Improving Rapid Detection Methods for Foodborne Pathogens

Researchers Develop Microfluidic Device that Exploits Cell Movement to Separate Live and Dead Bacteria

The food processing industry is interested in technologies or methods that can quickly and accurately detect viable (live) bacteria, as these are the pathogens that can cause illness. Common foodborne pathogen screening methods like PCR (polymerase chain reaction) use DNA-based methods to perform the detection. However, because both viable (live) and non-viable (dead) bacteria contain the same DNA and other properties, it is difficult to distinguish between them without performing additional time-consuming incubation and culturing steps.

In response, researchers at the Georgia Tech Research Institute (GTRI) have developed a microfluidic device that exploits cell movement to separate live cells from dead ones for real-time pathogen detection. The phenomenon known as chemotaxis is the movement of an organism in response to a chemical stimulus. For example, live bacteria naturally sense nutrient molecules such as sugars and amino acids and move toward them.

“The hypothesis is that by changing the local environment of the cells, their movement can be manipulated so all the viable cells can be separated and concentrated,” explains Dr. Jie Xu, GTRI research scientist and project director. “This would improve the probability of detection and also provide a high level of confidence that viable cells are being detected.”

GTRI’s chemotaxis-based microfluidic device consists of a 100-micrometer thick nitrocellulose membrane layer engraved with a micron-sized center channel to contain the bacteria-laden sample. Two additional side channels are engraved into the same membrane layer that contains nanometer-sized pores that allow the formation of a chemical gradient across the center channel. The bacteria interact with these chemicals in the center channel and then move based on the nature of these interactions, either toward it if it is a food source or away if it is a repellant. The separated bacteria are then collected in the channel’s respective outlets.

continued on page 2
In recent experiments, *E. coli* 0157:H7 was used as the model bacterium, and aspartic acid (an attractant) and nickel ion (a repellent) were used as the chemotactic effectors. Researchers found the chemical gradients inside the channel can be maintained for an extended period. They also observed the cell population shift toward the side channel with attractant when live cells flowed inside the center channel, while the dead cells remained in the primary flow stream and exited the center channel.

The team is now in the process of optimizing the separation efficiency by adjusting the concentrations of the chemicals, the design of microfluidics, and the flow rate.

“This innovation includes an inexpensive and scalable fabrication process and the use of disposable and bio-compatible materials that make it suitable for laboratories and field testing around the world,” says Alireza Mahdavifar, a micro-mechanical engineer and GTRI graduate research assistant who designed and fabricated the prototype.

Xu believes successful implementation of lab-on-a-chip technology like GTRI’s microfluidic device could enable faster and more effective food safety control.

“The success of this project will make rapid viable pathogen detection possible, so the intervention process can be monitored and tailored for better food safety,” says Xu. “Food products could also be delivered quickly to consumers because the current holding time to obtain testing results would be virtually eliminated. The technology could also help to identify the cause of a foodborne illness outbreak quicker.”

In fact, the team’s work is already reaping recognition and results. A paper* was published in the peer-reviewed *Journal of The Electrochemical Society*, and Mahdavifar was awarded Best Presentation for the team’s poster titled “A Cost-Efficient Microfluidic Device for Study of Chemotaxis and Bacteria Separation Purposes,” at the Society’s 224th Meeting held October 27-November 1, 2013, in San Francisco, California. The team also filed a provisional patent on October 28, 2014, titled “Chemotaxis-based Bacterial Cell Separation and Preconcentration.”

---

**Thinking Outside the Box**

Each year the Agricultural Technology Research Program (ATRP) funds special exploratory research projects. With a theme of “thinking outside the box,” these projects investigate a highly unconventional idea, which, if successful, could lead to significant improvements over current systems and/or processes.

The projects also play a unique role in ATRP’s quest to drive transformational innovation in the poultry industry. Transformational innovation can be defined as the creation of something entirely new that eventually eclipses the existing norm. In short, exploratory research projects can help to define the next generation of poultry processing methods and technologies.

“The challenge with identifying transformational innovation is that early on it often does not perform as well as the current state-of-the-art. However, if you look at the rate of development or improvement, transformational innovation far outpaces the current state-of-the-art. It is the early investments in these higher risk ideas that can ultimately lead to higher reward and outcomes. The trick is knowing where and how to invest,” says Dr. Doug Britton, ATRP program manager.

Exploratory research projects are the incubators for ATRP’s full research portfolio, he explains. So, researchers seek to provide a balance in the exploratory research projects across the ATRP research thrusts in robotics and automation systems, environmental and energy systems, and worker and food safety technologies.

“In ATRP, we really try to focus on identifying the key limitation of an idea or approach, and then spend our time and energy seeking to address that. By doing this we can ‘fail fast’ without investing a significant amount of time and energy in the broader overall idea or concept,” notes Britton.

Nine exploratory research projects were funded in fiscal year 2014, which ended June 30. The following briefs highlight research results.

---

**Automated Cone Loading with Low-Cost Robot Baxter**

Researchers programmed a humanoid Baxter robot manufactured by Rethink Robotics to assess its ability as a robotic solution for poultry processing tasks.

They designed custom grippers in-house (based on a commercially available Robotiq gripper) and integrated them on Baxter. The in-house designed grippers proved effective at grasping bird front-halves from a moving conveyor and placing them on deboning cones.

**Evaluation of Novel Intervention Strategies for Pathogen Control**

Researchers explored a group of new antimicrobial compounds to reduce pathogens in food products. They found low levels of compounds can reduce *Salmonella Typhimurium* on chicken and lettuce more effectively than 50 ppm chlorine in 10 minutes. This discovery was confirmed by blind tests performed at the USDA-ARS Richard B. Russell Research Center and the Georgia Poultry Lab. It was noted that the antimicrobial efficiency was not affected by room temperature.

**Studying Animal Reaction to Robotics in a Broiler Growout House Environment**

Researchers evaluated the feasibility of using commercially available robotic systems to perform growout house management tasks. The systems were outfitted with 2D and 3D sensors/cameras and operated in an experimental growout facility at UGA’s Poultry Research Farm in Athens, Georgia. Video and audio data were collected with 500 birds for a 6-week growout cycle in a miniature-scale house. Researchers developed and calculated metrics for the robotic systems and for humans, which allowed for quantitative analysis of the birds’ reactions to both. Results indicate that there is not a negative impact on the performance of the birds due to the operation of the robotic systems when compared to their reactions to humans.

**Systems Modeling of Poultry Plant Water Usage**

Researchers modeled the water usage in a typical poultry processing plant to define areas of potential optimization of water use. Based on the model, the plant can adjust water use for particular processes, which can be used to estimate fluctuations of food pathogen contamination. Researchers also developed a computer model for higher fidelity simulation of the poultry chilling process. The model keeps track of the temperature history of birds currently in the chiller and the water temperature of the chiller at various locations at each particular time.

**Aquatic Biomass for Poultry Feed**

Researchers explored the feasibility of using algae as feed for broiler chickens during growout. They found the use of chitosan in small concentrations to be a viable means of harvesting algae. They were also able to produce approximately 20 kg dry weight of algae and duckweed combined. It was decided that a full broiler trial would not yield sufficient data at this point, and instead, the team opted to conduct battery trials involving one-day-old chicks in a controlled environment requiring less feed.

**Advanced Enrichment Reactor**

Researchers are studying better low-pathogen concentration approaches to improve pathogen prevention and control in large-volume poultry processing samples. During FY 2014, the

---

*continued on page 8*

---
Low-Cost Sensors Enable New Possibilities for Advanced Systems in Poultry Management and Processing

BY COLIN USHER

Advanced automation and robotics systems for manufacturing have been expensive to develop, with final price tags ranging from $50,000 to over $500,000 due in large part to the high cost of the sensors. For poultry companies to be able to justify implementing these types of systems in processing plants, costs need to be significantly lower. Fortunately, recent developments in consumer technology have brought to market several low-cost sensing solutions. This dynamic shift has allowed researchers at the Georgia Tech Research Institute’s Food Processing Technology Division (FPTD) to explore a new range of possibilities for low-cost advanced sensor systems for poultry processing and management.

One such example of a newly available low-cost sensor is the Nintendo Wii video game controller that uses accelerometers and gyros based on advanced inertial navigation systems from military aircraft such as the USAF C-141. A $30 controller now contains the same sensors that previously cost thousands of dollars (albeit with a sacrifice in accuracy). Most recently, these sensors can be purchased in single units for as little as $10.

Microsoft changed the playing field with the release of a 3D sensor called the Kinect for $199. This device was originally developed for use with their video gaming system, the XBOX 360, but was almost immediately modified by hackers to work with a computer. A community of software developers quickly formed that used the Kinect to implement applications ranging from simple 3D scanning to advanced sensing for robotics. Recognizing its potential, Microsoft then released a Kinect sensor for the PC along with a software development kit and a commercial license to allow for development of commercial applications outside of their core video game space.

The Kinect sensor uses a structured light approach to generate a 3D image. This is achieved by using a projector to project an infrared light pattern onto objects in the sensor’s field of view. This pattern, much like a camouflage pattern, is then processed and deformations identified in the pattern allow the Kinect to generate a 3D image. Earlier this year, Microsoft released the second generation of their Kinect sensor, dubbed Kinect V2. The Kinect V2 is a next generation time-of-flight (TOF) camera that boasts a resolution of 512x424 pixels and a cost of $199. In comparison, the FPTD research team purchased a TOF camera with a resolution of 320x240 pixels in 2010 for a whopping $8,000. This represents a reduction in cost of more than 97 percent!

Generally, a TOF camera works by modulating a light source and calculating the time it takes for that light to reflect off an object and return to the sensor. Distance is resolved based on the known speed of light. Light will arrive back to the sensor later for objects farther away than for objects that are closer. TOF imaging has benefits over the structured light approach in the sensors ability to operate effectively in non-uniform or ambient lighting environments.

FPTD researchers thoroughly tested both Kinect sensors and the commercial TOF camera to establish accuracy and potential drawbacks of each sensor, with an eye toward potential applications in poultry processing. What the research team found is that the low-cost Kinect sensors are indeed a viable alternative with accuracy and operation on par with the much higher cost sensors.

Ongoing Research Using Kinect Sensors

Currently, the Kinect sensors are being leveraged heavily for two projects: Advanced Sensing and Grasping and Growout House Robotics. The Advanced Sensing and Grasping project involves development of algorithms to automatically sense poultry parts such as wings, breasts, legs, thighs, etc., and detect locations for robotic manipulators to grasp or operate on the parts. Chicken can be both singulated on a belt or batched together in bins. 3D information from the Kinect is used to assist in both the detection of the parts and the determination of approach vectors for robotic end effectors. Researchers have collected sample data from a singulated bird and batched birds. A sample 3D point cloud of a single bird is shown below.

For the Growout House Robotics project, the Kinect sensor is mounted on top of a mobile ground-based robot. The robot was recently operated in an experimental growout...
The Modernization of Poultry Inspection Final Rule was published in the Federal Register on August 21, 2014, a mere 937 days after it was proposed. During that time, the chicken industry was negatively portrayed by the media, consumer groups, and others spreading many misconceptions about the inspection system and chicken processing in general. Also during that time frame, the chicken industry remained steadfast — continuing to support a modernized poultry inspection system that focuses more on actual food safety issues that could affect public health, rather than organoleptic and quality issues. The New Poultry Inspection System (NPIS), which is the modernized poultry inspection system included in the August 21st Final Rule may play a role in improving food safety, but that remains to be seen.

The final rule is quite different than the proposed rule in various areas including participation, food safety requirements, and line speeds. Many of these aspects were never commented on by those on either side of the rule since they were never included in the proposed rule. Regardless of this fact, below are some of the main topics included in the final rule that will impact the industry.

First, the new rule is completely voluntary for traditional establishments. If establishments are satisfied operating under traditional inspection, they can continue to operate as is. If establishments are currently one of the 20 HIMP pilot plants, they must opt into NPIS or their line speeds will be capped at 140 birds per minute. Current HIMP establishments have until February 23, 2015, to notify their District Offices of their interest in participating in NPIS.

If establishments currently operate under traditional inspection and choose to opt into NPIS, a U.S. Department of Agriculture (USDA) carcass inspector (CI) will be stationed just before the chiller to conduct on-line bird-by-bird inspection ensuring that all birds have been properly processed. Additionally, each line will have an off-line inspector (VI) to conduct verification activities. Establishments will now be required to hire and train on-line sorters (replacing current USDA inspectors) to remove any quality defects from carcasses thereby allowing Food Safety and Inspection Service (FSIS) inspectors to focus more on food safety-related parameters. These are significant changes from the current inspection system that will require substantial investments on behalf of the chicken industry. Traditional establishments have until February 23, 2015, to notify their District Offices of their interest in participating in NPIS. These establishments can opt into NPIS after February 23, 2015, but they will not be included in the first implementation wave.

With regards to food safety, there are several new requirements that all establishments must have in place in the upcoming months regardless if they continue to operate under traditional inspection or participate in NPIS. For example, all establishments will be required to test for pathogens both pre- and post-chill for every 22,000 birds processed. In that same light, establishments are no longer required to use generic E. coli as an indicator organism but are required to select and validate an alternate indicator of process control (examples include aerobic plate count, Enterobacteriaceae, and others). Additionally, establishments must develop and implement written procedures to address contamination during the evisceration process. It is inevitable that contamination may occur during the evisceration process, but according to the final rule, establishments will need to focus on prevention of contamination rather than rely on their multi-hurdle approach to minimize any downstream risks. Large establishments had until November 19, 2014, to implement the new requirements including the written program and testing requirements. Small establishments have until December 19, 2014, and very small establishments have until February 17, 2015, to have these food safety-related parameters in place.

The proposed rule would have allowed all chicken establishments to operate at 175 birds per minute — a speed that has proven to be safe for 15 years in this country, and in major poultry-producing countries around the world. Unfortunately, USDA capped the industry at 140 birds per minute in the final rule — the maximum speed at which traditional establishments can currently operate. With the line speed incentive gone, it is very difficult to estimate how many chicken establishments will opt into NPIS.

Regardless of the inspection system in place, the chicken industry remains committed to ensuring a safe, wholesome, and abundant supply of poultry products for both domestic and international markets.

For more information about the Modernization of Poultry Inspection, please visit www.chickeninspectionfacts.com.

Ashley B. Peterson, Ph.D., is vice president of scientific and regulatory affairs for the National Chicken Council.
With every five-year renewal, complying with discharge permit requirements for stormwater from industrial activities is often like grabbing the pot of gold at the end of a rainbow. Everyone has heard that the pot of gold exists, and you can see the path that supposedly leads there. But just head out on your journey and the path starts changing.

The stormwater pot of gold is the vision that ‘all waters of the United States will have water quality standards that include the highest attainable uses, combined with water quality criteria that reflect the current and evolving body of scientific information to protect those uses.’ The stormwater permit effluent thresholds, founded on both technology- and water quality-based limits, is the path. But like the end of the rainbow, the intersection between technology- and water quality-based limits keeps moving as industry works to make progress toward reaching attainable water quality goals. The water quality standards program is intended to protect and improve water quality beyond what is provided for through technology controls under the effluent guidelines program.

Recent permitting initiatives have included benchmarks or pollutant concentrations at which a stormwater discharge presents a level of concern, meaning it could potentially impair or contribute to impairing water quality or affect human health from the ingestion of water or fish. Below the benchmark, a facility effluent presents little potential for water quality concern. Typically associated with facility stormwater plans or best management practices (BMPs), the benchmarks also provide a measure of successful implementation even though the benchmark concentrations are not effluent limitations and should not be interpreted or adopted as such.

Benchmarks specifically require monitoring to assess progress toward meeting pollution concentrations, and if not achieved, adaptive management approaches are required that will allow the permittees to propose and implement continual improvement efforts toward meeting the benchmarks. This approach is contained throughout the 29 sectors covered by the U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Multi-Sector General Permit for Industrial Activity stormwater permitting program.

As sedimentation, pathogens, and nutrients from stormwater remain responsible for an estimated 40 percent of water quality impairments nationally, benchmarks are designed to serve as a means of reducing pollutant discharges to the maximum extent practicable. The difficulty is that the vision of water quality standards that includes the highest attainable uses was defined under a different set of natural, human-caused, and economic conditions. Consequently, the overall success of pollution-control efforts depends on a reliable set of underlying designated uses in water quality standards, particularly as stormwater permitting programs are increasingly tied to the waste load allocations associated with the Total Maximum Daily Load (TMDL) program. Without an understanding of the non-point sources of pollution, developing appropriate mitigation strategies to meet TMDLs is extremely difficult if not impossible.

For industrial activities, particularly within poultry processing, work continues toward strengthening and maintaining the scientific foundation of water quality programs, including targeting criteria development for specific pollutants of highest importance. The Georgia Poultry Federation and the State of Georgia have cooperated to study components for fecal coliform standards when regulating discharges and establishing important technical and policy linkages between the water quality standards.

Still, resolution is needed to address concerns regarding natural background levels of coliform bacteria. Background levels often exceed water quality standards and thus the permitted benchmark value by orders of magnitude. Additionally, microbial source tracking (MST) is an evolving approach for associating specific types of animals, birds, or human sources with fecal pollution of natural waters. However, discriminating between broiler chickens in the case of poultry processing as a source of fecal coliform versus other avian sources is not yet possible. Interestingly, discriminating non-human from human sources to the maximum extent practicable is viable. Related research further indicates that human sources are far more infectious relative to non-human sources.

Moving forward, Georgia Tech researchers are reviewing the stormwater permits in place throughout the major poultry-producing states. A prioritized list of effective BMPs that target fecal coliform sensing and mitigation is being proposed to various funding sources for development in partnership with faculty from the University of Georgia. These efforts include working with companies using MST and other technologies for determining the source (host organisms) of fecal coliform bacterial contamination in natural waters related to poultry operations.

John Pierson, P.E., is a principal research engineer in the Georgia Tech Research Institute’s Food Processing Technology Division. His areas of expertise are wastewater pretreatment alternatives, environmental control systems, pollution control, and biofuels. He leads the division’s environmental technical assistance program and can be contacted by email at john.pierson@gtri.gatech.edu.
Low-Cost Sensors Enable New Possibilities for Advanced Systems in Poultry Management and Processing

continued from page 4

house, where 3D data was collected for an entire growout cycle. Researchers plan to use the data for automation tasks, allowing the robot to autonomously navigate through a house among chickens. They are also exploring methods of characterizing the growth of the chickens based on the 3D data. A sample 3D image taken from this testing is shown below.

Sensors that previously were very high-cost components of automation and robotic systems are now much more economical. Researchers hope that this introduces new opportunities for more advanced systems development along the entire poultry production and processing chain. This article barely touches on the application space being explored by the research team. Please keep an eye out for future PoultryTech articles for more detailed information on the above-mentioned projects in addition to other interesting developments made possible by these new low-cost sensors.

Colin Usher is a research scientist in the Georgia Tech Research Institute’s Food Processing Technology Division. His areas of research expertise are software development, intelligent systems, computer imaging, robotics, and automation technologies. He can be contacted by email at colin.usher@gtri.gatech.edu.

Environmental Boot Camp Education Program Offered at 2015 IPPE

Thursday, January 29, 2015 | 9 a.m.–11:30 a.m. | Room A-411

The International Production & Processing Expo (IPPE) will host an Environmental Boot Camp as part of its educational programs at the 2015 Expo. The boot camp will provide an overview of environmental regulations that commonly affect the poultry, egg, and meat processing industries. Discussions on the importance of environmental audits and inspections are also planned.

Featured Speakers/Topics

Christian Richter — Principal, The Policy Group — Regulatory Overview

John Pierson, P.E. — Research Engineer, Georgia Tech Research Institute — Stormwater NPDES Permitting and SPCC Compliance

James Faison — Regulatory Compliance Manager, Mar-Jac Poultry — National Emission Standards for Hazardous Air Pollutants for Feed Mills

Sam Hardin, P.E. — Consulting Engineer, Clear Water Consultants — Environmental Reporting (Tier I, Tier II, and TRI Reporting)

Warren Howe, P.E. — Vice President, Woodruff & Howe Environmental Engineering — Environmental Audits and Inspections

Sponsored by the U.S. Poultry & Egg Association, IPPE is the world’s largest annual poultry, feed, and meat industry trade show. The 2015 Expo will be held January 27-29, at the Georgia World Congress Center in Atlanta. Visit www.ippexpo.org for more information and to register to attend.

Olga Kemenova

Job title: Research Engineer II

Education: M.S., Public Policy, Georgia Institute of Technology; M.S./B.S., Mechanical Engineering, St. Petersburg’s Marine Technical University

Areas of research expertise: Systems modeling; statistical modeling; environmental and transportation policies analysis; air quality modeling and monitoring; emission control programs evaluation; environmental impact assessment

List of any poultry industry projects you’re working on and your role: I am the PI for the Poultry System Simulation Model (PRISSM) project. This model can be used as a tool to evaluate potential improvements or changes in a poultry plant’s operations. I also do statistical modeling for the Intelligent Cutting and Deboning System project.

What I find most rewarding about working on poultry industry projects: Seeing how your work can improve or complement the current process

A talent I wish I had: Ability to learn languages quickly

Another occupation I’d like to try: Medicine, I’d like to be a doctor

My first job: Sales person for home and kitchen appliances

If I could meet someone famous, who would it be and why: Margaret Thatcher, being the longest-serving British Prime Minister and the only woman to have held the office, she had an amazing career. I just wonder how she did it.

One thing people may not know about me: I got my first driver’s license at 37.

My day would not be complete without: A cup of tea

The last book I read: The Great Gatsby

The last movie I saw: The Grand Budapest Hotel

My favorite song: St. Petersburg by Supergrass

My motto: I like this one: “Be a hero of your life not a victim”

My hobbies: Reading
research focused on completing a repeatable method for deploying growth mediums within the reactor. Experiments used *Salmonella*-inoculated tryptic soy broth and whole bird rinses. Subsequent industry interactions highlighted the need to address improvements to classical culture methods in order to reduce enrichment time and enhance viable pathogen recovery from non-liquid samples (e.g., ground poultry).

**Adaptive Perception During Manipulation**

Researchers are developing perception algorithms and 3D sensing modalities that will learn, model, and track deformable poultry objects (such as chicken front halves) for robotic manipulation. The goal is to develop a system that can continually track an object while it is being handled — gripped, pulled, flipped, cut, etc. — and adapt the manipulation in real time. This adaptive ability is crucial to robotic handling of poultry products, which are variable by nature. During FY 2014, researchers further improved modeling and data alignment algorithms. They also integrated a developer pre-release of the new Microsoft Kinect Version 2 sensor to obtain higher quality data with greater resolution and improved precision. In addition, analysis of initial results produced using a current deformable data alignment method showed that both shape and physical characteristics, specifically stiffness, can be recovered by image data alone, where no prior physical or shape models exist. This can then be used in simulation for improved perception and manipulation.

**Ultrasonics for Poultry Processing Chiller Water Disinfection**

Researchers evaluated the effectiveness of ultrasound for the inactivation of *Salmonella* in poultry processing chiller water. In experiments using intentionally contaminated water, simulated chiller water, and actual chiller water, it was found in all cases that samples treated with ultrasound, combined with either different concentrations of chlorine or peracetic acid, exhibited slightly better disinfection than samples treated with the chemicals alone. Researchers concluded the study indicates that it may be feasible to use ultrasonic energy to enhance product safety; however, cost-effective scale-up of the technology may prove challenging given the incremental benefits.

**Enhancing the Water and Energy Efficiencies of Poultry Chilling via Ice-Water Slurries**

Researchers evaluated the incorporation of ice slurries in the poultry chilling process, with the goal of significantly reducing water use and allowing for faster chilling of product. It was thermodynamically quantified that a unit of ice slurry has a higher cooling capacity than a similar unit of liquid water and, therefore, should require less mass to achieve a comparable cooling result. For example, approximately 125 percent more liquid water is needed in comparison to ice slurry (half ice-half liquid) given each system is experiencing a 32°C temperature rise. There would thus be less total water needed (in slurry form) to address a chiller’s heat load. The ability to pump slurry throughout a facility adds to its attractiveness when compared to ice formation. In addition, the slurry serves as an excellent means of refrigeration load deferral to off-peak hours when leveraging cooling capacity storage. A software platform was used to begin quantifying this culminating economic benefit.

---

**Don’t Forget to Stop by ATRP’s Exhibit at the International Production & Processing Expo, January 27-29, 2015, at the Georgia World Congress Center in Atlanta. Location: Booth 9142 – C Hall**

ATRP’s exhibit will highlight the program’s research advancements and display prototype systems that seek engineering solutions that enhance process efficiency and product safety in today’s poultry industry. Program researchers will be available to answer questions, and a program video and handouts will describe current projects.

**Like us on Facebook**

ATRP’s Facebook page features information about exciting research initiatives underway, interesting poultry and food industry news, industry events, photos, videos, and more!  
[www.facebook.com/ATRP.GTRI](http://www.facebook.com/ATRP.GTRI)