Georgia Tech Research Institute
Agricultural Technology
Research Program

2023 ANNUAL REPORT

50th ANNIVERSARY
DRIVING TRANSFORMATIONAL INNOVATION
1973 - 2023

Celebrating 50 Years of Innovation

MESSAGE FROM THE PROGRAM MANAGER

Doug Britton, Ph.D., ATRP Program Manager

2023 was a very special year for the Agricultural Technology Research Program (ATRP), as we celebrated the 50th Anniversary of the program. Started in 1973, ATRP has provided continuous support to the poultry and agricultural communities across the state. In April 2023, we celebrated this landmark achievement at a very special event with many of the program's friends and contributors. A special meeting of the advisory committee was followed by a lunch and then a program that highlighted reflections and comments from Georgia Tech and GTRI leadership, University System Chancellor Sonny Perdue, Agriculture Commissioner Tyler Harper, and David Bleth, president of Harrison Poultry. A highlight of the afternoon was the presentation of awards to Abit Massey, president emeritus of the Georgia Poultry Federation, and Craig Wyvill, the now retired visionary director who grew the program into what it is today. Capping off the celebration was an opportunity for attendees to browse some of the research projects and demonstrations that highlight the transformational nature of the work being done in the program.

On a personal note, it has been such an honor to be able to continue the work, the foundation of which, so many have laid before us. We take great satisfaction in seeing the research have a real impact, as we tackle very big challenges facing the poultry and ag industries. Our vision to transform poultry, agribusiness, and food manufacturing through advanced technologies is as relevant today, as it was 50 years ago. And to this end, we will continue to stay the course, push the boundaries, and explore new and emerging technologies to keep our poultry and ag industries viable for many years to come.

Thank you to all of our partners, friends, and colleagues, both current and past, for joining us in celebrating 2023. We could not accomplish what we hope to achieve without your unwavering support and collaboration. So thank you, and here's to another 50 years of ATRP!

ADVISORY COMMITTEE

The Agricultural Technology Research Program is conducted in cooperation with the Georgia Poultry Federation with input from an external Advisory Committee consisting of representatives from leading poultry companies and allied organizations.

Members

Jonathan Green, Perdue Farms (Chair)
Matt Nelson, Boehringer Ingelheim
Randy Segars, Boehringer Ingelheim
Brian Porter, Cantrell-Gainco Group
Steve Snyder, Claxton Poultry
Mark Hamby, Cobb-Vantress
William Herring, Cobb-Vantress
Bill Crider, Crider Foods
Kelly Horne, Darling Ingredients
Terry Paschall, Darling Ingredients
David Walker, Darling Ingredients
David Wicker, Fieldale Farms
John Wright, Fieldale Farms
Paul Breure, Foodmate
Jim James, Foodmate
Scott Hazenbroek, Foodmate
Jason Bragg, Georgia EMC
Gary Funk, Georgia Power
Ed Harmon, Georgia Power
Blake Wikle, Gold Creek Foods
David Bleth, Harrison Poultry
Humberto Hernandez, JBT FoodTech
Joe Gasbarro, JBT-Prime Equipment Group
Cezary Mroz, JBT-Prime Equipment Group
Kirk Reis, JBT-Prime Equipment Group
David Sewell, Koch Foods
Matt Brass, Marel
Luke Pollock, Marel
Phillip Turner, Mar-Jac Poultry
John Weeks, Mar-Jac Poultry
Mike Bell, MP Equipment
Tom Van Doorn, MP Equipment
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Lucas Hill, Pilgrim's
Adam Willis, Pilgrim's
Andre Weltman Tatar, Salvus
Mike Rhodes, Southern Company
Terry Bruce, Tip Top Poultry
Steve Schimweg, Tyson Foods
Juanfra DeVillena, Wayne-Sanderson Farms
Dwayne Holifield, Wayne-Sanderson Farms

Advisors

Mike Giles, Georgia Poultry Federation
Abit Massey, Georgia Poultry Federation
Louise Dufour-Zavala, Georgia Poultry Laboratory Network
Todd Applegate, University of Georgia
Denise Heard, U.S. Poultry & Egg Association

FY 2023 PROGRAM HIGHLIGHTS

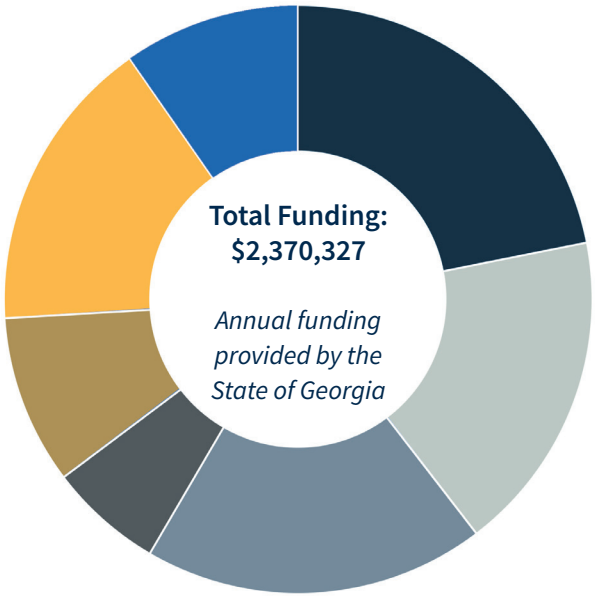
July 1, 2022 - June 30, 2023

By the Numbers

7	4	2	1	1	39	13	14
RESEARCH PROTOTYPES IN VARIOUS STAGES OF DEVELOPMENT	EXPLORATORY RESEARCH PROJECTS	PROVISIONAL PATENT APPLICATIONS	FULL PATENT APPLICATION	INVENTION DISCLOSURE	PUBLISHED ARTICLES, PAPERS, AND PRESENTATIONS	PARTICIPATING INDUSTRY AND ACADEMIC PARTNERS	TECHNICAL ASSISTANCE SERVICE REQUESTS FULFILLED

ATRP annually participates in outreach activities, including co-hosting the National Safety Conference for the Poultry Industry with the U.S. Poultry & Egg Association, publishing the PoultryTech newsletter, and coordinating exhibits at the International Production and Processing Expo (IPPE) and Poultry World at the Georgia National Fair.

FINANCIAL SUMMARY



Funding Breakdown by Program Area

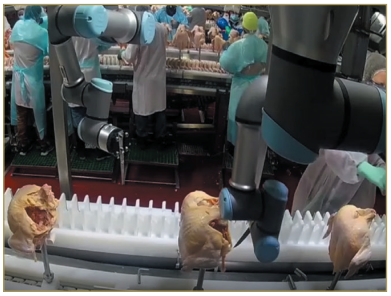
- Automation and Robotics Research 21.9%
- Imaging and Sensing Research 17.7%
- Environmental and Biological Systems Research 18.8%
- Row Crops Research (new initiative) 6.3%
- Future Concepts 9.3%
- Technology Transfer/Outreach/Technical Assistance 16.3%
- Program Support 9.7%

THANKS TO OUR INDUSTRIAL AND ACADEMIC PARTNERS

Industrial collaborators support research projects by providing industry expertise and access to facilities for data collection and systems testing and contributing in-kind and cash support on an “as needed” basis. Academic partners collaborate with research teams by providing cross-disciplinary expertise and experience as well as access to university research facilities.

Auburn University
    Department of Poultry Science
Aviagen
Fieldale Farms
Harrison Poultry
KWJ Engineering
Marel
Mar-Jac Poultry
Perdue Farms
Salvus™
University of Florida
    Agronomy Department
University of Georgia
    Department of Poultry Science
USDA-ARS U.S. National Poultry Research Center
Wayne-Sanderson Farms

Advanced Intelligent Cutting



Background: Manual chicken carcass deboning is one of poultry processing's most laborious tasks. Researchers are evaluating the automation of poultry deboning by designing knife trajectories based on learning from expert demonstration (LfD). LfD methods allow expert practitioners (human deboners in this case) to inform/optimize robot knife paths that achieve maximal yield while avoiding bone chips. Researchers believe the approach holds promise for advancing the incorporation of more robotic solutions for manual poultry processing tasks.

FY 2023 Research Results: During FY 2023, researchers successfully ported the previously developed compliant controller to a new test robotic arm with 6 degrees of freedom. Velocity and force control feedback were implemented, and cutting trajectories were successfully demonstrated on a simulated joint model.

Integrated Water Management System

Background: Water quality in poultry processing operations is monitored constantly to maximize water recycling/reuse and optimize wastewater treatment. However, current characterization practices are labor-intensive and require a variety of reagents and testing equipment. Researchers believe full development of an integrated water management system will not only provide a tool for in situ water quality monitoring for process optimization and wastewater treatment but also enable real-time dynamic tracking of water conditions. This, in turn, will advance the scientific understanding of the fate of contaminants and nutrients in water distribution systems.

FY 2023 Research Results: Researchers continued development of a reagent-free system using an ultrasensitive and multiplexed interferometric sensor for monitoring the amount of the antimicrobial peracetic acid (PAA) in processing waters. The sensor's detection limit is below 0.1 ppm, and the sensing response is not influenced by the presence of hydrogen peroxide, acetic acid, and other constituents commonly found in poultry processing waters. To validate the sensing results, researchers developed a PAA quantification method based on the detection of methyl p-tolyl sulfoxide (MTSO), an oxidation product, from the reaction between methyl p-tolyl sulfide (MTS) and PAA using gas chromatography mass spectrometry (GC-MS). The produced methyl phenyl sulfoxide (MPSO) can be extracted from the water sample using Twister®-based stationary phase extraction. This method provides a simple way to quantify PAA inside the complex water matrixes. The sensor unit was then field tested, and the results were compared to GC-MS, DPD colorimetric, and titration methods. Results showed close agreement between the PAA measurements based on the sensor and GC-MS. Both titration- and DPD-based measurements showed significant differences with the PAA quantification compared to the sensor and GC-MS.

On-Farm Processing and Transport (FPaT)

Background: Researchers are evaluating the suitability, effects on processing, and economic feasibility of using a prototype shackle system for on-farm bird harvesting and transport tasks. The project re-imagines the process of transporting live chickens to processing plants and instead explores processing at the farm. This eliminates live haul transport, minimizes weight loss, and eliminates mortality risks. The system has potential to alleviate bird welfare concerns while producing economic benefits by reducing manual labor requirements and transportation costs.

FY 2023 Research Results: Researchers conducted experiments at a local poultry processing plant to evaluate feather picking efficiency, carcass bacteriological loading, and meat quality for delayed processed carcasses (i.e., FPaT carcasses). Experimental observations suggest that delaying the time between initial broiler slaughter steps (stunning-bleeding) and carcass defeathering is not detrimental to most meat quality characteristics and may actually improve cooked meat texture. In addition, there were no significant differences in defeathering and bacteriological loading. Additional tests are planned for FY 2024.

Growout House Robotics

Background: Researchers are investigating the use of robotic systems to perform broiler and broiler-breeder rearing and management tasks in growout houses.

Such tasks include mortality collection, egg picking (in breeder operations), in addition to environmental and animal health monitoring. These tasks are currently conducted with a significant amount of manual labor. Researchers believe robotic systems have the potential to provide growout managers with the capability to collect data for decision support as well as perform utility tasks that can reduce the required labor load while potentially mitigating disease and contamination factors.

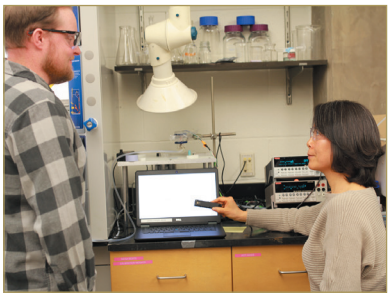
FY 2023 Research Results: The research team continued testing a ground robot that can autonomously navigate a broiler-breeder house and pick up floor eggs for an extended period. During FY 2023, an egg drop-off and automatic charging functionalities were added, and a docking/charging station that is more suitable to a chicken house environment was built. Additional testing is underway to further solidify the system's fully autonomous operation in a commercial facility.

Enhanced Chilling Automation Via Alternative Media and Motion

Background: Typically, during processing chicken carcasses are immersed in screw augers of chilled water, which lowers their core temperature to a degree that inhibits pathogen growth. While effective, the process usually requires carcasses to be removed from a shackle line for immersion. This unshackling results in lost product traceability, product cross-contamination risks, and additional labor needed for subsequent reshackling, known as rehang. To address these concerns, researchers designed and built a laboratory test rig that keeps the carcasses shackled during immersion while adding rotational motion. The rotational motion improves chilling in conventional chiller water, and researchers believe optimized rotation should also magnify the chilling benefit of alternative chiller media like ice slurry.

FY 2023 Research Results: Researchers further investigated the use of advanced motion patterns to enhance in-line immersive chilling in poultry processing. Experimental results suggest that rotational kinematics could retain significant yield within the pre-chiller without the need for air agitation. Additionally, mini-zones of thermal treatment were simulated to demonstrate the customized sequencing of exposures that could be implemented during carcass chill. These thermal exposures simulated pre-chiller, conventional main chiller, and sub-zero Celsius advanced chilling modes, and such were tested in varied order to assess the impact of sequence. Finally, detailed designs of a compact in-line, immersive chiller were progressed.

Multi-Function Sensor System



Background: Ammonia, resulting from biochemical reactions of chicken droppings in litter, is prevalent in the air of poultry growout houses and must be constantly monitored to maintain safe levels. Most currently available ammonia sensors have short battery life and require frequent recalibration while also suffering from baseline drift, poor selectivity, and false alarms. Researchers believe a durable and dependable ammonia sensing system with the capability to be integrated into a ventilation system opens a new path to smart and efficient ventilation in poultry farms and improved energy consumption, resulting in a healthier environment for the chickens.

FY 2023 Research Results: Researchers continued development of a low-power electro-thermal gas sensor that exhibits high selectivity, fast response and recovery time, and is capable of real-time monitoring of ammonia levels. During testing, the sensor successfully detected ammonia at 5, 25, and 50 ppm using TCD (thermal conductivity detector) and solid-state ZnO (zinc oxide) sensors.

Non-Destructive Egg Fertilization Detection via VOCs

Background: Researchers are using gas chromatography mass spectrometry (GC-MS) to capture volatile organic compounds (VOCs) from infertile eggs, fertile eggs, and eggs containing female and male embryos to enable early-stage fertility and sex detection and separation 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.

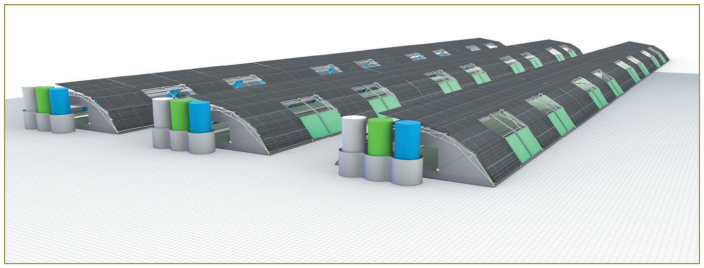
FY 2023 Research Results: Researchers continued to further identify and characterize the VOCs emitted from fertile and infertile eggs with increased control

ensuring the same breed, flock, age, diet, environment, and collection day. Statistical analysis such as principal component analysis (PCA), linear discriminant analysis (LDA), and random forest have been applied to discover potential fertilization-specific VOC biomarkers. A trend among fertile and infertile groups is visible in PCA results as early as day 0. LDA was utilized to classify eggs into fertile and infertile categories. Preliminary results have shown a good performance on a training dataset (0% misclassified on day 7 of incubation) and promising results on a validation set (20% misclassified). Random forest techniques provide more promising results delivering models that are able to classify eggs into fertile and infertile categories with satisfactory accuracy metrics starting from day 7 of incubation. Several chemical classes including aldehydes, alkanes, ketones, and alcohols have again shown to be of significant importance.

Poultry Farm of the Future

Background: 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.

FY 2023 Research Results: Researchers developed several viable designs, with the most promising version resulting in a fully modeled representation. Three main objectives were considered in the design: 1) poultry waste management — to reduce source of moisture that has to be ventilated, 2) reduction in air volume inside of the house that needs to be conditioned, and 3) on-site energy generation to minimize power demand from the grid.

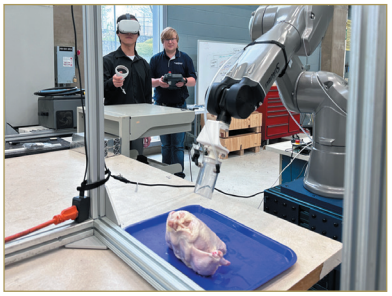


PAA Decay Kinetics

Background: Peracetic acid (PAA) is used as a food safety measure for microbial control in poultry carcass chilling operations. Previous studies have shown that increases in organic carbon may cause PAA concentration to vary dramatically throughout a processing day. Researchers believe a full understanding of PAA decay kinetics in chilling operations will allow processors to optimize water reuse systems and lower the amount of PAA needed for microbial control.

FY 2023 Research Results: Results revealed several key factors that affect PAA stability. The first was that the stock formulation of PAA plays an important role in PAA stability. It was determined that the biggest difference in stability was due to peroxide levels, with formulations containing lower peroxide levels degrading faster than those with higher peroxide levels. Next, it was found that the starting potability of water has an effect on PAA lifetime. The results indicate that PAA will last longer in water with TDS (total dissolved solids) lower than 25 ppm, and once protein is added, PAA will degrade rapidly. Further, results showed that stomaching and shaking recover similar amounts of bacteria in microbial testing. This removed a bottleneck step, resulting in quicker testing. Finally, preliminary results indicate that for treating *Salmonella*, pH and air agitation levels play an important part in microbial reductions.

Virtual Reality for Robotics System Control and Development



Background: Researchers are exploring virtual reality (VR) systems for aiding the development and deployment of robotic systems in processing environments. Essentially, a person makes a decision, and the robot performs the labor, all from a VR environment. Successful implementation of VR-based systems could alter poultry processing tasks like loading chicken front halves on cones for deboning by removing workers from harsh environments and repetitive tasks.

FY 2023 Research Results: Researchers conducted a benchmark study using a VR training simulation of the chicken deboning task at a local poultry processing plant. Most of the participants believed that the VR technology would be useful to them and thought that they could operate it for multiple hours. In all, participants were positive toward the technology and the experience, giving credence to the possibility of using robotics and VR in practical environments. The results of the training also showed that most participants could perform the operations adequately with very little practice, and early results indicate that performance would improve over time.

EXPLORATORY RESEARCH PROJECTS

Developing concepts and ideas for later transition into full-scale projects

Ammonia Capture and Recovery

Researchers are exploring ways to reduce ammonia levels inside poultry growout houses. A low-cost gas adsorbent to capture the ammonia was developed, with preliminary studies indicating the adsorbent has similar removal efficiency compared to current commercially available products. Researchers further plan to develop a method to produce a concentrated ammonia stream that can be used as a value-added fertilizer.

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. During FY 2023, both the manipulation and perception experienced significant improvements over previous years' efforts. The manipulation strategy was improved to be significantly faster and more robust, completing the rehang task in approximately 65% of the time needed previously (concluding in about 20 seconds rather than 30 seconds). The perception pipeline was also greatly improved, with a new methodology for scanning and training the canonical model. Notably, performance in perception deteriorated during final testing on real WOG (whole bird without giblets) images due to noisy canonical mapping estimations, partially arising from the difficulty in associating distinct scans to live data. These challenges, however, could be overcome by a more robust training set. Overall, results showed that autonomous rehang using machine vision and robotic labor is possible, but it will take the efforts of future work to make the system feasible for industrial use.

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 has been designed that can remove cartilage, bone, and fat from the fillets while reducing excess trimming. During FY 2023, researchers modified the device, making it more ergonomic and lightweight. Added functionality included installing vacuum power for removing product trimmings that can then be placed in an adjacent container. Yield studies revealed the trimming mechanism removed less usable product while still targeting unwanted cartilage, bone, and fat. Further testing in a commercial facility is planned for FY 2024.

Poultry Production Odor Analysis

Researchers are seeking to gain a deeper understanding of the compounds and conditions that are responsible for poultry house odors. Litter and soil samples were collected from poultry houses and analyzed using two-dimensional gas chromatography mass spectrometry (GCxGC-MS). Results revealed numerous compounds that make up the overall odor associated with poultry production. While ammonia is a component of that odor profile, given its volatility compared to many of the other compounds found, it seems to be of little concern to neighboring areas. Compounds of particular importance belonged to the fatty acid class as well as several nitrogen and sulfur containing classes as well. This project also revealed how crucial it is to maintain drinker lines in a state of good repair as areas that were damp from leaking drinker lines showed high levels of odorous compounds, particularly fatty acids, compared to drier areas under well-maintained drinkers and feeder lines. Ultimately, this research demonstrates that you can better control the odor, including ammonia, if you can control the moisture. This baseline study of the sources and makeup of poultry production odor can serve as a basis for mitigation efforts and future house improvements in moisture management.

ROW CROPS RESEARCH INITIATIVE

Utilizing Peanut Volatile Organic Compounds to Detect *Aspergillus* in Peanut Plants, Pods, and Kernels

To further serve Georgia's agriculture sector, in FY 2023, ATRP received additional state funding to establish a Row Crops Research Initiative focused on using volatile organic compounds (VOCs) for aflatoxin detection in peanuts. Aflatoxin, a toxin generated from the fungus, *Aspergillus*, costs peanut growers millions annually. Researchers are seeking to not only deliver novel approaches to mitigating aflatoxin risk, but also to further refine and make available novel sensing systems for both crop stress as well as product quality. Over the course of the year, VOCs were collected from various genotypes of peanut plants (and by extension, pods and kernels), infected with *Aspergillus*. The collected VOCs were analyzed using gas chromatography mass spectrometry (GC-MS) and in-house data analysis methods, to identify and verify unique signature VOCs emitted from the plants, pods, and kernels. Initial results showed that separation based on genotype and infection status was possible using VOCs. Ongoing studies are planned for FY 2024.

SPECIAL PROJECT

ATRP 50th Anniversary Podcast

A special podcast series was began to memorialize ATRP's 50th Anniversary and its role in driving transformational innovation in the poultry industry. Six episodes were produced in FY 2023, highlighting individuals and projects key to ATRP's success. An additional six episodes are planned for FY 2024 to complete the series.

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