ENGINEERING TOMORROW'S POULTRY INDUSTRY

PoultryTech

VOLUME 34 NUMBER 2 FALL 2022

Interferometric Sensor Could Enable Real-Time Monitoring of Peracetic Acid Concentration in Poultry Chillers

Researchers with the Georgia Tech Research Institute's (GTRI) Agricultural Technology Research Program (ATRP) have developed an interferometric sensor that is poised to help poultry processors better monitor antimicrobial interventions during processing operations.

The poultry industry uses antimicrobial agents including peracetic acid (PAA) in chiller tanks to control microbial loads on chicken carcasses during processing. Carcasses are dropped in these large water-filled cooling systems to lower their core temperature to a degree that prohibits pathogen growth while exposing them to antimicrobials like PAA as an additional safeguard.

However, PAA's efficacy is hampered by its decomposition when exposed to high pH levels and organic loads like proteins as well as total suspended solids in the chiller water. It is suspected that the presence of these and other organic species speed up PAA decay, resulting in concentrations below target levels or requiring the addition of extra doses to maintain target PAA levels within the chiller.

Walker Byrnes, GTRI research engineer I (left), and Lance Barrett, a 2022 R. Harold and Patsy Harrison Student Intern in ATRP's Abit Massey Student Internship Program, are part of a team evaluating an interferometric sensor for real-time monitoring of the concentration of the antimicrobial peracetic acid (PAA) in poultry chillers. Recent field trials at a local poultry processing plant demonstrated the sensor's ability to achieve a detection limit below 0.1 ppm. This desired detection sensitivity and selectivity make it possible to track PAA variations in processing waters and immediately determine whether additional doses are needed, thus enabling adaptive intervention.

Therefore, processing plants must constantly monitor the chiller water to estimate the actual PAA dose. Ideally, the PAA analysis should be performed immediately after sampling to minimize decomposition. However, current monitoring practices require manual sample collection and measurement. Not to mention accuracy can be affected by the presence of color and turbidity in the chiller water.

Here, enters GTRI's interferometric sensor, a compact device that contains the PAA sensing unit, an automatic liquid handling system, and data collection software, enabling end-to-end automation of the sample collection and analysis process. The data collected from each chiller sample is automatically analyzed and visualized on a web-based interface, enabling real-time remote monitoring of PAA concentration. And the sensor chip can be used for at least two weeks without fouling or recalibration.

The science behind this sensing technology is called waveguide interferometry, which exploits the interference of light waves to

continued on page 5

IN THIS ISSUE

PAGE 1: Interferometric Sensor Could Enable Real-Time Monitoring of Peracetic Acid Concentration in Poultry Chillers

PAGE 2: Manager's Corner

PAGE 3: Dual-Arm Robotics

PAGE 4: Envisioning the Future of Poultry Production

PAGE 6: Researcher Profile: Yu Hang He

Visit ATRP in Booth C13536 — Exhibit Hall C at the 2023 International Production & Processing Expo

PAGE 7: ATRP Co-Hosts National Safety Conference for the Poultry Industry

PAGE 8: Why Choose Chicken?

MANAGER'S CORNER

One of the many ways to measure the impact of a state-funded program like the Georgia Tech Research Institute's Agricultural Technology Research Program (ATRP) is the transition of technology from the research lab to commercialization. Inherent in this transition is a "valley of death" that must be overcome for technologies to succeed in the commercial landscape. And while a good amount of research and time has been invested in understanding how to improve the survivorship of technologies through this transition, it really comes down to a trio of key factors. First, the technology must be a viable solution to the problem at hand. It must be practicable and effective at meeting a real need. Second, it requires a truly functional partnership between the research team and the commercial partner. And finally, it requires resources tied to a long-term vision of how the technology will be deployed that will allow the commercial partner to weather the early years of market penetration. While these may seem simple, it really does take the right idea, at the right time, with the right team to make it a success.

Fortunately for ATRP, we have had several successful technology transfer endeavors over the years. This edition of our *PoultryTech* newsletter highlights our sensor platform for detecting and managing peracetic acid (PAA), which is an antimicrobial for the control of pathogens. This work builds on interferometric biosensor technology that has been licensed by Salvus, LLC, a Valdosta, Georgia-based company. It has been great to see this underlying technology migrate from a lab prototype to a commercial reality, but we would be remiss if we gave the impression that it was straightforward. It really has been and continues to be the hard work and dedication of the team at Salvus supported by our research team here in ATRP that is making this possible. In fact, our research team, led by Dr. Jie Xu, recently attended the grand opening of Salvus' new research facility dedicated to the development of interferometric detection technology (see photo below).

In the end, it is timely partnerships and collective hard work that allow technologies to survive the transition from the laboratory to the marketplace. Careful and effective cultivation is required, and we have been fortunate to find partners like Salvus to license technology and make it available to industry.

On behalf of ATRP, I would like to thank Salvus and all of our industry partners who have collaborated with us in so many different ways to make technology transfer a success. Such partnerships are core to our vision of "transforming poultry, agribusiness, and food manufacturing through advanced technologies." And if you have interest in commercializing technologies or research underway in ATRP, please feel free to email me at doug.britton@gtri.gatech.edu.

Doug Britton, Ph.D.
ATRP Program Manager

ATRP researchers joined Salvus, LLC officials at the company's new facility grand opening on November 3 in Valdosta, Georgia. The facility expands capacity for engineering, research, testing, and production of Salvus™ Detection Technology, the world's first handheld chemical and biological interferometric detector. The device is based on interferometric detection technology developed by ATRP and is suitable for applications in health care, environmental sciences, food safety, and agriculture. According to Salvus, the device can rapidly identify chemical and biological substances in liquid, air, or surface environments at detection levels comparable to the gold standards used today.

"The successes we're seeing in our research and testing efforts combined with the advancements we're making in the design and scalability of the handheld device, discreet sample cartridge, and flow monitoring cartridge are bringing us closer to commercial readiness," explained Clinton Beeland, president and CEO of Salvus. "As a result, we now have agreements with multiple commercial partners for delivering the platform to select markets. Our new facility enables our launch into commercial application."

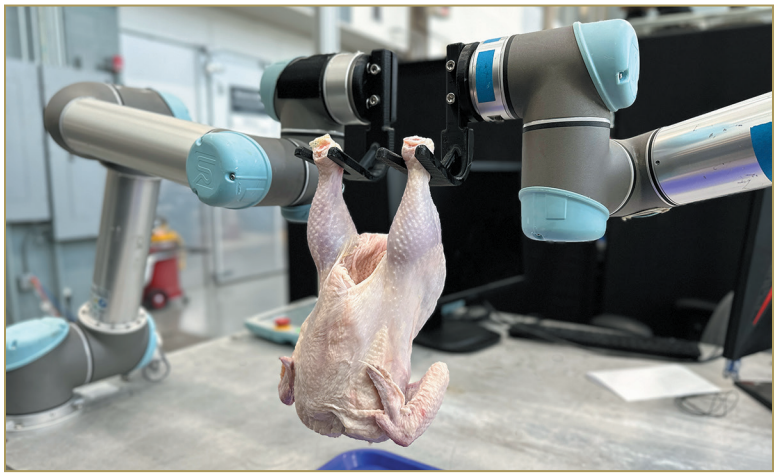
Dual-Arm Robotics

BY KONRAD AHLIN, PH.D.

Automation in poultry processing has been a century-long battle to enable machines to perform complex tasks as efficiently as a person. While tremendous progress has been made, current, state-of-the-art devices are still inferior to human labor in many respects. A consequence of this discrepancy is that a large number of tasks within a poultry plant must be performed by human labor. An example of such a task is "rehang," the process in which a WOG (a processed bird without giblets) is placed onto a moving shackle line after exiting the chiller. It is the objective of the dual-arm technology, currently being developed at the Georgia Tech Research Institute (GTRI), to empower robotics to mimic the behaviors and dexterity of a human operator, which will allow for greater automation in poultry processing.

An important engineering concept relevant to this work is the idea of "degrees of freedom" (DOF). A degree of freedom is a controllable parameter, and in robotics, this will typically refer to a motor joint. Degrees of freedom are important because they loosely correlate to the dexterity of the system. Typical robot manipulators will have six DOF, while basic pick and place robots will often only have three or four DOF. However, a person hanging a WOG may use more than 70 DOF in order to accomplish this task (seven DOF per arm, about 27 DOF per hand, and the torso). Thus, the average person performing the rehang task will utilize an order of magnitude more degrees of freedom than a robot arm. In order for a robotic system to have a chance at mimicking human behavior, either the task needs to be simplified or the robot needs to be more sophisticated.

The dual-arm robotics research is addressing the discrepancy between human performance and robotic limitations by using two manipulators simultaneously to attempt the rehang task. This system has 12 DOF as well as two end effectors, greatly increasing the capabilities of both robots. In this system, each manipulator can grasp a hock (leg joint), and then they can jointly manipulate the WOG to its desired location onto the shackle. The benefit of this approach is that is uses off-the-shelf robotics rather than custom machines. A pair of six DOF manipulators becomes a 12 DOF system if they are programmed to work together.



The dual-arm robotics research is addressing the discrepancy between human performance and robotic limitations by using two manipulators simultaneously to attempt the rehang task.

The research that allows for a 12 DOF manipulator is not simple. In order to control the robot's end effector, knowing how the end effector moves in relation to its motors must be understood. Systems with more than six DOF require complex methods of control. This sophistication is where the research of the dual-arm robotics takes place: to create a system that can treat both arms as if they were a single system with 12 DOF rather than two, six DOF systems.

Without detailing the mathematical challenges that have been overcome in achieving this advancement, research has shown that this level of control is possible. Initial results have demonstrated that two arms situated with this algorithm can work together to pick up a WOG (one arm per leg) and jointly place the WOG onto a stationary shackle. The current limitation for implementing this system in a real operating environment is the performance speed. To emulate line speeds, the system will need to hang WOGs at a rate of approximately one every 5-10 seconds, whereas current tests are limited to about 30-45 seconds. However, further optimizations and advancements are underway to address this issue.

The rehang task is only the beginning of this system's capabilities. Many operations within poultry processing and the food industry in general require dexterous motions guided by skilled operators. Also, the dual-arm motion is only half of the equation that enables this technology. The other half of the system is a sophisticated sensing system with advanced learning techniques. The dual-arm technology tells the arms how to move, but they require intelligence to know where to move. It is the summation of many advanced robotic disciplines that empowers the system's capability to perform even a fraction of the abilities of a human. However, with each development, more tasks fall into the domain of robotic capabilities, easing the strain on the poultry industry and freeing the human operator from the need of manual labor.

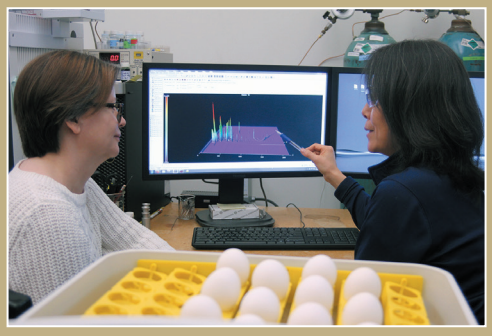
Konrad Ahlin, Ph.D., is a research engineer II and the R. Harold and Patsy Harrison Research Faculty Fellow in Poultry Technologies in GTRI's Agricultural Technology Research Program.

EXPLORATORY RESEARCH BRIEFS

Envisioning the Future of Poultry Production

Each year the Agricultural Technology Research Program (ATRP) funds a number of small-scale research projects. These "exploratory" projects investigate unconventional ideas that, if successful, could lead to significant improvements over current systems and/or processes. As such, the projects seek to tackle the challenge of envisioning the future of poultry production. Four exploratory projects were funded in FY 2022, which ended June 30. The following briefs highlight research results.

NON-DESTRUCTIVE EGG FERTILIZATION DETECTION VIA VOCS

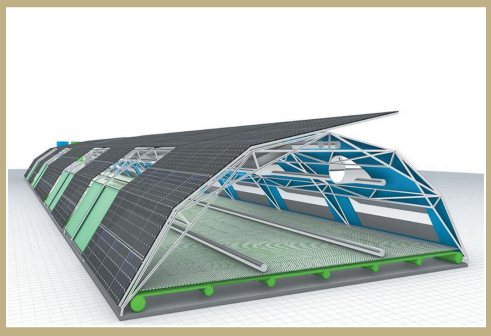


Researchers are using gas chromatography mass spectrometry to capture volatile organic compounds (VOCs) from infertile eggs, fertile eggs, and eggs containing female and male embryos to enable early-stage fertility detection and sex identification of eggs. A fast, online, and non-destructive pre-screening of eggs for fertility identification before being passed for incubation would improve hatcher utilization and overall hatch rates, thereby increasing throughput and efficiency of operations. Initial statistical analysis has shown promising classification results on the determination of fertility status (fertile or infertile) through the detection of VOC differences in broiler eggs at a very early incubation time (~ 3 days).

INTELLIGENT BUTTERFLY TRIMMING

Researchers are exploring ways to increase overall yield and reduce labor in deboned chicken breast (known as butterfly fillets) trimming operations. A prototype semi-automated trimming device was designed that can remove cartilage and bone from the fillets while reducing excess trimming.

POULTRY FARM OF THE FUTURE



Researchers are exploring next-generation poultry house design concepts that are conducive to automation and integrates structural design, behavioral modeling, and operational requirements. The goals are to enable better litter management, reduce energy needs, reduce labor, and be economically viable. Researchers developed several viable concepts, with the most promising version resulting in a fully modeled representation.

CANONICAL MANIPULATION

Researchers are exploring the use of advanced image sensing and high degree-of-freedom robotic path planning to create a generalized pipeline for single and multi-arm autonomous robotic manipulation in poultry processing operations. A successful demonstration of the rehang task was accomplished using two robotic arms with simple end effectors to lift a WOG (whole bird without giblets) by its hocks and place it on a shackle. A canonical mapping model aided the robotic arms' predictions of the hocks location for accurate lifting.

Technical Assistance Is Just a Phone Call Away

The Agricultural Technology Research Program (ATRP) provides no-cost technical assistance to Georgia-based firms and individuals in the poultry industry. These assists range from simple inquiries regarding information or help needed to address a problem to extensive on-site consultations in which researchers collect data and provide a report on their findings and recommendations. The program also offers in-plant energy usage/cost assessments and workplace safety evaluations.

ATRP uses input from all assists to gauge situations calling for new research initiatives in energy, environmental, safety, and other areas. Researchers provided more than 20 technical assistance services in FY 2022.

To inquire about the program or to schedule an assist, call ATRP Program Manager Doug Britton at (404) 407-8829 or email him at doug.britton@gtri.gatech.edu.

Interferometric Sensor Could Enable Real-Time Monitoring of Peracetic Acid Concentration in Poultry Chillers

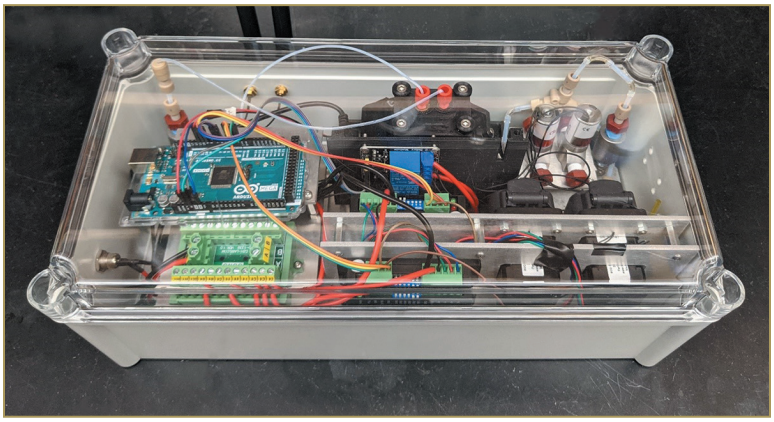
continued from page 1

accurately measure the concentration of PAA in the chiller water. The process is rather straightforward. An evanescent field on the top of the waveguide's surface (the tail of the electromagnetic field associated with the propagation of light) is sensitive to index of refraction changes in the volume immediately above the waveguide's surface. Coupling a selective sensing film to the waveguide's surface provides the basis for chemical detection. For PAA sensing, researchers have developed a sensing film based on a charge-transfer chemistry. The sensing film is selective and reversible toward PAA sensing.

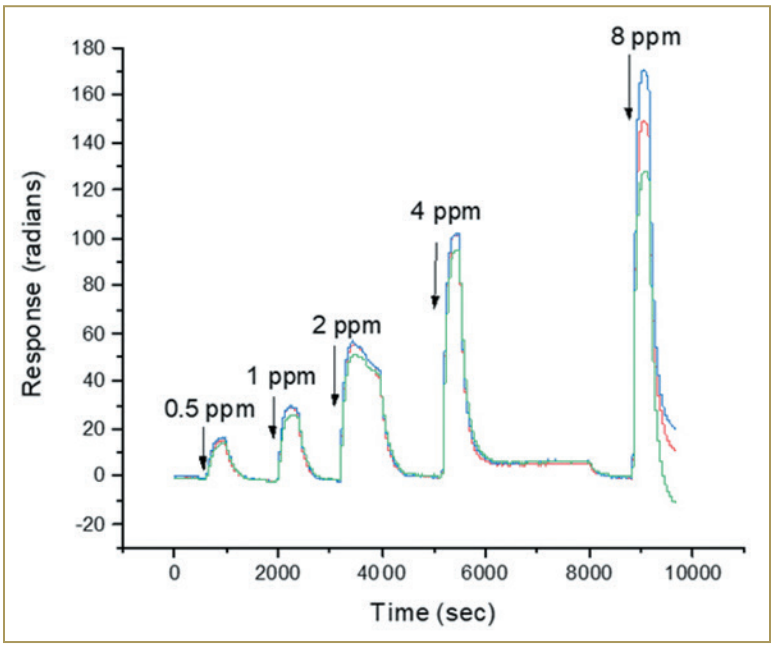
> ***"Our PAA sensor removes the existing labor requirement, increases the accuracy to which the plant can manage its PAA loading, and provides a higher sampling frequency, while also automating the currently manual process." – Jie Xu, Ph.D., GTRI principal research scientist and project director***

"Our PAA sensor removes the existing labor requirement, increases the accuracy to which the plant can manage its PAA loading, and provides a higher sampling frequency, while also automating the currently manual process," says Jie Xu, Ph.D., GTRI principal research scientist and project director.

Recent field trials at a local poultry processing plant demonstrated the sensor's ability to achieve a detection limit below 0.1 ppm, and confirmed the sensing response is not influenced by the presence of hydrogen peroxide, acetic acid, and other constituents commonly found in poultry processing waters. Xu explains that the desired detection sensitivity and selectivity make it possible to track PAA variations in processing waters and immediately determine whether additional doses are needed, thus enabling adaptive intervention.



GTRI's interferometric sensor contains the PAA sensing unit, liquid handling system, and microcontroller in a compact device to provide automated continuous PAA monitoring in processing waters. The sensing data is processed and visualized on a web-based interface, enabling real-time remote monitoring of PAA concentration.



Typical sensing data for PAA solutions in the range of 0.5 ppm to 8 ppm. Arrows indicate the time PAA solutions were introduced into the sensing system.

"Because of the development of our in-line PAA sensor, the real-time control of targeted PAA levels in processing waters becomes possible. So, the disinfecting efficacy can be maintained at a minimum cost," adds Xu.

A provisional patent has been filed on the PAA sensor, and the team plans to validate its detection accuracy in terms of detection sensitivity and selectivity with a gas chromatography mass spectrometry (GC-MS)-based PAA quantification method in the very near future.

The team will hold demonstrations of this technology at the upcoming International Production & Processing Expo (IPPE) on January 24-26, 2023, at the Georgia World Congress Center in Atlanta; stop by ATRP's Booth C13536 to learn more.

RESEARCHER PROFILE

Yu Hang He

Job title: Research Engineer I

Education: B.S., Mechanical Engineering, University of Nevada-Las Vegas

Areas of research expertise: Robot Manipulation, Mixed Reality, VR/AR, Human-Robot Interaction, Mobile Robots

List of any poultry industry projects you're working on and your role:

- Virtual Reality Interfaces for Enabling Robotic Operations for Poultry Processing Applications
  - » Goal: Accelerate the integration of robotic technology into poultry processing by bridging the gap between automated solutions and human decision-making skill
  - » Role: Automating the cone-loading operation using a human in a virtual reality environment; creating the communication framework to translate human decisions into robot commands and sensor information into visual feedback; designing a virtual reality interface and enabling remote operation through the internet
- Field Testing and Commercialization Demonstration of Poultry House Management Robot
  - » Goal: Develop and test a mobile robot capable of autonomous navigation through commercial flocks with the additional capability of removing floor eggs and recording micro-climate data
  - » Role: Creating automatic docking and charging capability and a scheduler for detailed planning; updating the ultrasonic-based localization system; conducting extensive field testing of the robot in commercial houses
- Advanced Intelligent Cutting
  - » Goal: Automating bird shoulder deboning by incorporating learning from demonstration methods to allow expert practitioners to inform/optimize robot knife paths that achieve maximal yield while avoiding bone chips
  - » Role: Porting the intelligent cutting system onto the more robust Staubli robot platform to achieve in-plant cone line speed

What I find most rewarding about working on poultry industry projects: Robotics research often revolves around experiments and applications that are impractical in real-world environments. Frequently, a robot can only perform its task under laboratory conditions where the environments are artificially constrained. While laboratory experiments are important, extensive efforts are required to apply this research to solve real-world problems. Working on poultry industry projects allows me to bridge the gap between experiments and real-world problems. Knowing my work can have practical impacts on other people's lives gives me satisfaction.

A talent I wish I had: Drawing

Another occupation I'd like to try: Video Game Developer

My first job: Research Associate

If I could meet someone famous, who would it be and why: John Oliver, because he can provide comedic relief while covering serious news. He often imparts important insights and raises awareness about issues that are buried under public consciousness.

One thing people may not know about me: I am a VR enthusiast

My day would not be complete without: A good night of sleep

The last book I read: Brandon Sanderson's *Oathbringer* in the Stormlight Archive Series

The last movie I saw: Bullet Train

My favorite song: Porter Robinson's "Goodbye to a World"

My motto: "Every one of us is, in the cosmic perspective, precious. If a human disagrees with you, let him live. In a hundred billion galaxies, you will not find another." — Carl Sagan, Cosmos

My hobbies: Video games, anime, reading fantasy and sci-fi books, learning about space travel and technologies

Visit ATRP in Booth C13536 — Exhibit Hall C at the 2023 International Production & Processing Expo

The Agricultural Technology Research Program (ATRP) is excited about its plans to participate in the 2023 International Production & Processing Expo (IPPE), scheduled for January 24-26, 2023, at the Georgia World Congress Center in Atlanta.

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 plant. Program researchers will be available to answer questions, and a program video and highlights will describe current projects.

For more information, visit ippexpo.org

ATRP Co-Hosts National Safety Conference for the Poultry Industry

2022 National Safety Conference for the Poultry Industry Focused on Workforce Engagement and Taking Care of Employees

Industry safety professionals recently gathered in Destin, Florida, to examine and discuss the safety challenges facing those involved in poultry production and processing. The National Safety Conference for the Poultry Industry is co-hosted by the Georgia Tech Research Institute's Agricultural Technology Research Program (ATRP) and U.S. Poultry & Egg Association (USPOULTRY).

The theme of this year's conference was one of engaging with and listening to employees.

Avian Influenza Safety

Patricia Adams, Livestock/Poultry Northeast field supervisor for the Georgia Department of Agriculture, presented on safety's role in an avian influenza outbreak. She related several key points about the potential hazards encountered by those tasked with responding to an avian influenza event, including the possibility of a heat-related illness brought on by the combination of strenuous activity, heat, and personal protective equipment required for the response. She also noted the importance of fit-testing respirators and having identifying information visible on the exterior of Tyvek or similar suits. She remarked that it was important to provide employees with a safe, appropriate area to don and doff protective equipment.

Workplace Violence Prevention

The workplace violence panel, facilitated by James Ferrell, corporate manager of risk for Foster Farms, and included Matt Jackson, senior regional safety manager, Animal Nutrition and Pet Food for Simmons Foods, and Dr. David Schaller, director of safety for Darling Ingredients, noted that while workplace violence incidents have been on the decline for the past 30 years, these incidents are still serious events and measures can be taken to prevent them. The panelists noted that several employers have chaplains available to their employees, and this has seemed to provide an intervention opportunity to prevent workplace violence incidents. Partnerships with local law enforcement, particularly in the event of a serious incident, are encouraged, as well as having an anonymous tip line in place to help head off incidents.

Heat Stress Management

James Ferrell also led a discussion on managing heat stress, echoing some of the concerns that Adams shared during her presentation. He related that heat is the number one weather-related cause of death worldwide, and acclimating employees to the heat is a necessary part of working in the heat. Ferrell remarked that the most significant risk time for employees is during the first day and first week of working in the hot environment. He noted that this includes working indoors and outdoors, as there are several environments in the poultry, egg, and rendering segments of the industry that are inside but still present a potential heat hazard. Employees being able to recognize the signs of heat illness and being empowered to act appropriately to them was suggested as a key strategy to prevent the worst effects of heat illness.

Employee Support Services

Antigoni Guevara, senior director of occupational health for Tyson Foods, spoke about the importance of caring for the whole person when an injury occurs, not just the physical injury. The Tyson Chaplaincy Program was discussed as a model for providing support services to employees with any type of issue, from serious issues to just needing to talk. This program was further expanded by the integration of critical incident stress management, which is a specialized intervention intended to address traumatic events and sometimes called "psychological first aid." First adopted for combat veterans and later applied to first responders, it is now recognized that this approach can help people in a myriad of traumatic experiences. Guevara's take home message was that the focus should be on the injured employee and their family rather than the injury status, and timely, best-in-class care must be provided with follow-up throughout the recovery process.

Source: USPOULTRY

Why Choose Chicken?

It's no surprise that Americans eat more chicken than any other protein, and for good reason. Shoppers across the nation love its taste, nutritional value, affordability, sustainability, and versatility — chicken is a table-pleaser for eaters of all ages. Check out these reasons to choose chicken, America's favorite protein.

Our Bodies Love Chicken

- It's a high-quality, complete protein.
- It builds muscle and strengthens bones.
- It supports weight loss and flexes with various diets (Keto, Paleo, Mediterranean, Dietary Guidelines for Americans).
- It delivers vital, under-consumed nutrients, such as magnesium, potassium, choline, vitamin B12, and iron.

Our Brains Love Chicken

- Chicken contains tryptophan, an amino acid linked with increasing levels of serotonin — the "feel good" neurochemical.
- It contains vitamin B12 and choline, which together, may promote brain development in children, help the nervous system function properly, and aid cognitive performance in older adults.

Our Planet Loves Chicken

- Chicken is more sustainable than ever before!
- It takes 75% fewer natural resources to produce today than it did in 1965.
- It requires 58% less water and 72% less farmland than it did 54 years ago.

More Reasons to Love Chicken

- Chicken is a meal that's a people-pleaser for all ages.
- It's more affordable than other types of poultry, beef, or pork.
- It's one of the most accessible sources of protein.
- It plays an important role in nutrition through the stages of life.

Source: chickencheck.in/why-choose-chicken (a website sponsored by The National Chicken Council)

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!

facebook.com/ATRP.GTRI

PoultryTech

Published by the Agricultural Technology Research Program of the Georgia Tech Research Institute, a program conducted in cooperation with the Georgia Poultry Federation with funding from the Georgia Legislature.

Agricultural Technology Research Program
GTRI/ATAS/ISTD
Atlanta, GA 30332-0823

Phone: 404-407-8812
FAX: 404-407-8569

Angela Colar
Editor
angela.colar@gtri.gatech.edu

Steven Thomas
Graphic Designer/Photographer
steven.thomas@gtri.gatech.edu

Doug Britton, Ph.D.
ATRP Manager/Editorial Adviser
doug.britton@gtri.gatech.edu

Online:
atrp.gatech.edu

PoultryTech is published twice a year (Spring and Fall) and delivered free of charge to subscribers. To subscribe, visit atrp.gatech.edu/subscribe or scan our QR code.