Ice Slurry Shows Promise as an Antimicrobial Aid for Poultry Immersion Chillers

The main purpose of poultry immersion chillers is to submerge carcasses in water that has been chilled to a temperature low enough to inhibit pathogen growth. As an extra precaution, processors add chemical disinfectants to the water to eliminate any microbes that may pose a food safety risk.

Researchers with the Georgia Tech Research Institute’s (GTRI) Agricultural Technology Research Program have been investigating the use of ice slurry (a mixture of micro-sized ice crystals and water) as an alternative chilling medium that may also have antimicrobial properties.

“We began the project operating on the assumption that the ice slurry’s increased cooling capacity per unit mass of water would likely reduce water consumption while also providing a faster chill compared with conventional chilled water,” says Dr. Comas Haynes, GTRI principal research engineer and project director.

In fact, initial scaled experiments using an auger chiller demonstrated the ice slurry’s superior cooling capacity as compared with conventional chilled water. Results showed carcass core temperatures decreased on average an additional 25 percent in 45 minutes within the ice slurry at an initial temperature of minus 1°C compared with 45 minutes within the chilled (liquid) water at an initial temperature of 4°C. The corollary, explains Haynes, is that a target temperature could be reached in the same processing time but with less water if the slurry form is used.

Having shown that the ice slurry does, in fact, allow for significantly greater cooling per unit mass of water, researchers began to wonder if the slurry’s texture could act as a scrubber along the carcasses’ skin. The idea is that the scrubbing motion would be like an abrasive force that could help to loosen or weaken potential microbial colonies or biofilms adhering to the carcasses, thus creating an opportunity for the slurry to aid antimicrobial activity.

Microscopic view of ice slurry comprised of crystals suspended in fluid. The inset photo shows a close-up view of a chicken carcass immersed in ice slurry within an experimental auger chiller. GTRI researchers are investigating the use of ice slurry to enhance thermal efficiencies and reduce the presence of pathogens in poultry chillers.

continued on page 8
Leading People and Understanding Culture

One of the things that I enjoy the most about managing the Agricultural Technology Research Program (ATRP) here at Georgia Tech is interacting with people, whether it be internally with colleagues or externally with visitors and stakeholders. However, for many of us, it is the people part of our operations that is often one of the more challenging aspects of our business. I’d like to share a rather basic framework from the book *Tribal Leadership* by Dave Logan that I have found useful for leading people and understanding culture within an organization.

The Tribal Leadership framework focuses on five distinct cultural levels that are characterized by the words that people within the tribe use and the relationships they form. The tribe in this context is a small- to mid-sized group of people who have some common connection or affiliation. The level at which most members in the tribe are functioning will establish the culture of that tribe within the organization. Every person has the capability of functioning at every level, so be sure not to define someone as “being” a specific level, but rather refer to individuals as “functioning” at a specific level.

**Level 1** – At this level, individuals are completely alienated, see no value or purpose in life, regardless of economic or social status. They are despairingly hostile and band together only to get ahead in what they see as a violent and unfair world. It is characterized by the language “Life Sucks!” and individuals functioning at this level make up only a small fraction of the population. The best way to help individuals at this level grow is to help them understand relationships and within societal norms.

**Level 2** – This level is characterized by the language “My Life Sucks!” Individuals at this level still function separately, but are beginning to recognize that the lives of others (particularly organizational leaders) seem to be pretty good. Tribes at this level tend to be made up of fragile alliances around common themes of disdain for the system or the boss. They are often sarcastic, passive-aggressive, apathetic victims who don’t feel that their contributions matter. Ironically, the best way to help them is to give them tasks that they excel at and can complete that have clear and demonstrable value to the tribe or organization. Then encourage them to form relationships with folks at level 3.

**Level 3** – People operating at this level see themselves as the very best at what they do, and their characteristic language “I Am Great!” clearly denotes that. The unspoken but clearly inferred rest of that phrase is “But You Are Not!” We often see these individuals in academic or medical fields, where they truly are experts that are surrounded by a support cast (students, medical assistants, nurses, etc.). For them, knowledge is power and winning is personal. They are always competing (both internally and externally), and as a result, they operate as lone warriors hoarding information, resources, and relationships. Roughly half of the population functions at this level. As you are looking to lead people to the next level, it is important to show them that real power is in the network, not just knowledge. Encourage them to connect their contacts, work on bigger projects (that they alone cannot complete), and begin to build teams.

**Level 4** – This level is comprised of individuals who are truly functioning as teams characterized by the language “We Are Great!” with the inferred end of the phrase being “But They Are Not!” There is still a strong adversary. Individuals in a level 4 tribe are excited to work together, share common values and strategies, with an overarching focus on the good of the tribe. The network is generally very strong, interconnected, and owned by the tribe, not individuals. Less than one quarter of the population functions at this level, and as leaders our focus should shift from changing levels to stabilizing individuals at level 4. Ensure the tribe is operating on shared values, resist the elevation of certain individuals (experts) in the tribe who can quickly revert to level 3 thinking. Allow the tribe to solve problems and challenge them with ambitious “stretch” projects.

**Level 5** – The language here is “Life Is Great!” No qualifiers! Individuals and tribes functioning at level 5 have a sense of destiny, greatness, that they will make history, and the only competition is the impossible. Relationships consist of highly networked teams that include both internal and external contacts. A quick confession: most individuals and organizations cannot stay at level 5. Even the very best will end up bouncing between levels 4 and 5, as sustained long-term operation at level 5 is simply not human.

One way to shape the culture within an organization is to help individuals within the tribe progress through the levels. The language they use and the relationships they form indicate the level they are on. Successfully getting people to progress is also predicated on establishing a set of shared core values and a vision that identifies the “noble cause” of the organization. Individuals simply cannot skip levels. They really do need to develop at each level prior to moving up, and once a critical mass of individuals has been established at a particular level, the tribe will take over and establish the culture. Then it is time to start helping them move up to the next level.

If you’re interested in learning more about the five levels of Tribal Leadership and how they affect organizational leadership and employee culture, I encourage you to buy a copy of Dave Logan’s book, *Tribal Leadership*.
Researchers with the Georgia Tech Research Institute’s (GTRI) Agricultural Technology Research Program continue to add modules to their Poultry System Simulation Model. The system-of-systems model for poultry processing simulates plant water usage, wastewater content, and energy consumption to help processors pinpoint areas for production improvements.

“The Poultry System Simulation Model is designed as a fully customizable tool that poultry processors can use to evaluate production-related needs that are specific to a particular plant and link them with existing solutions,” explains Olga Kemenova, GTRI research engineer and project director.

Nicknamed PRYSSM by the research team, the model’s interrelated modules afford poultry processing plant managers the opportunity to evaluate alternatives to current practices that could potentially result in water quality improvements or reductions in water use at poultry plants, actionable cost benefit analyses of wastewater treatment options, and accurate estimations of power consumption.

**How PRYSSM’s Modules Work**

**Water & Wastewater Modules**

The water and wastewater modules work together seamlessly. The water module uses monthly bird production rates and live bird weights as input parameters to simulate water usage in processes such as stunning, scalding, plucking, chilling, and general sewer discharge. The wastewater module is designed to operate based on outputs of the water model and calculates contaminants concentrations in wastewater flow such as total suspended solids (TSS); biochemical oxygen demand (BOD); fats, oil, and grease (FOG); total kjeldahl nitrogen (TKN); and phosphorus.

Researchers recently validated the water and wastewater modules at a local poultry processing plant. Preliminary results confirmed PRYSSM’s predictive capabilities, with outputs on par with the plant’s typically measured contaminants levels.

“We were pleased to discover that our model performed as intended, and that industry sees it as a useful tool for estimating production and quality outputs,” says Kemenova.

**Energy Module**

The energy module simulates power consumption associated with pumping, filtering, heating, and cooling water inside the plant as well as wastewater treatment operations. Inputs that are currently varied include water flow for each process, number of chickens processed, and wastewater components included in the treatment process. Based on those inputs, energy consumption is calculated for each process. The outputs of the module can be represented in several different forms such as charts and data tables.

Plant managers can use the energy module to evaluate current power consumption, compare it with industry best practices, identify operations that are falling behind industry standards, and develop strategies for improvements.

**Next Steps**

The team is currently working on adding a labor module to PRYSSM that will simulate labor requirements to pinpoint areas for better allocation. But, explains Kemenova, the module will go beyond a simple assessment of how many workers of a particular type should be employed. It will also include economic analyses associated with changes in workforce composition if plant managers decide to change current practices in favor of new technologies and automation.

In addition, researchers are also characterizing water samples to determine wastewater composition at different stages of processing and treatment operations.

“Knowing wastewater composition at different stages of processing and at each stage of treatment will allow for better identification and evaluation of water reuse options and allow for better placement of new treatment technologies,” says Kemenova.

PRYSSM’s high level of customization allows plant managers to evaluate design modifications in the production and water treatment processes before committing to actual building contracts and expenditures.

Kemenova says the team will continue to enhance PRYSSM, with interest in adding modules to simulate additional processes that are not well understood but still important to industry like water recirculation.
Using Ferric-Based Disinfectants in Food Processing Waters

Researchers demonstrated the efficacy of using ferric-based compounds as antimicrobials for *Salmonella* and *Listeria* in chicken meat and fresh produce. Results showed that about a 2-log bacterial load reduction can be achieved in 30 seconds on both pathogens. Contact time and temperature had minimal impact on antimicrobial efficacy, and there was no noticeable change in food quality properties like color, texture, and taste after treatment. Researchers believe the compounds have potential as low-cost alternative antimicrobials.

Removal of Free Fatty Acids from Rendered Oil

Researchers developed a method to remove free fatty acids (FFAs) from rendered oil using magnetic nanoparticles (MNPs). Experiments with samples of brown grease showed a reduction in the FFA level from an unacceptable 5% to a desired 3.6% with only a 4% weight loading of MNPs. A 10% loading further reduced the FFA level to 2.3%. The lower the FFA, the better for shelf life and oil quality.

Individual Bird Monitoring

Researchers created an Android smartphone Data Logger app to record data from a small, wireless EEG device. The portable device measures individual bird bio-responses and can be used to assess bird well-being during live operations. Initial tests were performed on birds at the University of Georgia; results are pending. The project is helping researchers test new techniques for live operations. It also helped them obtain a research grant from the U.S. Poultry & Egg Association to study chick euthanasia.

On-Farm Production and Transportation System

Researchers completed a conceptual design of a mobile, on-farm poultry processing and transportation system. The system includes modules for catching, stunning, slaughtering, and shackling birds at the farm. A separate unit transports them to poultry processing plants. The system can easily move between multiple poultry houses with loading times comparable to existing industry standards. Researchers believe the concept is technically feasible and could produce savings over current production and transportation processes.

Multi-Function Sensory System for Smart Poultry Farming

Researchers designed a micro-sensor system aimed at measuring emissions of odor, ammonia, hydrogen sulfide, methane, and non-methane volatile levels at poultry farms with minimal interference from other sources. The prototype includes a micro detector and processor with a wireless module for real-time data collection and analysis. Samples of volatile organic compounds were successfully measured during laboratory testing with only minimal signal interference. System optimization is underway with the goal of further testing at an actual poultry farm.

Advanced Enrichment Reactor

Researchers refined their advanced enrichment technique for detection of pathogens in large-volume poultry processing samples. Using the technique, they were able to reduce the lag time before the start of exponential growth and subsequently increase the overall growth rate. Preliminary results with *Salmonella enterica* serovar Typhimurium outperformed the control, yielding a 37.6% shorter lag time followed by a 109.6% greater growth rate. Researchers believe these results suggest that accelerating the enrichment step for real-time detection is within reach.

Enhancing Predictive Modeling for Livestock Harvesting

Researchers evaluated the feasibility of using 3D model analysis to estimate bird weight for harvesting. The Microsoft Kinect
V2 sensor was used in experimental growout houses to collect 3D data of broiler chickens over a 6-week period and breeder chickens over a 4-week period. The team compared the 3D data with manual weight measurements. Results indicated a 90% correlation, suggesting the sensor could be used in growout houses as an alternative non-contact weight estimation tool.

Correlations with Broiler Processing Characteristics and Genetic Traits
Researchers explored the weight and physical measures of different genetic species of broilers in an effort to determine the most efficient processing machinery design. Analyses showed correlations are stronger between various physical dimensions than with weight. Researchers believe this discovery opens up the possibility of improving processing efficiencies through the use of automation. It could also enable the use of computer-aided design and virtual reality tools to support equipment design.

Growout Sanitation
Researchers studied 1,280 broilers during growout to determine the effects of water and litter quality and antibiotic use on broiler mortality and growth velocity. The broilers were divided into groups and raised under varying treatments: new or used litter, with and without chlorine-treated water, and with and without antibiotic feed. Data analysis is underway, and in addition to determining any potential linkage, researchers hope to define economically viable options for reducing or eliminating the use of prophylactic antibiotics.

RESEARCHER PROFILE

John Pierson

Job title: Principal Research Engineer

Education: M.S., Environmental Engineering, Georgia Institute of Technology; B.S., Engineering, United States Military Academy (West Point)

If I could meet someone famous, who would it be and why: Tom Silva (This Old House) – king of historic home renovation

One thing people may not know about me: I am an early riser (4:21 a.m.)

My day would not be complete without: Hugs from my daughters

The last book I read: Area 51: An Uncensored History of America’s Top Secret Military Base

The last movie I saw: ASCE’s (American Society of Civil Engineers) Dream Big IMAX (shameless plug)

My favorite song: Let It Ride by BTO (Bachman-Turner Overdrive)

My motto: Begin each day with a grateful heart

My hobbies: Home renovation

Visit ATRP’s Exhibit in Booth 5133 – Hall B at the 2017 International Production & Processing Expo

The Agricultural Technology Research Program (ATRP) is excited about its plans to participate in the 2017 International Production & Processing Expo (IPPE), scheduled for January 31-February 2, 2017, 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.

THE EXHIBIT WILL BE LOCATED IN EXHIBIT HALL B, BOOTH 5133.

The IPPE is a collaboration of three trade shows — International Feed Expo, International Meat Expo, and the International Poultry Expo — representing the entire chain of protein production and processing. The event is sponsored by the American Feed Industry Association, North American Meat Institute, and U.S. Poultry & Egg Association.

For more information, visit www.ippexpo.org.
Whole Genome Sequencing 101

In recent years, we have seen many instances where foodborne illnesses have been traced back to specific products, triggering recalls of products and investigations into production practices. This has affected all segments of the food industry including our own, poultry. Investigations into foodborne illnesses are complex, but one of the standard practices is to try to match the organism which is causing the foodborne illness to an organism in some product eaten by a sick patient.

Various techniques have been used to analyze the DNA sequence of the organisms to see if there is a match. We often call this a DNA fingerprint, with the assumption that if two organisms — for example, two salmonella isolates — have the same DNA fingerprint then they are identical. So, if the salmonella from the sick patient has the same DNA fingerprint as the salmonella from a food product eaten by that patient, the foodborne illness is attributed to that food product.

Attribution of a foodborne illness to a specific food product has become more accurate as the DNA fingerprinting techniques have become more advanced. … Today, DNA fingerprinting is rapidly moving toward a technique that provides the sequence of the entire DNA in the organism. The entire DNA of an organism is called its genome.

Therefore, when all of the genome is sequenced, the technique is called Whole Genome Sequencing (WGS). The switch to WGS has come about because the cost of the technique has become very reasonable. The cost now of WGS is similar to previous DNA fingerprinting techniques which looked at only a small part of the genome.

WGS has been adopted by the U.S. Food & Drug Administration (FDA), the Centers for Disease Control & Prevention (CDC), and the USDA/ Food Safety & Inspection Service (FSIS) to characterize organisms associated with foodborne illness. The data (genomes) are stored in a public database at the National Center for Biotechnology Information (NCBI). Fifty thousand E. coli, salmonella, listeria, and campylobacter genomes have already been stored at NCBI.

The source of these bacterial isolates varies. For example, when FSIS obtains salmonella isolates from a poultry plant, the whole genome sequence of that isolate is stored at NCBI. Likewise, salmonella isolates obtained by CDC from sick patients are sequenced, and the sequences are stored at NCBI. Also, if FDA isolates salmonella from a food product in a store, the whole genome sequence of that organism is stored at NCBI. So, in the case of an outbreak of salmonellosis in people, the isolate from the ill people can be quickly compared to all salmonellas in the NCBI database, potentially facilitating the finding of a “match” and pointing the investigators to the likely food source associated with the outbreak.
In 2011, a network of laboratories, called the GenomeTrakr Network, was established to accelerate the source tracking and tracing of foodborne outbreaks through use of WGS. The network has a partnership with NCBI to store and share the sequence data in the public domain. Today, the network consists of laboratories at FDA, CDC, FSIS, 14 state labs, and nine international labs. When expansion of the network is complete, laboratories from every state will be included.

The relatively rapid adoption of WGS by regulatory agencies has generated much controversy surrounding the security of the data, the interpretation of the data, the use of WGS in foodborne illness investigations, and the actual techniques used to generate the genome sequences. In the NCBI public database, each genome sequence is identified by its source. The source information (metadata) does not include names of companies or people. There is considerable concern from the food industries about the continued anonymity of source identification.

Do two bacteria have to have exactly the same DNA sequence to be considered identical? Regulators and experts disagree on how closely two organisms must match in order to be considered a match? Regulators and experts disagree on how closely two organisms must match in order to be considered identical. In the past, epidemiology (documentation that the ill patient actually ate the suspected contaminated food) has been a critical part of foodborne illness investigations. FDA, CDC, and FSIS disagree on whether epidemiology will continue to play a key role in foodborne illness investigations or whether WGS can be used alone. There are two major techniques for performing WGS, and the two methods provide differing data sets. The food industries would like the laboratory network to use just one technique and that the technique used be the one that is most accurate and reliable.

The industry also has an opportunity to adopt WGS. WGS can serve as a tool that not only identifies pathogens in your processing facilities, but it can also serve as a way to analyze the overall microbial population of entire production complexes. WGS can provide information to analyze microbial communities during processing stages and can help develop indicator microbial profiles for optimal intervention performance and quality control of microbial testing. It can also identify the changes in bacterial populations in products and help make decisions on how to best handle spoilage and disease causing microorganisms.

Whole Genome Sequencing and the development of the GenomeTrakr Network provide foodborne illness investigators new powerful tools for determining the source of foodborne illness. The food industries need to educate themselves about this technology and these regulatory efforts. In addition, the food industries must interact with FDA, CDC, and FSIS to bring about standardization of the WGS techniques and interpretation of the data, ensure the continued use of epidemiology in investigations, and strengthen the commitment to the security of the metadata in the public NCBI database. The interactions with regulatory agencies must also allow the adoption of this technology by the industry for product improvement, process efficiency, and food safety.

Dr. John Glisson is vice president of research programs for the U.S. Poultry & Egg Association.

Rafael Rivera is manager of food safety and production programs for the U.S. Poultry & Egg Association.

Technical Assistance Is Just a Phone Call Away

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. In-plant energy usage/cost assessments and workplace safety evaluations are also offered.

ATRP uses input from all assists to gauge situations calling for new research initiatives in energy, environmental, safety, and other areas.

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.
Ice Slurry Shows Promise as an Antimicrobial Aid for Poultry Immersion Chillers
continued from page 1

“We began to wonder if this perceived scrubbing phenomenon could possibly improve the effectiveness of chemical disinfectants,” says Haynes. He also likens the plausible effect to “scrubbing while sanitizing” common household surfaces using the popular two-sided kitchen cleaning sponges.

To test the hypothesis, experiments were conducted using whole-bird carcasses inoculated with a specialized strain of *Salmonella* and chilled by either water or ice slurry that contained various levels of the antimicrobial agent peracetic acid (PAA). The carcasses were then compared with a control set of carcasses that were not chilled or treated.

Using a 50 ppm PAA concentration and 20 minutes of immersion, the results showed an average of 0.6-log reduction in pathogen presence versus the control set when using water chilling, while the ice slurry chilling showed an average 1.2-log reduction versus the control set. This was an instance of twice the log-scale reduction when slurry was used as the intervention medium instead of chilled water.

“Aside from these log reduction numbers, we believe ice slurry amplifies the effect of the antimicrobial agent,” says Haynes. “We think that ultimately greater pathogen reduction may be possible through an extensive investigation of processing conditions.”

To this end, researchers have built several 15-gallon micro-testers that are alternatives to the 250-gallon scaled auger chiller previously used. The micro-testers allow them to conduct more experiments on the impacts of ice slurry conditions within a shorter period of time.

“These micro-testers afford more operational control and degrees-of-freedom to explore optimal settings such as fluidic routing of chiller media to maximize benefits,” explains Haynes.

Experiments with chicken parts, specifically wings, are underway. These tests of chicken parts as opposed to whole-birds will provide insight for processors who are interested in chilling or applying antimicrobial interventions to individual parts only.

Researchers are also using the micro-testers to further explore the ice slurry’s observed antimicrobial benefits. Haynes says the team is hoping to determine if these benefits are due to the scrubbing effect or if there are other physical phenomena at play.

“Ice slurry is emerging as a more potent form of water for cooling and antimicrobial chiller efficacy in poultry processing, and we are excited that our research efforts are helping to optimize these benefits,” says Haynes.

This research is conducted with support from several industrial and government partners: IceSynergy and Highland Refrigeration have loaned ice slurry machines; whole-bird carcasses have been donated by a local poultry company; the USDA’s Russell Research Center has provided a laboratory-scale auger chiller; Enviro Tech Chemical Services has provided the peracetic acid (PAA) for antimicrobial tests; and representatives from Southern Company Services have provided sponsorship and technical advice in regard to electricity/energy savings.

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