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SHORT SUMMARY ON FOOD DEFENSE

Food terrorism is defined by the WHO (2002) as: "an act of threat of deliberate contamination of food for human consumption with chemical, biological or radionuclear agents for the purpose of causing injury or death to civilian populations and/or disruption of social, economic or political stability". In this context "food" includes crops, farm animals, minimally processed and processed foods and water (whether for drinking, use as a food ingredient or for use in food processing). By extension, so-called "eco-terrorism" covers the ideologically-motivated destruction of crops or animals and associated research facilities.

All societies are crucially dependent upon the food supply, therefore, its disruption is an obvious prime target for terrorism.

Although explosive devices have been the favorite tool of environmental, animal rights and political terrorists to date, a number of different materials have been used to contaminate consumer goods, foods, and drugs across the world. The deliberate introduction of plant or animal diseases could also cause widespread disruption of the food supply.

Responding to Acts of Terrorism against the Food Supply
Responses to terrorist acts may be divided into three categories. The first, is directed towards the immediate treatment of those affected; the second, involves a criminal investigation and apprehension of the perpetrators; and the third, minimizing casualties through the recall of the suspect product(s); the detection of the causative agent or its vector, and limiting the spread of the contamination. Governmental and private sector planning activities must focus on response measures and the development of preventive measures to protect product, facilities and members of the community as well as traceability measures for tracking and recovering affected materials.

Effective Food Contaminants

Biological materials and chemicals are the most likely agents for food contamination. There are several toxins could be easily dispersed into a food, would survive a conventional thermal process used in food processing, and are stable under acidic conditions. Many of these are difficult to isolate and detect in a complex food matrix or take a long time to recover and identify. An agent that would impart little change to the sensory properties of a food so neither food sellers nor consumers would be suspicious that the food had been contaminated would pose the greatest risk. The most effective ones would be potent and easy to conceal. Despite governmental efforts to study more exotic materials, the most likely agents for a food contamination event remain common industrial chemicals and microbes with which the food industry and public health professionals are familiar.

To be effective, a small amount of contaminated product should be sufficient to harm large populations and/or cause injury or damage over a broad geographic region; this is potentially the greatest risk to agriculture through introduction of a crop or animal disease. The contagious nature of some disease causing microorganisms makes it possible for one infected individual to continue to spread the disease to others depending upon the agent used. One of the most worrisome food defense scenarios is a surreptitious attack with an agent that produces symptoms that are easy to misdiagnose. In this situation,

the first responders are likely to be health professionals rather than law enforcement or other traditional first responders. Under such a scenario, a terrorist-induced epidemic could go unrecognized and undiagnosed for a significant period of time, delaying treatment and other control efforts for containment and quarantine. The effectiveness of a possible agent can be based on the following factors:

1. Potential impact to human, animal or plant health,
2. The type of food material contaminated,
3. Ease of detecting contamination of the food through discernible changes in appearance, odor or flavor,
4. The point in the food supply chain where the contamination was introduced,
5. The potential for widespread contamination and
6. The fear people would have from the use of the contaminant or the particular food to spread illness or disease.

Food Materials and Products at Greatest Risk

A wide variety of food products are at risk including those that are perishable, ready-to-eat, and frequently consumed. They have a rapid turn around time and which would be consumed before detecting the hazard. Also at high risk are foods or food ingredients prepared in large batches into which a toxic agent could be dispersed throughout a large quantity of material (including via water), and then into numerous servings of a wide variety of products. Because food is distributed rapidly, often over great distances, and to large populations in different locations, this creates a potential for widespread impact. The efficiency of food distribution could make it difficult to mount an appropriate response because the public health impact would occur within a matter of hours or days. The systems in place for producing and distributing food also create opportunities for intentional contamination (USDA, 2003). Food and agriculture products are commonly accessible at some point during growing, harvesting, processing, storage and distribution. The unit operations involved in food production such as mixing, incorporation of minor components, dilution, or size reduction could spread a toxic material throughout a large batch or into numerous batches of product. Spreading contamination throughout a facility also poses a food safety as well as an occupational hazard and would result in a facility being taken out of service until it could be decontaminated.

Risk Assessment

Developing a model for risk assessment for a terrorist act against the food supply should consider first the *ability* of a terrorist to carry out an attack, the *intent* of the terrorist to execute an attack, and the *opportunity* to conduct an attack. This creates a *threat*. *Risk* is the threat coupled with vulnerability. *Vulnerability* is the accessibility of the targeted food or food production operation to attack. Regardless of the scenario, the role of the food industry remains reducing the opportunity for an attack.

The concepts and principles of HACCP or Hazard Analysis Critical Control Point programs commonly used for food safety risk assessment are also useful for addressing food defense concerns and have been promoted as a reasonable model by the World Health Organization and numerous other experts. HACCP is familiar to both industry and regulators making programs based upon it relatively easy to implement. However, caution must be exercised since vulnerabilities could exist at locations immediately after terminal Critical Control Points (CCP's) within conventional HACCP programs. Food defense components can also be incorporated into ISO 22000 food safety or ISO 9001 quality management systems. HACCP in a food defense context involves development and implementation of preventive measures to reduce the risk of intentional contamination of a food product prior to receipt, within a food facility, and during its distribution. An effective food defense plan would be built upon a foundation that integrates an already effective HACCP plan with the security and food safety aspects of good manufacturing (GMP) and good agricultural (GAP) practices, a workable and effective sanitation standard operating procedure, food traceability, and an up-to-date product recall program. A food defense plan would have to be compatible with these programs regardless of the model used to develop it.

Other common risk assessment models, specifically Operational Risk Management (ORM) and CARVER (see below) use both objective and subjective criteria to determine whether intentional contamination would be *reasonably likely to occur* at any particular point in an operation and whether a *preventive*

measure could be instituted at this point to prevent or eliminate the risk, or reduce it to an acceptable level. Critical control points (known as critical nodes in CARVER-shock) denote points in a process that present a high risk for food contamination. Critical limits are set at each of these nodes to control the risk. A monitoring system is instituted for the critical control points or nodes, and corrective actions developed to "fix" an underlying food defense problem if a critical limit is not met and control is lost. A confidential records system and verification program should also be established as part of a food defense program. Reevaluation of the plan should occur when there has been a change in production practices, logistics, shipping or distribution, suppliers, or employee practices, which may alter how a product could be intentionally contaminated.

A detailed account of factors involved in ORM for the food industry is given at http://foodsafety.cas.psu.edu/Food_Safety_and_Security.pdf

A number of risk assessment models have been created that use more formalized scales or ratings than HACCP to characterize risks. One of the most useful is 'Risk Ranger' which uses a simple statistical risk calculation to aid in determining relative risks from different products, pathogens, and processing combinations (www.foodsafetycentre.com.au/riskranger.html). Risk Ranger uses a generic robust model to rate risks from negligible to extremely high.

ORM models use scales and ratings to categorize different risks. The major advantage of an ORM approach is pragmatism - to accept no unnecessary risk and to make risk control decisions at the most appropriate level. The problem with ORM is that the risk characterization may be based upon assumptions that are not valid. The conventional matrix developed for ORM is considered by many to be overly simplistic for business use (Ryan, 2005) and use of traditional ORM does not permit an organization to assign either an unknown likelihood or an unknown severity to a particular risk (Rasco and Bledsoe, 2005). Despite these flaws, ORM has proven to be a reasonable model for simple operations and has been promoted for use in food service operations. When subjective analysis can be overlaid with reliable scientific information, the model is useful. A modification of the conventional ORM model is presented in Table 1 to make it more appropriate for risk assessments in the food industry.

Table 1. An Operational Risk Management Matrix for Food Defense

		PROBABILITY					
		Frequent-A	**Likely-B**	**Occasional -C**	**Seldom-D**	**Unlikely- E**	**Unknown- F**
SEVERITY							
Catastrophic	I	Extremely high	Extremely high	High	High	Medium	Unknown
Critical	II	Extremely high	High	High	Medium	Low	Unknown
Moderate	III	High	Medium	Medium	Low	Low	Unknown
Negligible	IV	Medium	Low	Low	Low	Low	Unknown
Unknown	V	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Implementation of ORM is similar to HACCP and involves the following steps: 1) identify the hazards, 2) assess the risk, 3) analyze possible risk control measures, 4) make control decisions, 5) implement risk controls (this would include monitoring) and 6) supervise and review the ORM plan for effectiveness. There are a number of risk control options for an ORM based model. *Reducing the hazard* require systems and operations to be designed to function to minimize risk through the incorporation of preventive measures, the addition of safety and monitoring and warning devices, verifying hazard control programs, and conducting training and exercises. *Rejecting the product or refusing* to take a risk may also be an appropriate strategy if the overall cost of the risk exceeds its benefits to the business or operation. Another alternative is to avoid the risk altogether *by canceling* a job, unit operation or production or sale of a specific product. *Delaying* the risk is another possibility if timing is not critical to the operation or if removing a particular product from the market for a short period when the perceived risk level is high is an option, for example replacing a self-serve deli or salad line with prepackaged items. Also it may be possible to *transfer* the risk to others by forming a cooperative or through insurance coverage, if this is available, to reduce the overall impact of a loss if one should occur. *Spreading* the risk is often possible by increasing the exposure distance, spreading deliveries across a longer time interval,

and by selecting multiple suppliers and carriers. *Compensating* for a risk is also a common methods to control risk and involves creating redundant capacity and backup systems for critical equipment, materials, staff and logistical support.

CARVER + Shock is based upon an offensive targeting prioritization tool to assess vulnerabilities within a food system or its supporting infrastructure to an attack. It requires an individual to think like an attacker by identifying the most attractive targets. In theory, the most vulnerable points within the infrastructure can be determined, and then resources can be focused to protect these points. The major advantages are not the precision but the identification of nodes that are vulnerable and then ranking those nodes within a specific facility to minimize or eliminate the most significant vulnerabilities. The most useful feature as well as the greatest flaw with CARVER models is that it is based upon the perspective of the attacker and not on intrinsic vulnerabilities of a facility, the inherent risks of a particular food product, or the characteristics or behaviors of the consuming population. CARVER covers the risk assessment component *only*, so from there on, either a HACCP or ORM based implementation plan would have to be devised.

- For CARVER to be useful, one has to know who the attacker is likely to be. In practice, most food facilities using CARVER consider two types of a generic attacker, a politically motivated 'outsider', and a disgruntled 'insider,' and conduct the analysis using both of these scenarios. A new type of attack should also be considered as part of a CARVER analysis, and that is a conspiracy between an 'insider' and one or more 'outsiders'.

The acronym CARVER+Shock stands for:

- **Criticality** – considers the public health and economic impacts of a successful attack.
- **Accessibility –** relates to the attacker's physical access to the target. The target is accessible when the attacker has sufficient resources along with the physical ability to reach a specific location and achieve the desired effect.
- **Recognizability** – is the ease of identifying a target and is more significant for 'outside' attackers.
- **Vulnerability** – evaluates whether the attacker has the means and resources to accomplish an attack with the desired effect, and the ease of accomplishing the attack.
- **Effect**— relates to the actual, direct and immediate impact of an attack. The effect of an attack includes impact to public health and financial losses (*e.g. product* losses, physical damage to assets, cost for repair, rebuilding and decontamination, costs to return workforce to normal levels, and contract and liability losses).
- **Recuperability** – is the ability to recover from an attack financially and emotionally and to rebuild the physical assets and customer base for the business.
- **Shock** – are the psychological effects of an attack and incorporates both the short and long-term behavioral changes that may be precipitated by an attack. Attacking a significant or well-known target, a target with broad geographic scope, or a target with high emotional impact such as a food product for young children, would add to the shock value. Some attackers may take advantage of the cascading effect throughout the food supply chain by understanding the broad ranging impact that an attack on a key food product may have across the population or over a long period of time.

A series of five point scales have been added to each of the factors in the CARVER model in an attempt to quantify a particular risk. Again, as with ORM, CARVER contains the flaw that it fails to provide an option of notating that any of the listed factors is 'unknown'. This is often the case and is an important determination to make if an accurate assessment of vulnerability is to be made. Scales may be useful in some cases, such as an evaluation of an entire food supply chain, the agricultural economy of a small nation, or the risk posed to a multinational company, but would be of little use to small or medium size food business. Also problematic are the assumptions used to generate these scales. In the USA, FDA has sponsored development of CARVER + Shock software that can be downloaded. Having on-line CARVER + Shock software allows any member of the food processing industry to conduct a vulnerability assessment of their facilities and processes in a confidential manner (http://www.cfsan.fda.gov/~dms/vltcarv.html).

Addressing a Hoax

Accessibility to a specific type of attack, the method of the attack, and controls in place to deter such an attack, are all critical to determine if an incident is a hoax. Here a vulnerability assessment in conjunction with a security analysis can be used to determine exposure and evaluate weaknesses within a business operation. Questions to ask are:

"Could the attacker reach the product without detection?"

"Could an attacker bring enough material through the conventional security infrastructure at the facility?",

"Could an attacker introduce enough material at a point in the process to successfully contaminate the product at levels high enough to cause harm without this action being detected?,"

"Could the contaminant be detectable in the product by a simple testing?"

Having appropriate detection and mitigation strategies in place are important. A company must be able to tell law enforcement, government regulators, and the media, that enough barriers were established within the operation to deter the alleged attack and that these barriers could not have been breached without detection. In the case of a hoax, a company must be able to say, with certainty, that the contamination did not happen, making a statement that it is likely that it did not happen is not good enough anymore (Ryan 2005).

Mitigation Strategies

The basic tenets of threat assessment take into consideration the value of the asset to be attacked, the vulnerability of the asset, the likelihood of an attack and the intent and capability of the attacker. Food businesses face the task of reducing the capability and likelihood of an attack by addressing foreseeable risks and developing effective and efficient means to reduce the risk and can be implemented within a facility. One workable and simplified food defense awareness program is called ALERT. This pneumonic identifies the key five food defense points and stands for: **A**ssure **L**ook **E**mployees **R**eport and **T**hreat. Detailed mitigation strategies that may be useful in a food processing operation are set out in http://www.cfsan.fda.gov/~dms/alerttoc.html

Conclusion

Food and agriculture are part of the critical infrastructure in every country in the world and it behooves everyone involved in these sectors to support the establishment of a coordinated strategy at the regional and national level to protect the food supply by conducting reasonable risk assessments and developing realistic defensive strategies (Goodman, 2006) to address the risk of intentional contamination. Food has been targeted in the past, and is a relatively soft target. Recent developments in food defense include more sophisticated models for risk assessment with the current focus on devising protective measures to ensure a safe food supply. As part of this, the food industry needs to have the support of governments at all levels to support the implementation of realistic and workable food defense programs without the imposition of additional regulatory burden, cost, or impediments to trade. The role of governmental entities remains to ensure that response efforts are rapid, and coordinated in such as way to protect public health, and that avoid confusion and unnecessary duplication of effort. It remains our hope that large-scale intentional contamination incident involving the food supply will not occur, but if this should happen that we shall be prepared to respond and limit its impact.

References

Goodman, T. 2006. Connecting food safety and food security. Presentation to the Association of Food and Drug Officials. Public Health Administration and Food Security Specialist. Division of Food Protection, Indiana State Department of Health.

Rasco, B.A. and Bledsoe, G.E. 2005. *Bioterrorism and Food Safety*. Boca Raton, FL. pp. 1-32.

Ryan, R. 2005. Risk assessment to drive research on contaminant detection. *Proceedings of the Institute of Food Technologist's First Annual Food Protection and Defense Research Conference.* Nov. 3-4, 2005. www.ift.org.

USDA, 2003. *FSIS Safety and Security Guidelines for the Transportation and Distribution of Meat, Poultry, and Egg Products,* Washington DC, August.

WHO. 2002. Food Safety Issues. Terrorist Threats to Food. Guidance for Establishing and Strengthening Prevention and Response Systems. World Health Organization, Food Safety Department, Geneva, Switzerland.

Recommended Websites relating to Food Defense

American Institute of Baking (AIB), food security audits,
https://www.aibonline.org/auditservices/foodsafety/foodsecurityaudits/

Biological and Toxin Weapons Threat to the United States
http://www.nipp.org/Adobe/Toxin%Weapons2.pdf

Canadian Food Inspection Agency, http://www.inspection.gc.ca/english/toce.shtml

Countering Bioterrorism and Other Threats to the Food Supply (Food Safety.gov)
http://www.foodsafety.gov/~fsg/bioterr.html

Disaster Response, http://www.fmi.org/foodsafety/disaster.htm

Early Warning Systems for Hazardous Biological Agents in Potable Water,
http://ehp.niehs.nih.gov/realfiles/docs/2000

European Food Safety Authority, http://www.efsa.europa.eu/en.html

European Union, food safety, http://europa.eu/pol/food/index_en.htm

FEMA (terrorism), http:\\www.fema.gov/hazard/terrorism
Food and Agriculture Organization,
Food safety, risk management, http://www.fao.org/docrep/meeting/008/ae339e.htm

Food Marketing Institute, http://www.fmi.org/foodsafety/bio security.htm

Food Products Association (FPA), http://www.fpa-food.org

Food Safety Commission (Japan), http://www.fsc.go.jp/english/index.html

Food Standards Agency (United Kingdom), food safety and hygiene, http://www.food.gov.uk/safereating/

National Restaurant Association Educational Foundation, Food Security,
http://www.nraef.org/foodsecurity/

Office of Hazardous Materials Safety (HAZMAT)

Transporting Anthrax/contaminated materials,
http://hazmat.dot.gov/training/mgmt/guide_anthrax.htm

Transporting infectious substances, http://hazmat.dot.gov/training/mgmt/InfectSubstances.pdf

Risk Ranger (Australia) www.foodsafetycentre.com.au/riskranger.htm

Terrorist threats to food, guidance, http://www.who.int/foodsafety/publications/general/en/terrorist.pdf

US Agency for Toxic Substances and Disease Registry (ATSDR), http://www.atsdr.cdc.gov

US Center for Disease Control (CDC) (lists biological and chemical agents), http://www.bt.cdc.ov

US Federal Emergency Management Agency (FEMA), http://www.fema.gov

US Food and Drug Administration: Food Defense and Terrorism, http://www.cfsan.fda.gov/~dms/fsterr.html

- ALERT, http://www.cgfsan.fda.gov/~dms.alsert.html
- Bioterrorism Act (2002), http://www.fda.gov/oc/bioterrorism./bioact.html
- CVM and Counterterrorism, http://www.fda.gov/cvm/counterror.htm
- Guidance, http://www.cfsan.fda.gov/~dms/fsbtact.html
- Risk Assessment, http://www.csfan.fda.gov/~/rabtac.html
- ORM http://foodsafety.cas.psu.edu/Food_Safety_and_Security.pdf
- CARVER +Shock http://www.cfsan.fda.gov/~dms/vltcarv.html

US Homeland Security, http://www.dhs.gov/xprepresp/

US National Center for Food Protection and Defense, http://www.start.umd.edu/

US National Center for Foreign Animal and Zoonotic Disease Defense, http://fazd.tamu.edu

USDA/FSIS/APHIS

- FSIS directives, http://www.fsis.usda.gov/Regulations_&_Policies/index.asp
- FSIS Food defense and emergency response, http://www.fsis.usda.gov/Food_Defense_&_Emergency_Response/index.asp
- FSIS Industry Self-Assessment Checklist for Food Security, http://www.fsis.usda.gov/pdf/self_assessment_checklist_food_security.pdf
- Guidance for security practices in transporting agricultural and food commodities, http://www.usda.gov/homelandsecurity/aftcsecurguidfinal.pdf
- FNS-Biosecurity/school food service, http://healthymeals.nal.usda.gov

WHO, http://www.euro.who.int/foodsafety

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