distinct, that is, no food fraud overlap between food quality and food safety (see Figure 2) and (ii) that of GFSI (2014), where all 4 terms are seen as overlapping.

The rationale for determining the 4 elements food safety, food defense, food fraud, and food quality, as highlighted in this research, is important when developing either a national or an organizational food control system.

Approaches to Developing Independent Food Crime Risk Assessment (FCRA)

Increasingly, there is a requirement to consider a more holistic approach that encompasses not only scientific criteria, but also aspects of social science in order to risk assess adulteration. Six of the existing FCRA models have been compared (Table 6) in terms of their aims, mechanisms of operation, and practicalities of use. Table 6 highlights the value of each model in different situations. The ability to actually quantify the likelihood of a threat or vulnerability in a given situation is in many ways influenced by the degree of adoption of countermeasures and their effectiveness.

The standard BS EN ISO 31000: 2009—Risk management: principles and guidance provides principles, framework, and a process for managing risk. The standard defines uncertainty (or lack of certainty) as a state or condition that involves a deficiency of information and leads to inadequate or incomplete knowledge or understanding. In the context of risk management, uncertainty exists whenever the knowledge or understanding of an event, consequence, or likelihood is inadequate or incomplete. Once determined, BS EN ISO 31000: 2009 provides a hierarchy of how risk should be dealt with:

(1) avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk;
(2) accepting or increasing the risk in order to pursue an opportunity;
(3) removing the risk source;
(4) changing the likelihood;
(5) changing the consequences;
(6) sharing the risk with another party or parties (including contracts and risk financing); and
(7) retaining the risk by informed decision.

HACCP too develops a hierarchy for assessing and mitigating food safety risk (CAC 2003), the so-called 7 principles of HACCP:

PRINCIPLE 1 Conduct a hazard analysis.
PRINCIPLE 2 Determine the Critical Control Points (CCPs).
PRINCIPLE 3 Establish critical limit(s).
PRINCIPLE 4 Establish a system to monitor control of the CCP.
PRINCIPLE 5 Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.
PRINCIPLE 6 Establish procedures for verification to confirm that the HACCP system is working effectively.
PRINCIPLE 7 Establish documentation concerning all procedures and records appropriate to these principles and their application

To develop a food safety control system, CCPs are identified using qualitative, semiquantitative, or quantitative means of assessment. Matrices, scoring systems, and decision trees are commonly used to identify specific CCPs and mechanisms to eliminate or reduce risk to an acceptable level. The degree of uncertainty is difficult to determine absolutely, so semiquantitative mechanisms are often used. This approach is also favored with TACCP to determine threats and vulnerabilities. The TACCP approach considers the following questions (PAS 96 2014):

(1) Who might want to attack us?
(2) How might they do it?
(3) Where are we vulnerable?
(4) How can we stop them?

The threat assessment uses a similar semiquantitative matrix approach, but despite the name CCPs are not identified as TACCP is more of a threat prioritization system based on the presence or absence of appropriate countermeasures. The Carver+ Shock or CAV approach of VACCP again uses a semiquantitative scoring approach through a scoring system without defining CCPs specifically. Marsh (2015) suggests that VACCP and TACCP must be undertaken simultaneously, so an organization can have a clear picture of both threats and vulnerabilities. Instead of using CCPs, Marsh (2015) decided to use Vulnerability and Threat Points (VTP) as a mechanism for prioritizing risk. In another approach, the NSF Fraud Protection Model can be used to assist organizations to "think like a criminal"—particularly in assessing vulnerability from the perspective of what is advantageous to the fraudster (NSF 2015). Hence, the model was based on the assumption that fraudsters tend to target food products of higher value where the adulteration is difficult to detect. This can be used to create a hierarchy of low medium and high food fraud risk scenarios (Figure 3).

Six models have been analyzed TACCP, VACCP, the food protection risk matrix (Spink and Moyer, 2011), the food fraud model (NSF 2014), the USP Preventive Food Fraud Management System, and the CARVER + Shock Tool (FDA 2014). The mechanisms employed are ones of semiquantitative risk assessment using prioritization matrices or weighted scoring systems. This approach is often weakened by the degree of uncertainty as to the exact nature of the threat and its likelihood of occurrence. This means that "unknown" threats cannot be mitigated using this approach alone. The most important element of FCRA is the development of a holistic hierarchy (adapted from BS EN ISO 31000: 2009) of how risk should be mitigated:

(1) Avoiding the risk by ceasing activity or removing the source (only of value with risks that can be quantified).
(2) Avoiding the risk by not commencing the activity (only of value with risks that can be quantified).
(3) Reducing the risk by implementing countermeasures to reduce the likelihood of occurrence (this approach can address both known and unknown threats where they are controlled by the same countermeasure).
(4) Sharing the risk with another party or parties including contracts, insurance, and risk financing—again this of limited value if a threat and its potential impact cannot be quantified.

Table 6–Comparison of existing FCRA models.

	Threat assessment critical control point (TACCP)	Vulnerability assessment and critical control point (VACCP)	Food protection risk matrix (Spink and Moyer 2011)	NSF fraud protection model (NSF, 2014)	USP preventive food fraud management system (USP nd)	CARVER + shock tool (US FDA)
Aims	To assess threats and prevent behaviorally or ideologically motivated intentional adulteration (Leathers 2014).	To assess how exposed/susceptible organization or premise is to food fraud incidents. Prevention of intentional EMA.	To differentiate food fraud among other food control elements such as food safety, food defense, and food quality.	To better anticipate the likelihood of fraudulent attack on food products especially according to product value.	To assist users in how to develop and implement a preventive system specifically for the adulteration of food ingredients.	Allows user to think like an attacker and to determine the most vulnerable point within a system or premise to an attack. To focus resources on protecting the most susceptible points in the system.
Mechanisms	Qualitative assessments (likelihood × impact) of threats	Qualitative assessments (likelihood × impact) of threats	Risk matrix is designed to identify the cause of risk and the motivations driving the fraud but not the effect.	Built on a 4 quadrant Boston Consulting Group (BCG) matrix. -Top right = products most attractive to fraudster -Bottom left = least attractive to fraudster -Size of circle of a food product represents the perceived difficulty of conducting the fraud.	Structured approach to characterize food fraud vulnerabilities with associated guidance to develop mitigation strategies. Nine contributing factors considered and how they impact on vulnerability using a matrix approach. Lifecycle approach proposed for food fraud management.	Based on 7 attributes which are scored on a scale of 1 to10 (FDA 2014) • Criticality—measure of public health and economic impacts of an attack. • Accessibility—ability to physically access and egress from target. • Recuperability—ability of system to recover from an attack. • Vulnerability—ease of accomplishing attack. • Effect—amount of direct loss from an attack as measured by loss in production. • Recognizability—ease of identifying target. • Shock—combined health, economic, and psychological impacts of an attack. Provides relative risk rankings for nodes/process steps in a production process or national food system.

[a]

(Continued)

Table 6–Continued.

	Threat assessment critical control point (TACCP)	Vulnerability assessment and critical control point (VACCP)	Food protection risk matrix (Spink and Moyer 2011)	NSF fraud protection model (NSF, 2014)	USP preventive food fraud management system (USP nd)	CARVER + shock tool (US FDA)
Practicalities	Likelihood and impact scores and use of priority matrix in TACCP provides hierarchy for action by risk for organizations. Assess threats within manufacturing environment or within an organization but will be difficult to assess suppliers that is, prior to delivery (Marsh 2015).	Can be used in the wider supply chain.	The 4 quadrants in the matrix assist in exploring criteria. Food quality – may be caused by mishandling. Food safety – may be caused by unintentional contamination. Food fraud – intentionally done to increase profit margin. Food defense – deliberately carried out to cause harm (Spink and Moyer 2011).	Food industries and regulatory teams can use the model to anticipate which products are most likely to be targeted by fraudsters, the factors for targeting, and whether previous frauds had occurred.	Four step process. First 3 characterize fraud vulnerabilities associated with an ingredient by considering occurrence and impact. Last step is guidance.	Critical or vulnerable nodes/process steps are identified based on the scores. Prioritize mitigation measures and resources to reduce likelihood of attack. Another option in CARVER + Shock would be to only use the Criticality, Accessibility and Vulnerability (CAV) scores and facility or process line level.
Suggestions / Extensions	To assess both threats and vulnerabilities and combined under one system. Combine threat and vulnerability assessment and manage risk under one management system.					

(5) Retaining the risk or accepting the level of risk by informed management decision with the associated monitoring and verification activities.

In many cases, there is a requirement at national or organizational level for informed decision making with regard to degree of risk that is also centered on the balance between cost and benefit derived, which is often difficult to determine in the case of unknown or unquantified threat.

Conclusion

The aim of this research is to undertake a literature review and critique the definitions that can be found in the literature in order to compare and contrast existing FCRA models and their application. Figure 1 has been developed to demonstrate the clear distinction between food safety, food quality, and food defense, and the overlapping nature of food fraud incidents depending on whether the intentional criminal activity has the potential to cause harm or impact on product quality. It is important to recognize, as with the Jenson Brothers case study described in this paper, that in certain circumstances a food safety incident albeit that the consequences that prevailed could be deemed as unintentional can still be determined as a criminal offense and thus those held responsible face prosecution. This figure builds on existing literature by clearly differentiating what is and is not included in terms of threat, or as in food safety defined as a food safety hazard, that is, the cause and then how the effect before and after countermeasures have been implemented is quantified when undertaking a VACCP, TACCP, or HACCP assessment. The challenge is that the distinction between a potential threat (hazard) and the consequences (effect) should it arise, and the difference between adulteration and unintentional contamination of food and thus the associated countermeasures that should be adopted, is not always fully appreciated by individuals at the facility level who are involved in developing an overarching food protection/control system. This is an organizational weakness that can then lead to the implementation of an adequate food protection/control system, which is of little value to the organization in mitigating threat. Intentional food crime is plural in nature in terms of the types of crime and the differing levels of financial gain. This can also be said in terms of the multiplicity of definitions of food safety, food defense, food fraud, and food quality found in both academic and gray literature. This plurality creates confusion and multiple interpretations when FCRA is adopted and implemented. In further iterations of regulations, standards, and industry protocols, increasing harmonization will benefit the industry in developing cohesive food protection/control programs that address all 4 elements described in this paper and clearly differentiate between contamination and adulteration. Successful modes of food crime are dependent on how well the crime has been carried out and at what point, or even if, detection actually occurs. BS EN ISO 31000: 2009 provides a hierarchy of how risk should be dealt with including avoiding, accepting or retaining risk. Appropriate countermeasures should be adopted as a result of the use of an FCRA model and reassessment to either remove the risk source; change the likelihood of the risk or the consequences should it occur, sharing, or spreading the risk or retaining but monitoring the risk on an ongoing basis. Further research is therefore required to support the development of global countermeasures over and above the critique in Table 4. A framework of countermeasures that are developed in consort with FCRA activities is of value to any organization as has been demonstrated with the development of OPRP to address potential hazards and mitigate food safety risk at facility and supply chain levels.

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