Researchers at the Georgia Tech Research Institute (GTRI) recently completed a six-week pilot test of an innovative magnetic nanoparticle-based (MNP) phosphorus removal and recovery method for use in poultry processing wastewater. The method has potential as a low-cost and environmentally friendly alternative to currently used technologies.

Environmental regulations require poultry wastewater be treated to remove phosphorus before discharge as excessive amounts of the nutrient can degrade water quality and harm aquatic life in nearby waterways. Most poultry processing operations use a metal salts-based removal method known as chemical precipitation. However, it is rather expensive and produces sludge that must be disposed of, further adding to treatment costs.

“The current phosphorus removal practices are not only costly but also not sustainable,” says Dr. Jie Xu, GTRI principal research scientist and project director. “Our MNP-based method removes and recovers the phosphorus from poultry processing wastewater. In addition, by reusing the MNPs, the phosphorus removal approach is more cost effective as well as environmentally sound.”

The GTRI Method

The GTRI method uses a proprietary MNP to capture and then remove phosphorus from poultry processing wastewater. The adsorption process only takes 30 minutes, and the treatment process only requires one step. There is no filtration, centrifugation, or chemical addition. The entire process takes place in a continuous flow-through device where the MNPs are regenerated for repeated use, currently more than 20 times, which lowers treatment costs. Residual MNP particles in the treated wastewater are negligible, and the method does not generate a large amount of sludge compared to chemical precipitation, thus processors can reduce disposal costs. An added benefit long-term is the recovered phosphorus can be converted into value-added products like fertilizer and chicken feed.

“The best thing about working with nanoparticles is that they are very easy to use. The physical nature of separating the particles using gravity and magnetic fields is easier than other processes and requires less chemical input than traditional wastewater treatment,” says Marc Zanghi, a GTRI research engineer who leads the project’s MNP testing and analysis. “With these particles, it is a quick process of add, mix, and separate.”

Dr. Aklilu Giorges, GTRI principal research engineer, holds samples of collected wastewater (L-R): DAF (dissolved air flotation) effluent, magnetic nanoparticle (MNP)-treated wastewater, and untreated raw wastewater. Results showed GTRI’s MNP-based treatment was significantly better at removing phosphorus and slightly better at removing other contaminants compared to typical DAF treatment.
Six-Week Pilot Test and Results

The six-week pilot test allowed the team to compare the efficacy of their system to a DAF (dissolved air flotation) system at a local poultry processing wastewater treatment plant. The GTRI team set up a test site consisting of two 1,000-gallon tanks next to the plant. A rigorous weekly, three-day treatment schedule involved filling the tanks with wastewater from the plant, applying MNPs, and then mixing for 30 minutes each time. The team took pre- and post-mixing samples of the wastewater from the tanks. These samples were compared to those taken from the plant’s DAF units. The team also collected sludge generated from MNP treatment, which will be analyzed in a follow-up study.

Overall, the team made about 35 kg of MNPs and treated nearly 10,000 gallons of poultry processing wastewater. Three dosages of MNPs were tested on phosphorus removal in the effluent of post screening (raw wastewater effluent). This type of wastewater contains high levels of contaminants, including total suspended solids (TSS); chemical oxygen demand (COD); fats, oils, grease (FOG); total Kjeldahl nitrogen (TKN); and total phosphorus (TP). All the contaminants need to be reduced dramatically before discharge.

Significant phosphorus removal was observed for all dosages of MNP. The highest dosage achieved more than 95 percent phosphorus removal, where the lowest dosage removed more than 80 percent of phosphorus. Furthermore, the lowest dosage MNP used 75 percent less nanoparticles than the highest dosage with only 15 percent reduction in TP removal. In fact, the MNP-based phosphorus removal was significantly better than the DAF system, which achieved only about 25 percent removal on average. Removal of other contaminants (i.e., TSS, FOG, COD, and TKN) was slightly better than the DAF system.

“Our pilot test went very well,” says Zanghi. “The results are exciting for us because they demonstrate that our particles, when applied to raw wastewater effluent, perform better than primary DAF systems currently implemented even when we treat large volumes of wastewater.”

In addition, Zanghi says the pilot test proved that not only can the MNPs be produced in large quantities without hindering their contaminant removal abilities, but they can also be easily applied and separated from processing effluent streams.

Next Steps

The team plans to examine the composition and nutritional value of the dried MNP sludge collected during the pilot test. This sludge contains high levels of protein, fats, and phosphorus nutrients, which can be potentially used in feedstuff.

“We expect our method will prove to advance the capture and reclamation of nutrients contained in poultry processing effluents, particularly phosphorus, that can be recovered as value-added products,” says Xu.

Xu also says it is worth noting that the cost for the MNP-based approach is below $1 per 1,000 gallons compared to the current practice that is about $1.50 per 1,000 gallons.

“Currently, there is a finite amount of available phosphorus in the world, and we are consuming it at a staggering rate. We hope with our new treatment method, we can recover some of this consumed phosphorus and repurpose it to produce more chicken or aid other agricultural endeavors that may support the poultry industry,” adds Zanghi.
The ever-increasing demand for high-quality protein has led to massive growth in the poultry industry over the last 50 years. With this growth comes concerns about the environmental impacts of this large-scale and increasingly concentrated industry. Compared to other animal proteins poultry has a considerably smaller environmental impact thanks in large part to the short maturation period and high feed conversion efficiency of modern broilers.

However, through modern technological advances, there are a number of opportunities to further improve poultry’s standing as one of the most sustainable and environmentally friendly animal proteins. Furthermore, many of these technologies can provide economic benefits to growers.

Over the past year, researchers at the Georgia Tech Research Institute (GTRI) have reviewed various green technologies that can be integrated into broiler houses to assess their environmental and economic impacts.

One of the biggest shifts in the industry in recent years has been the move to fully enclosed houses with advanced environmental controls. These houses have been shown to improve feed conversion efficiency and bird well-being.

In addition, the improved insulation significantly reduces the energy used for heating during cold seasons, although energy usage is increased during hotter weather due to the use of more active cooling systems. Overall, well-designed fully enclosed houses that make use of tunnel ventilation, evaporative cooling pads, proper insulation, and high-efficiency fans have been shown to use less total energy throughout the year while providing significant improvements in broiler growth.

Lighting upgrades were found to be one of the most cost-effective ways to lower energy use. The move to high-efficiency LEDs or compact fluorescent lighting can save as much as 30,000 kWh per year compared to incandescent lighting systems.

LEDs, in particular, are continuing to become even more efficient while rapidly dropping in price. Studies have shown that LED lighting systems may also have some benefits for bird well-being.

Beyond just saving energy, many growers are exploring the use of solar technology to further reduce their carbon footprint. The Federal Solar Investment Tax Credit and other incentive programs across the country can reduce the levelized cost of energy for solar systems in line with, or even below, grid prices for electricity in areas with high solar irradiance. Like LEDs, solar technology continues to improve in terms of efficiency and cost. Growers should explore incentive programs in their area even if they aren’t ready to install a photovoltaic system yet.

Due to their long lifetimes and high efficiencies, LED lighting systems are highly recommended for any modern broiler house.

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Incorporating these environmentally beneficial and cost-saving technologies in grow house facilities will ensure that poultry production will continue to be a sustainable, humane, and profitable method of providing high-quality animal protein.
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. Ten exploratory projects were funded in Fiscal Year 2019, which ended June 30. The following briefs highlight research results.

**Next Generation Yield and 3D Scanning**
Researchers developed a novel 3D reconstruction system using multiple stereo cameras to generate high-fidelity models of live chicken and processed parts. Several tests were conducted using data generated from CT (computerized tomography) scans. Yield estimation tests showed promise in the ability to quantify the amount of meat removed from a carcass by using the volume of the generated models. Most promising was live weight estimation, where a correlation coefficient between 96% and 99% was identified when directly comparing the live weight of a chicken with the volume of the CT scan data.

**Dynamic Laser Speckle Imaging for Detecting Living Bacteria**
Researchers designed a rapid and non-contact imaging system that analyzes time-varying granular or speckle patterns in images to identify living bacteria. Initial analyses of experimental time-lapse laser speckle images show clear differences between background and bacteria-grown pads. However, further investigation is needed to correlate the differences with bacteria growth and/or mobility.

**The Investigation of Bacterial Transport During Secondary Processing (Cross-Contamination)**
Researchers studied the forces associated with bacterial transfer from chicken tissue and processing surfaces. FY 2019 efforts focused on pinpointing areas of possible cross-contamination during secondary processing operations by studying carcass bacterial loads. Six sample locations (breast, leg, cavity, shoulder, back, and tail) and two depths (skin and muscle) were selected from carcasses after chilling. Results indicate that bacteria loads vary depending on the sampling location and depth, with the breast skin showing the highest CFU (colony-forming unit).

**Antibiotic Resistance in Concentrated Poultry Feeding Operations**
Researchers collected and analyzed samples from concentrated animal feeding operations (CAFOs) to understand the impacts on the transfer of antibiotic-resistant genes and organisms in the surrounding environment. Analyses revealed that most of the antibiotic-resistant genes found in environmental samples were resistant to bacitracin. No other significant antimicrobial resistance associations were found between litter and environmental samples. Generally, there has been a significant decrease in antibiotic use in poultry operations over the past three years.

**Farm Processing and Transport (FPAT) System**
Researchers continued to evaluate the suitability and economic feasibility of using new technologies for on-farm bird harvesting and related tasks. FY 2019 activities focused on performing an economic analysis of the proposed system compared to current industry practice. Preliminary findings suggest the proposed system, even though it requires larger upfront investment, is an attractive economic choice and will produce sizable economic benefits over the lifetime of the system. An investigation is underway to confirm the findings.

**Immunodominant Membrane Proteins (IDPs) Importance as Disease Agents**
Researchers studied plant-pathogenic bacteria like Phytoplasmas to better reduce energy usage while also providing secondary benefits like improved productivity and/or profits. These include high-efficiency LED lighting, fully enclosed houses with advanced climate control, solar energy systems, waste management systems, and biomass heating systems.
understand the role of membrane proteins in disease transmission, particularly within plants used in poultry feed. Literature reviews identified bacterial outer membrane proteins, vesicles, and bioactive proteins as key components triggering pathogenic responses due to the surrounding environment. Researchers also identified MALDI/MS (matrix-assisted laser desorption/ionization mass spectrometry) as a promising approach for detecting asymptomatic conditions (i.e., when a disease or disease agent is present without noticeable symptoms) due to its quantitative nature.

3D Perception for Bin Picking
Researchers continued to develop a machine learning-based approach to predict a deformable object’s pose and the best way to grasp it for poultry processing tasks like robotic bin picking. During FY 2019, researchers developed the components of the full bin picking pipeline along with the necessary manipulation algorithms. Initial testing proved promising, and further work is underway to develop advanced 3D reasoning for robotic manipulation and improve the robustness of pose estimation and processing of 3D input.

Poultry Product Manipulation
Researchers developed a prototype automated system that can sense, grasp, and transfer nuggets and fillets from one conveyor to another for further processing. Initial tests showed the system successful in grasping both nuggets and fillets. Further development is underway to demonstrate transferring the products onto a conveyor.

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 26 technical assistance services in FY 2019.

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.

RESEARCHER PROFILE

Konrad Ahlin

Job title: Research Engineer II

Education: Ph.D., Robotics, Georgia Institute of Technology; M.S. and B.S., Mechanical Engineering, Rochester Institute of Technology

Areas of research expertise: Robotics, Dynamics, Controls

List of any poultry industry projects you’re working on and your role: The Re-Hang project under Dr. Ai-Ping Hu. We are looking to use advanced robotics to perform re-shackling procedures. I am responsible for some of the robotics in this project.

What I find most rewarding about working on poultry industry projects: The idea that we are helping to feed America

A talent I wish I had: Artistry

Another occupation I’d like to try: Writer

My first job: This is my first full-time job outside of college

If I could meet someone famous, who would it be and why: Abraham Lincoln, to better understand a man who stood for justice in full knowledge of its cost

One thing people may not know about me: I ride a unicycle

My day would not be complete without: Coffee

The last book I read: The Lord of the Rings

The last movie I saw: The Death of Stalin

My favorite song: “Under Pressure” by Queen

My motto: Who of you by worrying can add a single hour to your life? Since you cannot do this very little thing, why do you worry about the rest? (Luke 12:25-26)

My hobbies: Writing, juggling, and woodworking
The Chemistry of Peracetic Acid
BY DANIEL SABO, PH.D.

Bacterial pathogens, such as Salmonella spp. and Campylobacter, continue to be the leading suspected causes of foodborne illnesses from poultry products today. Currently, multiple intervention strategies in processing help reduce and eliminate these pathogens, with one fast becoming dominate over the others: Peracetic Acid (PAA). This article serves as an overview of the chemistry and interaction of PAA with materials common to poultry processing plants. This is by no means an exhaustive description of PAA, but serves as a brief introduction.

Peracetic acid, also known as peroxyacetic acid, is a peroxide version of acetic acid (vinegar) with an oxygen-oxygen bond. It is similar to hydrogen peroxide in structure, however, is more stable and a stronger antimicrobial compared to hydrogen peroxide due to the placement of this oxygen bond. For food applications, common formulations also usually contain a synthetic stabilizer to slow the rate of decomposition back into hydrogen peroxide and acetic acid. PAA is a colorless liquid, with a characteristic pungent vinegar smell.

A PAA solution is a mixture of acetic acid, hydrogen peroxide, water, and peracetic acid, which allows for many concentrations of PAA and hydrogen peroxide. Another reason for the various concentrations is its application. For example, the food industry typically uses a stock PAA with concentrations of 15-25%, while the paper industry requires a much higher concentration of PAA, around 50%, due to its bleaching ability.

While there are many modes of action for the disinfection activity of PAA, the main one is due to the release of the reactive oxygen species when PAA is activated by light in water. These reactive oxygen species cause irreparable damage to biomolecules common to bacteria as well as disruption to their normal cellular function.

The disinfection efficiency of PAA is dependent on certain factors that include: temperature, pH, total suspended solids, and metal ions. PAA can function over a wide range of temperatures typical for the poultry industry; however, the rate of PAA degradation increases with temperature. It is sensitive to changes in pH and has its highest activity at or below 8.2. In general, PAA efficacy increases as the concentration of total suspended solids and biochemical oxygen demand decrease. The presence of metals, such as pure iron, will cause PAA to decay. Exposure to large amounts of metal in a short period of time can result in fire and/or explosions. Great care needs to be taken to avoid direct contact of PAA with iron metal.

Its efficacy for a wide range of pathogens makes PAA an attractive antimicrobial for the poultry industry. However, due to its reactive nature, great care is needed regarding how and where it will be stored and used within a facility. As the compatible and incompatible materials listed above are not exhaustive, managers should verify PAA material compatibility with equipment used throughout a plant by requesting a compatibility chart and consulting their PAA supplier.

Advantages of PAA include:
- Antimicrobial agent for a wide range of bacteria, viruses, spores, fungi, and protozoan cysts
- Effective antimicrobial agent over a wide range of temperatures and pHs up to 8.5
- Decomposes into innocuous products of acetic acid, water, and oxygen
- Compatible with some commonly used materials such as stainless steel, polytetrafluoroethylene (PTFE), and polyvinylidene fluoride (PVDF)

Disadvantages of PAA include:
- Strict storage conditions to prevent fire
- Cost
- Corrosive to copper, copper alloys, iron, and synthetic rubber
- Decomposes into acetic acid, which increases chemical oxygen demand in wastewater

Dr. Daniel Sabo is a research scientist in the Georgia Tech Research Institute’s Food Processing Technology Division.
USPOULTRY Releases First-Ever Report Quantifying Antimicrobial Use in Poultry

The U.S. Poultry & Egg Association (USPOULTRY) released the U.S. poultry industry’s first-ever report quantifying antimicrobial use on broiler chicken and turkey farms on August 5, 2019. The new report shows dramatic reductions of turkey and broiler chicken antimicrobial use over a five-year timeframe. As part of its commitment to the transparency and sustainability of a safe food supply, the poultry industry aims to strike a balance between keeping poultry flocks healthy and the responsible use of antimicrobials, especially those medically important to human health.

Under the research direction of Dr. Randall Singer, DVM, PhD, of Mindwalk Consulting Group, LLC, this report represents a five-year set of data collected from 2013 to 2017 regarding the use of antimicrobials in U.S. broiler chickens and turkeys throughout their lifetime, from hatchery to day of harvest. It was prepared through a systematic collection of on-farm antimicrobial use data to capture the disease indications and routes of administration through which antimicrobials were given to the poultry.

Given several key differences among broiler chickens and turkeys — namely differences in weight, life span, susceptibility to lifetime illness, and the number of effective medical therapies available — the data from broiler chickens and turkeys should neither be combined nor compared.

Key changes among broiler chickens over the five-year period show:
- Broiler chickens receiving antimicrobials in the hatchery decreased from 93% to 17%
- Hatchery gentamicin use decreased approximately 74%
- Medically important in-feed antimicrobial use in broiler chickens decreased by as much as 95%. For example: tetracycline 95%, virginiamycin 60%
- Medically important water-soluble antimicrobial use in broiler chickens decreased by as much as 72%. For example: penicillin 21%, tetracycline 47%, sulfonamide 72%
- There was a documented shift to the use of antimicrobial drugs that are not considered medically important to humans (e.g., avilamycin and bacitracin BMD)

Key changes among turkeys over the five-year period show:
- Turkeys receiving antimicrobials in the hatchery decreased from 96% to 41%
- Hatchery gentamicin use decreased approximately 42%
- Medically important in-feed antimicrobial use in turkeys decreased: tetracycline 67%
- Medically important water-soluble antimicrobial use decreased substantially. For example: penicillin 42%, tetracycline 28%, lincomycin 46%, neomycin 49%, erythromycin 65%

Antimicrobial use among broiler chickens and turkeys decreased dramatically between 2013 and 2017, and there are a couple of key explanations for this:
- Changes in FDA regulations, which were fully implemented in January 2017, effectively eliminated the use of medically important antimicrobials for production purposes and placed all medically important antimicrobials administered in the feed or water of poultry under veterinary supervision
- A continued focus by poultry companies on disease prevention, thereby reducing the need for antimicrobials
- Improved record-keeping of all antimicrobial administrations, which is a key component of antimicrobial stewardship

Furthermore, the broiler chicken and turkey industries have increased the production of animals raised without antimicrobials.

Participation in this effort was entirely voluntary. The poultry industry recognized the importance of this work and responded. The 2017 data in this report represent more than 7.5 billion chickens (about 90% of annual U.S. chicken production by the major companies on the WATT PoultryUSA list) and 160 million turkeys (about 80% of annual U.S. turkey production by the major companies on the WATT PoultryUSA list).

USPOULTRY Vice President of Research, Dr. John Glisson, DVM, MAM, PhD, affirms, “This research is the first step in determining how antimicrobials are used in the entire poultry production system of the U.S., and to succeed, we need participation from the majority of companies. We couldn’t be more pleased with the response of the poultry industry.”

Glisson cautions, though, that there are still serious bird illnesses (e.g., necrotic enteritis, gangrenous dermatitis, and colibacillosis) for which the poultry industry has few effective interventions. And when birds get sick from these diseases, they must receive therapy. He confirms that “driving good antimicrobial stewardship in poultry, as opposed to simple documentation of reduced use, is our end goal for the best outcomes for both the people and the poultry.”

Moving forward, Dr. Singer will continue the annual collection of data from the broiler chicken and turkey industries and will begin collecting data from the U.S. table egg industry. Glisson anticipates this new data will provide greater clarity about antimicrobial use in individual flocks, stating, “We expect even more detailed data on flock antimicrobial usage and record-keeping in the years ahead, which thoroughly supports USPOULTRY efforts to ensure proper stewardship of medications.”

A copy of the report is available at uspoultry.org/poultry-antimicrobial-use-report.
Visit ATRP in Booth 5126 – Exhibit Hall B at the 2020 International Production & Processing Expo

The Agricultural Technology Research Program (ATRP) is excited about its plans to participate in the 2020 International Production & Processing Expo (IPPE), scheduled for January 28-30, 2020, 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 handouts will describe current projects.

For more information, visit ippexpo.org.

Register Early for the International Food Automation Networking (IFAN) Conference

The 2020 International Food Automation Networking (IFAN) Conference is scheduled for April 8-10, 2020, at the Georgia Tech Hotel and Conference Center in Atlanta. IFAN Conference 2020 will focus on robotics and automation in the food industry and examine new technology trends, industry challenges, and evolving research. The conference brings together industry leaders from across the globe for two days of education sessions and networking opportunities.

Register at ifan.gtri.gatech.edu.

POULTRY TRIVIA

What’s Really in that Chicken Nugget?

Chicken nuggets are, in fact, typically made of the same meat that you see in the supermarket, that is, broiler meat.

Most chicken nuggets start as a split breast of chicken. You might read on the package that the product contains “rib meat.” Rib meat is simply a natural extension of the breast meat. It is NOT an additive or a filler.

Other boneless chicken meat (for example, from the legs and thighs) or skin from the meat could be added for flavor and texture. The meat might then be marinated to enhance the meat’s juiciness and flavor.

The meat is then ground and formed, just like you would form a meatball from a ground meat product. It is then breaded and cooked, usually baked or fried in oil.

Source: nationalchickencouncil.org

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