



Georgia Tech Research Institute  
Agricultural Technology  
Research Program

2021  
ANNUAL  
REPORT



**TRANSFORMING POULTRY, AGRIBUSINESS,  
AND FOOD MANUFACTURING  
THROUGH ADVANCED TECHNOLOGIES**

# MESSAGE FROM THE PROGRAM MANAGER

DOUG BRITTON, PH.D., ATRP PROGRAM MANAGER



Fiscal Year 2021 will most likely be known as the year of lockdown with most work being conducted remotely and over video conferencing platforms. This was also the case for the Agricultural Technology Research Program (ATRP) as most of the students and faculty worked remotely with a small but dedicated crew coming into the office and labs to conduct research that required specialized equipment. Despite these disruptions, research teams continued to make progress on the 13 research projects presented in this report, including three important technology trials. These technology trials are part of ATRP's technology commercialization strategy for migrating innovation from research to the marketplace, with the success of these trials playing a major role in determining the readiness state of the technologies.

Over the past five years, ATRP research teams have placed a major emphasis on technology transfer, whether that be through licensing agreements with existing companies or the launching of start-up companies to prove the viability of the concepts in the marketplace. This has resulted in three technologies being migrated out of the lab into active commercialization endeavors. These include the interferometric bio/chem sensing technology with partner Salvus™, intelligent bird audio sensing for automated control with AudioT, and the dynamic filtration separations technology with Watson Agriculture and Food (which is highlighted in this report). In addition, ATRP is actively seeking industrial or start-up partnerships to commercialize four other efforts: our intelligent cutting technology, the enhanced chilling technology, the magnetic nanoparticle separation technology, and the poultry house robotics system. Each of these technologies offers the potential to provide solutions to unique challenges facing the poultry industry, and many of you have helped us get these technologies to this point. So, thank you for being active and engaged partners.

While we were not able to support the level of outreach and engagement activities that we normally would have, please know that we are still very interested in supporting the industry through technology assistance and conferences. We are looking forward to seeing all of you again soon, and appreciate your support as we navigated a very challenging FY 2021.

A handwritten signature in black ink that reads "Doug Britton". The signature is fluid and cursive, with a large initial "D".

## 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.

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Todd Applegate, University of Georgia  
Denise Heard, U.S. Poultry & Egg Association

# FY 2021 PROGRAM HIGHLIGHTS

JULY 1, 2020 - JUNE 30, 2021

## BY THE NUMBERS

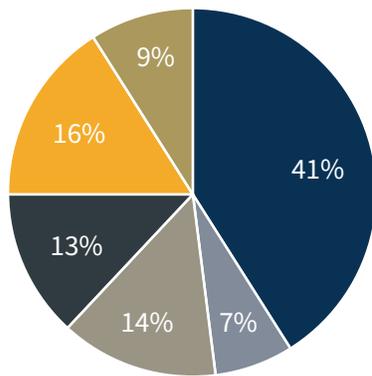
- ▶ **9** RESEARCH PROTOTYPES IN VARIOUS STAGES OF DEVELOPMENT
- ▶ **5** EXPLORATORY RESEARCH PROJECTS
- ▶ **3** PROVISIONAL PATENT APPLICATIONS
- ▶ **5** INVENTION DISCLOSURES
- ▶ **33** PUBLISHED ARTICLES, PAPERS, AND PRESENTATIONS
- ▶ **18** PARTICIPATING INDUSTRY AND ACADEMIC PARTNERS
- ▶ **21** 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

**Total Funding: \$2,031,272**

*Annual funding provided by the State of Georgia*



### Funding Breakdown by Program Area



## PROJECT COLLABORATORS

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.

Cobb-Vantress  
Ecologix  
Fieldale Farms  
Georgia Institute of Technology  
School of Civil and Environmental Engineering  
VentureLab  
Georgia Poultry Federation  
Harrison Poultry  
International Poultry Breeders  
JBT-Prime Equipment Group  
KWJ Engineering  
Marel  
Mar-Jac Poultry  
Salvus™  
TechnoCatch  
University of Georgia  
College of Veterinary Medicine  
Department of Poultry Science  
USDA-ARS Richard B. Russell Research Center  
U.S. Poultry & Egg Association  
Watson Agriculture and Food  
Wayne Farms

# FULL-SCALE RESEARCH PROJECTS

ADDRESSING CRITICAL ISSUES FACING POULTRY PROCESSING AND PRODUCTION



## ENHANCED CHILLING AUTOMATION VIA ALTERNATIVE MEDIA AND MOTION

Researchers investigated the use of advanced motion patterns to enhance in-line immersive chilling in poultry processing. 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 while adding rotational motion. In initial testing, this optimized rotation increased the amount of thermal transfer that occurs between the carcasses and chiller fluid because the rotational agitation is superimposed onto line speed. In fact, early results indicate that required chilling times for in-line immersive chilling with chilled water can be reduced by 30-40 percent. Specifically, in one set of experiments, the projected dwell time for chilling a weight class of carcasses from 40°C down to 4°C decreased from approximately 75 minutes to approximately 45 minutes, a 40 percent reduction.

Researchers believe optimized rotation should also magnify the chilling benefit of alternative chiller media like ice slurry. Experiments will continue with both chilled water and ice slurry, and larger carcass sizes will be tested to investigate efficacy in processing bigger birds. Success of the project could make in-line immersive chilling a viable option for poultry processing.

## PAA DECAY KINETICS

Researchers investigated the effects of organic carbon on the stability and breakdown of peracetic acid (PAA) within poultry chillers (pre-chiller and main chiller). PAA is used as a food safety measure for microbial control in chilling operations. Previous studies have shown that increases in organic carbon may cause PAA concentration to vary dramatically throughout a processing day.

During FY 2021, researchers collected chiller water samples on an hourly basis from two processors and characterized the samples for specific organic species, including total suspended solids (TSS); total dissolved solids (TDS); fats, oils, and grease (FOG); chemical oxygen demand (COD); and total Kjeldahl nitrogen (TKN). Two goals were undertaken. The first focused on quantifying the amount of organic loading and buildup in the chiller media, while the second focused on using that data to then measure the rate of PAA decay. Analysis of the data indicated a majority of the organic carbon load (with the exception of TKN) increased rapidly in the pre-chiller before reaching a steady state within 4-6 hours. In the main chiller, those same carbon species continually increased throughout a typical processing day. In addition, data showed TSS and protein had little to no effect on PAA decay, while TDS and TKN caused a rapid breakdown of PAA.

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 effective microbial control.





### **GROWOUT HOUSE ROBOTICS**

Researchers continued to investigate 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. The research team has developed a ground robot that can autonomously navigate a growout house.

During FY 2021, researchers tested the robot in commercial facilities. In breeder house testing, the robot demonstrated an egg-picking accuracy of approximately 90 percent. Preliminary broiler house testing of autonomous navigation showed adequate performance; additional testing is planned. In addition, initial testing of a drone system evaluated its potential to perform management tasks taking into account the chickens' response. During testing, the chickens showed no adverse reactions to the drone.

Researchers believe such 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.

### **MULTI-FUNCTION SENSOR SYSTEM**

Researchers continued development of a multi-function micro-sensor system for measuring levels of ammonia in poultry farms with minimal interference from other sources.

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 are developing 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 FY 2021, the team tested a handheld version of the sensor inside a commercial broiler house to evaluate its sensitivity and repeatability at various ammonia concentration profiles. Specifically, the sensor successfully detected ammonia at 5, 25, and 50 ppm.

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.



### **INTEGRATED WATER MANAGEMENT SYSTEM**

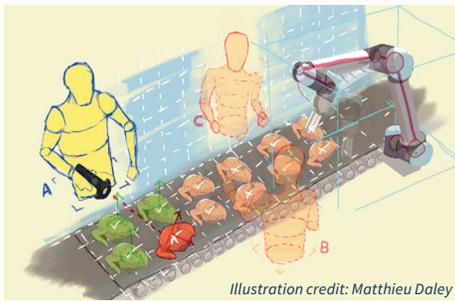
Researchers began development of a reagent-free system using an ultrasensitive and multiplexed interferometric sensor for monitoring key parameters in situ in poultry processing water streams. Water quality in poultry processing operations is monitored constantly to maximize water recycling/reuse and optimize wastewater treatment. However, current characterization practices are labor-intensive and require a variety of reagents and testing equipment.

During FY 2021, researchers focused on developing sensing chemistries for monitoring the amount of the antimicrobial peracetic acid (PAA) in processing water and the amount of fats, oils, and grease (FOG) in processing wastewater. The PAA sensing method, based on a charge-transfer complex chemistry, proved to be sensitive and selective for monitoring pre-chiller and chiller water, achieving a linear sensing range between 1 and 20 ppm. An initial FOG sensing chemistry based on a bulk refractive index, while promising, produced an irreversible adhesion on the sensor's waveguide surface. Further surface treatment strategies will be examined to improve surface regeneration.

Researchers believe full development of the system will not only provide a tool for in situ water quality monitoring for wastewater treatment but also enable real-time dynamic tracking and control of water conditions. This, in turn, will advance the scientific understanding of the fate of contaminants and nutrients in water distribution systems.

# EXPLORATORY RESEARCH PROJECTS

DEVELOPING CONCEPTS AND IDEAS FOR LATER TRANSITION INTO FULL-SCALE PROJECTS



## VIRTUAL REALITY FOR ROBOTICS SYSTEM CONTROL AND DEVELOPMENT

Researchers explored virtual reality (VR) systems for aiding the development and deployment of robotic systems in processing environments. During FY 2021, the team developed and tested an “expert-in-the-loop” robotics solution that allows human operators to provide key information to robot systems enabling their operation. This is performed by using cameras and 3D sensors to capture real-world information and pipe it into a virtual environment. Essentially, the human is performing the sensing task, and telling the robot what to do, all from a VR environment. Successful implementation could alter poultry processing tasks like loading chicken front halves on cones for deboning by removing workers from harsh environments and repetitive tasks.

## SPATIOTEMPORAL MODELING AND SIMULATION OF POULTRY PROCESSING PLANT

In response to the coronavirus pandemic, researchers completed a project specifically targeted at helping the poultry industry identify architectural and operational parameters that potentially affect transmission of diseases like COVID-19. The team developed a comprehensive model that combines an agent-based spatiotemporal model of processing plant common spaces (hallways, break rooms, etc.), airflow, people pathways/interactions, and design layout that can be used to pinpoint potential hot spots in both existing and new

facilities. Researchers believe the model can provide the industry alternative options for managing personnel interactions that could reduce the risk of infection.

## ON-FARM PROCESSING AND TRANSPORT (FPaT)

Researchers continued to evaluate the suitability, effects on processing, and economic feasibility of using a proof-of-concept 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. During FY 2021, the team field tested on-farm harvesting using traditional stunning methods and the FPaT system followed by transport. All carcasses were examined for physical damage (broken limbs), de-feathering quality, and meat quality parameters such as pH, cook loss, lean color, and texture. No significant differences were observed between a control group and carcasses processed and transported via the FPaT system. Researchers believe the system has the potential to alleviate bird welfare concerns while producing economic benefits by reducing manual labor requirements and transportation costs.

## ADVANCED INTELLIGENT CUTTING

Researchers evaluated the automation of poultry deboning by designing knife trajectories based on learning from expert demonstration. Manual chicken carcass deboning is one of poultry processing’s most laborious tasks. The team’s approach incorporates learning from demonstration (LfD) methods to allow expert practitioners (human deboners in this case) to inform/optimize robot knife paths that achieve maximal yield while avoiding bone chips. During FY 2021, data was

collected from human deboners using an instrumented knife to sever the shoulder joint of a bird carcass. This resulted in implicit expert-based optimized knife path functions that were then extracted using machine learning. These preliminary real-time knife/cutting paths were translated to an experimental robot that successfully performed similar cutting operations. Researchers believe the approach holds promise for advancing the incorporation of more robotic solutions for manual poultry processing tasks.



## DUAL ARM ROBOTICS

Researchers investigated the feasibility of using two robotic arms and a coordinated vision system to automatically place chicken carcasses onto a shackle line after chilling operations, commonly known as rehang. Currently performed manually, the task involves a repeated lifting motion that is physically demanding for operators. The team’s solution employs a robot with a passive gripper that captures and holds the carcasses’ legs and transfers them to a shackle line. The incorporated vision system determines placement of the leg joint (hocks) in a 3D environment. During FY 2021 laboratory testing, researchers successfully performed a single leg rehang with a single robot arm. However, due to communication difficulties between multiple robotic devices, the dual arm robotic approach was limited to simulation only. Hardware improvements are planned for FY 2022, and researchers believe the approach shows promise as an automated solution for manual handling tasks like rehang.

# SPECIAL TECHNOLOGY TRANSFER PROJECTS

TRANSITIONING FROM LABORATORY PROTOTYPES TO PLANT-READY SYSTEMS



## INTELLIGENT CUTTING TECHNOLOGY TRIALS

Researchers conducted in-plant trials of an Intelligent Cutting System. The robotic system is designed to perform deboning of chicken carcass front halves. While there are a handful of fixed automation solutions in today's poultry processing plants, such systems are no match for human deboners in terms of their ability to extract the maximum amount of yield in meat.

The distinctiveness of the Intelligent Cutting System is that it automates the process by intelligently adjusting to the natural variability of carcasses, thus enabling it to potentially achieve in-plant performance on par with human deboners. Commercialization discussions are ongoing.

## DYNAMIC FILTRATION TECHNOLOGY TRIALS

Researchers conducted in-plant trials of a Dynamic Filtration System. During the trials, the patented filtration technology (U.S. Patent 10,646,828) was licensed for poultry processing by a start-up company, Watson Agriculture and Food. The in-plant trials confirmed the system's feasibility for processing poultry liquid streams through a 100-micron screen and identified a better means of delivering a throughput of 100 gallons per minute. The system is designed to improve water recycling and byproduct recovery for poultry processing operations. The small footprint Dynamic Filtration System aims to ensure particles are stopped before the filter and removed as quickly and cost-effectively as possible.

Developed with sanitation in mind, the system will meet U.S. Food Safety and Inspection Service (FSIS) compliance guidelines for water reuse applications that achieve needed physical, chemical, or microbiological improvements in the reuse water.

## MAGNETIC NANOPARTICLE SEPARATION TECHNOLOGY

Researchers tested and evaluated the use of an innovative magnetic nanoparticle-based (MNP) method for poultry processing wastewater treatment applications. Environmental regulations require poultry processing wastewater be treated to remove contaminants before discharge. Most poultry processing operations use a multi-step process to treat the wastewater. In particular, a metal salts-based removal method known as chemical precipitation is used to remove phosphorus species. However, it is rather expensive and produces sludge that must be disposed of, further adding to treatment costs.

The team's single-step MNP-based method has proven to be significantly better at removing phosphorus species from wastewater samples compared to industry methods like dissolved air flotation. The reusability of the MNPs also lowers overall treatment costs. In fact, a cost analysis found the MNP-based treatment cost is less than \$1 per 1,000 gallons compared to \$1.50 per 1,000 gallons found with the current practice. Commercialization discussions are ongoing.





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