

ABSTRACTS
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S1 Microbial intervention strategies for *Salmonella* and *Campylobacter* reduction in commercial turkey processing. S. M. Stevens*¹, A. J. Byrd², D. J. Nisbet², A. P. McElroy³, S. M. Anderson¹, and D. J. Caldwell¹, ¹Texas A&M University, ²USDA, Agriculture Research Service, ³Virginia Tech.

To date, compared to similar studies in broiler plants, very few large-scale studies have been conducted in commercial turkey processing plants to investigate the effectiveness of microbial intervention strategies. The objective of the present investigation was to compare *Salmonella* and *Campylobacter* recovery incidence from commercially processed turkeys immediately prior to, and following pre-chill and immersion chiller intervention strategies being used in three distinct turkey processing facilities. In each plant, on a single day of processing, 100 carcass rinse samples prior to and following each post-evisceration, pre-chill intervention and immersion chilling were obtained for *Salmonella* and *Campylobacter* recovery. The most common pre-chill intervention used among these plants was an inside-outside bird wash (IOBW). Two of three plants demonstrated a trend of decreased *Salmonella* on carcasses following the IOBW, with reductions of 13%, and 11% being observed for Plants 1 and 2, respectively. Results for reductions of *Campylobacter* contamination were not as straightforward, with only Plant 3 demonstrating decreased levels (11% reduction) following the IOBW. Plant 2 used an additional pre-chill intervention, a low pressure, acetic acid final wash, which was not shown to be effective in causing an additional reduction in either *Salmonella* or *Campylobacter* on carcasses. In all three plants, properly managed immersion chilling systems were the most effective microbial intervention for achieving *Salmonella* and *Campylobacter* reduction on processed turkey carcasses. While not as effective, the IOBW present in each plant likely contributed to the effectiveness of immersion chiller interventions.

Key Words: Turkey, Pathogen reduction, Chiller, *Campylobacter*, *Salmonella*

S2 Carcass defects attributable to carrying from catch to cooping with preslaughter handling. E. T. Moran, Jr.*¹, J. Galobart Cots, and N. S. Joseph, Dept. of Poultry Science, Auburn University.

Broken bones, bruising, and other defects with the chilled carcass indicate adverse animal welfare and loss in product yield. Broilers encounter many sources of pre-slaughter trauma. Present experimentation measured the nature and incidence of defects contributing to the total. Two commercial strains of broiler males known to differ in body weight were grown in pens having pine shaving litter to 7 weeks of age (32 total pens each starting with 25 chicks). Three broilers were carried by one leg in each hand after catching over a distance of 75 m before cooping and used as the standard procedure. An optimal situation that represented the control involved broilers that were cooped immediately after catching. Carrying was imposed at 6 weeks with each strain then birds were returned to the pen. Carry was again conducted at 7 weeks in a factorial relationship to the 6 week treatments and strains. All broilers were held in coops after carrying at 7 weeks a total of 16 hours before on-line processing. Chilled carcasses were evaluated by one and the same person for the incidence of a common array of defects at predetermined locations. Imposing carrying prior to slaughter led to a loss in chilled carcass weight and a 30% decrease in the percentage not having defects. Employing the standard of carrying was associated with increased incidence of wings that were bruised and having red tips, as well as bruised and broken drumsticks, breast bruising, and the thigh-back area with bruises and scratches. If carrying had been performed at 6 weeks of age and one week ensued before processing, then increased red wing tips was the only persistent effect. Although distinct differences in live and carcass weights existed between strains, their response to carrying was indistinguishable. Bruising at all levels was the defect most extensively increased by the standard of carrying. Extent of expression with each defect can be expected to change with terms used to represent the carrying treatment in present experimentation.

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Key Words: Broiler, Pre-slaughter handling, Processing, Carcass defects

S3 Bacteria recovery from genetically feathered and featherless broiler carcasses after immersion chilling. R. J. Buhr*¹, D. V. Bourassa², J. K. Northcutt¹, A. Hinton, Jr.¹, K. D. Ingram¹, J. A. Cason¹, ¹USDA-ARS, Russell Research Center, Poultry Processing and Meat Quality Research Unit, ²The University of Georgia, Department of Poultry Science.

Feathered and featherless sibling broilers were reared and processed together to determine the influence of feather follicles on carcass bacteria recovery following chilling. In each trial, 24 broilers were inoculated one week prior to processing by oral gavage with a suspension of 10⁶ cfu/mL salmonellae or *Campylobacter*. Broilers were stunned and bled, and carcasses were either triple-tank scalded at 46, 53, and 58 C (115, 128, and 136 F) or single-tank scalded at 55 C (132 F), a total immersion time of 2 min, and then defeathered. The feet and heads were removed prior to evisceration and the neck was removed prior to mechanical washing at 689 kPa (100 psi). Carcasses were chilled for 45 min in ice and water immersion paddle chillers with or without 20 ppm chlorine added. Carcass rinses were evaluated for *E. coli*, coliforms, total aerobes, salmonellae and *Campylobacter*. Following processing and immersion chilling, genetically featherless carcasses had significantly higher counts (by log₁₀ 0.35 cfu / 100 mL of carcass rinse) for *E. coli*, coliforms, and total aerobes than the genetically feathered carcasses. However, there were no significant differences in the recovery of salmonellae and *Campylobacter* between feathered and featherless carcasses. Recovery of bacteria (total aerobes,

E. coli, coliform, or direct plated salmonellae and *Campylobacter* counts) was not different for carcasses that were single or triple-tank scalded. However, following enrichment, salmonellae were recovered from more carcasses subjected to the triple-tank (86%) than single-tank (71%) scalding. Chlorinated chiller water significantly decreased carcass recovery (by log₁₀ 0.43 cfu / 100 mL carcass rinse) for *E. coli*, coliforms, total aerobes, and *Campylobacter*, but had no effect on salmonellae recovery. The presence of feathers and feather follicles during grow-out, transport, processing, and immersion chilling does not appear to influence the recovery of salmonellae or *Campylobacter* from carcasses sampled after immersion chilling.

Key Words: Scaleless, Scalding, Chilling, Salmonellae, *Campylobacter*

S4 Plant-cell-produced vaccines for animal health. C. Mihaliak, S. Webb*, Dow AgroSciences LLC.

Researchers have pursued plant-made vaccines as a method to deliver safer, convenient and efficacious vaccines for well over a decade. Plant-cell-produced vaccines represent a significant advancement toward realizing these benefits by combining features of a plant-production system with the ability to produce biologics in a conventional biocontained production facility. Plant-cell-produced vaccines offer numerous benefits including unparalleled safety, ease of administration and exceptional antigen stability. In addition, research to date has demonstrated that the plant cell line used is capable of expressing multiple classes of biologically active proteins. Since biocontained plant-cell-produced vaccines are manufactured under conditions similar to conventional vaccines, the regulatory path to licensure closely follows current 9 CFR guidelines and procedures. This presentation will describe the characteristics of the plant-cell-produced vaccine technology with several poultry vaccine antigens as examples of near term product candidates.

Key Words: Plant-cell-made, Vaccine, Production, Poultry

S5 Spray washing and sanitizer immersion to lower *Campylobacter* numbers on broiler transport cage flooring. M. E. Berrang*, J. K. Northcutt, USDA-ARS-Russell Research Center.

Broiler transport cages become soiled with feces during transportation and holding. Feces may contain high numbers of *Campylobacter* which can cross contaminate the next flock of broilers placed into the cages. The objective of this study was to examine the effect of spray washing and immersion in chemical sanitizer on *Campylobacter* contamination in feces left on the floor surface of broiler transport cages. Fiberglass floor material was cut into squares (25 cm²). One gram of *Campylobacter* contaminated feces was placed onto each of ten sterile floor squares per treatment and allowed to dry for 60 min. Treatments included: i) untreated control, ii) 15 s water spray, iii) water spray followed by a 15s, 1 min or 5 min dip in 200 ppm chlorine, and iv) water spray followed by a 15 s, 1 min or 5 min dip in 200 ppm quaternary ammonium chloride based sanitizer. Following treatment, each flooring square was sampled by means of a sterile cotton tipped applicator pre-moistened with neutralizing broth. Serial dilutions were plated onto the surface of Campy-cefex agar. A 15 s tap water spray at 10 psi caused significant reduction in *Campylobacter* numbers recovered from fiberglass flooring material. This decrease ranged from 2 to 4 log cfu / 25cm². Immersing spray washed flooring in either sanitizing chemical for 15 s did not further reduce the numbers of *Campylobacter* recovered. Longer dip times in sanitizer solutions actually resulted in higher numbers of *Campylobacter* recovered. This improved recovery was likely due to an increased hydration effect during immersion which softened remaining fecal material thereby making surviving *Campylobacter* more readily available for surface sampling. Removal of visible feces by a water spray can lower the numbers of *Campylobacter* recovered from broiler transport cage flooring; however, the organism is not entirely eliminated. Subsequent wetting may allow injured cells to recover or become more available thus regaining the potential for cross contamination.

Key Words: *Campylobacter*, Transport cage, Sanitization, Sanitation, Washing

S6 Effects of a commercial transport cage washing system on wastewater characteristics and surface bacteria recovery. J. K. Northcutt*, M. E. Berrang, USDA-ARS.

A study was conducted to determine the effects of a commercial transport cage washing system on wastewater characteristics and surface bacteria recovery. During each of three sampling times, fiberglass flooring of three commercial transport cages from the same farm (5 high, 3 door) was sampled before washing (left side of flooring), after washing (middle of flooring) and after sanitizing with quaternary ammonium chloride (right side of flooring). Three compartments (top, middle, bottom) were sampled from the center section on each cage. Water samples were collected from spray nozzles before contacting cages (tap), and from two run-off drains after washing (initial and final wastewater). Water was analyzed for pH, chlorine, chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), total dissolved solids (TDS), total suspended solids (TSS), and total solid (TS). Water and surface swabs were sampled for total aerobic bacteria, coliforms, *E. coli*, *Salmonella* and *Campylobacter*. Water used to wash cages contained 40 to 200 PPM chlorine and had a pH of approximately 8.5. Chlorine and pH of initial and final wastewater (0.4 and 7.1, respectively) were not significantly different ($P < 0.05$). Initial wastewater samples (first stage of cage washing) contained higher levels of TSS and TDS than final wastewater samples (second stage of cage washing), but the final wastewater sample had higher levels of TKN and COD. Spray washing reduced counts of coliforms, *E. coli* and total aerobic bacteria on the fiberglass flooring by 1.5, 1.5 and 1.2 log₁₀ cfu per 36 in² respectively. After sanitation, counts of coliforms, *E. coli* and total aerobic bacteria on the fiberglass flooring decreased further by 0.7, 0.7 and 0.9 log₁₀ cfu per 36 in². Incidence of *Salmonella* and *Campylobacter* on the cages was low and neither bacterium was detected after sanitizer application. The present study demonstrates that washing chicken transport cages may lower surface bacterial contamination.

Key Words: Transport cage, Sanitation, Cage washing, Microbiology

S7 Microbiological impact of spray washing broiler carcasses with acidified electrolyzed water J. K. Northcutt*, D. P. Smith, K. D. Ingram, A. Hinton, Jr., M. T. Musgrove, USDA-ARS.

A study was conducted to investigate the microbiological impact of spray washing broiler carcasses with acidified electrolyzed water for 5, 10 or 15 sec. Commercial broiler carcasses were obtained from a local processing facility prior to the inside-outside bird washer. Carcasses were subjected to a whole carcass rinse (WCR) before treatment (pre-treatment). Broiler ceca were also obtained from the processing facility. Broiler cecal contents (4.95 g) were inoculated with a co-suspension (0.1 mL) containing 10⁷ cells of *Campylobacter* and nalidixic acid resistant *Salmonella*, and 0.1 grams were applied to each carcass after the pre-treatment WCR. Inoculated carcasses were held at room temperature for 12 min before washing in a cabinet washer with either 50 PPM chlorine (HOCl) or 50 PPM acidified electrolyzed water (EO). Carcasses were washed for 5, 10 or 15 sec at 80 psi. Immediately after washing, carcasses were subjected to another WCR (post-treatment). Bacterial counts were determined on both the pre- and post-treatment rinses, as well as on the WCR of inoculated unwashed control carcasses. After 5 sec of washing, treatment (HOCl or EO) had no effect on the total aerobic bacteria, *E. coli*, *Campylobacter*, or nalidixic acid resistant *Salmonella* counts. After 10 sec of washing, carcasses treated with HOCl had bacterial counts that were 0.5, 0.8 and 0.4 log₁₀ higher than the carcasses treated with EO for *E. coli*, *Campylobacter* and *Salmonella*, respectively. Counts for *E. coli*, *Campylobacter* and *Salmonella* were similar for carcasses treated with both EO and HOCl after 15 sec of washing. Total aerobic bacteria varied by only 0.4 log₁₀ after 15 sec of washing, with the lower counts on the EO treated carcasses. Applying EO water in a cabinet washer for 10 sec reduced the level of *E. coli*, *Campylobacter* and *Salmonella* to a level below that obtained with HOCl, but these reductions were all less than 1 log₁₀.

Key Words: Inside-outside bird washer, Fecal contamination, Microbiology

S8 The effect of an experimental chlorate product (ECP) during simulated chill immersion conditions on the recovery of foodborne pathogens. J. A. Byrd*¹, J. L. McReynolds¹, D. J. Caldwell², D. J. Nisbet¹, ¹USDA, ARS, Southern Plains Agricultural Research Center, ²Texas A&M University.

Previous investigations in our laboratory have shown that chlorate compounds reduce *E. coli* and *Salmonella* infections in preharvest food animals. The objectives of this study were to evaluate an experimental chlorate product (ECP) on the reduction of *Salmonella* and *Campylobacter* in broiler carcasses during a simulated chill immersion system. Pre-chill immersion broiler carcasses were submerged in a *Salmonella* (10⁴ CFU/mL) and *Campylobacter* (10⁴ CFU/mL) mixture and allowed to drain for 15 min. *Salmonella* and *Campylobacter* exposed carcasses were placed in a tub containing equal parts of distilled ice and water with 20 ppm sodium hydrochloride, 1.59 ppm ECP, 15.9 ppm ECP, 159 ppm ECP, or 1590 ppm ECP (1x ECP is equivalent to a 15 mM chlorate ion concentration). Carcasses were agitated in the appropriate solution for 1 h. Chill immersion water was monitored for pH, temperature and chlorine concentrations pre and post chill immersion. At the termination of the experiment, standard carcass rinses were performed with buffered peptone water and evaluated for *Salmonella*, *Campylobacter*, total aerobes, and *E. coli*. In the present investigation, carcasses immersed in 159 ppm ECP or greater had significantly lower numbers of *Salmonella* (log₁₀ 0.83 cfu) and *Campylobacter* (log₁₀ 0.15 cfu) when compared to the controls (log₁₀ 0.96 cfu and log₁₀ 1.46 cfu, respectively). When evaluating the effects on total aerobes (log₁₀ 3.5 cfu) and *E. coli* (log₁₀ 2.4 cfu) no significant difference were evaluated when compared to the controls (log₁₀ 3.75 cfu & (log₁₀ 2.70 cfu, respectively). This experiment suggests that the experimental chlorate product significantly reduces *Salmonella* and *Campylobacter* recovery from broiler carcasses under a simulated chill immersion.

Key Words: Broiler Carcass, Chlorate, Immersion Chilling, *Salmonella*, *Campylobacter*

S9 Inhibition of biofilm formation using HabaGUARD® conveyor belt-ing materials. L. Cediell¹, B. Sandel*², ¹Habasit AG, ²ST Associates.

To reduce the risk of cross contamination, processing plant surfaces are maintained as sanitary as possible. One potential support for this is the use of antimicrobial surfaces, making cleaned surfaces less likely to support microbial growth. The objective of this study was to examine the relative attachment and growth of bacterial cells on commercial belting materials with and without added antimicrobial. Three types of experiments are described. In qualitative laboratory simulations, belting materials were exposed to bacterial cultures for 72 hours, rinsed under controlled pressure and volume conditions, stained with acridine orange and viewed with fluorescence microscopy. Fluorescence associated with attached cells indicated that attachment to the standard belting materials was greater than to the belt containing antimicrobial. In quantitative experiments, samples of belting materials were suspended in an annular biofilm reactor through which was circulated a dilute inoculum for 24 hours. The medium was then sampled and withdrawn and attached cells allowed to grow for up to 24 hours with periodic sampling of surfaces. Relative to the standard belt, the belting containing antimicrobial reduced growth in the medium by 4.6 logs. Final populations on the belts with antimicrobial were at the limit of detection for the belt, a log reduction of at least 4.7 relative to the control. Finally in plants processing ready-to-eat and raw meat, conveyor belts fabricated from segments with and without an antimicrobial additive were sampled during the first six months of use. Besides routine QA testing, removed samples were exposed to buffered peptone solution overnight in plastic bags. Loosely attached cells were enumerated by plating duplicate 1 mL portions. Samples were then rinsed, placed in a fresh aliquot of buffered peptone solution and sonicated with glass beads to remove adhered cells. Relative numbers of free and adhered cells for the two belt types depended on the nature of the belt use, length of service, and sanitation practices.

Key Words: Biofilm, Conveyor belt, Inhibition, Food safety

S10 Penetration of *Salmonella enteritidis* and *S. heidelberg* through the vitelline membrane in an *in vitro* egg contamination model. R. Gast*¹, P. Holt¹, T. Murase², ¹USDA-ARS, Southeast Poultry Research Laboratory, ²Tottori University.

Eggs containing *Salmonella* in their edible contents pose a significant threat to transmit disease to consumers. Although *Salmonella* deposition inside yolks is a highly infrequent event in naturally contaminated eggs, bacterial penetration through the vitelline membrane could result in rapid and extensive multiplication in the nutrient-rich contents of the yolk. The present study used an *in vitro* egg contamination model to assess the ability of *Salmonella* strains to penetrate through the vitelline membrane and multiply inside yolks. After inoculation onto the outside of vitelline membranes, an *S. enteritidis* strain and two *S. heidelberg* strains were all able to enter the yolk contents (at frequencies ranging from 10 to 25% of experimentally contaminated eggs) during 24 hours of incubation at 30° C. Variants of these parent strains, obtained by *in vivo* passage into eggs laid by infected hens, penetrated through the yolk membrane at significantly higher frequencies. These results emphasize the importance of prompt refrigeration for minimizing the opportunities for pathogens such as *S. enteritidis* and *S. heidelberg* to multiply and attain more dangerous levels after penetration into the yolks of contaminated eggs.

Key Words: *Salmonella enteritidis*, *Salmonella heidelberg*, Yolk, Vitelline membrane, Penetration

S11 Predictive model for growth of *Clostridium perfringens* in cured and uncured injected turkey during exponential cooling. M. Sanchez-Plata*^{1,2}, A. Amezcua^{3,2}, H. Thippareddi², ¹Texas A&M University, ²University of Nebraska-Lincoln, ³Unilever Research Colworth.

Spores of foodborne pathogens can survive traditional thermal-processing schedules used in the manufacturing of processed meat and poultry products. Heat activated spores can germinate and grow to hazardous levels if these products are improperly chilled. Germination and outgrowth of *Clostridium perfringens* spores in injected turkey chilled under simulated, commercial processing schedules was studied. Turkey breasts were injected with marinade formulations (1% salt, 0.2% potassium tetraphosphosphate and 0.2% starch) supplemented with and without curing ingredients. The ground product was inoculated with a three-strain cocktail of *C. perfringens* spores (NCTC 8238, 8239 and ATCC 10388), mixed, vacuum packaged and thermally processed under simulated commercial cooking conditions. Isothermal growth of *C. perfringens* was determined at 10, 15, 17, 25, 30, 35, 40, 43 and 47°C for primary modeling with the Baranyi's non-autonomous differential equation. Two forms of the square-root Ratkowsky equation were evaluated for secondary modeling to describe *C. perfringens* growth as a function of temperature change. The first order differential equations obtained were solved using the fourth-order Runge-Kutta method. Models were validated under simulated exponential chilling from 54.5 to 7.2°C. *C. perfringens* spores were able to germinate and grow from an initial population of ca. 3.0 log CFU/g by 2.4, 3.3, 3.9, 5.5 and 5.7 log CFU/g in uncured samples subsequent to 9, 12, 15, 18 and 21 h exponential chill rates, respectively. Outgrowth in cured samples was 1.5, 2.9, 3.1, 4.8 and 5.9 log CFU/g after 12, 15, 18, 21 and 24 h of exponential chilling. Predictive models to describe germination and outgrowth of *C. perfringens* spores during exponential cooling of cured and non-cured injected turkey were developed. In general, the *C. perfringens* predictive model for non-cured turkey accurately predicted growth from spore inocula during exponential cooling. The model for cured turkey tends to overpredict (fail-safe) in some of the validation trials.

Key Words: *C. perfringens*, Turkey, Modeling, Chilling, Ready-to-eat