The stunning of poultry (including chickens and turkeys) before slaughter is a fundamental practice used at poultry processing facilities in the United States. Yet little is known about the level of knowledge and opinions among chicken consumers in the USA on current poultry stunning methods. The main objective of this project was to determine consumer preference of chicken meat produced through various stunning methods. Through Zoomerang, an online survey software program, a participant pool of 371 primary household shoppers and chicken consumers across the country completed a 31-question survey. Worker safety, product quality, food safety, price and animal welfare were the key elements examined in relation to stunning practices. The participating consumers (18 years and older/Female & Male/All Ethnicities) provided meaningful feedback regarding specific stunning methods. Employing a descriptive statistical approach, the survey data was classified by categorical variables and analyzed. Contingency tables displayed the relationships between preferences for poultry purchasing and specific stunning methods. Chi-squared analysis also evaluated the significance of the relationships between the variables. Overall, survey respondents preferred electrical stunning over gas stunning (Electrical preference: 26%; Gas preference: 18%), while 35% of the respondents did not have a preference for either method and 21% of the respondents did not want birds stunned before slaughter. Further, 65% of survey respondents did not wish to obtain further information about poultry stunning methods. These findings may point to consumer confidence in the poultry industry. Respondents who purchase poultry from specialty markets tended to favor gas stunning when surveyed on the topic of animal welfare. In addition, respondents who purchase poultry from conventional super-markets tended to favor electrical stunning with respect to food safety. In conclusion, the results of the consumer-focused evaluation of stunning methods allows poultry producers to make informed decisions about the implementation and marketing of future practices and technologies in response to preferences and feedback.

Key Words: stunning, consumers, preferences, poultry, marketing

Yield compared with Strain A, and both commercial strains yielded more (P < 0.05) than Strain C. Muscle pH decreased (P < 0.05) between 2 and 6h PM with Strains A and B; for Strain C, there was no decrease (P > 0.05) in pH over time. However, Strain C had lower (P < 0.05) pH at 2h PM than both Strains A and B. Cook loss was higher (P < 0.05) at 2h PM than fillets deboned at 6h for Strains A and B, but no difference was noted for Strain C due to debone time and no differences were observed among strains at 6h PM. Fillets deboned at 2h for all strains had higher (P < 0.05) shear force than fillets deboned at 6h. Strain B fillets had higher (P < 0.05) shear force compared with Strain A fillets at 2h PM, and fillets from both Strain A and B had higher (P < 0.05) shear force (both would be disliked by consumers) than Strain C (would be liked by consumers) at 2 and 6h PM. Strain did not impact sarcomere length at 6h, but Strain B had shorter sarcomeres than Strain C at 2h PM. Fiber diameters were not different (P > 0.05) between Strains A and B, but Strain C had smaller (P < 0.05) fiber diameter than the other strains. These results suggest that factors other than sarcomere shortening are involved in toughness in modern large broilers.

Key Words: broiler strain, pH, tenderness, fiber diameter, sarcomere length

Detection of Salmonella spp. by insulated isothermal PCR. H. F. G. Chang*, J. M. Shi1, C. W. Lin1, P. H. Teng2, L. J. Ma2, H. Y. Chen2, and Y. C. Chang1, 1Hung Kuang University, Shalu, Taichung, Taiwan, 2GeneReach Biotechnology Corporation, Taichung City, Taiwan, 3Dayeh University, Dacun, Changhua, Taiwan.

Salmonella spp., one of the most serious pathogens, can cause serious gastrointestinal illness including the salmonellosis of humans and animals. Contamination with Salmonella spp. in poultry and fresh eggs are the main causes of salmonellosis in humans. Various molecular diagnostic methods based on DNA analysis, e.g., polymerase chain reaction (PCR), multiplex PCR, and DNA probe, have been used for the detection of Salmonella spp. However, the above-mentioned methods often require trained technicians. Recently, a novel convective PCR carried out in polycarbonate capillary tubes under insulated isothermal condition (insulated isothermal PCR) has been developed. To test whether insulated isothermal PCR can be used to detect Salmonella spp., a set of PCR primers and TaqMan probe were designed to specifically amplify and detect Salmonella spp. Here we report that specific signal of Salmonella spp. was detected within 1h. No false-positive results were observed. The detection limit was up to 10 → 0 cfu/g in the food samples including chicken meat, pork, beef, and milk without the enrichment. Furthermore, with a 4h enrichment step, as low as 10 → 0 cfu/g in the food samples could be detected. Since the fluorescent amplification signals are detected at 520 nm, there is no need for electrophoresis. The insulated isothermal PCR system requires less expertise and provides a more reliable tool of result interpretation compared with the conventional PCR. In addition, this system is economically feasible compared with most of DNA analysis methods, and the results could be obtained within hours instead of days. To conclude, the insulated isothermal PCR system is accurate, time-saving and can be used as on-site routine testing for the inspection of food samples.

Key Words: Salmonella spp., insulated isothermal PCR, convective PCR, on-site detection, salmonellosis
218 Evaluation of novel essential oil-containing phosphate blends for growth inhibition of Salmonella enterica in ready-to-eat products. G. Casco*, T. M. Taylor1, and C. Z. Alvarado1, 2Texas A&M University, College Station, 2Texas A&M University, College Station.

Essential oils (EO) and their constituents are reported to possess potent antimicrobial activity, but their use in food processing is limited due to low solubility in aqueous systems and volatilization during processing. The objective of this study was to evaluate 2 non-commercial EO-containing phosphate blends for antimicrobial activity against Salmonella enterica serovars inoculated on deli meats. Four treatments, Carnal-145 (chicken and pork) or Carnal-245 (beef), Carnal-26 (0.45% and 0.6%, respectively, of final product weight), a 2.0% potassium lactate control (PL), and a negative control with no applied antimicrobial (NC) were tested on 4 replicate trials. Each treatment was inoculated with 6.0 log₉ CFU/g of a 3 strain Salmonella cocktail individually bagged for sampling at 0, 7, 14, 21, 28, 35, 42, 49, and 60 d post-preparation. Results show that in pork, PL and Carnal-26 did not differ with respect to surviving salmonellae for all sampling days. In chicken, there were no differences among the treatments until d 22, when the Carnal treatments and the PL had significantly fewer (0.6 log₉ CFU/g) Salmonella survivors compared with the NC. In beef loaves, there were no differences among treatments until d 32 when the NC had a significantly higher (0.5 log₉ CFU/g) number of Salmonella survivors compared with the other treatments (P < 0.05). In conclusion, Carnal-26 can function to replace PL to inhibit Salmonella growth in ready-to-eat (RTE) deli products. However, further testing is needed to ensure consumer acceptability.

Key Words: Salmonella, Campylobacter, essential oils, thyme, orange

219 In vitro evaluation of essential oils for inhibiting Salmonella and Campylobacter spp. R. Thanissery* and D. P. Smith, North Carolina State University, Raleigh.

Plant essential oils (EOs) are natural compounds studied for their potential antimicrobial properties. Previous research using a disc diffusion assay showed the blend of thyme and orange oil was an effective combination to inhibit both Salmonella and Campylobacter species. To further confirm these results a macro-disc diffusion assay was conducted to determine the minimum inhibitory concentrations (MIC) of 4 select EOs (thyme, rosemary, orange, and clove) and thyme orange oil combination against 3 strains of nalidixic acid-resistant S. enterica serovars and a mixture of all 3, as well as 2 strains of C. coli and 1 strain of C. jejuni and a mixture of all Campylobacters. Dimethyl sulfoxide was added to the oils to increase their solubility. Serial 2-fold dilutions from 1.000 to 0.008% (v/v) of the essential oils tested were prepared and placed in tubes. Overnight broth cultures of the individual test organisms was used to inoculate the tubes. The Salmonella tubes were incubated at 37°C for 24h, and Campylobacter tubes at 42°C under microaerophilic conditions for 24h. Turbidity was visually determined, and the least concentration of the oil at which there was no visible growth was recorded as MIC. The turbidity of orange oil impaired visual determination of MIC therefore the minimum bactericidal concentration (MBC) was determined by plating 100 µL on to agar plates. The lowest concentration at which there was no growth in the plates was recorded as MBC. Results are reported as mean values of 8 tubes in 2 replicate trials. Thyme was most effective against Salmonella with a MIC of 0.06%, followed by clove (0.15%), and rosemary (1%). The MBC for orange oil was > 1%. However the orange and thyme oil blend showed an MBC of 0.13%. Campylobacter was sensitive to all essential oils when compared with Salmonella at all concentrations of oils tested in this study. In conclusion, the blend of thyme and orange oil is a potential combination to inhibit both Salmonella and Campylobacter. However, further investigation is needed to explore whether these findings apply to poultry carcasses and products.

Key Words: Salmonella, Campylobacter, essential oils, thyme, orange

220 Feed withdrawal effects on turkey live shrink and gastrointestinal contents. D. P. Smith*, 1J. K. Northcutt2, 2J. L. Grimes1, and P. R. Ferkel1, 1North Carolina State University, Raleigh, 2Clemson University, Clemson, SC.

Feed withdrawal (FW) of turkeys before processing is necessary to minimize in-plant contamination but typically results in lost weight. Therefore, experiments were conducted to determine optimum FW time to minimize gastrointestinal (GI) contents and reduce live shrink. Tom turkeys, approximately 20 weeks of age, were withdrawn from feed for 6, 12, or 18 h before processing or remained on feed until processing (Control). Water was removed 4 h after FW. Trial 1 utilized 30 FW and 30 Control birds with natural day length lighting. Trial 2 consisted of 12 FW and 12 Control birds that were converted to 24 h lighting 1 to 3 d before processing. All birds were left on litter during FW. Birds were transported to the processing area and electrically stunned, exsanguinated, scalped for 60 s at 68 C and picked for 90 s. Head and feet were removed, and carcasses were manually eviscerated. Weights recorded included live pre-FW, live post-FW, carcass weight, intestinal tract contents, gizzard contents, and full ceca. Shrink was calculated as the difference between pre- and post-FW live weight. Data are reported as mean ± SEM. FW significantly (P < 0.05) increased shrink at 18 h compared with Control (0.49 ± 0.10 vs. 0.18 ± 0.10 kg, respectively). Mean FW vs. Control shrink differences at 6 h (0.21 kg) and at 12 h (0.26 kg) were not significantly different. FW significantly decreased gizzard contents from 22.7 ± 3.1 to 13.0 ± 2.1 g, and intestinal contents from 91.9 ± 6.4 to 53.5 ± 3.9 g. There was no FW effect on full ceca (mean weight of 59.2 ± 1.2 g). FW increased live shrink at 18 h, but not at 6 and 12 h, and reduced GI content weights regardless of time off feed.

Key Words: turkey, feed withdrawal, live shrink, GI contents

221 Microarray analysis of Salmonella Enteritidis Phage Type 8 treated with subinhibitory concentrations of trans-cinnamaldehyde or eugenol. A. Kollanoor-Johny*, 1J. G. Frye2, S. Porwollik3, M. J. Darre1, A. M. Donoghue2, D. J. Donoghue5, M. McClelland3, and K. Venkitanarayanan1, 1University of Connecticut, Department of Animal Science, Storrs, 2Richard B. Russell Research Center, USDA-ARS, Athens, 3Vaccine Research Institute of San Diego, San Diego, 4Poultry Production and Product Safety Research Unit, USDA-ARS, Fayetteville, 5Center of Excellence for Poultry Science, University of Arkansas, Fayetteville.

Salmonella Enteritidis phage type 8 (PT8) is a major poultry-associated Salmonella isolate implicated in foodborne outbreaks in the United
222 Effect of therapeutic supplementation of plant compounds, trans-cinnamaldehyde and eugenol on Salmonella Enteritidis colonization in market-age broiler chickens. A. Kollanoor-Johny* 1, A. Upadhyay2, S. A. Baskaran1, I. Upadhyay1, S. M. Mooyottu1, M. J. Darre1, M. I. Khan2, A. M. Donoghue1, D. J. Donoghue4, and K. Venkatarayanan1, 1Department of Animal Science, University of Connecticut, Storrs, 2Department of Pathobiology and Veterinary Science, University of Connecticut, Storrs, 3Poultry Production and Product Safety Research Unit, USDA-ARS, Fayetteville, 4Center of Excellence for Poultry Science, University of Arkansas, Fayetteville.

This study investigated the therapeutic efficacy of plant compounds, trans-cinnamaldehyde (TC) and eugenol (EG) on reducing Salmonella Enteritidis in commercial, market-age broiler chickens. Eighty-four (n = 84) straight run, day-old, commercial broiler chickens were randomly grouped into 6 groups (n = 14/group): a negative control (no S. Enteritidis, no TC or EG), EG control (no S. Enteritidis, 1% EG), TC control (no S. Enteritidis, 0.75% TC), a positive control (S. Enteritidis, no TC or EG), an EG challenge group (S. Enteritidis, 1% EG) and a TC challenge group (S. Enteritidis, 0.75% TC). Before the start of each experiment, the flock was screened for any inherent Salmonella (n = 2 birds/group). Birds were given ad-libitum access to Salmonella-free feed and water. On day 30, birds were challenged with a 4-strain mixture of S. Enteritidis (8 log10 cfu/bird). Two birds from each group were sacrificed after 24 h (d 31) to check for colonization of S. Enteritidis in the cecum. Birds were given feed supplemented with TC (0.75%) or EG (1%) for 5 d before slaughter on day 42 (n = 10 birds/group) for determination of S. Enteritidis populations in cecum and cloaca. The experiment was repeated. Trans-cinnamaldehyde and EG consistently reduced S. Enteritidis in the samples in both experiments (P < 0.05). Body weights and feed consumption did not differ among the groups (P > 0.05). Histological analysis revealed no abnormal changes in the cecum or liver due to supplementation of plant molecules. The results suggest that TC and EG supplemented through feed could reduce S. Enteritidis colonization in market-age chickens.

Key Words: Salmonella, chicken, trans-cinnamaldehyde, eugenol, antibacterial

223 Delayed carcass deboning results in significantly reduced cook yield of boneless skinless chicken thighs. H. Zhuang* and E. M. Savage, USDA-ARS, Athens, GA.

Boneless skinless chicken thighs are a new deboned poultry product in the retail market. Three trials were conducted to investigate the effect of postmortem carcass deboning time on cook yield of boneless skinless chicken thighs as well as boneless skinless chicken breasts. Broiler carcasses (42-d old birds) were obtained from a commercial processing plant. The thighs and breast fillets were hot-boned 45 min, cold-deboned 2 h (2h), or cold-deboned 24 h (24h) postmortem. The trimmed thighs and breast fillets were then individually bagged and stored in a −20°C freezer before being cooked directly from their frozen stage to an endpoint temperature of 77−78°C in a Henny-Penny combi oven. The cook yield was calculated by 100 x cooked meat weight/raw meat weight before bagging. The average cook yield was 81% for the hot-boned thighs and 80% for the hot-boned fillets, 79% for the 2h thighs and 78% for the 2h fillets, and 74% for the 24h thighs and 78% for the 24h fillets. There was no difference (P > 0.05) between the hot-boned thighs and fillets for the cook yield. However, the cook yields of the 2h thighs and fillets, which did not differ from each other, were 2% lower (P < 0.05) than those of the hot-boned samples. The cook yield of the 24h thighs was 7% lower (P < 0.05) than that of the hot-boned thighs, 5% lower than the 2h thighs (P < 0.05), and 4% lower (P < 0.05) than the 24h fillets. There were no differences (P > 0.05) for the cook yield between the 24h and 2h fillets, and between the 24h and hot-boned fillets. The effects of postmortem carcass deboning time on the cook yield were also investigated by using fresh and freezing/thawing (overnight) boneless skinless thigh and breast fillet samples. The 24h postmortem deboning resulted in significantly reduced cook yields of boneless skinless chicken thighs than the hot-boning and 2h deboning regardless of the sample preparation method. The results from this study indicate that delayed carcass deboning may result in a greater reduction in the cook yield of boneless skinless chicken thighs than that of boneless skinless chicken fillets.

Key Words: postmortem, carcass deboning, chicken thigh, chicken breast, cook yield

224 Quality and safety of broiler meat in various chilling systems. E. Demirok*, C. Z. Alvarado2, G. Veluz3, P. Castañeda3, W. V. Stuyvenberg4, and J. A. Bryd5, 1Ankara University, Ankara, Turkey, 2Texas A&M University, College Station, 3Universidad Nacional Autónoma de México, México, D.F. México, 4TopKip B.V., Enschede, Netherlands, 5USDA-ARS, Southern Plains Agricultural Research Center, College Station, TX.

Chilling is a critical step in poultry processing to attain the best quality meat and safety standard. Generally, eviscerated carcasses are chilled by immersion chilling (IC) or air chilling (AC) systems. Recently, combi in-line air chilling (CIAC) system was introduced with the purpose of resolving the disadvantages of both immersion and air chill systems. This
study was conducted to determine the effects of these chilling systems on quality and safety of broiler meat. A total of 300 carcasses were randomly selected from a commercial processor and subjected to 3 systems: IC, AC, and CIAC. Incidence of Salmonella and Campylobacter was determined on pre- and post-chilled carcasses along with carcass yield, drip loss, cook loss, texture, moisture content, sensory, color, and APC of boneless skinless breast fillets and drums. IC resulted in a significant reduction \( (P < 0.05) \) of Salmonella \((39.7\%)\) and Campylobacter \((43\%)\) prevalence due to the washing effect and presence of chlorine in the chilled water. There were no significant differences in APC among the treatments. IC had the highest \( (P < 0.05) \) immediate post-chill carcass yield \((+6.5\%)\) followed by CIAC \((+1.98\%)\) and then AC \((-1.10\%)\). Drip loss, cook loss, and moisture content of boneless skinless breast fillets were not significantly different among chilling systems but drip loss and cook loss were significantly higher in drums from immersion chilled carcasses. At 24 h PM, no difference \( (P > 0.05) \) in L value was noted between IC and CIAC for breast fillets. However, in drums IC exhibited higher L value while AC was significantly lower. There were no significant differences in texture between AC and CIAC. There were no differences in sensory characteristics of breast fillets and drums among the 3 chilling systems. In conclusion, CIAC was very comparable to the IC and performed better in the quality and safety parameters when compared with AC system.

**Key Words:** immersion chilling, air chilling, combi in-line air chilling, broiler meat, quality and safety

225 **A chemical additive to limit transfer of Salmonella and Campylobacter during immersion chill.** B. T. Schambach*1,2, M. E. Berrang2, and M. A. Harrison2, 1USDA ARS Russell Research Center, Athens, GA, 2University of Georgia Food Science and Technology, Athens.

Historically, chill tanks are chlorinated to help prevent cross contamination between broiler carcasses during chilling, however, other additive options have become available for lowering bacterial counts during chilling. The objective of this study was to test the effectiveness of a proprietary chemical additive (T-128) to lower numbers of Salmonella and Campylobacter transfer in chill water. To test this, 8 containers were inoculated with approximately 106 cells each of an antibiotic resistant strain of *Salmonella* and *Campylobacter*, the second wing was left uninoculated. Two containers were assigned to each of 4 treatments, as follows: control (no additive), 50 ppm (ppm) chlorine, 0.5% T-128 (by volume), and a combination of 50ppm chlorine and 0.5% T-128. All containers were covered and shaken at 130 rpm for 45 min. After 45 min of agitation chill treatment, each wing was rinsed in 30 mL of PBS; antibiotic resistant marked *Salmonella* and *Campylobacter* were enumerated per mL by plating on BG-Sulfa agar with the addition of nalidixic acid and Campy-Cefex agar with the addition of gentamicin, respectively. This specifically measured transfer of the 2 inocula from wing to wing through varying wash environments. After control chill treatment, a mean of log 2.9 cfu of both inocula were detected per mL of un-inoculated wing rinse. Chlorine addition alone resulted in a 1.9 log decrease in *Salmonella* and a 2.4 log decrease in *Campylobacter* detected on un-inoculated wings. T-128 applied alone did not cause a significant decrease in *Salmonella* numbers but resulted in a 2.6 log decrease in *Campylobacter*. Compared with the control treatment, the combination of T-128 and chlorine was the most effective treatment resulting in a 2.3 log decrease in *Salmonella* and a 3.0 log decrease in *Campylobacter* numbers detected from un-inoculated wings.

**Key Words:** chemical additive, *Salmonella*, *Campylobacter*, chill

226 **Ability of lactate and pyruvate to stimulate aerobic growth of Campylobacter in media supplemented with fumarate.** A. Hinton Jr.,* Russell Research Center, Athens, GA.

*Campylobacter* spp. are human, foodborne, bacterial pathogens that are frequently isolated from live poultry and from processed poultry products. These pathogens are classified as microaerophiles; therefore, *Campylobacter* cultures are generally grown in atmospheres with reduced oxygen levels and elevated carbon dioxide levels. *Campylobacter* are unable to utilize carbohydrates; however, these bacteria can metabolize some organic acids. The objective of the present study was to examine the growth of *Campylobacter* under aerobic conditions in media supplemented with fumarate and various concentrations of lactate or pyruvate. Basal broth media composed of tryptose, yeast extract, and a mineral-vitamin solution was supplemented with 30 mM of sodium fumarate. Sodium lactate or sodium pyruvate was then added to the medium to produce final concentrations of 0, 10, 20, 30, 40, 50, or 60 mM of lactate or pyruvate with a final media pH of 7.0–7.1. Media was then inoculated with approximately 106 colony-forming-units/ml of *Campylobacter coli*, *Campylobacter fetus*, or *Campylobacter jejuni*. Inoculated media was incubated aerobically at 37°C for 72 h in a Bioscreen C microbiology reader, and changes in the optical density (OD) of cultures were measured at 600 nm. Statistical analysis of the differences in final culture OD was performed. Results indicated that there was significantly \( (P < 0.05) \) greater growth of each *Campylobacter* isolate in fumarate media supplemented with lactate or pyruvate than in media that was not supplemented with one of these organic acids. Additionally, there was significantly greater growth of the isolates in fumarate media supplemented with pyruvate than in media supplemented in media supplemented with lactate. Findings of this study indicate that *Campylobacter* spp. are capable of aerobic growth in media supplemented with fumarate and lactate or pyruvate.

**Key Words:** *Campylobacter*, fumarate, lactate, pyruvate, aerobic growth