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Supplemental Section

Science and Technology Based Countermeasures to Foodborne Terrorism†: Introduction

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Since the beginning of civilization, nations have endeavored to assure their citizenry of an abundant, nutritious, and wholesome food supply. Historically, governmental food protection efforts have been directed against spoilage, accidental contamination, improper processing or handling, economic fraud, and the addition of unsafe agents. Food was assumed to be an unlikely terror target and remained largely unprotected from intentional contamination. However, current terrorist tactics have shifted our attention to protection of food from that risk. As a consequence, defense of the food supply—from intentional tampering, counterfeiting, or major attack—has now become a worldwide concern for the 21st century.

Global efforts to protect food products require a multilateral and multifaceted approach. Concerned governments, companies, and academic institutions are increasing efforts to evaluate, develop, and implement counterterrorism measures spanning the entire food chain. To realize this essential goal, research is needed to develop and deploy technologies that minimize the likelihood and reduce the scope of an attack against the food supply and permit rapid recovery from such an attack.

The 8 articles that follow were derived from a workshop entitled Science and Technology Based Countermeasures to Foodborne Terrorism, which was held 29 June to 3 July 2003 in Shepherdstown, W.Va. The workshop focused on technology-based efforts with potential to predict, prevent, detect, and minimize the health and environmental impacts of terrorist attacks throughout the food chain, from production to consumption.

Conference objectives were to (i) provide a forum to discuss the current state of knowledge associated with foodborne terrorism, including threat assessment methods, analytical methods of detection, track, trace, authentication, and antitampering technologies, and hazard mitigation; (ii) identify research needs to develop effective science- and technology-based countermeasures; and (iii) foster collaborative ties to advance the scientific and technological basis for threat reduction.

A high level of interest was indicated by over 100 attendees representing industry, government, and academia from Canada, Israel, the United Kingdom, New Zealand, Switzerland, and the United States.

The opening session, entitled ''Perspectives,'' included presentations from government (U.S. Department of Agriculture, U.S. Food and Drug Administration, U.S. Environmental Protection Agency, Israel Ministry of Agriculture, United Kingdom Food Standards Agency, and World Health Organization of the United Nations) and industry (National Food Processors Association). Speakers indicated an acute awareness of the potential for terrorist attacks on the food supply. The societal impact of such an event could be scaled from minor to catastrophic and could result in public health, economic, and psychological consequences. Multifaceted actions and programs are being developed and implemented to prevent, deter, and respond to potential attacks. They consist of (i) increased awareness; (ii) enhanced laboratory capability and capacity, including development of new analytical methods and laboratory networks; (iii) better emergency response plans; (iv) evaluation of advanced tracing, tracking, antitampering, and authentication technologies; (v) better constituent and customer communication and guidance; (vi) increased inspections, examinations, or audits; (vii) enhanced surveillance programs; (viii) more training for personnel engaged in food security activities; (ix) development of backup systems (should primary systems fail); (x) development of appropriately scaled responses to terrorist threats; (xi) recovery plans (should a terrorist event occur) designed to minimize disruption to everyday life; and (xii) new medical treatments.

Five technical sessions followed during the 3-day meeting and were entitled ''Threat Assessment Models,'' ''Microbiological Sampling and Detection Methodologies,'' ''Technologies for Tracking, Authentication, and Antitampering,'' ''Chemical and Nuclear Sampling and Detection Methodologies,'' and ''Hazard Mitigation Technologies.'' Summaries of each follow.

Threat assessment models. Science-based models to assess threats from intentional contamination are being developed that include specific foods, threat agents, and high-potential points of contamination in the food chain. Models can be used to rank the likelihood and severity of threat,

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which can allow policy makers to develop a systematic approach to addressing risks. Probabilistic risk assessment techniques can be used to predict the likely public health consequences, should an event occur (see Elad, p. 1302; Stark, p. 1285).

Microbiological, chemical, and nuclear sampling and detection methodologies. These two sessions provided overviews of techniques and technologies in various phases of development for use in detection and characterization of potential threat agents (see Bennett, p. 1264; Sharma and Whiting, p. 1256). Sampling plans are typically more limiting than the analytical method (see Whitaker and Johansson, p. 1306). For most purposes, numbers and sizes of samples need to be increased to screen a reasonable number of food products with a high degree of confidence. For microbiological analysis, a critical goal must be the reduction or elimination of sample matrix effects that lead to false-positive and false-negative results. There is convergence of techniques for chemical and microbiological hazard detection, such as the enzyme-linked immunosorbent assay. Novel materials may be helpful with selective recognition of analytes and sample concentration. Many new techniques are being developed as screening methods for field and laboratory use (see Garber et al., p. 1294), with many applications being targeted to the elimination of negative samples and the application of confirmatory methods for presumptive positive samples. Genetic and other techniques are being used as forensic tools, especially when merged with bioinformatics analysis, to determine similarities and differences among microbial strains (see Cebula et al., p. 1271). Secure network systems are being developed to transmit laboratory data and develop algorithms to permit rapid identification of unusual or suspicious findings.

Technologies for tracking, authentication, and antitampering. A descriptive review of industrial product security systems that have potential applications for food products was presented (see Jotcham, p. 1314). Use of natural biological systems or components, such as insects, whole cells, or tissues, may provide monitoring, safety, and/or security systems that have applicability to agricultural products.

Hazard mitigation technologies. Presenters covered technologies for inactivation of various mycotoxins and decontamination of food plants. In the event of a mycotoxin attack on the food supply, chemical and bioremediation technologies currently exist to significantly reduce toxin concentrations. Technologies and products are being developed for remediation of buildings and food plants contaminated with a biological agent.

WORKSHOP CONCLUSIONS

Speakers, session chairs, and members of the Scientific Advisory Committee were asked to identify science and technology needs to enhance food counterterrorism efforts. These are summarized as follows.

1. Threat Awareness

- Create computer models to assess threat and estimate vulnerability and public health consequences of an attack.
- Develop models to permit better understanding of the psychology of terrorism.
- Rank the vulnerability of foods to attack and relative risk to people when foods are intentionally contaminated.
- Establish objective thresholds for law enforcement and intelligence agencies to share threat information with the agriculture and food industries.
- Compile databases that include successful and poorly executed communication strategies from past emergencies.
- Develop a national consumer hotline.
- Consolidate information on product tampering and counterfeiting that has occurred globally and methods used to combat these attacks.

2. Prevention and Protection

2.1. Disease and Food Surveillance
- Develop early warning surveillance systems for human, animal, and plant diseases and food contamination.
- Adapt remote sensing technologies for in-field, in-line, or in-transport detection of threat agents to monitor farms, food processing plants, ports of entry, and quarantine stations.
- Develop algorithms to differentiate natural from intentional food contamination.
- Conduct food surveillance testing programs.

2.2. Product Testing
- Develop better food sampling plans and sample preparation methods.
- Develop and validate rapid detection methods.
- Reduce false-positive and false-negative results in analytical tests.
- Undertake nucleic acid sequencing and functional genomic analysis of biological threat agents.
- Conduct proteomic research on pathogens to understand virulence expression.
- Develop an electronic mechanism for sharing critical laboratory testing information.
- Develop national and international laboratory networks.
- Compile central databases of research conducted on likely threat agents.

2.3. Interventions
- Develop and validate commodity-specific intervention technologies.
- Investigate gaseous antimicrobials for treatment during the postprocessing stages of the food chain (trucks, ships, warehouses).

2.4. Product Protection
- Develop and implement tracking, tamper evident, and smart packaging technologies.
- Develop authentication technologies to ensure the integrity of products.

3. Response

3.1. Technology

- Develop on-site expert systems to permit first responders to generate predictions about the effect of dissemination of threat agents on the temporal and logistical distribution of contaminated foods and the health impact on consumers.
- Develop technologies to permit rapid tracing and removal of contaminated products from the food supply.
- Develop hazard analysis and critical control point programs for high-likelihood and high-impact threats.

3.2. Communication

- Conduct research to determine the ability of media and public communications to limit the impact of an attack on the food supply.
- Investigate socially responsive risk communication techniques that will reassure the public during a crisis to avoid loss of confidence in major institutions.

3.3. Risk Assessment

- Determine the stability of biological, chemical, and radiological threat agents in foods during processing and under storage conditions.
- Develop animal models and other surrogates to determine the effects of exposure to threat agents.
- Identify biomarkers in humans and animals to detect exposure to toxicants.
- Develop better data on the pathological mechanisms of action of threat agents, background incidence, and treatment strategies.

4. Recovery

4.1. Facilities and Equipment

- Determine the effect on threat agents of common sanitizers and disinfectants used to clean facilities and equipment.
- Develop criteria for validation and verification of clean-up procedures for contaminated establishments.
- Identify or develop large-scale chemical or bioremediation technologies to remediate facilities and equipment.

4.2. Products

- Identify processes and develop facilities to remediate, inactivate, or dispose of contaminated product.
- Develop criteria for disposition of contaminated products.

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