Joint Institute for Food Safety and Applied Nutrition, University of Maryland

2134 Patapsco Building
5201 Paint Branch Parkway
College Park, MD 20742

Tel 301-405-8382

Fax 301-405-8390

www.jifsan.umd.edu

ANNUAL REPORT

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Mission

JIFSAN advances sound strategies that improve public health, food safety, and applied nutrition using risk analysis principles through cooperative research, education, and outreach programs.

Vision

To be a premier source of scientific information and education programs on food safety and applied nutrition that enables the development of sound public health policy and reduces the incidence of food-related illness.

From the Director

JIFSAN has made tremendous strides toward becoming a strong, sustainable organization that provides research, education and outreach opportunities in food safety and applied nutrition. This report summarizes JIFSAN's accomplishment in its programs during calendar year 2014. Our efforts in developing sustainable partnerships for training with the global food safety community have paid off. JIFSAN will continue working closely with FDA and other partners to help ensure the safety of the global food supply.

Jianghong Meng, PhD

Director

Contents

Research Initiatives

JIFSAN continues to work with scientists at FDA, UM and other organizations to conduct innovative research to address major issues in food safety, applied nutrition, and other areas that impact the public health (Appendix B). During this reporting period, projects funded through JIFSAN's internal research program and internship program, and research collaborations between JIFSAN and FDA have generated 13 publications in peer-reviewed journals and 5 presentations/abstracts at research conferences (Appendix C). Research progress of several projects is highlighted below:

<u>Genomic analysis of *Salmonella* and Shiga toxin-producing *Escherichia coli* (Lead – J. Meng, UMD; E. Brown and M. Allard, FDA)</u>

Whole genome sequencing (WGS) is a powerful technology that can be used to detect and track foodborne pathogens, and to investigate the mechanisms of virulence and antimicrobial resistance. *Salmonella* Bareilly was implicated as the cause of an outbreak associated with frozen raw yellowfin tuna used for spicy tuna sushi from Moon Marine USA Corporation in 2012. WGS analysis was performed among a representative set of 100 isolates of the pathogen, including those from the 2012 outbreak. The data showed WGS was able to differentiate outbreak strains from the rest of closely related *S.* Bareilly, proving as a powerful tool for outbreak investigations. The technology was also used to analyze plasmids responsible for resistance to multiple antimicrobials (MDR) in *Salmonella*. MDR determinants are often encoded on mobile plasmids, which enhances the likelihood for transfer of MDR phenotypes from foodborne pathogens to more virulent human pathogens. An efficient plasmid isolation protocol directed for use with *Salmonella* serovars was developed for sequencing with the PacBio technology. The DNA of IncA/C plasmids derived from six serovars was sequenced. An evolutionary picture of antimicrobial resistance development in *Salmonella* was determined as a consequence of these plasmids, which help elucidate mechanisms of the development and dissemination of antimicrobial resistance in *Salmonella*.

We also sequenced, assembled and closed plasmids from *S.* Typhimurium of National Antimicrobial Resistance Monitoring System (NARMS) and historical collections. These isolates were from humans, animals and retail meats over the last 60 years. Thirty isolates were completely closed for their genomes and plasmids, and were annotated, analyzed and classified for diverse resistance (and other) extra-chromosomal gene classes carried on plasmids.

A collection of historic *E. coli* O157 strains (*n* = 400) in the late 1980s to early 1990s in the United States were examined. They were predominantly serotype O157:H7 (55%), and various O157:non-H7 (41%) serotypes that were not previously reported regarding their pathogenic potential. Although lacking Shiga toxin (*stx*) and *eae* genes, serotypes O157:H1, O157:H2, O157:H11, O157:H42, and O157:H43 carried several virulence factors. Strains from two particular H types (H2 and H11), among the most commonly found non-O157 EHEC serotypes (O26:H11, O111:H11, O103:H2/H11, and O45:H2), unexpectedly clustered more closely with O157:H7 than other H types and carried several virulence genes. This suggests an early divergence of the O157 serogroup to clades with different pathogenic potentials. The appearance of important EHEC virulence markers in closely related H types indicates their potential to cause illness in humans. Monitoring of those serotypes in food safety surveillance programs would help prevent foodborne infections caused by non-O157 STEC.

Bioinformatics for characterization of foodborne pathogens (Lead – R. Stone, University of New Castle; J. Meng, UMD; E Brown and M. Allard, FDA)

Several bioinformatics methods were developed to analyze genomics data of foodborne pathogens under different storage and growth conditions. Analytic methods on differential gene expression patterns between different foodborne pathogens (*Salmonella*, *E. coli* and *Listeria*) were developed. *K*-means is a clustering method of vector quantization; originally from signal processing that is popular for cluster analysis in data mining. The *k means* clustering of gene expression datasets was explored for bacterial gene expression data of bacterial growth phases using RNA-Seq sequencing data. This has the potential to be used in other conditions, e.g. a different number of nutritional growth mediums or a different number of environmental conditions.

Analytical methods were also developed to identify the location of potentially modified nucleotide bases in both genic regions and non-genic regions. These methods exploited the potential to identify DNA modifications because when sequencing bacterial genomes using Pacific Biosciences RS instrument, sequencing is detected by synthesis by a DNA polymerase. Sequencing by synthesis records the time point of the incorporation of a nucleotide base by a DNA polymerase, as well as the detection of what type of base is incorporated into the growing sequencing DNA strand. Delays in the incorporation can be associated with a modification of the nucleotide in the opposite DNA strand.

We also developed a method for predicted epigenetic DNA motifs to be searched against the annotated GenBank datasets of *Salmonella* of whole closed genomes sequenced using Pacific Biosciences. We were able to identify motif patterns that can be matched against potential

modified bases and the associated gene and non-gene region results reported. At least one fully annotated closed GenBank file is required (chromosome and/or plasmids) and the corresponding modification gff file (Gene-Finding Format) from the Pacific Biosciences instrument to successfully process data files.

Enhance Model Capacity and Expand Library of Risk Scenarios (Lead – G. Paoli, Risk Sciences International; Y. Chen, FDA)

The FDA risk ranking tool FDA-iRISK is a web-based tool that allows users to evaluate the risk posed by various food-borne hazards in the food supply, and conduct a preliminary ranking of these hazards in order to efficiently prioritize risk management options.

In 2014, chemical risk scenarios including arsenic, cadmium, and lead were developed. The health outcomes selected for arsenic and cadmium were chronic effects (e.g. cancers and kidney disease) because those are the adverse effects associated with prolonged exposure to these two compounds. For lead, the adverse effect, intellectual disability, occurs shortly after or concurrent with exposure. Therefore the health effect period considered for arsenic and cadmium was a lifetime, consisting of two years of consumption of the contaminated food (babyfood) followed by 68 years of no consumption of the food, whereas the health effect period considered for lead was immediately following a two year period of exposure during infancy.

Burden is estimated for consumers of individual foods, however the dose response model for lead is a threshold model and therefore the diet should be considered in totality. A "multi-food" consumption model was developed, in which the per capita consumption of the four foods across all infants aged birth to 24 months was represented, and the scenarios were also implemented using this model. The threshold for lead was not exceeded even using the multi-food consumption. The multi-food model produced a smaller estimate of burden due to cadmium, as spinach is the main source of cadmium among the four foods and is eaten by relatively few infants, whose consumption is not well-represented in the multi-food model.

Extracting Mentions of Adverse Effects of Nutritional Supplements from Social Network Postings by Consumers (Lead – Garcia Gonzalez, Arizona State University)

The goal of this project was to establish and evaluate the basic software infrastructure to enable surveillance of potential adverse event reports through natural language processing of online user-generated postings about CFSAN-regulated products. Techniques developed from this project could be used to develop tools to monitor social media sites and identify CFSAN-

regulated products associated with adverse events. This information can be used to focus CFSAN's enforcement efforts for nutritional supplements. We collected and annotated approximately 40,000 Amazon.com reviews from 2708 products. These products were grouped by their Amazon.com product categories. The system enables us to assign a score to each product in each category with respect to others in the same category that reflects, relative to the products in the category, the tendency of comments for the product to contain more (or less) references to adverse effects. The scores indicated that the novel scoring approach resulted in a spread of scores for the category, likely to reflect the safety of the products with respect to others in their class. The ongoing expert-driven validation of these results will allow us to establish this novel technique as a data-driven (unsupervised), user-generated content analysis platform that allows the identification of nutritional products that seem to deviate from the norm for their class in terms of adverse reactions reported.

One limitation of the scoring system is that it could miss occurrences of serious effects if they are only reported a few times, as the method proposed does not rely on specific mentions, but on the overall trends of the comments for the different products in the class. This could be addressed by complementing the score-based classification with a rule-based system that is geared to detect serious effects through phrases such as "had to call 911" or "went to the ER".

Risk Perception and Fatalistic Belief as Predictors of Information Seeking and Sharing related to a Food Recall (Lead – Xiaoli Nan, UMD; Linda Verrill, FDA)

This research examined how risk perception and fatalistic belief predict information seeking and sharing related to a food recall based on the 2010 Food Safety Survey conducted by FDA (N = 1,780). More people believe they are at risk of getting food poisoning by consuming a recalled food, the more likely they will seek and share information about the recall. People who are more likely to seek information about a food recall possess a higher education level and are non-black. In comparison, people who are more likely to share information about a food recall tend to be women, have a lower education level, and are Latino. Whether or not people hold fatalistic belief about food poisoning is not a significant predictor of information seeking and sharing. Neither is the interaction between risk perception and fatalistic belief. The findings will help develop more effective ways for food recall and other food safety information to reach consumers.

International Food Safety Trainings

Training programs constitute a significant component of JIFSAN's mission. The support for the programs has been leveraged through partnerships with host countries, industry, and government agencies, which is key to JIFSAN's success for expanding international training activities.

JIFSAN offers several training programs that are mostly delivered in-country, including Good Agricultural Practices (GAP), Good Aquacultural Practices (GAqP), Commercially Sterile Packaged Foods (CSPF), and Food Inspector Training (FIT). International Food Safety Training Laboratory (IFSTL) program supported through a public-private partnership has established itself as a global center that teaches various methods for detecting and identifying chemical and microbial contaminants in food. Programs conducted in 2014 are listed in Appendix D.

Expanded GAqP Program

This program has recently expanded significantly to include a full-week offering in Good Fishing Vessel Practices (GFvP). The GAqP and GFvP programs both offer the option for participants to obtain Seafood HACCP Certification (+HACCP) if they satisfy all of the requirements. In 2014, the GFvP and GAqP program were offered in Indonesia in August and September. HACCP program was included in collaboration with the Fish Quarantine and Inspection Agency Ministry of Marine Affairs and Fisheries.

Global Collaborative Training Initiative

Phase II of the CSPF Collaborative Training Center with Thailand was held on May 12 – 23, 2014 in JIFSAN and IFSH (Illinois Institute of Technology, Institute for Food Safety and Health) for 11 selected participants from the Phase I training in 2013. Phase III programs of Supply Chain Management for Spices and Botanical Ingredients (SMSBI) in India were in progress as per the agreement with the India Spices Board and CII-FACE. Reports from our India collaborators indicate that about 15 programs have been conducted with over 500 people trained.

International Food Safety Training Laboratory (IFSTL)

The IFSTL continues to grow and expand its course offerings. For example, in order to meet the demand on advanced technologies and the need of FDA's GenomeTrakr program, JIFSAN developed and offered the first laboratory training program on whole genome sequencing in collaborating with FDA. The course will be offered again in 2015.

We have also expanded our networking activities in an effort to secure additional funding and increase participant enrollment. Extramural funding was secured through U.S. government funding opportunities and industry to provide both partial and full support for participants to the laboratory trainings. JIFSAN has also developed close collaborations with the World Bank's Global Food Safety Partnership (GFSP) program, and took the lead in the Laboratory Capacity Building Expert Working Group since July 2014. An important new aspect of the train-the-trainer program is that the initial training at JIFSAN includes the development of organizational skills needed to host laboratory training; it was realized in previous reproductive trainings that new trainers have difficulties in the preparation phase of workshops. JIFSAN will be working with GFSP and China to pilot the program.

Global Capacity Building in Risk Analysis

JIFSAN's Food Safety Risk Analysis Professional Development Training Program offers an integrated program involving both a qualitative and quantitative track, residency risk analysis fellowship, customized in country training programs, and online distance learning. Since 2013, the program provides a refresher on quantitative risk assessment, advanced quantitative risk assessment, international food law and regulation, and food defense.

The demand for the integrated program has increased. In 2014 the integrated program was offered both in the summer and the fall with a record number of attendants. The combined summer and fall programs had 299 class seats. Participants represented China, Hong Kong, Jamaica, Japan, Korea, Malaysia, Nigeria, Saudi Arabia, Taiwan, as well as the United States.

JIFSAN's Foodrisk.org was updated to highlight unique items exclusively available to the risk analysis community. Several new items have been included:

Produce Point of Origin Database (PPOD), launched in July 2014. PPOD is a searchable database that provides selected commodity-specific information on the movement of produce in the United States, either domestic or international, based on seasonality data. JIFSAN built, hosts, and maintains this tool. PPOD facilitates access to source information of a particular commodity associated with on-going outbreaks, as well as historical data in a user-friendly format to evaluate how produce has moved through the country for a specific period of time. It also has commodity-specific facts on the shelf life of the produce; examples of related outbreaks, if applicable, for each type of produce; and links to CDC's Foodborne Outbreaks and FDA Outbreak Investigations web-pages.

On-Line What We Eat in America - Food Commodity Intake Database (FCID) was developed by EPA. FCID goal is to: (1) improve transparency of coded fields; (2) make recipes fully searchable; (3) make recipe format more user-friendly; and (4) enable users to estimate consumption of food commodities based off weighted mean and percentile calculations. The tool was improved with a newer dataset and improvements to the user experience in 2014.

Educational Resources for Training a Skilled Workforce

JIFSAN offers opportunities for both students and professionals through undergraduate research internship, graduate assistantship/postdoctoral fellow, and on-line distance learning programs, as well as scientific symposia, workshops and conferences (Appendix F). JIFSAN education programs have provided domestic and international participants tools and techniques to assure that food products are wholesome and safe for consumption. The JIFSAN Internship Program is a unique undergraduate research program designed to provide UM undergraduate students with an opportunity to collaborate with FDA scientists on specific research projects related to CFSAN's mission. The Internship Program continues to attract high caliber undergraduate students who are eager to have an opportunity to work with FDA researchers in a "hands on" environment. There were 25 students who participated in the program from June 2013 to May 2015 (Appendix E).

Appendices

A – JIFSAN Staff

Administration
Jianghong Meng, DVM, Ph.D. Director
Vernora (Nora) Petty, Assistant to the Director
Mary Grimley, Financial Officer
Pamela Biery, Business Services Specialists

International Training Program
Paul Mazzocchi, Ph.D., Associate Director
James Rushing, Ph.D., Manager
Judy Cooper, Coordinator
George Evancho, Senior Fellow

Risk Analysis Program
Clare Narrod, Ph.D., Manager

International Food Safety Training Laboratory (IFSTL)
Janie Dubois, Ph.D., Manager
Angela Winslow, Ph.D., Microbiologist

IT Program
Kyle McKillop, Coordinator
Timothy Shaffer, IT Support Assistant
Paul Guevara, IT Support Assistant
Scott Feingold, IT Programmer
Kai Yang, IT Programmer

Internship Program
Kaci Thompson, Ph.D., Director of Undergraduate Research &Internship Programs, College of Computer, Math and Physical Sciences, UM

B – Research and Extramural Projects

COOPERATIVE PROJECTS:

Project	Funding Source	Outcome	Impact
Enhance Model Capacity and Expand Library of Risk Scenarios of FDA-iRisk tool	FDA	RSI has done various improvements, bug fixes, and a major update to the FDA-iRISK public tool including the user guides and technical documentation	The improved tool will enable users to expand their ability to rank and compare risks from multiple foodborne microbial and chemical hazards and predict effectiveness of preventive control measures; an increase collaborations with other federal agencies, other countries and industry
Whole genome sequencing analysis of Foodborne Pathogens	FDA	Whole genome sequencing data showed genetic diversity and its association with virulence and antimicrobial resistance among different Salmonella serovars including Newport and Heidelburg [publication numbers 1, 2, 3, 4]. First fully closed genome sequence of S. Cubana from a foodborne outbreak was completed. The genome of multidrug-resistant S. Typhimurium var. 5 was also sequenced.	This research will provide data for better understanding of virulence and tools for more effective tracking Salmonella for the industry and regulatory agencies in field testing and outbreak investigations.

Virulence analysis of Shiga toxin-producing E. coli	FDA	Shiga toxin-producing E. coli (STEC) from food and other sources showed variations in their ability to cause illness in humans [5, 6, 7]. There was a strong association between potential virulence and serotypes. Certain serotypes were among most virulent groups of STEC. A genetic element termed CRISPR was also associated some specific serotypes and virulence.	A scheme based on virulence genes and other molecular characteristics can be used to differentiate highly virulent strains from less harmful organisms.
Genetic basis of disinfectant resistance in E. coli	FDA	Genes responsible for resistance to common disinfectants (quaternary ammonium compounds [QAC]) in E. coli and their association with antimicrobial resistance were analyzed [8]. They were commonly present in E. coli. The qac and sugE(p) genes were highly associated with multidrug resistance in E. coli.	Determine how the use of disinfectants in animal production and food processing environment plays a role in the development of resistance to antibiotics. Using QACs in the food industry may not be as effective as expected in disinfecting and could provide selection pressure for strains with acquired resistance to other antimicrobials.
Extracting Mentions of Adverse Effects of Nutritional Supplements from Social Network Postings by Consumers	FDA	A basic software infrastructure was developed. It enables surveillance of potential adverse event reports through natural language processing of on-line user-generated postings about CFSAN-regulated products.	The language technique may eventually provide the ability to detect the association of adverse events and products earlier than current surveillance methods.

Laboratory methods for food outbreaks	FDA	A multiplex PCR method to BioPlex method were analyzed and compared. The multiplex PCR method has the potential to be used in outbreak investigations	Faster methods for the identification of source of outbreaks potentially will improve the State, CDC and FDA response time to detect the food source and organism responsible for a food outbreak.

EXTRAMURAL PROJECTS

Project	Funding Source	Outcome	Impact
Student research project on measuring the effectiveness of hand washing	UMD student (unfunded), Waters Corporation (facility and faculty's salary)	A method to measure the effectiveness of hand washing was developed in this project. This method may become a reference for stakeholders who wish to use hand washing techniques other than suggested by the Food Code to demonstrate the effectiveness of the proposed alternatives. A publication in a trade journal is in preparation.	It is expected that the method developed in this research will enable stakeholders from the farming and food service industries to present quantitative data to FDA in support for proposals to implement hand washing techniques that differ from the technique described in the Food Code.
Leafy Greens and Tomatoes Safety Metrics (Lead - J. Meng)	USDA grant; $440000	Microbiological data of leafy green, tomato, water, and environment showed that pathogens in well managed field operations are rare.	Provide scientific and technological knowledge to develop metrics to enhancing produce food safety, and identify improved approaches and techniques that allow the attainment of the metrics to be verified simply and cost effectively.
Laboratory measurement of human exposure to deoxynivalenol (DON), and mycotoxins as determined by the presence of metabolites in urine (Lead - J. Dubois)	Bill and Melinda Gates Foundation	Data on exposure to DON in various populations.	The exposure information will help focus exposure reduction measures on populations that have high prevalence of the toxins in their system, and the analytical methods refined for the study will be amenable for deployment locally (in partnership) to monitor the effect of the reduction strategies.

Laboratory measurement of aflatoxins in ginger from Nigeria (pilot work) (Lead - J. Dubois)	registration fee; Waters Corporation (facility and pay faculty's salary)	A procedure for the extraction and measurement of aflatoxins in dry ginger was developed, which will be easy to implement in Nigerian government laboratories.	The method will be deployed at the Nigeria NAFDAC to monitor aflatoxins in dry ginger; better monitoring will enable market expansion for Nigerian ginger internationally.

C - Publications

Journal Articles

1   Cao G, Allard M, Strain E, Stones R, Zhao S, Brown E, Meng J. 2014. Genetic diversity of Salmonella pathogenicity islands SPI-5 and SPI-6 in Salmonella Newport. Foodborne pathogens and disease 11:798-807.

2   Hoffmann M, Muruvanda T, Pirone C, Korlach J, Timme R, Payne J, Evans P, Meng J, Brown EW, Allard MW. 2014. First Fully Closed Genome Sequence of Salmonella enterica subsp. enterica Serovar Cubana Associated with a Food-Borne Outbreak. Genome announcements. 2(5): e01112-14

3   Hoffmann M, Zhao S, Pettengill J, Luo Y, Monday SR, Abbott J, Ayers SL, Cinar HN, Muruvanda T, Li C, Allard MW, Whichard J, Meng J, Brown EW, McDermott PF. 2014. Comparative genomic analysis and virulence differences in closely related salmonella enterica serotype heidelberg isolates from humans, retail meats, and animals. Genome biology and evolution 6:1046-1068.

4   Ju W, Rump L, Toro M, Shen J, Cao G, Zhao S, Meng J. 2014. Pathogenicity islands in Shiga toxin-producing Escherichia coli O26, O103, and O111 isolates from humans and animals. Foodborne pathogens and disease 11:342-345.

5   Rump LV, Gonzalez-Escalona N, Ju W, Wang F, Cao G, Meng S, Meng J. 2014. Genomic diversity and virulence characterization of historical Escherichia coli O157 strains isolated from clinical and environmental sources. Applied and environmental microbiology. online 7 November 2014, doi: 10.1128/AEM.02616-14

6   Toro M, Cao G, Ju W, Allard M, Barrangou R, Zhao S, Brown E, Meng J. 2014. Association of clustered regularly interspaced short palindromic repeat (CRISPR) elements with specific serotypes and virulence potential of shiga toxin-producing Escherichia coli. Applied and environmental microbiology 80:1411-1420.

7   Zou L, Meng J, McDermott PF, Wang F, Yang Q, Cao G, Hoffmann M, Zhao S. 2014. Presence of disinfectant resistance genes in Escherichia coli isolated from retail meats in the USA. The Journal of antimicrobial chemotherapy 69:2644-2649.

8   Allard, S., A. Enurah, E. Strain, R. Blodgett, P. Millner, S. Rideout, E. Brown, J. Zheng. 2014. In situ evaluation of Paenibacillus alvei in reducing carriage of Salmonella Newport on whole tomato plants. Applied and Environmental Microbiology, 80: 3842-3849.

9   Wang F, Yang Q, Qu Y, Meng J, Ge B. 2014. Evaluation of a Loop-Mediated Isothermal Amplification Suite for the Rapid, Reliable, and Robust Detection of Shiga Toxin-Producing Escherichia coli in Produce. Applied and environmental microbiology 80:2516-2525.

10   Liu Y, Wu H, Li M, Yin J-J and Nie Z. 2014 pH dependent catalytic activities of platinum nanoparticles with respect to the decompostion of hydrogen peroxide and scavenging of superoxide and singlet oxygen. Nanoscale 6:11904-11910.

11   Liu Y, Yin J-J, Nie Z. 2014 Harnessing the collective properties of nanoparticel ensembles for cancer theranostics. Nano Research 7(12):1719-1730.

12   Kim E., Liu Y, Leverage WT, Yin J-J, White IM, Bently WE, and Payne GF. 2014 Biomacromolecules 15:1653-1662.

13   Li M, He W, Liu Y, Wu H, Wamer WG, Lo M, and Yin J-J. 2014 FD&C Yellow No. 5 (Tartrazine) Degradation via Reactive Oxygen Species Triggered by TiO2 and Au/TiO2 Nanoparticles Exposed to Simulated Sunlight. J. Agric. Food Chem. 62:12052-12060.

Abstracts at Conferences

1   Cao, G., M. Allard, M. Hoffmann, S. Monday, T. Muruvanda, Y. Luo, J. Payne, K. Meng, S. Zhao, E. Brown, J. Meng. 2014. Genomic Analysis of Multidrug-resistant Salmonella Newport. 54th Interscience Conference on Antimicrobial Agents and Chemotherapy. Washington, DC.

2   Toro, M. G. Cao, S. Ayers, R. Timme, M. Allard, J. Meng. 2014. Diversity of the CRISPR-cas system in Salmonella Bareilly. International Association for Food Protection Annual meeting. Indianapolis, IN.

3   Liu, Y., Fratamico, P.M., Debroy, C., Yan, X., Needleman, D.S., Li, R.W., Wang, W., Losada, L., Brinkac, L., Rodune, D., Toro, M., Meng, J. 2014. DNA sequence and analysis of the O-antigen gene clusters of Escherichia coli serogroups O62, O68, O131, O140, O142, and O163 and serogroup-specific PCR assays. The Association of Biomolecular Resource Facilities Annual Conference, Albuquerque, NM

4   Zhang, J., F. Wang, H. Jin, J. Hu, Z. Yuan, X. Yang, X. Xu, J. Meng. 2014. Laboratory Monitoring of Bacterial Gastroenteric Pathogens Salmonella and Shigella in Shanghai, China 2006–2012. General Meeting of American Society for Microbiology, Boston, MA.

5   Allard, S., A. Wallis, E. Prinkey, J. Pettengill, J. Zheng, A. Ottesen, C. Walsh, E. Brown, S. Micallef. 2014. Investigating the effect of Salmonella biocontrol agent Paenibacillus alvei and poultry litter soil amendment on the eastern shore tomato microbiome. International Association for Food Protection Annual meeting. Indianapolis, IN.

D - International Trainings

Program	Collaborating Partner(s)	Outcome	Impact
GAP program in Belize 08/11-15/2014	Belize Agricultural Health Authority	Anticipate course participants will conduct their own trainings.	Will assist the Belize fresh produce industry in being FSMA compliant.
FIT program in Malaysia 10/27 – 31/2014	Ministry of Health - Malaysia	Trained: 26 Malaysian food inspectors	An additional FIT training is planned and funded by the Malaysian government.
GAqP with HACCP in Bangladesh, 02/24-28/2014	Bangladesh Fish and Shrimp Foundation (BFSF) together with the Department of Fisheries.	Trained: 44 Members of BSFF, private industry, and a Department of Fisheries	Possibility of future JIFSAN GAqP training opportunities in Bangladesh
GFSP laboratory capacity building, 07/6 -10/2014	GFSP, USDA, FDA, Industry, China: CFS, CAAS and CAIQ	Developed train-the-trainer workshops for delivery in various regions, and a global cadre of trainers.	The global cadre of trainers will be able to propagate training all over the world
Rapid Methods in Food Microbiology, 04/1-5/2014	FDA, BioMerieux, Thermos, DuPont, 3M, Bio-Rad, Microbiologics, Waters	Trained 8 participants	This training gave a better understanding of requirements for the use of rapid methods for food microbiology.
Determination of Salmonella for Food Safety in Malaysia, 06/01/14	Ministry of Health - Malaysia, DuPont.	Trained 16 analysts from State laboratories in Malaysia	Adoption of FDA-recommended methods for *Salmonella* domestic market and export.

Listeria in Food-accelerated, 09/01/14	USDA Cohran, FDA, BioMerieux, Thermos, DuPont, 3M, Bio-Rad, Microbiologics, Waters	Trained 1 participant from the Ministry of Agriculture in Barbados.	The participant from the Ministry of Agriculture in Barbados has already been promoted to Head the microbiology analytical services and implement screening following a model similar to FDA's annual sampling plans.
Salmonella and Campylobacter, 09/01/14	FAO, USDA, FDA, BioMerieux, Thermos, DuPont, Bio-Rad, Waters	Trained 3 microbiologists from Bangladesh	Will reproduce the training in their country. The training will be propagated to government and academic laboratories.
Pesticide Residue Analysis and Introduction to Risk Analysis, 09/01/14	USDA, FDA, BioMerieux, Thermos, DuPont, Bio-Rad, Waters	Trained 8 participants from Bangladesh, Jamaica, and Korea.	Will apply their learning to deploy testing of pesticide residues using newly acquired LC/MS/MS equipment.
Shiga-toxin producing E. coli, 10/01/14	FAO, UNIDO, USDA, FDA, BioMerieux, Thermos, DuPont, Bio-Rad, Waters	Trained 13 participants from Chile, Canada, Namibia, Tanzania, US Bangladesh, Korea, Brazil, and Qatar.	The impact should be the start of beef import from Tanzania and Namibia to the US, and improved alignment of laboratory methods between the US and countries

Veterinary Drug Residues in Aquaculture, Meat and Poultry, 10/01/14	FAO, USDA, FDA, Waters	Trained 6 participants from Korea, Bangladesh, Iowa State University	To support their industry, and to do some testing of animal feed and possibly animal biological fluids.
Determination of Mycotoxins in Food, 10/01/14	FAO, USDA, FDA, Waters	Trained 14 participants from Nigeria, Saudi Arabia, Bangladesh, India, Mexico, and the US	To monitor the presence of mycotoxins in food
Food Defense in Malaysia, 01/14	International Food Safety Training Center (IFSTC) of the Food Safety & Quality Division of the Ministry of Health - Malaysia	Trained 28 people	Additional Food Defense course planned in Malaysia
Introduction to Global Law and Regulations in Malaysia, 03/14	International Food Safety Training Center (IFSTC) of the Food Safety & Quality Division of the Ministry of Health - Malaysia	Trained 30 people	Additional Food law course planned in Malaysia and held in the US
Overview of Risk Analyses – GMA, 04/14	Pre-conference training for GMA members; profit split	Trained 16 people	More industry players incorporating concepts of risk analyses into production
Overview Risk Analysis, 11/14	Costco	Trained 25 of Costco's Global Product Safety and Quality team members	More industry players incorporating concepts of risk analyses into production

Appendix E – Undergraduate Internship/Graduate Assistantship

Undergraduate Internships (June 2013-May 2014)			
Last Name	**First Name**	**Mentor**	**Project Title**
Flamer	Marie-Laure	Junia Jean-Giles	Identification and Characterization of Salmonella enterica from Spices
Partan	Elizabeth	Sufian Alkhaldi	MassCode PCR spectroscopy liquid array as a tool for genetic Listeria spp
Same	Mary	Sherri Denis	Food Safety Risk Analysis: Quantitative Risk Assessments
Forster	Jacqueline	Eric Garber	Rapid Detection and Quantitation of Gluten Using Hand-Held Diagnostic Devices
Hanh	Justin	Augusto A. Franco-Mora	Identification of virulence factors that contribute to the enterotoxicity of Vibrio parahaemolyticus
Trach	Larisa	Venugopal Sathyamoorthy	Testing a multiplex rel-time PCR method for simultaneous detection of Salmonella spp., *Escherichia coli 0157*, and *Listeria monocytogenes* in FDA regulated foods
Pahlavan	Autusa	Girdhari Sharma	Screening of polyclonal antibodies against gluten from specific grain and develop enzyme linked immunosorbent assay (ELISA) for grain specific gluten detection
Chase	Hannah	Ben D. Tall	Investigating the Global Genomic Diversity and Evolution of *Cronobacter* spp. using a Next-Gen DNA Microarray technology for inclusion into the Pathogen-annotated Tracking Resource Network (PATRN) via NCTR's ArrayTrack for technology transfer to FDA Field and FERN laboratories.
Park	Hoon Yong	Jon W. Wong	Analysis of Chemical Contaminants in Foods
Gladding	Anne	Joy Johanson	Ensuring Fresh Produce Safety: Susceptibility of Fresh-Cut Produce to Microbial Invasion; and Produce Safety Practices at Foreign Farms

Undergraduate Internships (June 2014-May 2015)			
Haile	Ermias	Cynthia Srigley	Evaluation of Quantitative Methods for the Determination of Omega-3 Polyunsaturated Fatty Acids in Marine Oil Dietary Supplement Products
Chang	Michael	Sefat E. Khuda	Major Allergen Detection by Immunoassays from Processed Complex Food Commodities
Hay	Gregory	Sherri Denis	Food Safety Risk Analysis: Quantitative Risk Assessment
Cheng	Raymond	Eric Garber	Rapid Detection and Quantitation of Hydrolyzed Gluten
Eltoweissy	Somayah	Mohammend Alam	Dose-response and Immunological-response Studies in Mice after Oral Infection with Murinized Listeria monocytogenes
Noroozi	Natalia	Venugopal Sathyamoorthy	Testing a multiplex real-time PCR method for simultaneous detection of Salmonella spp., Escherichia coli 0157, and Listeria monocytogenes in FDA regulated foods.
Pahlavan	Autusa	Girdhari Sharma	Source grain specific gluten detection by immunoassay
Chase	Hannah	Ben D. Tall	Characterization, identification, and subtyping of Cronobacter spp. from powdered infant formula and other dried foods using next-generation automated hybridization and sequencing technologies.
Park	Hoon Yong	Jon W. Wong	Analysis of Chemical Contaminants in Foods
Taylor	Gabrielle	Cecilia Crowley	Ensuring Fresh Produce Safety: Susceptibility of Fresh-Cut Produce to Microbial Invasion; and Produce Safety Practices at Foreign Farms

Srinivasan	Devi	Laurel Burall	Development of a multiplex qPCR method for detection and serotyping of Listeria monocytogenes directly from food.
Zhao	Mei	Rebecca Bell	Phenotypic Characterizations and Comparisons of Salmonella Isolated from Tomato-Related Agricultural Environments
Chen	Mia	Sherri Denis	Food Safety Risk Analysis: Quantitative Risk Assessment
McDonald	Jennifer	Cecilia Crowley	Ensuring Fresh Produce Safety: Susceptibility of Fresh-Cut Produce to Microbial Invasion; and Produce Safety Practices at Foreign Farms
Patel	Purvi	Cecilia Crowley	Ensuring Fresh Produce Safety: Susceptibility of Fresh-Cut Produce to Microbial Invasion; and Produce Safety Practices at Foreign Farms
Graduate Assistantship			
Cao	Guojie	Marc Allard (CFSAN) / J. Meng (UM)	Whole Genome Sequencing of Salmonella Newport
Allard	Sara	Marc Allard (CFSAN) / C. Walsh (UM)	Control of *Salmonella* in tomato

F – Symposia/Conferences

JIFSAN Advisory Council Symposium: The Annual JIFSAN Advisory Council Spring Symposium: The Case of Avoiding Risk: Truth or Consequences was held on April 24-25, 2014. What are the tradeoffs and unintended consequences of avoiding risk? In 2013, we explored the concept of chasing zero. The 2014 symposium leveraged key learning's in our quest to ultimately reach zero risk to our food. But what are the truths and consequences of actually achieving zero risk? What are the tradeoffs to avoiding food risks altogether and how might unintended consequences impact public health, the environment and consumer confidence in the safety of our food supply. What would it mean for your overall diet and health if we completely eliminated certain seafood from our diets because of the mercury content; reduced sodium to the lowest recommended levels of intake or set action levels for arsenic in juice and rice at astronomically low levels, or only purchase 'fresh' fruits and vegetables to avoid BPA? International speakers with a broad range of expertise and perspectives led discussions that explored key challenges in their respective fields of research.

The 2014 Annual Fera (CSL)/JIFSAN Joint Symposium on Food Safety and Applied Nutrition (June 9-11, 2014) The symposium on Emerging Issues in Food Safety was purposely highly topical and forward-looking, selected in light of recent, largely un-anticipated, high profile incidents which have impacted the global food industry, consumer confidence, and placed all involved in the food supply chain under increasingly intense scrutiny. Under the spotlight were instrumental methods of analysis; emerging sciences; developments in 'horizon scanning'; and recent food incidents. The symposium tackled the way that regulators, researchers and industry can work together to assess, monitor, manage and mitigate the impact of food scares on global economies, industry, and consumer safety and confidence. Over 100 people attended the symposium.

Dietetics and Nutrition Webinar (September 22-23, 2014). The Webinar was designed for professionals with a focus on nutrition and dietetics including practitioners, students, interns, and faculty in dietetics and nutrition as well as other professional areas. The Webinar provided timely information that was accessible to a large audience.