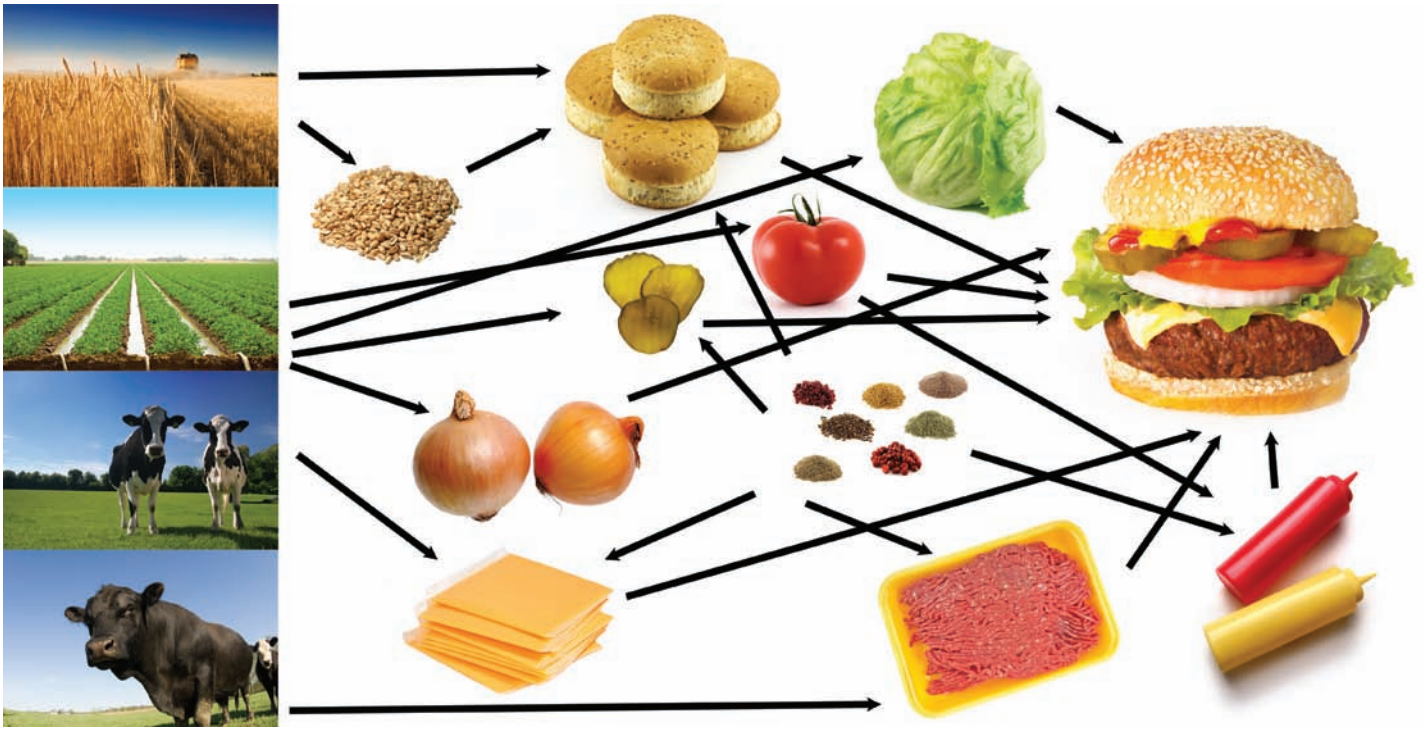
# National Center for
# Food Protection and Defense

## A Homeland Security Center of Excellence



## *Report for Years*
## 2004 - 2007

# National Center for Food Protection and Defense

*A Homeland Security Center of Excellence*

## Report for Years

*2004-2007*

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# Director's Message

The U.S. food system is vast, with over 2 million farms and 30,000 food manufacturing facilities in the United States alone. In addition, there are more than 90,000 manufacturing facilities and tens of millions of farms abroad, making the food system an attractive and vulnerable target for intentional contamination. Because the food supply reaches into every home, an intentional attack of biological, chemical, or radiological agents would be devastating in its effects on human health and the economy.

In 2003, The Department of Homeland Security requested proposals for a research center dedicated to defending the safety of the food system. The University of Minnesota was selected, and the National Center for Food Protection and Defense was launched in 2004. This consortium of academic, private sector, and public sector partners had an initial three-year, $15 million grant, which was followed by an additional two-year, $9 million renewal in June of 2007. The Center's goal is to develop technologies and strategies to prepare, protect, respond to, and recover from intentional contamination of the food system in order to mitigate the potentially catastrophic public health and economic effects of a food system attack.

The vision of NCFPD to defend the safety of the food supply through research and education is currently being carried out by 30 universities in three countries, a private sector advisory board composed of 31 national and multinational partners and an executive advisory board from academia, government and the private sector. In addition to these partners, NCFPD has established information sharing efforts and collaborations with a number of membership organizations, trade associations, intergovernmental organizations and state, local, and federal agencies associated with the food system. NCFPD has more than 60 current and completed projects dealing with agents, education, event modeling, risk communication, and system strategies, conducted by more than 150 experts from education, industry, and government and including collaborations with businesses across the entire food supply chain.

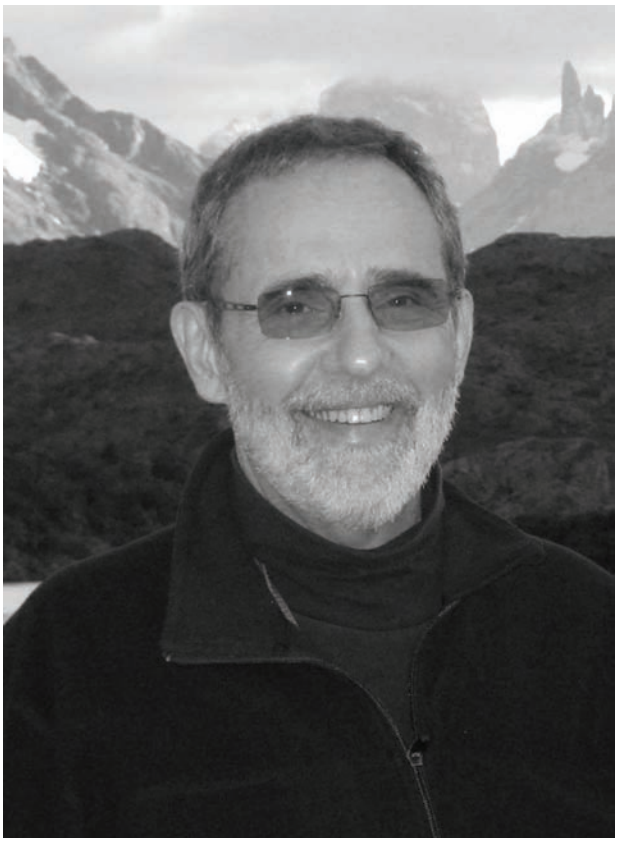
One aspect of the Center that is particularly unique is its emphasis on education; research coming out of NCFPD has led to the development of new coursework, such as director Shaun Kennedy's courses at the University of Minnesota's Summer Public Health Institute on food defense strategies and biosecurity for food facilities, and Michigan State's Food Protection and Defense course. This in turn enhances expertise in food defense through the development and expansion of programs of study for undergraduate, graduate, and post-doctoral students as well as professionals in the field. Former students on NCFPD projects are now working in positions in government and industry as diverse as the CIA, the World Bank, SuperValu and Ecolab.

This report will highlight examples of research that has been conducted since NCFPD was created, dealing with our three main areas of concern: prevention, response, and recovery. The examples focus on a specific project from each of our research themes: agent behavior, event modeling, systems strategies, risk communication, with an overarching emphasis on education. Further information about NCFPD's many other projects from the first three years can be found in the appendix at the end of the report.

NCFPD's research and education help keep the country's food supply safe and strong by reducing the likelihood of an intentional attack while also improving the nation's ability to effectively respond. Continued partnerships between NCFPD and universities around the world, coupled with our association with government and industry, will ensure that early detection, consistent response, and coordinated communication become the standard for protecting the public and the $1.2 trillion food and agriculture economy in the United States.

Shaun Kennedy, Director 2007 to Date
Frank Busta, PhD, Director 2004-2007

*Shaun Kennedy*



*Frank Busta*

# Consumer Citizen Survey

Researchers with the University of Minnesota wanted to learn what perceptions the public had about keeping the nation's food supply safe from terroristic attack, especially after several recent incidences made food safety a more prominent issue. To survey the public the researchers partnered with other National Center for Food Protection and Defense investigators to gauge what consumer perceptions exist in regards to food defense, to measure their confidence in the government to protect against terrorist attacks, and to assess over time whether and how those attitudes might change.

Creating a survey of this size began with four focus groups meant to help researchers learn how to ask questions about the relative value of food defense and expenditures on a variety of anti-terrorism activities. With a preliminary survey created, researchers tested questions on focus group participants while also having food industry marketing experts assess the survey's design in order to create an appropriate poll.

Once the final survey was created and refined, researchers conducted the Consumer/Citizen Survey the first week of August, 2005. Yielding a sample of 4,260 Americans over the age of 16 whose responses were weighted to reflect the national population, the responses to the Internet-based survey proved to be both surprising and revealing to researchers. Participants felt trains and subways were the most likely target for a future terrorist attack (84 percent of respondents said they expected a terrorist attack to occur on some form of transportation in the next year). They felt food was a less likely target than transportation (44 percent said the food supply would be a target for attack in the next year), yet they also felt that protecting the food supply chain and/or preventing the release of a chemical or biological agent in a public area deserves more funding for protection. Respondents said the percentage of anti-terrorism spending allocated to protecting against a deliberate chemical or biological contamination of a common food deserves 19 percent of all homeland defense funding compared to the 17 percent they suggested for transportation defense. (Current spending is less than 2% on food and foreign animal disease.)

For research fellow Dennis Degeneffe of the University of Minnesota, these responses – which included the fact that 98 percent of participants expect more terrorist attacks to occur in their lifetime – highlight the fact that terrorism is on the minds of Americans, and food defense is a major concern. "The results suggested food was up there in terms of where people see us vulnerable to attack," says Degeneffe. When asked specifically whether they were confident the country's food supply is secure, almost one-third of participants stated they were not confident at all.

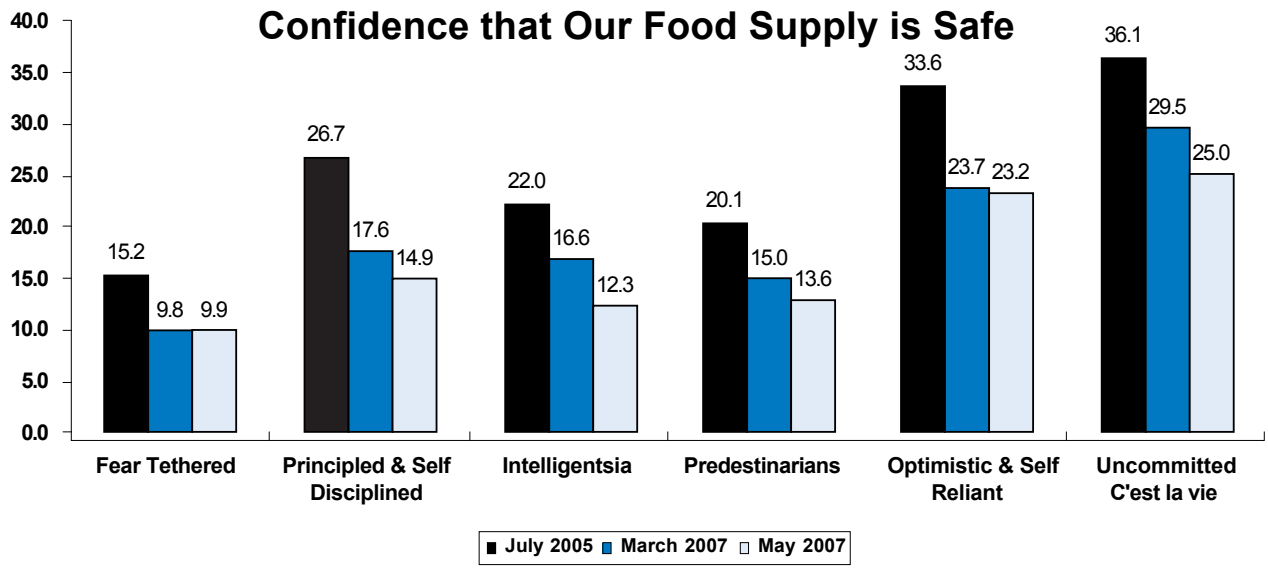
Following the first survey in 2005, several incidents – including the E. coli outbreak in spinach in September 2006, contaminated pet food at the beginning of 2007, and peanut butter contamination in early 2007 – allowed researchers to witness firsthand how consumer attitudes shifted as these outbreaks occurred. "We had a baseline in place in regards to consumer confidence in the safety of food so we were able to do similar surveys and trend the results," explains Degeneffe of the two subsequent surveys that followed the original 2005 survey. "It was surprising to see with the subsequent surveys how there had been a fall in confidence in food defense that went from 31 percent confident down to 15 percent – that's really dramatic."

The results from the two additional surveys, which each consisted of 2,000 respondents, are still being analyzed, but Degeneffe says the changes are obvious based on the results he's seen, and he credits that change to the amount of attention the aforementioned incidences received from the media. "We saw an increase in concerns over dry goods and canned foods that hadn't been there before," says Degeneffe. "Traditionally consumers are more concerned about perishables, but the peanut butter and pet food incidences were in areas of the grocery store that we don't think of as being safety issues, so we saw increases in concern over those areas."

The surveys have resulted in the publication of several papers (sections have been published in *Choices* online journal and *Homeland Security Affairs Journal*, among others) as well as attention from the media (articles have appeared in the *Minneapolis Star Tribune* and *Minnesota Daily* newspapers) and researchers have plans do a 47-week continuous survey thanks to new funding from NCFPD. Starting in March 2008, 175 different people each week will

be responding to questions about consumer concerns and confidence in food safety and defense.

Degeneffe sees the surveying of the public about terrorism fears and food to be an ongoing project that continuously benefits industry and government. "These surveys tell us how consumers are feeling with regards to food defense and how government and industry needs to go about solidifying consumer confidence in the food supply chain. It tells us that basically there are some major issues right now, and that we need to convey all of the things that are being done from a security standpoint to make sure that there's not overt misconceived apprehension about food defense."




## Definitions of Consumer Segments Identified in Study:

**Fear Tethered**
- General high level of fear/anxiety
- Sense of powerlessness and vulnerability

**Principled & Self-Disciplined**
- Disciplined in life… finances, health
- Avoid risks
- Strong sense of morals, personal integrity
- Socially conscious

**Intelligentsia**
- Passion to learn
- Seeking respect of others
- Views self as knowledgeable
- Tends to question authority

**Predestinarians**
- Values traditionalists
- Future is predestined
- Trust in leadership

**Optimistic & Self-Reliant**
- Optimistic toward future
- Building wealth
- Interested in trends & fashions

**Uncommitted C'est la vie**
- Few commitments
- Less concerned about health and safety risks
- Not worried about the future

# Risk Communication

Risk communication is a key component of food defense because of the diversity of message recipients in a food contamination event and the need to convey messages relating to that event with clarity. The National Center for Food Protection and Defense's Risk Communication Theme has so far encompassed nine individual projects that covered everything from improving best practices to training potential communicators for rapid response and preparedness. Below is a sampling of projects that highlight some of that research.

**Under-Represented Populations**

When communicating with the public about a food contamination situation, researchers have found that different populations receive and interpret the same information in different ways. NCFPD, in conjunction with the Risk and Crisis Communication Project at North Dakota State University, wanted to assess the variance in message needs and receptivity amongst various under-represented populations. Researchers assembled focus groups composed of under-represented populations including Hmong, African-American, Middle-Eastern, Hispanic, Somali, and Native American participants in order to test these messages.

In the focus groups participants viewed a variety of messages based on specific scenarios, like *E. coli* contaminated spinach, and their receptivity to each was measured and discussed. "Messages were tested to see what different preferences were and to identify how best to communicate with a population, whether that was through broadcast, print, state-based organizations, or a leader in the community," explains Lisa Brienzo, of the University of Minnesota, one of the project's investigators. Key challenges that were addressed included diverse learning styles, a history of mistrust, a lack of trust for standard media, and a general lack of access to information. Clear distinctions were drawn for each population, proving there is no homogenous audience for a crisis message, and that there is no crisis message that speaks to all groups.

Results culled from the focus groups allowed researchers to create booklets summarizing generalizable concerns for those charged with communicating about food-related crises to under-represented populations. According to the study, the more that is known about the beliefs and values of the audience receiving the crisis message, the more likely it is the message can reflect those beliefs and values.

**Risk Communication Training Curriculum**

Maintaining public trust and control in an intentional food contamination situation is almost as important as handling the containment of the emergency itself. Knowing all the aspects that make for good risk communication (which includes elements of psychology and journalism, among others) are essential when dealing with the public. To that end, NCFPD and the International Food Information Council partnered to create a risk communicator training curriculum that can be easily disseminated to food system stakeholders in preparation for a catastrophic food-related event.

Created in a five-module system – an introduction to risk communication, food defense and the psychology of terrorism, message development and delivery, preparedness and planning, and media relations and practice – the program is designed to be presented in 10 instructional hours (or two days) and can easily be adapted, abridged, or expanded depend-


*Slides developed for Risk Communication Training Curriculum*

ing on the specific audience and its needs. The program includes a Trainer's Guide, which includes learner outcomes, suggested discussion questions, activities, readings, resources, and a glossary of terms. The entire curriculum is posted online to make it easy for trainers and audiences around the country to obtain the required information to run the training via the Internet.

### Stand-by Just-in-Time Risk Communication Briefings for Food Systems Leaders and Communicators

The Internet has made it possible to rapidly respond to terroristic crises, and researchers from NCFPD recognized the value of webcasts for reaching stakeholders around the country. Partnering with IFIC, NCFPD researchers created and used a new tool that uses webcasting technology to broadcast a Just-in-Time (JIT) briefing to food system leaders and communicators within four hours of activating NCFPD's Center Response Plan.

In the event of a large-scale food-related crisis, researchers wanted the ability to quickly provide scientific, technical and analytical expertise to priority stakeholders throughout different phases of an emergency. A 20-minute JIT Briefing broadcast would allow NCFPD and IFIC to supply its audience with a known event and science backgrounder (this would include details of the event as well as key information about the contaminant), risk communication best practices (with event-specific strategies), and media pointers (opportunities as well as pitfalls). "The first 10 minutes we give an overview of the event, what we know about the event and its science background, such as what we know about the agent or consumer attitudes towards the food affected, and then also talk about what isn't known," says Tim Sellnow of the University of Kentucky, one of the project's leads. "The next five minutes would be an overview of risk communication best practices as they pertain to this event, and how you talk about things when there's quite a bit that's unknown. The last five minutes of the webcast involves reminders in terms of media pointers, anticipated questions, and how you can be prepared to answer those."

By providing JIT Briefings to key points of contact such as commodity groups and trade organizations, researchers hope to enhance understanding of technical and scientific aspects of the emerging event, readily apply risk communication best practice principles to the event, and provide useful media reminders leading to more effective message dissemination. Sellnow describes it as a "telephone tree" of sorts among "various organizations who have a major role in shaping messages and talking points in an emergency." That means having a stable of knowledgeable experts on hand around the country who can collaborate instantly with NCFPD staff. "We have subject matter experts, so if it's a contamination involving certain products or certain agents we'll try to have experts that are familiar with that agent," says Sellnow.

In addition to facts about the situation and best practices tips, Sellnow adds that webcast viewers will be advised about some key basics as well. "We remind these bureaucrats that you not only have to talk about specifics of what is occurring but acknowledge in a human way how you feel about it and say you understand anger and sorrow at what's happened." ◆

# Consequence Management System

Getting a look at the real-time effects of a food contamination event offers researchers valuable information on everything from how to prepare in advance for an attack to how best to contain an outbreak once tainted food is in the hands of consumers – and that's what makes the Consequence Management System so vital.

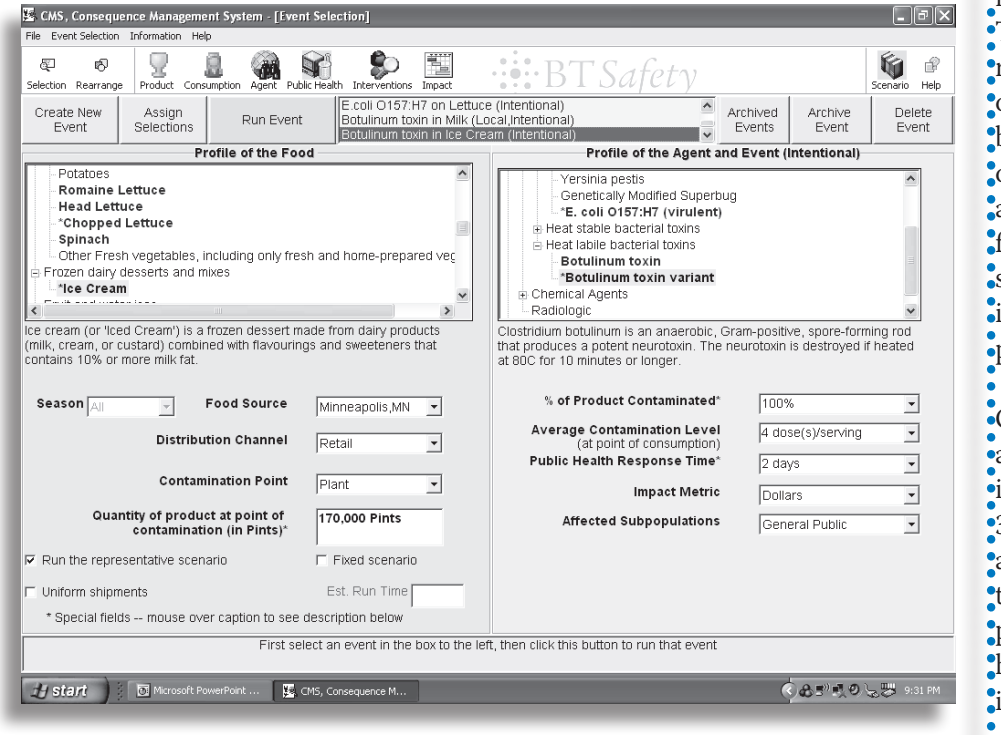
As a high-tech computer-based planning and advance-warning program, the CMS simulates, hour by hour, the impact of an intentional food contamination spreading through the supply chain from the farm all the way to the consumer – the perfect tool for researchers looking to test out theories, responses, and containment plans. With the click of a mouse you watch the milk work its way from supplier to distributor to grocery store and, ultimately, into consumer hands. It's a live action "what if" that plays out on your computer screen with the touch of a button.

"The CMS allows users to select a food and couple it with a bioterrorism agent and then it illustrates on a map of the United States the timing and geographic distribution of food to wherever it's delivered to consumers," explains Susan Harlander of BT Safety, the Minnesota-based company that partnered with the National Center for Food Protection and Defense to create the software. "Users can follow a timeline of bringing that product home, eating it, getting sick, seeking healthcare, how long it would take public health to recognize what is going on, and then the ultimate consequences of morbidity and mortality. It's fairly sophisticated software."

BT Safety began creating the browser-based CMS back in 2004 at the request of the Food and Drug Administration, which wanted an advanced visual model for predicting, tracking, and assessing the public health and economic impact of foodborne illness outbreaks. To create that system, researchers began by gathering extensive information from major food manufacturers, distributors, retailers, and foodservice outlets about processing information, shipping records, residence times, inventory turnover, and consumption.

"We worked directly with food companies to gather the shipping records we needed to follow the flow of a product from the time it's manufactured to the time it's consumed," says Harlander. For example, researchers gathered data on milk distribution from several different companies, anonymized and pooled that data, and then came up with representative scenarios to demonstrate what the consequences of a milk contamination would be. Through NCFPD support, the researchers also factored in data on characteristics of a variety of bioterrorism agents; information on consumer handling practices and patterns of consumption for each food product; and seasonal and geographic sourcing information for raw agricultural products.

Outside of food data, researchers also had to complete extensive interviews with approximately 30 emergency room physicians and nurses, board certified toxicologists, clinical laboratory personnel and roughly 15 public health officials to factor their roles into the CMS software.




*Screen shot from the Consequence Management System*


*Screen shot from the CMS demonstrating the effects of Botulinum toxin in ice cream*

With that wealth of information, the CMS has the ability to show users the consequences of a contamination, including the rate at which illness occurs, the likelihood/timing of medical care, and even the expected cost of the event to individual consumers, the food industry, and the public health system. Because the public health system will be a major player in just such an attack, the CMS also allows for the exploration of various public health recognition and response timelines as well as the impact of various intervention strategies on the economic and human health outcomes of a contamination. "The CMS is very visual, so it depicts how an event will unfold and that in of itself is extremely educational," says Harlander. "The Department of Homeland Security would like to use it for training and exercises in all 50 states as a basis to bring anyone involved in such an emergency and use the CMS to walk them through hour by hour how things would unfold in their area."

Today the CMS is capable of producing scenarios around romaine lettuce, milk, ice cream, ready-to-eat meat, ground beef, infant formula, shrimp, chocolate bars, and bottled water. While it currently doesn't have an infinite capacity for options, Harlander sees that changing. "The CMS will never be done in my view, we will forever be adding more food and more agents to continue working on it," she says. "The FDA has expressed an interest in some way to apply the tool to imported foods because right now it only deals with domestic foods. I see a constant evolution of the CMS and more applications as we're able to collect more data and build it in." The CMS can also be used for risk assessment: the FDA utilized the program to assess the relative risk of contamination between various foods -- for example, milk vs. chocolate bars -- in order to "risk rank" foods (since milk gets into the home faster and has a shorter shelf life, it moves a contaminant more quickly than a food that sits on the pantry shelf). DHS also employed CMS for the 2008 Bioterrorism Risk Assessment.

For pre-event strategic planning and training, Harlander doesn't see another tool coming close to what the CMS offers to everyone from local emergency responders all the way to Department of Homeland Security officials when it comes to simulating all-too-realistically what could happen in an intentional contaminations situation. "It's a cornerstone tool that will be used for risk assessment and training exercises to show how events might evolve." ◆

# Supply Chain Benchmarking

What are the industry standards for protecting consumers from intentional contamination, and how does one company compare to another? The food supply chain is like a steel chain, the whole is only as strong as each link: a manufacturer and wholesaler are only as good as the retailer and vice versa: the retailer depends on the manufacturer and wholesaler. How are best practices established in order to ensure the chain is as strong as it can be?

Researchers from Michigan State University, University of Minnesota, and Georgia Institute of Technology worked together to survey several areas of the food supply chain in order to understand what the industry best practices are. At the University of Minnesota Jean Kinsey focused on food service companies and retailers, Alan Erera and Chelsea (Chip) White at Georgia Institute of Technology worked with food transporters, and David Closs at Michigan State surveyed manufacturers. Each research team was looking to understand what systems are currently in place for food defense in each respective area of the supply chain. By creating a benchmark against which firms could compare themselves, weaknesses and vulnerabilities to terrorist attack can be identified and addressed, and communication along the supply chain could be improved. "Those who do not already have effective implementations of identified best practices can set new goals for improvement in those areas, to catch up with their competitors," explained Erera of the goals for each survey. "This competitive pressure helps raise the bar for all industry players, and since a system is only as secure as its weaker elements, this is particular useful in the security context."

Each university initially conducted in-person interviews with quality control and security officers in their respective sectors to determine which security methods were currently being used, this qualitative process served as the basis for the quantitative surveys. The survey from each university to its sector generally mirrored the other two universities' surveys and consisted of more than 100 questions looking at best practices in management, employment, communication, and information preparedness.

Jean Kinsey and others from The Food Industry Center turned their research into a tool to help food firms across the supply chain better understand not only their own preparedness but also the preparedness of the companies they rely on every day.

The original survey responses were evaluated as to their explanatory power and isolated into operational competencies that were used as the basis for a shorter on-line diagnostic tool for industry looking at food defense practices in four key areas areas:

Practices – measuring the companies' security and food defense performance by evaluating their use of physical security, audits/metrics, and strategy/security protocols;

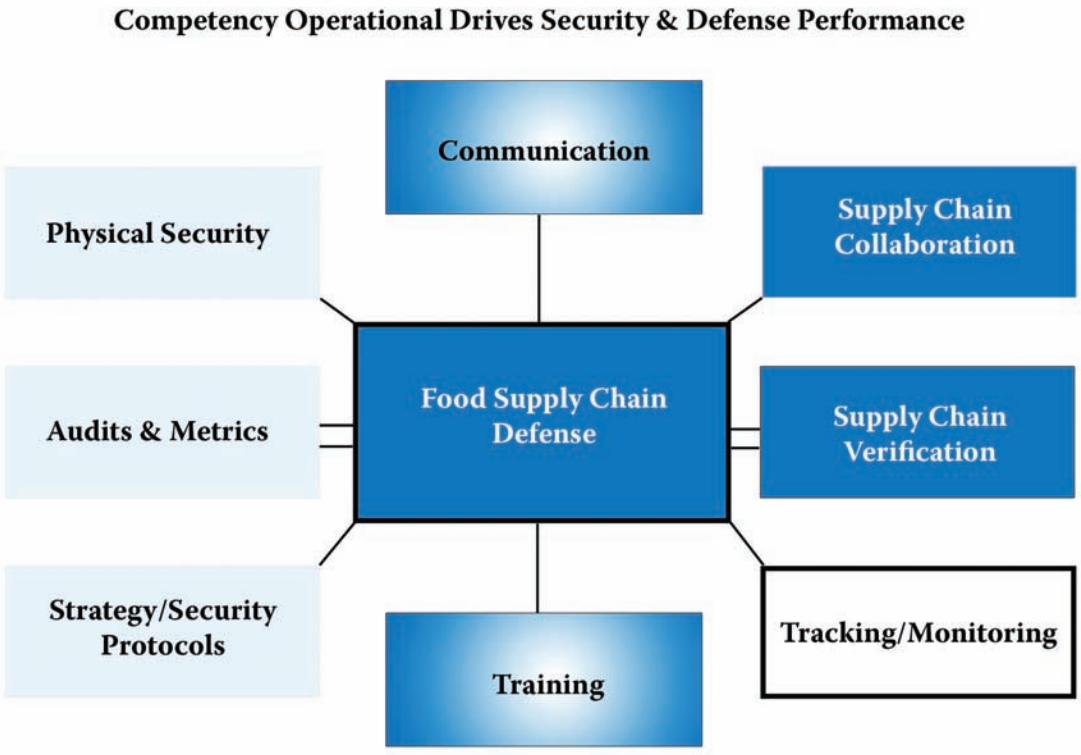
People – evaluating the companies' practices in communications with the members of the supply chain and training of both employees and supply chain partners;

Supply Chain Partners – assessing the companies' supply chain collaboration and verification practices;

Food Products – determining the companies' abilities to track and monitor the flow of their food products.

The Diagnostic Tool was put online in 2007. By answering 42 questions, companies can find out how they measure up compared to other companies in their industry and gauge how to achieve overall best practices themselves. The diagnostic tool's user-friendly interface and quick results – the tool generates immediate feedback – are its best features, especially compared to traditional studies, where results might not be available for weeks or months. As of April 2008, 44 companies had either completed or were in the process of completing the survey.

Ultimately, Kinsey sees the benchmarking tool being utilized by businesses and their collaborators to become more vigilant about security measures when it comes to food. "What we expect is that companies will use the results they get from the diagnostic tool when they meet with their supply chain partners to help them establish their priorities and improve practices when it comes to food defense."




## Definitions of Competencies

- Practices – evaluates the company's food security and defense practices by analyzing its focus on:

1. Physical Security - the presence of access controls, cameras, security protocols during the stages of processing, transportation, and storage;

2. Audits & Metrics - the use of audit/certification of both internal and external security programs and the use of universal supply chain security metric systems;

3. Strategy/Security Protocols - the presence of security protocols, continuity plans, and enterprise-wide strategy to address security concerns.

- People – evaluates the company's relationship with its employees by analyzing the following practices:

1. Communication – the presence of communication protocols and strategies for providing information about security/contamination incidents to its employees, supply chain partners, and governmental/public agencies;

2. Training – the use of education programs and emergency-preparedness simulations to train the employees to respond/recognize security breaches and contamination hazards.

# Botulinum Toxin

Botulinum toxin is the most poisonous naturally occurring substance on earth; it is on the Centers for Disease Control and Prevention's "category A" list of bioterrorism agents along with just five other biological agents (which include the equally dangerous Ebola virus and anthrax) that are considered to pose the highest risk to the public and national security. The Department of Health and Human Services has spent $363 million stockpiling doses of Heptavalent Botulism Antitoxin as part of the government's Project Bioshield program. In order to work with the toxin in a lab, the Patriot Act deems that scientists need an FBI background check and special permission to access the select agent.

Professor Eric Johnson at the University of Wisconsin-Madison has been working with botulinum toxin for 24 years, and he has partnered with National Center for Food Protection and Defense on a program to develop sensitive and specific micro-scale detection systems used to detect botulinum toxin in intentionally contaminated foods. "Our overall goal is to develop a rapid but sensitive method for detection of botulinum neurotoxin," explains Johnson, who collaborated with microbiologists, chemical engineers, and professionals in microfluidics on the sensing technology.

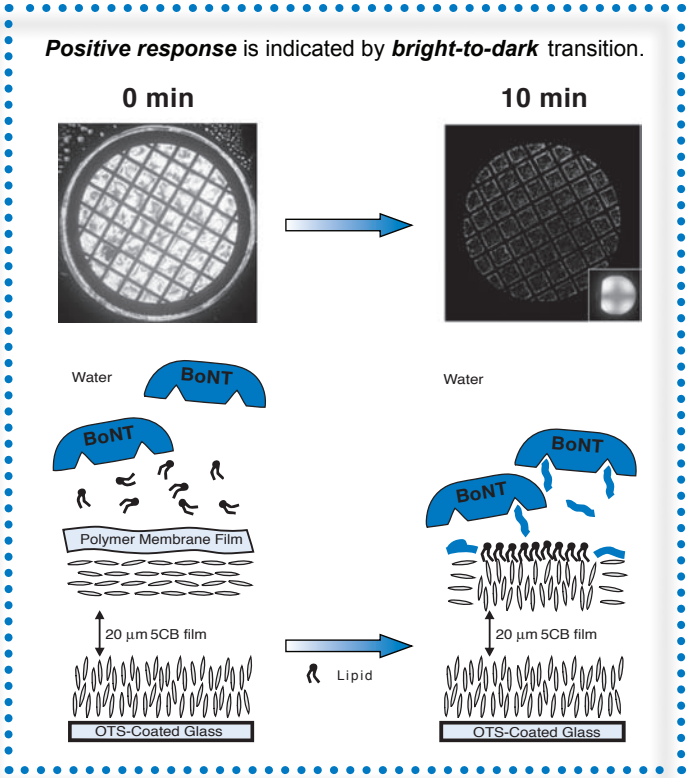
Currently, the only accepted detection method recognized by the Food and Drug Administration is the mouse neutralization test, in which a mouse is injected intraperitoneally with the sample in question, and scientists must wait up to 48 hours for results. Johnson's goal was to find a quicker, easier, and more cost-effective way to assess whether botulinum toxin was in the food supply. "There's a real desire and a real need to get away from this animal-based method," says Johnson. "It's sort of the holy grail of assays because this is such a poisonous substance." To support this assertion, Johnson adds that one gram of correctly prepared botulinum toxin would be sufficient to kill one million people.

Johnson's first detection breakthrough came in the form of liquid crystal sensors, which change orientation when exposed to the toxin. This orientation shift leads to a change in light transmission, which means a visual read of a simple color change alerts scientists to the presence of botulinum toxin. "Liquid crystal sounds fancy, but it's what all our laptops are made of, so it's very common," says Johnson. "This assay can be active at levels similar to the mouse test and it can be carried around with you; it's hard to carry animals around for detection. And it's much more rapid than mice."

The second detection system Johnson and his team created involved the use of microfluidics. The first approach used stimulus-laden hydrogels that respond to botulinum toxin by degrading upon exposure, causing a visual output.

The second microfluidics approach involved the formation of self-assembled monolayers that have a specific peptide, which, when attacked by the toxin, releases a fluorophore-labeled fragment into the solution. Free fluorophore can be detected by fluorescence microscopy. This permits the detection of botulinum toxin at very low concentration levels.

Both of Johnson's systems have been used to detect botulism in milk, and Johnson plans to take both even further. "Right now we've only looked at milk, but our proposal has been renewed and one of the objectives is to isolate the toxin in other foods," says Johnson. And while Johnson says it is difficult to speculate when a practical botulinum toxin sensor will be in use, he suggests two years isn't an unrealistic goal for a sensor that can work at a variety of points in the supply chain. "As potent as it is, the government stays on top of it and it's a fairly high priority," he explains.




*Liquid crystal sensor for detecting Botulinum toxin*

# Appendix A
# Project Index

## Agent Behavior Projects

### *Determination of Y. pseudotuberculosis Survival in Milk under Temperature Stress*

Teshome Yehualaeshet, Tuskegee University

Since yersiniae survive in food matrix at different temperatures, their impacts and implications in food storage and processing need to be studied. The long-term focus of this project is to determine the survival and growth rate of *Yersinia spp* (*Y. pseudotuberculosis* and *Y. enterocolitica.)* in milk after temperature stresses. Furthermore, the temperature-regulated genes were identified and characterized.
*Y. pseudotuberculosis* and *Y. enterocolitica* were spiked in milk and subjected to different temperatures (-80$^0$C, -20$^0$C, 4$^0$C, 26$^0$C, 37$^0$C, 60$^0$C and 72$^0$C). After the temperature challenges, the organisms were detected using standard culture and real-time PCR methods. Differential gene expression in yersiniae after temperature challenges and their significance in the food system were analyzed. RT-PCR, Pulsed Field Gel Electrophoresis (PFGE) and DNA Microarray were employed to analyze the gene expression profile. The output from temperature-tolerance and knowledge of temperature-induced genes will be valuable information for food safety and food defense.
Specific objectives were:
1) Determine the survival and growth rate of *Y. pseudotuberculosis and* Y. *eterocolitica* in milk under temperature stresses.
2) Optimize the extraction of PCR-compatible genomic DNA of *Y. pseudotuberculosis* and Y. *enterocolitica* from spiked milk.
3) To examine temperature-modulated genes of *Y. pseudotuberculosis* and Y. *enterocolitica*

### *Hydrophobic Extraction of B. anthracis Spores from Liquid Foods*

Francisco Diez-Gonzalez, University of Minnesota
Ted Labuza, University of Minnesota

The lack of effective pre-analytical methods for quick recovery of select agents in foods is a major weakness of our national food defense system. Milk and other liquid foods are potential targets for bio-terrorist attack with a number of select agents, including *Bacillus anthracis*. The purpose of this study was to investigate methods of extracting and concentrating *B. anthracis* from milk based on hydrophobicity and density differences. Raw milk inoculated with specific levels of spores was subjected to heat, centrifuge treatments, and hexadecane to determine concentration efficiency. Inoculated milk was also centrifuged with and without a silicone oil layer of greater density than milk. Spores were effectively concentrated and extracted (> 90% recovery) from inoculated raw milk when first heated at 85°C for 60 s, then centrifuged with silicone oil. A low percentage of spores were recoverable from milk that had not being heated prior to centrifugation. Few spores were recovered from extraction with milk using hexadecane. Spore concentration increased in the cream phase following separation. This data suggests that it is possible to rapidly and effectively concentrate and extract spores from milk.

### *Electrochemical Biosensors for B. anthracis*

Vangie Alocilja, Michigan State University

A proof-of-concept electrochemical biosensor for quickly detecting *Bacillus anthracis* spores has been developed. The biosensor can detect the target in 6 minutes (from sample application to final readout). Sensitivity is

100-1000 spores per milliliter. The biosensor is reagentless and disposable. For prevention, the biosensor may be used to quickly monitor and check for potential biological contaminants in food products of high economic and health importance in the food supply chain. A quick and regular monitoring of these food products will discourage terrorism and help prevent large scale casualties. In case of a bioterrorism event, the biosensor may be used in the field to quickly screen for the presence of *Bacillus anthracis* in various media – food, water, and even air. A quick screening could result in rapid diagnosis and lead to the implementation of rapid response strategies, thus minimizing both human and economic casualties. The biosensor could also be useful in emergency rooms for rapid diagnosis of patients, at borders for on-site evaluation of suspicious materials, and in postal offices for quick screening of suspicious powders.

### *Rapid Testing for Botulinum Toxin using Egg Yolk Antibodies*

Mark Cook, University of Wisconsin–Madison

The overall objective of this proposed research was to investigate the use of an egg yolk antibody production platform for the detection and neutralization of any toxin-contaminated food source. The specific objective of this research project was to demonstrate the capacity of the egg antibody platform in detection and neutralization of botulinum toxin. Utility of egg yolk antibodies as a detection reagent by developing a sandwich ELISA for non-toxic botulinum toxoid A was demonstrated as was the utility of egg antibody to botulinum toxin A for detection of toxin. Toxin neutralization capability of egg yolk antibody to botulinum toxin A using a mouse model was quantified. The egg yolk antibody production capability of one laying hen in one month using botulinum toxin A as antigen also was quantified and the storage methods of egg yolk antibody were defined. Data from these experiments indicate that under proper cool and dry storage conditions, antibody activity in freeze-dried egg yolk may be maintained for years.
The capability of the egg antibody platform to produce essentially unlimited antibody in a short amount of time, e.g. 28 days, has been demonstrated. The technology has been proven and is ready to be applied commercially.

### *Botulinum Neurotoxin Sensing Technologies*

Eric Johnson, University of Wisconsin–Madison

The overall goals of this project were to develop sensitive and specific micro-scale detection systems for botulinum neurotoxin (BoNT) that can be used to detect BoNT in intentionally adulterated foods or other samples and quickly communicate detection events using wireless technology. Additionally, the liquid crystal sensing component of the system lends itself to integration with food packaging to provide visual indicators of contamination. By developing and merging two sensing methods, (a) biomembrane sensing and bio-electronic transduction and (b) liquid crystal-based sensors, this project has evolved into an integrated, wireless, modular platform for sensing BoNT. During this project, our laboratories successfully carried out a multidisciplinary collaboration to develop sensing platforms for BoNTs based on microfluidics and liquid sensor platforms. Wireless and optical sensing for biological toxins was also a method developed in this the project.

### *FASTMAN Integrated Device for Detection of Select Agents*

Vivek Kapur, University of Minnesota/ANDX

This project's objectives have been to develop and validate accurate and convenient analytical methods for quantitative assessment of *Bacillus anthracis* as a key prerequisite for identifying natural or intentional introduction of this select agent in the food supply. The results of our investigations suggest that DNA extracted using CST magnetic bead technology compared well with QIAamp spin column methodology for real-time PCR-based detection of *B. anthracis* DNA. Overall, the ABI and Eppendorf commercial reagent systems performed consistently for both the *B. anthracis rpoB* and *pag* assays. Knowledge of distinctive assay performance characteristics of commercially available qPCR reagent mixes is critical for carefully designing analytical assay systems for detection of foodborne pathogens. The availability of these commercially available reagent systems

for performing the TaqMan-based 5'-nuclease assays is indeed an advantage for a food diagnostic laboratory as these reduce the time required for assay set-up thus improving throughput. Since assay sensitivity could vary with each individual reagent system available for use, this knowledge of performance characteristics for a particular diagnostic assay is important for the detection and quantification of bioterror pathogens such as *B. anthracis*.

The development of PCR-based methods has allowed the detection of a single copy of target DNA and a single pathogenic bacterium can potentially be detected by amplifying the target DNA sequence instead of the signal. This has led to a number of PCR-based methods for food pathogen testing. Because PCR-based testing may be subject to the varying nature of food samples, both quality control and quality assurance have been of concern due to PCR inhibitors in food matrices, variation in thermal cycler performance, reagents used to perform the analytic test and human errors. A critical drawback in many published PCR-based methods is the lack of an IAC (Internal Amplification Control). An IAC for *B. anthracis* spores was developed. The use of IACs, in conjunction with the target system, can be applied to identify samples that are positive and negative for the specific target sequence. The use of an IAC with real-time PCR should decrease false positives and false negative results as well as enable quantitative estimates of *B. anthracis* levels in complex food matrices such as foods.

### *Biosensors for Detection of Chemical Toxins*

Paul Takhistov, Rutgers University

The goal of this project was to develop a working prototype of a biosensor-based system for rapid, sensitive and reliable detection of Category B toxins. The fabricated device is planned to be integrated into an existing system of the microbiological safety and biosecurity for real time label-free detection of toxins in food matrices. An impedimetric immunosensor for the detection of trace concentrations of category B chemical toxins (S*taphylococcus* enterotoxin B (SEB) and Ricin) was designed and developed. A new immobilization method allows development of a highly reproducible and stable sensing device. Using the developed immobilization method and optimized detection regime, it is possible to determine the presence of the toxins in the real food matrices at levels as low as 10 pg/ml in real time. Sensors have been tested in 18 food product matrices.

### *Bioluminescent Bacteria as Biological Sensors for Toxic Agents in Food*

Vangie Alocilja, Michigan State University

The overall goal of this project is to evaluate the effectiveness of using luminescent bacteria as "canaries in the mine" for rapid non-specific and on-site detection of toxic contaminants in food products. The proof-of-concept results demonstrate that *Vibrio fischeri* bacteria can be used to detect toxins suspended in food matrices through bioluminescence quenching. Quenching was observed in food with potassium cyanide added at 5mg/kg (LD50, assuming a 75-kg person) and even at 80%, 60%, 40% and 20% of the LD50 (1mg/kg) in a 240-ml serving of skim milk. Quenching was also observed in food spiked with 615ppm of sodium hypochlorite. The assay from sample application to final detection was completed in less than 60 minutes. These results show that this biological sensor can be used for high-frequency testing at the last likely or highest impact contamination point. In this way, contaminated food products may be prevented from reaching the consumers. Furthermore, this biological sensor may be used as an inexpensive, highly renewable defense system for our food supply.

### *Bioluminescent Imaging for High Throughput Screening for Bacterial Pathogens and Toxins*

Mansel Griffiths, University of Guelph

Fifteen bioluminescent strains were constructed and bioluminescence was measured for different dilutions of bacteria. For all strains there was a strong correlation between bioluminescence intensity in Relative Light Units (RLU). There were no significant differences between strains within the group and between groups. Unfortunately both *in vivo* bioluminescence and fluorescence did not reveal any signal, which indicates lack of reporter gene expression.
Reasons for this are currently being investigated.

### *A Systematic Approach for the Detection of Bioterrorism Agents in Complex Sample Matrices*

Lee-Ann Jaykus, North Carolina State University

The purpose of this project was to develop selective ligands (peptide and nucleic acid) to facilitate pre-analytical capture and subsequent detection of priority pathogens and bioagents (ricin B chain and *B. anthracis* spores) in foods. Twenty peptides displaying affinity to ricin B chain have been identified. Strong homologies at the amino acid level were observed among those peptides identified and twelve individual peptide sequences have been selected for further characterization of their binding affinity/ specificity to ricin B chain in complex food matrices. Single strand nucleic acid aptamers have been generated against intact spores of *B. anthracis* and ricin B chain following several rounds of selection and amplification. These aptamers are currently being evaluated for their ability to capture and subsequently detect each of these two biological agents in complex matrices. Detailed binding kinetics are also currently being evaluated.

### *Concentrating Bacterial Spores from Milk and Juices using Dielectrophoresis-Based Microfluidic Capture Systems*

Suresh Pillai, Texas A&M University
Ali Beskok, Old Dominion University

A microscale prototype device that can be ultimately scaled up for concentrating bacterial spores from large volumes of milk and apple juice was developed. Dielectrophoresis (DEP) is utilized to concentrate *Clostridium sporogenes* spores as surrogates of *Bacillus anthracis* and *Clostridium botulinum* spores from the suspending medium in a microfabricated channel. Effectiveness of the DEP as functions of the applied electric field frequency and amplitude, and the conductivity of the ionic solution is validated both experimentally and theoretically. The first set of experiments were conducted utilizing interdigitated electrode geometry that amplifies positive DEP. Experimental results were correlated with the theory using a scaling analysis that considered the relative magnitudes of dielectrophoresis, electrophoresis, AC-electroosmosis, gravity and Brownian motion. Using simple electrode designs that amplify the negative DEP effectively, DEP was successfully utilized for concentrating spores from milk and apple juice. The prototype device under design will allow fast and effective concentration of biological species in high conductivity media.

### *Extraction, Concentration, and Detection of Toxins in Solid Food Systems using Molecular Imprinted Polymer Films*

Keith Warriner, University of Guelph
Subrayal Reddy, University of Surrey (UK)

The overall objective of the study was to demonstrate the proof-of-principle to concentrate and detect toxins present in buffered solutions. Although the current study focuses on *Staphylococcus aureus* enterotoxin B, the approach can be extended in to other relevant biological and chemical agents that pose a risk to homeland security. Initially, hydrogel imprinted polymer films for concentration of enterotoxin were fabricated and impedimetric immunosensors based on enterotoxin-antibodies immobilized within conducting polymer electrodes were constructed. The proof-of concept of fabricating protein imprinted hydrogels for concentrating and extracting SEB for the first time was demonstrated. Fabrication of conducting polymer electrodes as an alternative to expensive carbon and noble metals for sensor fabrication was accomplished. An electrochemical immuno-sensor which can be readily automated for sensitive detection of SEB has been developed.

### *Heat Inactivation Kinetics of Spores in Liquid Milk*

Ted Labuza, University of Minnesota
Francisco Diez-Gonzalez, University of Minnesota

*Bacillus anthracis* spores or ricin toxin, potential bioterrorism agents, could be purposely released at different points of the dairy chain. The dairy system is also considered susceptible because pasteurization temperatures

are not capable of inactivating spores. This project was undertaken to identify thermal processes that could effectively inactivate *B. anthracis* spores and ricin in milk samples at temperatures that typical milk processors could use, as well as to characterize their thermal inactivation kinetics. The inactivation of spores and ricin was also enhanced by using a combination of sodium hypochlorite (SH), hydrogen peroxide (HP) and peracetic acid (PA). A set of thermal inactivation kinetics were determined in the range of 72° to 112°C. Six-log viability reductions were achieved when the spores were heated at 120°C for 6 sec. These results suggest that a commercial ultra-high pasteurization (UHT) could be applied to decontaminate milk. Using temperatures in the range of HTST pasteurization, a 6-log CFU spores/ml reduction was also achieved in less than 30 seconds using combinations of SH (1 to 1.5%), HP (0.3 to 0.6%) and/or PA (0.05 to 0.1%). Ricin was inactivated in less than 30 s at milk pasteurization temperatures or room temperature using biocides added individually or combinations of two biocides that included SH (0.1 to 1%) and sodium hydroxide (0.01 to 0.15 N).

### *Chemical Stability of Ricin Under Conditions That Mimic Pasteurization of Beverages*

Peter Varelis, National Center for Food Safety and Technology–Illinois Institute of Technology

The primary goal of this project is to understand the relationship between pH and the relative immunogenicity of ricin over the pH range of 3-9 and under conditions that mimic the pasteurization of beverages in both a select number of beverages such as fruit juices and milk and buffers. Two further goals of this work are to understand whether components in beverages affect the inactivation kinetics of ricin and, on the basis of this work, provide a strategy to decontaminate plant equipment.

Our results to date demonstrate that over the broad pH (3.5-7.5) of beverages such as milk and fruit juices, the immunogenicity of ricin is not significantly affected under conditions that mimic pasteurization, i.e. at temperatures around 85 °C and for times less than 1 minute. However, at high pH values (>8) and at temperatures around 85 °C and for times greater than 1 minute, the immunogenicity of ricin is significantly reduced. On the basis of these preliminary results, the threat of ricin in beverages such as fruit juices and milk remain a concern insofar as this protein toxin is resilient to the conditions used to pasteurize milk and fruit juices. However, because of the labile nature of ricin under hot mild caustic conditions it may be practical to decontaminate plant equipment using alkaline solutions.

### *Fate of Toxins in At-Risk Foods*

Ramona Parra, New Mexico State University

The two main objectives of this project were: (1) to develop fast GC/MS analyses using micro-bore columns and hydrogen as a carrier gas for the rapid and accurate detection of potential food toxins; and (2) to characterize thermal toxin breakdown products of potential food toxins using a thermo gravimetric analyzer/differential scanning calorimeter (TGA/DSC).

The following analytes were successfully recovered from flour: deoxynivalenol, nicotine, malathion, diacetoxyscirpenol, caffeine, atropine, T-2 toxin, patulin and ricinine. Breakdown products have not been characterized to date.

### *Use of Commercial Household Sanitizers to Inactivate Spores*

Michael Davidson, University of Tennessee–Knoxville

The overall goal of this project was to investigate the sporicidal capabilities of commercially available household disinfectants and other products against spores of *Bacillus cereus* used as a surrogate for *Bacillus anthracis*. Products were evaluated in vitro, in milk, on potential food contact surfaces and on produce. The purpose of the study was to develop recommendations for consumers to decontaminate food and/or household areas in the event of a large scale terrorism event. Hypochlorite-containing products were found to be the most effective at

reducing *B. cereus* spore populations in vitro, in fluid milk, on stainless steel surfaces and on produce. Additionally, an HCl-containing product was found to be effective at reducing the population of spores in some instances. It has been demonstrated that hypochlorite-containing products and, to a lesser extent, an HCl-containing product are capable of decontaminating foods at the consumer level. It is recommended that commercial bleach be included as a part of all household disaster preparedness or home security kits for both consumer protection and to assist in preventing the spread of high concentrations of pathogenic microorganisms in the solid waste or wastewater systems in the event of a massive intentional contamination by terrorists.

### *Inactivation of Microbial Agents with High Concentrations of Industrial Sanitizers*

Katie Swanson, Ecolab Inc.
Bruce Cords, Ecolab Inc.

This study showed that commonly used liquid biocides can effectively inactivate *Bacillus anthracis* spores in the presence of food residues. However, successful inactivation often requires application conditions outside those allowed by U.S. law (e.g., requiring longer application time, higher temperature, or higher biocide level). In fact, all successful application parameters were outside EPA-approved label instructions for use. Obtaining EPA approval for the use-instructions proposed in this report is a crucial next step that must precede commercial use. Decontamination efficacy was often reduced in the presence of food residue – fat and protein were more troublesome than starch. There were two biocides that were not effective against *B. anthracis* spores: the quaternary ammonium chloride biocide and the iodophor biocide.

Research with *Yersinia pseudotuberculosis* (a surrogate for *Yersinia pestis*) supported historical data and use patterns which predicted that routine disinfection protocols would effectively inactivate *Y. pestis*. However, consistent with *B. anthracis* studies, the presence of food residue reduced decontamination efficacy – sometimes making it ineffective.
The outcome of this research was the creation of *Decontamination guidelines for Bacillus anthracis spores or Yersinia pestis* (Appendix B). These guidelines were constructed to help bioremediation specialists use commonly available biocides in a way that results in effective decontamination under varying conditions (e.g., on food-soiled surfaces and when treatment times or temperatures vary).

### *Containment and Remediation System*

Susan Harlander, BT Safety LLC

BTSafety's Crisis Management and Response System (CMRS) software is designed for use when an intentional food contamination event is confirmed which requires disposal of the contaminated food, remediation (cleaning and sanitizing) of all facilities, and resumption of capabilities. The system contains a database of containment, cleaning and sanitizing protocols developed in collaboration with industry experts for a wide variety of bioterrorism agent classes that could be used to contaminate a number of different food products. The CMRS enables users to select protocols to apply to each contaminated location from the source through where the products would be consumed. This includes fields, processing plants, transportation vehicles, distribution centers, warehouses, supermarkets, restaurants, home refrigerators, etc. The system employs a "drag-and-drop" interface that enables users to create graphical plans of incidents locally and to transmit plans over the Internet within or between organizations. The CMRS is also able to track the progress of containment and remediation activities at every site and share that information through a browser-based system with secured access for different types of users. Extensive crisis response information has been collected and stored in repositories in the CMRS.

### *Plasma Technology to Decontaminate Surfaces*

Amy Wong, University of Wisconsin–Madison
Ferencz Denes, University of Wisconsin–Madison

The project goal was to use plasma-aided technology to disinfect surfaces and air in food processing environ-

ments contaminated with *Bacillus cereus* spores, a surrogate for *Bacillus anthracis*. We developed a unique atmospheric pressure array electrode plasma reactor (AER) and demonstrated that it can be used successfully for spore inactivation. Results showed that an air-mist plasma (flow rate 500sccm) was more effective than air or oxygen alone, and viable spore numbers (initial concentration 5 log/2.5cm2) on stainless steel (type 304 #4 finish) could be reduced by more than 4 log (>99.99%) in 2 min at a power level of 100W. Increasing the power level to 300W did not result in higher inactivation levels while 70W was slightly less effective, and a decrease of >3.77 log spores was achieved in 2 min. To simulate a potential in-plant challenge, spores were suspended in dilute skim milk before drying on a stainless steel surface. A >3.49-log reduction (>99.9%) was achieved in 3.5 min. Spores on the belting material were slightly more resistant to plasma inactivation, however >4-log reduction (>99.99%) was attained in 4 min. A second generation AER was designed that can generate more uniform plasma and enhanced temperature control. Spore inactivation efficiency was increased using this redesigned system. The technology and equipment developed in this project can be used for static or continuous flow conditions and also for air disinfection, and can be scaled up or down depending on need. Therefore, it is adaptable and can be applied to different locations in food processing plants for either food safety or food defense.

### *Evaluation of Methods for Decontamination of Food Processing Equipment and Facilities Deliberately Contaminated with Bacillus Spores*

Martin Cole, National Center for Food Safety and Technology–Illinois Institute of Technology
Peter Slade, National Center for Food Safety and Technology–Illinois Institute of Technology

The goal of this project was to investigate the effects of cleaning and sanitizing agents on *Bacillus anthracis* (Sterne strain) spores and their surrogates (*Bacillus cereus* and *Bacillus thuringiensis*) embedded in food matrices on representative food contact surfaces.

We were successful at maintaining full viability of spores without germination in complex food matrices through a combination of application in 70% alcohol solution and drying under refrigeration. This is important because the effects of treatments can be assessed against spores without germinating or vegetative cells confounding the assessment. Although cleaning with water was not significantly better than use of Enforce™ at removing spores in foods from coupon surfaces, the ATP bioluminescence measurements indicated that detergent treated surfaces were considerably cleaner than those treated with water alone. The significance of this is that residual foodstuffs on food contact surfaces could well harbor a low number of spores which may be protected from inactivation by secondary application of sanitizers and/or sterilants. Cleaning food contact surfaces with cleansing agents such as detergents (the choice of which depends on the type of soil being removed) before application of the sanitizer is therefore critical. The majority of spores removed in cleaning operations were not inactivated by the cleanser preparations and maintained full viability. However, early indications suggest that treatment with 5-10% Vortexx™ sanitizer solutions is effective at inactivating spores eluted in the rinse waters. The significance of these findings is significant when considering surfaces soiled with contaminated hazardous food systems.

There was no significant difference between the inactivation of spores by sanitizers/sterilants following either "sensitization" under vacuum or by holding for various periods at ambient pressure, although decreases in surviving spore numbers were observed after 5 days by either holding under vacuum or ambient pressure. The presence of peanut butter residue on food contact surfaces significantly decreased the inactivation of spores of both *B. cereus* and *B. thuringiensis*. This again underlines the need to clean surfaces if possible and/or advisable prior to application of sanitizers. Spores on stainless steel (with or without food soils) were more readily inactivated than those on glazed tile. Generally, 10% Vortexx™ in both liquid and vaporized form was more effective than 5% Vortexx™ at inactivating spores, although the liquid application was more effective than the vapor, indicating a more significant remediation challenge in facilities that are designed for dry cleaning. At a concentration of 0.4%, Vortexx™ was significantly less effective at inactivating spores. In all trials there were only minor, non-significant differences between the spores of *B. cereus* and those of *B. thuringiensis*.

### *Toxin/Pathogen Inactivation and Disposal of Intentionally Contaminated Foods*

Craig Benson, University of Wisconsin–Madison

This study was conducted to evaluate issues that need to be considered when intentionally contaminated foods are disposed in conventional pollution control systems such as landfills, wastewater treatment plants, and incinerators. The study focused on defining the regulatory, policy, technical, and practical issues related to disposal of intentionally contaminated foods, and identified gaps in knowledge regarding the fate of agents during disposal processes.

The meetings with key stakeholders illustrated that greater coordination is needed between federal and state agencies involved in managing and regulating the food supply and the agencies involved in managing the environment. Regulations, policies, and procedures need to be developed that define how terrorist wastes are to be managed, where they can be disposed, and what liabilities associated with managing these wastes will be assumed by the government and by industry. There also was a strong request for more information regarding the fate of terrorist agents in conventional pollution control systems such as landfills and wastewater treatment plants. This information is needed so that rational decisions can be made regarding the impacts of accepting intentionally contaminated foods. Representatives of the disposal industry indicated clearly that intentionally contaminated foods most likely would not be accepted for disposal unless data are available demonstrating the risks associated with disposing of these materials. An investment in collecting the scientific data necessary to make rational decisions is clearly justified. This effort should begin now, before society and the disposal industry are faced with a daunting disposal problem without a well-defined methodology for management.

The literature review and modeling illustrated that the risks posed by accepting intentionally contaminated foods vary considerably depending on the agent that is used for contamination. Some agents will be quickly degraded within common pollution control systems. Others will be much more persistent, and will have the propensity to escape in effluents, gaseous discharges, or in solid matter. However, insufficient data currently exist to make confident predictions of the fate of most terrorist agents in pollution control systems. Even less data exist regarding the fate and toxicity of the degradation products of many terrorist agents. These issues should be explored immediately so that a sound technical basis exists in the future to predict the fate of various terrorist agents in pollution control systems in the same manner that the fate of other potentially hazardous constituents is assessed today.

Regardless of the agent in the food, monitoring of pollution control facilities accepting foods contaminated with terrorist agents will almost certainly need to be enhanced to ensure public safety and protection of the environment. Operation and management of facilities will also need to be changed to be cognizant of worker safety and the potential for inadvertent releases. Efforts should be undertaken now to address the amount of monitoring required, the type of instruments that will be needed for monitoring, and the changes to operations and management necessary to ensure public safety and protection of the environment.

## Event Modeling Projects

### *Consequence Management System*

Jeff Sholl, BT Safety LLC

BTSafety's Consequence Management System (CMS) is a 'user friendly' PC-based simulation model that depicts in real time the movement of selected food products that might be particularly vulnerable to intentional or unintentional contamination from the farm through distribution channels to consumer's homes. The model further illustrates the public health consequences of the contamination including the rate at which illness occurs, the likelihood and timing of medical care, public health recognition and response timelines, and the impact of various interventions on the timing and extent of consequences (morbidity and mortality) for selected bioterrorism agents. The CMS is designed both as a planning tool that can be used to prepare in advance for either an unexpected incident (e.g., a "Food 9/11") or a predictable event (e.g., a "Food Katrina") and to respond appropriately and effectively when in the midst of an event. The model can be used to create "what-if scenarios" that

depict the likely outcome of any food-agent combination which can be useful for pre-event strategic planning and training. In addition, it provides a valuable decision making tool during an actual event.

### *Modeling the Public Health System Response to a Terrorist Event*

Don Schaffner, Rutgers University, and Craig Hedberg, University of Minnesota

The objective of this project was to conduct simulation modeling of the public health system, specifically focusing on the detection of deliberate food contamination events by the public health system, and the response of that system to such events. A working prototype using Arena and Microsoft Excel has been developed. The model uses inputs of three types: Hazard specific inputs, product type inputs and information on the degree of dispersal of hazard. Hazard specific inputs relate to the nature of the agent, and can be customized for each specific agent, based on published data or expert opinion. The second set of hazard specific inputs relate to the parameters which control the issuance of an advisory. The "product type inputs" include the (a) expected total number of people exposed – to determine the overall size of the outbreak as well as (b) a product-type variable – to determine how the cases will be distributed in time. The final set of user inputs controls the degree of geographic dispersal of the hazard. The simulation model can be used to evaluate the impact of improving performance of different components of the public health system, and the subsequent impact on food terrorism events.

### *Evaluation of Timelines for Botulism Outbreaks*

Craig Hedberg, University of Minnesota

Botulism has become a rare foodborne disease in the US and a leading concern for bioterrorism. From 1993-2005, 346 cases of foodborne botulism and 42 foodborne outbreaks of botulism were reported in the US. Only 4 outbreaks (10%) involved > 5 persons. In each of these outbreaks the event was recognized within 4 days following exposure because of the occurrence of multiple cases with identifiable linkages presenting at a common health care center. However, multiple other cases occurred for which the diagnosis was delayed because the individual cases were not epidemiologically linked to other suspected cases. For a widely distributed food item, recognition of the outbreak and its source would depend in part on the likelihood of cases clustering in households or among friends. The characteristics of product distribution and use should be factored into assessments of the potential impact of intentional contamination events and public health response. The attributes of the outbreaks also suggest approaches to more rapidly identify a new outbreak.

### *Public Health Investigation of Multistate Foodborne Outbreaks*

Craig Hedberg, University of Minnesota

This project had the goal of developing approaches to improve outbreak detection response time, a critical element in reducing the impact of an intentional event. The findings were incorporated into The Council to Improve Foodborne Outbreak Response (CIFOR) multi-jurisdictional guidelines, which are intended to help improve communication and coordination between agencies investigating multi-jurisdictional outbreaks at all levels of governmental organization.

The guidelines are proposed to help agencies identify multi-jurisdictional outbreaks, and increase the speed of investigation and control of outbreaks, using the following recommendations:

1) provide a definition of when an outbreak may be considered a multiple jurisdictional outbreak,
2) establish a framework for rapidly assessing whether multiple jurisdictions are affected by a given foodborne disease event,
3) promote early and effective communication and coordination among agencies involved in multi-jurisdictional investigations,
4) detail specific actions that may need to be carried out in a multi-jurisdictional outbreak,

5) provide guidance on how to manage the transition between the phases of an outbreak investigation during which leadership of the investigation changes,
6) provide guidance on post-outbreak debriefing and dissemination of findings.

### *FoodSHIELD*

Craig Hedberg and Jeff Bender, University of Minnesota

The FoodSHIELD project goal is to create a national, web-based system for communication, coordination, education and training for communities that protect and defend the food supply and the public's health. This system allows the diverse groups of state, federal, and local regulatory officials, laboratorians, researchers, and stakeholders that are responsible for protecting the nation's food supply to interact and function as one unified network. Additionally, FoodSHIELD houses agency and laboratory capacity and capability data regarding their ability to respond to food emergencies. The research objectives are to develop the web-based system, to recruit personnel from targeted agencies and laboratories to participate, and to evaluate the ability and utility of: (1) the system to provide a secure web-based system of contact directories and communication tools to food protection and defense governmental agency personnel, (2) the system to allow for rapid communication with food regulatory personnel and supplement federal agency Web-based communications systems, (3) the laboratory database to provide timely access to current information on the capacity of food and agriculture laboratories to perform analytical testing for traditional and likely bioterrorism agents, (4) the agency database to provide timely access to current information on the nation's food regulatory agencies identifying types of programs and activities, (5) the FoodSHIELD system to be used to assess the capability to respond to unintentional and intentional food safety emergencies, and (6) the FoodSHIELD site to provide timely and pertinent information, education, and outreach materials to various audiences and stakeholders across the food system. The primary source of funding for FoodSHIELD is a four-year USDA CSREES/NIFSI grant obtained by NCFPD (Craig Hedberg PI).

## Systems Strategies Projects

### *Supply Chain Security Best Practices—Suppliers and Manufacturers*

David Closs, Michigan State University

Based on a sample of over 200 food manufacturers, a survey was used to determine supply chain defense practices, supply chain defense performance, and moderating factors. Using the supply chain competency framework (Closs et al., 2006; Bowersox et al, 2000), reported competencies and performance characteristics were evaluated by quality, security, and supply chain professionals using Likert-scaled questions. Generally, respondents perceive that firms have substantially improved their ability to detect and recover from supply chain incidents. A number of significant differences were found between firm and respondent demographics as they relate to 1) firm security practices and 2) the perceived results of these actions. Auditing, background checks, and establishing emergency training communications, and procedures, and security expenditures differentiated larger firms from smaller firms. Results indicate that firms are primarily focusing their efforts on Process Management, Management Technology, Communications Management, Infrastructure Management, Metrics/Measurement, and Process Strategy competencies.

### *Supply Chain Productivity and Resiliency—Logistics and Transportation*

Alan Erera, Georgia Institute of Technology
Chip White, Georgia Institute of Technology

Food Supply Chain Security and Productivity continues to be a major consideration in food defense.
U.S. security initiatives and industry best security practices are intended to help prevent, detect, respond to, and recover from terrorist attacks. Such initiatives and best practices have ancillary impact on supply chain productivity.

The design of food supply chains that explicitly take into consideration resiliency to enhance productivity is challenging. Resiliency is the ability to quickly identify, respond to, and recover from events that severely disrupt supply chain operations. Such events have low probability but high potential consequences. Food supply chains need to be resilient to ensure a reliable food supply, and providing resiliency cost-effectively is crucial.
The goals were to:
1. Create a set of best practices through that improve food supply chain security with minimal negative economic impact, focusing on food transportation. We were not able to generate a response rate greater than approximately 2%.

2. Develop methodology to determine economic productivity impacts of improved security practices within the food transportation industry segment. For typical lane lengths found in U.S. long-haul trucking, if we restrict driver rest to 2 or 3 designated secure facilities per lane, we expect to see minimal impact on driver productivity and hence required driver fleet sizes, indicating that such a strategy may deserve further consideration as a mechanism to improve the security of trucking systems without compromising efficiency.

3. Create a food supply chain design framework that provides decision-support to industry for configuring cost-effective resilient supply chains. The results indicate the importance of contingency planning and disruption management for all stakeholders, including both private firms and public agencies. Firms without contingency plans may see complete elimination of operating margins, or firm failure, for reasonable-length disruptions.

A major challenge turned out to be eliciting a high response rate from food transportation companies. Companies did not respond to the survey request in high numbers, noticeably different from the other two surveys; anecdotal evidence suggests that companies did not participate due to the lack of mandate, and general mistrust in sharing data with researchers supported by government agencies. In the end, a low survey response rate prevented rigorous statistical inference from the survey data.

### *Supply Chain Benchmarking—Wholesale, Retail, and Food Service*

Jean Kinsey, University of Minnesota

This project addresses the need to increase awareness of food system vulnerabilities among retail and wholesale food companies and enhance their preparedness for catastrophic incidents. Initial interviews and pilot surveys established the management and operations practices at retail, wholesale, and food service companies that lead to tightened security at a variety of food companies. The lessons learned from that stage of the project were incorporated into a comprehensive survey to ascertain the best practices in management, employment, communication, and information preparedness among firms in the wholesale/retail end of the food supply chain. The project will provide benchmark reports to each participating company regarding the level of preparedness for prevention, detection, response, and recovery. Results will be used to develop a set of best practices, a benchmarking (diagnostic) software tool for food companies to use and recommendations on improving food security practices, protecting employees and consumers, reducing vulnerabilities, and enhancing consumer confidence in the safety of the food supply.

The diagnostic tool to distribute to food companies to measure their performance in implementing anti disaster measures has been built (programmed) and tested by a few food company executives. It is now up on the web site of The Food Industry Center and will be available for at least a year. (http://webapps.cfans.umn.edu/TFIC/Main/index.html)

On Nov. 1, 2007 NCFPD cosponsored with The Food Industry Center and the Trucking Center at Georgia Tech a major symposium on the UMN Campus. The title was *Terrorism, Pandemics, and Natural Disasters: Food Supply Chain Preparedness, Response, and Recovery* - Information about the symposium and an executive summary can be found at http://foodindustrycenter.umn.edu/Past_TFIC_Workshops.html

### *Economic Impact Analysis*

Tom Stinson, State of Minnesota and University of Minnesota

This project was designed to provide estimates of the indirect national economic costs associated with a terrorist attack on the nation's food supply chain. That information will be of use to policy makers as they decide on the level of resources to be devoted to programs designed to combat terrorism. The objectives were:
1) to develop realistic parameter estimates of the shocks to the economy that would follow a terrorist attack in the United States.
2) use those parameter estimates in a large-scale business cycle model of the U.S. economy to derive estimates of the short-term impacts of terrorism on U.S. GDP.
3) improve the information content going into homeland security budget decisions by informing policy makers about the potential losses in GDP that would accompany a terrorist attack.
4) present the results at conferences and publicize the results in policy oriented journals as well as academic journals.

Six major geo-political shocks affecting the U.S. economy were identified and monthly changes in key macroeconomic variables for the 12 months following each of those shocks were calculated. Mean values of the monthly shocks were then converted to quarterly values and used as inputs to create an alternative scenario for use in a large-scale macro economic forecasting model. That scenario was used to produce quarterly estimates of U.S. GDP for the four years following a terrorist event. The short-term economic impacts of the terrorist related shocks were assumed to have completely dissipated by the end of four years. Values for the terrorism scenario were then compared to those obtained using the baseline scenario and the quarterly differences in GDP noted. The simulation was run assuming the terrorist attack occurred in mid 2005. Under these assumptions the cumulative loss in real GDP over the four year forecast horizon totaled $190 billion before discounting to present value. That lost output is never recovered even though growth rates, after the terrorist shock has run its course, are assumed to return to normal. When larger shocks are assumed, the losses in economic output are substantially greater.

### *Consumer/Citizen Survey*

Jean Kinsey, University of Minnesota
Tom Stinson, University of Minnesota and State of Minnesota

This project compiled and analyzed data on consumers' attitudes toward food protection and defense activities. This data is relevant to determining appropriate levels of public sector resources for efforts to secure the nation's food supply, beyond current efforts to support food safety. Researchers conducted a large, nationwide household survey to collect information on consumers' awareness, concern, attitudes toward, and expectations for a security food supply. The project also assessed the relative value consumers place on reducing risk and damages from potential terrorist attacks on a variety of targets including deliberate food contamination.

The published results show that Americans are very concerned about future terrorist attacks and believe that protecting the food supply system and preventing the release of chemical or biologic agents in public areas should receive the greatest emphasis. On average U.S. residents would allocate about 13.3 percent more for food protection and about 12.0 percent more for protection against release of a chemical or biologic agent than they would for protection against another terrorist attack using hijacked aircraft. Currently about $5 billion is being spent to protect civil aviation while the 2005 budget provided $3.4 billion of fiscal authority for programs to protect against all types of catastrophic terrorist incidents. Americans would likely support additional spending to protect the food system and defend against release of a chemical or biologic agent.

Using "Predictive Segmentation" this study demonstrates that consumers can be grouped based on their general attitudes and values in such a way that their diversity can be captured in a simple framework of six segments reflecting striking differences with respect to their level of concern over potential terrorist attacks. The segments were named as follows: "Fear Tethered," "Principled & Self-Disciplined," "Intelligentsia," "Predestinarians," "Optimistic & Self-Reliant," and "Uncommitted C'est la vie." Each of these segments differ on their preferences for information should an attack happen, and on their preferred source of news. Based on their information

needs and media behavior, some preliminary guidance is offered for the development of communication strategies for each segment.

Only about 31% of consumers were confident that the food supply was safe. This varied by segment and demographic group.

### *Reduction of Economic Impact*

William Nganje, Arizona State University

Establishing priorities to reduce the economic impact of a terrorist attack on the food supply involves targeting limited resources to mitigate the greatest risk. Several economic and financial models were developed to evaluate cost-effective investments in security measures along the food supply chain and across food products (including lettuce, milk, small grains, ground beef, and poultry) and terrorist events. The specific objectives were to 1) design a database on costs and benefits of alternative mitigation strategies including real time tracking with radio frequency monitoring (RFEM), 2) develop real options - Tomato Garden models to determine where and when to invest in security measures, 3) assess the risk of food terrorism from within plant employees and outside terrorist using firm-level survey data. The firm-level survey was completed in conjuncture with risk communication experts.

Our year one objective involved developing of real option models (for small grains, fresh vegetables, and milk) to value private or firm-level and public sector investments to mitigate agroterrorism risk in the food supply chain. The real option model results identified areas where investment in food protection measures is recommended now, and areas along the supply chain where such investments will not be economically beneficial. The stochastic optimizations models reveal that caution should be taken to tighten security measures because these can have adverse effects on buyer/seller risks. We also concluded that organizations that function with high reliability are more effective in reducing risk from terrorism and potential economic impacts.

### *Statistical Risk Metrics*

Hamid Mohtadi, University of Wisconsin–Milwaukee and University of Minnesota

A new dataset was developed on criminal/terrorist activities involving the use of chemical, biological or radio-nuclear (CBRN) agents on a global scale over the past 40 years. These include agents that would be the likely candidates to be used for any food-sector incident. A risk metric was constructed using a novel statistical technique known as Extreme Value Theory to calculate probabilities and forecast the risk of such CBRN events at different casualty levels. Due to the large sample requirements of this method, however, we succeeded in our analysis only when we combined this dataset, with a much larger dataset that we compiled, event-by-event, from an existing dataset (MIPT) of nearly 24000 observations.

The essence of our method stems from the observation that extreme events are not normally distributed, but belong to some variant of "fat tailed" distributions. Here, traditional statistical methods fail, but a method based on Extreme value theory (EVT) can accurately estimate such fat tails. Using this method, we thus estimated the probabilities of extreme terrorism events. We also compiled a unique dataset of 448 observations on CBRN events gathered from
numerous primary sources such as newspaper articles, internet postings, de-classified intelligence documents, as well as an earlier literature on terrorism. Such data did not exist before. (The previously largest dataset on CBRN recorded only 41 incidents). Our dataset has been made publicly available to users via the NCFPD website, http://www.ncfpd.umn.edu/. Our data suggest a dramatic rise in attacks on food and water supplies globally. One important finding, among many others, was forecasting the likelihood of catastrophic events with large fatalities or injuries. For instance an event on the same scale as Aum Shinrikyo's attack on the Tokyo subway, with over 5000 injuries and fatalities, could occur by 2009 (as of June of 2006). The reoccurrence period for an attack of this size however is becoming shorter and by 2020 is expected to occur every 2 ½ years.

### *Determining Optimum Investments in Security Measures and Assessing Vulnerability in Information Flow*

Hamid Mohtadi, University of Wisconsin–Milwaukee and University of Minnesota

The incidence of food security breaches has been on the rise over the past decade. The goal of this project was to devise an optimum investment strategy by food companies (retailers and manufacturers) to mitigate exposure to catastrophic risks. Our results suggest that, in comparison to a regulated rate for terrorism risk insurance, the optimum level of investments to mitigate risk is somewhat larger, but does depend on the level of risk. However, the limitations that exist on the availability of catastrophic insurance at these regulated rates, and their high level of deductibility, together with the one-time nature of the alternative risk-mitigating investment strategies suggest that such investments should be undertaken whether or not catastrophic risk insurance is available, particularly as their impact on risk financing may not be negligible at all.

### *Models of Interdependent Security in Food Supply Chains*

Vicki Bier, University of Wisconsin–Madison
William Nganje, Arizona State University

This research focused on protection from terrorism using risk analysis and game theory. In particular, game-theoretic models were developed to evaluate how investments in security by some partners in the supply chain can affect the risks and returns faced by others. Stochastic optimization models were also used to evaluate the costs, risks, and returns associated with security investments.

The results of our analysis revealed that there can be multiple equilibria for investment in security. This can prevent the socially optimum investment strategy from being reached, in the absence of some type of coordinating mechanism. Therefore, it might be beneficial to institute some type of coordinating mechanism to ensure that players invest when that is the social optimum. Examples of such mechanisms can include low-interest loans or contracts between supply-chain partners, voluntary standards by trade associations, or regulations. Empirical analysis also suggests that price discounts and perceived increases in the probability of a terrorist attack can provide better incentives for participants to invest in security than direct subsidization of security.

### *The Role of Information Transmission and Coordination in Supply Chain Resiliency*

Hamid Mohtadi, University of Wisconsin–Milwaukee and University of Minnesota

This project was an empirical analysis of firms' response to safety, security and resilience considerations in food supply chains. The concepts of safety, security and resilience are strongly intertwined and there are spillovers. Specifically, this research measures firms' preparedness as indicative of how well the firms will be able to cope with food security incidents. This work is also linked to a second segment of the research funded by CREATE (another DHS Center of Excellence) which focuses on the analytical aspects of modeling resilience in terms of the economic incentives and disincentives for firms risk minimizing investments when faced with risky inputs of production.

The results of our analysis suggest that size and scope of a firm could determine its security behavior. Although the relation may not be exactly linear, but the interaction of these two factors could explain behavioral differences in resilience of firms. Our efforts are now directed towards improving our clustering procedure to get more refined clusters that will help us in teasing out the firm characteristics effects. We find in our analysis that a large number of firms complete all the regulatory compliance procedures, have information systems, senior management attention and prevention, detection and response capabilities in place. However, there is very little collaboration along the supply chain apart from what is prescribed by regulation. Firms also lack strong security education programs for their corresponding suppliers. Thus the culture of security and shared concern across the supply chain is yet to be imbibed. Another important and concerning fact that has emerged from our analysis is that a certain section of the large firms are more negligent towards security practices than smaller firms. The research explores the causes of this phenomenon.

### *Supply Chain Standards*

Omar Helferich, Griggs and Associates LLC
John Griggs, Griggs and Associates LLC

The primary goal of this research was the development of a Food Safety and Defense Standards Process that defines the steps that all food safety and defense ("protection") programs must consider to achieve Best Practice. The objective was to assist in the implementation of integrated standards processes across the extended food supply chain to better defend against a catastrophic food supply chain system incident.

The research has led to the development of a recommended 10 Step Food Safety and Defense Standards Process that can serve as a framework for any corporation addressing food protection issues across its extended food supply chain, including, but not limited to, links with suppliers, customers, health agencies, and NGO response organizations. A Best Practices Food Safety and Defense Standard Process will assist in addressing the following:

- Assignment of security responsibility within the organizational unit and site
- Development of security policies/procedures/guidelines
- Transfer of competence through employee security awareness, documentation, and training
- Controlling access to people, property, product, information and facilities
- Reporting security related incidents and responding to reported incidents
- Annual validation of security systems and services
- Areas of collaboration across the supply chain including customers, suppliers, and agencies

### *Supply Chain Food Protection and Defense Incident Management Infrastructure*

John Griggs, Griggs and Associates LLC
Omar Helferich, Griggs and Associates LLC

The project objective was to implement a prototype version of a web-based decision support tool that could significantly reduce the time required to identify sources of contamination in the food supply chain and, concurrently, more rapidly identify points of consumer purchase or consumption placed at-risk by specific sources of food supply chain contamination. The name given to the developed prototype decision support tool is Rapid Track and Respond, or RTR. The value proposition of Rapid Track and Respond lies in its ability to: 1) Reduce the level of illness and death caused by a food supply chain incident by providing critical information access to agencies seeking to determine the root cause of an incident and protect consumers; 2) Mitigate economic damage to food supply chain members by providing critical information access that allows supply chain members to reduce unnecessary short term losses (e.g. disposal of product) and maintain consumer trust.

## Education Projects

### *Educational Programs*

Ed Mather, Michigan State University

A conference was held on April 16-17, 2007 in East Lansing, Michigan to report the findings from the work carried out by a learning community of individuals, subcommittees and additional groups contributing to education needs nationwide, and to provide an evaluation and determination of the status of education specifically related to the protection and defense of our nation's food system since 9/11. Special attention was to be given to the merit of "partnering" within the food system, the evolution of international and global component in the food system, an assessment of student audience participation, and to the determination of effective delivery methods appropriate to students in 2007 and beyond. An 81-page report from the conference has been published and is available.

A substantial number of graduate level courses in homeland security in general, and specifically in food protection and defense, are being developed and successfully implemented at major universities. In addition, there are

non-credit courses, seminar series, short-courses, workshops, and a variety of printed and electronic materials available for students seeking education material in food defense. As was the case with the National Academies (National Research Counsel) report (2005), little sentiment was voiced for support of structured programs in food defense at the undergraduate level. The group left unresolved the need for separately identified multi-course graduate degree programs in food defense. Also unresolved is public ambiguity as to what should constitute a specific curriculum for a course, a certificate, a program, or a degree.

Within the past decade, and especially the past three years, the magnitude of international trade has mushroomed, further globalizing the food supply. Unresolved is how extensive our global food supply will become and what our responsibility will be to educate non-domestic students in food defense. As with general homeland security offerings, food defense offerings utilize traditional classroom, seminar, on-line, experiential learning opportunities, and other delivery settings to a wide range of audiences. While only minimally discussed when this project was initiated, the use of "educational gaming" as a delivery method in food defense education has become an area of potential and effective delivery of information. Thus, future research should examine educational gaming, blogs, and the multitude of newer communication avenues being offered to the public for their effectiveness as educational delivery tools.

Creating a uniform and acceptable definition of specific terms or words remains a difficult task considering the very broad range of participants involved with food defense education. It was observed throughout the project that different groups preferred terms that were acceptable to their particular audience. Unresolved is the use of a common term by numerous agencies, industries, cultures, and nations for food protection, food defense, food security, bio-security, agro-security, or food terrorism.

"Partnering" was an all-inclusive term used throughout the conference and many examples were made where education success was a result of combined action and effort of groups that are usually detached. Substantial agreement was reached that inclusion of skilled faculty from other DHS Centers have contributed to the broad intellectual resources needed to address food defense and have aided in protecting our food supply.

### *Assessment of Industry Use of Best Practices for Food Security*

Fred Shank, Institute of Food Technologists

The goal of this project was to compile, analyze, and assess current guidance and recommendations pertaining to best food defense practices with regard to intentional attack on the food supply, and generate an educational tool to help individuals in the food industry, particularly small and medium-sized companies, improve their food defense plans.

IFT developed a mechanism to assist those in industry in determining which food defense practices, currently considered "best practices" are actually being implemented by their facility using a self explanatory, user friendly tool. Various programs and systems exist that provide physical security "best practices" of food processing facilities and efforts are underway to develop a more comprehensive approach to address the potential risk to the food industry of a specific intentional act of terrorism or contamination. This project created a tool that allows an individual to address whether or not these best practices are being practiced through a comprehensive security program that includes acquisition of ingredients, plant security including personnel, product security, etc.

Using the assessment tool developed, it is possible for a plant employee or external auditor to assess current practices pertaining to security for potential intentional contamination of food and to improve the understanding of general security measures in the overall food production operation.

*Risk Communication Training*
William Hueston, University of Minnesota, and Timothy Sellnow, University of Kentucky

The NCFPD Risk Communication Project strives to enhance the nation's food defense capacities through translational research, risk communicator training development and rapid response deployment. These activities are defined by best practices in effective risk communication for active engagement of multiple audiences prior to, during and after potentially catastrophic foodborne outbreaks.

**Multi-disciplinary Risk Communication Team**
The NCFPD Risk Communication Project Team is represented by scholars and experts from communication, food science, veterinary medicine, public health, journalism, and education from sixteen institutions and organizations. In addition, the team members include liaisons from the NCFPD Event Modeling, Systems Strategies and Education theme groups to encourage integration of risk communication throughout the food defense project. Team members have also collaborated with the NCFPD Economic Analysis Team in assessing consumer perceptions. In addition, team members are participating in a risk communication project with FAZD (the National Center for Foreign Animal and Zoonotic Disease Defense)
Through monthly conference and on-site working meetings, the Risk Communication Team functions as a 'think tank' in analyzing emerging events, responding to industry and government requests in addition to conducting research projects and developing training resources that expand the utilization of risk communication as a mitigation strategy.

**Translational Research**

*Message Testing with Underrepresented Populations*
Robert Littlefield, North Dakota State University

The primary objective of this project was to determine the variance in message needs and receptivity among under-represented populations and mainstream American consumers.

Data was collected using focus groups and surveys. Information was collected from several groups: Native American tribes; Hmong, Middle Eastern, and Somali immigrants; and African Americans. Participants viewed a variety of messages and their receptivity to each was measured and discussed.

Clear distinctions were drawn for each population studied. Generalizable concerns were summarized in a booklet for distribution to those charged with communicating about foodborne crises to under-represented populations. Some key challenges that were identified include diverse learning styles, history of mistrust, lack of trust for mainstream media, and a general lack of access to information.

*Rapid Response Communication Survey*
William Benoit, University of Missouri-Columbia

The primary objective of this project was to develop and test a survey instrument that can be administered to a wide sample of American consumers immediately following a catastrophic foodborne event to provide an accurate portrayal of how people respond to the crises, what type of information they find useful, and where they seek their information.

Using the theory of planned behavior and a review of existing instruments, a survey instrument was developed. The instrument was tested following the Virginia Tech shooting crisis in the spring of 2007. The results are currently being analyzed.

### *Consumer Perceptions Data Analysis*

Steven Venette, University of Southern Mississippi

The objective of this project was to test various message types to determine their receptivity by key stakeholders. Much of the data for this project involved a survey of the general population in response to the spinach recall that occurred late in 2006. Consumers were surveyed to determine their knowledge level about the crisis, their preferred channel of information (e.g., television, internet, newspaper), their most trusted source of information (e.g., speaker, agency), and their preferences in terms of message type.

Some preliminary findings indicate that the media is most trusted, followed by government agencies; public figures such as the president, other politicians, and agency leaders; health professionals, and subject matter experts. In general, respondents favored messages that focused on what they should do to remain healthy over messages that focused on the scientific details of the case. This project creates opportunities for future collaboration with the food recall project and with the under-represented populations project. The information generated by this project is particularly useful in determining the most effective type of information, channels of information, and general approach for writing and delivering emergency messages in a catastrophic foodborne event.

**Risk Communicator Training for Food Defense Preparedness, Response and Recovery**

The 5-module training curriculum has been piloted in four settings with public health, industry and government stakeholders. To encourage the use of NCFPD resources by food system stakeholders, all training materials have been posted on the International Food Information Council (IFIC) website. Because the majority of the online training resources material has been presented in formats that can be modified, various stakeholders have adapted the NCFPD materials to meet the needs of their constituencies. For example, JIFSAN located at the University of Maryland, included many of the training slides into their risk communication training course in July, 2007.

**Stakeholders Relations**

The Risk Communication Project has convened three meetings for food system stakeholders from government and industry. In addition, Risk communication project overviews have been presented to the DHS Office of Health Affairs, FDA, CFSAN and USDA FSIS/OFDER staffs. These meetings have provided opportunities for key stakeholder from industry and government to respond to the team's research priorities, training objectives, and emergency response preparedness activities.

**Rapid Response Preparedness**

The Risk Communication Team has collaboration with NCFPD in developing components of Center Response plan to address emerging catastrophe food-related events. A principle component of the NCFPD plan is for the deployment of a Risk Communication Rapid Response Team to develop content for a just-in-time risk communication briefing for key food system organizations. In addition, the Response Team would be available to review NCFPD key messages, coach NCFPD investigators serving as subject matter experts for media interviews, and to monitor public response to emerging events.

### *Web-Based Ten Best Practices of Risk Communication Training*

Paul DeVito, Saint Joseph's University

The online training developed is an entry-level awareness course designed to build awareness about food defense and risk communication. The course is divided into two lessons.

The first lesson focuses on providing an overview of food terrorism, including recent incidents, food system vulnerabilities, food terrorism agents, common perpetrators, tactics used to contaminate a food supply and the impact of and public reaction to a food terrorism incident. Lesson one also outlines the goals of food defense and provides an overview of U.S. food defense initiatives, including the Bioterrorism Act of 2002 and the Homeland Security Presidential Directive nine (HSPD 9).

Lesson Two highlights the importance of risk communication during a food terrorism incident. This lesson provides an introduction to risk communication, explains the importance of risk interpretation, identifies components of an effective risk message and provides recommendations on how to successfully deliver a risk message.

# Appendix B

**Decontamination Guides**

## Decontamination guide for *B. anthracis spores*

Scope: *This guide is intended to help bioremediation specialists to choose an effective cleaning and sanitation protocol for a food processing facility that is known to be contaminated with B. anthracis spores. This guide does not address personal protection, chemical safety, or biosafety procedures. Following this guide does not negate the need to verify material compatibility before cleaning, and to verify decontamination effectiveness with microbiology or other testing after procedures are complete.*

| | |
|---|---|
| Step 1<br>Remove bulk food: | Before chemical application, remove as much bulk food as possible. Chemical decontamination efficacy is reduced by the presence of foods. |
| Step 2<br>Preliminary decontamination: | Pick a decontamination protocol based on the cleanliness of the surface (with respect to food residues) and the biocide available. Use the information in Table 1 to identify the biocide concentration. |

| Surface condition | Biocide choices[1] | Application choices |
|---|---|---|
| 1) No food residue<br>2) Starch residue<br>3) Milk residue<br>4) Egg residue*<br>*Also use for mixtures of protein and fat | 1) Sodium hypochlorite<br>2) Acidified sodium chlorite<br>3) Hydrogen peroxide<br>4) Peroxyacetic acid<br>5) Peroxyacetic/octanoic acid | Time:<br>10 or 30 minutes<br><br>Temperature:<br>10 to 30 °C (50 to 86°F) |

| | |
|---|---|
| Step 3<br>Drain: | After preliminary decontamination is complete, let the biocide drain from all treated surfaces. |
| Step 4<br>Clean & water tinse: | Clean all surfaces thoroughly follow standard operating procedures for that facility. A chlorinated alkaline detergent is recommended. |
| Step 5<br>Secondary decontamination & water rinse: | Same as Step 2 except pick a decontamination protocol based on a clean surface (no food residue) and the biocide available. Use the Information In Tables 1 to 5 to identify the recommended concentration. Follow with a water rinse. |
| Step 6<br>Sanitizing rinse: | Rinse any direct food contact surfaces with an EPA registered food contact surface biocide. |

[1]Biocides used to develop these recommendations:

Ecolab Inc. *XY-12* (Sodium hypochlorite)
Ecolab Inc. *Exspor* (Acidified sodium chlorite)
Sigma-Aldrich Inc. food-grade hydrogen peroxide
Ecolab Inc. *Oxonia Active* (Peroxyacetic acid and hydrogen peroxide mixture)
Ecolab Inc. *Vortexx* (Peroxyacetic, octanoic acid and hydrogen peroxide mixture)

## Decontamination guide for *Yersinis pestis*

Scope: *This guide is intended to help bioremediation specialists to choose an effective cleaning and sanitation protocol for a food processing facility that is known to be contaminated with Y. pestis. This guide does not address personal protection, chemical safety, or biosafety precautions. Following this guide does not negate the need to verify material compatibility before cleaning, and to verify decontamination effectiveness with microbiology or other testing after procedures are complete.*

| | |
|---|---|
| Step 1<br>Remove bulk food: | Before chemical application, remove as much bulk food as possible. Chemical decontamination efficacy is reduced by the presence of foods. |
| Step 2<br>Preliminary decontamination | Pick a decontamination protocol based on the cleanliness of the surface (with respect to food residues) and the biocide available. Use the information in Table 2 to identify the biocide concentration. |

| Surface condition | Biocide choices[1] | Application choices |
|---|---|---|
| 1) No food residue<br>2) Starch residue<br>3) Milk residue<br>4) Egg residue*<br>*Also use for mixtures of protein and fat | 1) Sodium hypochlorite<br>2) Acidified sodium chlorite<br>3) Hydrogen peroxide<br>4) Peroxyacetic acid<br>5) Peroxyacetic/octanoic acid<br>6) Quaternary<br>7) Iodophor | Time:<br>10 or 30 minutes<br><br>Temperature:<br>10 to 30 °C (50 to 86°F) |

| | |
|---|---|
| Step 3<br>Drain: | After preliminary decontamination is complete, let the biocide drain from all treated surfaces. |
| Step 4<br>Clean & water tinse: | Clean all surfaces thoroughly follow standard operating procedures for that facility. A chlorinated alkaline detergent is recommended. |
| Step 5<br>Secondary decontamination & water rinse: | Same as Step 2 except pick a decontamination protocol based on a clean surface (no food residue) and the biocide available. Use the information in Tables 6 to 12 to identify the recommended biocide application concentration. Follow with a water rinse. |
| Step 6<br>Sanitizing Rinse: | Rinse any direct food contact surfaces with an EPA registered food contact surface biocide. |

[1]Biocides used to develop these recommendations:

Ecolab Inc. *XY-12* (Sodium hypochlorite)
Ecolab Inc. *Exspor* (Acidified sodium chlorite)
Sigma-Aldrich Inc. food-grade hydrogen peroxide
Ecolab Inc. *Oxonia Active* (Peroxyacetic acid and hydrogen peroxide mixture)
Ecolab Inc. *Vortexx* (Peroxyacetic/octanoic acid and hydrogen peroxide mixture)
Ecolab Inc. *Whisper* (Quaternary ammonium chloride)
Ecolab Inc. *Mikroklene DF* (Iodophor)

# Appendix C

## Risk Communication 10 Best Practices

# Best Practices for Effective Risk Communication

1. **Risk and Crisis Communication is an Ongoing Process**
   - Incorporate risk communication into the policy development process
   - Continuously evaluate and update crisis communication plans

2. **Conduct Pre-Event Planning and Preparedness Activities**
   - Address existing, emerging and anticipated issues
   - Determine how to reduce risk, plan an initial response, update regularly
   - Conduct practice exercises and drills

3. **Foster Partnerships with Public**
   - Identify your "publics"
   - Build positive relationships with key publics before a crisis occurs
   - Publics could include consumer groups, racial and ethnic communities, stakeholders, etc.

4. **Collaborate and Coordinate with Credible Sources**
   - Establish strategic relationships and networks before a crisis
   - Identify subject area experts

5. **Meet the Needs of Media and Remain Accessible**
   - Recognize that the media is the primary channel to the public
   - Participate in media training
   - Remember that the media is not the enemy…

6. **Listen to Public's Concerns and Understand Audience**
   - Respond to the public's beliefs whether or not they are accurate
   - Monitor a full range of communication formats: hotlines, letters to the editor, radio talk shows, public forums, blogs, etc.

7. **Communicate with Compassion, Concern and Empathy**
   - Enhances credibility and perceived legitimacy
   - These characteristics do not preclude professionalism

8. **Demonstrate Honesty, Candor and Openness**
   - Without openness, the public will seek information from less accurate sources
   - Recognize that situation involves risk sharing

9. **Accept Uncertainty and Ambiguity**
   - Acknowledge inherent uncertainty of crisis and risk
   - Assure that accurate and reliable information will be shared as soon as it is available

10. **Give People Meaningful Actions to Do (Self-Efficacy)**
    - Helps restore sense of control over an uncertain and threatening situation
    - Present as must do… should do… could do...

# Appendix D

## Bibliography of Publications by Project

**Publications**

The projects below are listed alphabetically, with the publications listed chronologically by year.

### *Biosensors for Detection of Chemical Toxins (Paul Takhistov, Rutgers University)*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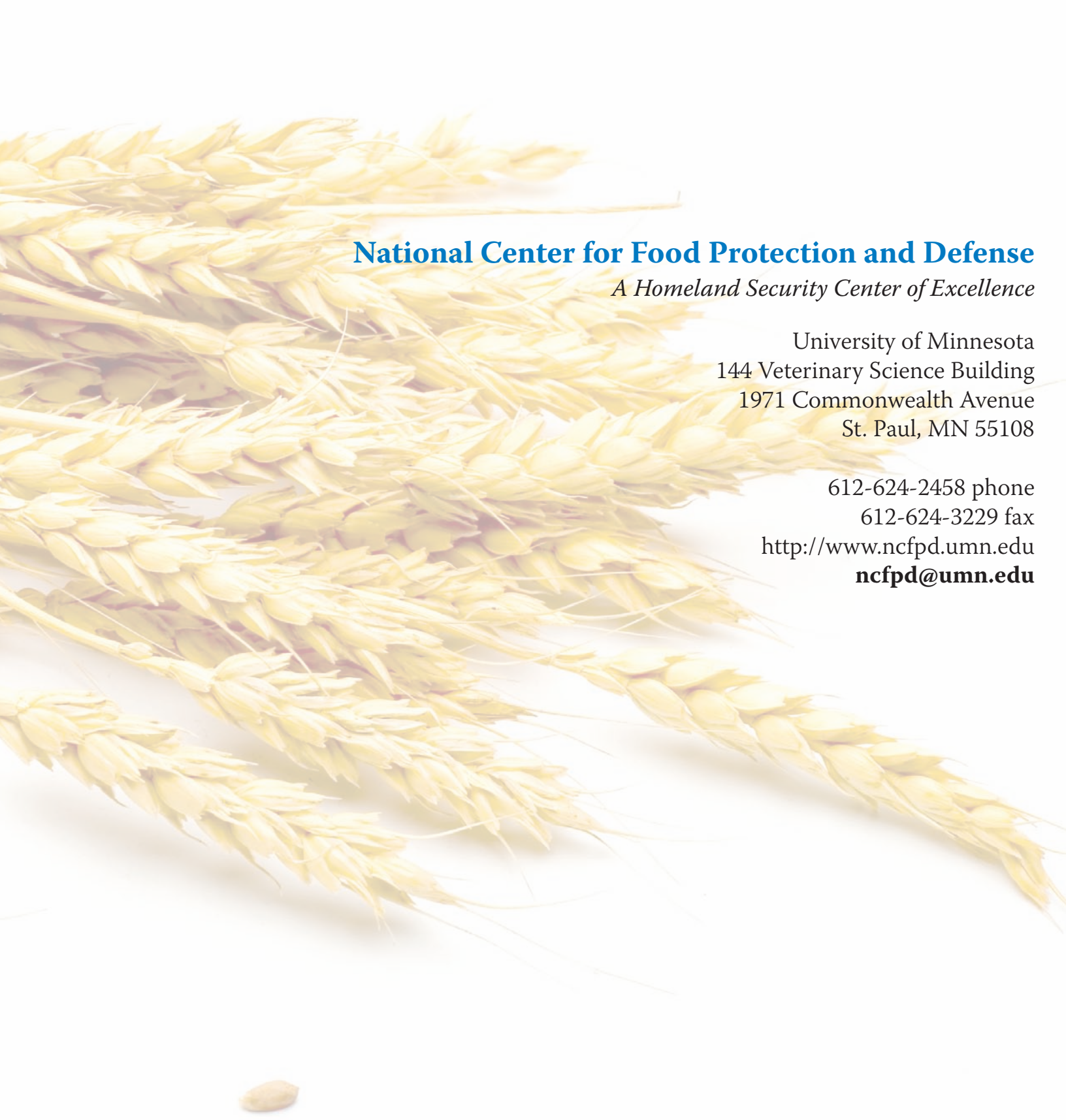
This publication was developed under DHS Science and Technology Assistance Agreement No. N-00014-04-1-0659 awarded by the U.S. Department of Homeland Security. It has not been formally reviewed by DHS. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security. The Department of Homeland Security does not endorse any products or commercial services mentioned in this publication.

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