Objectives: As a result of genetic selection pressures, economically important traits continue to make gains in fast growing boilers. In order to understand the impact that has taken place over time on profitable traits, such as live weight, as well as indirectly selected traits, whole leg and tibia parameters of two genetic broiler lines representing the 1995 and 2015 broiler maintained at the U. Arkansas were compared.

Materials and Methods: One hundred twenty broilers, evenly split between the 1995 RAN and 2015 RAN lines, were reared straight-run with ab libitum access to industry standard feed and water (IACUC Approval #15039). Fifteen birds were weighed, then euthanized at each time point from each line (d 0, d 14, d 28, and d 42). Left legs were disarticulated, weighed and cleaned of flesh and tendons. The following tibia measurements were collected; tibia weight, tibia lengths, proximal width-frontal, distal width-frontal, midpoint width, proximal width-sagittal, distal width-sagittal. Max load, load break, load extension, and compressive strain was calculated for d 14, d 28, and d 42 using an Instron Universal Testing Machine (IUTM). Spacing used for IUTM test are as follows: 2 cm for d 14, 4 cm for d 28, 5 cm for d 42. In order to compare means between data collected for each age of both lines, JMP Pro v. 12 was used though t-tests with a significance level (p<0.05).

Results: Body weight was significantly larger in 2015 RAN line compared to 1995 RAN at ages d 14, d 28, and d 42. Tibia weight was significantly smaller in the 2015 RAN line at d 0 (p=0.0304), but surpassed the RAN 1995 line at d 14 of age (p=0.0206). Mean weight was not significantly different between the two lines at d 28 and d 42. Mean leg weight to body weight ratio is significantly larger in the 1995 line on d 0 and d 28 (p=0.0031 and p=0.0290, respectively), and indicate no significant differences on d 24 or d 42. This trend is also seen in tibia weight to body weight ratio being significantly larger in the 1995 line on d 0 and d 28 (p=0.0170 and p=0.0070, respectively). Drum weight to body weight ratio indicate significantly larger ratios for 1995 RAN line on d 0 (p=0.0008), but this trend does not continue in older ages. Dimensional ratios of tibia proximal width (sagittal) to tibia length (p=0.0370), tibia distal width (sagittal) to tibial length (p=0.0118), and tibial midpoint width to tibial length (p=0.0161) all indicate significantly larger ratios in d 0 1995 RAN compared to d 0 2015 RAN lines, but this trend does not continue in older ages. No differences were detected in the max load, load at break, load extension, and compressive strain force measures.

Conclusion: Interestingly, many of the parameter reported indicated that at day of hatch, broilers of the 2015 RAN have reduced size associated with the tibia. Allocations of nutrients during embryonic development may be contributing to the discrepancy in birds between the two lines at d 0 and can act as a focus in future genetic selections aimed to reduce the incidence of lameness in broilers.

Keywords: Genetic Selection, Lameness, Poultry, Welfare
2- CONSUMER ACCEPTABILITY AND WILLINGNESS-TO-PAY OF COOKED BEEF BRATWURST SAUSAGE FORMULATED WITH PRE- OR POST-RIGOR BEEF

A. Theradiyil Sukumaran 1,*, A. Holtcamp 1, M. Wes Schilling 2, J. Ellington 3, K. Coatney 3, T. T. Dinh 1
1Animal and Dairy Sciences, 2Food Science Nutrition and Health Promotion, 3Agricultural Economics, Mississippi State University, Starkville, United States
at1179@msstate.edu

Objectives: The current study was designed to determine consumer acceptability and willingness-to-pay (WTP) of two products, pre- and post-rigor beef Bratwurst sausages.

Materials and Methods: From 524-month-old Holstein steers, the left chucks were deboned, ground (1.27-cm particle size), and salted (1.5 % w/w) within 2 h post-mortem (pre-rigor treatment); whereas the right chucks were deboned at 72 h post-mortem (post-rigor treatment). On the day of sausage production (d 6 post-mortem), post-rigor trimmings were ground to 1.27-cm particle size and salted with 1.5% sodium chloride (w/w). Both pre- and post-rigor ground beef was processed into sausage batter by grinding the lean and fat trimmings separately through a 0.16-cm plate and mixing them with ingredients (beef bratwurst spice mix, water/ice slurry, corn syrup, erythorbate, nitrite, salt, and 0.25% w/w sodium tripolyphosphate). Sausages were cooked to 74 °C by a generic smoked sausage cycle, including pre-drying, smoking, steaming, and cold shower, vacuum-packaged, and stored for 30 d at 2 °C. Sausage links were warmed to 74 °C and cut to 2.54-cm thickness. A total of 100 consumers evaluated appearance, aroma, flavor, texture, and overall acceptability on a 9-point hedonic scale. Each consumer was served with both pre- and post-rigor sausage from the same steer during each session. Immediately after the sensory evaluation, subjects were asked to formulate a WTP for each product using the information recorded on the evaluation sheets. A Becker–DeGroot–Marshall auction mechanism was used to solicit truthful WTPs. An aggregate unit-demand curve was constructed from the entire subject pool’s bidding data. Cluster analysis was conducted by the Agglomerative Hierarchical Clustering procedure in XLSTAT 2018.2.50198 using Ward’s method. Consumer acceptability was subsequently analyzed in each cluster by the GLIMMIX procedure of SAS 9.4 at 0.05 level of significance.

Results: Cluster analysis revealed 5 consumer clusters based on overall acceptability. Cluster 1 (7.9 and 8.1 overall acceptability units for pre- and post-rigor, respectively; \( P = 0.130 \)) and 5 (3.9 and 3.4 for pre- and post-rigor, respectively; \( P = 0.340 \)) consisted of 40 consumers and had no difference in any sensory attribute between pre- and post-rigor treatments \( (P \geq 0.091) \). However, panelists in cluster 3 (37 consumers) preferred the aroma, flavor, and texture of pre-rigor than post-rigor sausage \( (P \leq 0.011) \). Similarly, eight consumers in cluster 4 preferred the flavor, texture, and overall acceptability of pre-rigor than post-rigor sausage \( (P \leq 0.020) \). However, 15 consumers in cluster 2 liked the texture of post-rigor sausage better \( (P = 0.004) \). Average predicted demand was 0.7 lb greater for pre-rigor than post-rigor sausage \( (P = 0.001) \). In a scenario with a realistic market price of $6/lb, demand for pre-rigor sausage was 5% greater than post-rigor sausage. This greater demand for pre-rigor sausage might be driven by the greater acceptability of flavor and texture found in cluster 3 and 4.

Conclusion: Pre-rigor processing yields sausage with greater consumer acceptability and demand. However, scalable production costs should be considered before finalizing the decision to implement pre-rigor processing in an industrial setting.

Keywords: Consumer Preference, pre-rigor, sausage, willingness to pay
3- CONSUMER SENSORY EVALUATION OF BEEF STRIP LOIN STEAKS FROM FIVE QUALITY TREATMENTS COOKED TO SIX DEGREES OF DONENESS

B. Olson 1,*, L. Drey 1, L. Prill 1, J. Gonzalez 1, T. Houser 1, E. Boyle 1, J. Vipham 1, T. O'Quinn 1
1Kansas State University, Manhattan, United States
brittyolson@ksu.edu

**Objectives:** The objective of this study was to determine the effect of degree of doneness (DOD) on the palatability of beef strip loin steaks of varying marbling levels.

**Materials and Methods:** Paired strip loins (IMPS # 180) were collected from 4 USDA quality grades [Prime, Top Choice (Modest and Moderate marbling), Low Choice, Select; n=12 pairs/quality grade]. Additionally, 12 pairs of Select strip loins were collected for a salt and alkaline phosphate enhancement solution (108% of raw weight). Subprimals were aged for 21 d and fabricated into 2.54-cm thick steaks. Steaks were fabricated in groups of 3 consecutively cut steaks, with a total of 6 groups per strip loin pair. Groups were assigned to a DOD: very-rare (55°C), rare (60°C), medium-rare (63°C), medium (71°C), well-done (77°C) or very well-done (82°C). Steaks were cooked on clamshell style grills to their specified DOD. Consumers (n=360) were fed 8 samples under red lighting and evaluated for juiciness, tenderness, flavor, and overall liking on continuous line scales. Additionally, consumers rated each trait as either acceptable or unacceptable.

**Results:** There were no interactions (P>0.05) between quality treatment and DOD for consumer ratings of all palatability traits. Select Enhanced steaks had the highest (P<0.05) consumer ratings for all traits, followed by Prime steaks having higher (P<0.05) ratings than Top Choice, Low Choice, and Select steaks. Select steaks had the lowest (P<0.05) consumer ratings for all traits except tenderness, for which they were similar (P>0.05) to Low Choice. Juiciness was similar (P>0.05) between very-rare and rare, as well as between rare and medium-rare. Very-rare, rare, and medium-rare steaks had similar (P<0.05) ratings for all palatability traits except juiciness. There was a quality grade by DOD interaction (P<0.05) for the percentage of steaks rated acceptable for juiciness, tenderness, and overall liking. At very rare, rare, and medium-rare, all quality grades except Select were similar (P>0.05) in the percentage of steaks rated acceptable for juiciness. However, as DOD increased, marbling had a greater impact, with Prime having a greater (P<0.05) number of samples rated acceptable for juiciness than all non-enhanced samples at very well-done. Select Enhanced steaks had the greatest (P<0.05) percentage of samples rated acceptable for tenderness at very-rare, but Prime was similar (P>0.05) to Select Enhanced for all other DOD. Additionally, Select had the lowest (P<0.05) percentage of steaks rated acceptable for tenderness at medium-rare and medium, but were similar (P>0.05) to Low Choice at all other DOD. Prime and Select Enhanced steaks had similar (P<0.05) percentages of samples rated acceptable overall for all DOD except medium and well-done, in which Select Enhanced was higher (P<0.05). Select had a similar (P>0.05) percentage of steaks rated acceptable as both Choice treatments at very-rare and rare, but had a lower (P<0.05) percentage than Low Choice at medium-rare and was lower than both at medium.

**Conclusion:** These results indicate that increased marbling level or enhancement has a positive impact on palatability ratings across all DOD. However, beef with higher marbling levels are acceptable at a higher rate at elevated DOD. With this, consumers can purchase steaks of lower quality when cooking to lower DOD, and vice versa, and still have a desirable eating experience.

**Keywords:** beef, consumer, degree of doneness, marbling, palatability
4. NEW ZEALAND AND U.S. CONSUMER ASSESSMENT OF VARIOUS SLOW COOKED MUSCLES FROM NEW ZEALAND BEEF

C. Bendele 1,*, A. J. Garmyn 1, T. G. O’Quinn 2, J. Legako 1, J. C. Brooks 1, R. J. Polkinghorne 3, K. Spivey 1, M. F. Miller 1
1Animal and Food Sciences, Texas Tech University, Lubbock, 2Animal and Food Sciences, Kansas State University, Manhattan, United States, 3Birkenwood, Research, Murrurundi, Australia
clay.bendele@ttu.edu

Objectives: A consumer study was conducted to measure sensory differences between country (United States and New Zealand) and muscle or muscle group for eleven different cuts of New Zealand beef when using a slow cook method.

Materials and Methods: Beef sourced from New Zealand was slow cooked and tested by untrained consumers (n = 360) in either the United States (n=180) or New Zealand (n=180) following the Australian MSA (Meat Standards Australia) testing protocols (US ethics code 503510, NZ ethics code 503743). Subprimals were collected at two commercial abattoirs in New Zealand and were aged 7-10 d postmortem. Subprimals were fabricated into slow cook samples, focusing on the following muscles or muscles groups for slow cooking: adductor femoris, pectoralis profundus, supraspinatus, triceps brachii, semitendinosus, foreshank, gracilis, hindshank, vastus lateralis, serratus ventralis, thin flank (obliquus externus abdominus and rectus abdominus). The denuded muscles were cut into cubes, vacuum packaged (22 cubes per bag) and frozen at -20°C. Paired samples were divided between New Zealand (NZ) and the United States (US). Testing was conducted in Lubbock, TX or Dunedin, NZ. Each sample was browned for 90 seconds and then transferred to a steamer pan, then simmered at 93°C to 95°C for 2 hours. Consumers scored each sample for tenderness, juiciness, flavor liking, overall liking using 100-mm line scales for each trait. Data were analyzed using PROC GLIMMIX in SAS to determine if the fixed effects of country, muscle group, or their interaction influenced eating quality (α =0.05).

Results: No interactions were detected between country and muscle (P > 0.05). Country influenced (P =0.05) juiciness scores only, while muscle impacted all response variables (P < 0.01). US consumers scored samples juicier (P = 0.05) than NZ consumers, regardless of muscle. For juiciness, the same 4 muscle groups were consistently rated higher (P < 0.05) than the remaining muscle groups – serratus ventralis, gracilis, hind shank, and thin flank, with scores ranging from 5.7 to 68.6. The serratus ventralis was also rated higher for flavor and overall liking (P < 0.05) with scores of 64.8 and 66.5, respectively. On the opposite end of the scale, the vastus lateralis consistently scored lower (P < 0.05) for juiciness, flavor and overall liking than the remaining muscle groups, with scores ranging from 32.8 to 42.7 for tenderness, juiciness, flavor liking, and overall liking. In addition, pectoralis profundus was rated as one of the least tender muscles (P < 0.05).

Conclusion: Only minor differences in juiciness perceptions existed between US and NZ consumers when evaluating samples that were slow cooked, while tenderness, flavor liking, and overall liking were scored similarly between the two countries. Of the 4 muscle groups that were consistently rated greater than the remaining muscles, average scores for those traits would classify samples as good everyday quality based on the scoring system. However, of the 3 muscles that were consistently scored lower than the remaining muscles, average scores for those traits would likely result in samples being classified as unsatisfactory for the slow cook method. For slow cook methods, the same results outside of juiciness were achieved for both participating countries, indicating that palatability evaluations and comparisons among different muscles are not country dependent.

Keywords: Beef, Consumer Panels, Cook Method, Country, Palatability
5- PALATABILITY OF BEEF FROM CATTLE EXPOSED TO A HIGH-CONCENTRATE DIET PRIOR TO PASTURE-FINISHING

D. Evers 1,*, M. F. Miller 1, J. T. Milopoulos 1, B. M. Koch 2, S. K. Duckett 2

1Animal and Food Sciences, Texas Tech University, Lubbock, 2Animal and Veterinary Sciences, Clemson University, Clemson, United States
danielle.evers@ttu.edu

Objectives: The objective of this study was to evaluate the effects of exposure to a high-concentrate diet prior to pasture-finishing on the perceived palatability of beef strip loin steaks by untrained consumer panelists.

Materials and Methods: Forty-eight Angus-cross steers (n = 12 / treatment) were fed a high-concentrate corn-based diet after weaning for 0 d (0D), 40 d (40D), 80 d (80D), or 120 d (120D). Following grain-feeding, cattle were finished to a target BW (487 kg; 188 – 354 d on pasture) on high-quality pastures (non-toxic tall fescue, rye/ryegrass, oats, alfalfa). Carcass data and strip loins were collected 24 h post-mortem. Loins were aged under vacuum at 4°C for 21 d then frozen (-20°C). Eight strip loins from each treatment were selected based on USDA marbling scores targeting USDA Select quality grade. New Zealand process-verified grass-fed strip loins (NZ; n = 8) were selected by trained personnel targeting USDA Select and included as a baseline for comparison. The NZ strip loins were collected and aged under vacuum for 21 d at 4°C then frozen. Steaks (2.54 cm) were fabricated from frozen loins and assigned from anterior to posterior end to laboratory analyses or sensory evaluation. Thawed steaks were cooked on an electric clamshell grill to a medium degree of doneness (71°C). Steaks were cut into 4 equal pieces and evaluated by consumers (n = 220; Lubbock, TX) for tenderness, juiciness, flavor and overall liking using 100-mm anchored line scales (0 = not tender/juicy, dislike flavor/overall extremely; 100 = very tender/juicy, like flavor/overall extremely). Consumers were also asked to rate each sample as acceptable or unacceptable for each trait and assign samples to 1 of 4 perceived quality levels.

Results: Consumers detected differences in tenderness among treatments and the percent acceptability of tenderness also differed (P < 0.01). Samples from NZ received the greatest scores for tenderness (P < 0.05) and were most often rated as acceptable by consumers (P < 0.05). Steaks from 120D treatments received lesser (P < 0.05) scores for tenderness than NZ but greater scores than all other treatments (P < 0.05). Steaks from 120D were equally often rated as acceptable for tenderness as 80D (P > 0.05) but less often rated as acceptable than NZ (P < 0.05). Differences among treatments were reported for juiciness, flavor liking and overall liking (P < 0.05). Steaks from NZ and 120D were perceived as juicier than 0D and 80D (P < 0.05); 40D was intermediate (P > 0.05). Consumers rated 120D and NZ steaks as acceptable for juiciness more often than all other treatments (P < 0.05). Flavor acceptability did not differ among treatments (P > 0.05). Scores for overall liking were greater for NZ and 120D than all other treatments (P < 0.05), and NZ was more often rated as acceptable than all other treatments (P < 0.05) except 120D (P > 0.05). Steaks from NZ were least often rated as unsatisfactory compared to all treatments (P < 0.05) except 120D (P > 0.05), and a minority of all treatments (10.63 – 20.14%) were assigned to the unsatisfactory quality level.

Conclusion: Results indicate cattle could be finished on high-quality pastures without detrimental effects on palatability with or without grain supplementation. Traditional NZ grass-fed beef was generally rated higher by consumers, but exposure to grain for 120 d prior to pasture-finishing produced beef of similar palatability.

Keywords: beef, palatability, pasture-finished
THE EFFECT OF GRILLING OR ROASTING COOK METHODS ON CONSUMER ASSESSMENTS OF EATING QUALITY IN THE UNITED STATES AND NEW ZEALAND

E. S. Beyer 1,*, A. J. Garmyn 1, M. F. Miller 1, T. G. O’Quinn 2, J. C. Brooks 1, R. J. Polkinghorne 3, K. S. Spivey 1
1Texas Tech University, Lubbock, 2Kansas State University, Manhattan, United States, 3Birkenwood, Murrurundi, Australia
erin.beyer@ttu.edu

Objectives: Consumer assessment was conducted in two countries using two cook methods to determine if eating quality differed based on location or cook method for six muscles.

Materials and Methods: Consumers in the United States (US)(n=480) and New Zealand (NZ)(n=480) evaluated grilled or roasted beef according to Meat Standards Australia testing protocols under the 503510(US) and 503743(NZ) ethic codes. Subprimals were collected at two commercial abattoirs in New Zealand and were aged 7-10 d postmortem. Before subprimals were fabricated into steaks or roasts, secondary muscles were removed leaving the triceps brachii (TB), semitendinosus (ST), psoas major (PM), infraspinatus (IF), rectus femoris (RF), and gluteus medius (GM). Muscles were fabricated so samples for grilling and roasting in both countries were obtained from each muscle. The denuded muscles were sliced into 2.5-cm steaks or 15 x 7.5 x 7.5-cm roasts, vacuum packaged and frozen at -20°C. Paired samples representing each cook method were divided between NZ and the US. Consumers scored each sample for tenderness, juiciness, flavor liking, and overall liking using 100-mm line scales for each trait. Data were analyzed using PROC GLIMMIX in SAS by muscle to determine if the fixed effects of country or cook method influenced eating quality (α =0.05).

Results: Country and cook method interacted (P≤0.05) to influence all traits for ST as liking preference between cook methods depended on the country for tenderness, and flavor, but the overall liking preference of the roast depended on the country. Country influenced (P≤0.03) tenderness for TB, IF, RF, GM, and PM, with US consumers rating each more tender than NZ consumers. Cook method affected (P<0.01) tenderness of GM and PM, with roasts scoring lower than steaks. Country influenced flavor for TB only (P<0.01), as US consumers liked TB flavor less than NZ. Roasting had a negative effect on flavor liking of IF and PM compared to grilling (P<0.01). Country and cook method interacted (P≤0.05) to influence flavor liking for RF and GM. Roasts were scored lower for flavor by NZ consumers, but US consumers scored flavor similarly, regardless of cook method of the two muscles. An interaction between country and cook method was observed (P=0.04) for juiciness of ST and RF. Otherwise, country influenced (P≤0.01) juiciness for all muscles except TB with US consumers rating each juicier than NZ consumers. Cook method also affected (P<0.01) juiciness for all muscles except ST as roasts were scored lower than steaks. Overall liking was influenced by country (P<0.01) for RF and GM only, where US consumers liked RF more than NZ consumers. Overall liking was also influenced by cook method (P≤0.02), where roasting had a negative effect on overall liking of IF, RF, and PM compared to grilling.

Conclusion: Consumers in NZ and US became most divergent when assessing tenderness and juiciness compared to the other traits, as US consumers typically rated beef samples more tender and juicier than New Zealand consumers. Fewer differences between countries existed for flavor and overall liking. Additionally, grilling had a positive effect on juiciness, regardless of country, but had a reduced effect on tenderness and flavor liking since it only influenced 2 of the 6 muscles for those traits.

Keywords: Beef, Consumer, Cook Method, Country, Palatability
7- RELATIONSHIP BETWEEN DESCRIPTIVE FLAVOR AND TEXTURE ATTRIBUTES ON IN-HOME CONSUMER ACCEPTANCE OF GROUND BEEF

H. L. Laird 1,*, B. A. Beavers 1, R. K. Miller 1, C. R. Kerth 1, E. Chambers IV 2, K. Adhikari 3, S. Wang 3

1Animal Science, Texas A&M University, College Station, 2Department of Food, Nutrition, Dietetics and Health, Kansas State University, Manhattan, 3Food Science and Technology, University of Georgia, Griffin, United States

hannah_laird@tamu.edu

Objectives: Ground beef comprises between 50 and 60% of the beef sold and consumed in the U.S. It is one of the most popular protein sources due to its affordability and versatility. Emerging trends in the industry are changing the way ground beef is formulated to include different formulations and grind treatments in order to change the flavor and texture attributes. In this study, sixteen treatments were utilized, including four meat sources (chuck, regular, sirloin, round), two fat percentages (10 and 20%), and two grind treatments (6.4 mm grind and bowl chopped) to better understand consumer attitudes and preferences of ground beef in a home use test.

Materials and Methods: Knuckle, outside round flat, and chuck shoulder clod subprimals and 50/50 beef trim were used to formulate the sirloin, round, and chuck treatments, respectively for both fat percentages. Regular 80/20 coarse ground beef was used for the 20% fat and it was supplemented with trimmed knuckle to formulate the 10% fat treatment. For each source, the ground beef was divided into two final grind batches either 6.4 mm or bowl chopped to approximately 6.4 mm grind. Patties were then formed with a patty maker using a 2.5 cm mold or 454 g chubs. Patties and chubs were vacuum packaged and frozen until use. Each consumer received eight samples including four patties and four chubs from the same treatment. Treatments were randomly selected for each consumer. Eighty consumers were recruited from Griffin GA, Portland OR, Manhattan KS, and State College PA. Of the 314 consumers that were given product, 218 actively participated and returned the ballots.

Results: Consumers varied in their preparation methods. More consumers used an outdoor grill to cook the patties and more consumers pan fry/sautéed the meat when given chubs. More consumers ate the patties as a main course when compared to the chubs. Meat source affected raw appearance, overall, flavor and texture liking. Raw appearance liking was highest (P < 0.05) for the regular meat source treatments and lowest (P < 0.05) for the round and sirloin. For overall, flavor, and texture liking, the consumers rated chuck the highest (P < 0.05) and regular and round the lowest (P < 0.05). Patties with 6.4 mm grind size were rated higher (P < 0.05) than the bowl chop method for overall, flavor and texture liking. Fat level affected the raw appearance, cooked appearance and texture liking. Consumers preferred the 10% lipid level over the 20% lipid level. Form did not affect overall liking. A grind by fat interaction was present for overall liking (P < 0.05). Consumers preferred the 6.4 mm grind size with 10% lipid over the 6.4 mm with 20% lipid and both bowl chop treatments. The meat source by fat interaction was significant for texture liking (P < 0.05). Regular 20% lipid, round 10% lipid, and sirloin 20% lipid beef patties rated lowest in texture liking compared to chuck and sirloin ground beef patties. Texture liking also had a grind by form interaction (P < 0.05). Both the 6.4 mm treatments for patties and chubs were liked more than (P < 0.05) the bowl chop patties and chubs.

Conclusion: With ground beef accounting for such a large percentage of beef consumption, it is crucial to understand how flavor and texture affect overall liking. Overall, consumers preferred 10% lipid ground chuck beef in patties or chubs ground to a 6.4 mm grind size.

Keywords: Descriptive Sensory, Flavor, Ground beef, Home Use Test
Objectives: Skin-on goat meat is preferred among many Asian cultures for its unique texture and flavor. The current U.S. market for skin-on goat meat is largely fulfilled by Australian imports. However, the significant growth of Asian population in the U.S., especially California, may provide an opportunity for the production of domestic skin-on goat meat. The objective of this study was to evaluate Chinese/Chinese American consumer’s preference for California and Australian skin-on goat meat.

Materials and Methods: For this study, five Boer/dairy crossbred goats averaging 25.5 kg and 4 months of age were purchased from local producers in Red Bluff, CA and shipped to California State University, Chico (CSUC) Meat Goat and Sheep Unit. After two days of acclimation period, all five goats were harvested at the CSUC Meats Laboratory on the same day. Goat carcasses were scalded and dehaired at 61°C for 3 - 4 minutes to remove > 95% of the hair after stunning and exsanguination. After 24 hours of postmortem chilling at 2°C, hind legs were removed from all five carcasses and kept frozen at -20°C until fabrication. Five Australian imported skin-on goat hind legs of similar size and weight as the California goat hind legs were purchased from an Asian ethnic supermarket in Sacramento, CA and transported back to CSUC Meats Laboratory in frozen condition. Hind legs from both treatments were fabricated using a bandsaw and cut into 5 cm x 5 cm cubes. On the sensory evaluation day, two kg of cubes from each animal were cooked in ten identical pots (8 quart), broth (water, rice cooking wine, green onion and salt) and cooking time (2 hours) on ten identical gas burners with the same heat setting (low). Twenty-eight Chinese/Chinese American consumer panelists were recruited from Chico, CA and evaluated appearance, flavor, juiciness, texture and overall liking of all ten samples in one session on a 9-point hedonic scale (1=Dislike extremely and 9=Like extremely).

Results: Consumer panelists did not detect any difference in appearance (6.23 vs. 6.28; P = 0.86), flavor (6.06 vs. 6.29; P = 0.59), juiciness (6.32 vs. 6.21; P = 0.82), texture (6.08 vs. 6.24; P = 0.76) and overall liking (6.05 vs. 6.33; P = 0.55) between California and Australian skin-on goat meat. Background survey from this study further indicated that Chinese ethnic consumers considered quality and price as the two most important factors for meat purchasing decisions, whereas the country-of-origin of meat products had little to no importance to them.

Conclusion: While the preliminary results showed no apparent differences in sensory attributes between California and Australian skin-on goat meat for Chinese/Chinese American consumers, the survey data suggested that California skin-on goat meat must be competitively priced compared to its competitors to capture market share. Additional economic research on consumer’s willingness-to-pay for California skin-on goat meat for Chinese and other Asian ethnic groups are needed to determine the sustainability of this niche meat product in the current market.

Keywords: Australian, Chinese, goat meat, sensory evaluation, skin-on processing
9- COMPARISON OF NUTRIENT COMPOSITION, QUALITY, AND SENSORY DIFFERENCES AMONG DORPER, DOMESTIC COMMERCIAL CROSSBRED AND AUSTRALIAN COMMERCIAL CROSSBRED LAMB MEAT.

K. Villatoro 1,*, Z. Bauer 2, T. Lew 2, D. Woerner 3, X. Yang 1, M. Chao 2
1Animal Science, University of California, Davis, 2College of Agriculture, California State University, Chico, 3Animal Science, Colorado University State, Colorado, United States
kmvillatoro@ucdavis.edu

Objectives: The Dorper sheep breed is gaining popularity in the U.S. because of the general perception that Dorper breed produces lamb meat with greater tenderness, milder flavor, and greater consumer preference in comparison to the wool sheep breeds. However, limited research has been conducted to characterize the genetic effects on lamb meat quality and comparative information on the Dorper sheep breed. Thus, the objective of this study was to compare the nutritional, quality, and sensory attributes among Dorper sheep breed, domestic commercial crossbred (DCC) and Australian crossbred lamb meat.

Materials and Methods: A total of 60 untrimmed lamb saddles (NAMP #231) from three treatments (Dorper, n=20; DCC, n=20; and Australian, n=20) were purchased from commercial packing plants and warehouses. Lamb saddles from all treatments were aged in cooler (2˚C) according to their production dates to achieve an aging time between 29-32 days. All aged saddles were frozen (-20˚C) until sample preparation. On the sample preparation day, each saddle was cut on a bandsaw to 2.54 cm chops, deboned and trimmed to 0.30 cm subcutaneous fat. The chops were used to measure pH, objective color (L*, a*, and b*), objective tenderness [Warner-Bratzler Shear Force (WBSF)], cook loss (differences in weight between raw and cooked samples) and nutrient analysis (moisture, protein, fat, ash, carbohydrate, and calories). A consumer panel of 120 untrained participants was used to evaluate tenderness, flavor, juiciness, and overall acceptance using a 9-point hedonic scale (1=Dislike extremely and 9=Like extremely). A trained panel with 6 trained panelists was used to evaluate flavor intensity, tenderness, and off-flavor intensity using an unstructured line scale anchored at both ends (0= absence or low intensity of specified attribute, 100= extreme intensity of specified flavor attribute).

Results: The DCC lamb meat had lower (P < 0.05) pH, carbohydrate content and off-flavor intensity compared to Australian and Dorper lamb meat. The DCC lamb meat was also rated with more flavor acceptability (P < 0.05) compared to Dorper lamb meat by untrained panelists, while Australian lamb meat was rated similar (P > 0.05) in flavor acceptability compared to DCC and Dorper lamb meat. Untrained panelists preferred (P < 0.05) the tenderness of Australian lamb, which was also rated with greater (P < 0.05) tenderness by trained panelists compared to Dorper lamb. Finally, Dorper lamb meat had greater (P < 0.05) WBSF value and was rated with the lowest (P < 0.05) rating in overall acceptance by the untrained panelists compared to Australian and DCC lamb meat. No differences (P > 0.05) were found for L*, a*, b*, cook loss, moisture, fat, ash, calories, juiciness and flavor intensity among the treatments.

Conclusion: These results indicated that there are apparent meat quality differences among the three lamb meat sources. Overall, consumers preferred DCC lamb meat compared to Dorper and Australian lamb meat. However, factors such as specific genetic makeup, age, and diets were not accounted in this research. Additional research with a more controlled environment is needed to shed light on the true palatability traits of Dorper lamb meat.

Keywords: Australian lamb, Domestic cross-bred, Dorper, Lamb, Meat quality
**Objectives:** The objective of this study was to determine the impact of four dry cookery methods following sous vide preparation on consumer ratings of beef strip loin steaks from two quality grades.

**Materials and Methods:** Strip loins (n = 40, 20/grade) were selected from 2 USDA quality grades: upper 2/3ths of Choice (Modest 0-100 – Moderate 100-200 marbling) and Select. Subprimals were aged at 2-4°C for 21 d. Strip loins were then fabricated into 2.5 cm steaks, packaged, and frozen at -20°C. Steaks were thawed, then cooked sous vide in a circulating hot water bath under vacuum at 63.5°C for approximately 1.5 h to a medium-rare degree of doneness (63°C). Immediately prior to serving to panels, steaks were finished to a medium degree of doneness (71°C) on 1 of 4 randomly assigned cooking methods: charbroiler grill (CHAR), clamshell grill (CLAM), convection oven (OVEN), or salamander broiler (SALA). Cooking surfaces were heated to 200°C and monitored during cooking using surface thermocouples. Steaks were then cut into 2.54 × 1 × 1 cm cubes and 2 cubes were served to each panelist. Untrained consumer panelists (n = 100) evaluated 8 samples, one from each treatment, for flavor, tenderness, juiciness, and overall liking on unstructured 10 cm line scales using a digital survey on an electronic tablet. Each panelist was also asked to rate each trait as acceptable or unacceptable.

**Results:** There were no cooking method × quality grade interactions (P ≥ 0.55) for all traits evaluated. However, SALA steaks were rated higher (P < 0.05) by consumers than CLAM steaks for all palatability traits. Oven steaks were rated higher (P < 0.05) than CLAM steaks for flavor and overall liking but were similar to CLAM steaks (P > 0.05) for tenderness and juiciness. Charbroiler steaks were similar (P > 0.05) to CLAM steaks for flavor, juiciness, and overall liking, but were rated higher (P < 0.05) for tenderness. When asked if samples were acceptable for each palatability trait, consumers rated a greater percentage (P < 0.05) of SALA steaks as acceptable for flavor, tenderness, juiciness, and overall acceptability than CLAM steaks. Salamander steaks had the greatest percentage (P < 0.05) of steaks rated as acceptable for juiciness in comparison to all other treatments, which were similar (P > 0.05). For flavor acceptability, a similar percentage of OVEN and CHAR steaks were rated as acceptable (P > 0.05), however, a greater percentage of OVEN steaks were rated as acceptable in comparison to CLAM steaks (P < 0.05). Clamshell steaks had the lowest percentage of steaks rated as acceptable (P < 0.05) for tenderness in comparison to all other treatments, which were higher and similar (P > 0.05). Overall, SALA steaks had a higher percentage of steaks rated as acceptable overall (P < 0.05) compared to CLAM steaks, however, CHAR and OVEN steaks were intermediate and similar to both treatments (P > 0.05). Quality grade did not influence (P ≥ 0.07) palatability traits or acceptability, as consumers rated both Top Choice and Select steaks similar for flavor, tenderness, juiciness, and overall liking.

**Conclusion:** These results indicate cooking method has a significant impact on consumer palatability ratings. This may be due to increased cooking times or differing types of heat transfer possessed by the various cooking methods. These data suggest cooking steaks by radiant flame or convection results in a more desirable eating experience.

**Keywords:** Beef, Consumers, Cooking method, Quality grade, Sous vide
Objectives: The objective of this study was to determine if increased marbling counteracts the negative trained palatability scores associated with increased degree of doneness, as stated in the insurance theory.

Materials and Methods: Five quality treatments [Prime, Top Choice (Modest and Moderate marbling), Low Choice, Select, and Select Enhanced (enhanced to 110% of raw weight with salt, alkaline phosphate solution)] were equally represented \((n=12)\) pairs/quality treatment) from paired beef strip loins (IMPS # 180). Strip loins were fabricated into 2.5cm steaks after a 21d aging period. Steaks were grouped into sets of three consecutive steaks with each set randomly assigned one of six degrees of doneness (DOD): very rare (55°C), rare (60°C), medium rare (63°C), medium (71°C), well-done (77°C), or very well-done (82°C) so that each carcass had representation for each DOD. Steaks were cooked on a clamshell grill (Cuisinart Griddler Deluxe, Model GR-150, East Windsor, NJ) to their designated DOD using a thermometer (Super-Fast Thermopen, ThermoWorks, American Fork, UT) to monitor peak temperatures. Panelists were trained according to AMSA guidelines (2016) and evaluated each sample for initial and sustained juiciness, myofibrillar and overall tenderness, connective tissue amount, beef flavor, and salt flavor intensity on continuous line scales. Panelists were fed eight samples representing differences in quality treatment and degree of doneness in a random order. Data were analyzed as a split-plot with the whole plot factor of quality treatment and sub-plot factor of degree of doneness.

Results: There was only an interaction \((P<0.01)\) between quality treatment and DOD for initial and sustained juiciness. Panelists rated Prime steaks 12 to 13% higher \((P<0.05)\) than Select steaks for initial juiciness when samples were cooked to medium rare and lower; however, when samples were cooked to medium, well done, and very well done, panelists rated Prime 66, 98, and 123% higher \((P<0.05)\), respectively. The same trend was seen for sustained juiciness, as Prime steaks were rated 19 to 25% higher \((P<0.05)\) than Select steaks when cooked to medium rare and lower, but at medium, well done, and very well done, Prime was rated 108, 152, and 211% higher \((P<0.05)\), respectively. Select Enhanced was similar \((P>0.05)\) to Prime for myofibrillar and overall tenderness, and both were rated more tender \((P<0.05)\) than all other quality treatments, with Select being rated the toughest \((P<0.05)\). Select Enhanced was similar \((P>0.05)\) to Prime and was rated as having the least \((P<0.05)\) amount of connective tissue. As quality grade increased, so did beef flavor intensity, with Prime having the highest \((P<0.05)\) beef flavor scores, and Low Choice and Select having the lowest \((P<0.05)\). When looking at the main effect of degree of doneness on overall tenderness, steaks cooked to well done and very well done were rated tougher \((P<0.05)\) than all other degrees of doneness, with very rare, rare, and medium rare all similar \((P>0.05)\) and lower than the two highest DOD. Additionally, steaks cooked to medium had the greatest \((P<0.05)\) beef flavor intensity, except for steaks cooked to rare, which were similar \((P>0.05)\) to medium.

Conclusion: According to trained panelists, the effect of increased DOD was substantially more detrimental to juiciness of steaks with lower degrees of marbling, consistent with the beef insurance theory.

Keywords: beef, degree of doneness, juiciness, marbling, sensory
12- PROVIDING LEAN BEEF FOR THE NEXT PROJECT: BEEF AS A COMPONENT OF A HEALTHY DIETARY PATTERN IN CANCER SURVIVORS

M. Foster 1,*, M. LeMaster 1, A. Braun 2, E. M. England 1, C. Spees 2, S. Clinton 3
1Department of Animal Sciences, 2School of Health and Rehabilitation Sciences, 3College of Medicine, The Ohio State University, Columbus, United States
england.146@osu.edu

Objectives: An analytical characterization study was conducted at The Ohio State University Department of Animal Sciences in support of a dietary intervention research trial conducted by researchers in the James Comprehensive Cancer Center to incorporate lean beef as a component of a healthy dietary pattern in cancer survivors. For this study, half of the participants were expected to consume 12-18 oz of lean beef each week for 24 weeks. According to the United States Department of Agriculture (USDA), lean beef is defined in part as beef containing less than 10% lipid by weight. Because lipids constitute the most variable of all nutritional components in meat, quantification of extractable lipid content of beef provided by The Ohio State University Meat Science Laboratory was necessary to ensure the criteria of lean beef was met for the nutritional trial. Therefore, the objective of this study was to quantify extractable lipid content in all beef samples prior to incorporation into the diet of the study participants.

Materials and Methods: Beef semimembranosus, semitendinosus, biceps femoris and rectus femoris muscles were obtained from the round primal of beef carcasses classified as A maturity. Muscles were trimmed until no more than 8 mm of subcutaneous fat was present. To provide variety for the participants, muscles were fabricated into nine retail cuts including fine ground beef, coarse ground beef, top round steaks, bottom round steaks, eye of round steaks, thinly sliced beef (cut from the biceps femoris), fajita meat (cut from the semimembranosus), stew meat (cut from the rectus femoris), and cubed steaks (cut from the semimembranosus). Representative samples were collected from each batch of retail cuts and powdered in liquid nitrogen in duplicate. After weighing powdered samples into packets and lyophilizing, extractable lipid content was quantified using a Soxhlet extraction with an 87:13 mixture of chloroform:methanol. Extractable lipid content (%) was determined using the following equation: extractable lipid (%) = (mass after lyophilization - mass after soxhlet extraction)/(original mass of sample) x 100. Any cut that did not classify as USDA lean beef could have been rejected from the study and not provided to the participants. However, no beef was excluded from the study.

Results: A table of descriptive statistics of the extractable lipid content of the nine different retail cuts is provided (Table 1). A total of 124 samples were analyzed and the beef provided for the study contained an average overall extractable lipid content (%) of 3.6% ± 2.0% (mean ± SD).

<table>
<thead>
<tr>
<th>Retail Cut</th>
<th>N</th>
<th>Mean Extractable Lipid (%)</th>
<th>SD</th>
<th>Min. (%)</th>
<th>Max. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Ground Beef</td>
<td>5</td>
<td>5.5</td>
<td>2.7</td>
<td>2.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Coarse Ground Beef</td>
<td>5</td>
<td>3.3</td>
<td>2.7</td>
<td>0.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Top Round Steak</td>
<td>5</td>
<td>2.8</td>
<td>1.4</td>
<td>1.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Bottom Round Steak</td>
<td>26</td>
<td>4.1</td>
<td>2.6</td>
<td>0.3</td>
<td>9.6</td>
</tr>
<tr>
<td>Eye of Round Steak</td>
<td>42</td>
<td>4.4</td>
<td>2.6</td>
<td>0.1</td>
<td>9.8</td>
</tr>
<tr>
<td>Thinly Sliced Beef</td>
<td>23</td>
<td>2.9</td>
<td>2.4</td>
<td>0.2</td>
<td>8.8</td>
</tr>
<tr>
<td>Fajita Meat</td>
<td>3</td>
<td>1.4</td>
<td>0.7</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Stew Meat</td>
<td>8</td>
<td>2.0</td>
<td>1.3</td>
<td>0.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Cubed Steak</td>
<td>7</td>
<td>1.8</td>
<td>1.3</td>
<td>0.1</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Conclusion: Lean beef was provided for this human nutrition study. Further results and conclusions from the dietary intervention research trial are forthcoming.

Keywords: extractable lipid, human nutrition, lean beef
Objectives: Beef flavor is very complex and the most important driver for consumer acceptance. Cooking method, Quality grade, and cooked internal temperature may affect beef flavor. In this study, three beef cuts (outside skirt, inside skirt, and flap), two Quality grades (USDA Choice and Select), three cooking methods (pan fry, pan grill, and outside grill), and three internal cook temperature endpoints (58°C, 70°C, and 80°C) were used to better understand trained descriptive beef flavor and texture attributes, and Warner-Bratzler shear force (WBSF) tenderness.

Materials and Methods: Meat sources were purchased as subprimals in six reps for each cut and were fabricated into 10.16 cm wide steaks. USDA upper two thirds Choice and USDA Select inside skirt, outside skirt, and flap steaks were cooked using a pan fry, pan grill, or outside grill methods. The steaks were cooked to an internal temperature of either 58.3, 70 or 80°C to represent medium rare, medium and well-done steaks. The steaks were evaluated by an expert trained meat descriptive panel for beef flavor and texture attributes. The trained panel descriptive flavor attributes, and WBSF were analyzed using Proc Means and Proc GLMMIX procedures of SAS (version 9.4, SAS Institute, Cary, NC) with a predetermined alpha of 5%.

Results: Cooking method and internal cook temperature endpoint tended to impact beef flavor to a greater extent than USDA Beef Quality grade for outside skirt, inside skirt and flap steaks. Internal cook temperature endpoint affected beef identity, brown, bloody/serumy, metallic, burnt, smokey-charcoal, and juiciness (P < 0.05). Pan frying tended to result in more off-flavor development and outside grilling was more often associated with positive flavor attributes. Choice steaks tended to have more positive beef flavor attributes such as beef identity, umami, brown and roasted. Quality grade affected fat-like, cardboardy, juiciness, muscle fiber tenderness and beef flavor (P < 0.05) for all three cuts. Pan grilling tended to result in intermediate flavor for steaks when compared to steaks cooked using outside grilling and pan frying cooking methods. The flavor attributes generally affected by cooking method included beef identity, brown, metallic, smokey-charcoal (P < 0.05).

Treatments had an effect on flap tenderness measured by WBSF, Choice flap steaks were more tender (P < 0.05) than Select flaps and flap steaks cooked to 80°C were less tender (P < 0.05) than other internal temperatures. Pan-grilled flap steaks were more tender (P < 0.05) than steaks from the other cooking methods. For inside skirts, there was no effect (P > 0.05) for Quality grade on tenderness measured by Warner-Bratzler shear force values. However, inside skirts cooked to 58°C were more tender than other internal temperature endpoints, and pan-grilled skirts were more tender than other cooking methods (P < 0.05). Lastly, for WBSF measurements, treatments had no impact (P > 0.05) on outside skirt steaks.

Conclusion: In the beef industry, beef flavor is a driver of consumer acceptability. This research was conducted to assist in the development of the Beef Flavor Myology tool that will aid in determining factors that impact beef flavors across various cuts, cooking methods, marbling levels, and cooked internal temperature.

Keywords: Beef Flavor, outside grill, pan grill, pan-fry, sensory evaluation
14- UNDERSTANDING BEEF NUTRITIONAL ATTRIBUTES CONTRIBUTES TO CONSUMERS’ WILLINGNESS-TO-PAY FOR A HEALTHIER PRODUCT

S. Flowers 1, B. R. McFadden 2, C. Carr 1, R. G. Mateescu 1
1Animal Sciences Department, 2Food and Resource Economics, University of Florida, Gainesville, United States
sarahflowers1029@ufl.edu

Objectives: Nutritional value impacts consumers’ purchasing decisions of food products. Beef is a nutrient rich foodstuff excelling in protein, vitamins, and minerals. There is growing controversy regarding fat content of beef and its healthfulness in the diet. Although much of the fatty acid (FA) content in beef is considered “healthy fats,” many consumers are confused about the different classifications of FA. Research at the University of Florida shows there is variation among cattle for FA composition. This provides opportunity to identify cattle with a favorable composition and market this product to the increasing population of health-conscious consumers. Before producers invest in such marketing opportunities, it is necessary to understand how consumers perceive this information. The objective of this study was to determine consumers’ knowledge of beef nutritional value and its importance in their purchasing decisions and willingness-to-pay.

Materials and Methods: A national survey was administered online to over 1,000 respondents. The study began with seven questions, each asking the respondent to choose between two steaks that varied in polyunsaturated and saturated FA levels, iron content, and price. Following the seven choice questions, respondents were asked to categorize “Trans Fat,” “Saturated Fat,” “Monounsaturated Fat,” and “Polyunsaturated Fat,” as either “healthy” or “unhealthy.” After receiving an educational excerpt, respondents were re-asked the seven steak choice questions and the fat categorization question. Lastly, respondents were asked demographic questions along with questions regarding their normal fat consumption habits.

Results: The results from the survey indicate many consumers are confused about the differences in beef nutritional value, specifically FA content. Initially, only 66.40%, 69.05%, 79.14% and 79.24% of respondents correctly categorized the monounsaturated, polyunsaturated, saturated, and trans fat, respectively. However, a favorable shift occurred and more than 90% of respondents correctly categorized the various FA once provided the educational excerpt. Furthermore, once respondents better understood the healthfulness of FA in beef, respondents were willing-to-pay a premium for a product of improved FA composition (Table 1). Also, prior to information regarding FA, respondents preferred more iron content, especially compared to better FA composition, but these preferences reversed after the informational excerpt was provided and respondents better understood that not all fat in beef is bad.

Table 1: The premiums/discounts in U.S. dollars respondents are willing-to-pay per pound of steak before and after the educational excerpt.

<table>
<thead>
<tr>
<th>Nutritional Improvement</th>
<th>Premiums/discounts Before information</th>
<th>Premiums/discounts After information</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% more favorable fat composition</td>
<td>-1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>100% more favorable fat composition</td>
<td>-1.4</td>
<td>4.2</td>
</tr>
<tr>
<td>50% iron content increase</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>100% iron content increase</td>
<td>1.3</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

Conclusion: In the past, much controversy surrounding fat content of red meat and its role in the diet led to many health professionals recommending cutting such food from the diet. In recent years, research on different FA categories supports the idea that not all fat is bad. Our results indicate that relaying this information to consumers is extremely important to their purchasing decisions and willingness-to-pay for beef. These findings provide insight for beef promotion and marketing opportunities to the increasing population of health-conscious consumers.

Keywords: Beef, Consumer Preference, Nutritional Value
Objectives: Evolving consumer trends for the animal agriculture industry highlight concern for animal welfare, food safety, and environmental sustainability. Customers are increasingly motivated to buy meat products that align with their lifestyles and personal values. Growing meat products outside of the animal has become a buzzworthy solution to meet the needs of these customers. The emerging cultured meat industry produces meat through biomanufacturing, using techniques initially developed for medical research, such as cell and tissue culture. The research described here presents the development of a culture process for pork and turkey meat: establishing animal cell lines, culturing cells to increase mass yields, and designing cultured meat product prototypes.

Materials and Methods: Myogenic porcine cells were isolated from the biceps femoris muscle of a 3 month old female domestic pig, and myogenic turkey cells were obtained from the pectoralis major muscle of a 1 week old male domestic turkey. A sample of cells from each species were immunostained for myosin heavy chain to confirm their ability to fuse into multinucleated muscle fibers. Myogenic porcine and turkey cells were expanded in vitro and used to make 3-dimensional cultured meat prototypes. The meat was grown using a tissue engineering technique that embeds muscle cells into an edible scaffold composed of animal collagen. The collagen assembles the cells into a 3D matrix and provides texture. The meat samples were matured for 7 days to allow muscle fiber formation and tissue development and immunostained for myosin heavy chain. The samples were imaged with an Olympus multiphoton microscope and the images were processed in Fiji.

Results: The cell isolation method produced myogenic porcine and turkey cell populations that could spontaneously form multinucleated myotubes, and these myotubes expressed myosin heavy chain. Embedding the muscle cells into a collagen 1 protein matrix allowed growth of 3D pork and turkey meat prototypes. These samples possessed long multinucleated muscle fibers expressing myosin heavy chain, with similar histological architecture to muscle from an animal.

Conclusion: This research demonstrates that small cultured pork and poultry meat prototypes can be easily grown in a laboratory setting. However, many technical challenges remain for scaling up biomanufacturing methods to produce cultured meat at a commercially viable level. These challenges include: 1) Developing immortalized meat cell lines to avoid the need to repeatedly sample animal tissues to obtain new cells, 2) Creating ultra low cost fetal bovine serum-free culture media to feed the cells, 3) Improving tissue engineering/bioprinting techniques to increase the size of meat that can be grown, and 4) Inventing 'proliferation' bioreactors that manufacture high yields of meat cells, and 'maturation' bioreactors that can support 3D meat growth and development.

Keywords: Cultured Meat, Meat quality, meat safety, Muscle source
**Environment, Production Systems**

16- CYCLIC HEAT STRESS AND SUPPLEMENTATION OF ZINC AT A HIGH OR LOW LEVEL FROM INORGANIC AND ORGANIC SOURCES MINIMALLY IMPACT DISPLAY SHELF-LIFE OF FRESH AND PROCESSED PORK.

J. A. Feldpausch 1,*, K. M. Mills 1, S. K. Elefson 1, E. A. Ford 1, S. M. Zuelly 1, Y. H. B. Kim 1, Z. J. Rambo 2, B. T. Richert 1
1Animal Sciences, Purdue University, West Lafayette, 2Zinpro Corporation, Eden Prairie, United States
jfeldpau@purdue.edu

**Objectives:** Heat stress (HS) induces metabolic changes associated with physiologic adaptation to stress and pigs exposed to acute heat experience musculoskeletal oxidative stress. Zinc may be particularly beneficial to HS animals due to its involvement in nutrient and insulin mediated metabolism. Thus, our objective was to determine the effects of Zn supplementation on color and oxidative stability of fresh and processed pork products from pigs subjected to a summer HS.

**Materials and Methods:** Commercial crossbred pigs (initially 72.0 kg) were housed 5 pigs/pen under thermoneutral (TN; 18.9–16.7°C) or cycling HS conditions simulating chronic summer heat (30°C/26.7°C for 12h:12h on days 24-63) with acute heat waves (32-33°C/29-30°C for 12h:12h on days 21-24, 42-45, & 63-65). Core body temperatures were recorded to validate HS. Pens (experimental units) were randomly allotted to eight treatments arranged as a 2×2×2 factorial with main effects of environment (ENV; TN vs. HS), supplemented Zn level (LEV; 50 vs. 130 mg/kg available Zn), and Zn source (SRC; inorganic from ZnO vs. organic/inorganic-blend). One pig per pen (n=80) was slaughtered on day 65, and at 1 day postmortem chops were fabricated from the 4th-10th rib portion of the loin (M. longissimus dorsi). Dissected lean and fat from the picnic shoulder of each carcass was combined as a 70/30 lean:fat blend with a nitrate-free sausage seasoning blend and formed into 2.54 cm thick patties. Chops and patties were packaged on styrofoam trays with PVC film overwrap and stored at 4°C under 40-watt fluorescent light for 0, 3, 7, or 10 days. At each display endpoint, assessment was made of CIE L*a*b* color attributes on all products with a Hunter MiniScan colorimeter (D65 illuminant/10°) and of lipid oxidation via 2-thiobarbituric acid reactive substances (TBARS) assay on all patties and a subset of chops (n=48). Data were analyzed as a RCBD in SAS 9.4 using preplanned contrasts.

**Results:** Color and oxidative changes occurred over time in all products but no interactions (P>0.10) between display day and treatment were observed. For chops, day 3 L* was less when Zn was fed at the 50 mg/kg level from organic source, but less at the 130 mg/kg level from inorganic source (LEV×SOR, P=0.014). Inorganic Zn increased day 10 a* (6.16 vs. 5.83, P=0.008) and decreased discoloration (hue angle, P=0.004) compared to organic Zn. Day 3 b* was less for 50 mg/kg vs. 130 mg/kg (P=0.048) and ENV×SOR interactions (P<0.05) were observed for day 3 discoloration, day 7 b*, and day 10 b* and chroma. For sausage patties, day 3 L* was decreased at the 50 mg/kg Zn level relative to 130 mg/kg. No differences were observed in sausage a* but HS decreased (P<0.01) day 0 and day 10 b* and day 10 chroma compared to TN. Initially, sausage derived from HS animals tended (day 0, P=0.071) to have less lipid oxidation than TN but within each subsequent display day, no lipid oxidation differences (P>0.05) due to treatment were observed in either loin chops or sausage.

**Conclusion:** In conclusion, the HS model did not appear to reduce display shelf-life of fresh and minimally processed pork as indicated by lack of differences in lipid oxidation and color stability. The effects of Zn source on chop color differed by environment and Zn level but greater amounts of Zn failed to impart any benefit to oxidative stability and color.

**Keywords:** Heat stress, Lipid oxidation, Pork color, Shelf-life, Zinc
Objectives: Brassica Carinata is an oilseed crop that shows potential to produce jet fuel. The byproduct remaining after the oil is extracted is a high quality protein meal. Carinata meal supplementation has been documented to improve the growth of developing heifers. However, protein meal inclusion is a rather small percentage of the supplementation of ruminants. If Brassica carinata oil production is to become cost effective, more opportunities to utilize this high protein meal byproduct will need to be identified. The objective of this study was to evaluate the impact replacing soybean meal with Brassica Carinata meal (BCM) on the growth, feed efficiency, carcass merit, and lean quality of finishing pigs.

Materials and Methods: Over a 42-d trial period, Thirty crossbred pigs were blocked by weight and placed in fifteen mixed-gender pens, each including one barrow and one gilt. Pigs were fed one of three diets: a corn soybean meal control diet (CON; n=10), or the same diet with carinata meal replacing 25% (25; n=10), or 50% (50; n=10), of soybean meal. The pH of the LM and the semimembranosus muscle (SM) was measured between the 10th and 11th rib with a temperature-compensating pH meter. At 24-h postmortem, left carcass sides were fabricated into primal cuts. Loin were ribbed between the 10th and 11th rib and LM area. 10th rib fat thickness, subjective marbling scores, lean color (NPPC, 2000), and lean firmness scores (NPPC, 1991) were taken at the 10th rib. Additionally, LM objective lean color (L*, a*, b*; CIE, 1978) were measured using a Minolta Chroma-Meter CR-310. LM chops were fabricated from the 10th-11th rib interface and used to record 24 h drip loss. After 7 d of storage, posterior loin section reweighed to measure purge loss. Longissimus muscle chops for Warner Bratizer shear force analysis were cooked to internal temperatures of 71°C. LM Chops were allowed to cool then six 1.3-cm diameter cores were removed and sheared using a Warner-Bratzler shear head attached to an Instron Universal Testing machine. Longissimus muscle chops used for sensory panel evaluation were cooked using the same procedures as for Warner Bratzer shear force. A trained sensory panel evaluated all samples for tenderness, juiciness, pork flavor intensity, connective tissue, and off-flavor and firmness.

Results: Dietary treatment did not influence average daily gain (P = 0.86) or any measurement of carcass composition (P ≥ 0.17). Pigs fed 50 tended to have greater liver weights (P = 0.07) than pigs fed the CON and 25. Inclusion of BCM in the diet had no effect (P ≥ 0.15) on any measurement of intramuscular pH or fat color. Chops from CON pigs tended (P = 0.09) to have greater marbling scores than chops from pigs fed experimental diets. Loin roasts from pigs fed 25 had greater 7d loin purge loss (P = 0.04) than pigs fed the other two diets. Boneless loin chops from CON carcasses had more reddish pink lean color scores (P = 0.003) and had lower (darker) L* values across retail display than pigs fed experimental diets. Loin chops from pigs fed 25 or 50 had greater trained sensory tenderness scores (P < 0.01), when compared to CON.

Conclusion: Overall, replacing up to 50 percent of soybean meal with BCM is a viable option for in the diets of finishing pigs. However, more research is needed to determine BCM’s impact on lean color, water holding, and tenderness.

Keywords: Brassica carinata, pork quality
**Objectives:** Two experiments were conducted to determine the impact of ergot alkaloids fed during two stages of gestation (MID, d 35 to 85, or LATE, d 86 to 133/parturition) on prenatal (Experiment 1, Exp1) and postnatal (Experiment 2, Exp 2) lamb muscle growth.

**Materials and Methods:** Pregnant Suffolk ewes (Expt. 1, n = 36, BW 78.02 ± 9.53 kg; Expt. 2, n = 60, BW 83.13 ± 1.69 kg) were fed endophyte-infected tall fescue seed (E+; 1772 µg/hd/d ergovaline+ergovalinine) or endophyte-free tall fescue seed (E-; 0 µg/hd/d ergovaline+ergovalinine) during MID or LATE gestation, which created four dietary treatments of E+/E+, E+/E-, E-/E+, and E-/E-. Maternal and fetal necropsies were performed at d 133 of gestation. Semitendinosus (ST) muscle was removed from each fetus, immediately frozen in liquid nitrogen and stored at -80°C. Total cellular RNA was extracted using the mirVana miRNA Isolation Kit (Ambion, Austin, TX) and quality analysis of RNA performed using an Agilent 2100 Bioanalyzer, with a RIN threshold of 7.0. The tRNA from 3 fetuses per treatment from the ST was used for miRNA sequencing and data analysis (LC Sciences, Houston, TX). Data was analyzed as a randomized block design with a 2×2 factorial with fescue treatment (E+ or E-), stage of gestation (MID or LATE), and two-way interaction in the model. In Expt. 2, Suffolk ewes were stratified by genotype (dopamine receptor 2 [DRD2] SNP; AA, AG, GG) and assigned to fescue treatments of E+ or E- fed during two stages of gestation, MID or LATE similar to Expt. 1, except that ewes were allowed to lamb naturally. Data for Expt. 2 were analyzed as a 3×2×2 factorial with ewe genotype, fescue treatment, time of gestation and all interactions in the model. Lamb weights were recorded at birth and weaning. At weaning, wethers (n = 44) were fed individually a high concentrate diet until they reached 59 kg or 185 d postweaning.

**Results:** Prenatal (d 133) lamb fetal weights were lower (P < 0.05) for ewes fed E+ fescue during LATE gestation (E-/E+ and E+/E+). Total and individual muscle mass were also lower in fetal lambs from ewes fed E+ fescue during LATE gestation. miRNA transcriptome were altered in the semitendinosus muscle of fetal lambs from ewes fed E+ fescue during LATE gestation. Exp. 2 lamb birth and weaning weight was lower (P < 0.05) for ewes fed E+ tall fescue seed during LATE gestation. At slaughter, wethers from GG ewes fed E+ had greater live weight than E-. Hot carcass weights, dressing percentage, and carcass traits did not differ due to fescue treatment. Biceps femoris muscle was lower on a percentage of hot carcass weight for wethers from ewes fed E+ fescue during LATE gestation. Carcass fat percentage, as measured by dual-energy X-ray absorptiometry at 24 h postmortem, did not differ (P > 0.05) by ewe genotype or fescue treatment.

**Conclusion:** Exposure to ergot alkaloids from E+ fescue during LATE gestation reduces prenatal and postnatal muscle growth in lambs, and alters prenatal muscle miRNA expression.

**Keywords:** Ergot alkaloid, Lamb, Muscle, Postnatal, Prenatal
Effects of Replacing Supplemental Sucrose with Beef on Maternal Health and Fetal Growth and Development Using a Sow Biomedical Model

M. A. Nelson 1,*, A. K. Ward 1, K. C. Swanson 1, K. A. Vonnahme 1, E. P. Berg 1

1Animal Science, North Dakota State University, Fargo, United States
megan.nelson.6@ndsu.edu

Objectives: A diet high in sucrose is reflective of a Western diet that the average American consumes. When consuming a Western diet, individuals consume roughly 20 teaspoons of sucrose per day. The Western diet has been previously linked to metabolic disorders such as diabetes and obesity, which may be prevented by replacing dietary sucrose with a healthy protein alternative like beef. The objectives of this study were to investigate the impact of substituting dietary sucrose with beef supplementation on maternal health and fetal development utilizing the sow as a biomedical model.

Materials and Methods: Multiparous pregnant sows (Landrace x Yorkshire; BW = 222 kg; n = 21) were fed a complete sow gestation diet (corn-soybean meal-based, CSM; NRC 2017) at one percent of BW on sow d 30 of gestation at 700 h daily from d 30 to 39 of gestation. Sows were then fed CSM at one percent of BW on d 39 of gestation at 700 h daily from d 40 to 110 (± 0.58) of gestation. Sows were randomly assigned to 1 of 4 isocaloric dietary supplements consisting of 126 g CSM (CON, n = 5); 110 g cooked ground beef (CGB; BEEF, n = 6); 54.8 g CGB and 42.7 g sucrose (B+S, n = 5); or 85.5 g sucrose (SUCROSE, n = 5). Dietary supplements were fed three times daily from d 40 to 110 (± 0.58) of gestation. Sows were housed in gestation crates from d 30 to 111 (± 0.58) of gestation and euthanized on d 111 (± 0.58) of gestation. Blood was collected via jugular venipuncture from sows on d 29 and 111 (± 0.58) of gestation. Blood chemistry was immediately analyzed using iSTAT point-of-care device. Bodyweights were measured on d 30, 39, 54, 68, 82, 96, and 111 (± 0.58) of gestation. Tenth rib and last rib fat depth were measured on d 35, 70, and 110 (± 0.58) of gestation utilizing an ALOKA SSD-500V ultrasound. Fetal growth measurements were recorded for all fetuses. Two median weight male and female fetuses were selected from each sow for tissue collections which included pancreas, kidney, liver, heart, heart fat, lung, empty body weight, semimembranosus, and semitendinosus weights. A repeated measures design, using sow as the repeated measure, was modeled using the MIXED procedure of SAS using compound symmetry variance covariance matrix. Alpha level was 0.05.

Results: Dietary treatment did not influence blood metabolites of sows on d 29 or 111 of gestation (P = 0.09 and P = 0.20, respectively). Sow weight throughout gestation was not influenced by dietary treatment (P = 0.74). Dietary treatment did not influence tenth rib or last rib fat depth on d 35, 70, or 110 of gestation (P = 0.27). Compared to CON and SUCROSE, fetuses from sows supplemented with BEEF had greater nose to crown lengths (6.03 ± 0.29, 6.02 ± 0.28, and 7.33 ± 0.36 cm, respectively; P = 0.04). Compared to CON, fetuses from sows supplemented with sucrose had respectively greater BW (1296 ± 73.6 vs. 1556 ± 68.8 g; P = 0.02); heart girths (22.90 ± 0.39 vs. 24.13 ± 0.39 cm; P = 0.03), and liver weights (36.48 ± 2.19 vs. 43.44 ± 2.05 g; P = 0.04). Dietary treatment did not influence other fetal characteristics or organ weights (P ≥ 0.05).

Conclusion: Beef supplementation during mid to late pregnancy had minimal effects on maternal blood metabolites, bodyweight, or backfat depth or fetal growth. The increase in fetal weight due to sucrose supplementation should be further explored.

Keywords: Beef, Biomedical Model, Sucrose, Swine
Exploring New Dimensions of Poultry Meat Quality Using Advanced Technologies

A. E. Smith 1*, R. S. Moon 2, R. J. Beyers 3, M. K. Cox 4, L. J. Garner 1, A. Morey 1

1Poultry Science, 2College of Veterinary Medicine, 3Department of Electrical and Computer Engineering, Auburn University, Auburn University, 4Seafood Analytics, Juneau, United States

aes0027@auburn.edu

Objectives: In the poultry industry, breast meat is the most valuable portion of a value-added carcass. Recent advances in poultry science have allowed for rapid increases in breast yield. However, several defects in poultry breast meat quality have arisen in modern broilers, resulting in loss of product quality and therefore decreasing the value of affected filets. Further complicating the issue, instrumental methods used to examine meat quality and detect these conditions are often destructive or inaccurate. Woody Breast (WB) was selected as a model defect for this research due to its pervasiveness, negative impact on meat quality, and lack of accurate organoleptic detection technique. In the modern poultry industry, these filets are frequently detected at the plant level using manual palpation, but this is highly unreliable and results in erroneous sorting of both affected and unaffected filets. Additionally, this method is difficult to apply in live birds or whole carcasses, limiting its application. The objective of this research was to examine potential new methodologies of determining meat quality in poultry breast meat, including bioelectric impedance analysis (BIA), shear wave elasticity imaging (SWEI), ultrasonography (US), and magnetic resonance imaging (MRI). Each of these methods have been applied in various capacities to soft tissue analysis in either traditional or veterinary medicine.

Materials and Methods: To evaluate and compare these methods, fresh jumbo boneless skinless butterfly breast filets were collected, separated into right and left breasts, and categorized by manual palpation into WB severity categories: normal, mild, moderate, and severe. Three filets to represent each severity category were selected for a total of 12 filets. BIA analysis was performed using a handheld device approximately 5-6 hours postmortem. Left side filets were then vacuum packaged, followed by MRI scanning at approximately 8-10 hours postmortem and US/SWEI imaging at approximately 24 hours postmortem. Right side filets were frozen at approximately 5-6 hours postmortem, stored at -80°C, then thawed, ground, and analyzed for proximate composition using a Foodscan Lab Meat Analyser. This allows for verification of WB severity and is made possible due to the compositional nature of WB, which has been shown to have significantly higher moisture and lower protein content compared with normal filets. Data were analyzed using SAS ANOVA with Tukey’s HSD.

Results: Significant differences (P<0.05) were found between severely wooden and normal categories using MRI generated data, with average T1 relaxation times of 846 m/s in normal filets and 933 m/s in severely woody filets. Conversely, BIA values were not significantly different between filet groups, though this finding was inconsistent with previous, larger studies. SWEI also did not generate statistically significant differences in this study, however, examination of filet architecture using US and SWEI generated images suggest that further investigation of this technique, increased sample size, and improvement of methodology may yield valuable results.

Conclusion: In conclusion, the lack of appropriate instrumental quality detection methods and the rise of meat quality defects in the poultry industry presents an opportunity to explore advanced technologies. However, these methods may require further investigation before they can be used as standalone techniques.

Keywords: Bioelectric Impedance Analysis, magnetic resonance imaging, Meat quality, ultrasonography, woody breast
Meat and Poultry Quality and Composition - Measurement and Prediction

21- DETERMINING THE RELATIONSHIP BETWEEN EARLY POSTMORTEM LOIN QUALITY ATTRIBUTES AND AGED LOIN QUALITY ATTRIBUTES USING META-ANALYSES TECHNIQUES

B. Harsh 1,* D. Boler 1, S. Shackelford 2, A. Dilger 1
1University of Illinois, Champaign, 2U.S. Meat Animal Research Center, Clay Center, United States
bharsh2@illinois.edu

Objectives: The objectives were to: 1) evaluate changes in pork quality parameters during postmortem aging, 2) correlate early postmortem loin quality parameters with aged loin quality parameters, and 3) determine the predictive ability of early postmortem loin quality parameters on aged color and marbling as well as sensory tenderness, juiciness, and flavor using meta- and holo-analysis techniques.

Materials and Methods: Eleven independent experiments were selected for inclusion in the analysis. Inclusion criteria included studies where pigs were slaughtered at a commercial facility, loins were evaluated on the ventral surface of the loins on day 1 postmortem, and then again after an aging period that ranged from 12 to 28 days. Data sets encompassed approximately 3,957 loins. The effects of aging on ventral loin surface quality was determined using a paired-T test. Pearson correlation coefficients within original data sets were calculated and then sample-weighted mean correlations (r) and variances [Var(r)] were calculated across data sets. Stepwise regression, using a holo-analysis approach, was used to determine the predictive ability of early postmortem ventral color, marbling, firmness, and pH on sensory ratings.

Results: Ventral loin surfaces became 8% lighter (P < 0.0001), 44.5% redder (P < 0.0001), and 46% more yellow (P < 0.0001) during the aging period. Therefore, it was apparent that loin quality changes during postmortem aging. Because of this, it was necessary to determine the correlation between early and aged pork quality parameters. Early postmortem ventral instrumental lightness (L*) was moderately correlated with aged ventral L* (r = 0.50), aged ventral visual color (r = -0.38), aged chop face (freshly cut) L* (r = 0.44), and aged chop face visual color (r = -0.38). Early postmortem ventral instrumental redness (a*) was moderately correlated with aged ventral a* (r = 0.49) and aged chop face a* (r = 0.46). Early postmortem ventral visual color was moderately correlated with aged ventral L* (r = -0.51), aged ventral color (r = 0.50), aged chop face L* (r = -0.43), and aged chop face visual color (r = 0.43). However, no instrumental or visual color parameters were moderately or strongly correlated to instrumental tenderness or sensory panel ratings of tenderness or juiciness (|r| ≤ 0.36). Early postmortem ventral visual marbling was moderately correlated with aged ventral marbling (r = 0.63) and aged chop face visual marbling (r = 0.56). Visual marbling was not (|r| ≤ 0.12) correlated to instrumental tenderness or sensory panel ratings of tenderness and juiciness. The combination of color, marbling, firmness, and pH were poor predictors (R² ≤ 0.13) of sensory tenderness (R² = 0.13) and juiciness (R² = 0.09), but were moderately predictive of sensory flavor (R² = 0.28).

Conclusion: Early postmortem color and marbling are important pork quality traits in consumers purchasing decisions, but are poorly related to traits associated with eating experience.

Keywords: correlation, meta-analysis, pork, quality, sensory
Objectives: It has been well established that cooking method, marbling level and cooked internal temperature endpoint affect beef flavor also, beef flavor has been shown to be the most important driver of consumer acceptance. But beef cuts respond differently to cooking method and cooked internal temperature endpoint based on their inherent chemical characteristics. The objective of this study was to determine the relationship between descriptive flavor attributes and volatile flavor compounds of major beef cuts as affected by cooking method and internal cooking endpoint.

Materials and Methods: In this study, three beef cuts (outside skirt, inside skirt, and flap), two Quality grades (USDA Choice and Select), three cooking methods (pan fry, pan grill, and outside grill), and three internal cook temperature endpoints (58°C, 70°C, and 80°C) were evaluated by an expert descriptive sensory attributes panel and volatile flavor aroma compounds were determined using gas chromatography-mass spectrometry-olfactory (GC-MS-O). Meat sources were purchased as subprimals in six reps for each cut and were fabricated into 10.16 cm wide steaks. Partial least squares regression biplots were used to show relationships.

Results: Eighty volatile aromatic compounds were reported by cuts. Most flap treatments were clustered near butanoic acid, benzeneacetaldehyde, phenyl acetaldehyde, and 2,6-dimethyl-pyrazine, generally sweet, rancid, and floral aromas respectively. Choice flap steaks pan-fried to 58°C were closely related to 3-ethyl-benzaldehyde, 3-dodecen-1-al, (E)-2-heptenal, and 1-octanol. Select flap steaks pan-grilled to 80°C were closely related to 2-methyl-butanal, a malty, green, fruity, musty aroma. Generally, inside skirt treatments were related to acetic acid, sulfur dioxide, methyl-benzene, and 1-heptanol, sour, sulfur, and fruity aromas respectively. Select inside skirt steaks pan-fried to 70°C were closely related to nonanal, styrene, carbon disulfide, tetradecanal, 2-octenal, trans-2-undecenal, and 2,4-decadienal. Choice inside skirt steaks pan-fried to 80°C were closely related to octane, pentanal, heptane, 2-ethyl-6-methyl-pyrazine, trimethyl-pyrazine, and 3-ethyl-2,5-dimethyl-pyrazine. Outside skirts are clustered around aromas such as dl-limonene, 2-acetyl-2-thiazoline, carbon disulfide, and undecanal – citrus, soapy, and buttery aromas respectively. Select outside skirt steaks outside grill to 70°C were closely associated with benzeneacetaldehyde, 2-ethyl-6-methyl-pyrazine and buttery volatile aromatic compounds and flavor attribute.

Conclusion: Beef flavor has been identified as a key driver for consumer acceptability, so understanding the factors that attribute to flavor is essential. This research showed that volatiles differed across various cuts, cooking methods, marbling levels, and cooked internal temperatures and were associated with descriptive beef flavor attributes.

Keywords: Beef, outside grill, pan grill, pan-fry, volatiles
Meat and Poultry Quality and Composition - Measurement and Prediction

23- BENCHMARKING NEW ZEALAND CARCASS QUALITY AND YIELD CHARACTERISTICS
C. A. Sepulveda 1,*, A. J. Garmyn 1, K. S. Spivey 1, M. R. Hunt 1, R. J. Polkinghorne 2, M. F. Miller 1
1Animal and Food Science, Texas Tech University, Lubbock, United States, 2Birkenwood International Pty Ltd, New South Wales, Australia
cesar.sepulveda@ttu.edu

Objectives: New Zealand’s current carcass classification system focuses on dentition, sex, fat depth, hot carcass weight, and overall muscling, but limited information is collected or available pertaining to carcass quality attributes. The objective of this study was to perform carcass assessments to determine quality and yield traits to establish a beef carcass benchmark in New Zealand.

Materials and Methods: Carcass data from steers and heifers were collected at three different times of year (August, 2012; November/December, 2012; April, 2013) at 3 commercial abattoirs, representing three geographical regions (Hawke’s Bay, Canterbury, and, Otago) of New Zealand, to characterize carcass quality and yield traits. All carcasses were classified based on the current New Zealand carcass classification system. In addition, three Texas Tech University (TTU) personnel trained in carcass assessment, were each stationed at one plant during each assessment period and performed daily assessments on all carcasses presented for grading. The traits collected included 12th rib fat thickness, ribeye area, hot carcass weight (HCW), calculated USDA yield grade (YG), dressing percent (calculated using live weight and carcass weight after standard carcass trim and removal of internal fat, when both weights were available), hump height, dentition (number of permanent teeth), pH, marbling score, and skeletal/lean maturity (USDA, 1997). Data were summarized in SAS using PROC MEANS and PROC FREQ.

Results: Data were collected on 17,758 carcasses, with the following frequencies for gender: steer (72%), heifer (28%). The means for USDA skeletal maturity was A58 and the mean for USDA lean maturity was B07. Frequencies for skeletal maturities were A, 94.4%; B, 4.9%; and C or greater, 0.7%. The mean for USDA marbling score was Select80. Marbling score distribution was Slightly Abundant or greater, 1.6%; Moderate, 2.3%; Modest, 4.9%; Small, 26.1%; Slight, 51.3%; and Traces or less, 13.9%. The mean USDA calculated YG was 2.0±0.6; frequencies for YG distributions were YG 1, 48.5%; YG 2, 43.1%; YG 3, 7.4%; and YG 4 or greater, 1%. Means for other traits were: fat thickness, 6.4±4.4 mm; ribeye area, 71.8±9.6 cm²; HCW, 297.9±44.6 kg; dressing percentage, 54.6±2.6%; dentition, 3.1±1.8 permanent teeth; hump height, 44.9±10.2 mm; and pH 5.57±0.17. The frequencies for pH were Normal (< 5.8), 94.4%; High (≥ 5.8%), 5.6%.

Conclusion: This was the first benchmark study measuring carcass characteristics, particularly those impacting carcass and eating quality. Information from this survey will establish a baseline for carcass traits and identify areas for improvement to help drive progress in the New Zealand beef industry. The results of this survey represent a benchmark, which could be used to evaluate the efficacy of livestock improvement programs in the future.

Keywords: Beef quality, Carcass, New Zealand
Meat and Poultry Quality and Composition - Measurement and Prediction

24- NATIONAL BEEF QUALITY AUDIT - 2016 : FREQUENCY DISTRIBUTIONS OF BEEF RIBEYES WITHIN USDA QUALITY GRADES


1Department of Animal Science, 2Animal Science, Texas A&M University, College Station, 3Department of Animal Sciences, Colorado State University, Fort Collins, 4Department of Animal Science, Oklahoma State University, Stillwater, 5Beef Carcass Research Center - Department of Agricultural Sciences, West Texas A&M University, Canyon, 6Department of Animal Science, University of Nebraska-Lincoln, Lincoln, 7Department of Animal Sciences, North Dakota State University, Fargo, 8Department of Animal Sciences, University of Florida, Gainesville, 9Department of Animal and Dairy Science, University of Georgia, Athens, 10Agricultural Marketing Service-USDA, Washington, DC, United States a.arnold@tamu.edu

Objectives: The National Beef Quality Audit (NBQA) – 2016 instrument-grading assessment evaluated beef carcass traits over the course of a year from selected beef processors. The objective of this study was to determine frequency distributions of ribeye areas within USDA quality grades.

Materials and Methods: There were 4,544,635 beef carcasses represented in the NBQA–2016 instrument-grading assessment. These data were collected from 18 federally-inspected processing facilities owned by 5 major beef processors over a 12-mo period (January 2016 through December 2016). Information was recorded during 1 wk of production each month at each facility. A variety of carcass trait information was collected at each facility including hot carcass weight, ribeye area, and marbling score, from which quality grades were determined. In an effort to create uniform ribeye area categories, ribeye area measurements were rounded down to a whole figure (i.e. 13.0 – 13.9 in² rounded down to 13.0 in²) and then were converted to metric units after data analysis.

Results: Analysis of the NBQA–2016 data revealed ribeye area frequency within USDA Prime, Choice, and Select quality grades reached its highest rate in the 83.9 cm² category, at 23.2%, 22.4%, and 20.1%, respectively. Of the 183,856 Prime carcasses evaluated, over two-thirds (67.7%) were recorded in the four smallest ribeye area categories, ranging from 64.5 cm² to 83.9 cm². For Select, 30.1% of the 960,157 carcasses possessed a ribeye area falling into one of the 4 largest categories between 96.8 cm² to 116.1 cm² compared to 24.1% Choice and 12.7% Prime. Additionally, evaluation of all 4,484,420 carcasses from NBQA–2016 found that the majority of each quality grade, 62.4% Prime, 60.4% Choice, and 55.2% Select, yielded a ribeye area between 77.4 cm² and 90.3 cm².

The mean ribeye area for all carcasses recorded was 88.9 cm², an increase in area from 88.45 cm² in the NBQA–2011. When considering USDA Certified Programs, ribeye area mean was within qualification parameters with 86.2% of carcasses evaluated meeting the ribeye area specification for Certified Angus Beef (not considering additional specification requirements). Notably for Prime, 92.5% of the carcasses met the ribeye area specifications for Certified Angus Beef. Moreover, the NBQA–2016 demonstrated an increase in hot carcass weight when compared to the previous study, at 393.6 kg and 371.28 kg, for NBQA–2016 and NBQA–2011, respectively. The correlation between ribeye area and hot carcass weight (r = 0.40) is indicative of a moderate, positive relationship, meaning a heavier carcass weight tends to result in a greater ribeye area.
Conclusion: These results show the relationship between ribeye area and USDA quality grade that can be considered in future industry specification and/or sorting programs.

Keywords: beef quality, instrument grading, quality grade, ribeye area
THE EFFECT OF POTASSIUM/SODIUM LACTATE (PL/SL), SODIUM ERYTHORBATE (NAE), AND SODIUM BICARBONATE (SB) ON QUALITY OF AEROBICALLY STORED BEEF TRIMMINGS

C. Wu 1, J. Valenta 1, E. Hamilton 1, K. Modrow 1, W. N. Osburn 1

1Animal Science, Texas A&M University, College Station, United States

kagamiwolf@gmail.com

Objectives: The objective of the study was to investigate various concentrations of solutions that can be applied to aerobically stored beef trimmings as a processing aid to prevent further deterioration of color, lipid, odor and/or microbial growth.

Materials and Methods: Beef trimmings (~15 kg) were fabricated from beef forequarters and aerobically stored (5°C) for 6 days in a plastic container covered with linear low-density polyethylene film (LLDPE; Oxygen Transmission Rate: 5000 cc/m²/24h at 25°C and 0% R.H.) to simulate the collection, storage, transportation and receipt of a combo of beef trimmings. A total of 12 treatments (4 solutions X 3 concentration levels) consisting of PL and SL at 0.1, 0.2 and 0.5 M; NaE at 1, 2 and 100 mM; and SB solutions at 0.1, 0.2 and 1.5 M; and a control (water). Concentrations of the solutions were based on previous research. After aerobic storage the beef trimmings (~20% fat) were coarse ground (12 mm) and 9 mL of each treatment and control solution was applied to ~454 g samples. The treated samples were reground (3 mm) placed into petri dishes and overwrapped with LLDPE film. The patties (2 per treatment/control (13) x 2 storage days; N=52 per replication) were stored under simulated retail conditions: 5°C under cool white fluorescent light (200-300 lux) and analyzed at 0 and 5 days of storage to assess the effectiveness of each treatment solution in preventing further quality deterioration. Objective color (L*, a*, b*; metmyoglobin concentration, MMB), 2-thiobarbituric acid (TBA) determinations, GC-MS identification of volatile compounds for off-odor assessment and aerobic plate counts (APC) were conducted. The results of two replications were analyzed using one-way ANOVA and Tukey HSD with a significance level of P<0.05.

Results: No differences were observed for treated and control patties for color, lipid oxidation or microbial analyses on storage day 0. Additionally, no differences were observed between treatments and the control for any volatile off odor compounds (ketones, aldehydes and acids) at 0 and 5 days of storage (P>0.05). Samples treated with varying concentration of PL did not significantly impact any quality factors evaluated (P>0.05). Analyses of SL, SB and NaE treated patties at 5 days of retail storage exhibited differences in color, lipid oxidation and microbial growth (P<0.05). Pattie samples treated with SB (1.5 M) exhibited the highest a* value (13.63) and lowest MMB content (33.92%) compared to other treatments (P<0.05). Samples treated with NaE (100 mM) had the lowest TBA value (0.79) compared to other treatments and control. Samples treated with SL (0.4 M) exhibited the lowest AM and AP counts (8.4 and 7.4 log10 CFU/g, respectively) compared to other treatments and control.

Conclusion: In conclusion, samples treated with the SB (1.5 M), NaE (100 mM), and SL (0.4 M), had the greatest effect on improving color stability, reducing lipid oxidation, and controlling microbial spoilage, respectively at 5 days of retail storage. Results of this study suggest that a solution could be developed as a processing aid using a combination of SB, NaE, and SL to prevent further deterioration of beef trimmings prior to use in the manufacturing of ground beef products.

Keywords: Beef trimmings, Color, Lipid oxidation, microbial spoilage
Objective: Dry-aging is a natural value-adding process, where primal/sub-primal cuts are stored without packaging materials in a controlled cooler for several weeks. While dry-aging is known for the development in palatability attributes (flavor in particular) of meat, compounds associated with dry-aged flavor have not been fully established. Given metabolomics is an emerging analytical technique that enables detection and measurement of small compounds, we hypothesized that chemical compounds associated with dry-aged flavor (or other palatability attributes) could be identified by using the metabolomics approach. Therefore, our objective in this study was to identify key metabolites associated with eating quality attributes of dry-aged beef via using metabolomics analysis.

Materials and Methods: Paired beef loins (M. longissimus lumborum) from 9 beef carcasses (Angus, Select Grade) were obtained at 7 d postmortem, cut into two sections and assigned to three different aging methods: conventional dry-aging (DA), vacuum packaged wet-aging (WA) and dry-aging in a high water permeable bag (DAW) for 28 d at 2°C as previously reported. After aging, multiple steaks from each section were collected for consumer panel sensory evaluation (n=120) and metabolomics analyses. The consumer panelists were asked to provide additional descriptive comments on eating quality attributes, which were quantified for further analysis. Selected samples (n=5) from each treatment were analyzed by UPLC-ESI-MS metabolomics. The relative abundance of metabolites was quantified and normalized for the statistical analyses. Data were analyzed by split-plot ANOVA using PROC MIXED from SAS and LS means were separated (P<0.05). Principal component analysis (PCA) was performed on the metabolites using R software.

Results: The metabolomics platform detected 1666 compounds, in which 125 metabolites were found to be significantly responsive to aging treatments (P<0.05). PCA analysis exhibited distinct clusters of metabolites between dry-aged and wet-aged treatments (PC1 55.1%). Higher abundance of compounds possibly related to flavor, such as thiamine thiazole, thymidine monophosphate and pyroglutamic acid were observed in DA and DAW compared to WA (P<0.05). Multiple glutamine containing dipeptides as well as adenosine monophosphate were also observed to be higher in DAW and DA compared to WA (P<0.05). Based on the consumer comment analysis, descriptive flavor attributes (e.g. beefy, smoky) were observed more frequently in DA samples compared to WA counterparts. The comment analysis also indicated that there was a higher preference toward DA over WA in most eating quality attributes, which were in agreement with our previous sensory results.

Conclusion: The results from the current study found that some flavor-related metabolites were liberated through dry-aging, which could be associated with dry-aged taste/flavor of beef loins. Descriptive comments from non-trained consumer panelists effectively provided descriptive attributes of dry-aged beef. Further research on identifying potential biomarkers for dry-aged flavor/taste by correlating those metabolites, other volatile chemical compound analysis, and sensory results is highly warranted.

Keywords: Beef loin, Dry aging, Metabolomics, sensory
27- PREDICTING PORK QUALITY MEASURES AT THE 10TH RIB USING MEASUREMENTS COLLECTED FROM VARIOUS LOCATIONS ON THE BONELESS LOIN

E. R. Moore 1,*, T. Krause 1, D. Pringle 1
1Department of Animal Science, University of Georgia, Athens, United States
erm56194@uga.edu

Objectives: Many U.S. pork export markets demand high quality pork with darker color and higher marbling content than domestic markets. Although, the U.S pork industry does not have a quality grade program through the USDA-Agricultural Marketing Service, application of voluntary quality grade standards may result in financial benefits to the pork industry as well as enhanced eating experiences for consumers. This study analyzed quality measurements collected at locations along the surfaces of boneless pork loins to determine the relationship between these measures and traditional pork quality measures collected at the 10th rib.

Materials and Methods: Market hogs (n=83) from two genetic lines and two sexes were slaughtered at 113.4, 136.1 and 158.8 kg endpoints. One genetic line was selected for increased lean yield, while the other was selected for meat quality attributes. Seven litters from each line with at least 6 pigs (3 barrows and 3 gilts) were used in the study. When the pigs reached their preassigned endpoint, they were transported to the University of Georgia Meat Science and Technology Center and slaughtered under federal inspection. Following a 24-hr chill period, carcasses were ribbed between the 10th and 11th ribs, bloomed for 20 min and the following pork quality attributes were measured on 10th rib surface: Hunter L*, a*, b* (D65); Minolta L*, a*, b* (D65); and NPPC color and marbling score. Carcasses were then fabricated and the boneless loin (IMPS# 413C, trimmed to 0.64 cm of fat) was weighed. The loin was allowed to bloom, ventral side up, for at least 20 min before collection of the previously listed loin quality attributes collected at the following 5 locations anterior to posterior: blade-end and sirloin-end (cross section), and at approximately the 7th/8th rib, 12th/13th rib, and 1st/2nd lumbar regions on the ventral surface of the loin.

Results: These locations were evaluated since they would allow assessment of quality attributes without devaluing the loin. Pearson correlations were calculated between 10th rib color and marbling scores and all other loin measures and Max R² regression was used to determine the best variables to predict 10th rib color and marbling scores (SAS Institute Inc.). Sirloin end marbling score had the strongest correlation with 10th rib marbling score (r=0.78; P<0.01), followed closely by the 7th/8th rib location on the ventral surface (r=0.77; P<0.01). Instrumental L* values were more highly correlated to 10th rib color than subjective color scores. For regression, subjective measures collected on the ventral surface of the loin were better predictors of 10th rib marbling score (R²=0.61) than 10th rib color score (R²=0.30), with marbling score and color score collected at the 7th/8th rib region being the most valuable predictor. Inclusion of all subjective measures slightly increased the prediction accuracy for 10th rib marbling score (R²=0.71) and 10th rib color score (R²=0.35). In contrast, instrumental measures were better predictors of 10th rib color (R²>0.41) than 10th rib marbling score (R²<0.29).

Conclusion: These results suggest that the U.S. pork industry could use measures on the intact loin to predict 10th rib color and marbling scores, providing the potential to sort loins into quality-based grades.

Keywords: marbling, Pork color, pork quality, quality grade
EFFECTS OF FEEDING PECANS ON CARCASS CHARACTERISTICS, COLOR, LIPID STABILITY, AND NUTRITIONAL VALUES OF LAMB

F. M. Giotto 1,*, E. L. A. Ribeiro 2, F. A. Grandis 2, F. Fernandes Junior 2, L. S. Leite 2, A. S. De Mello 1

1Department of Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, United States, 2Department of Animal Sciences, Londrina State University, Londrina, Brazil

Objectives: Utilization of byproducts is an efficient strategy to decrease costs of feeding. During processing, pecans that show defects are usually discarded, generating a byproduct with high levels of oleic acid (C18:1n9). In this study, we evaluated the effects of feeding pecan byproducts on growth performance, meat quality attributes, and fatty acid profile of lamb.

Materials and Methods: Forty-four Santa Ines lambs (24 ram lambs and 20 ewe lambs) with approximately 20.77 ± 1.60 kg of body weight were randomly assigned to 1 of 4 dietary treatments (n=11 per treatment). Diets were formulated with sorghum silage, broken rice, soybean meal, a commercial mineral mix, calcitic limestone, soybean oil, and four different levels of pecans: 0%, 3%, 6% and 9% (DM basis). All diets were isoenergetic. Lambs were fed for 52 days and after slaughtered, hot carcass weight was recorded, carcasses were chilled, and the M. longissimus dorsi et lumborum was excised from loins 24 h post mortem. Loin chops (2.5 cm) were cut and pH was assessed by using a Hanna® pH meter and objective color (L*, a*, b*) was recorded by using a CR-10 Konika Minolta® color reader after 30 minutes of blooming at room temperature. Samples were evaluated for proximate composition, fatty acids profile, cooking loss, Warner-Bratzler Shear Force (WBSF), and lipid oxidation. Data were analyzed as a completely randomized design using the GLIMMIX procedure of SAS, whereas dietary treatment and gender was considered main effects.

Results: Inclusion of pecans in lamb diets did not affect moisture, protein, pH, cooking loss, lipid oxidation, and WBSF. Rams yielded heavier carcasses (P<0.01), whereas fat % in the lean was significant higher in meat from ewes. An interaction between the two fixed effects was observed only for ash, whereas higher levels were detected in meat from rams fed control when compared to 9% pecan diets. Dietary treatments did not affect objective color parameters. However, meat from ewes were significant redder (a*) and yellower (b*) when compared to meat from rams. Greater levels of margaric (C17:1n7) and oleic (C18:1n9) acids were observed in the lean of ewes (P=0.03 and 0.01, respectively), whereas meat from rams had greater values of linoleic acid (C18:2n6) (P<0.01). Feeding 9% of pecans significantly increased deposition of Eicosapentaenoic acid (EPA, C20:5n3) when compared to 0% and 3% (0.15a, 0.08ab, 0.03b, and 0.01b for 9%, 6%, 0%, and 3%, respectively). Additionally, the inclusion of 6% of pecans in diets led to greater values of Docosahexaenoic acid (DHA, C22:6n3) when compared to lamb fed 0% and 3% diets (1.12a, 1.02ab, 0.68bc, and 0.60c for 6%, 9%, 0%, and 3%, respectively).

Conclusion: Inclusion of pecans in finishing diets did not affect performance and quality attributes of lamb. Corn has linoleic acid (C18:2n6) as the predominant fatty acid in the fat, whereas pecan has high levels of oleic acid (C18:1n9). In this study, feeding pecans positively affect nutritional value of lamb by increasing deposition of desirable fatty acids such as EPA and DHA, without compromising carcass weights, color, and lipid stability. Utilizing pecan byproducts as feeding source is a sustainable alternative for producers who may have access to this feedstuff.

Keywords: DHA, EPA, Fatty acids, Lamb, Pecan
THE EFFECTS OF ANTIBIOTIC ALTERNATIVES ON FEED EFFICIENCY, GROWTH PERFORMANCE, AND CARCASS TRAITS IN SWINE

H. N. Shoemaker 1,*, L. G. Garcia 1
1Animal Science, THE OHIO STATE UNIVERSITY, Columbus, United States
garcia.625@osu.edu

Objectives: U.S. swine producers have been challenged to find antibiotic alternatives to use in their swine heard. With feed expenses accounting for the majority of their costs, the lack of an antibiotic could lead to increased expenses. Scours is a common occurrence that will cause problems with not only the animals, but producers as well; therefore, the need to investigate alternative sources is a necessity. The objectives of this study were to: 1. Determine the effects of antibiotic alternatives (lysozyme and show feed additive) on feed efficiency in market swine and 2. Determine effects on carcass characteristics.

Materials and Methods: Thirty pigs (15 barrows/15 gilts) were assigned to one of three treatments (TRT). Treatments included: TRT C: control (commercial diet with no additives, n=10), TRT L: lysozyme alternative (commercial diet with lysozyme additive, n=10), TRT S: Ohio show feed alternative (commercial diet with show-feed additive, n=10). Animals used in the current study were approved by IACUC (2017A00000075). On a weekly basis, pig weights and feed consumption were recorded. Carcass characteristics were measured upon a 48 hr. chill where carcass traits (back fat, LEA, carcass weight, subjective and objective color scores, and marbling, firmness, and wetness scores) were recorded, at the 10th/11th rib interface (left side of carcasses).

Results: With little to no variation between treatments, results revealed no significant (P > 0.05) differences in feed efficiency or carcass characteristics. Treatments L and S revealed higher feed efficiency levels than control between d 42-77; however, by the end of the trial no differences (P > 0.05) were noted.

Conclusion: Overall, Trt S resulted in less mortalities when compared to other treatments. Additionally, TRT S was the most cost effective overall when viewed on an economic basis; which will be beneficial to the producer. However, with the combination of number of observations and the significant reduction in numbers due to a Scours outbreak (E. coli), authors recognize the need to repeat the study with an increase number of animals per treatment. On a side note, Trt L proved to not be suitable for E. coli.

Keywords: Lyzozyme; antibiotics; swine
Objectives: The objective of this study was to expand the availability of nutrient data for beef variety meat items and to provide relevant data to update the USDA Food Composition Database. Previous to this study, much of the nutritional information for these items was outdated, and was imputed, rather than true analytical data.

Materials and Methods: Beef heart, liver, kidney, tongue, honeycomb tripe, oxtail, and marrow bones were obtained from three different processing facilities (Texas, Nebraska, Kansas) in the United States. Rocky mountain oysters (beef testicles) and beef blood were obtained from separate, single facilities. Standardized dissection procedures were used to yield the following separable components: lean tissue, external fat, internal fat, and refuse. Each of the separable components from each sample, excluding refuse, were homogenized individually, immediately following dissection. Three composites of each item were created and were frozen (-80 °C) until further analysis. For items containing separable fat, all fat homogenates of the same item and fat type (internal or external fat) were combined to produce a single fat composite per item. Nutrient analysis occurred at USDA-ARS approved laboratories using validated methods and standards. Proximate analysis (protein, ash, moisture, fat), fatty acid profile, ICP minerals, cholesterol, vitamin A, vitamin E, vitamin D, 25-hydroxy vitamin D, and vitamin K analysis were performed for heart, liver, kidney, tongue tripe, oxtail, bone marrow, rocky mountain oysters, and blood. Additionally, B-vitamin content was analyzed for heart, liver, kidney, and tongue. Using R statistical software, mean and standard error of the mean of nutrient values were calculated from the three composites of each item.

Results: The protein content of the variety meat items ranged from 1.25 to 19.91g per 100g of separable lean. Fat content of bone marrow was 77.09g per 100g, while all other items contained between 1.15 and 11.20g fat per 100g separable lean. The fatty acid found to be most prevalent (as a percentage of total fatty acids in each sample) for both lean and fat tissue was oleic acid, a monounsaturated fatty acid. Vitamin B₁₂ was the most abundant B-vitamin in all samples analyzed, varying between 54.27 and 849.00µg/g of separable lean. Each of the items discussed in this study qualifies for at least one “Good Source” or “Excellent Source” labeling claim as regulated by the USDA based on the separable lean component. “Good source” indicates that a product contains 10-19% of the Daily Value (DV) or Recommended Daily Intake (RDI) per RACC (reference amount customarily consumed) for that nutrient, while “Excellent Source” designates that the food contains at least 20% of the DV or RDI per RACC for that nutrient. Vitamin K₂ has been studied recently in regard to beneficial effects on human health. Although there is not an established daily reference value for vitamin K₂, this nutrient was present in all samples analyzed and results are reported for 13 forms of vitamin K₂.

Conclusion: This study provides current, analytically derived nutrient information for U.S. beef variety meat items. Results reflect that these variety meat items could be beneficial in providing essential vitamins and minerals as a component of a healthy diet. This data will be valuable for use by the meat industry, those selling variety meats, researchers, dietetic professionals, and consumers.

Keywords: nutrients, nutrition, offal, variety meat
RELATIONSHIP BETWEEN DESCRIPTIVE FLAVOR AND TEXTURE ATTRIBUTES ON VOLATILES OF GROUND BEEF

H. Martinez 1,*, B. Beavers 1, H. Laird 1, R. Miller 1, C. Kerth 1, E. Chambers 2, K. Adhikari 3, S. Wang 3
1Texas A&M University, College Station, 2Kansas State University, Manhattan, 3University of Georgia, Griffin, United States
hend4790@tamu.edu

Objectives: The objective of this study was to better understand the impacts of various ground beef formulation methods on volatile aromatic compounds through GC/MS/Olfactory and trained descriptive sensory panel analysis.

Materials and Methods: Sixteen treatments including four meat sources (chuck, regular, sirloin, round), two fat percentages (10 and 20%), and two grind treatments (6.4 mm grind and bowl chopped) were formulated. Patties were formed with a patty maker using a 2.54 cm mold and cooked on a commercial flat top to an internal temperature of 70°C. Samples for GC analysis (n = 124) were placed in glass jars with a Teflon cover and allowed to thaw in a 70°C water bath. A SPME was inserted into each jar and the headspace was collected for two hours. The SPME was injected into a multi-dimensional GC/MS/Olfactory machine and aroma compounds were separated, identified, and smelled. A trained descriptive attribute panel evaluated 144 samples for beef flavor and texture attributes using the Beef Lexicon (Adhikari et al., 2011).

Results: Partial least squares regression biplot were developed to illustrate trained descriptive flavor panel and volatile aromatic compounds that contributed to flavor. A cluster of beef flavor identity, roasted, umami, refrigerator stale, and cooked milk flavor attributes, as well as 2-(hexyloxy)-ethanol, decanal, 2-heptanone, hexanoic acid, and 3-ethyl-2,5-dimethyl-pyrazine volatile compounds, and chuck bowl chopped 20% lipid and sirloin 6.4 mm 20% lipid ground beef treatments were identified as contributing positively to flavor and texture. A cluster of butanoic acid, trimethyl-pyrazine, 3-methyl-butanal, 2-propanone, 2-butane, 2-ethyl-6-methyl-pyrazine, acetic acid, methanethiol, octane, 2,5-dimethyl-pyrazine, and 2-ethyl-5-methyl-pyrazine, medicinal flavor, and round 6.4 mm 20% ground beef patties represents attributes that positively impacted flavor, but negatively impacted texture. A majority of the volatile compounds positively impacted perception of flavor. Volatile compounds were positively associated with texture. Bitter, liver-like, and sour descriptive attributes, as well as 2-nonenal clustered indicating both a negative impact for texture and flavor. A cluster surrounding particle size, springiness, petroleum like, burnt, and smoky charcoal flavor attributes, 2-methyl-butanal and 2-ethyl-3,5-dimethyl-pyrazine volatile compounds, and regular 6.4 mm 20% fat, chuck 6.4 mm 20% fat, regular bowl chopped 20% fat, round bowl chopped 20% fat, and sirloin bowl chopped 10% fat treatments, clustered indicating a negative impact on flavor but positive impact on texture.

Conclusion: This study confirmed that fat level contributes to flavor development but is one of the first to highlight the importance of ground beef texture to the eating experience. Differences in relationships among beef flavor attributes, texture attributes, and aromatic volatiles are present through the manipulation of meat source, fat percentage, and grind treatments.

Keywords: Ground beef, Partial least squares regression, sensory evaluation
32- CORRELATION COMPARISONS AMONG EARLY POSTMORTEM LOIN QUALITY AND AGED LOIN AND PORK CHOP QUALITY CHARACTERISTICS BETWEEN FINISHING PIGS FROM EITHER DUROC OR PIETRAIN ANCESTRY

J. Lowell 1,*, E. D. Schunke 1, B. N. Harsh 1, E. E. Bryan 1, C. A. Stahl 2, A. C. Dilger 1, D. D. Boler 1

1University of Illinois, Urbana, 2Choice Genetics USA, Des Moines, United States
lowell2@illinois.edu

Objectives: Due to economic value, pork quality traits are now integrated into breeding objectives. Early postmortem loin quality is correlated with aged loin quality. However, it is unclear if those correlations differ between pigs raised for lean growth and pigs raised for quality where compositional and fiber type differences likely exist. The objective was to compare correlations among early postmortem loin quality characteristics and aged loin and chop quality characteristics between pigs sired by boars of either Duroc (D, meat quality) or Pietrain (P, lean growth) ancestry.

Materials and Methods: Early and aged loin quality traits were measured on 80 barrows and 80 gilts, slaughtered over 4 days. Pigs were held in lairage for approximately 16 hours and immobilized using head-to-heart electrical stunning. Carcasses were chilled at 4°C for a minimum of 20 hours. Early (1 d postmortem) quality measures included ultimate pH, instrumental color (L*, a*, b*), and visual color, marbling, and subjective firmness on the ventral surface of boneless loins. Loins were vacuum-packaged and aged at 4°C for 14 d. Loins were removed from packaging, exposed to oxygen, and reevaluated on the ventral surface for the same loin quality traits (aged quality). Aged loins were sliced into 2.54 cm thick chops, and exposed to oxygen. Quality measurements were measured on the chop-face. Chops were cooked to an internal temperature of 63°C for Warner-Bratzler shear force (WBSF) and cook loss. Data were grouped into two data sets based on sire line. Pearson correlation coefficients were calculated and transformed using Fisher’s r to z transformation in the CORR procedure in SAS to compare correlations between sire lines. Correlations between traits were considered moderately correlated at |r| ≥ 0.36. Correlation comparisons between sire lines were considered different at P ≤ 0.05.

Results: Early ultimate pH was correlated with aged ventral L*, chop L*, and chop color (D, |r| ≥ 0.43; P, |r| ≥ 0.33). However, correlations did not differ (P ≥ 0.10) between the Duroc and Pietrain sired pigs. Early ventral L* was correlated with aged ventral pH, aged ventral L*, aged ventral color, and chop color (D, |r| ≥ 0.52; P, |r| ≥ 0.28), but not WBSF or cook loss (D, |r| ≤ 0.09; P, |r| ≤ 0.06). Early ventral a* was correlated with aged ventral a* and chop a* (D, |r| ≥ 0.33; P, |r| ≥ 0.44), but not with WBSF or cook loss (D, |r| ≤ 0.03; P, |r| ≤ 0.06). None of these correlation comparisons differed (P ≥ 0.06) between the Duroc and Pietrain sired pigs, with the exception of early ventral L*. Early ventral L* was strongly correlated with chop L* in Duroc pigs (|r| = 0.64), but was only weakly correlated in Pietrain pigs (|r| = 0.35, P = 0.02).

Conclusion: Early loin pH was correlated with color and water-holding capacity regardless of sire line. Early ventral color measurements were correlated with aged ventral and chop color measurements, but not with tenderness. Early ultimate pH, L*, and a* could be used as indicators of aged color. With the exception of early ventral L*, there were no differences in early and aged postmortem correlations between Duroc and Pietrain sired pigs, indicating that sire line does not need to be accounted for when using early quality traits to predict aged quality.

Keywords: correlation, genotype, loin quality, pork, sire line
DURATION OF EXPOSURE TO A HIGH-CONCENTRATE DIET PRIOR TO PASTURE-FINISHING AFFECTS FATTY ACID COMPOSITION AND VOLATILE COMPOUNDS OF BEEF STRIP LOIN STEAKS

J. T. Milopoulos 1*, B. M. Koch 2, M. F. Miller Jr. 2, J. F. Legako 1, S. K. Duckett 2, M. F. Miller 1

1Animal and Food Science, Texas Tech University, Lubbock, 2Animal and Veterinary Sciences, Clemson University, Clemson, United States
jillian.milopoulos@ttu.edu

Objectives: The objective of the present study was to determine the effects of exposure to a high-concentrate diet prior to pasture-finishing on fatty acid composition and volatile flavor compounds produced during cooking of beef strip loin steaks.

Materials and Methods: Angus-cross steers (n = 48 [12 head / treatment]) were provided a high-concentrate cracked corn-based diet for 0 d (0D), 40 d (40D), 80 d (80D), or 120 d (120D) prior to pasture-finishing on high-quality forages (non-toxic tall fescue, rye/ryegrass, oats, alfalfa) to a target final BW (487 kg). Carcass data were recorded and strip loins removed 24 h postmortem. Eight strip loins (USDA Select) were selected per treatment for further analyses; 8 additional process-verified grass-fed strip loins were selected from a commercial processing facility in New Zealand (NZ) by trained personnel targeting USDA Select quality grade to be used as a baseline comparison. All subprimals were aged under vacuum for 21 d postmortem at 4°C then frozen (-20°C). Strip loins were fabricated frozen into 2.54 cm steaks, and a single steak from each strip loin was used for fatty acid analysis and volatile compound analysis. Fatty acids were quantified from fatty acid methyl esters and volatile flavor compounds were evaluated on cooked samples using gas chromatography. Data were analyzed using a one-way ANOVA with animal serving as the experimental unit.

Results: Total fatty acids (g/100g) were greatest in NZ (3.23 g/100 g; P < 0.05) and least in 0D (1.53 g/100 g; P < 0.05). Concentration of saturated fatty acids was decreased (P < 0.05) and concentration of monounsaturated fatty acids was increased (P < 0.05) in NZ compared to all other treatments. Odd-chain fatty acids were greater in 40D, 80D, and 120D than NZ and 0D (P < 0.05). Trans-vaccenic acid and conjugated linoleic acid concentrations were greater in 40D, 80D, and 120D than NZ (P < 0.05), with 0D intermediate (P > 0.05) for trans-vaccenic acid. Concentration of n-6 polyunsaturated fatty acids was greater in 80D and 120D than all other treatments (P < 0.05), and concentration of n-3 polyunsaturated fatty acids was greater in 0D than all other treatments (P < 0.05). Consequently, the ratio of n-6:n-3 polyunsaturated fatty acids was greater in 80D and 120D than all other treatments (P < 0.05). Non-enzymatic browning-derived ketones (2,3-butanedione and 3-hydroxy-2-butanoic) were increased in NZ compared to all other treatments (P < 0.05). Differences among treatments in lipid-derived volatile compounds were primarily of alcohols and aldehydes. In particular, 1-penten-3-ol was greater in NZ than all other treatments (P > 0.05), and 1-octanol was greater in NZ than all treatments (P < 0.05) except 120D. 1-Pentylfuran was greater in NZ than all other treatments (P < 0.05), and 1-octylfuran was greater in NZ than all other treatments (P < 0.05) except 40D.

Conclusion: Concentrations of fatty acids and quantity of volatile compounds produced during cooking are affected by exposure to grain prior to pasture-finishing. Additionally, beef produced in NZ chemically differs from that produced through pasture-finishing systems in the United States. Changes in fatty acid composition affect lipid oxidation products in cooked beef.

Keywords: Beef, Fatty Acids, Flavor, Volatiles
USE OF IMAGE ANALYSIS TO IDENTIFY WOODY BREAST CHARACTERISTICS IN 8 WEEK OLD COMMERCIAL BROILER CARCASSES

J. P. Caldas-Cueva 1, A. Mauromoustakos 2, C. M. Owens 1
1Department of Poultry Science, 2Agricultural Statistics Laboratory, University of Arkansas, Fayetteville, United States
jpcaldas@uark.edu

Objectives: Woody breast (WB) myopathy causes a significant economic loss to poultry industry and the lack of an objective, reliable and rapid tool to identify this abnormal condition is a contributing factor. The aim of this study was to determine if there are conformation changes that can be used to identify broiler carcasses exhibiting WB characteristics using image analysis.

Materials and Methods: Images of 8-wk male broiler carcasses (n = 297) of high breast yielding commercial strain were captured prior to evisceration. Whole breast fillets were scored at 3 h postmortem for WB severity based on tactile assessment [0 or 0.5 as normal (n1 = 93); 1 or 1.5 as mild (n2 = 96) and 2, 2.5 or 3 as severe (n3 = 108)] and the instrumental texture of these samples were measured using the compression analysis. Broiler carcass images were processed and analyzed using ImageJ software. Parameters for carcass conformation were M1: breast width in the cranial region; M2: a vertical line from the tip of keel to 1/5th of breast length; M3: breast width at the end of M2; M4: angle formed at the tip of keel and extending to outer points of M3; M5: area of the triangle formed by M3 and lines generated by M4; M6: area of the breast above M3; M7: M6 minus M5. In addition, three ratios [M8 (M3/M1), M9 (M3/M2), and M10 (M7/M5)] were considered. Spearman correlation coefficients were estimated for WB severity scores, compression force and image measurements. A stratified random split was used to divide the data into two sets of 70% and 30% for training and validation, respectively. Generalized Regression platform (JMP Pro ver. 14.0, 2018) was carried out to evaluate and select suitable prediction models with a binomial distribution for WB occurrence (WB score > 1.0) and lognormal distribution for compression force. Elastic Net was selected as the variable selection method with the validation column for authentication process.

Results: Spearman correlation between WB severity scores and compression force was highly significant (r = 0.86, P < 0.01). M4 (angle at keel), M9 (M3/M2) and M3 (caudal width) had the highest correlation to WB score (r = 0.81, 0.80 and 0.78, respectively; P < 0.01) and compression force (r = 0.76, 0.75 and 0.75, respectively; P < 0.01) followed by measurements M6, M5, M8, M7, M1 and M10, respectively (r = 0.42 to 0.72, P < 0.01), whereas M2, showing the lowest coefficient, was inversely correlated with WB score (r = -0.18, P < 0.01). The simplest and most adequate validated prediction models included M1, M2, and M3 (P < 0.05) measurements for WB occurrence [Gen. R² of 0.70 and 0.77, misclassification rates of 13% and 8%, and AUC of 0.94 and 0.96 for training and validation sets respectively]. The same three predictors were similarly highly significant and selected as the best subset for predicting compression force [Gen. R² = 0.59 (training) and 0.61 (validation)].

Conclusion: These data support the possibility of the use of image analysis to predict WB condition in broiler carcasses. The potential integration of these image measurements into commercial in-line vision grading systems would allow processors to identify and sort broiler carcasses by WB category. However, additional research is required to validate relationships when broilers from other ages, strains and gender are included.

Keywords: image analysis, in-line carcass sorting, meat quality, processing, wooden breast
Objectives: When determining instrumental color, even when researchers use standardized equipment and the same device with the same operational settings, differences may still persist. It is also not known if the loin, machine, or replication is the greatest contributor to variability in instrumental pork. The objectives were to 1) evaluate the effects of machine, anatomical location and measurement replication on instrumental color and 2) characterize the variation to color contributed by each of these factors.

Materials and Methods: Boneless loins were collected from 2 groups of pigs (250 total) that were slaughtered 14 days apart. The first set contained 100 loins and the second set had 150 loins. Loins were aged until 14 d postmortem in the dark at 4°C. After aging, loins were removed from packaging and positioned on tables so that the ventral side was exposed to oxygen, then allowed to oxygenate for at least 20 min. Instrumental color was measured 3 times on the anterior end and 3 times on the posterior end of the loins with two different Minolta CR-400 Chroma meter devices. Each Minolta was programmed to use a D65 illuminant, 0° observer with an 8 mm aperture, and calibrated with white tiles specific to the machine. A total of 12 instrumental color measurements were collected on each loin. Color data were analyzed with the MIXED procedure of SAS as a split-split plot design where loin served as the experimental unit. The whole plot was machine, the split plot was location, and the split-split plot was replication. The VARCOMP procedure in SAS was used to estimate the proportion of variation contributed by each factor to CIE L*, a*, b*, chroma and hue.

Results: Loins evaluated with machine 1 were instrumentally 0.71 L* units darker (P < 0.01), 1.09 b* units more yellow (P < 0.01), 0.47 chroma units more saturated (P < 0.01), and had a hue angle 5.12 units greater (P < 0.01) than when evaluated with machine 2 but were not different (P = 0.24) in terms of redness. The anterior portion of the loin was lighter, less red, more yellow, more saturated and had a greater hue angle than the posterior end (P < 0.01). All color traits increased (P < 0.01) as replication number increased. Inherent color differences in the loin contributed the greatest proportion of variability for lightness (58%), redness (57%), yellowness (70%), saturation (70%) and hue angle (49%). Machine contributed a small amount of variation to lightness (1%) and saturation (3%), a greater amount to yellowness (23%) and hue angle (31%) but did not contribute to variability for redness. Anatomical location contributed 41% to lightness, 43% to redness, 7% to yellowness, 27% to saturation and 31% to hue angle. Replication did not contribute to total variation for any color traits.

Conclusion: Overall, there were differences in instrumental color values between the 2 machines tested but those differences were likely less than the threshold for detectability by a consumer. Even so, inherent differences in the loin was a greater contributor to total variability than the differences between the 2 machines.

Keywords: color, instrumental color, Minolta, pork, variation
EVALUATION OF THE INSURANCE THEORY USING OBJECTIVE MEASUREMENTS OF TENDERNESS, JUICINESS, AND PROXIMATE COMPOSITION OF BEEF STRIP STEAKS

L. N. Drey 1,*, L. L. Prill 1, B. A. Olson 1, E. A. Rice 1, J. M. Gonzalez 1, J. L. Vipham 1, T. A. Houser 1, E. A. Boyle 1, T. G. O’Quinn 1
1Animal Sciences and Industry, Kansas State University, Manhattan, United States
Indrey@ksu.edu

Objectives: The objective of this study was to evaluate the insurance theory with objective measurements of tenderness, juiciness, and raw and cooked proximate analysis, and to determine their relationship with sensory scores.

Materials and Methods: Paired strip loins (IMPS # 180) were collected to equally represent 5 quality treatments [Prime, Top Choice (Modest and Moderate marbling), Low Choice, Select, and Select Enhanced (110% of initial raw weight); n=12 pairs/quality treatment]. Following a 21d aging period, strip loins were fabricated into 2.5cm steaks with the face steak designated for raw proximate analysis. Steaks were grouped into sets of three consecutive steaks. Each set within a strip loin pair were randomly assigned a degree of doneness (DOD): very-rare (VR; 55°C), rare (RA; 60°C), medium-rare (MR; 63°C), medium (ME; 71°C), well-done (WD; 77°C), or very well-done (VWD; 82°C), so that each carcass had representation for each DOD. Steaks were cooked to their designated DOD on a clamshell grill (Cuisinart Griddler Deluxe, Model GR-150, Stamford, CT) with temperatures monitored using a probe thermometer (Super-Fast Thermopen, ThermoWorks, American Fork, UT). From each DOD group, one steak was used for Slice Shear force (SSF), Warner Braztler shear force (WBSF), pressed juice percentage (PJP), and cooked proximate analysis. The other two steaks were assigned to consumer or trained sensory testing. Data were analyzed as a split-plot with the whole plot factor of quality treatment and sub-plot factor of degree of doneness.

Results: There was an interaction (P<0.05) between DOD and quality treatment for cooked moisture (CM), cooked fat (CF), and cooked moisture + fat (CMF). Select Enhanced contained the greatest (P<0.05) CM content, and Prime the least (P<0.05) across all DOD. Select had similar (P>0.05) CM to Low Choice at R, M, and VWD. At VR, R, and MR, Prime contained the greatest (P<0.05) CF content, followed by Top Choice and Low Choice, with Select having similar (P>0.05) CF content to Select Enhanced. However, when cooked to M and higher, Low Choice, Select and Select Enhanced had similar (P>0.05) CF. Prime was similar (P>0.05) to Select Enhanced for CMF when cooked to R and MR, and similar (P>0.05) to Top Choice at VR, MR, and M. Top Choice, Low Choice and Select samples had similar (P>0.05) CMF when cooked to VR, R, and VWD. When evaluating the correlation coefficients, CM was associated (P<0.01) with consumer juiciness (r=0.27), tenderness (r=0.17), flavor liking (r=0.23), and overall liking (r=0.19), while CF was associated (P<0.05) with consumer juiciness (r=0.12) and tenderness (r=0.15). The strongest (P<0.01) correlations for consumer juiciness, tenderness, flavor liking, and overall liking occurred with CMF (r=0.69, r=0.56, r=0.45, and r=0.49, respectively). A logistic regression was performed to predict the probability of a sample being rated juicy by consumers using CMF, and had an adjusted $R^2$ value of 0.47. The model identified CMF percentages of 68.25, 69.85, and 71.20% for a probability of 50, 75, and 90% for a consumer rating a steak juicy.

Conclusion: Combined, cooked moisture and fats showed the strongest association with consumer sensory scores and could be used to predict whether a strip steak would be rated juicy by a consumer.

Keywords: Beef, cooked proximates, degree of doneness, juiciness, marbling
**Objectives:** Grass-fed beef imported from New Zealand has been known to be lower in fat content and undergo a longer wet-aging period during transport compared to domestically produced beef. The effects of wet-aging time on oxidative metrics in highly marbled grass-fed beef are not fully known at this time. Therefore, the objective of this research was to assess the lipid stability of grass-fed strip loin steaks in comparison to grain-fed strip loin steaks from five different United States Department of Agriculture (USDA) quality grades, wet-aged for 7, 21 and 42 days.

**Materials and Methods:** Beef strip loins (n = 200) representing two fed cattle types (n = 100/finishing type: grass-finished and grain-finished) and five different USDA quality grades (n = 20 per quality grade: USDA Standard, Select, Low Choice, “Top” Choice: High and Average Choice, and Prime) were acquired from beef processing facilities in New Zealand (grass-fed) and Nebraska (grain-fed). Each strip loin was equally portioned into thirds, vacuum packaged, and assigned to one of three wet aging periods (7 d, 21 d or 42 d). After the appropriate aging period, portions (n = 600) were frozen and stored at the Gordon W. Davis Meat Science Laboratory until further fabrication. Frozen strip loin portions were cut into 2.54 cm steaks using a band saw. Prior to cutting portions into steaks, steak samples for thiobarbituric acid-reactive substances (TBARS) were taken from the anterior and posterior face steaks of each strip loin portion. The steak pieces for TBARS analysis were vacuum packaged and frozen until homogenization. Samples were thawed for 12 to 24 hours, trimmed of subcutaneous fat and connective tissue, frozen in liquid nitrogen and homogenized for TBARS analysis. The amount of TBARS was determined to estimate lipid oxidation, and results were reported in mg malondialdehyde/kg sample. Statistical analyses were conducted using the procedures of SAS (Version 9.3; SAS Inst. Inc., Cary, NC). Treatment comparisons were tested for significance using PROC GLIMMIX with $\alpha = 0.05$.

**Results:** A diet by age time interaction was found for TBARS values ($P < 0.05$). No difference was found between grass-fed 7, 21 or 42 d treatments for TBARS ($P > 0.05$), indicating prolonged aging periods had no detrimental effect on grass-fed strip loins. Whereas, grain-finished strip loins aged 42 d had greater TBARS values than shorter aged product ($P < 0.05$). All grain-finished strip loins, regardless of age, had higher TBARS values than all grass-finished strip loins ($P < 0.05$). Finally, no difference was found between quality grades for TBARS ($P > 0.05$). The TBARS values for all samples were low, ranging from USDA Standard at 0.098 mg/kg to USDA Low Choice at 0.111 mg/kg.

**Conclusion:** In conclusion, all steaks had very low levels of lipid oxidation, due to aging in a vacuum package. Although lipid oxidation tended to increase with longer periods of wet-aging time, steaks from grass-fed cattle were less susceptible to lipid oxidation than grain-fed cattle.

**Keywords:** aging, grain, grass, marbling, oxidation
Correlation of Beef Longissimus Thoracis Quality and Composition with Semimembranosus Quality and Composition

L. M. Wang 1,*, S. Huang 1, S. Chalupa-Krebsdak 1, S. M. Vasquez Mejia 1, B. M. Bohrer 1
1Food Science, University of Guelph, Guelph, Ontario, Canada
bbohrer@uoguelph.ca

Objectives: Previous research has investigated the quality of individual muscles and separate cuts within a beef carcass. However, few studies have examined the relationship between the quality of different beef muscles. Understanding this relationship could determine the necessity of certain meat quality analyses to assess the value of beef carcasses. Thus, the objective of this study was to examine the correlation between the quality and composition of beef semimembranosus (SM) and longissimus thoracis (LT) muscles.

Materials and Methods: At 4 d post-mortem, beef inside round (IMPS #168) and rib (IMPS#107) cuts from the right side of steer carcasses (n=63) were collected from a commercial processing facility and delivered to the University of Guelph Meat Science Laboratory. At 5 d post-mortem, pH and objective color (L*, a*, b*, chroma, hue; measured with a Minolta CR-400) were collected for the SM muscle within the round section. At 6 d post-mortem, pH and objective color were collected for the LT muscle. Duplicate 5 to 6 g homogeneous samples from each the SM and LT samples were analyzed for moisture content by forced-air convection oven drying at 100˚C for at least 24 hours (Method 950.46, AOAC, 2000). Lipid content of the dried duplicate samples were determined by soxhlet extraction with petroleum ether, followed by at least 24 hours of oven drying at 100˚C. PROC CORR of SAS 9.4 was used to calculate the Pearson correlation coefficients for all parameters. Correlation coefficients were regarded as weak at r < |0.35|, moderate at |0.36| ≤ r ≤ |0.67|, and strong at r ≥ |0.68|. PROC REG of SAS was used to create linear regression models between parameters that had meaningful relationships. PROC GPLOT of SAS was used to create scatter plots to allow better visualization of the correlations between meaningful parameters.

Results: There was a weak and statistically insignificant correlation between LT and SM pH values (r = 0.20, P = 0.11); as well as, a weak correlation between LT and SM hue (r = 0.24, P = 0.06). There was a slightly stronger, positive linear correlation between LT and SM L* (lightness) values (r = 0.34, P = 0.01). Moisture content of LT and SM had a significant, moderately correlated linear relationship (r = 0.66, P < 0.0001). Similar to moisture, the correlation between LT and SM lipid content was moderately correlated (r = 0.67, P < 0.0001). All other LT and SM quality parameters were very weakly correlated (r = -0.06 to 0.01), thus no further statistical analyses were performed.

Conclusion: Results from this study showed that in general meat quality attributes from beef longissimus thoracis and semimembranosus muscles were weakly correlated with one another, and composition was only moderately correlated. Thus, analyses measuring individual beef muscle quality are required to achieve more accurate results and more meaningful assumptions of eating experience. Future studies could examine the relationship of the remaining beef primal cuts.

Keywords: Beef, beef rib, beef round, correlation, Meat quality
Using Blunted Versions of the Meullenet-Owens Razor Shear Method for Assessing Poultry Meat Texture

L. D. Combs¹,*, C. M. Owens ¹
¹Poultry Science, University of Arkansas, Fayetteville, United States
luc007@uark.edu

Objectives: The objective of this study was to evaluate the use of blunt versions of MORS to instrumentally assess meat texture. Consumer perception of texture is a recent concern within the poultry industry due to multiple factors including common shortened aging periods and breast myopathies. Woody breast (WB) is a myopathy characterized by a distinct hardness of the raw fillet and is associated with increased collagen due to infiltration after muscle fiber degeneration. The Meullenet-Owens Razor Shear (MORS) method is a common method for indirectly assessing poultry meat tenderness. It has similar ability to predict meat tenderness as Allo-Kramer and Warner-Bratzler methods, but it requires less sample preparation as an intact fillet can be sheared. Because WB texture is complex, MORS has not always been associated with those texture changes. A blunt version of the MORS (BMORS) has been shown to be a more sensitive method at higher degrees of toughness. Both the MORS and BMORS use a disposable blade. A slightly larger stainless steel incisor blunt blade may offer probe longevity and may be useful in assessing tough meat with or without WB characteristics.

Materials and Methods: Breast fillets were deboned from broiler carcasses at 0.5 h postmortem (PM) and aged on ice in a 4°C cooler overnight. Fillets were scored for severity of WB and were placed into 2 categories, normal (NORM) and mild woody breast (WB) in two replications. Breast fillets (n = 48; 24 per category) were cooked to 76°C, cooled to 4°C, and sheared using MORS (8.9 mm wide, steel razor straight edge; TA-45), BMORS (8.9 mm wide, 0.5 mm thick steel blunt edge), and an incisor blade (IMORS; 11 mm wide, 1.5 mm thick stainless steel blunt edge; TA-46) on the TA.XT Plus Texture Analyzer (Texture Technologies, Corp.). Total energy and force were measured and data was subjected to ANOVA. The main effects were method type and WB category.

Results: There was a method by WB category interaction (P<0.05). For NORM and WB fillets, the IMORS was significantly higher (P<0.05) than the BMORS which was significantly higher (P<0.05) than MORS for total energy and force. However, the differences due to method were greater in the WB fillets; the total energy and force for IMORS and BMORS were higher (P<0.05) in WB than in NORM, but there was no difference (P>0.05) due to WB category for the MORS energy and force. The higher energy and force values in the IMORS and BMORS are likely related to the mechanisms related to increased hardness of the fillets and the use of compression in the blunted versions of shearing which is essentially absent in the MORS method due to the razor edge. This suggests that the blunted versions of MORS are better at distinguishing differences in texture due to WB. MORS was highly correlated to BMORS (r=0.7) while only moderately correlated to IMORS (r=0.5) for either energy or force. The difference in correlation was likely due to the thickness of the blades used. BMORS and IMORS were highly correlated (r=0.8) to each other likely due to the blunted aspect of the method.

Conclusion: In conclusion, the results of this study suggest that the blunted versions of MORS may be useful in assessing meat tenderness and distinguishing differences due to WB. However, future research is needed to assess these methods over a wider range of data including traditionally tough and tender meat along with varying degrees of woody breast.

Keywords: Instrumental Assessment, Meat Tenderness, Poultry, Shear, Woody Breast
40- CHARACTERISTICS OF BEEF CARCASSES DERIVED FROM COSTA RICAN CATTLE AS AFFECTED BY GENDER AND DENTITION AGE

J. Rodriguez 1, N. Huerta-Leidenz 2*, O. Murillo 1, M. O’Connor 3, A. R. Rodas-Gonzalez 4
1Tecnologico de Costa Rica, San Carlos, Costa Rica, 2Animal Science, Texas Tech University, Lubbock, 3O’Connor Consulting and Management, Inc, Washington D.C., United States, 4Animal Science, University of Manitoba, Winnipeg, Canada
ARGENIS.RODASGONZALEZ@UMANITOBA.CA

Objectives: To evaluate variation of carcass traits and cutability by gender and dentition age of cattle harvested in Costa Rica.

Materials and Methods: Cattle produced in Costa Rica were harvested in one of the three main federally-inspected plants of the country. The Bos indicus-influenced animals were selected randomly and sex class was recorded (CLASS; 193 intact males [bulls], 123 castrates [steers] and 61 cull females predominantly cows). Liveweight (LIVEW) was taken immediately before harvesting, and the hot carcass weight (HCW) was recorded after processing to calculate the dressing percentage (DRESS%). Dentition age (AGE) was estimated postmortem to segregate the animals in 12 mo (12MOA), 24 mo (24MOA) and 36 mo (36MOA). Scores for carcass finish (FINISH) and muscling (MUSCLING), and other carcass linear measurements (carcass length = CLENGTH; round circumference = ROUND; and Achilles tendon length = TENDONL) were taken before chilling. After 24 h postmortem, chilled carcasses were evaluated for determining ribeye area (REA), backfat thickness (BACKFAT), and fat color (FATCOL) scores. Chilled carcasses were weighed and fabricated following precise instructions on style and maximum fat cover, removing subcutaneous fat in excess to 2 mm. The weight of boneless, closely trimmed, total saleable cuts (TSP), clean bone (BONE%) and trim fat (FAT%) from the whole carcass were computed as a percentage of the chilled carcass weight (CCW). Descriptive and variance analyses were performed to determine the variation associated with gender, dentition age and their interaction.

Results: The LIVEW, HCW and CCW had a moderate variation (CV 15 to 18%) which corresponded well with the moderate variation observed in ROUND, REA, and BONE% (CV 13 to 15%). However, with this HCW range, FINISH and BACKFAT had a high variation (CV > 30%), as well as MUSCLING and FATC. In contrast, a low variation was detected (CV < 10%) for DRESS%, CLENGTH, TENDONL, and TSP%. As expected, mean values of traits related to carcass meat yields were in favor of the bull and steer carcasses, which dressed the heaviest carcasses, with the most convex profile (MUSCLING) and bulging leg muscle (ROUND), the longest carcasses, the largest ribeye area and higher yields of TSP as compared to female carcasses (P < 0.05). In contrast, carcasses from females exhibited more abundant/uniform distribution FINISH, thicker BACKFAT, yellowish FATC, and higher BONE% (P < 0.05) than those from steers or bulls. As AGE advanced, carcasses were heavier, had longer TENDONL and CLENGTH, exhibited more abundant fat cover, and yielded more BONE% and TSP%. Analysis of variance detected a significant effect of the CLASS x AGE interaction on LIVEW, HCW, CCW, ROUND, FINISH, BONE%, TSP (P < 0.05). Both bulls and steers at 36MOA showed a noticeable heavier body and carcasses with higher TSP yields with respect to the female carcasses; however, steer carcasses at 36MO presented most bulging round, more abundant/uniform FINISH and lower BONE% with respect to bull and female carcasses at the same AGE (P < 0.05).

Conclusion: These findings support the long-standing preference for raising and fattening bulls in Costa Rica. However, the castration did not affect the carcass yield or cutability, and instead, the steers outperformed the bulls in carcass quality attributes such as FINISH and ROUND, which opens a marketing opportunity for castrates.

Keywords: beef, Bos indicus influence, carcass cutability, carcass traits, saleable beef cuts
Objectives: The objective of this study was to evaluate the effects of finishing diet and enhancement on the composition and objective tenderness of Honduran beef.

Materials and Methods: Bos indicus cross bred bulls (n = 105) were fed experimental finishing diets in Honduras, consisting of either a traditional grass-finished control (CON; n = 15) or a diet with the inclusion of distiller’s dry grain (DDG; n = 15), palm kernel meal (PKM; n=15), a PKM replication (PKMR; n = 15), sorghum (SORG; n = 15), soybean meal and corn (SBMC; n = 15), or sugar cane (SC; n = 15). After finishing, cattle were harvested at a commercial beef abattoir in Honduras and chilled for 18 hr at 0 to 4 °C. Paired strip loins were collected from each carcass. One loin was enhanced (ENH) to 112.5% of green weight with water, 0.5% NaCl, 0.25% sodium tripolyphosphate, and 0.02% maltodextrin, and the other remained untreated and was designated as non-enhanced (NE). Both loins were fabricated into steaks, aged for 21 d, and the second most anterior steak was transported frozen to the Texas Tech University Gordon W. Davis meat science laboratory for slice shear force (SSF), raw ultimate pH, cooked proximate, and cooked sarcomere length analyses. Data were analyzed using PROC GLIMMIX in SAS (version 9.4, SAS Inst. Inc., Cary, NC) with fixed effects of diet, enhancement, and their interaction at a significance level of \( \alpha = 0.05 \). Cooking loss was included as a covariate for SSF (\( P<0.05 \)).

Results: Diet and enhancement interacted (\( P<0.01 \)) to influence SSF values. Enhancement reduced (\( P<0.05 \)) the SSF values of beef from the animals finished on PKM, PKMR, SC and SORG compared to their NE counterparts, but enhancement had no effect (\( P>0.05 \)) on SSF values of steaks from the remaining diets. No interaction was observed (\( P>0.05 \)) for raw ultimate pH, cooked sarcomere length, or cooked proximate components. However, pH was influenced (\( P<0.01 \)) by both diet and enhancement. Enhanced loins possessed a greater (\( P<0.01 \)) pH compared to their NE counterparts. Moreover, diet also influenced (\( P<0.01 \)) the ultimate pH of samples, regardless of enhancement, as CON had a greater (\( P<0.05 \)) ultimate pH than all other treatments. Diet influenced (\( P=0.02 \)) sarcomere length, while no difference was observed between ENH and NE samples (\( P>0.05 \)). Sorghum and SC had shorter sarcomeres than SBMC (\( P<0.05 \)); however, SBMC sarcomere length was similar (\( P>0.05 \)) to all other diets. Enhancement had no effect (\( P>0.07 \)) on proximate composition; however, fat, protein, moisture, and ash were each impacted by finishing diet (\( P<0.05 \)).

Conclusion: Results from this study indicated that the dietary inputs fed to cattle influence the physiochemical composition of beef. Although enhancement of beef has the potential to reduce slice shear force values and increase ultimate pH, it had no impact on cooked composition of beef.

Keywords: Beef, Composition, Enhancement, Finishing Diet, Tenderness
Objectives: The objectives of this study were to investigate the equivalency of two different cooked steak sampling methods as well as the number of samples per steak, and different muscles on Warner-Bratzler shear force values. In addition, the effect of end-point temperature was evaluated.

Materials and Methods: Muscles used to evaluate two steak sampling methods included the longissimus dorsi (LD), semimembranosus (SM), and semitendinosus (ST). Steak sampling was performed with both a strip and coring method in which 6 and 9 samples per steak were sheared. Two scalpels were mounted parallel to one another so that when used to excise a sample strip the sample shear area was equivalent to the core (12.7 mm diameter). The distance between the scalpel blades was 11.3 mm. A variety of steaks (postmortem age, quality) were collected to ensure there was a wide range in inherent tenderness. Steaks collected were stored frozen (-20°C). The steaks were cooked on George Foreman grills (325°F). Steaks were flipped once at 115°F and were removed from the grill at 160°F or 170°F. Cooking loss percentage was determined approximately 15 minutes after the steaks were removed from the grill. Strip and core sections were removed parallel to the muscle fibers on the same day the steaks were cooked for shear force determination. Samples were sheared perpendicular to the muscle fibers. Data were analyzed as a 3 x 2 x 2 factorial (muscle, shear method, number of cores) for steaks cooked to 160°F. For the SM steaks cooked to two different temperatures (160°F, 170°F) the data were analyzed as a 2 x 2 x 2 factorial (temperature, shear method, number of cores). Statistical analysis was determined using PROC MIXED with muscle representing the experimental unit (LD, n=14; SM, n=27; ST, n=4).

Results: There were no differences (P > 0.05) in cooking loss between the shear methods. In addition there were no differences (P > 0.05) in the mean, standard deviation, and coefficient of variation as affected by sampling method and number of samples sheared from the LD or ST. However, the SM strips resulted in a greater (5.70 kgf, P < 0.05) Warner-Bratzler shear force mean than core samples (4.95 kgf) when cooked to 160°F. No differences (P>0.05) were found between the strip and core method when the SM steaks were cooked to 170°F. This result may be related to the cooked meat being less firm at the lower cooking temperature and with the coring method, it tends to deform the steak during coring which may reduce the actual diameter. There were no differences (P >0.05) in the standard deviation and coefficient of variation in the SM as affected by method, number of samples and cooking temperature.

Conclusion: The results from this research suggest that using the paired-scalpel method achieves similar shear force values as the core method. However, steaks cooked to lower endpoint temperature may create differences between these methods. A minimum of 6 samples appears to be sufficient for shear force determination.

Keywords: Beef, Method, Muscles, Temperature, Warner-Bratzler shear
43- THE EFFECTS OF BELLY WEIGHT AND LOCATION WITHIN THE BELLY ON BACON QUALITY CHARACTERISTICS, PROXIMATE COMPOSITION, AND FATTY ACID PROFILE

T. Krause 1, E. Moore 1, D. Pringle 1, M. Azain 1, R. Detweiler 1, H. Gilleland 1, N. Rinke 1, L. Thompson 1
1Department of Animal and Dairy Sciences, University of Georgia, Athens, United States
trk73598@uga.edu

Objectives: Pork production in the U.S. is progressing towards the slaughter of heavier hogs. This shift in production has altered the composition and size of pork bellies, thus affecting the quality and consumer acceptability of bacon. In this study, bacon quality attributes were evaluated across belly weight and location within the belly.

Materials and Methods: There were 129 bellies used, representing 4 weight categories (5.9-6.8, n=31; 6.8-7.7, n=24; 7.7-8.6, n=42; 8.6+ kg, n=32) currently used in the pork packing industry. Following selection, bellies were trimmed and green weights were recorded. Bellies were then pumped, smoked, chilled, pressed, sliced and packaged from anterior to posterior. Three packages (0.45 kg) were selected from each belly to represent the blade, middle, and flank regions. Bacon packages (n=378) were evaluated for package firmness and percentage of visible lean. Bacon slices from these packages were evaluated for uncooked and cooked proximate composition, fatty acid profile, and calculated iodine value (IV). Data were analyzed using PROC GLM (SAS Institute Inc.) with belly weight and location within the belly as the main effects.

Results: Uncooked and cooked moisture percentage was greatest (P<0.05) in bacon from the 5.9-6.8 kg bellies compared to all other groups. Cooked moisture percentage was lowest (P<0.05) in bacon from the 8.6+ kg bellies compared to all other groups. Uncooked and cooked fat percentage was lowest (P<0.05) in bacon from the 5.9-6.8 kg bellies compared to all other groups. Whereas, the 8.6+ kg bellies had the greatest (P<0.05) percentage of fat for cooked bacon compared to all other groups. Composition changes that occurred during cooking indicated that the bacon from the 5.9-6.8 kg bellies had the greatest (P<0.05) percentage of moisture loss and the lowest (P<0.05) percentage of fat loss compared to all other groups. Total monounsaturated fatty acid (MUFA) percentage was lowest (P<0.05) in uncooked bacon from the 7.7-8.6 kg bellies compared to all other groups. Total MUFA (P=0.46) and total saturated fatty acid (P=0.52) percentage did not differ for cooked bacon across the weight classes. Total polyunsaturated fatty acid (PUFA) percentage was greatest (P<0.05) in the 5.9-6.8 kg bellies for uncooked bacon compared to all other groups. Total PUFA percentage was lowest (P<0.05) in the 8.6+ kg bellies for both uncooked and cooked bacon compared to all other groups. The IV for uncooked bacon were greatest (P<0.05) in the 5.9-6.8 kg bellies compared to all other groups. Packages from the 5.9-6.8 kg bellies were the softest (P<0.05), while packages from the 8.6+ kg bellies were the firmest (P<0.05), compared to all other groups. Packages from the flank region had the lowest (P<0.05) package firmness scores and the highest (P<0.05) percentage of visible lean, compared to the middle and blade region. Packages from the 5.9-6.8 kg bellies had the greatest (P<0.05) percentage of visible lean compared to all other groups.

Conclusion: Overall, the 5.9-6.8 kg bellies optimized quality traits by having the greatest moisture content, lowest fat content, and greatest percentage of visible lean. The heavier bellies tended to have higher lipid content which is linked with negative consumer perception. Therefore, by increasing the slaughter weight of hogs, consumer acceptance of bacon appearance could be adversely impacted.

Keywords: bacon, Composition, pork, quality characteristics
NATURAL HARDWOOD SMOKED SUGAR IMPROVES OXIDATIVE AND FLAVOR STABILITY OF NATURALLY CURED, AEROBICALLY PACKAGED, FOOD SERVICE BACON

A. Hobson 1,*, R. Johnson 2, T. O'Quinn 1, E. Boyle 1, J. Gonzalez 1, C. Vahl 3, T. Houser 1

1Animal Sciences and Industry, Kansas State University, Manhattan, 2Red Arrow, Kerry Ingredients, Manitowoc, 3Statistics, Kansas State University, Manhattan, United States

awhobson@ksu.edu

Objectives: The purpose of this study was to determine the effectiveness of adding naturally smoked sugar into a curing brine to prevent lipid oxidation and maintain flavor in naturally cured, frozen, aerobically packaged, food service bacon.

Materials and Methods: Fresh pork bellies (6.3-7.2 kg) were trimmed and cut in half yielding an anterior and posterior belly section. Within each belly, each section was randomly assigned to one of two treatments with a targeted 12% pump: a control brine or a curing brine with added natural hardwood smoked sugar (n=15/treatment). Final target concentrations for control brine ingredients in the raw belly were 1.6% salt, 1.0% cane sugar and 0.8% cultured celery juice. Raw belly sections assigned to the naturally smoked sugar brine targeted 1.6% salt, 0.8% cane sugar, 0.8% cultured celery juice, and 0.6% smoked sugar (RA12032, Red Arrow Products, Manitowoc, Wisconsin). After injection, bellies were smoked and cooked to an internal temperature of 53°C using a standard bacon processing schedule. After cooking, bellies were chilled for 12 hrs. at 0-2°C then sliced 1.5 mm thick with a horizontal slicer from the anterior to posterior end. Slices were randomly selected from the sliced belly and laid out onto food service bacon sheet paper. Sheets of bacon slices were randomly assigned to 4 sensory frozen storage periods (0, 40, 80, and 120 d) or 7 thiobarbituric acid reactive substances (TBARS) frozen storage times (0, 20, 40, 60, 80, 100, and 120 d). All boxed bacon slices were stored aerobically at -18±2°C for the designated storage period. After the appropriate frozen storage time, trained sensory panelists evaluated saltiness, smoke intensity, bacon flavor, oxidized flavor intensity, and other off-flavor intensity. The distillation method for TBARS analysis was utilized to measure lipid oxidation. Sensory and TBARS analysis were analyzed as a split-plot design with repeated measures with the whole plot consisting of the half belly and treatment with the split-plot consisting of storage day.

Results: There was a Treatment × Day interaction (P<0.001) for oxidized flavor intensity. Control bacon had increased (P<0.001) panelist scores for oxidized flavor intensity from d 0 to 120. However, bacon manufactured with naturally smoked sugar had oxidative flavor intensity scores that remained constant (P>0.936) over the 120 d of frozen storage. Additionally, trained panelists scored bacon samples manufactured with the naturally smoked sugar higher (P<0.001) for saltiness, smoke intensity, and bacon flavor intensity compared to control samples. In confirmation of the oxidized flavors found during sensory evaluation, there was a Treatment × Day (P<0.001) interaction found for TBARS values. The TBARS values for the control treatment displayed increased TBARS values from d 20 to d 120 (P<0.001). Bacon formulated with naturally smoked sugar exhibited static TBARS values throughout the 120 d frozen storage period (P>0.196).

Conclusion: The ability of naturally smoked sugar to function as an antioxidant in sliced naturally cured bacon was confirmed with both sensory evaluations and objective measurement of lipid degradation products. Also, aerobically packaged, frozen, naturally cured bacon formulated without added antioxidants had significant challenges in flavor stability due to increased lipid oxidation as frozen storage length increased.

Keywords: frozen storage, lipid oxidation, naturally cured bacon, naturally smoked sugar, sensory
EFFECTS OF INCLUSION OF TANNIC ACID ON COLOR, LIPID STABILITY, AND SENSORY ATTRIBUTES OF GROUND BEEF PATTIES

A. P. B. Fruet 1, A. M. Cavender 1, M. A. Fonseca 1, J. L. Nörnberg 1, A. S. De Mello 1,*
1Department of Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, United States
amilton@cabnr.unr.edu

Objectives: Oxidation negatively affects meat quality leading to changes in sensory and nutritional properties. Inclusion of antioxidants in ground beef improves lipid stability and extends case life. In this study, we examined the effects of tannic acid as a novel antioxidant source on lipid oxidation, color stability, and sensory attributes of ground beef patties.

Materials and Methods: A beef trim 80% lean composite from 4 different carcasses aged for 14 d was acquired from Wolfpack Meats, the University of Nevada, Reno (UNR) USDA harvest and processing facility. Trim was transferred to the UNR Meat Quality laboratory, ground, and divided in four batches. Each batch was treated with 0 (Control), 0.5%, 1%, or 1.5% of a burgundy food-grade tannic acid powder. Ground beef portions weighing 120 g were formed into 11.5 cm diameter/1.5 cm thickness patties (n=5 per treatment). Patties used for sensory analysis were vacuum-packaged and held at -80°C until testing. Prior to sensory analysis, patties were thawed for 24 h at 4°C and cooked on an electric grill to an internal temperature of 71 °C. Pie-shaped pieces were obtained from each sample and served to a 7-member sensory panel. Each panelist evaluated tenderness, chewiness, juiciness, off-flavor, and overall desirability using an unstructured linear 10 cm scale (0=extremely tough, chewy, dry, mild, and undesirable to 10 = extremely tender, soft, juicy, intense, and desirable). For color and lipid stability (TBA values), patties were placed in polystyrene trays, overwrapped with an oxygen permeable PVC film, and stored at 4°C. Samples were displayed for 6 days under fluorescent lights with intensity of approximately 1300 lux. Objective color (L*, a*, b*) measurements were taken daily by using a Minolta CR-400 and lipid oxidation was evaluated on days 0, 3, and 6. Data were analyzed as a CRD with repeated measures using PROC GLIMMIX of SAS. Fixed effects included tannic acid treatment (TA) and day of display.

Results: Significant interactions between fixed effects of tannic acid treatment and day of display were observed for a*, b*, and Chroma values. For all three variables, values decreased as display time increased. Control samples were redder from day 1 to 4 when compared to treated samples. Regarding yellowness, samples treated with 1.5% of TA showed the highest b* values from day 1 to day 6, whereas minimal differences between control and 0.5% TA samples were observed during display time. Chroma values were higher on samples treated with 1.5% of TA on days 5 and 6 when compared to control and 0.5% samples. At the end of display (day 6). All TA treatments similarly improved lipid stability when compared to control samples. However, inclusion levels above 0.5% led to detrimental effects on sensory attributes.

Conclusion: Inclusion of 0.5% of tannic acid is effective to improve lipid stability without compromising objective color parameters and sensory attributes of ground beef. Levels above 0.5% decrease redness and scores of sensory attributes, possibly due to the burgundy color and the astringent flavor of the powder.

Keywords: Antioxidants, Ground beef, Lipid oxidation, sensory evaluation, Tannic Acid
EFFECTS OF ANTIOXIDANTS ON LIPID STABILITY, COLOR PARAMETERS, AND AEROBIC PLATE COUNT OF BEEF PATTIES FROM STEERS FED DISTILLERS GRAINS

A. P. B. Fruet 1, A. M. Cavender 1, J. L. Nörnberg 2, C. R. Calkins 3, A. S. De Mello 1,*

1Department of Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, 2Department of Science and Food Technology, Federal University of Santa Maria, Santa Maria, 3Department of Animal Science, University of Nebraska, Lincoln, United States

amilton@cabnr.unr.edu

Objectives: Beef from steers fed distillers grains plus solubles (DGS) is more susceptible to lipid oxidation due to higher deposition of polyunsaturated fatty acids in the lean. Inclusion of antioxidants in ground beef is an efficient strategy to improve lipid stability. In this study, we tested the hypothesis that a novel composition of citrus extracts combined with buffered vinegar leads to improved color stability, lower lipid oxidation, and lower microbial loads of ground beef from steers fed distillers grains, when compared to other antioxidants commonly used by the industry.

Materials and Methods: A total of 24 crossbred steers were randomly assigned to 1 of 3 dietary treatments including CORN, Dry DGS (DDGS), and Modified DGS (MDGS) (8 steers per treatment). Distillers grains diets were formulated with inclusion levels of 40% DM basis. After slaughter, shoulder clods were collected and transferred under refrigeration to the University of Nevada, Reno Meat Quality Laboratory. After 7 d of aging, the M. latissimus dorsi, M. tensor fasciae antibrachii, and approximately 7.6 cm of the caudal part of the M. Triceps brachii were excised from each clod and ground. Ground samples from individual clods were divided into 4 batches that were subsequently treated with 0.3% of ROSEMARY, 0.25% of ACEROLA, and 0.6% of CITRIC (plus buffered vinegar) extracts. A CONTROL batch was formulated without any ingredient. Patties of 11.5 cm diameter were formed and displayed for 6 days. Instrumental color (L*, a*, b*) was recorded daily using a CR-400 Minolta® chroma meter whereas lipid oxidation (TBA), and aerobic plate count (APC) were evaluated on days 0, 3, and 6. The data were analyzed using GLIMMIX procedure of SAS whereas animal (dietary treatment) was considered the main plot and antioxidant treatment the sub plot. Color and TBA data were analyzed as repeated measures.

Results: For all instrumental color parameters, interactions between dietary treatment and day of display, and antioxidant treatment and day of display were observed (P < 0.01). Patties from steers fed DGS were darker than CONTROL samples on day 1 (48.77b, 50.18b, and 51.86a, for DDGS, WDGS, and CORN, respectively), whereas redness (a*) was greater on DGS patties on day 6 (13.20a, 14.67a, and 11.39b, for DDGS, WDGS, and CORN, respectively). Patties treated with ROSEMARY were significantly lighter than all other treatments on day 6 (53.14a, 50.34b, and 50.98b, for ROSEMARY, ACEROLA, CITRIC, and CONTROL respectively), whereas CITRIC samples were the reddest on days 5 and 6 of display. ACEROLA and CITRIC treatments led to similar lipid stability during display, whereas CITRIC samples showed less oxidation on day 6 when compared to CONTROL and ROSEMARY (0.21c, 0.29bc, 0.41b, and 0.90a, for CITRIC, ACEROLA, ROSEMARY, and CONTROL, respectively). Treatment CITRIC inhibited APC growth by 2 log when compared to all other treatments (3.73b, 5.34a, 5.44a, and 5.42a, for CITRIC, ACEROLA, ROSEMARY, and CONTROL, respectively).

Conclusion: The inclusion of CITRIC in ground beef improved redness of patties, whereas patties treated ROSEMARY were lighter. ACEROLA and CITRIC extracts provided better lipid stability to ground beef whereas CITRIC was the only ingredient that inhibited bacterial growth, possibly due to its combination with buffered vinegar.

Keywords: Acerola, Antioxidants, Beef patties, Citric extract, Rosemary
**Objectives:** The objective of this study was to evaluate the effects of rosemary/beef flavor-enhancement and modified atmosphere packaging on retail display, flavor, and muscle tenderness of beef *longissimus lumborum* muscle.

**Materials and Methods:** No-roll, dark-cutting beef strip loins (n = 8; pH > 6.0) and USDA Choice beef strip loins (n = 5) were selected from a commercial packing plant within 72 h of harvest. Dark-cutting strip loins were divided into 2 equal sections, and randomly assigned to one of the following enhancement treatments: control non-enhanced or rosemary/beef flavor-enhanced treatment. Dark-cutting enhanced loins were injected with a rosemary/beef flavor-enhancement consisted of solution containing 1.1% rosemary, 5.0% salt, and 5.5% beef flavor to 10% of its green weight. Six 2.54 cm steaks were cut from non-enhanced USDA Choice (CH), non-enhanced dark-cutting (DC), and enhanced dark-cutting (DCE) strip loins, and assigned to 1 of 3 packaging treatments: vacuum packaging, carbon monoxide modified atmosphere packaging (CO-MAP; 0.4% CO, 69.6% N, and 30% CO2), and high-oxygen modified atmospheric packaging (HiOx-MAP; 80% O2 and 20% CO2). Packages were placed under simulated retail display using continuous fluorescent lighting in a coffin-style retail display cases at 2°C for 3 d. Following 3 d retail display, instrumental color measurements were recorded and one steak from each packaging type was subjected to a 6 member trained sensory panel, while the other steak was used to measure Warner-Bratzler shear (WBS) force. Steaks subjected to trained sensory panel and WBS force analysis were cooked to an internal temperature of 68 °C using an XLT Impingement Oven (model 3240-TS, BOFI Inc., Wichita, KS) set at 200°C.

**Results:** There was a significant enhancement x packaging interaction for a* values. Enhanced dark-cutting steaks packaged in HiOx-MAP and CO-MAP were more red (greater a* values; P < 0.0001) than other non-enhanced dark-cutting steaks in any other packaging types. Furthermore, enhanced dark-cutting steaks were lighter (P < 0.0001, greater L* values) than non-enhanced dark-cutting steaks. Additionally, a trained sensory panel was conducted on each treatment and packaging type. Enhanced dark-cutting steaks exhibited a higher (P = 0.03) overall juiciness values compared to non-enhanced dark-cutting steaks, indicating a juicier steak when subjected to an antioxidant and beef flavor enhancement. Enhanced and non-enhanced dark cutting steaks had a higher (P = 0.002, more tender) tenderness value than the USDA Choice steaks. However, there was no difference (P > 0.05) in WBS force values between non-enhanced dark-cutting and USDA Choice steaks. Steaks from enhanced dark-cutting loins possessed a lower (P = 0.04) beef flavor score compared to USDA Choice steaks. Lastly, both enhanced dark-cutting steaks and the USDA Choice steaks had a higher (P < 0.0001, stronger) sour flavor score compared to non-enhanced dark-cutting steaks.

**Conclusion:** The results suggest that rosemary/beef flavor enhancement does not improve beef flavor and may increase sour flavor compared to USDA Choice and dark-cutting steaks. However, results also show it does have the potential to improve surface color of dark-cutting beef while increasing juiciness compared to non-enhanced dark-cutting steaks.

**Keywords:** Antioxidants, Beef Flavor, Dark Cutter, Enhancement
Objectives: The amount of curing solution permitted to be retained in bellies during bacon production varies from country to country. In the United States, according to 9 CFR 319.107, “the weight of cured pork bellies ready for slicing and labeling as “bacon” shall not exceed the weight of the fresh uncured pork bellies.” While in Canada, according to the Canadian Food Inspection Agency (CFIA), “side bacon, Wiltshire bacon, salt beef, and pork jowls are exempted from the minimum protein standard and the percent (%) meat protein label declaration.” Therefore, the objective of this study was to evaluate the effect of belly pump uptake and cook yield during thermal processing on bacon slice composition and sensory attributes.

Materials and Methods: Forty-four fresh pork rind-on bellies were sourced and obtained from a commercial pork processor. Each belly was skinned and cut into two halves at the medial point of the belly. Twenty-two of the paired belly halves were randomly assigned to experiment 1 and the remaining twenty-two paired belly halves were assigned to experiment 2. The two experiments addressed different cooking techniques used by bacon processors – bacon in experiment 1 was cooked to an internal meat temperature of approximately 55˚C, and bacon in experiment 2 was cooked to an internal meat temperature of approximately 62˚C. Belly halves were assigned to treatment within each experiment so that an equal number of anterior halves (blade ends) and posterior halves (flank ends) would be represented in each treatment. Treatment consisted of target levels of pump uptake. Belly halves targeted at a pump uptake of 15% were assigned to the normal pump uptake treatment (NORM) and belly halves targeted at a pump uptake of 30% were assigned to the high pump uptake treatment (HIGH). Cure ingredients were formulated in accordance with manufacturer instructions (15% pump target = 313 g cure/ 1 kg water; 30% pump target = 156 g cure/ 1 kg water). Processing characteristics, bacon slice composition, and trained sensory attributes were evaluated. Treatment means for processing characteristics and bacon slice proximate composition were compared using PROC MIXED of SAS with a fixed effect of treatment. Treatment means for sensory characteristics were compared using PROC GLIMMIX of SAS with a fixed effect of treatment and a random effect of panelist, day, and their interaction.

Results: In experiment 1, cook yields were 107.8% for the HIGH bellies and 101.5% for the NORM bellies. Bacon from the HIGH treatment in experiment 1 had lesser ($P = 0.04$) protein percentage and tended to have greater saltiness ($P = 0.07$) when compared with bacon from the NORM treatment in experiment 1. In experiment 2, cook yields were 97.4% for the HIGH bellies and 94.7% for the NORM bellies. Bacon from the HIGH treatment in experiment 2 had greater ($P = 0.02$) moisture percentage and greater gumminess ($P < 0.0001$) when compared with bacon from the NORM treatment in experiment 2. All other bacon slice composition and sensory attributes were not different ($P > 0.10$).

Conclusion: Overall, bacon slice composition and sensory attributes of bacon from bellies with greater pump retention were largely unaffected, accordingly it was concluded that cook yields ranging in level of pump retention does not affect most attributes of bacon.

Keywords: bacon, bacon processing, bacon pump, bacon yield, sensory evaluation
EFFECTS OF SALT AND NITRITE ON THE SPOILAGE MICROBIOTA OF DELI-STYLE HAM
C. G. Bower 1,*, R. Stanley 1, S. Fernando 1, D. Burson 1, G. Sullivan 1
1Animal Science, University of Nebraska, Lincoln, United States
cbower357@gmail.com

Objectives: The objective of this study was to determine the effect of salt and nitrite concentration on the microbial shelf life characteristics of deli-style ham.

Materials and Methods: Three replications of deli-style ham treatments were manufactured in a 3 x 4 factorial arrangement of salt concentration (0.7%, 1.4%, or 2.1%, meat block basis) and nitrite concentration and source (0 ppm, 100 ppm or 200 ppm sodium nitrite, SN, or 100 ppm sodium nitrite equivalent from pre-converted celery juice powder, CP). All treatments contained 1% sugar, 0.35% sodium phosphate and either 495 ppm sodium erythorbate or 440 ppm of ascorbic acid from cherry powder with the balance added as water to achieve a 25% extension. After cooking and chilling overnight, hams were sliced, vacuum packaged, and stored at ~4 °C in covered lugs. Samples were stored for 14 weeks and evaluated every two weeks for aerobic plate count (APC), anaerobic plate count (AnPC), and microbial community structure. Data were analyzed using PROC GLIMMIX of SAS, and means were separated using the LSMEANS PDIFF option (α = 0.05) with Tukey’s adjustment. Bacterial community analysis was performed using high throughput 16S rRNA gene sequencing on the Illumina Miseq® platform. Sequences were processed using QIIME, and binned into operational taxonomic units (OTUs) at 97% similarity and assigned taxonomy using the Greengenes database as reference. Alpha and beta diversity of the bacterial community was performed using QIIME and R to determine differences in the overall bacterial community structure. Alpha diversity was estimated using observed OTUs and Chao1 diversity estimates, and beta diversity was calculated using a weighted UniFrac distance matrix. Linear discriminant analysis effect size (LEfSe) was performed to identify differential OTUs between treatments.

Results: There was a salt by nitrite and a nitrite by week interaction for aerobic plate count (APC). In all treatments containing SN or CP, APC decreased as salt increased, however in the 0 ppm SN treatments, APC did not change based on salt. Throughout storage time, APC decreased with greater concentrations of nitrite, while 0 SN treatments had the most growth throughout the sampling period. Bacterial community richness estimates of observed OTUs and Chao1 were affected by storage time (P = 0.016 and P < 0.001, respectively), where communities showed greater richness in week 0 than the rest of storage time. Nitrite concentration affected bacterial community composition, where uncured and 100 ppm CP were more similar than 100 ppm or 200 ppm. Bacterial communities consisted of mostly Pseudomonadaceae, which composed ≥ 73.2% of the bacterial community, regardless of treatment. Based on differentially abundant bacterial species, Pseudomonas and Janthinobacterium lividum were less abundant in the 100 ppm CP treatments compared to all others, and Prevotella were greatest in 100 ppm SN.

Conclusion: Treatments with 200 ppm of sodium nitrite provided the longest shelf life to deli-style ham. Furthermore, 0.7% salt resulted in the shortest shelf life. When aiming to reduce sodium and reduce or use alternative sources of nitrite in, processors should bear in mind implications on the microbial shelf life of deli-style hams.

Keywords: bacterial community, ham, Nitrite, Salt, shelf life
Objectives: The objective of this study was to evaluate the spoilage microbiota of various sliced, case ready deli-style hams and identify differences between their microbiological communities.

Materials and Methods: Ham samples were procured at local retail stores from products available on the shelf. Three brands (A, B, C) of smoked, sliced, Ham, Water Added were purchased with a brand being considered the same product and establishment number. Replication was defined as having the same sell-by date indicating a common date of production; three different sell-by dates for each brand created three replications. Multiple packages of each brand and sell-by date were purchased to allow an unopened package to be used for each sampling date and were stored at 4 °C. Sampling times were determined as follows: -4, -2 (4 and 2 weeks prior to sell-by, respectively), 0 (sell-by date), 2, and 4 (2 and 4 weeks after the sell-by day, respectively). Water activity and salt concentration were sampled at -4 only. Objective color (CIE L*, a*, b*), pH, aerobic plate count (APC) and anaerobic plate count (AnPC) were evaluated throughout storage time. Bacterial community analysis was performed using high throughput 16S rRNA gene sequencing on the Illumina MiSeq® platform. Sequences were processed using QIIME, binned into operational taxonomic units (OTUs) at 97% similarity and assigned taxonomy using the Greengenes database as reference. Water activity and salt concentration data were analyzed using R. Color, pH, and plate counts were analyzed as a 3 (brand) by 5 (storage time) factorial using R. Alpha and beta diversity of bacterial communities were analyzed using QIIME and R. Alpha diversity was estimated using observed OTUs and Chao1 estimates, and beta diversity was determined using a weighted UniFrac distance matrix.

Results: Salt and water activity were different between brands ($P < 0.007$). Brand A had less salt compared to brands B and C, while brand B had a lower water activity than brands A and C. Objective color values for $L*$ and $a*$ were not different ($P > 0.182$) between brands or storage times, but $b*$ was different between brands ($P < 0.001$). Brand A had greater $b*$ (yellowness) than brands B and C. There was a brand by storage time interaction for pH ($P = 0.021$). At week 0, the pH of brand B was lower than any time during the study. There was a significant main effect of brand on both APC and AnPC ($P < 0.001$). Brand A had greater APC and AnPC when compared to brands B and C. Observed OTUs and Chao1 diversity estimates indicated there was a brand by storage time interaction for bacterial richness, where brand A week -4 had the greatest bacterial richness followed by brand A week 0. There was a main effect of storage time on the bacterial community structure ($P < 0.001$). Brand B and brand C were more similar in community structure compared to brand A.

Conclusion: The lower salt concentration in brand A may affect bacterial spoilage. Furthermore, results from this study indicate that the spoilage community associated with similar types of sliced ham is dependent on brand, implying that spoilage patterns and characteristics are related to environmental bacteria composition of the initial post-lethality contamination.

Keywords: bacterial community, ham, microbial spoilage
Objective: Addition of mechanically separated chicken (MSC) modifies the texture, flavor, and color of processed meat products; however, there is little modern literature characterizing its behavior in a model system and qualities in applied formulations. The objectives of this study were to determine differences between MSC and chicken breast trim when used as frankfurter raw materials and to identify rheological attributes of their myofibrillar proteins during gelation. An improved understanding of MSC properties will facilitate optimization of its processing parameters.

Materials and Methods: MSC obtained from two different separation methods (MSC1 Beehive separator, aged bones; MSC2 Poss separator, fresh bones) were compared to chicken breast trim (BT) as raw materials for frankfurters. Chicken was blast frozen (-44.4°C for 72 h) and stored at -20°C for < 20 days. Frankfurters were produced, vacuum packaged, and stored under display lights (florescent, 2300 lux) for 98 days; 3 rep. Color (L*, a*, b*), texture profile analysis, and lipid oxidation were evaluated every 2 weeks. Dynamic oscillatory rheology (40mm parallel plates, 0.25% strain and 1 Hz frequency) was performed on the solubilized myofibrillar proteins of each raw material. Myofibrillar proteins were isolated by differential centrifugation, solubilized (0.6 M NaCl, 50 mM sodium phosphate, 2.8% (w/v) protein concentration, pH 6) and a temperature sweep (20–85°C at 1°C/ min) was conducted. Storage modulus (G'), loss modulus (G'') and phase angle (δ) were measured. Protein profile was evaluated using SDS-PAGE. Shelf-life (fixed: treatment, day and treatment*day, random: replication) and rheological (fixed: treatment random: treatment*day) data were analyzed using SAS 9.4 mixed proc.

Results: All raw materials were significantly different in moisture and fat content (P<0.05). Both MSC raw materials contained greater fat and less moisture than BT. MSC2 frankfurters were greatest in fat and lowest in moisture content (P<0.05). Both MSC frankfurters had significantly darker (L*), and redder (a*) external and internal color than BT frankfurters with MSC2 being the darkest and reddest treatment (P<0.05). Greater hardness, cohesiveness, gumminess and chewiness values were documented in MSC2 product than in BT and MSC1 product. All treatments exhibited gelation with increased temperature (decreased δ). A peak, decline, and subsequent increase was observed in all 3 treatments at the 50–55°C range in both the G’ and G’''. G’ slopes on both sides of the peak (S2, S3) and following the decline (S4) were significantly different between BT and both MSCs (P<0.05). BT’s S3 was significantly steeper indicating a greater instability of the solid-like structure in the temperature range of 50–55°C (myosin rod denaturation). BT S2 and S3 were significantly different from MSC treatments in G’'' (P<0.05), but not significantly different during S3.

Conclusion: The data demonstrate that physical properties of myofibrillar proteins from MSC and chicken breast meat differ during thermal gelation. This indicates a different protein profile that could be explained by muscle source or by denaturation during isolation of the MSC. The data reveal that properties of different MSC can result in significant variation in finished product quality, underscoring the importance of understanding the features of raw materials that affect processing functionality.

Keywords: Frankfurter quality, Mechanically Separated Chicken, Myofibrillar Protein, Rheology
Objectives: The objective of this research is to identify compound(s) associated with and potentially responsible for saltiness potentiation from the volatile and aqueous fractions of frankfurters containing soy sauce.

Materials and Methods: Previous research has shown sodium can be reduced in frankfurters through the addition of soy sauce (SS) while maintaining or potentiating a salty taste. This study involved two phases of research. The purpose of Phase I was to identify compounds potentially responsible for saltiness potentiation by manufacturing two treatments (TRT) of frankfurters with 2.50% salt (total formulation) with varying levels of flake salt (FS) and SS. The control (C) contained 100% FS, and the TRT contained 50% salt from FS and 50% salt from SS. A trained sensory panel evaluated the samples for the following attributes: smoke, meaty, salt, umami, hardness and crosswise hardness. Aqueous fractions were generated by centrifugation and analyzed using LC-MS. Volatile compounds were analyzed using SPME and GC-MS.

The purpose of Phase II was to evaluate compounds identified in Phase I for their ability to potentiate saltiness. Traditionally manufactured frankfurters contained 2.50% salt (100% FS) were injected with aqueous solutions, post-manufacture, sufficient to yield various concentrations of selected volatiles at levels near published aroma thresholds. Volatile solutions were added by injecting into the center of each piece with a sterile hypodermic needle and allowed to equilibrate within the frankfurter at refrigeration temperature. A trained sensory panel evaluated the samples for the following attributes: smoke, meaty, salt, umami, astringent, hardness and crosswise hardness. Physiochemical analysis was conducted at day 14 for both research phases and included proximate analysis, internal and external measure of color ($L^*$,$a^*$$b^*$), salt, pH, purge, emulsion stability, cook yield, and texture and puncture analysis.

Results: Phase I trained sensory analysis results showed the TRT had higher (p<0.05) sensory scores for saltiness and umami flavor. Further, specific sensory attributes were unique to the SS containing TRT. Seven aqueous compounds identified were present at higher levels (p<0.05) in the TRT. Fifty-six volatile compounds were identified in both the TRT and C. Semi-quantitative and qualitative means were used to identify specific volatiles that were either more abundant (p<0.05) or unique to the TRT. Based on Phase I associations and high correlations with the salt attribute, specific volatiles were selected to be evaluated in Phase II. The TRT revealed lower (p<0.05) internal $L^*$ and $a^*$ and external $a^*$ values, and higher (p<0.05) internal and external $b^*$ values. Phase II results revealed TRT 1 was saltier (p<0.05) and scored higher (p<0.05) with aromas associated with the Phase I sensory studies than C. A nonlinear relationship was observed for volatile concentrations and their sensory attributes, which likely influenced saltiness perception. For external color, TRTs 1 and 2 had lower (p<0.05) $L^*$ values compared with C, and TRT 1 had higher (p<0.05) $a^*$ and $b^*$ values than C.

Conclusion: This research identified a possible mechanism for the saltiness potentiation phenomenon observed in frankfurters containing SS, where results suggest volatile compounds have the ability to contribute to saltiness potentiation in processed meat products.

Keywords: frankfurters, sodium replacement, soy sauce
Objectives: Meat is complex, so a simplified model curing system was used to observe curing reactions. The purpose of this study was to compare the effect of nitrite sources and reducing compounds on the specific nitrosylation/nitrosation reactions of myoglobin and cysteine.

Materials and Methods: Five model curing systems were evaluated: sodium nitrite (SN), sodium nitrite with sodium chloride (NaCl) to equal the salt in celery juice powder (0.5% in solution; SN-NA), sodium nitrite with NaCl and sodium erythorbate (SN-SE), celery juice powder (CP; VegStable 504, Florida Food Products, Inc.), and celery juice powder with acerola cherry powder (CP-CH; VegStable 515). Solutions were made to compare nitrite sources: synthetic sodium nitrite, and pre-converted celery juice powder with and without reducing agents (2.76 mM of sodium erythorbate, or ascorbic acid from cherry powder) at ingoing nitrite concentrations of 0.072, 0.362, 0.725, 1.087, and 1.450 mM (equivalent to 10, 50, 100, 150, and 200 ppm added to the final solution). Two model meat solutions, cysteine (5.06 mM) or cysteine and myoglobin (5.06 mM, and 0.029mM respectively), were prepared in pH 5.6 buffered phosphate. To simulate the curing process, model meat solutions (5ml) were mixed with the curing solutions (5ml) in 13 ml test tubes, capped, heated (30 min. at 40°C, 30 min. at 80°C) and cooled (15 min. at 23°C). Three replications were made. All samples were analyzed for residual nitrite, sulfhydryl groups, and reducing capacity. Solutions containing myoglobin were evaluated for cured meat pigment. Data were analyzed as a completely randomized design in a factorial arrangement of treatments (5 curing systems, 5 ingoing nitrite concentrations, 2 model meat solutions) for interactions and main effects using GLIMMIX procedure of SAS. For significant effects ($P \leq 0.05$), LS means separation was conducted using a Tukey adjustment.

Results: A significant curing system by ingoing nitrite concentration interaction occurred for residual nitrite, and sulfhydryl groups ($P < 0.05$). More residual nitrite was in systems without reducing agents (SN, SN-NA, CP) than SN-SE and CP-CH and increased with higher ingoing nitrite. In all treatments, sulfhydryl groups decreased as ingoing nitrite increased and CP, CP-CH and SN-SE treatments had more sulfhydryl groups than SN and SN-NA. Curing systems with reducing agents (SN-SE, and CP-CH) showed greater ($P < 0.001$) reducing capacity than SN, SN-NA and CP. The reducing capacity decreased with increasing ingoing nitrite in all curing systems ($P < 0.001$). Curing systems with reducing agents had greater ($P < 0.001$) cured meat pigment, and all curing systems had similar cured meat pigment with ingoing nitrite concentrations higher than 50 ppm ($P < 0.001$). The cysteine and myoglobin model had greater sulfhydryl groups and residual nitrite ($P < 0.001$) than the cysteine only model.

Conclusion: Using model meat curing solutions, synthetic and natural curing systems result in similar curing reactions with myoglobin and cysteine. SN and CP had similar concentrations of residual nitrite and cured meat pigment, but CP, CP-CH, and SN-SE treatments had greater sulfhydryl groups. Salt found in CP did not affect curing reactions. Nitrite reactions occur with myoglobin before cysteine. This supports similar cured meat characteristics observed in meat cured with synthetic and natural compounds.

Keywords: Meat curing reactions, Model system, Nitrite source, Reducing agents
MEASURES OF OXIDATION IN BEEF FOLLOWING RETAIL DISPLAY IN VARIOUS PACKAGE TYPES

J. Ponce 1,*, J. C. Brooks 1, M. F. Miller 1, J. F. Legako 1
1Animal and Food Sciences, Texas Tech University, Lubbock, United States
jacqueline.ponce@ttu.edu

Objectives: This study aimed to investigate the influence of package type and muscle on thiobarbituric reactive substances, non-heme iron, and carbonyls in raw Longissimus lumborum (LL) and Gluteus medius (GM) muscles.

Materials and Methods: Thiobarbituric reactive substances (TBARS), non-heme iron (NHI), and carbonyls (C) were measured in raw Longissimus lumborum (LL) and Gluteus medius (GM) muscles packaged in one of five package types: high-oxygen modified atmosphere lidded trays (80% O₂/20% CO₂, HIOX), carbon monoxide modified atmosphere lidded trays (0.4% CO/30% CO₂/69.6% N₂, CO), rollstock (forming/non-forming films, ROLL), vacuum packaging (VAC), and traditional overwrap (remained under vacuum prior to being placed on foam trays and sealed with polyvinyl chloride film, OW) in a 2 × 5 factorial arrangement. Paired strip loins and top sirloin butts (n = 10 paired subprimals from USDA Choice, “A” maturity beef carcasses) were vacuum packaged, stored in darkness (4°C) and aged for 14 d; prior to fabrication into 2.54 cm steaks. Steaks were kept in darkness (4°C) in their respective packaging for an additional 7 d until retail display for 48 h under continuous fluorescent lighting (4°C); while VAC steaks remained in darkness. Malonaldehyde was measured in steaks using the TBARS method. Carbonyl content was evaluated as a measure of protein oxidation by derivatization with 2,4 dinitrophenylhydrazine (DNPH). Non-heme iron (NHI) concentration was measured using a ferrozine method. All data were analyzed utilizing statistical procedures in SAS (9.4). Significance was determined at α=0.05.

Results: No muscle × package type interactions (P > 0.05) occurred for TBARS, C, or NHI. Package type (P < 0.001) and muscle (P < 0.004) had an impact on TBARS. The HIOX treatment had the greatest (P < 0.05) TBARS values compared to all other package types. Additionally, samples packaged in CO had greater (P < 0.05) TBARS than VAC. Moreover, the GM possessed greater (P < 0.05) TBARS values than the LL. Package type had no effect (P > 0.05) on carbonyls or NHI content. However, C and NHI differed among muscles (P < 0.05). The GM possessed greater (P < 0.05) C and NHI content compared to the LL.

Conclusion: These results indicate high oxygen packaging environments are detrimental to the chemical stability of raw beef as measured by TBARS. Furthermore, the GM is more susceptible to oxidation than the LL; possibly because of increased NHI.

Keywords: Beef, Display, Oxidation, Packaging
Objectives: The objective of this study was performed to develop the low-salt sausages with basil seed gum (BSG) to have a similar properties of regular-salt sausages.

Materials and Methods: Pork sausages were manufactured with 1% dried BSG at low- or regular-salt concentrations (1.0 and 1.5%). BSG powder was extracted from outer pericarp of swelled basil seed and obtained by drying at 50°C dry-oven. pH, color, expressible moisture (EM, %), cooking loss (CL, %), textural profile analyses, fourier transform infrared spectroscopy (%T), sulfhydryl group (A415), and protein surface hydrophobicity (μg) were measured. The experimental design was one-way analysis of variance at the significant level of 0.05%

Results: No differences in pH, color, EM, gumminess, chewiness, cohesiveness of the low-salt sausages with or without BSG powder were observed. Although CL of the sausage at low salt concentration (1.0%) increased, regardless of the addition of BSG, hardness values of sausages with regular-salt increased when BSG was added. However, no difference in hardness values were observed with the addition of BSG at low-salt level. The addition of BSG powder decreased the springiness, resulting in the lowest values among other sausages. The quantitative analysis of the changes in band at 1650 cm⁻¹, 1624 cm⁻¹, and 1680 cm⁻¹ (α-helix/unordered structures and β-sheet) were decreased with increased salt concentrations. The changes of band were not much different at different salt concentrations. Increasing salt concentration showed low content of sulfhydryl groups and high protein surface hydrophobicity indicating that there were more interaction among them. However, protein surface hydrophobicity and sulfhydryl contents of sausages were increased with BSG, resulting in more hardness and less springiness than those without BSG.

Conclusion: The addition of BSG into the sausage mixture had better effect as a water-binding agent at regular-salt sausages than at low-salt sausages.

Keywords: Basil seed gum, Fourier transform infrared spectroscopy, Hydrophobicity, Low-salt sausage, Sulfhydryl content
Effects of Oxidative Cross-Linking of Its Myofibrillar Protein on Texture During the Processing of Air-Dried Yak Meat

J. Ma¹, W. Cui¹, L. Zhang¹, Y. Song¹, Q. Yu¹, Y. Wang¹, H. Wang¹, X. Liu¹
¹Food Science and Technology, Gansu Agricultural University, Lanzhou, China
zhanglwubd@163.com

Objectives: This study aimed to examine the mechanism of cross-linking of myofibrillar protein and its influence on texture during the processing of air-dried yak meat.

Materials and Methods: The semimembranosus of nine healthy and disease-free male yaks when they were 3 to 4-year-old under natural grazing was selected for 20 kg, and these yaks are all from Gannan Prefecture, Gansu Province, China. The fascia and fat on the surface of the raw meat were removed and cut into strips with a cross section of 2 cm × 2 cm in a freeze-dried room away from direct sunlight and naturally ventilated (room temperature -10 ~ -15°C, relative humidity 50% ~ 75%). The meat was hung on the wire, and the distance between adjacent two meats was maintained at 1 to 2 cm. Samples were collected during natural air-drying for 60 days. Carbonyl content, total thiol concentration, disulfide bond content, SDS-PAGE, dimeric tyrosine content, the surface hydrophobicity, histological characteristics and texture were measured respectively. All of the experiments were conducted in triplicate for each sample, and the final results from the mean of three independent experimental replications.

dimeric tyrosine content, the surface hydrophobicity, histological characteristics and texture were measured respectively. All of the experiments were conducted in triplicate for each sample, and the final results from the mean of three independent experimental replications.

Results: The carbonyl content of raw meat is 2.63 nmol/mg, and increased by 6.35 nmol/mg in 60 d. With the increase of protein oxidation, the proportion of protein α-helices decreases while β-sheets increase, and β-turns and random coils remain basically unchanged. The lost sulphhydryl group is cross-linked in the form of disulfide bonds, significant difference between 4 to 50 d (P<0.05). Through SDS-PAGE experiments found that the cross-linking of myosin heavy chain formed macromolecules to stay on the top of the separation glue, fully verified this point. The sensitive amino acid tyrosine was cross-linked by dimerization of dimeric tyrosine and changed significantly from 0 to 30 days (P<0.05). Changes in the surface hydrophobicity of the protein can be obtained, and the aggregation of the protein is greater than that of the structure during processing from 4 to 60 d. These changes cause contraction of myofibrils in both the transverse and longitudinal directions, which in turn leads to hardness, cohesiveness, gumminess and chewiness were significantly increased in air-dried yak meat, springiness and resilience decreased significantly during processing. These changes cause contraction of myofibrils in both the transverse and longitudinal directions, which in turn leads to hardness, cohesiveness, gumminess and chewiness were significantly increased (P<0.05) in air-dried yak meat, springiness and resilience decreased significantly (P<0.05) during processing.

Image:

Conclusion: With the increase of protein oxidation of yak meat during non-artificial freeze-drying, myofibrillar molecules crosslink and aggregate in the form of disulfide bond and dimeric tyrosine. These changes cause the muscle fibers to contract both horizontally and vertically, which in turn leads to hardness, cohesiveness, gumminess and chewiness were increased significantly, and result in decreased springiness and resilience ultimately.

Keywords: histological structure, protein oxidation, texture, unartificial drying, yak
OBJECTIVES: Alternatively-cured meats often contain lower amounts of nitrate and/or nitrite in the formulation, which can lead to decreased color stability and reduced shelf life. Alternatively-cured meats rely on natural sources of nitrate and/or nitrite which are primarily derived from vegetable sources, but these natural sources can result in vegetable-like flavors; thus, processors often decrease the relative ingoing level of nitrite and/or nitrate. This reduction can potentially lead to decreased color stability and negatively affect the product’s shelf life. Furthermore, consumer perception of natural sources of nitrite has led to consideration of other nitrite alternatives. The objective of this study was to determine the efficacy of nitrite-embedded film (NEF) in extending the color stability and shelf life of all-beef bologna, a cured and cooked meat product.

MATERIALS AND METHODS: Three different product formulations were manufactured with five treatments of all-beef bologna. The treatments consisted of a vacuum-packaged, conventionally-cured (sodium nitrite with sodium erythorbate) control (CON), and two alternatively-cured (nitrite from cultured celery juice powder with cherry powder) treatments, with one treatment packaged in vacuum packages (CJP) and the second treatment packaged in NEF pouches (CJP-NEF). An additional two alternatively-cured (Natpre T-10 EML Plus S supplied by Wenda Ingredients, Inc.) treatments included one treatment packaged in vacuum packages (WEN) and the second packaged in NEF pouches (WEN-NEF). After thermal processing and chilling, the bologna was sliced to 6.35 mm thick and 4 slices were packaged in either traditional vacuum packages or NEF pouches. For the duration of the study, all treatments and replications were subsequently stored at 1°C under simulated, continuous retail display conditions using fluorescent lights. Color (HunterLab L*, a*, b*) of external and internal slice surfaces were measured, as was external and internal residual nitrite and nitrate on days 1, 6, 13, 27, 41, 55, 69, 83, and 97 post-packaging. Microbial analysis was conducted on days 0, 7, 14, 30, 60, 90, and 120 for both aerobic and lactic acid bacteria populations with a detection limit of 5 CFU/g. Results were statistically analyzed using a mixed linear model. Significance was determined at a p-value of 0.05.

RESULTS: The results for external package color a* values (redness) indicate that WEN was significantly lesser compared to all other treatments (P<0.05), and WEN-NEF was significantly greater than WEN (P<0.05). CJP was not significantly different from CON at any storage point (P>0.05). External and internal color a* value increased significantly in WEN-NEF over the first 27 days of storage (P<0.05). External and internal residual nitrite values were significantly lesser in both WEN and WEN-NEF compared to all other treatments (P<0.05). Results show increased external and internal redness for low nitrite-containing products (WEN-NEF) packed in NEF without significantly affecting residual nitrite levels (P>0.05). Bacterial growth counts indicated no difference (P>0.05) between treatments.

CONCLUSION: Therefore, results showcase promise of using NEF technology for increasing the color stability in alternatively-cured meat products.

KEYWORDS: Active packaging, Color stability, Cured meat color, Nitrite, Nitrite-embedded film
Objectives: The objective of this study was to evaluate the effect of a plant extract blend containing rosemary and citrus extract on controlling the growth of *Listeria monocytogenes* in highly extended sliced *cook-in* ham during refrigerated storage at 7°C.

Materials and Methods: The experiment comprised two treatments, control (no plant extract addition) and 0.4% of rosemary-citrus extract blend (Cleanatis M1, Naturex). This study was conducted using a standard ham formulation yielding an end product weighing 170% of the raw material used, in this case pork leg meat cuts. The different ham muscles obtained from the pork leg were injected with a brine solution containing water, sodium chloride, phosphates, sodium nitrite, sodium erythorbate, hydrolysed corn syrop 40DE, monosodium glutamate, carrageenan and aromas. Each lot included one batch of samples tumbled (7 cycles/min) under vacuum, at controlled temperature between 0 and 4°C for 9 h and stuffed in polyamide impermeable casings (60mm diameter to form cooked ham pieces with approximately 1.2kg each. The ham pieces were cooked in water tanks (80°C) at a commercial pilot plant to reach 72°C. Cooking time was approximately 1 h and 30 min. After the cooking stage, samples were cooled with ice and refrigerated at 0–4°C overnight The ham pieces were transported to CTC/ITAL on ice box and immediately sliced for microbiological analysis at arrival. The ham slices (2-3mm) were inoculated with 0.1 ml of *L. monocytogenes* ATCC7644, to yield approximately 4 log CFU/g. Inoculated samples were vacuum packaged in gas-impermeable pouches and stored at abuse temperature (7°C), very common in Brazilian retail market, for up to 16 days. Bacterial populations were determined following ISO 11290-2:2017 method. Triplicate samples of each treatment were assayed at 0 time and after 2, 4, 6, 8, 10, and 12 days of storage for *L. monocytogenes* populations. In addition, triplicate inoculated samples were assayed for lactic acid bacteria populations following ISO 15214:1998 method. Data Interactions and main effects were considered significant at P<0.05. The data were submitted to analysis of variance to evaluate the effect of the treatments, storage time and the treatment X time interaction using Statistica 7.0 (StaSoft Inc). The difference between the mean values was evaluated by Tukey’s test at the 95% confidence level.

Results: During storage, the difference between *L. monocytogenes* counts in the treatment containing the plant extracts and control was 0.5 log CFU/g. There was a significant effect (P<0.05) of the interaction treatment *versus* time on *L. monocytogenes* growth, the counts remained 0.5 log lower on samples containing the plant extract blend. Lactic acid bacteria counts were below 1.0 Log CFU/g during shelf life for both treatments.

Conclusion: These data suggest that the plant extracts blend can enhance the safety of sliced *cook in* ham. It is important to evaluate the effect in meat systems without nitrite addition or along with other interventions that inhibit growth, like post packaging pasteurization.

Keywords: cook in ham, *Listeria monocytogenes*, plant extract
OBJECTIVES: Developing meat products with high levels of dietary fiber, low calorie levels, and suitable technological properties creates both opportunity and challenge for the meat industry. β-glucans (βG) are a source of soluble fiber and soluble fiber has been associated with decreasing glycemic index and cardiovascular health. Microcrystalline cellulose (MCC) is an insoluble fiber recommended for application in many food products. So far, interactive effects between βG and MCC with intentions of reaching high levels of dietary fiber in the final product has not been evaluated. This study evaluated the influence of the incorporation of βG, MCC, and a mixture of both on the technological properties of beef emulsions when compared with traditional emulsions using starch.

MATERIALS AND METHODS: βG, MCC, and starch were added to emulsions containing lean ground beef, olive oil (15%), salt (2.36%), and water (22.14%). Inclusion levels of 1%, 2%, and 3% of βG, MCC, or starch were tested independently. Additionally, a mixture of βG (1.5% inclusion level) and MCC (1.5% inclusion level) was tested. The ingredients and hydrocolloids (treatments) were mixed in a food processor until a complete emulsion was obtained. The emulsions were packaged in polyethylene bags, weighed, vacuum sealed, and stored under refrigeration at 4±0.5 °C until further analysis was completed. Cooking loss, βG (%), instrumental color, and texture profile analyses (TPA) were determined using three independent replications. One-way ANOVA analysis and means separation using a Tukey’s multiple comparison adjustment was performed using Statistica version 7.0.

RESULTS: Cooking loss was not different (P > 0.05) among treatments and was less than 1.3% for all treatments indicating the high water holding capacity of the hydrocolloids used in this study. βG remaining in the emulsions after processing were between 0.71 ± 0.02 and 2.07 ± 0.11 (w/w) with a significant difference in the samples containing βG. These levels of βG are potentially available to function during digestion forming viscous solutions in the intestine, which would increase stool volume, and prevent accelerated absorption of glucose and lipids. In both raw and cooked emulsions, emulsions with the greatest levels of MCC (3%) and starch (3%) had greater (P < 0.05) lightness (L*) and presented the greatest (P < 0.05) hardness values compared with all other treatments. In contrast, βG inclusion at 3% presented the least L*(darkest samples), the least hardness values, greatest adhesiveness, and lowest cohesiveness and springiness compared (P < 0.05) with all other treatments. The mixture of βG and MCC showed an intermediate level of hardness, cohesiveness, springiness, gumminess, and chewiness values compared with other treatments.

CONCLUSION: A combination of βG (1.5%) and MCC (1.5%) resulted in emulsions with appropriate technological properties (low cooking loss and intermediate TPA and L* values). The type of hydrocolloid used influenced color and texture of emulsions; although, the formation of the interstitial film in the emulsion was not affected. The consumption of 100 grams of these emulsions could supply approximately 2.5% of the daily dietary fiber intake. The amount of βG in the emulsions could meet recommended intake levels of soluble fiber with one serving (0.75g). Starch could be replaced effectively by an insoluble fiber (MCC) in emulsions to maintain suitable technological properties.

KEYWORDS: beta-glucans, healthy meat emulsions, microcrystalline cellulose, starch
INCORPORATION OF B-GLUCANS IN MEAT EMULSIONS THROUGH MODELING SYSTEMS
S. M. Vasquez Mejia1,2,*, A. de Francisco2, P. L. Manique Barreto2, C. Damian2, A. Wust Zibetti3, H. Suarez Mahecha4, B. M. Bohrer1
1Food Science, University of Guelph, Guelph, Ontario, Canada, 2Food Science and Technology, 3Informatics and Statistics, Federal University of Santa Catarina (UFSC), Santa Catarina, Brazil, 4Food Science and Technology, National University of Columbia, Bogota, Colombia
bbohrer@uoguelph.ca

Objectives: Recent trends suggest novel ingredients can be added to meat products to achieve lower fat while incorporating functional compounds such as soluble fiber into the product. Incorporation of β-glucans (βG) at high quantities into meat products is an opportunity to provide recommended daily soluble fiber intake (3 g/day). This work aimed to evaluate the effects of the incorporation of βG in meat emulsions with modeling systems using carrageenan (C) and starch (S) as supplemental ingredients.

Materials and Methods: Modeling systems were accomplished with the incorporation of βG, C, and S in beef emulsions using an experimental design by “Design for constrained surfaces and mixtures”. The inclusion level of βG were selected based on daily intake requirements of this fiber (FDA recommendation of 3 g/day). Meat emulsions were manufactured with a standard formulation consisting of 59.2% lean beef, 10% olive oil, 24.4% water, 2% sodium chloride, 0.35% sodium polyphosphate, and 0.01% sodium nitrate. The emulsions were then combined with βG, C, and S according to 14 treatments generated by the software. Subsequently, the emulsions were packaged in collagen casings and vacuum sealed, weighed, and refrigerated at 4 ± 1°C until further analysis was conducted. Cooking loss (%), instrumental color, and textural profile analysis (TPA) were analyzed for the determination of optimal emulsion characteristics. Fitting response value was conducted using linear, quadratic, and cubic models. The results were expressed as the mean of three independent replicates and ANOVA was used to evaluate the statistical significance (P < 0.05) of each model equation. Then, the best mathematical models to describe cooking loss, instrumental color, and TPA were selected. The content of βG, TPA parameters, color, and microstructure were performed on the optimized emulsion to determine desirability.

Results: The cubic models were best at describing cooking loss, instrumental color, and TPA parameters, with the lone exception of springiness. Emulsions with greater levels of βG and S had less cooking loss (< 1%), intermediate L* values (between 54 and 62 units), and greater hardness, cohesiveness, and springiness values compared with emulsions with lower levels of βG and S. The βG/S interaction showed a synergistic effect for cooking loss, while the use of C was eliminated during the optimization. The optimized emulsion contained 3.13 ± 0.11% βG, which could meet the daily intake levels of βG recommendations. Cooking loss, lightness (L*), and cohesiveness presented values similar or close to those expected by the optimization. On the other hand, hardness of the optimized emulsion was greater than planned and springiness decreased, possibly because the water was immobilized. Finally, the optimized emulsion presented a greater degree of aggregation, more compact and homogeneous structure with smaller pore size indicating the complete incorporation of hydrocolloids in the protein matrix.

Conclusion: Addition of βG and its mixtures with C and S decreased cooking loss and increased lightness (L*). Homogeneous mixtures were created with greater degree of aggregation, without requiring the binding capability of C. The optimization allowed for manufacturing of emulsions with lesser quantities of S and greater quantities of βG while achieving appropriate technological characteristics with the exception of hardness, which was greater in the optimized emulsion.

Keywords: beta-glucans, functional attributes, mixture design, optimized emulsion, soluble fiber
EVALUATION OF THE INCORPORATION OF B-GLUCANS IN WHOLE MUSCLE CHICKEN BREAST

S. M. Vasquez Mejia 1 2, A. de Francisco 2, R. Sandrina 2, T. da Silva 2, B. M. Bohrer 1
1Food Science, University of Guelph, Guelph, Ontario, Canada, 2Food Science and Technology, Federal University of Santa Catarina (UFSC), Santa Catarina, Brazil
bbohrer@uoguelph.ca

Objectives: The use of soluble fiber (β-glucans) incorporated into whole muscle meat products is still unexplored and needs clarification on a number of factors including 1) if incorporation can be achieved, 2) possible levels of incorporation, 3) stability and bioavailability under conditions of storage and cooking, and 4) influence on the quality characteristics of the meat. Therefore, this study evaluated the incorporation of soluble fiber (β-glucans) in whole muscle chicken meat and identified changes in physical-chemical, textural, and microbiological properties during 9 days of storage under refrigeration at 4°C.

Materials and Methods: Barley β-glucan solutions were incorporated by injection into whole muscle chicken breast 48 hours after slaughter. Three chicken breast samples were injected with a handheld injector with target pump uptake of 20% for each treatment. Treatments were injected at 4°C and included 1) a salt solution (2% NaCl and 0.2% sodium tripolyphosphate (STPP); Treatment A), 2) a β-glucan solution (1.5% of β-glucan; Treatment B), and 3) a combination of salt and β-glucan solution (2% NaCl, 0.2% STPP, and 1.5% of β-glucan; Treatment C). Three independent replications were produced for each treatment. The treatments were injected at 4°C into the chicken breast samples. The samples were stored under refrigeration and evaluated at day 1, 6, and 9 for pH, cooking loss, instrumental color, shear force, microbiology, and thermal behavior by differential scanning calorimetry (DSC). One-way ANOVA analysis and means separation using a Duncan test comparison adjustment were performed using Statistica version 7.0. Statistical significance was assumed at P < 0.05.

Results: Absorption of treatments was 8.15 ± 1.38% (m/m) without a significant difference among treatments, indicating a low absorption capacity of the samples. The maximum amount of β-glucan concentration remaining in the chicken breast after injection was 0.59 ± 0.1%. Cooking loss was less (P < 0.05) in Treatment C on day 6 and 9 compared with Treatment A and Treatment B. Shear force values were between 18 and 25 Newton (N) during storage. Shear force values were less (P < 0.05) in Treatment C samples (day 1 and 6) and Treatment A samples (day 9) when compared with other treatments on given days. No differences (P > 0.05) among treatments were observed in microbiology analyses. Coliforms decreased and psychrotrophic bacteria increased in all treatment groups during the storage period. After cooking, the maximum amount of β-glucan concentration that remained in the chicken breast was less than 0.1%, indicating that soluble fiber concentration is greatly impacted by cooking of whole muscle products injected with both β-glucans alone and in combination with a salt solution.

Conclusion: The application of β-glucans in whole muscle chicken breast did not present advantages in cooking loss with respect to samples injected with salt alone. Under the conditions evaluated, incorporation of β-glucans into whole muscle chicken did not present detrimental effects to product quality or safety. However, after cooking, the fiber concentration in the final product was reduced to levels where it would not be sufficient for health benefits or for the product to be declared as a source of dietary fiber. Therefore, challenges to increase the concentration of dietary fiber in whole muscle meat products continues.

Keywords: beta-glucans, fiber enhancement, fiber inclusion, poultry injection, poultry processing
A COMPARISON OF THE COMPOSITION OF BEEF BACON PRODUCTS SOLD IN SOUTHERN ONTARIO, CANADA

S. Chalupa-Krebsdak 1,*, B. M. Bohrer 1
1Food Science, University of Guelph, Guelph, Ontario, Canada
bbohrer@uoguelph.ca

Objectives: Unlike pork bacon, beef bacon has no standard product identity. Identifying a product using the word “bacon” can imply a certain likeness to pork bacon; however, without a standard identity, this is not necessarily the case. Beef bacon can be produced using a variety of different processing techniques and still currently be labeled “beef bacon”. The potential result is poor product recognition among consumers, a paucity of scientific literature surrounding beef bacon, and ultimately, low process and profit optimization for meat processors. The objective of this study was to examine the composition of commercial beef bacon products sold in southern Ontario, Canada and further investigate the sources of variation. It was hypothesized that due to the lack of standard product identity, there would be a great degree of variability in the appearance and composition of products labelled as “beef bacon”.

Materials and Methods: Beef bacon was purchased at the retail level from six different meat processors in southern Ontario, Canada. Products were analyzed for moisture, protein, and lipid content, along with a visual lean to fat ratio comparison. Moisture, protein, and lipid content were analyzed from a master batch that was created by mincing two strips of beef bacon from three different packages of the same brand (six strips in total per master batch). From the master batch produced from each brand, protein was determined by Dumas, moisture was determined by oven drying at 100°C for 24 hours, lipid was then successively tested via Soxhlet, and other components were determined by difference. The lean to fat ratio was determined by analyzing the proportion of black to white in high contrast black (lean) and white (fat) beef bacon renderings through ImageJ. Statistical analysis included determining descriptive statistics with the MEANS procedure of SAS and determining the fixed effect of brand using the MIXED procedure of SAS.

Results: Different brands of beef bacon ranged significantly in moisture content (45.6 – 66.6%; SEM = 0.4; P < 0.0001), lipid content (5.0 – 36.6%; SEM = 1.0; P < 0.0001), protein content (11.5 – 25.8%; SEM = 0.3; P < 0.0001, and other components (1.4 – 7.8%; SEM = 0.9; P = 0.01). Total slice area among different brands of beef bacon ranged (P < 0.0001) from 38.5 – 130.4 cm² with a SEM of 14.3 cm². Slice lean percentage among different brands of beef bacon ranged (P < 0.0001) from 51.1 – 94.8% with a SEM of 2.0%. Lean:fat among different brands of beef bacon ranged (P < 0.0001) from 0.9 to 26.8 with a SEM of 1.7.

Conclusion: The macronutrient composition and appearance of products that were labeled as “beef bacon” in southern Ontario, Canada, was highly variable. The variability was believed to be due to meat processors utilizing different value-added cuts of beef for the production of beef bacon. Further research is necessary to determine the utilization of different beef cuts for the production of beef bacon and the associated effects on processing parameters, storage capabilities, product composition, and sensory characteristics.

Keywords: bacon, beef bacon, beef bacon composition, value-added beef
THE EFFECT OF BREADFRUIT (ARTOCARPUS ALTILIS) FLOUR ON TEXTURAL PROPERTIES OF COMMINUTED BEEF COMPARED WITH OTHER FLOUR SOURCES

S. Huang 1,*, B. M. Bohrer 1
1Food Science, University of Guelph, Guelph, Ontario, Canada
bbohrer@uoguelph.ca

Objectives: Breadfruit flour as an ingredient in processed meat products has not previously been investigated. The objectives of this study were to investigate the effect of breadfruit (Artocarpus altilis) flour on textural properties of comminuted beef when compared with other flour sources.

Materials and Methods: All flour sources were obtained commercially and were unmodified. Flour sources included breadfruit, corn, soy, tapioca, and wheat. Beef samples originating from one master 15 kg batch of ground beef were comminuted to include 500 g lean beef, 200 g water, and 17.5 g salt. Comminuted beef samples were then prepared with breadfruit flour and other flour sources at varying inclusion levels (0%, 1%, 2%, 3%, 4%, 5%). Cooking loss was determined after comminuted beef samples were prepared and cooked to 72°C in a circulating water bath. Texture profile analysis (TPA) was determined using a texture analyzer (TA.XT Plus; Stable Micro Systems Ltd.) with a 30 kg load cell. The prepared and cooked samples were cut into 15 mm diameter and 10 mm thick samples and were compressed twice to 75% of their original height at a cross-head speed of 1.5 mm/second. Data were collected on the following TPA parameters - hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness, and resilience. The entire experiment (preparation of comminuted beef with flour at differing inclusion levels) was conducted in its entirety three times for each treatment. Statistical analyses were conducted using the MIXED procedure of SAS with fixed effects of flour source, inclusion level, and their interaction. LS means were separated using the PDIFF option with a Tukey’s adjustment. LS means were further separated using polynomial estimate statements to analyze linear and quadratic effects for inclusion level of each flour source.

Results: Flour source, flour inclusion level, and their interaction significantly affected cooking loss ($P < 0.05$). Cooking loss of comminuted beef prepared with breadfruit flour and the other flour sources decreased at differing rates as the inclusion level increased (Linear $P < 0.05$). The interaction of flour source and flour inclusion level affected a number of texture profile parameters, namely hardness ($P = 0.05$) and cohesiveness ($P < 0.01$). Hardness was at similar values and decreased as inclusion level increased (0 – 5%) for comminuted beef prepared with breadfruit and soy flour; while hardness was at greater values and remained constant or increased as inclusion level increased (0 – 5%) for comminuted beef prepared with corn, wheat, and tapioca flour. Cohesiveness decreased in value as inclusion level increased (0 – 5%) for breadfruit and soy flour; while cohesiveness remained constant or increased as inclusion level increased (0 – 5%) for comminuted beef prepared with corn, wheat, and tapioca flour. Overall, there were significant linear relationships ($P < 0.05$) as the inclusion of breadfruit flour was increased (0 – 5%) for cooking loss, hardness, cohesiveness, gumminess, chewiness, and resilience.

Conclusion: The results indicate that breadfruit is a promising ingredient in comminuted beef products. Greater research is warranted to further examine the effect of breadfruit starch on rheological characteristics and microstructure of emulsified beef products; as well as, determine the most appropriate inclusion level of optimal product formation.

Keywords: breadfruit flour, comminuted beef, ingredient technology
EFFECT OF CILANTRO EXTRACT (CORIANDRUM SATIVUM) APPLICATION ON COLOR AND OXIDATIVE STABILITY OF GROUND PORK UNDER DIFFERENT PACKAGING CONDITIONS

J. M. Guedes-Oliveira¹, S. Xue¹*, D. Setyabrata¹, Y. H. B. Kim¹
¹Meat Science and Muscle Biology Lab., Department of Animal Science, Purdue University, West Lafayette, United States julianamgo@gmail.com

Objectives: Prevention of oxidation-related quality defects, such as discoloration and/or rancidity, is crucial to extend shelf-life of fresh meat products during retail display. Ground meat is more susceptible to oxidation than whole muscle/meat due to increased contact surface with oxygen. As one possible mitigating strategy, plant extracts are often applied as natural antioxidants in meat products. Given cilantro is known for high levels of natural antioxidants, such as phenolic acids and flavonoids, it can be hypothesized that cilantro could be utilized to minimize oxidation-related quality defects in ground meat products. The objective of the present study was to evaluate the antioxidant property of cilantro extract (CE) on the color and oxidative stability of pork patties packaged in high-oxygen modified atmosphere (HIOX) and polyvinylchloride (PVC) film during display.

Materials and Methods: Pork hams were trimmed of any visible adipose and connective tissues and minced through a 5-mm meat mincer. Ground pork were divided into four groups and four different CE concentrations (Kalsec®, Kalamazoo, Michigan, USA) were applied reaching a final concentration of 0% (CON), 0.5% (CE05), 1.0% (CE10) and 1.5% (CE15). 25 patties (80 g/patty) were prepared for each treatment. Patties were placed on polystyrene trays with soaker pads, and were subdivided into 2 groups assigned to HIOX (90% O₂, 10% N₂) and PVC-overwrap packaging. Instrumental color, trained panel sensory evaluation (color, rancidity and herb aroma), 2-thiobarbituric acid reactive substances (TBARS) and carbonyl content were measured on the manufacture day (day 0), 7 days of storage under dark and further display under light for additional 7 days at 4 °C. Experimental design was a 4 x 2 factorial design; three independent batches were performed. Data were analyzed using ANOVA and Tukey test at 95% confidence level utilizing XLStat.

Results: Packaging types significantly affected the color of patties, where patties under HIOX showed more discoloration, indicated by lesser a* values and sensory discoloration scores compared to the patties under PVC at day 14 (P < 0.05). In general, no substantial CE impacts on color and color stability of patties were found in patties under HIOX. Conversely, CE10 patties in PVC maintained the greatest a* value throughout the storage and display periods compared to other treatments (P < 0.05). Following the similar trend, CE treatment did not affect lipid oxidation of HIOX-patties; whilst CE10 patties in PVC showed the least TBARS values among treatments at day 14 (P < 0.05). In terms of protein oxidation, CE05-HIOX and CE10-HIOX exhibited lesser (P < 0.05) carbonyls values than CON-HIOX and CE15-HIOX at day 14; while for PVC-patties, only CE10-PVC exhibited lesser (P < 0.05) carbonyls values than CON-PVC at the end of display. At day 14, CE patties under HIOX showed lesser rancidity scores (P < 0.05) compared to other treatments, which was likely related to the stronger herb aroma presented in CE patties (P < 0.05).

Conclusion: CE did not provide positive impacts on surface color of patties during refrigerated storage and retail display. However, inclusion of 1.0% of CE has a potential to reduce lipid and protein oxidation and mask rancidity odor development under HIOX conditions.

Keywords: cilantro, ground pork, natural antioxidant, plant extract
Utilization of Psyllium Husk Powder As a Dietary Fiber Source for Improving the Quality of a Processed Turkey Product

T. Harper 1,*, A. D. Clarke 1

1 Food Science, University of Missouri, Columbia, United States
tlhmb4@mail.missouri.edu

Objectives: The objectives of this study were to determine the effects of different dietary fiber levels (0, 1, 2, or 3 g per serving) of psyllium husk powder on the functional properties of a processed ground turkey product and determine consumer preferences for the processed ground turkey product containing the dietary fiber additive.

Materials and Methods: Each processed turkey product contained 10.9 kg ground turkey, 0.6% sodium alginate, 0.6% encapsulated lactic acid, 0.3% calcium carbonate, 5.0% distilled water, and 0, 1.6, 6.4, or 12.8% psyllium husk powder (PHP). The Genesis R&D Food Formulation and Labeling Software was used to determine the appropriate PHP percentages to create a 55 g serving size with 0, 1, 2, or 3 g of dietary fiber. Samples were prepared and stuffed into fibrous casings and cooked until an internal temperature of 74 °C was obtained via smokehouse using a step cooking method. The entire experiment was repeated three times. During each trial, four samples per treatment were initially used for functionality testing, two samples per treatment were vacuum-sealed and stored at 4 °C for 1 week for a secondary texture profile analysis, and the remaining four samples per treatment were vacuum-sealed and stored at -10 °C for sensory evaluation. Forty-nine panelists volunteered for the taste panel in which each panelist evaluated 12 samples on a 9-point hedonic scale regarding flavor, texture, and appearance, and were asked to answer one "purchasing" question. Data was analyzed using One-Way ANOVA through the general linear model of SAS. Means were separated by least significant difference when P < 0.05 values were detected.

Results: The cook yield values concluded that the 6.4 and 12.8% PHP treatments had significantly (P < 0.05) higher percentages, 90.0 and 90.6%, respectively. There were no significant (P > 0.05) differences observed for the raw and cook pH, cooked water activity, and raw water holding capacity values. Within the raw samples, as the fiber percentage increased the moisture content significantly (P < 0.05) decreased. The 1.6 and 6.4% PHP cooked treatments showed the highest values (P < 0.05) for moisture content at 70.1 and 69.4%, respectively. The 12.8% PHP had the highest significant (P < 0.05) values for cooked water holding capacity, hardness, springiness, cohesiveness, gumminess, chewiness, and resilience when compared to the other three treatments. There was no significant (P > 0.05) interaction observed between the texture profile analysis on week 0 and week 1. As the fiber percentage increased, the consumers’ degree of liking for flavor and appearance significantly (P < 0.05) decreased; however, no significant (P > 0.05) difference was observed for the texture category.

Conclusion: Overall, this study indicated that adding dietary fiber into a processed meat product can benefit functionality properties such as cook yield, moisture content, water holding capacity, and texture. Ultimately though, creating a product that contains an adequate amount of psyllium husk fiber for the health benefits can become challenging and negatively impact sensory evaluation. Potentially, further research can be done with this fiber at the same or lower levels to determine shelf-life, microbiological growth, and consumer acceptability if incorporated into a specific product category.

Keywords: calcium alginate, functional product, meat extender
INFLUENCE OF PACKAGING AND RETAIL DISPLAY LIGHTING ON BEEF FLAVOR AND SENSORY ATTRIBUTES

T. Cramer1,*, J. F. Legako1, J. C. Brooks1
1Department of Animal and Food Sciences, Texas Tech University, Lubbock, United States
traci.cramer@ttu.edu

Objectives: This study aimed to evaluate various packaging methods and retail display lighting conditions on the consumer preference of steaks from five different muscles.

Materials and Methods: Subprimals (n = 40 strip loins, 60 shoulder clods, 60 tenderloins, 60 top butts, 24 inside rounds) were collected from USDA choice beef carcasses and shipped to Texas Tech University. At 7d postmortem muscles (Longissimus lumborum, LL; Triceps brachii, TB; Psoas major, PM; Semimembranosus, SM; Gluteus medius, GM) were fabricated and sliced into 1 in. steaks. Steaks (n = 120 per muscle) were randomly assigned to four packaging treatments: vacuum rollstock (ROLL); high-oxygen modified atmosphere (80% O₂/20% CO₂; HIOX); traditional overwrapped and stored in a motherbag with carbon monoxide (0.4%CO/30%CO₂/69.6%N₂; CO); and traditional overwrapped (OW), which was vacuum packaged until immediately prior to display. Steaks were stored an additional 13 days prior to retail display; they were displayed under fluorescent lights (FL) or light-emitting diodes (LED), with a third treatment remaining in dark storage (DARK). Steaks were displayed for 72h and then individually vacuum packaged. Steaks were cooked to a medium doneness and consumers (n=300) rated flavor, juiciness, tenderness, and overall liking. Significant (P=0.05) three-way interactions were evaluated as slices of package×light interactions within each muscle types.

Results: A packaging×light interaction influenced flavor liking (P=0.02). Dark storage improved flavor liking in OW and CO compared with FL for those treatments (P<0.05). Rollstock had greater flavor liking scores than other packaging treatments among FL and LED display (P<0.05). For packages placed under dark storage, HIOX had the lowest (P<0.05) flavor liking. Muscle type influenced flavor liking (P<0.0001), with PM being more liked (P<0.05) than all other muscles. The SM had the lowest (P<0.05) flavor liking compared to all other muscles. A muscle×packaging×light interaction was observed for juiciness liking (P=0.0003). For GM steaks, each packaging type displayed under FL had the greatest (P<0.05) juiciness liking. For the SM, HIOX had less (P<0.05) juiciness than ROLL under FL display. Under LED display SM HIOX was lower (P<0.05) in juiciness compared with SM CO. Tenderness liking also showed a muscle×packaging×lighting interaction (P=0.002). In GM ROLL-DARK was less (P<0.05) tender than ROLL-FL and ROLL-LED, which did not differ (P>0.05). For LL, CO was more tender (P<0.05) than HIOX steaks under FL display. Within SM, ROLL-DARK had similar (P<0.05) tenderness as OW-DARK and each were more (P<0.05) tender than all other packaging and lighting treatments. In TB, OW-FL had greater (P<0.05) tenderness than all other TB steaks under FL display. The TB ROLL-LED and CO-LED were more (P<0.05) tender than each other packaging type under LED display. A muscle×lighting interaction influenced overall liking (P=0.05), where consumers liked PM most (P<0.05) and SM least (P<0.05), regardless of lighting treatment.

Conclusion: This study indicates that both lighting and packaging influence palatability of multiple beef muscles. Therefore, specific environments may be selected which lend to greater palatability.

Keywords: Flavor, Light-Emitting Diode, Packaging, Retail Display
Objectives: The objective of this study was to evaluate the trained sensory panel and Warner-Bratzler shear force (WBSF) responses to five different grilling temperatures on USDA Select strip steaks.

Materials and Methods: Thirty USDA Select strip loins were collected from a major packing plant where carcass data was collected, then aged for 14 days. After aging, 10 steaks were cut 2.54 cm thick from each loin, randomized among 1 of 5 treatment grill surface temperatures (149°C, 177°C, 204°C, 232°C, or 260°C), and given a WBSF or trained sensory panel designation. Steaks were individually vacuum-packaged and placed in frozen storage until analyses were performed. Individual steaks were thawed in refrigerated storage (4°C) for 12 to 24 hours prior to cooking. Steaks were cooked on a commercial flat top grill, preheated to the designated grill surface temperature treatment. All steaks were cooked to an internal end point temperature of 71°C, turning once at 35°C. Six, 1.3 cm diameter core samples were collected from each WBSF steak after being refrigerated (4°C) overnight. Steaks designated for trained panel were cut into 1.3cm cubes and served, warm, to an expert trained beef flavor descriptive panel. Each steak was evaluated on a 16-point intensity scale for 18 flavor attributes, tenderness, and juiciness. Data were analyzed using the GLM procedure in SAS with significance set at an alpha value < 0.05, where grilling temperature served as the main effect and loin, panelists, day, and serving order served as covariates. The LSMeans procedure in SAS was used to separate significant means (P < 0.05).

Results: Warner-Bratzler shear force values were not affected (P > 0.05) by grill temperature and were generally low (mean WBSF= 3.1779 kg). At lower grill temperatures, beef identity, brown, roasted, burnt, and bitter were lower (P < 0.05) and bloody/serumy, sour, and juiciness were higher (P < 0.05). As grill temperatures increased, bloody/serumy, sour, and juiciness were lower (P < 0.05) and beef identity, brown, roasted, burnt, and bitter were higher (P < 0.05).

Conclusion: Grill surface temperature can be used to change beef flavor trained sensory panel scores, but has no impact on tenderness.

Keywords: Beef Flavor, grilling, sensory evaluation
Meat and Poultry Processing, Ingredient Technology and Packaging

69- EFFECTS OF FABA BEAN (VICIA FABA) INGREDIENTS ON TEXTURAL AND SENSORY PROPERTIES OF LOW-FAT PORK BOLOGNA

X. Wei 1,*, M. Tulbek 2, J. Wasunudara 3, P. Shand 1

1University of Saskatchewan, 2AGT Food and Ingredients, 3Agriculture and Agri-Food Canada, Saskatoon, Canada

xiw630@mail.usask.ca

Objectives: Faba beans (FB) have a long history of consumption as feed and food. Due to the significant amount of macronutrients, especially proteins (35% in cotyledon flour, 60% in protein fraction, and 13% in starch fraction), FB is an economical, gluten-free and non-GMO source to enhance the protein level in comminuted meat products. The objective of this study was to evaluate the feasibility of utilizing FB ingredients as binders in bologna products with comparison to two commercial products: pea starch (6% protein) and wheat flour (12% protein).

Materials and Methods: The control bologna formulation included 70.7% pork picnic, 26.8% water, and 2.5% of other ingredients (salt, sodium tripolyphosphate, sodium erythorbate, sodium nitrite and seasoning) with targeted fat content at 10-11%. Six binders: wheat flour (WF), pea starch (PS), Malik FB cotyledon flour (MFB), Fabelle FB cotyledon flour (FFB), FB starch fraction (FBS), and FB protein fraction (FBP) were substituted for water at 3% (w/w), respectively. The meat was ground through a 3.8 mm plate, and then chopped and mixed with nonmeat ingredients in a bowl cutter. An emulsion mill and vacuum tumbler were used to develop a fine textured bologna without air holes. Batters were stuffed into waterproof casings and cooked in a water bath until the internal temperature reached 72 °C. Effect of binders on cook loss, expressible moisture (centrifugation), purge loss (2 weeks storage), surface color (Hunter L*, a*, b*), texture (TPA and torsional gelometry) was studied. Twelve trained panelists evaluated the intensity of firmness, cohesiveness, juiciness, graininess, overall flavor, and foreign flavor of cooked bologna. Panelists were also asked to rate the overall acceptability of each sample. Three replications were performed. Data were analyzed using the PROC MIXED procedure of SAS 9.4, and means were separated by Tukey’s test (P < 0.05).

Results: All binders significantly (P < 0.05) increased viscosity of the raw meat batters. The cook loss of all bologna treatments was low (0.5%, w/w), and there was no significant effect on purge loss among all binders. WF and FBP significantly (P < 0.05) decreased expressible moisture content when compared to the control. The ranges of L* (69-70), a* (16-18), or b* value (14-16) of the cooked bologna surfaces were narrow for all samples. The TPA results showed binders did not change the hardness, cohesiveness, springiness, and chewiness. WF significantly (P < 0.05) increased the torsional true stress at failure, but binders had no effect on shear strain, when compared to the control. Sensory results indicated only addition of WF gave significantly (P < 0.05) higher sensory firmness scores than the control. Addition of all binders significantly (P < 0.05) reduced the perception of juiciness. Binders at 3% addition level had no effect on graininess, overall flavor, and foreign flavor. No significant difference found in overall liking among bologna with any of the binders.

Conclusion: The addition of FB ingredients at 3% would not negatively affect the color, textural, and sensory properties of bologna products, and functioned similarly to other binders in current use. At the current level of inclusion, FB flour and FBP would contribute 1% and 2% additional protein, respectively to the bologna. FB may offer a useful option to increase protein content and replace traditional binders in the current market.

Keywords: Faba bean, bologna, TPA, binder, sensory
Meat and Poultry Quality

70- **IS BLADE TENDERIZATION STILL NEEDED FOR INHERENTLY TENDER TOP SIRLOIN STEAKS?**

A. R. Murray 1,*, S. B. Tindel 1, A. N. Arnold 1, R. K. Miller 1, D. B. Griffin 1, K. B. Gehring 1, J. W. Savell 1

1Animal Science, Texas A&M University, College Station, United States

a.arnold@tamu.edu

**Objectives:** Although blade tenderization has historically been used to enhance tenderness, it may create a food safety concern. Therefore, the objective of this study was to determine if consumer satisfaction improves by blade tenderizing today’s inherently tender beef.

**Materials and Methods:** Paired USDA Choice top sirloin butts (n = 20 total pieces) were collected from 10 carcasses representative of the typical carcass in today’s fed beef market. Carcasses from dairy-type cattle, *Bos indicus*-influenced cattle, and from cattle over 30 months of age were not used. No selection preference was given to carcass sex class, weight, or presence or absence of black hide, but excessively heavy or light carcasses that would not yield a representative sample of what today’s consumers call an “average steak” were not selected.

Subprimals were subjected to a 28-day refrigerated wet aging period before treatments were administered, with “Day 0” defined as the day of carcass fabrication. Top sirloins from the left side of the carcass were blade tenderized once before portioning into steaks, whereas top sirloins from the right side of the carcass received no treatment and served as the control. Paired top sirloin butts were subjected to Warner-Bratzler Shear (WBS) force testing as a measure of objective tenderness. Consumer sensory evaluation was used to determine if consumer liking of tenderness, flavor, juiciness, and overall liking differed for steaks from blade tenderized (BT) subprimals versus those from non-blade tenderized (NBT) subprimals. Steaks were cut into fourths after cooking, with each sample (one-fourth of a steak) presented on a plate along with a metal steak knife and a plastic fork. This serving style allowed panelists to cut into the product, which sometimes influences consumer acceptability. Data were analyzed with paired t-tests using the matched pairs function of JMP (Version 12, SAS Institute, Inc., Cary, NC), at an alpha of 5%.

**Results:** Consumers assigned BT steaks higher (*P* < 0.05) ratings for tenderness liking rating, flavor liking rating, and overall liking compared to NBT steaks. No differences (*P* > 0.05) were seen for juiciness liking ratings or WBS force values.

**Conclusion:** Although today’s beef is inherently tender, these data show that blade tenderization improved consumer sensory panel ratings for tenderness, flavor, and overall likeability for beef top sirloin steaks. Therefore, discontinuing the use of blade tenderization could result in less favorable consumer eating experiences.

**Keywords:** beef, blade tenderization, consumer panels, top sirloin, Warner-Bratzler shear force
Meat and Poultry Quality

71- COLOR, METMYOglobin REDUCTASE ACTIVITY, AND LIpID OXIDATION IN GROUND BEEF PATTIES DURING RETAIL DISPLAY FROM ANGUS STEERS FED ENDOPHYTE-INFECTED TALL FESCUE SEEDS.

A. Holtcamp 1,*, A. Sukumaran 1, B. Karisch 1, D. Burnett 1, T. Dinh 1
1Animal and Dairy Sciences, Mississippi State University, Mississippi State, United States
ajh420@msstate.edu

Objectives: Endophyte-infected tall fescue has toxic ergot alkaloids that can bind to serotonin receptors and cause vasoconstriction in cattle, which reduce animal’s ability to dissipate heat. Heat stress has been shown to increase oxidative stress, i.e., an increase in reactive oxygen species in tissues. The objective of the current study was to determine the effects of feeding endophyte-infected tall fescue seeds to Angus steers on color, metmyoglobin reductase activity (MRA), and thiobarbituric reactive substances (TBARS) in ground beef patties.

Materials and Methods: Twelve Angus steers, blocked by initial BW, were randomly fed with either KY32 (E- or control; n = 6) or KY31 seeds (E+ or treatment; approximately 20 µg of ergovaline/kg BW; n = 6). Steers were fed individually using Calan® gates during a 70-d feeding period in the summer of 2015, followed by a 149-d withdrawal period, and a 64-d feeding period in the winter of 2016. Following the second feeding period, steers received a dose of Ralgro®, finished on summer perennial pastures for 66 d, and slaughtered at approximately 21 mon of age and 500 kg of BW. Lean and fat trimmings were collected at 72 h post-mortem, vacuumed packaged, and stored at -20°C until ground beef production. Two 3-oz patties were placed on black Styrofoam® trays, overwrapped with PVC film, and placed under simulated retail display conditions (2ºC, 900-lux, and 80% RH) for 7 d. The color was measured repeatedly on the same tray per animal every 24 h using a Hunter Lab MiniScan 4500L spectrophotometer (Hunter Associates Inc, Reston, VA) on the surface of the patties. For TBARS and MRA, one tray per animal was withdrawn at 0, 1, 3, 5, and 7 d. Thiobarbituric reactive substances were extracted in 10% trichloroacetic acid, reacted with 0.02 M TBA solution, and quantified at 532 nm (Spectra max plus 384; Molecular Devices, Sunnyvale, CA). Metmyoglobin reductase activity (µM of MMb reduced/min/g of muscle) was determined by extracting muscle reductases, reacting them with equine skeletal metmyoglobin, and measuring deoxymyoglobin at 580 nm (Spectra max plus 384; Molecular Devices, Sunnyvale, CA). Statistical analysis was performed by the GLIMMIX procedure of SAS 9.4 (SAS Institute Inc., Cary, NC) at 0.05 level of significance.

Results: Endophyte-infected tall fescue seeds did not impact lightness (L*), oxymyoglobin (OMb), and metmyoglobin (MMb; P ≥ 0.467). However, deoxymyoglobin was 0.5% greater in E+ patties (P = 0.017). For redness (a*) there was a treatment × day interaction, in which a* between E- and E+ patties on d 0, 1, 3, and 4 was similar (P ≥ 0.166), however, a* was greater in E+ patties on d 2 and 5 (P ≤ 0.027). Feeding of endophyte-infected tall fescue seeds had no impact on TBARS or MRA (P ≥ 0.082). As expected, TBARS were increased from 1.53 to 3.42 mg MDA/kg and MRA was decreased from 5.57 to 2.16 µM MMb reduced/min/g over 5 d of the retail display (P < 0.001).

Conclusion: Feeding endophyte-infected tall fescue seeds with long withdrawal periods did not have significant impacts on color, metmyoglobin reductase activity, and lipid oxidation in ground beef.

Keywords: beef, metmyoglobin reductase, tall fescue, TBARS
Meat and Poultry Quality

72- EFFECTS OF QUALITY GRADE AND AGING TIME ON YIELDS, OBJECTIVE TENDERNESS, PROTEIN DEGRADATION, AND MICROBIAL GROWTH OF DRY AND WET AGED SHORT LOINS

A. M. Cavender 1,*, Y. Yeh-Parker 1, F. M. Giotto 1, B. S. Ferguson 1, A. S. De Mello 1

1Department of Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, United States
amilton@cabnr.unr.edu

Objectives: Dry-aged beef is commonly merchandised by meat purveyors, upscale restaurants, and some retailers as a product with superior tenderness and flavor when compared to wet-aged. In order to provide a clearer understanding of this popular hypothesis, this study aimed to investigate in depth objective tenderness indicators of dry and wet-aged beef.

Materials and Methods: A total of 48 short loins (IMPS 174; 24 Prime and 24 Choice) were commercially acquired and assigned to a 2x2x2 factorial design. Fixed effects were: aging method (dry and wet), USDA quality grade (Choice and Prime), and aging time (21 and 42 d). Dry-aged samples were held at 2°C ±2. Cooler humidity was maintained at 80-85% and air speed at 2 m/sec. Wet aged samples were stored under same temperature in their original vacuum sealed bag. On day 21 and 42, the designated samples were weighed to calculate final yields and swabbed for Aerobic Plate Counts (APC). Strip loins were fabricated and two 2.54-cm steaks were obtained from each strip loin. For Warner-Bratzler Shear Force (WBSF), a minimal of 6 cores were sheared with a V blade set at 250 mm/min. For Slice Shear Force (SSF), the 5 cm slice was sheared with a straight blade set at 500 mm/min. Western blots were performed to evaluate degradation of desmin (38 KDa band). Data were analyzed using PROC GLIMMIX of SAS.

Results: A significant interaction between aging method and time was observed on final short loin yields. When dry-aged, higher shrinkage (%) was observed on 42-d samples when compared to 21-d (8.99 A vs 4.68 B, respectively). No effect of time within wet aging was noted. Wet-aged samples had significantly higher APC when compared to dry-aged, whereas longer aging time (42 d) led to higher counts when compared to 21 d. Slice shear force analysis revealed an interaction between grade and aging method (P = 0.04). Dry-aged Choice samples had lower SSF values when compared to wet-aged, whereas within wet aging, Prime loins resulted in lower shear force values when compared to Choice. For WBSF, statistical differences were observed for individual fixed effects of time and grade (P = 0.023 and P = 0.016, respectively) Steaks from loins aged 42 d were more tender than steaks aged 21 d. Prime steaks had lower WBSF compared to Choice. Within aging methods, wet-aged Prime steaks had higher degradation of desmin when compared to Choice. However, desmin degradation of dry-aged Choice and Prime loins did not differ.

Conclusion: Extending dry-aging time from 21 to 42 days significantly increased yield loss of short loins. Dry-aging beef decreased microbial counts when compared to wet-aging. Regarding objective tenderness methods, WBSF and SSF provided a detailed perception of effects of grade, aging method, and aging time. Dry-aging does not influence shear force of steaks from different USDA grades. However, Prime steaks usually had lower shear force values than Choice when wet aged. Overall, Prime steaks aged for 42 days had lower shear force than steaks aged for 21 d. This is in agreement with desmin degradation, which was higher on Prime wet-aged steaks. Although lower microbial loads were observed on dry-aged beef, wet-aging Prime showed lower shear force when compared to dry aging.

Keywords: Dry aging, Proteolysis, Tenderness, Wet aging
COLOR STABILITY OF LONGISSIMUS LUMBORUM AND PSOAS MAJOR MUSCLES FROM GRAIN-FINISHED Bos indicus CATTLE

A. P. A. A. Salim \(^1\) \(2\)\(^*\), S. P. Suman \(^1\), A. C. V. C. S. Canto \(^1\), B. R. C. Costa-Lima \(^1\), F. M. Viana \(^2\), M. L. G. Monteiro \(^3\), T. J. P. Silva \(^3\), C. A. Conte-Junior \(^2\) \(3\)

\(^1\)Animal and Food Sciences, University of Kentucky, Lexington, United States, \(^2\)Instituto de Quimica, Universidade Federal do Rio de Janeiro, Rio de Janeiro, \(^3\)Departamento de Tecnologia de Alimentos, Universidade Federal Fluminense, Niteroi, Brazil

spsuma2@uky.edu

**Objectives:** Fresh beef color is a muscle-specific trait, which is highly influenced by animal genetics and feeding management. Brazil is a major beef producer, and 80% of Brazilian cattle are Bos indicus animals. Finishing beef cattle on grains is increasing in Brazilian production systems. While the effects of muscle source on color stability of pasture-finished Bos indicus cattle have been examined, its influence on color stability of grain-finished Bos indicus animals has not been evaluated. Therefore, the objective of this study was to examine the color stability of longissimus lumborum (LL) and psoas major (PM) muscles from grain-finished Bos indicus cattle.

**Materials and Methods:** LL and PM muscles were obtained 24 h postmortem from eight (n = 8) carcasses of purebred Nellore (Bos indicus) bulls that were grain-finished for 90 days prior to harvest. The muscles were fabricated into 1.5-cm steaks. The steaks were individually packaged in polystyrene trays, overwrapped using oxygen-permeable polyvinyl chloride film, and stored at 4°C for 9 days in the darkness. Lightness (\(L^*\)), redness (\(a^*\)), yellowness (\(b^*\)), color stability (R630/580), and metmyoglobin reducing activity (MRA) were evaluated on days 0, 5 and 9. The effects of muscle source and storage were analyzed using XLSTAT with the repeated measure option. The differences among the means were detected at 5% significance level.

**Results:** The LL steaks demonstrated greater (\(P < 0.05\)) \(a^*\), R630/580, and MRA values than PM ones on days 5 and 9 of storage. PM steaks exhibited a decrease (\(P < 0.05\)) in \(a^*\), R630/580, and MRA during storage, whereas \(a^*\), R630/580, and MRA remained stable (\(P > 0.05\)) in LL steaks. In addition, LL and PM exhibited similar (\(P > 0.05\)) \(L^*\) and \(b^*\) values throughout the storage.

**Conclusion:** Muscle source influenced the color stability of fresh beef from grain-finished Bos indicus cattle. Muscle-specific strategies may be utilized to improve the color stability of beef from grain-fed Bos indicus animals.

**Keywords:** Color stability, Muscle source, Nellore cattle
Objectives: Synthetic, BHA and BHT, and natural substances such as rosemary are common antioxidants used in meat products to slow lipid oxidation. Sorghum bran, an important cereal in the world, contains either tannins or anthocyanins (high tannin and onyx, respectively) and have antioxidant properties that can be used in food products, including meat. Objective was to evaluate antioxidant properties, pH, color, and sensory attributes of high tannin and onyx sorghum bran in frozen ground pork and ground dark meat chicken products.

Materials and Methods: Pork trimmings (35% lipid) and dark meat chicken (8% lipid) were separated ground (4.8 mm) and mixed with water and salt at Tyson Foods into four treatments: 1) Control – no antioxidant; 2) 0.2% of rosemary plus green tea extract; 3) 0.5% high tannin sorghum bran; and 4) 0.5% of onyx sorghum bran. Pork pizza toppings (ground pork) and ground chicken were cooked, frozen, packaged using oxygen permeable package and stored for 0, 3, 6, 9 and 12 mo at -23°C. At 0, 3, 6, 9 and 12 mo of storage, frozen pre-cooked pork pizza toppings and ground chicken were heated in a microwave until the internal temperature reached 74°C. Samples were used for sensory panel, TBARS, pH, and objective and subjective color were determined. Cooked pork pizza toppings and ground chicken were used for a trained meat descriptive flavor attribute panel to determine the treatment effects. Data were analyzed using Proc GLM of SAS (SAS Institute, Cary, NC) at P≤0.05, using the STDERR PDIFF function. Antioxidant treatment and storage time was used as main effects, and their interactions were also included in the model.

Results: Pork pizza toppings TBARS values increased linearly with increased storage. Rosemary and both sorghum bran treatments resulted in similar TBARS values, lower than control. Onyx sorghum addition to pork toppings resulted in darker, redder color compared to other treatments (P<0.0001). Increase of storage time decreased objective red color up to 6 mo and did not change with additional storage. Subjective color was not affected (P=0.09) by treatment. Both treatments with sorghum had darker objective color. Control pork pizza toppings had higher rancid flavor across treatments (P<0.001), and rancid flavor was low for up to 6 mo of storage then slightly increased with 9 and 12 months of storage (P < 0.001). Onyx sorghum bran had the highest level of sorghum flavor in the pork pizza toppings followed by high tannin sorghum, rosemary and control. TBARS values were higher (P<0.0001) for control ground chicken compared to treated products, and TBARS values for storage time did not change (P>0.01). Onyx sorghum bran addition to ground chicken resulted in darker subjective and objective color, and redder objective color. Control chicken had slightly higher refrigerator stale and warmed-over flavor than treatments (P<0.001). In the ground chicken, onyx sorghum bran had the highest amount of sorghum flavor, followed by high tannin sorghum, rosemary and control.

Conclusion: In conclusion, high tannin sorghum or onyx sorghum can be added to pork pizza toppings and dark chicken meat as a natural antioxidant. Their addition decreases rancid flavor and minimizes lipid oxidation. It is recommended that either high tannin or onyx sorghum bran to be added to control lipid oxidation. However, the addition of sorghum bran, especially onyx sorghum bran, resulted in products with slightly darker color, and sorghum flavor.

Keywords: chicken, Natural antioxidant, pizza toppings, pork, TBARS
**Meat and Poultry Quality**

**75- EFFECT OF CONTROLLED TEMPERATURE-TIME VARIATION DURING THE CHILLED STORAGE OF BEEF ON TENDERNESS CHARACTERISTICS**


1 Centre for Red Meat and Sheep Development, NSW Department of Primary Industries, Cowra, 2 Graham Centre for Agricultural Innovation, 3 School of Agricultural and Wine Sciences, Charles Sturt University, Wagga Wagga, 4 NSW Department of Primary Industries, Cowra, 5 School of Animal and Veterinary Sciences, Charles Sturt University, Wagga Wagga, 6 Elizabeth Macarthur Agricultural Institute, NSW Department of Primary Industries, Menangle, Australia

ashleigh.kilgannon@dpi.nsw.gov.au

**Objectives:** The objective of this project is to provide industry with temperature-time management strategies for ageing beef by establishing the effects of temperature range, ageing duration, and their combination, on beef tenderness.

**Materials and Methods:** Beef loins (n=40; M. longissimus lumborum) were randomly selected from commercially processed carcases typical of prime grass-fed cattle in Australia from the boning room of a commercial abattoir. Loins were divided into 8 equal portions, vacuum-packaged and assigned to one of 72 temperature-time combinations (TTC), using ageing temperatures set at 0.5°C (control; average 0.62±2.08°C), 3°C (average 5.04±1.27°C), 5°C (average 5.86±0.95), 7°C (average 8.2±1.11°C) and ageing time intervals of 4d, 6d, 8d, 10d, 12d, and 14d (control). Each sample’s temperature remained constant over each interval with at most one variation of treatment temperature within the total time. At 6d, 8d, 10d, 12d, 14d, samples were analysed for particle size (PS); a determination of myofibrillar degradation using laser diffraction peak, ultimate pH (pHu), and cooked to an internal temperature of 71°C for shear force analysis (SF); measured in Newtons, and). SF and PS data were analysed with pHu as a covariate, using a linear mixed model fitted with the fixed effects of TTC and random effects of repeat and loin, as well as their interactions with TTC.

**Table 1:** Mean, standard deviation and range of ageing time intervals with regards to particle size (PS) and shear force (SF), including pH as a covariate. Lower PS indicates higher tenderness; lower SF indicates higher tenderness.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Time Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>PS (µm)</td>
<td>Mean (±sd)</td>
</tr>
<tr>
<td></td>
<td>Range (min-max)</td>
</tr>
<tr>
<td>SF (N)</td>
<td>Mean (±sd)</td>
</tr>
<tr>
<td></td>
<td>Range (min-max)</td>
</tr>
</tbody>
</table>

**Results:** The only significant contrast was between temperatures within 6d ageing time for PSA. Table 1 shows the distribution of the predicted means (adjusted for carcass variation) of temperature-time combinations (mean, min, max, standard deviation) for each time interval. The distribution of predicted means is similar across ageing times (including Controls), with the exception of 6d for PSA, which has a higher mean than other intervals.

**Conclusion:** The decreasing particle size over ageing until 10 days is evidence of proteolysis reinforcing the importance of ageing in the tenderisation of beef. The lower shear force means indicate that beef subjected to temperature time combinations were marginally more tender than the controls, but the overall differences would not be of practical significance. These findings suggest that alternative temperature time combinations result in the same level of shear force as observed in typical practice. Overall, the results suggest that it may be possible to age high quality prime beef for shorter periods without negatively impacting tenderness, primarily observed by comparison of the shear force treatment means with shear force control means.

**Keywords:** Beef, Particle Size, pH, Shear Force
**Meat and Poultry Quality**

76- CORRELATION OF CHICKEN BREAST (PECTORALIS MAJOR) QUALITY AND SENSORY ATTRIBUTES WITH CHICKEN THIGH QUALITY AND SENSORY ATTRIBUTES

B. M. Bohrer 1,*, S. Chalupa-Krebzdak 1, L. M. Wang 1, S. Huang 1, S. M. Vasquez Mejia 1
1Food Science, University of Guelph, Guelph, Ontario, Canada
bbohrer@uoguelph.ca

**Objectives:** In other meat commodities, the relationship between quality and eating experience of different cuts within the same carcass has garnered significant attention. While the poultry industry typically prioritizes lean growth and less information is available about the relationship of quality and sensory attributes of different cuts throughout the carcass, it is imperative to commit research efforts to better understand these relationships. Therefore, the purpose of this study was to characterize the relationship between chicken breast (pectoralis major) quality and sensory attributes with chicken thigh quality and sensory attributes.

**Materials and Methods:** Chickens of five different genetic strains were slaughtered at a common ending point at a commercial processing facility in Southern Ontario and chilled using immersion chilling. Fifty whole chicken carcasses were fabricated into a nine-piece fabricated chicken according to North American Meat Institute specifications. The chicken breast portion was further fabricated into a boneless, skinless breast and the chicken thigh portion was further fabricated into a boneless, skinless thigh. Immediately following fabrication, right side breast and thigh samples were assessed for pH, instrumental color (L*, a*, and b* using a Minolta colorimeter), and prepared for a 48-hour drip loss evaluation. Sensory attributes (tenderness, juiciness, flavor, and acceptability) using a trained sensory panel and cooking loss were assessed on the breast and thigh samples from the left side of the carcass. The trained sensory panel had a pool of twelve panelists, four of which were used for each sensory session. Eight breast or thigh samples were served at each of the ten sensory sessions. Correlation coefficients between traits were computed using the CORR procedure of SAS and considered significantly different from 0 at \( P < 0.10 \). Correlations were considered weak (in absolute value) at \( r \leq 0.35 \), correlations were considered moderate at \( 0.36 \leq r \leq 0.67 \), and correlations were considered strong at \( r \geq 0.68 \).

**Results:** Only the parameters with correlation coefficients that were different from 0 (\( P < 0.10 \)) were reported. Breast pH was weakly correlated (\( r = 0.25; \ P = 0.07 \)) with thigh pH, breast color (L*, a*, and b*) was weakly correlated (\( r \leq 0.30; \ P \geq 0.04 \)) with thigh color, and breast 48-hour drip loss was weakly correlated (\( r = 0.35; \ P = 0.01 \)) with thigh 48-hour drip loss. Breast sensory tenderness was moderately correlated (\( r = 0.38; \ P < 0.01 \)) with thigh sensory tenderness, while all other sensory parameters measured between breast and thigh samples were not significantly correlated (\( P \geq 0.24 \)). Breast sensory acceptance was strongly correlated with breast sensory juiciness (\( r = 0.86; \ P < 0.01 \)) and moderately correlated with breast sensory tenderness (\( r = 0.53; \ P < 0.01 \)) and breast sensory flavor (\( r = 0.66; \ P < 0.01 \)). Thigh sensory acceptance was strongly correlated with thigh sensory juiciness (\( r = 0.80; \ P < 0.01 \)) and moderately correlated with thigh sensory tenderness (\( r = 0.52; \ P < 0.01 \)) and thigh sensory flavor (\( r = 0.62; \ P < 0.01 \)).

**Conclusion:** Breast quality and sensory attributes were generally weakly correlated with thigh quality and sensory attributes. Further investigation into factors affecting breast and thigh quality parameters (pH, color, drip loss, and cooking loss) and their effect on sensory attributes are warranted.

**Keywords:** chicken, chicken breast, chicken thigh, correlation, sensory evaluation
**Meat and Poultry Quality**

77- IDENTIFYING THE INFLUENCE OF POST-MORTEM AGING LENGTH AND METHOD ON FLAVOR AND TENDERNESs OF BEEF STRIP LOINS

B. A. Foraker 1,*, D. R. Woerner 1, D. A. Gredell 1, J. F. Legako 2, J. D. Tatum 1, J. N. Martin 1, R. J. Delmore 1, A. Heuberger 1, K. E. Belk 1

1Colorado State University, Fort Collins, CO, 2Texas Tech University, Lubbock, TX, United States

bforaker@colostate.edu

**Objectives:** Aging of beef is one widely-accepted method to enhance palatability characteristics. There has not been a study published aimed specifically at identifying the effect of aging on flavor compound development. Therefore, the objective of this study was to identify compositional changes in flavor and tenderness of beef aged at different lengths and using different methods.

**Materials and Methods:** Pairs of strip loins (n = 38) were collected from commodity USDA Choice beef carcasses and fabricated into a total of eight sections per carcass. Sections were randomly assigned to 1 of 8 aging treatments: 1) 3 d wet-aged; 2) 14 d wet-aged; 3) 28 d wet-aged; 4) 35 d wet-aged; 5) 49 d wet-aged; 6) 63 d wet-aged, 7) 21 d dry-aged; 8) 14 d wet-aged followed by 21 d dry-aged. Upon completion of treatment, sections were fabricated into three steaks, each of which was allocated for sensory, shear force, or chemical analysis. Sensory attributes, including beef lexicon flavor notes and tenderness, were quantified by a trained panel using a 15-point scale. Slice shear force (SSF) and Warner-Bratzler (WBSF) shear force was determined for each sample. Uncooked samples were analyzed for volatile organic compounds known to contribute to beef flavor as well as fatty acids. Treatment comparisons made within the same carcass were tested for significance using SAS PROC GLIMMIX with α < 0.05.

**Results:** Wet-aging longer than 35 d resulted in decreased (P < 0.01) ratings for beef flavor ID, browned, and roasted flavors and increased (P < 0.01) ratings for sour, oxidized, nutty, musty/earthy, and liver-like. However, beef wet-aged up to 28 d showed no change (P ≥ 0.05) in flavor notes. Dry-aging resulted in the greatest ratings for beef flavor ID, browned, and roasted. Additionally, the additive effect of using both wet- and dry-age methods resulted in intensification of the musty/earthy and nutty flavor notes typically associated with dry-aged beef, as well as sour notes. SSF and WBSF generally decreased as aging time increased. Yet, no significant differences (P ≥ 0.05) in SSF values were found past 35 d of wet-aging, and no significant differences (P ≥ 0.05) in WBSF values were found past 28 d of wet-aging. Volatile flavor compound analysis showed n-aldehydes nonanal, octanal, and hexanal increase up to 35 d of wet-aging and decrease at subsequent aging lengths. Additionally, Strecker aldehydes phenylacetaldehyde, 2-methylbutanal, and 3-methylbutanal all increased after 35 d of wet-aging. Finally, ethanol production increased substantially after 35 d of wet-aging, while acetaldehyde production decreased at the same aging length.

**Conclusion:** These findings show aging as an effective method of improving palatability attributes in beef. Yet, utilizing extreme aging parameters changes the flavor profile of beef, as notes of sour, oxidized, nutty, musty/earthy, and liver-like develop, without a meaningful improvement in tenderness. This change in flavor profile may, in part, be due to volatile changes late in the wet-aging period, where the oxidative breakdown of lipids, generation of aldehydes, and the dehydrogenation of acetaldehyde to ethanol occur. Additionally, dry-aging in combination with wet-aging creates a unique flavor profile. Ultimately, these results provide a baseline for establishments to select an aging protocol best suited for their need in promoting a high-quality eating experience.

**Keywords:** aging, beef, flavor, tenderness, volatile flavor compounds
78- EFFECTS OF ELECTRICAL STIMULATION, CHILLING RATE, AND CARCASS SIZE ON RATES OF TEMPERATURE DECLINE AND PH DECLINE, AND BEEF QUALITY
B. A. Djimsa 1,*, D. R. Woerner 1, M. N. Nair 1, J. N. Martin 1, R. J. Delmore 1, K. E. Belk 1
1Animal Sciences, Colorado State University, fort collins, United States

Blanchefort.Allahodjibeye_Djimsa@colostate.edu

Objectives: Growing carcass size and increased carcass mass makes it difficult for packers to appropriately chill beef carcasses, resulting in issues associated with tenderness and color. Beef processors are struggling to meet requirements for acceptable deep tissue (center of the round or chuck) temperatures in heavier carcasses prior to fabrication. Additionally, foodservice and retail customers expressed concerns relative to inconsistencies in tenderness among muscles of the round and color of the tenderloin. Furthermore, challenges of temperature induced toughening long considered resolved have resurfaced. To our knowledge, few studies have looked at the impact of the combination of chilling and electrical stimulation on tenderness, juiciness and color among current beef carcasses. Hence, this study aimed at determining the effects of carcass size, chill rate, and electrical stimulation on tenderness, juiciness, and color of beef.

Materials and Methods: Cattle (N = 81, ≤ 30 months) were randomly selected at a local plant and grouped into weight categories (Light, n= 38; Heavy, n = 43). The left or right side of each carcass was electrically stimulated (ES) and the opposite side was not stimulated (NS). Each carcass was assigned to a conventional rate of chilling (CC) or delayed chilling (DC). Both chilling protocols involved spray-chilling. Temperature and pH were measured for the Semimembranosus (SM), Psoas major (PM), and Longissimus dorsi (LD) at 45 min., 6 h, 12 h, and 32 h postmortem. Color measurements were taken from PM steaks. Loin steaks (2.5 cm) were aged for 14, 21, and 28 d and evaluated for tenderness using Warner-Bratzler shear force (WBSF) and slice force (SSF). Six trained panelists appraised tenderness, juiciness, and flavor intensity on 14 d steaks. The data were analyzed as repeated measures design using PROC MIXED of SAS. Chilling treatment served as a fixed effect (α = 0.05).

Results: Carcass weight affected WBSF (P = 0.001) and tended to affect SSF values (P = 0.055). Heavy carcasses had lower WBSF values (P < 0.05). Aging decreased WBSF (P < 0.0001) and SSF values (P = 0.006). Electrical stimulation and chilling did not affect WBSF and SSF values (P = 0.70). Carcass weight, electrical stimulation, and chilling rate did not affect trained sensory panel ratings for tenderness, juiciness, and flavor (P > 0.05). Electrical stimulation decreased L*(P = 0.04) and b* (P = 0.04) values but did not affect a* values (P = 0.14). Carcass size influenced temperature decline in SM and PM (P < 0.0001) but did not affect temperature decline in the LD. Electrical stimulation and chilling treatments did not affect temperature decline in SM, PM, and LD (P > 0.05). The LD temperature dropped more rapidly in CC light carcasses than DC light carcasses (P < 0.0001). For heavy carcasses, temperature decline rates were similar (P > 0.05) for CC and DC treatments. Carcass weight influenced pH decline in SM, PM, and LD (P < 0.0001), with pH decline occurring more rapidly in heavier weight carcasses (P < 0.05).

Conclusion: Heavier carcasses chilled more slowly, had a more rapid pH decline, and were more tender. The electrical stimulation and chilling regime investigated in this study did not affect sensory attributes, but did significantly impact color parameters.

Keywords: Beef tenderness, beef color, temperature and pH decline
EFFECT OF PACKAGING TYPE DURING POSTMORTEM AGING AND DEGREE OF DONENESS ON PORK CHOP SENSORY TRAITS OF LOINS SELECTED TO VARY IN COLOR AND MARBLING

B. J. Klehm 1,*, D. A. King 2, A. C. Dilger 1, S. D. Shackelford 2, D. D. Boler 1

1Animal Science, University of Illinois, Urbana, 2ARS, USDA, Clay Center, United States
bklehm2@illinois.edu

Objectives: Consumers use color and marbling as indicators of tenderness and juiciness when making purchasing decisions because they are perceived to influence eating experience. The USDA has proposed a quality grading system based on visual color and marbling of the ventral surface of a boneless pork loin. Previous reports show that a combination of increasing extractable lipid and a darker surface color increased instrumental tenderness of pork chops cooked to a medium-rare degree of doneness. So, it stands to reason that a USDA grading system has the potential to sort pork loins to provide a desired eating experience based on consumer expectations. Nearly half (49%) of boneless pork chops in the U.S. are distributed to retail stores as case-ready chops and the remainder (51%) as noncase-ready. It is not known if this difference in packaging affects sensory traits of boneless pork chops. On the other hand, it is readily accepted that cooking pork chops to a medium-rare degree of doneness improves sensory tenderness and juiciness compared with cooking chops to a medium degree of doneness. Therefore, the objective was to determine the potential interactive effects of packaging type and degree of doneness on sensory traits of pork loins selected to represent the newly proposed USDA quality grades.

Materials and Methods: A total of 144 loins were selected from 2 groups of pigs to represent as much variation in visual color and marbling as possible. The ventral surface of the loins were evaluated for loin quality traits at 1d postmortem. At 2d postmortem loins were sliced into 28 mm thick chops. Chops within each loin were randomly assigned to either individual vacuum packages or to individual Styrofoam trays and overwrapped in polyvinyl chloride (PVC) oxygen permeable film. Overwrapped PVC packages were then placed in bulk packages and flushed with a gas mixture that contained approximately 0.4% carbon monoxide, 24.6% carbon dioxide, and 75% nitrogen. Vacuum-packaged chops were aged until 14d postmortem. Chops packaged in PVC overwrap were aged until 9d postmortem in bulk packaging, then placed in simulated retail display until 14d postmortem. Chops from each packaging type were cooked to an internal temperature of either 63°C or 71°C for the evaluation of slice shear force (SSF) or sensory tenderness, juiciness and flavor. Data were analyzed as split-split plot design with proposed USDA quality grade, packaging type, and degree of doneness as fixed effects.

Results: There were no three-way (P ≥ 0.19) interactions and only 1 two-way interaction among quality grade, packaging type or degree of doneness. There were no differences in sensory tenderness (P = 0.30), juiciness (P = 0.49), flavor (P = 0.89), SSF (P = 0.13), or cook loss (P = 0.06) among USDA quality grades. There were no differences in sensory tenderness (P = 0.06), juiciness (P = 0.32), flavor (P = 0.74), SSF (P = 0.99), or cook loss (P = 0.12) between packaging types. Chops cooked to 63°C were 4.6% more tender (P < 0.0001), 10.1% juicier (P < 0.0001), and 2.9% less flavorful (P = 0.01) than chops cooked to 71°C.

Conclusion: These data suggest that cooking chops to 63°C rather than 71°C was a more effective way to improve tenderness and juiciness than selecting chops of a certain quality grade or altering packaging postmortem.

Keywords: degree of doneness, packaging, pork, quality grade, sensory
80- EFFECT OF L-GLUTAMINE SUPPLEMENTATION IN REPLACEMENT OF ANTIBIOTICS ON MEAT QUALITY ATTRIBUTES OF PIGS EXPOSED TO TRANSPORT AND WEANING STRESS DURING DIFFERENT SEASONS

D. Ma 1*, Y. H. B. Kim 1, J. S. Johnson 2, A. Duttlinger 2, J. M. Guedes 1
1Animal Sciences, Purdue University, 2Livestock Behavior Research Unit, USDA-ARS, West Lafayette, United States
ma128@purdue.edu

Objectives: Transporting weaned pigs to separated growing facilities is commonly practiced in the pig industry to improve farming efficiency. However, concurrent stressors during weaning and travel may lead to physiological and metabolic alternations and negatively impact overall health, growth performance, and productivity of the animals. Antibiotics were commonly applied as a mitigation strategy; however, there is an increasing consumer demand for antibiotic-free animal farming practices. L-glutamine supplementation was recently reported as a potentially viable nutraceutical replacement to the use of antibiotics. Currently, most published studies have focused on the animal productivity and general carcass characteristics of pigs undergoing these environmental stressors. However, little to no information is available on how these multiple stressors and mitigation strategies during the early phase of pig handling affect the final meat quality attributes. Therefore, the study objective was to determine the effect of L-glutamine supplementation on quality attributes of different muscles from pigs exposed to weaning and transport stress at different seasons.

Materials and Methods: Pigs were weaned and transported in two different seasons: thermal-challenged summer vs. thermal-neutral spring. Each group were BW-blocked and randomly assigned to 3 different diets (supplemented with non-antibiotic, antibiotic, and 0.20% L-glutamine) for 14 d after transport, then fed antibiotic free basal diets until market weight. After reaching market weight, 30 gilts (n=10/diet treatment) were slaughtered at each season. Pairs of longissimus dorsi (LD) and psoas major (PM) muscles from each carcass were separated at 1d and 7d postmortem, respectively. Carcass yield and meat quality attributes, including Warner-Bratzler shear force, display color, water-holding capacity (WHC), proximate composition and lipid oxidation, were evaluated.

Results: Muscles from pigs transported under heat stress exhibited a decrease in tenderness and water-holding capacity as indicated by elevated shear force values, display loss, thaw loss, and cook loss (P < 0.05). Significant interactions between transport season and dietary supplementation treatment were found in WHC. In pigs that were subjected to the thermal-challenging transport condition, L-glutamine supplementation decreased display loss and cook loss (P < 0.05). In addition, L-glutamine supplementation decreased lipid oxidation (TBARS, P < 0.05) and discoloration (hue angle, P < 0.05), regardless of transporting season. Thermal-challenge coupled with wean/transport stress increased muscle pH, which would likely be due to decreased glycogen content. Transportation season also affected proximate components, where pigs that were transported during the thermal-neutral season have higher lipid and lower protein contents (P < 0.05) in LD and PM muscles than muscles from heat-stressed pigs.

Conclusion: The current results indicated that heat stress accompanied with transport stress at weaning could negatively affect meat quality characteristics, as shown by decreases in meat tenderness, WHC and oxidative stability. L-glutamine supplementation as a nutraceutical mitigation strategy showed a trend of resulting in better or equivalent impacts on meat quality attributes compared to meat from pigs treated with antibiotics.

Keywords: L-glutamine, pork quality, stress mitigation, transport at weaning
THE EFFECTS OF ULTIMATE PH AND COLOR ON SENSORY TRAITS OF PORK LOIN CHOPS COOKED TO A MEDIUM-RARE DEGREE OF DONENESS

E. Richardson 1,*, B. Fields 2, A. Dilger 1, D. Boler 1
1University of Illinois, Urbana-Champaign, 2Pig Improvement Company, Hendersonville, TN, United States
erchrds2@illinois.edu

Objectives: When pork loin chops are cooked to a medium degree of doneness (71˚C), ultimate pH and color can significantly impact overall eating quality. However, it is not known how these quality parameters affect sensory tenderness, juiciness, and flavor scores of pork cooked to a medium-rare degree of doneness (63˚C). Therefore, the objective was to determine the effects of pH and color on sensory characteristics of boneless pork loin chops cooked to an internal temperature of 63˚C.

Materials and Methods: Center cut loin chops (296 total) from barrows and gilts, 5 different sire lines, and a range in pH of 5.36 through 6.23 were used. Early quality measurements (1 d postmortem) included instrumental color (CIE L*, a*, b*), visual color, and ultimate pH. Loins were then selected to fill a 3 x 5 factorial arrangement using 1 d postmortem ultimate pH and 1 d postmortem NPPC visual color score as predictors for trained sensory tenderness, juiciness, and flavor as well as instrumental tenderness. Ultimate pH categories were based on historical data and were as follows: >5.95, n= 22; 5.80 to 5.95, n= 75; 5.65 to 5.80, n= 102; 5.50 to 5.65, n= 91; <5.50, n= 6. Three color categories (1.5 to 2.5, 3.0 to 3.5, and ≥ 4.0) were assigned using NPPC visual color score. Loins were aged in vacuum packages at 4˚C until 16 d postmortem. After aging, loins were cut into 2.54 cm thick chops, vacuum-packaged and frozen until sensory or instrumental tenderness analysis. Chops were weighed, cooked to 63˚C, cooled to approximately 23˚C, weighed again to determine cook loss, and then evaluated for Warner-Bratzler shear force. Another chop was cooked to 63˚C internal temperature and served warm to trained panelist to determine sensory traits. Coefficients of determination (R^2) were calculated to determine the predictability of ultimate pH and instrumental color on sensory tenderness, juiciness, and flavor. A one-way ANOVA and means separation test were used to determine specific differences among pH categories.

Results: Chops in the most elevated pH category (pH >5.95) were significantly (P < 0.05) more tender than those in lesser pH categories. However, ultimate pH explained only 5% of the variation in sensory tenderness scores and less than 1% of the variation in juiciness and flavor scores. Visual color score was not predictive (R^2 < 0.01) of sensory tenderness, juiciness, or flavor. Also, neither instrumental L* (R^2 = 0.02), instrumental a* (R^2 < 0.01), nor instrumental b* (R^2 = 0.03) were predictive of sensory tenderness. No instrumental color parameter was predictive (R^2 ≤ 0.01) of sensory juiciness or flavor.

Conclusion: Chops with a pH >5.95 were at least 8.7% more tender (P < 0.05) than chops with a pH <5.95. Visual and instrumental color were not predictive (R^2 ≤ 0.03) of any sensory traits. Overall, pH does not influence sensory traits of pork chops cooked to medium-rare degree of doneness unless pH is at least 5.95.

Keywords: color, degree of doneness, loin quality, tenderness, ultimate pH
Objectives: The study evaluated objective and subjective retail display color of ground beef produced from beef trim treated with or without lactic acid dip and stored 24 or 48 h prior to chub packaging and storage for 7, 14, or 21 d.

Materials and Methods: Ground beef produced from trim treated (TRT) with lactic acid dip (LA) or without (CON) and stored 24 h (24TS) or 48 h (48TS) was used. Samples (n = 84; 21/TRT, TS combination) were chub vacuum packaged (4.54 kg) and stored for 7, 14, or 21 d (CS) and finely ground when storage time completed. Ground beef was placed on a polystyrene tray overwrapped with low-barrier polyvinylchloride film. Packages were displayed for 3 d (2-3°C) under continuous fluorescent lighting. CIE \( L^* a^* b^* \) values were taken daily during simulated retail display to calculate hue angle (\( \tan^{-1} a/b \)) and saturation index (\( (a^2 + b^2)^{1/2} \)). Trained panelists (n = 6) evaluated worst-point lean color daily during retail display with an 8-point verbally anchored numeric scale with 0.5 increment scores (1 = very bright red, 8 = tan to brown). Data were analyzed as a split plot design with whole plot as a 2 × 2 factorial of TS and TRT and subplot combined CS with retail day.

Results: Visual color scores and \( L^* \) values differed (\( P < 0.0001 \)) among CS times and retail display day, as expected. Treatment, CS and retail display day interacted (\( P < 0.05 \)) for \( a^* \), saturation index, and hue angle. Hue angle and \( a^* \) values indicated a loss of redness (\( P < 0.05 \)) within TRT and CS as retail display increased. Initial display \( a^* \) values within TRT did not differ (\( P > 0.05 \)) across CS, but LA treated chubs were more red (\( P < 0.05 \)) than CON regardless of CS. Chubs stored 7 or 14 d had similar (\( P > 0.05 \)) hue angles and were less discolored (\( P < 0.05 \)) than 21 d stored chubs regardless of TRT at 0 d of display. Hue angle and \( a^* \) values did not differ (\( P > 0.05 \)) between LA and CON within CS after 0 d of display. Saturation index, or vividness, for 7 d stored chubs decreased (\( P < 0.05 \)) the longer packages were displayed in retail, but chubs stored 14 and 21 d had similar vividness (\( P > 0.05 \)) within day 2 and 3 of display. At initial display, chubs treated with LA were more vivid (\( P < 0.05 \)) than CON within CS. Lactic acid treated and CON chubs did not differ (\( P > 0.05 \)) within CS at day 1 and 3 of display. Chubs stored 7 d were more vivid (\( P < 0.05 \)) than 14 and 21 d stored chubs, which did not differ (\( P > 0.05 \)) at day 1, 2, and 3 of display. The vividness of LA treated chubs was greater (\( P < 0.05 \)) than CON for 7 d stored chubs at day 2 of display. A TS × CS retail day interaction (\( P < 0.05 \)) was observed for \( a^* \) and saturation index. Saturation index and \( a^* \) values for TS were similar (\( P > 0.05 \)) within chubs stored 7 and 21 d at retail day 1 and 2 of display, but no redness differences (\( P > 0.05 \)) within CS were observed at day 3 of display. Saturation index and \( a^* \) values decreased (\( P < 0.05 \)) as package display time increases within TS and CS, except 48TS vividness did not differ (\( P > 0.05 \)) between day 2 and 3 of display. \( L^* \) and \( b^* \) values indicated LA treated chubs were lighter and more yellow (\( P < 0.05 \)) than CON. Hue angle indicated 48TS was less red (\( P < 0.05 \)) than 24TS.

Conclusion: Longer trim and chub storage is detrimental, but LA combined with other factors can delay discoloration.

Keywords: Beef trimmings, ground beef color, lactic acid dip, storage time
83- EVALUATION OF THE QUALITY CHARACTERISTICS OF PREMIUM PORK LOINS
E. Rice 1,*, L. L. Priell 1, L. N. Drey 1, B. A. Olson 1, J. M. Gonzalez 1, T. A. Houser 1, E. A. E. Boyle 1, T. G. O’Quinn 1
1Animal Science, Kansas State University, Manhattan, United States
emilyrice@ksu.edu

Objectives: The objective of this study was to determine the quality attributes of premium pork loins.

Materials and Methods: Pork loins (n=30/treatment) from five premium (PRE A, B, C, D, and E) and two commodity brands (COM A and B), were purchased from food service purveyors and commercial abattoirs. Loins were fabricated at 14 or 15 d postmortem. Prior to fabrication, loins were weighed in the package to obtain an initial weight. After unpackaging, loins were dried and reweighed to determine the amount of purge lost during storage (PL). After unpackaging, L*, a* and b* values were collected on the ventral side of the loin using a Hunter Lab Miniscan spectrophotometer (Illuminant A, 2.54-cm aperture, 10° observer, Hunter Lab Associates Laboratory, Reston, VA). Each loin was evaluated for subjective color (SC) and marbling scores according to the National Pork Board Color and Marbling Standards. Loins were cut immediately posterior to the spinalis dorsi and the posterior end of the loin was used for all analyses. Loins were then fabricated into 2.54 cm chops. Chops were assigned to either: pH, instrumental (IC) and SC analysis, visual marbling (VM) and proximate analysis, Warner-Bratzler Shear force (WBSF), Slice Shear force (SSF) analysis or drip loss analysis. Chops designated for instrumental and visual color analysis were evaluated 30 minutes after slicing. Chops designated for WBSF and SSF were cooked on clam style grills to a peak temperature of 71°C.

Results: All PRE brands were similar (P>0.05) with lesser (P<0.05) SSF values than COM A, with the exception of PRE C, which had greater (P<0.05) SSF values than all other brands evaluated. Similar results were found for WBSF, with PRE C having greater (P<0.05) WBSF values than all other treatments, and no difference (P>0.05) found among the other PRE products. Commodity A was also tougher (P<0.05) than all PRE brands, except PRE C for WBSF. For SC evaluations, the two COM products had a similar (P>0.05) chop color score, however COM B, was lighter (P<0.05) than all PRE brands. Loin SC was similar (P>0.05) among all PRE brands, with only PRE C having a greater (P<0.05) color score than PRE B. Commodity B had a lesser (P<0.05) loin SC than all PRE products except PRE B and D. Also, COM B had a greater (P<0.05) L* value and lesser (P<0.05) a* value than all of the other brands. No difference (P>0.05) in a* was found among the PRE brands and only PRE D and E differed (P<0.05) for L*. Little variation was found among brands for pH, but COM B had a lesser (P<0.05) pH than all of the other brands. Premium A and E had greater loin VM than all other brands, with no difference (P>0.05) found among the two COM brands and the other 3 PRE brands. However, for chop VM, the two COM brands had less (P<0.05) marbling than all PRE brands, except PRE B and C. For fat percentage, all brands had between 2 – 3% fat, with COM A having less (P<0.05) fat than all PRE brands other than PRE B and D. Premium A, C and D had less (P<0.05) weight lost as purge than any of the other brands.

Conclusion: The differences observed within the quality traits evaluated show variation among different premium pork loin brands. This provides evidence that consumers and retailers will receive different levels of pork quality and eating satisfaction dependent upon the premium brand purchased.

Keywords: color, marbling, pork quality, shear force, tenderness
Objectives: Past research has reported that the most productive cows in a cow herd are approximately 6 years old or older. A recent study reported that dam age affected pre-weaning performance of crossbred male calves, but had minimal effect on carcass traits when steers were finished to a common compositional endpoint over three years. The purpose of this study was to evaluate the effect of dam age on Angus crossbred steer performance and carcass quality measurements over a four-year period.

Materials and Methods: A total of 248 fall-calving, mixed-aged Angus and Angus- crossbred cows bred to Angus or Hereford sires were utilized to determine the effects of dam age on offspring performance and carcass traits. Dams were allocated into 1 of 4 age groups based on age at the time of calving: 1) ≤3 years old (Age3), 2) 4 to 6 years old (Age4-6), 3) 7 to 10 years old (Age7-10), and 4) >11 years (Age11+). Cattle were housed at the University of Arkansas’ beef research unit with access to pastures. Calves were processed at birth and weaned in May. Dam age was not included in adjusted weaning weight (WW) because the effect of dam age was tested. For two months after weaning, steers grazed at the farm and then transported to the West Texas A&M research feedlot, located in Canyon, Texas and remained there until harvest. When steers reached a minimum 2.54 cm backfat thickness, they were transported to a meat processing plant in Friona, Texas to be harvested. Carcass data was collected for analysis.

Results: Calves born to cows in group Age11+ had increased (P<0.05) birth weight compared with the rest of the groups and Age3 and Age4-7 calves had decreased birth weight. Calves from Age7-10 had increased adjusted WW than Age3 and Age4-6 (P<0.05). Steer carcass measurements (hot carcass weight, ribeye area, yield grade, backfat thickness and marbling) were not different regardless of cow age group. The Age11+ had increased (P<0.05) percent kidney, pelvic and heart fat (%KPH) and similar to Age3. Age3 was similar in %KPH to Age4-6 and Age7-10. The percentage of steers grading choice, select, or prime did not differ between age groups.

Conclusion: Dam age affected birth weight of crossbred male calves. Carcass traits and measurements were not affected by dam age except %KPH. Future research should investigate dam age on pure bred calves.

Keywords: Carcass, Dam Age
Objectives: Finishing beef with corn-based distillers grains (DGS) diets alters fatty acid composition of beef when compared to corn-based diets. Producers utilizing DGS as feedstuff may obtain this byproduct with different moisture levels. In this study, we evaluated the null hypothesis that inclusion of DGS with different moisture levels in finishing diets do not lead to similar deposition of fatty acids in the lean of value-added beef cuts.

Materials and Methods: Crossbred steers (n=24) were randomly finished with 3 different diets: CORN (0 %DGS), Dry DGS (40% DM of DGS with 8-12% of moisture; DDGS), and Modified DGS (40% DM of DGS with 45-55% of moisture; MDGS). After slaughter, shoulder clods (IMPS 114) were excised from carcasses and transferred under refrigeration to the University of Nevada, Reno Meat Quality Laboratory. After 7 d of aging, the M. Infraspinatus (INF, IMPS 114D PSO1) and M. Teres major (TM, IMPS 114F) were fabricated from the clods and pulverized with liquid nitrogen. Total lipids were extracted by using chloroform and methanol and converted to Fatty Acids Methyl Esters (FAME). Fatty acid profile was analyzed by gas chromatography (Agilent Technologies, model 6890 series) using a capillary column (Chrompack CP-Sil 88 - 0.25 mm x 100 m). Oven temperature was programmed from 140 to 220°C at 2°C/min and held at 220°C for 20 min. Injector and detector temperature were maintained at 270 and 300°C, respectively. The carrier gas was hydrogen at a flow rate of 30 mL/min. Fatty acids (FA) were identified by comparison of retention times with known standards. Data were analyzed as a 3x2 factorial (diets x muscle) using PROC GLIMMIX of SAS and when significance was detected at P ≤ 0.05, means were separated using LSMEANS and DIFF functions.

Results: No interaction between muscle and diet was observed for all fatty acids, except for C6:0. Values of C14:1T ω5, C18:1Δ11 ω7, C18:2 ω6, C20:4 ω6, total PUFA, and total Omega 6 were significantly higher in TM when compared to INF, whereas C18:1 ω9 levels were significantly higher in INF than in TM. Feeding corn significantly increased levels of some saturated and monounsaturated FA including C14:0, C16:0, and C18:1Δ11 ω7 when compared to DGS. Overall, finishing diets containing DGS significantly led to higher deposition of C18:0, C18:2 ω6, PUFA, and total Omega 6 FA. When comparing DDGS versus MDGS, feeding DDGS led to higher concentrations of C14:0, C14:1 ω5, C16:0, and C16:1 ω7 whereas MDGS led to higher C17:0 in the lean (P ≤ 0.05). Feeding MDGS increased concentrations of C18:1T (ω9 and ω12), Total Trans, and C18:3 ω3 FA in the lean when compared to CORN, whereas beef from steers fed DDGS had higher Omega 6:Omega 3 when compared to CORN.

Conclusion: Inclusion of DGS with different moisture levels differently affected FA profile of beef. When compared to CORN-fed, beef fed MDGS had higher levels of Trans FA and C18:3 ω3, whereas beef fed DDGS had higher Omega 6:Omega 3.

Keywords: Beef, Distillers grains, Fatty Acids
Objectives: In the pork industry, the time between harvest and fabrication is typically 24-36 h. Some processors, particularly very small companies, may hold carcasses an extended period of time prior to fabrication. An earlier study found the microbial quality of pork carcasses was not affected when hung for 21 d at 0±1°C and 87.3% relative humidity (RH). The objective of the current study was to assess the microbial quality of vacuum packaged pork shoulder steaks held for up to 35 d at 0±1°C fabricated from pork carcasses previously hung for 21 d at 0±1°C.

Materials and Methods: Pork shoulder blade steaks \( (n=102) \) were fabricated from the right sides of pork carcasses \( (n=17) \) that had been previously hung for 21 d. Pork steaks were vacuum packaged, placed in corrugated boxes and held at 0±1°C for up to 35 d. Cooler temperature and RH were measured every hour using a data logger. Steaks were evaluated for aerobic plate count (APC), Enterobacteriaceae (EB), and yeast and mold populations by plating in duplicate on petrifilm™ on d 0, 7, 14, 21, 28, and 35 of storage. Additionally, surface pH was determined at each sampling time. Data were analyzed using SAS 9.3.

Results: The storage cooler temperature averaged 0±1°C over the 35 d storage time. Although pork steaks pH varied throughout the storage time, pH on d 0 was similar \( (P \geq 0.05) \) to pH on d 35. There was a day effect \( (P \leq 0.05) \) for APC on pork steaks. The initial APC population was 1.61 log CFU/g. On d 7, APC populations declined \( (P \leq 0.05) \) to 1.18 log CFU/g, then increased \( (P \leq 0.05) \) to 2.44 log CFU/g on d 14. On d 14 and 21, APC populations were similar \( (P \geq 0.05) \); however, there was a 1.50 and 1.89 log CFU/g increase \( (P \leq 0.05) \) in APC population on d 28 and 35, respectively. On d 35, APC populations reached 5.06 log CFU/g. There was no day effect \( (P \geq 0.05) \) for yeast population; however, there was a day effect \( (P \leq 0.05) \) for EB and mold populations. The detection limit (DL) for EB and yeast and mold populations on pork steak samples was 0.70 log CFU/g. On d 0 and 7, none of the samples were above the DL for EB populations and were similar \( (P \geq 0.05) \) to d 14 when the proportion of presumptive positive samples for EB populations above the DL was 23.5%. The percent of presumptive positive samples above the DL for EB populations was 41.2% on d 21, and was higher \( (P \leq 0.05) \) than d 0 and 7, but was not different \( (P \geq 0.05) \) than d 14. On d 28, there was an increase \( (P \leq 0.05) \) for presumptive positive EB populations on pork steaks, which had the highest percent of presumptive positive EB populations above the DL (94.1%) compared to the first 21 days of storage (0, 7, 14, 21 d). However, on d 35, the percent of presumptive positive samples EB populations above the DL declined \( (P \leq 0.05) \) to 41.2%. For all sampling days, none of the pork steak samples exceeded 4.40 log CFU/g for EB. Mold populations were not different \( (P \geq 0.05) \) on d 0, 7, and 14 with 100.0% of pork steaks being below the DL. However, 18, 24, and 12% of pork steaks on d 21, 28, and 35, respectively, were above the DL for mold populations. None of the pork steak samples exceeded 2.68 log CFU/g for mold populations.

Conclusion: The results indicate that pork blade steaks, from pork carcasses previously hung for 21 d, can be stored up to 35 d, and had a similar microbial quality to pork cuts from pork carcasses hung for 24-36 h.

Keywords: blade steaks, quality, storage
Objectives: The objective of this study was to evaluate the impact of experimental finishing diets on meat quality of Honduran beef, specifically focusing on fatty acid composition.

Materials and Methods: A total of 275 Honduran Bos indicus cross-bred bulls were fed one of seven finishing diets: grass finished (CON), dry distillers grain (DDG), palm kernel meal (PKM), palm kernel meal replicate (PKMR), sorghum (SORG), soybean meal and corn (SBMC), or sugar cane (SC). After harvest, 15 strip loins were selected randomly within each treatment (n =105) and aged for 21 d prior to freezing. During fabrication, all external fat was removed as the most anterior steak of each strip loin was retained for fatty acid analysis.

Results: Significant differences were found in the dodecanoic fatty acid (P < 0.01). Dodecanoic acid was prevalent in the DDG, PKM, PKMR, SC and SBMC diets and was found in lower quantities in the SORG and CON diets (P < 0.05). Differences were observed in two of the 18 carbon fatty acids: linoleic acid and linolenic acid methyl ester. Linoleic acid displayed a greater concentration in the DDG diet (P < 0.05). This indicates that DDGs will increase linoleic concentrations in beef. Linolenic acid methyl ester was found in greater amounts in both the CON and SORG diets, with no differences in the amount found in the PKM, PKMR, SC, or SBMC diets. The DDG had less linolenic acid (P < 0.01). Significant differences were also found in the C20 fatty acid (P < 0.01). Eicosadienoic acid displayed the greatest concentration within the DDG diet and the least amount in the CON diet with all diets displaying intermediate amounts. Similarly, the DDG diet showed the greatest amount of arachidonic acid compared to all other treatments (P < 0.05). Additionally, differences were observed in the dihomo-γ-linolenic fatty acid in which, both SORG and CON diets displayed the greatest amount; while SC, SBMC, PKM, and PKMR showed intermediate amounts and DDG had lower concentrations (P < 0.05). Cumulative unsaturated fatty acids (UFA) and monounsaturated fatty acids (MUFA) were greater (P < 0.05) in PKM, PKMR and DDG compared with all other treatments. Additionally, differences were detected with the SFA content (P < 0.05). The PKM and PKMR had the greatest amount of SFA (41.63 and 34.72 mg/1g, respectively), while the DDG, SC, SBMC and SORG diets (30.28, 26.78, 24.54, and 17.94 mg/1g, respectively) had intermediate SFA values that were not statistically different. Therefore, the lowest SFA content was obtained within the CON diet (13.07 mg/1g). No differences were observed in the amounts of PUFA content across dietary treatments (p = 0.28).

Conclusion: Results of this study indicate grain and various by-products in the finishing diet can alter fatty acid profiles of beef compared to beef from grass-finished cattle. Specifically, this study showed a greater amount of unsaturated and saturated fatty acids, in addition to greater amounts of MUFA content in beef where diets included grain or by-products.

Keywords: Beef, by-products, fatty acids, grass finished
EFFECTS OF TEMPERATURE, RELATIVE HUMIDITY, AND PROTECTIVE NETTING ON HAM MITE INFESTATION AND FUNGAL GROWTH ON DRY CURED HAMS

J. D. Hendrix 1*, X. Zhang 1, Y. L. Campbell 1, M. D. Byron 1, C. L. Cord 1, J. L. Silva 1, J. Goddard 2, T. Kim 3, T. Phillips 4, W. Schilling 1

1Food Science, Nutrition, and Health Promotion, 2Department of Biochemistry, Molecular Biology, Entomology, and Plant Pathology, Mississippi State University, Starkville, 3Food and Nutrition Department, University of Wisconsin-Stout, Menomonie, 4Department of Entomology, Kansas State University, Manhattan, United States
jdy35@msstate.edu

Objectives: Methyl bromide (MB) is a fumigant commonly used for pest control in the dry cured ham industry due to its efficacy for controlling ham mite infestations. MB is an ozone-depleting substance and is being phased out of use and there is a need to find alternative methods to control ham mites. Temperature and relative humidity (RH) are critical for dry cured ham production, and also affect mite reproduction rate and mold growth on hams. Therefore, the objective of this research was to determine the most effective temperature and RH combinations to inhibit mite reproduction and mold growth on dry cured hams in untreated and food-grade ingredient infused nets.

Materials and Methods: Patent pending food grade coating formulations consisting of 1) 1% xanthan gum (XG) and 40% propylene glycol (PG) and 2) 1% carrageenan (CG), 1% propylene glycol alginate (PGA), and 40% PG were infused into ham nets. Dry cured ham slices (2.5 cm×9.0 cm×15.5 cm) were wrapped with untreated (control) and two types of infused (treated) nets (XG+PG and CG+PGA+PG) and stored in ventilated glass jars. Three slices from each treatment were inoculated with 50 large mixed-sex mites and tested in an environmental chamber for 14 d at each temperature (24, 28, and 32°C) and RH (55, 65, 75, and 85%) combination. The resulting mite infestation was determined by counting the mobile mites on ham slices, nets, and jars. Six to eight trained panelists rated the amount of mold on the ham slice surfaces on a 0 to 100% scale. A 3×4 factorial arrangement within a completely randomized design with three replications was used to determine the impact of all combinations tested with respect to mite infestation and mold growth on ham slices. Tukey’s Honestly Significant Difference (HSD) test was used to separate treatment means (P<0.05).

Results: On average, the number of mites on ham slices in untreated nets remained below the original inoculum level at 85% RH; the 32°C×85% RH combination reduced mite counts to one mite on the three slices tested. The XG+PG net treatments inhibited (P<0.05) mite reproduction on dry cured ham slices at all tested conditions (0-20 mites), with the exception of ham slices evaluated at 24°C×65% RH (128 mites) and 28°C×65% RH (54 mites). The CG+PGA+PG net treatments inhibited (P<0.05) mite reproduction (0-31 mites) on dry cured ham slices at all conditions that were tested, with the 85% RH treatments completely inhibiting mite growth. On average, ham slices in untreated nets were covered with 1 to 61% mold, and the maximum mold coverage was observed at 24°C×65% RH. The use of XG+PG and CG+PGA+PG net treatments reduced the amount of mold on ham slices to a range of 0 to 9% and 0 to 13%, respectively. Complete inhibition of mold growth was observed at 24°C×85% RH and 28°C×75% RH for both net treatments.

Conclusion: The XG+PG and CG+PGA+PG net treatments controlled mite infestations and mold growth on ham slices at most conditions tested. Therefore, it is recommended to determine the efficacy of treated nets on mite infestation and mold growth of dry cured hams in a commercial setting.

Keywords: dry cured ham, methyl bromide, mite infestation, relative humidity, temperature
MEAT AND POULTRY QUALITY

89- EVALUATION OF CHANGES IN MICROBIOLOGICAL AND BIOCHEMICAL PROPERTIES, AND COLOR OF GROUND BEEF DURING AEROBIC STORAGE.

J. R. Levey 1,*, I. Geornaras 1, D. Woerner 1, J. Prenni 2, K. Belk 1, J. Martin 1

1 Department of Animal Sciences, 2 Proteomics and Metabolomics Facility, Colorado State University, Fort Collins, United States
Jennifer.Levey@colostate.edu

Objectives: Ground beef shelf-life is influenced by numerous microbiological, biochemical, and physical properties. The complex relationship of these variables has direct impacts on color. It is imperative to understand the relationship between microbial and chemical changes in ground beef and the subsequent changes to color occurring to develop solutions to extend shelf life. In that regard, a shelf-life study was conducted to evaluate microbiological and biochemical deterioration of ground beef and the concurrent impacts on color.

Materials and Methods: Three separate lots of finely ground beef (80% lean, 20% fat) were procured from two ground beef processing facilities in the Midwestern and Western United States, and were treated as three separate replicates. The lots of ground beef were stored at 2°C without exposure to light, at Colorado State University (Fort Collins, CO) for both a storage period of 16/17 d (Storage period 1- SP1) and 23/24 d (Storage period 2- SP2) post-processing. After the storage period, the ground beef chubs were finely ground, again, and portioned onto rigid trays overlapped with polyvinyl chloride film before placement into a retail case with fluorescent lighting (Hussman, Model No. M3X8GEP) for 5 d. Objective color was evaluated every 12 h during the retail display period, while microbial populations (lactic acid bacteria [LAB], psychrotrophic bacteria, Enterobacteriaceae [EB], and Pseudomonas spp.), pH, and lipid oxidation were evaluated every 24 h for the duration of retail display. Bacterial populations, pH, instrument color, and lipid oxidation indicators were analyzed in R (version 3.4.3) using the lme4, lmerTest, and lsmeans packages as a split-plot design. Objective color values were also analyzed in R using the nlme, plyr, and lsmeans packages as a repeated measures design. Data are reported as least squares means and are separated using an alpha of 0.05.

Results: As expected, microbial populations changed over retail display, but trends differed between the two storage periods. Populations of Pseudomonas increased (P < 0.05) by almost 2 log CFU/g during retail display for product stored for 16/17 d, while a less than 0.35 log CFU/g increase in Pseudomonas populations was observed in product stored for 23/24 d. Similarly, populations of psychrotrophic bacteria, Enterobacteriaceae, and LAB increased (P < 0.05) during retail display of both dark storage periods. Likewise, lipid oxidation increased (P < 0.05) during retail display. Instrument color assessments indicated that product became less red (decreased a* values; P < 0.05).

Conclusion: This research displays the complex biochemical and microbiological changes that occur during storage and retail display of ground beef. These results suggest that the changes and their impacts on sensory properties, namely color, are not consistent among dark storage lengths. Further exploration of the changes in microbial communities and biochemical properties, and their impact on organoleptic properties, should continue.

Keywords: Ground beef, Quality, Shelf-life
EFFECTS OF CATTLE BACKGROUNDING DIETS ON CARCASS CHARACTERISTICS AND 
BEEF QUALITY

J. Juckel 1,*, J. Zeltwanger 1, A. Dicostanzo 1, R. Cox 1
1Animal Science, University of Minnesota, St. Paul, United States
jucke004@umn.edu

Objectives: To determine how backgrounding cattle will affect carcass characteristics and fresh beef quality. It was hypothesized that backgrounding cattle will result in an increased hot carcass weight, without impacting fresh beef quality.

Materials and Methods: The impact of utilizing a moderate energy backgrounding diet was evaluated using 95 crossbred steers (initial body weight: 352 ±30 kg) that were randomly assigned to 1 of 15 pens. Each pen was randomly assigned one of two dietary treatments. Dietary treatments included a traditional high energy (HigE) finishing diet (n = 7) or a moderate energy (ModE) backgrounding diet (n = 8). Cattle on HigE were fed a high energy finishing diet for all 193 d; those fed ModE were fed the moderate energy diet for 63 d followed by feeding the HigE diet for the last 130 d. All steers received Revalor®-XS on d 1. Two steers were randomly chosen from each pen for further evaluation. Hot carcass weight (HCW), 12th rib backfat (BF), ribeye area (REA), marbling score, USDA yield grade, and percent kidney, pelvic, and heart fat (KPH) were collected 48 h postmortem. Strip loins (IMPS #180) were retrieved and evaluated for vacuum purge loss and objective backfat color. The strip loins were fabricated into 2.54 cm steaks for drip loss, Warner-Bratzler shear force (WBSF), sensory evaluation, and subjective and objective color score evaluation. Data were analyzed using the mixed procedure of SAS® with treatment as a fixed effect and pen as a random effect. Pen was the experimental unit. Significance was determined at p ≤ 0.05, while trends were determined at p ≤ 0.10.

Results: There was a tendency for HCW to be heavier for ModE cattle (P = 0.06). There was no treatment effect for BF (P = 0.43), REA (P = 0.96), Marbling (P = 0.16), YG (P = 0.76), or KPH (P = 0.22). No moisture loss attributes differed between treatments: Purge loss (P = 0.40) and drip loss (P = 0.41). Backfat a* (P = 0.43) and b* (P = 0.18) values were not statistically significant between treatments, however, L* (P = 0.06) tended to be higher for HigE cattle. Warner-Bratzler shear force values did not differ between treatments (P = 0.72). There were no treatment effects for any of the steak subjective sensory attributes evaluated: Overall liking (P = 0.80), flavor liking (P = 0.75), texture liking (P = 0.44), toughness (P = 0.31), juiciness (P = 0.65), and off-flavor (P = 0.21). Objective color score did not differ between the two treatments: L* (P = 0.39), a* (P = 0.55), and b* (P = 0.68). Subjective color (P = .11) and discoloration (P = .21) scores also showed no differences between treatments. Subjective sensory analysis showed that steaks from the HigE treatment tended to be more desirable (P = 0.10).

Conclusion: Feeding a backgrounding diet before finishing led to similar carcass characteristics with a lower reliance on concentrate feed ingredients. Backgrounded cattle also had similar fresh beef qualities but could be compromised at the retail display case with subjective desirability scores tending to be lower.

Keywords: backgrounding, beef quality
Objectives: This research was conducted to evaluate the effects of feeding high protein corn distillers grains on beef tenderness during aging, sarcomere length, pH, proximate composition, and fatty acid composition.

Materials and Methods: Steers (n=300) were fed for 190 d on either a corn control, 40% high protein dry distillers grains plus solubles (HP-DDGS), 40% dry distillers grains plus solubles (DDGS), 40% wet distillers grains plus solubles (WDGS), or 40% bran plus solubles (Bran) diet. Eighteen Choice carcasses (3 head/pen) were randomly selected within each treatment (n=90). Strip loin samples from the right side were collected and aged for 2, 9, or 23 d. Steaks were fabricated at each aging period and placed under retail display conditions for 0 or 7 d. Tenderness (Warner-Bratzler shear force), sarcomere length, pH, proximate composition, and fatty acid composition were determined. Data were analyzed using the PROC GLIMMIX procedure of SAS and pen was the experimental unit.

Results: Hot carcass weight at harvest was 391 kg (SD 31.6 kg). Steaks aged 2 d showed no difference (P=0.17) in tenderness across treatments, however a display effect (P<0.0001) was present. Steaks that were under retail display conditions for 7 d exhibited a lower Warner-Bratzler shear force value than steaks not placed in retail display (3.40 kg and 4.27 kg, respectively). Steaks aged for 9 d and 23 d exhibited no differences across treatments (P=0.14), however there was a significant age by treatment effect (P=0.01). As HP-DDGS, DDGS, and Bran increased in aging an increase of tenderness was observed. There was no difference (P>0.05) in tenderness between HP-DDGS and corn across aging periods. Retail display increased tenderness for steaks from 9 d and 23 d (P<0.0001). No differences were observed among treatments for sarcomere length (P=0.07), fat (P=0.51), moisture (P=0.71), or ash (P=0.74). An aging effect was found for pH (P<0.0001), however, the values were of little practical significance (5.49 23 d, 5.48 2 d, 5.44 9 d, respectively). Preliminary results suggest beef from cattle fed HP-DDGS had significantly higher (P=0.03) levels of 18:2 in muscle than cattle fed corn (480.61 mg/100g vs. 272.49 mg/100g). All other treatments presented intermediate levels of 18:2 (395.92 mg/100g for DDGS, 350.06 mg/100g for WDGS, and 321.53 mg/100g for Bran). Cattle fed corn had significantly more (P=0.03) 17:1 in their muscle when compared to Bran (85.51 mg/100g vs. 57.76 mg/100g).

Conclusion: These results suggest that feeding high protein distillers grains have no detriment on tenderness, but may alter the lipid profile of the muscle.

Keywords: distillers grains, fatty acid composition, high protein
Meat and Poultry Quality

92- NATIONAL BEEF QUALITY AUDIT-2016: COMPARISONS BETWEEN FED STEERS/HEIFERS AND MARKET COWS/BULLS FOR BY-PRODUCT CONDEMNATIONS


Objective: The National Beef Quality Audit (NBQA) has been an integral information source for the beef industry for almost three decades. The NBQA-2016 surveyed both fed steers/heifers and market cows/bulls, and one objective was to compare condemnation rates for by-products between these two sectors. With this knowledge, strategies may be developed to reduce economic losses related to by-product condemnations.

Materials and Methods: Data were collected with the assistance of USDA-Food Safety and Inspection Service personnel. By-products from fed steers/heifers (livers, lungs, and viscera: n = 24,940; heads and tongues: n = 26,657) and from market cows/bulls (livers, lungs, and viscera: n = 4,800; heads and tongues: n = 5,720) were assessed for condemnations, and when available, reasons for condemnation were recorded. Data were analyzed using JMP Pro, Version 12.0.1 (SAS Institute Inc., Cary, NC). Frequency distributions were evaluated using the distribution function of JMP for condemnation traits assessed. Tests of hypotheses regarding differences in prevalence of by-product condemnations between NBQA-2016 fed steers/heifers and market cows/bulls were conducted at P = 0.05 using Chi-square analysis.

Results: By-product condemnations tended to be higher for market cows/bulls than fed steers/heifers for livers, lungs, viscera, heads, and tongues. For liver condemnations, market cows/bulls had a higher incidence (P < 0.0001) of flukes (3.2% versus 1.1%), abscesses (20.7% versus 17.8%), and total condemnations (44.6% versus 30.8%), whereas fed steers/heifers had a greater incidence of contamination (P < 0.0001) of contamination (10.1% versus 7.8%). However, both cattle populations showed a high frequency of liver condemnations, with nearly a third (fed steers/heifers) and half (market cows/bulls) of all livers being condemned. Lung condemnations, primarily a result of contamination, were higher (P < 0.0001) for market cows/bulls (23.1%) versus fed steers/heifers (18.2%). Additionally, lung pneumonia was not different for the two groups of cattle (P = 0.6264). With conventional feedlot confinement, a higher incidence of lung pneumonia might be expected in fed steers/heifers, however, advanced chronological age of market cows/bulls may contribute to similar (7.4% versus 7.6%) pneumonia rates in this population. Viscera condemnations for abscesses were higher (P < 0.0001) in market cows/bulls (5.1% versus 2.8%), whereas fed steers/heifers had a greater incidence of viscera contamination (13.4% versus 10.1%; P < 0.0001). For both head and tongue by-products, market cows/bulls had a higher incidence (P < 0.0001) of condemnations than the fed steers/heifers.

Conclusion: Overall, rates of by-product condemnations identified during the NBQA-2016 were higher than anticipated. These condemnations can be a substantial and unnecessary economic loss to the industry, especially because they are often a result of inputs at the feedyard or management practices at the ranch. Producers and processors should consider ways to reduce condemnation of these valuable by-products.

Keywords: audit, beef, by-products, quality
Objectives: American lambs are often over-finished and lack consistent quality. It has been suggested that leaving male lambs intact can decrease USDA Yield Grade (carcass fatness) and improve growth efficiency. However, ram lamb carcasses are underutilized because of potential issues, the most crucial being off-flavor. We studied the effects of castration and slaughter weight on growth, carcass, and sensory characteristics to determine if ram lamb growth and efficiency can be advantageous without detriment to eating satisfaction.

Materials and Methods: Dorset lambs (n = 20) were randomly assigned to either ram or wether treatment group (10 rams, 10 wethers). Lambs assigned to the wether group were castrated within the first 7 d after birth and all lambs were fed the same grain-based diet for the duration of the study. Animals were balanced for mean age and 90 d weight and assigned to appropriate slaughter group. Targeted end live weights for slaughter designation were light (55 kg), medium (66 kg), and heavy (77 kg) classifications. Lambs were harvested in three weight groups, light (55 ± 1.5 kg; n = 6), medium (66 ± 1.3 kg; n = 8), and heavy (78 ± 1.5 kg; n = 6), with an even distribution of ram and wether in each group. Following harvest, carcasses were chilled for two days at 2°C, fabricated, and primal cut yields were recorded. Boneless legs were wet aged for 14 days, ground and formed into 1 oz. patties for sensory analysis. Untrained panelists (n = 107) evaluated meat sensory characteristics. Three samples of light, four samples of medium, and three samples of heavy weight lambs were served each day, and serve order was randomized. The Mixed procedure of SAS was used to evaluate fixed effects of sex (n = 2), slaughter weight (n = 3), and their interaction as well as random effects of sensory characteristics including panelist, day, and sample.

Results: Supporting our hypothesis, ram lambs exhibited greater ($P < 0.05$) ADG throughout the trial period when compared to wethers, and lambs in all three weight groups had similar ($P > 0.05$) ADG. Ram lambs had more desirable ($P < 0.05$) leg scores, larger ($P < 0.05$) ribeye areas and less ($P < 0.05$) backfat than wethers. Ram lambs also had lower ($P < 0.05$) USDA Yield Grades and better ($P < 0.05$) USDA Quality Grades than wethers. Sensory evaluation determined that meat from ram lambs had greater ($P < 0.05$) lamb flavor intensity than wethers, and meat from wether lambs had greater ($P < 0.05$) overall liking than ram lambs. Interestingly, the more intense lamb flavor found in ram lambs aligned closer ($P < 0.05$) to the preferred lamb flavor profile for consumers. Lamb originating from rams had greater ($P < 0.05$) off-flavor intensity scores than wethers, and heavy weight lambs had greater ($P < 0.05$) off-flavor intensity scores than light/medium weight lambs. Furthermore, there were no ($P > 0.05$) texture liking or juiciness intensity differences based on sex or slaughter weight.

Conclusion: Intact ram lambs provide the sheep industry an opportunity to improve growth, increase musculature, and decrease USDA Yield Grade while providing a satisfactory eating experience. Ram lamb flavor intensity was more preferred by consumers, yet, compounding of advanced physiological maturity and harvesting intact rams increased incidence of off-flavors.

Keywords: castration, lamb flavor, ram lambs, sensory, sheep
Meat and Poultry Quality

94- EFFECT OF DEGREE OF DONENESS, QUALITY GRADE, AND TIME ON OBJECTIVE COLOR READINGS FROM LONGISSIMUS LUMBORUM STEAKS COOKED TO SIX DEGREES OF DONENESS

L. L. Prill \textsuperscript{1,}\*; T. G. O’Quinn \textsuperscript{1}, E. A. Boyle \textsuperscript{1}, T. A. Houser \textsuperscript{1}, J. L. Vipham \textsuperscript{1}, E. A. Rice \textsuperscript{1}, B. A. Olson \textsuperscript{1}, L. N. Drey \textsuperscript{1}, J. M. Gonzalez \textsuperscript{1}

\textsuperscript{1}Kansas State University, Manhattan, United States

prillll@ksu.edu

Objectives: The objective of this study was to determine the effect of quality grade and time after cooking on the instrumental color of steaks cooked to varying degrees of doneness (DOD). An increase in internal temperature results in greater myoglobin denaturation and cooked color has a large impact on consumer perception.

Materials and Methods: Twenty-four beef strip loins (IMPS #180) from 12 animals representing five quality treatments [Prime, Top Choice (Modest\textsuperscript{00} – Moderate\textsuperscript{100} marbling), Low Choice, Select, Select Enhanced (108\%)] were collected from a Midwest beef processor and transported to the Kansas State University Meat Laboratory. Sub-primals were divided and cut into 2.54 cm thick steaks and aged 21 d. Steaks were assigned to a DOD so that each animal would be represented by a single steak within each DOD. Steaks were stored frozen at -40°C and thawed at 2-4°C for 24 h prior to cooking. Each steak was cooked to peak at an internal temperature to either very rare (55°C), rare (60°C), medium-rare (63°C), medium (71°C), well done (77°C), or very well done (82°C) on electric clamshell grills (Cuisinart Griddler; Cuisinart, Stamford, CT). Steaks rested for three min before being cut for evaluation. Each cooked steak was cut in half, perpendicular to the long axis of the steak, and color was measured on the internal face of the medial side and was evaluated immediately for $L^*$, $a^*$, and $b^*$ using a Hunter Lab Miniscan spectrophotometer (Illuminant A, 2.54-cm aperture, 10° observer; Hunter Associates Laboratory, Reston, VA) at three locations and averaged. $L^*$, $a^*$, and $b^*$ were also evaluated at 1, 2, 3, 6, 9, and 12 min post-cutting.

Results: For $L^*$, there was an interaction ($P < 0.05$) between quality treatment and time. There was no difference ($P > 0.05$) among quality treatments for $L^*$ value at any time point, except at 12 min, in which Top Choice samples were lighter ($P < 0.05$) than Select Enhanced samples. Additionally, the interaction between time and DOD was significant ($P < 0.05$) for $L^*$, $a^*$, and $b^*$. For $L^*$, within very rare, rare, and medium-rare the color lightened ($P < 0.05$) as time progressed from 0 to 12 min. Whereas for well done and very well done, the color darkened ($P < 0.05$) over time. However, for well done and very well done, time had only a minimal impact on $a^*$ values. For $b^*$, values increased ($P < 0.05$) within each DOD; however, these changes were more prevalent at lower DOD, with increased ($P < 0.05$) $b^*$ values at each successive time point within very rare samples, but similar ($P > 0.05$) across the final three time points for well done and very well done. For $a^*$, quality treatment had an effect ($P < 0.05$), with Select Enhanced having a lower value than all treatments other than Prime. Select Enhanced had a lower ($P < 0.05$) $b^*$ value than all other quality treatments.

Conclusion: The impact of time on cooked color was DOD dependent, with steaks cooked to lower DOD becoming lighter and more red in color with time and steaks cooked to higher DOD becoming darker. Additionally, quality treatment had no impact on cooked color measures of non-enhanced samples. These results provide insight into cooked beef color changes related to time and how this might impact DOD perceptions by consumers.

Keywords: Beef, cooked color, degree of doneness, Quality grade, time
Objectives: To determine the effect of vascular Rinse & Chill® technology on meat quality and shelf life of cull cows in comparison to conventional carcass harvest.

Materials and Methods: Two treatments were randomly implemented on lean dairy cows (LC) and grain-finished beef cows (GF). Ten LC carcasses were conventionally chilled (CC, plus high voltage electrical stimulation, ES) and twelve LC were chilled using Rinse & Chill® technology (RC; MPSC Inc.) without ES. Six GF were conventionally chilled (plus ES) and other five GF were chilled with RC (without ES). The RC process involved transfer of a chilled isotonic solution (98.5% water; balance: glucose, phosphates, and maltose) through the vascular system, beginning in the arterial and exiting the venous side of the vasculature. The pH and temperature of each carcass were taken at 1, 4, 8, 12, and 24 hrs postmortem. At 24 hours postmortem (PM) carcass swabs on LC were taken for total aerobic plate count (APC). Lean ground beef (10% fat) from only LC was made from a composite of the quadriceps femoris (round tip), longissimus muscle (LM, strip loin), and triceps brachii (shoulder clod). Fat ground beef (20%) was made from GF fat trim (navel) that was blended with LC lean. Moisture and fat content were determined in ground beef samples.

Shear force and cooking losses were measured on two steaks (aged postmortem: 14 d, LC; 10 d, GF) according to AMSA guidelines. Color (CIE L*, a*, b*) was measured (displayed 1, 4, 7 d) on LM, semimembranosus (SM), and ground beef. States of myoglobin (oxymyoglobin, deoxymyoglobin, metmyoglobin; Shimadzu Scanning Reflectance Spectrophotometer) were measured on ground beef (4d PM, displayed 1, 4, 7 d) and microbial analysis was determined on 7 d (APC, enterobacteriaceae, lactic acid bacteria; log CFU). Animal served as the experimental unit and data were analyzed with PROC MIXED model.

Results: Beef originating from cull cows tends to have issues with lean color and tenderness. RC is a technology that reduces carcass temperature early PM as well as facilitates greater blood removal which have the potential to improve muscle color and stability. RC process also modulates PM metabolism in a manner that can positively impact tenderness. RC resulted in greater (P<0.05, 51.3 vs 48.6%) dressing percentage for LC, but was not significant for GF cows (61.6 versus 56.2%). RC provided lower (P<0.05; 0.40 log CFU) APC on carcasses compared to the control (0.93). LC RC had a higher (P<0.05) pH than C (4, 8 hr PM). LC RC had a lower (P<0.05) temperature (LM, SM) at 1 hr PM than C. RC did not affect moisture or fat content in LC ground beef. Shear force varied depending upon cow type and PM age (LM: LC d7 not different, d14 RC less tender, 0.6 kgf difference; GF RC more tender, 1.2 kgf lower). Cooking losses on LC were not different but higher for RC on GF. LC ground beef and GF blended (20% fat) ground beef on d 7 display had higher CIE a* (RC vs CC: 15.8 vs 13.1; 15.9 vs 12.8, respectively), higher DMb, and lower MMb. SM LC steaks had higher CIE b* (d 4) and CIE L* (d 7). GF LM steaks had higher CIE a* (d 4). Higher values for lactics were found for RC (P<0.05), but no differences were observed for APC and enterobacteriaceae in ground beef.

Conclusion: Rinse & Chill® technology has potential to improve the quality and shelf life of meat from cull cows, but results may be influenced by cow type.

Keywords: carcass chilling method, color, dairy and beef cows, steak and ground beef, tenderness
Objectives: Summer sausages are currently fermented to a lower pH (≤4.6) and mildly heat treated to temperatures of ≥54.4°C to meet USDA FSIS performance standards for E. coli O157:H7. Alternatives such as high pressure processing (HPP) may allow for processing with greater pH and lower temperatures while still meeting performance standards, however, the effect of HPP and different processing parameters on sausage quality is not known. The objective of this project was to evaluate HPP in combination with greater pH and minimal heat treatment for their effects on sausage quality.

Materials and Methods: Three replicates of all-beef summer sausage products (11% fat) were produced following: (i) pH 4.6, 54.4°C with a traditional smoke house and cooler chill (T); (ii) pH 5.0, 54.4°C T; (iii) pH 5.0, 54.4°C with ice bath chilling (RC); (iv) pH 5.0, 48.9°C RC; and (v) pH 5.0, 43.3°C RC. After chilling, sausages were sliced (3.1 mm), vacuum packaged, transported to a commercial HPP processor, and subjected to HPP at 586 MPa for 0, 1, 150, or 300 seconds. Post HPP sausages were evaluated for proximate analysis (n=9), lipid oxidation (n=9), objective color (n=9), texture profile analysis (n=15; hardness, springiness, cohesiveness, gumminess, and chewiness), and sensory characteristics (n=9) including firmness, cohesion, springiness, and gumminess using trained panelists. Data were analyzed using Proc Mixed (SAS v9.4), as a completely randomized split plot design. The raw sausage chubs were considered the whole plot to which cooking treatments were applied, and the cooked chubs were the split plot, to which HPP times were applied.

Results: The fat content of the sausages was similar (P=0.17) among all treatments. There was no difference for moisture:protein attributed to final pH/cooking endpoint or HPP time (P>0.63), nor was there a difference for lipid oxidation due to pH/cooking endpoint (P=0.45) or HPP (P=0.69). Objective color measurements showed that fermentation of summer sausage to pH 4.6, heated to 54.4°C, and traditionally chilled was lighter in color (greater L*; P<0.01) than all other pH/cooking endpoint combinations which were similar (P>0.17). Additionally, treatment (i) was less red (lower a*; P<0.01) than all other treatments while (iv) and (v) exhibited the greatest redness (P<0.01). Samples became less red and had more fading as HPP time increased (P<0.05), however, the differences were small in magnitude. Texture profile and sensory characteristic analysis were in agreement and showed that as cooking intensity increased so did the hardness of the sausage (P<0.01). Similar trends were noted between sensory characteristics and texture profile analysis, with a positive correlation between cooking intensity and the springiness, cohesiveness, and gumminess of the sausage products. High pressure processing also had an effect on springiness and gumminess (P<0.05), however sensory panelists were unable to detect differences (P>0.46) for these same attributes.

Conclusion: High pressure processing at 586 MPa for up to 300 seconds can be used as an alternate method for manufacturing beef summer sausages with marginal impacts on final product quality. Further research needs to be conducted to evaluate the efficacy of the process in reducing E. coli O157:H7 and other STEC population using this alternate summer sausage manufacturing process.

Keywords: Beef, Color, Quality, Sausage, Texture
Objectives: To determine the effect of early postmortem carcass vascular rinsing and chilling combined with electrical stimulation on meat quality and color of lamb meat.

Materials and Methods: Five treatments were implemented on carcasses (average hot carcass weight 23.4 kg) from lambs (8 months; n=21). Treatments included a control with no electrical stimulation (ES) or vascular rinsing (C), control with ES (CES:15 Hz, 700 mA, 500 µs pulse width, 45 s pulse duration), Rinse & Chill® (RC; G415), RC with ES applied before the rinse (ESRC:15 Hz, 700 mA, 500 µs, 45 s), and RC with ES applied after the rinse (RCES:15 Hz, 600 mA, 1000 µs, 45 s). The RC process involved vascular rinsing out residual blood early postmortem (PM) using a chilled isotonic substrate solution (98.5% water; balance: glucose, polyphosphates, maltose; 14 °C). Carcass pH and temperature were taken at 0.75, 1, 2, 3, 4, 5, 8, 12, and 24 hours PM. At 24 h PM, both Longissimus et lumborum (LL) and Semimembranosus (SM) muscles were excised. On 3 d PM, SM and LL were cut up (15 mm thickness) and vacuum packaged. Color chops (15 mm) were aged fresh to 6 d PM then displayed. Remaining samples were frozen and stored (-18 °C). LL was also aged to 22 d PM (2 °C) before being cut up (15 mm) and frozen. Color measurements (CIE L*a*b*, chemical states of myoglobin) were obtained on 0, 1, 3, and 5 d of display. Reflectance spectrophotometry was used to estimate oxymyoglobin (OMb, %R610 nm/%R525 nm), deoxymyoglobin (DMb, %R474nm/%R525nm) and metmyoglobin (MMb, %R572nm/525nm). Samples were cooked in a water bath (endpoint temperature, 70°C). The likelihood of cold shortening was determined using the following parameters: pH>6 and temperature <15°C. Other dependent variables included purge, pH, rebloom, Warner-Bratzler shear (WBS; 1-cm wide strips), cooking loss, and consumer sensory evaluations. Animal served as the experimental unit and data were analyzed with PROC MIXED model. Significance is reported when P<0.05.

Results: The probability of cold shortening occurring was reduced the most by ESRC (down to 5%) in comparison to C (30%) and CES (14%). The pH of CES was lower than C while ESRC was lower than all other treatments at 5 hours PM. An overall treatment effect showed ESRC (3 d PM) resulted in greater purge than C in the SM with no difference in the LL. However, CES had greater purge than C. A cooking loss treatment effect (3 d, 22 d, LL) showed ESRC resulted in greater loss than CES. Cooking loss did not differ among C, CES, RC, and RCES. No differences were detected in ultimate pH, carcass shrink and sensory evaluations. No treatment differences were found for WBS in LL (3 d, 19.5; 22 d, 13.2 newtons). Reblooming (22 d PM) C chops had greater estimated OMb than RC, RCES and ESRC. There was a treatment effect (3 d aged LL) for CES having greater OMb and DMb content than RCES. Additionally, CES had greater DMb than RC. Treatments were not different in CIE L* (3 d aged) on the LL. Similarly, there were no differences in treatments for CIE a* for LL or SM. RCES LL was more yellow (CIE b*) and had a greater hue angle than C and CES. The RC SM had greater values for CIE b*, hue angle, and chroma than C.

Conclusion: The application of ES followed by RC has commercial potential to reduce the likelihood of cold shortening. The order in which RC and ES are applied may also influence color.

Keywords: carcass chilling method, color, electrical stimulation, lamb, muscle
98- ABILITY OF EARLY POSTMORTEM TRAITS TO PREDICT SENSORY QUALITY OF PORK LOIN CHOPS MAY DEPEND ON DEGREE-OF-DONENESS

M. F. Overholt 1,*, B. J. Klehm 1, D. A. King 2, A. C. Dilger 1, S. D. Shackelford 2, D. D. Boler 1

1Animal Science, University of Illinois, Urbana, 2ARS, USDA, Clay Center, United States
moverho2@illinois.edu

Objectives: The recommend degree-of-doneness (DOD) of whole muscle pork has been reduced from 71° C to 63° C. Previously, pork sensory research has focused on 71° C DOD. Therefore, it is necessary to reassess the prioritization of fresh traits used to predict eating experience. Fresh quality and sensory traits are weakly to moderately correlated amongst themselves. Therefore, a multivariate, rather than a univariate analysis approach may be more appropriate. Therefore, objectives were to use canonical correlation analysis (CCA) to 1.) Determine the relationship between canonical quality and sensory and constituent variables of pork loins cooked to 63° C or 71° C and 2.) Compare the relationships among loin quality traits and canonical sensory variates of pork loins cooked to 63° C or 71° C.

Materials and Methods: Pork loins were selected in batches of 36 over the course of 4 collection (Nt = 288) days at a commercial abattoir following a 22 h chilling period. Loins were selected using visual color and marbling to ensure variation in early postmortem quality traits. Instrumental color, visual color, marbling, pH (UpH), and firmness were evaluated on the ventral surface of the loin (used for canonical fresh quality; Q1, Q2, Q3) within 30 min of fabrication. Loins were vacuum-packaged and transported to the University of Illinois where they were stored at 4° C until 14 d postmortem. At this time, 2.54 cm chops were removed for determination of intramuscular fat (IMF), slice shear-force (SSF), and sensory tenderness, juiciness, and pork flavor (used for canonical sensory quality; S1, S2, S3). Data were analyzed using the CANCORR procedure of SAS. Canonical correlations were considered significant at P < 0.05. Individual factors were considered to load significantly to a canonical variate if |r| ≥ 0.35 and the standardized coefficient was |C| ≥ 0.25.

Results: In CCA, the first canonical variate of each group is calculated such that it maximizes the explanatory power between the first set of canonical variates. Therefore, the 1st canonical variates are considered the most important. The 1st three canonical correlations were significant (r1 = 0.42, r2 = 0.34, r3 = 0.33; P < 0.04); whereas, only the 1st canonical correlation was significant (r1 = 0.43; P = 0.01) for chops cooked to 71° C. Tenderness (C = 0.30; r = 0.60), juiciness (C = 0.40; r = 0.65), and flavor (C = 0.71; r = 0.79) all loaded onto S1 for 63° C loins, and was therefore related to general eating quality. Q1 was loaded with subjective firmness (C = 0.75; r = 0.54) and IMF (C = 1.15; r = 0.68), and therefore was related to marbling. For loin chops cooked to 71° C; S1 was characterized by only juiciness (C = 0.89; r = 0.78) and flavor (C = 0.51; r = 0.63), and Q1 was characterized by UpH (C = 0.51; r = 0.37) and IMF (C = 1.00; r = 0.40). Only weak cross-loadings existed among quality variables and S1 for both DOD, but firmness (r = 0.23) and IMF (r = 0.28) were most correlated with S1 for 63° C; whereas, UpH (r = 0.16), firmness (r = 0.15), L* (r = -0.13), and IMF (r = 0.17) were most correlated with S1 for 71° C loins.

Conclusion: Overall, the extent to which sensory variables contribute to eating experience variability differs by DOD. Moreover, marbling appears to be more important factor in estimating eating quality of chops cooked to 63° C than pH, with both pH and marbling contributing equally when cooking to 71° C.

Keywords: Canonical correlation, degree of doneness, loin quality, pork
EFFECT OF HOT CARCASS WEIGHT ON THE RATE OF TEMPERATURE DECLINE OF THE LONGISSIMUS DORSI AND SEMIMEMBRANOSUS OF PIGS SLAUGHTERED IN A BLAST-CHILLED COMMERCIAL ABATTOIR
M. F. Overholt 1,* E. K. Arkfeld 1, T. L. Wheeler 2, D. A. King 2, A. C. Dilger 1, S. D. Shackelford 2, D. D. Boler 1
1Animal Science, University of Illinois, Urbana, 2ARS, USDA, Clay Center, United States moverho2@illinois.edu

Objectives: Over the last 30 years, the average hot carcass weight (HCW) has consistently increased by approximately 0.5 kg per year. This trend towards increased HCW causes engineering challenges for aging facilities designed when average HCW was 85 kg, in contrasts to today’s average HCW of 95 kg. The rate of carcass chilling is among the primary concerns. Larger carcasses have a smaller surface area to volume ratio, and almost certainly do not reach desired internal temperatures at the same rate as smaller carcasses. However, differences in rate have not been routinely reported, and to the authors’ knowledge, no such model has been reported for a large-scale, blast-chilled pork abattoir. Therefore, the objective of this study was to model the effect of HCW on temperature decline of a contemporary population of pork carcasses slaughtered at a commercial abattoir that used a blast-chilling method. Additionally, carcasses were sorted into HCW classes and the effect of HCW group was tested on the rate of temperature decline of the longissimus dorsi and semimembranous.

Materials and Methods: Hot carcass weight, internal temperature of the loin muscle (at the 10th rib) and ham, as well as ambient temperature, were recorded from 40 to 1320 min postmortem (45 time points) on 754 pork carcasses. An exponential decay model based on Newton’s Law of Cooling, was fit to temperature decline of the ham and loin of the whole population using PROC MODEL of SAS. The initial models for the decline of both ham and loin temperature displayed significant autocorrelation of errors based on evaluation of the autocorrelation function plots and Durbin-Watson test (P < 0.0001). Therefore, 2nd and 3rd order autocorrelation parameters were tested. Based on Durbin-Watson tests, the use of 2nd order autocorrelation model with lags of 1 and 2 were deemed adequate and were therefore included in all subsequent models. This base model and its respective parameter estimates were all significant (P < 0.01) for the whole population. Carcasses approximating (± 1 kg) 85, 90, 95, 100, and 105 kg were selected and binned into their respective weight classes. Dummy variables were used to compare the effect of HCW class on parameter estimate of ham and loin models.

Results: The developed model significantly fit all weight classes (P < 0.01) for both ham and loin temperature decline. For both loin and ham models, estimates of the rate constant (k) generally decreased as HCW increased. For loin temperature, k estimate for 105 kg carcasses was 0.00124 less (P = 0.02) than 85 kg carcasses, with the intermediate HCW classes not differing from the 85 kg class. For ham temperature, estimates of k for 90, 95, 100, and 105 kg HCW were all significantly and successively less than the k estimate for 85 kg class. For perspective, loins of 95 kg carcasses were estimated to reach 2° C in 17 h; whereas, loins from 105 kg carcasses would not reach 2° C until 27 h. For hams, 95 kg carcasses were projected to reach 2° C in 21 h; whereas, those from 105 kg carcasses would take 28 h. These estimates generally agreed with observed values.

Conclusion: Overall, HCW significantly affects the rate of temperature decline of pork hams, but not loins from pork carcasses weighing between 85 to 100 kg. This method of analysis can be used to model temperature decline in individual facilities.

Keywords: autocorrelation, chilling, ham, loin, modeling
Objectives: The demand for beef brisket amongst barbecue enthusiasts throughout Texas has increased, and pitmasters have questioned if aging briskets optimizes tenderness. The objective of this study was to evaluate the effect of postmortem aging on the palatability of Texas-style smoked briskets.

Materials and Methods: Paired briskets \((n = 24)\) were collected from USDA Choice carcasses, stored under refrigeration \((2°C \text{ to } 4°C)\) for 7 d, 21 d, or 35 d, then frozen \((-40°C)\) and stored \((-10°C)\) until subsequent palatability evaluations were performed. Three postmortem aging period comparisons were made: 7 d vs. 21 d (Set 1), 21 d vs. 35 d (Set 2), and 7 d vs. 35 d (Set 3). Briskets were prepared Texas-style by seasoning with kosher salt and coarse ground pepper before smoking with post oak wood at a temperature of 98.8°C. Briskets were cooked over a long period \((\sim 11 \text{ h})\) using a commercial barbecue pit. After cooking, flat \((M. \text{ pectoralis profundus})\) and point \((Mm. \text{ pectorales superficiales})\) portions were separated, sliced \((1.27\text{-cm})\) for serving to consumer panelists \((n = 83; n = 6 \text{ samples per consumer})\) for assessment of tenderness, juiciness, flavor, and overall liking. An additional slice \((2.54\text{-cm})\) was cut from the flat and point portions for Warner-Bratzler shear (WBS) force determination. Data were analyzed using the PROC GLM function of SAS \((v9.3; \text{ SAS Inst. Inc., Cary, NC})\) with \(\alpha < 0.05\). Three analyses were conducted that compared 7 d vs. 21 d aging, 21 d vs. 35 d aging, and 7 d vs. 35 d aging. Main effects included in the model were aging time, portion \((\text{flat vs. point})\) and their interaction. Least squares means were calculated and separated using the PDIFF option \((P < 0.05)\) where appropriate.

Results: There were no \((P > 0.05)\) interactions between aging treatment and portion for consumer sensory or WBS force measurements for any of the three aging period comparisons. Consumer panelists did not \((P > 0.05)\) detect differences in overall liking, flavor liking, tenderness liking, or juiciness liking between briskets of differing postmortem aging treatments. However, consumer panelists were able to detect palatability differences between brisket point and flat portions regardless of the postmortem aging treatment. When comparing point and flat portions from Set 1, point portions were preferred over flat portions for juiciness liking \((P = 0.0004)\), while flat portions were preferred over point portions for flavor liking \((P = 0.0348)\). When comparing the point and flat portions from Set 2, panelists assigned higher ratings to point portions for juiciness liking \((P < 0.0001)\), but lower ratings for overall liking \((P = 0.0499)\). When comparing brisket portions from Set 3, panelists rated the point portion as juicier \((P = 0.0112)\), yet assigned higher overall liking ratings to the flat portion \((P = 0.0296)\). Across all three age-day comparisons, WBS force measurements did not differ \((P > 0.05)\) between aging treatments. However, WBS force measurements were lower \((P < 0.0001)\) for point portions compared to flat portions no matter the aging treatment.

Conclusion: Although differences in palatability between point and flat portion were observed, postmortem aging did not improve consumer acceptance of beef brisket. Overall, we concluded that preparing USDA Choice Texas-style beef briskets resulted in products with high consumer palatability ratings and low WBS values, which helps demonstrate why barbecued briskets are so popular.

Keywords: aging, beef, brisket, consumer panels, Warner-Bratzler shear force
PALATABILITY OF BEEF TOP LOIN STEAKS SOURCED FROM THREE QUALITY GRADE GROUPS FROM TEXAS AND NORTHERN ESTABLISHMENTS

M. C. Gooch 1,*, A. N. Arnold 1, D. B. Griffin 1, D. S. Hale 1, C. R. Kerth 1, R. K. Miller 1, K. B. Gehring 1, J. W. Savell 1
1Animal Science, Texas A&M University, College Station, United States
a.arnold@tamu.edu

Objectives: There is a long-held perception by some in the foodservice and retail sectors that beef produced in Texas is not of the same quality or does not have the same palatability characteristics as beef from northern (Kansas, Nebraska, and Colorado) establishments. The objectives of this study were to: 1) assess the palatability traits of Texas beef, and 2) compare the palatability traits of Texas beef against similar grades of beef sourced from northern establishments.

Materials and Methods: Beef loin, strip loin steaks were collected from foodservice distribution centers to represent four Texas and seven northern commercial beef harvest and processing facilities. USDA Top Choice (n = 174 Texas; n = 180 northern), USDA Choice (n = 156 northern), and USDA Select (n = 174 Texas; n = 174 northern) steaks were evaluated using Warner-Bratzler shear (WBS) force and consumer sensory panel ratings. Consumer panelists (n = 335) were recruited from the Bryan/College Station area using an existing database and email list serves.

Data were analyzed using JMP, Version 13.1.0 (SAS Institute Inc., Cary, NC), where main effects and significant two-way interactions were included in the model. Least squares means were calculated and where appropriate, means were separated using the PDIF procedure and an α < 0.05.

Results: Top Choice steaks from Texas were found to have a higher (P < 0.05) average WBS force value than Top Choice steaks sourced from states other than Texas. Furthermore, Texas Top Choice steaks had lower (P < 0.05) juiciness and tenderness liking values than northern Top Choice steaks. There were no differences (P > 0.05) in average WBS force values or consumer panel ratings for Texas Choice and northern Choice, or Texas Select and northern Select.

Conclusion: The reasons Top Choice steaks from Texas received lower consumer panel ratings than northern Top Choice steaks are unknown. These results indicate that Texas beef should not be a concern for those who purchase Choice or Select striploins.

Keywords: beef, consumer sensory panels, palatability, Warner-Bratzler shear force

<table>
<thead>
<tr>
<th>Source</th>
<th>Quality Grade</th>
<th>Overall Liking</th>
<th>Flavor Liking</th>
<th>Tenderness Liking</th>
<th>Juicy Liking</th>
<th>WBS (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas plants</td>
<td>Top Choice</td>
<td>6.2</td>
<td>6.3</td>
<td>6.1c</td>
<td>6.1b</td>
<td>23.2a</td>
</tr>
<tr>
<td>Northern</td>
<td>Top Choice</td>
<td>6.7</td>
<td>6.5</td>
<td>6.8a</td>
<td>6.5a</td>
<td>20.2b</td>
</tr>
<tr>
<td>Texas</td>
<td>Choice</td>
<td>6.6</td>
<td>6.4</td>
<td>6.7ab</td>
<td>6.3b</td>
<td>20.3b</td>
</tr>
<tr>
<td>Northern</td>
<td>Choice</td>
<td>6.5</td>
<td>6.3</td>
<td>6.7a</td>
<td>6.0b</td>
<td>18.9b</td>
</tr>
<tr>
<td>Texas plants</td>
<td>Select</td>
<td>6.3</td>
<td>6.2</td>
<td>6.4abc</td>
<td>6.0b</td>
<td>22.6a</td>
</tr>
<tr>
<td>Northern</td>
<td>Select</td>
<td>6.2</td>
<td>6.2</td>
<td>6.3bc</td>
<td>6.1b</td>
<td>22.5a</td>
</tr>
</tbody>
</table>

Means within a column and lacking a common letter (a, b, c) differ (P < 0.05).

Consumers used the following 9-point scales: overall liking (1=dislike extremely; 9=like extremely), flavor liking (1=dislike extremely; 9=like extremely), juiciness liking (1=dislike extremely; 9=like extremely), and tenderness liking (1=dislike extremely; 9=like extremely)

Conclusion: The reasons Top Choice steaks from Texas received lower consumer panel ratings than northern Top Choice steaks are unknown. These results indicate that Texas beef should not be a concern for those who purchase Choice or Select striploins.

Keywords: beef, consumer sensory panels, palatability, Warner-Bratzler shear force
**102- COMPARISON OF MICROBIAL COMMUNITIES ON DRY AGED BEEF BETWEEN AGING FACILITIES**

R. Capouya 1,*, T. K. Mitchell 1, P. Bass 2, D. Clark 3, D. Clark 4
1Department of Plant Pathology, The Ohio State University, Columbus, 2Department of Veterinary Science, University of Idaho, Moscow, 3Certified Angus Beef, 4Department of Animal Sciences, The Ohio State University, Wooster, United States
capouya.2@osu.edu

**Objectives:** Despite the high cost and significant attention to detail in the processing of dry aged beef, there is very little information about how quality attributes are incorporated into the meat. Consequently, there are many different dry-aging techniques that are thought to impart unique flavors into the finished product. Many artisanal meat professionals believe the microbial populations present on the outer crust contribute to these flavor profiles; however, to-date there is very little information about the microbial species that grow on dry-aged beef. The fungal and bacterial communities of nine dry aged beef loins from five aging facilities were compared to assess differences in the types of microbes present and relative ratios of detection.

**Materials and Methods:** The loins were aged for 49 days in refrigerated conditions. The average temperatures for the aging facilities ranged from 35.0 to 39.4°F, and average relative humidity ranged from 75.9 to 91.0%. Of these five facilities, one facility aged the meat under Ultraviolet light. Each loin was sampled in multiple spatial locations for DNA extraction and the fungal and bacterial sequences present in the samples were identified using a next-generation sequencing approach and subsequent bioinformatic computational pipeline.

**Results:** Insufficient microbial DNA was isolated from UV-treated loins, indicating that this treatment eliminates all or most microbial growth on the meat. The results indicated that each aging establishment, with the UV-treated facility removed from the dataset, was producing meat with different microbial communities, based on PERMANOVA (p<0.01) and visual analysis of clustering in the principal coordinates analysis plot of Bray-Curtis dissimilarity. The position on the loins from which samples were taken had negligible influence on microbial community structure. Aging facility was determined to be the only observed driver of community structure. Notable operational taxonomic units (OTUs) that were detected in a majority of samples included the bacterial spoilage-associated species *Pseudomonas fragi*, and the fungal species *Debaryomyces udenii* and *Penicillium polonicum*. Additionally, an OTU identified as *Mucor* sp PG272 was found to be present in over 75% of all samples. While this specific species is not known to be associated with dry aged beef or related products, we believe this OTU may represent a species similar to *Thamnidium*, a mold to which industry insiders often associate with product quality.

**Conclusion:** The proportions of these populations were variable depending on the meat’s location of origin, and may have significant consequences in the resulting sensory properties of the edible, cooked meat produced from their host loins. This study established a general core microbiome for dry aged beef, as well as confirmed that there can be significant differences in the microbial communities on dry aged beef from different aging facilities, which may be contributing to distinct flavors and improved tenderness of dry aged beef.

**Keywords:** Beef, dry aging
Objectives: Inclusion of lipids in finishing diets may improve feed efficiency and improve carcass quality. The objective of this study was to evaluate the effects of supplementation of different fat sources in the diet on meat fatty acids profile of feedlot Nellore cattle.

Materials and Methods: Nellore bulls (n = 96), with an initial body weight of 399.90 ± 19.32, were divided into 24 pens, where pen was considered the experimental unit. The experiment was a randomized block design, divided in four treatments: 1 - with addition of natural sources of fat, from cottonseed and corn germ; 2 - including a source of by-pass fat from soybean oil; 3 - with inclusion of a combination of by-pass fat from one blend of vegetable sources and 4 - with addition of natural sources of fat, from cottonseed, corn germ and combination of by-pass fat from one blend of vegetable sources. Feed and water were supplied ad libitum. After 108-day of feeding, animals were slaughtered, and samples of the Longissimus dorsi muscle were collected for fatty acid analysis.

Results: Treatments containing natural sources of fat had greater levels (P < 0.001) of stearic fatty acid (C18:0), compared to all other treatments. Inclusion of by-pass soybean oil led to greater (P < 0.001) levels of CLA cis9-trans11 compared to all other treatments. Diets which included by-pass soybean oil and natural fats did not differ (P > 0.05) in CLA cis7-trans9, but were greater (P < 0.05) than all other treatments. Increasing unsaturated fatty acids in meat, like CLA, is perceived to be desirable to consumers due to potential positive impacts on health.

Conclusion: In conclusion, treatments with inclusion of by-pass fat presented less concentration of stearic fatty acid. The results of this study indicate that meat fatty acid composition may be influenced by feedlot fat supplements. Therefore, there exists potential towards producing meat products with targeted fatty acid composition that meets consumer preferences.

Keywords: Fatty acids, Feedlot, Lipids, Meat quality, Nellore
104- FRESH HAM CHOP CHARACTERISTICS COOKED TO VARIOUS INTERNAL ENDPOINT TEMPERATURES

J. Sawyer 1, B. D. Lambert 1, J. P. Muir 2, J. K. Apple 3, J. J. Ball 3, R. N. Cauble 3,*
1Animal Science and Veterinary Technology, 2Wildlife Sustainability and Ecosystem Sciences, Tarleton State University, Stephenville, 3Animal Science, University of Arkansas, Fayetteville, United States
sawyer@tarleton.edu

Objectives: Today’s health conscious consumer perceives pork as a healthy, low fat food staple. Identifying alternative fresh pork options within ham muscles could potentially increase carcass value. Therefore, the objective of our research was to evaluate fresh and cooked characteristics of pork m. biceps femoris (BF) and m. semimembranosus (SM).

Materials and Methods: Pork BF and SM were evaluated for quality characteristics once cooked to 62, 68, or 73 °C endpoint temperatures. Ham (n = 27) subprimals were cut into 2.54cm chops and allocated randomly to cook loss (CL), Warner-Bratzler shear force (WBSF), pH, and instrumental cook color (ICC) analyses. Chops assigned to CL and WBSF were weighed raw, cooked to treatment temperature, cooled to 23 °C, and weighed again to calculate CL. Shear force was calculated from six 1.27-cm-diameter cores taken parallel to the muscle fiber orientation using a manual cork borer. Each sample was sheared once in the center with a Warner-Bratzler compression 60° angle V-notch cutting blade attachment on an Instron Universal Testing Machine. Intramuscular pH readings averaged three reading using a glass pH probe. Instrumental cook color was evaluated when chops reached room temperature. Chops were sliced horizontally, and color readings were taken immediately across the exposed surface. Readings were measured using a Hunter MiniScan EZ. The lightness (L*), redness (a*), yellow (b*) and red to brown ratio (R:B) values were determined from the mean of three readings on the surface of each chop.

Results: Data were analyzed using the MIXED procedure of SAS with significance declared at P ≤ 0.05. Cook loss was the greatest (P < 0.01) in SM and both CL and WBSF values increased (P < 0.01) when endpoint temperature increased. Chops cooked to 73°C were 7.59 and 10.34% tougher compared to 62 and 68 °C, respectively. There was a muscle × temperature interaction (P = 0.04) for L* as SM was lighter at 68 and 73 °C compared to SM at 62 °C and BM at any endpoint temperature. Biceps femoris was redder and expressed a greater R:B ratio (P < 0.01) compared to SM. Additionally, chops cooked to 62 °C had the greatest a* and R:B values (P < 0.01). There was a muscle × temperature interaction (P < 0.01) for b* where BF was more yellow at 73 °C compared to BF at 62 °C and SM at 68 °C. Although pH was not affected (P = 0.56) by treatment, it is important to note that the mean pH values were 5.93 and 5.89 for BF and SM which is indicative of dark, firm, and dry meat and could have affected the outcomes for color analysis.

Conclusion: The authors conclude that 68 °C would be the optimal endpoint temperature because chops cooked to 73 °C had greater shear force and CL values which would result in a tougher product. Chops cooked to 62 °C had greater a* and R:B values compared to those at 68 °C and would be less appealing to consumers according to previous studies.

Keywords: Chops, Cook Loss, Instrumental Cooked Color, pH, Warner-Bratzler shear force
Meat and Poultry Quality

105- TENDERNESS AND CONSUMER ACCEPTANCE OF STEAKS PURCHASED AT FARMERS MARKETS IN TEXAS

R. R. Kirkpatrick 1, A. N. Arnold 1, J. W. Savell 1, K. B. Gehring 1
1Animal Science, Texas A&M University, College Station, United States
a.arnold@tamu.edu

Objectives: Consumers make beef purchasing decisions based on price, expected palatability characteristics, and cattle production practices. The interest in production practices has increased demand for “local” foods, which creates a unique market for beef, especially small, niche producers who sell their products at Farmers Markets. Consumers expect that these beef products will meet their palatability expectations, including tenderness. Therefore, the objective of this study was to establish a baseline for tenderness of beef sold by Farmers Market vendors.

Materials and Methods: Beef steaks \((n = 39)\) ribeyes, \((n = 39)\) top loins, and \((n = 38)\) top sirloins) were procured from 25 vendors at Farmers Markets \((n = 21)\) across Texas. When possible, information was collected at the Farmers Markets on breed, feeding regimen, and other production practices as well as a variety of marketing claims. To compare consumer acceptability of Farmers Market and retail beef, steaks \((n = 20)\) ribeyes, \((n = 20)\) top loins, and \((n = 20)\) top sirloins) were procured from 3 major retail chains (one store per chain) in the Bryan/College Station area. Farmers Market steaks were evaluated using Warner-Bratzler shear (WBS) force and consumer sensory panels; retail steaks were evaluated using consumer sensory panels. Steak measurements, including steak thickness, external fat thickness, and steak weight, were also collected.

Results: While visually we observed a number of wedge-cut steaks, no significant differences were identified among cuts for mean WBS values. There also were no significant differences between cuts for sensory panel ratings (Table 1). However, when comparing consumer sensory panel ratings between sources, retail steaks received higher ratings \((P < 0.05)\) than Farmers Market steaks for overall liking and tenderness liking. Farmers Market ribeye and top loin steaks were thicker \((P < 0.05)\) than top sirloins. However, top sirloins were heavier \((P < 0.05)\) than top loins and ribeyes.

Conclusion: Farmers Market vendors understand consumers’ desire to know more about their food and, as a result, often provide information on their type of cattle and production practices. While no difference was seen in objective tenderness measurements between steak sources, reducing the number of wedge-cut products may aid small producers and niche vendors in improving consumer overall and tenderness liking ratings. Consumers value the opportunity to connect with their food but should not have to sacrifice palatability characteristics; therefore, increased uniformity in fabrication practices could enhance their eating experience.

Keywords: Beef, consumer panels, Farmers Market, Warner-Bratzler shear force
**Meat and Poultry Quality**

106- EVALUATION OF DIETARY SUPPLEMENTATION OF A PHYTOGENIC BLEND AND RACTOPAMINE HCL TO GROWING PIGS ON PORK MEAT QUALITY

S. M. Mendoza 1,*, I. Mueller 2, E. Hendel 1, R. Murugesan 1, G. Gourley 3

1BIOMIN America Inc., Overland Park, United States, 2BIOMIN Holding GmbH, Getzersdorf, Austria, 3Gourley Research Group, Webster, United States

santamaria.mendoza@biomin.net

**Objectives:** Phytogenics are plant-derived compounds that have biological activity to support animal health and growth. The present experiment aimed to determine the effect of dietary supplementation of a phytogenic feed additive (PFA, Digestarom® Finish, BIOMIN America INC.) and ractopamine (Paylean®, Elanco Animal Health) to growing pigs on pork meat quality.

**Materials and Methods:** A subset of 90 loins were collected from a performance study. During the performance study (d 0 to 127), pigs (PIC genetics, initial BW = 23.5 ± 1.1 kg) were fed corn-soybean meal-DDGs based diets and had ad libitum access to the diets. Dietary treatments consisted of 1) no feed additive [CON], 2) CON + 0.015% PFA, and 3) 5 ppm Ractopamine HCl from d 98 to 127 [RAC]. Pigs were sent to market at approximately 132 kg of BW. Pigs were stunned using electric shock. Carcasses were deep chilled out and 30 loins/treatment (balanced by gender) were collected and aged for 10 days before evaluation at the Iowa State University Sensory Center. Loins were assessed for purge, visual color score (1 to 6, light to dark), visual marbling, ultimate pH, reflectance, cook loss, instrumental force, and sensory attributes (1 to 10, juiciness, tenderness, chewiness, flavor, and off-flavor). Data were analyzed using Mixed procedure of SAS to determine the effect of diet and gender (the interaction was not significant). Differences between least square means were determined using the t-test and significance was defined as having a p-value ≤ 0.05.

**Table 1. Effect of dietary supplementation of a Phytogenic feed additive and Ractopamine HCL to growing pigs on pork meat quality**

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>PFA¹</th>
<th>RAC²</th>
<th>Diet</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of loin, g</td>
<td>4532b</td>
<td>4679b</td>
<td>4910a</td>
<td>7.3</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>5.9 ± 9.8</td>
<td>5.9 ± 9.8</td>
<td>5.9 ± 9.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purge, %</td>
<td>1.78</td>
<td>1.84</td>
<td>1.53</td>
<td>0.177</td>
<td>1.79</td>
</tr>
<tr>
<td></td>
<td>0.0 ± 1.45</td>
<td>0.0 ± 1.45</td>
<td>0.0 ± 1.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual color, score</td>
<td>2.59</td>
<td>2.77</td>
<td>2.85</td>
<td>0.109</td>
<td>2.644</td>
</tr>
<tr>
<td></td>
<td>0.0 ± 0.89</td>
<td>0.0 ± 0.89</td>
<td>0.0 ± 0.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marbling fat, %</td>
<td>1.80</td>
<td>1.66</td>
<td>1.58</td>
<td>0.106</td>
<td>1.489v</td>
</tr>
<tr>
<td></td>
<td>0.0 ± 0.87</td>
<td>0.0 ± 0.87</td>
<td>0.0 ± 0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultimate pH</td>
<td>5.725b</td>
<td>5.749b</td>
<td>5.831a</td>
<td>0</td>
<td>5.757</td>
</tr>
<tr>
<td></td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
<td>0.0 ± 0.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ PFA: Digestarom® Finish, BIOMIN America INC.
² Ractopamine HCL: Paylean®, Elanco Animal Health

* Corresponding author.
### Table 1: Effect of Ractopamine HCl on Red Meat Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reflectance, L* value</th>
<th>Cook loss, %</th>
<th>Juciness</th>
<th>Tenderness</th>
<th>Chewiness</th>
<th>Flavor</th>
<th>Off-flavor</th>
<th>Instrumental force, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PFA, Digestarom Finish</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50.23</td>
<td>49.85</td>
<td>49.23</td>
<td>49.83</td>
<td>49.83</td>
<td>49.72</td>
<td>49.83</td>
<td>49.72</td>
</tr>
<tr>
<td><strong>RAC, Paylean in the diets of pigs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.88a</td>
<td>21.43b</td>
<td>22.08ab</td>
<td>22.75a</td>
<td>21.51y</td>
<td>0</td>
<td>4.47</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>4.91</td>
<td>5.39</td>
<td>5.12</td>
<td>4.71y</td>
<td>5.57a</td>
<td>0</td>
<td>2.13</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>5.02</td>
<td>5.19</td>
<td>4.99</td>
<td>4.44y</td>
<td>5.69x</td>
<td>5</td>
<td>0.30</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>6.33</td>
<td>5.85</td>
<td>6.05</td>
<td>6.64x</td>
<td>5.51y</td>
<td>0</td>
<td>1.32</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>3.18ab</td>
<td>3.67a</td>
<td>3.01b</td>
<td>3.15</td>
<td>3.43</td>
<td>0</td>
<td>1.85</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>2.38</td>
<td>1.99</td>
<td>2.31</td>
<td>2.33</td>
<td>2.12</td>
<td>0</td>
<td>3.12</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>6.80</td>
<td>6.55</td>
<td>6.96</td>
<td>6.97</td>
<td>6.58</td>
<td>0</td>
<td>1.83</td>
<td>1.49</td>
</tr>
</tbody>
</table>

1PFA, Digestarom Finish in the diets of pigs at 0.015% from d 0 to 127
2RAC, Paylean in the diets of pigs at 5 ppm Ractopamine HCl from d 98 to 127

\(^{ab}\)Values in the same row show statistically difference among diets \((P \leq 0.05)\) as determined using the student t-test

\(^{xy}\)Values in the same row show statistically difference between genders \((P \leq 0.05)\) as determined using the student t-test

**Results:** RAC increased the weight of loin and ultimate pH compared to PFA and control (table 1). PFA reduced cook loss compared to control but was not different from RAC. PFA increased flavor attributes compared to RAC but was not different from control. Loins from males reported greater marbling fat, juiciness, and tenderness and lower weight loin, cook loss, and chewiness compared
to loins from females. Weight of the loin, juiciness and tenderness were numerically increased by PFA and chewiness and instrumental force were numerically reduced by PFA.

**Conclusion:** Data suggest that diet can affect meat sensory attributes and more research is required to understand the benefits of phytogenic compounds on pork meat quality.

**Keywords:** flavor, phytogenic, pork meat quality, ractopamine
Objectives: This study evaluated the influence of oven temperature and steak degree of doneness (DOD) on flavor related volatile compounds at different depths within a steak (surface, mid, center).

Materials and Methods: Beef strip loin steaks were randomly assigned to cookery treatment combinations (n=20) at 30 replicates each. Individual steaks served as the experimental unit. Four oven temperatures (65.5°C, 177°C, 246°C, 343°C) and six DOD (57°C, 63°C, 68°C, 74°C, 79°C, 85°C) were utilized. After cooking, steaks were chilled, vacuum packaged, and frozen. Steaks were then allocated to groups of ten within each set of 30 replicates that represented three replications for chemical analysis. The replicates were then sliced parallel to the cooked surface at a thickness of 0.4-mm to produce three layers (surface, middle and center). Individual volatile compounds were analyzed through a split-plot one-way ANOVA, where treatment combinations were the whole plot and steak layer was the sub-plot.

Results: A total of seventy-one volatile compounds were quantitated (ng/g cooked sample). Of these, thirty-two quantitated volatile compounds were impacted by a two-way interaction of TRT×LAYER (P ≤ 0.05). Eight Maillard reaction compounds had a two-way TRT×LAYER interactions (P ≤ 0.05). Among Maillard products, Strecker aldehydes, pyrazines and sulphur compounds differentiated (P ≤ 0.05) in agreement with the surface layer differing to mid and center. Twenty-two lipid derived compounds quantitated had a two-way TRT×LAYER interactions (P ≤ 0.05). Thirty-four quantitated volatile compounds were impacted by the main effect of layer (surface, mid, center) within a steak (P ≤ 0.05). Only eight out of seventy-one volatile compounds were impacted by the main effect of treatment combinations (P ≤ 0.05). Among lipid derived compounds, hexanal concentrations differed (P ≤ 0.05) at each layer (surface, middle and center) - being highest in center and lowest in surface. The same was not apparent for maillard derived compounds, where the majority of the quantitated volatile compounds differed at each layer (P ≤ 0.05) but were highest in surface layer and lowest in center.

Conclusion: Previous research has shown that compounds of similar pathways follow the same path with respect to volatile compounds formation on being cooked. Treatment combinations influenced both Maillard reaction and lipid derived volatile compounds. The greatest impact of treatment combinations seems to have occurred with lipid derived products where variation of lipid volatile compounds was reduced within surface layer.

Keywords: degree of doneness, flavor, layers, oven temperature, volatile compounds
Meat and Poultry Quality

108- US CONSUMER ASSESSMENT OF NEW ZEALAND LAMB
S. Morrow 1,*, A. J. Garmyn 1, M. F. Miller 1
1Texas Tech University, Lubbock, United States
sean.j.morrow@ttu.edu

Objectives: The objective of this study was to establish consumer eating quality benchmarks of New Zealand lamb by selecting various cuts from a controlled livestock range and across multiple locations and seasons.

Materials and Methods: Lamb carcasses (n=325) were selected to fit within 3 GR (fat thickness) score ranges (<6, 6-9, and >9) within 3 carcass weight brackets [Light (13-17 kg), Medium (17.1-21 kg), and Heavy (>21.1 kg)]. Four genders were represented: ram, wether, ewe and cryptorchid. Carcasses were selected in February and April from two abattoirs in New Zealand in the north and south island. Paired muscles/muscle groups [longissimus dorsi (LD), semimembranosus (SM), rump (gluteus medius and biceps femoris), and knuckle (vastus intermedius, vastus lateralis, vastus medialis, and rectus femoris)] were collected from each carcass, denuded and fabricated into 15-mm slices, aged 1-28 d postmortem, and frozen prior to shipment to the US for sensory evaluation. Consumers (n=1440) were fed in 5 states across the US and each tested 7 cooked samples by rating tenderness (TEN), juiciness (JUC), flavor liking (FLAV) and overall liking (OL) using 100-mm lines scales. Data was analyzed using PROC GLIMMIX in SAS examining fixed effects of abattoir, kill month, sex, weight bracket, GR bracket, muscle, postmortem aging and consumer feeding location at a significance level of $\alpha=0.05$.

Results: Carcass weight influenced ($P<0.01$) JUC, but had no effect ($P>0.05$) on TEN, FLAV and OL. Heavy carcasses were juicier than middle or light weight carcasses. GR score had no effect on any palatability traits ($P>0.05$). Gender impacted TEN and FLAV ($P\leq0.03$), but not JUC or OL ($P>0.05$). Ewes were more tender than rams or cryptorchids, but were similar to wethers. Consumers liked the flavor of ewes more ($P<0.05$) than wethers or cryptorchids, but had similar FLAV as rams ($P>0.05$). Also, south island lambs were favored ($P<0.01$) in JUC, FLAV and OL, but there was no difference for TEN. Lambs harvested in February ranked higher ($P<0.02$) in all palatability characteristics than April. Rumps were more tender ($P<0.05$) than all other muscles, knuckle and LD were intermediate, while SM was least tender. There was no difference ($P>0.05$) in JUC for knuckle and rump, but both were juicier ($P<0.01$) than LD. Rumps and LD had greater FLAV and OL than knuckles, which were intermediate, and SM were scored lowest for FLAV and OL. Postmortem aging influenced TEN ($P<0.01$), as 28 d cuts were scored greater than all other days except 24 d. There was a general trend for increasing TEN as postmortem aging increased, but adjacent periods often had similar TEN scores. The case was the same with JUC, except that 14, 24 and 28 d were similar ($P>0.05$). There were no differences ($P>0.05$) for FLAV between 7, 14, 24, and 28 d, but 24 and 14 d ranked higher ($P<0.01$) than 1 or 2 d. Plus, there was no difference ($P>0.05$) between 7, 14, 24, and 28 d for OL, yet 14, 24, and 28 ranked higher ($P<0.01$) than 1 and 2 d postmortem age. Lastly, state influenced TEN, JUC, FLAV and OL ($P<0.01$). CA had lower TEN and JUC ($P<0.01$) than all other states. CO and CA had greater FLAV and OL than all other states ($P<0.05$), except TX had similar OL. OH scored FLAV and OL lower than all other states ($P<0.05$).

Conclusion: Overall, region, season, cut and postmortem aging had the most profound effects on lamb consumer eating quality.

Keywords: consumer, eating quality, Lamb, New Zealand
Objectives: The aim of this study was to evaluate the effects of two aging temperatures (2°C or 7°C) and two aging times (21 or 42 days) on the physicochemical characteristics of Dry and Wet aged beef.

Materials and Methods: A total of 16 striploins (8 pairs), from Nellore intact males, were collected directly from the slaughterhouse and sent to the meat lab. Each pair was cut in 8 equal parts and assigned to one of each treatment combination (two aging temperatures: 2°C or 7°C; two aging times: 21 or 42 days; wet or dry). The aging chamber was set at 2°C or 7°C and the relative humidity was set at 75%. Samples designed for Wet aging were deboned and vacuum packed, while samples for Dry aging were boned. Dry samples were weighted and position within the aging chamber was rotated every three days. Aging loss (drip, evaporation and trimming), pH, moisture content, surface water activity, cooking loss and shear force were determined. The statistical analyses were performed using a factorial ANOVA, and means (±SEM) were tested by Tukey test at 5% significance.

Results: Greater weight loss occurred by evaporation for Dry-aged samples at 7°C than 2°C, from 3 to 42 days. At 42 days Dry-aged samples aged at 7°C lost 22.5% while samples at 2°C lost 20.8% of water. There was no effect of aging temperature on drip loss of Wet-aged samples. Samples aged 21 days had a lower drip (1.8±0.12%) than samples aged for 42 days (3.5±0.27%). The trimming loss (crust removal only for Dry-aged samples) was not affected by aging temperature. However, samples aged for 42 days had greater (8.1±0.24%) trimming loss than samples aged 21 days (5.0±0.34%). The pH was not affected by temperature, time or type of aging. There was an interaction between aging time and type of aging for moisture content (inner) and water activity (outer). Increasing the aging time from 21 to 42 days increased water activity of Wet-aged samples (0.989±0.001 to 0.994±0.001), and decreased water activity for the Dry-aged samples (0.934±0.002 to 0.922±0.003). The moisture of Wet-aged samples was not affected by aging time. However, Dry-aged samples aged 42 days had lower (71.61±0.52%) moisture content than samples aged 21 days (72.61±0.54%). At 21 days of aging there was no difference in moisture from Dry and Wet samples. However, at 42 days, Dry-aged samples had lower (71.61±0.52%) moisture content than Wet-aged samples (72.96±0.22%). There was no effect of temperature, time and type of aging on instrumental tenderness. An interaction was found between temperature and aging type, and between time and aging type, for cooking loss. Dry samples aged at 7°C had lower (19.61±0.63%) cooking loss than Wet samples (21.55±0.64%) for the same aging temperature. The same pattern was seen for Dry samples aged 42 days, which had lower cooking loss (19.81±0.69%) than Wet samples (22.11±0.57%) for the same aging time. No difference was detected at 2°C or 21 days for cooking loss between aging types. However, Wet samples aged 42 days had higher cooking loss (22.11±0.57%) than Wet samples aged 21 days (20.08±0.51%).

Conclusion: The higher aging temperature and time decreased the yield of Dry-aged samples, while the yield of Wet-aged samples was just decreased by time. The aging conditions did not affect instrumental tenderness, however the moisture content, water activity and cooking loss decreased in the Dry aging process, which could affect the perception of juiciness.

Keywords: aging condition, dry aging, temperature
110- EFFECT OF RELATIVE HUMIDITY ON WATER LOSS OF STRIP LOINS DRY-AGED IN A HIGHLY MOISTURE PERMEABLE BAG
F. M. Ferreira 1, A. P. S. Bernardo 1, C. L. Gomes 1, S. B. Pflanzer 1,*
1Department of Food Technology, State University of Campinas, Campinas, Brazil
spflanzer@gmail.com

Objectives: The aim of this study was to evaluate the effects of two relative humidity RH (65% or 85%) and two aging times (21 or 42 days) on water loss of dry-aged strip loins unpackaged or packaged in a highly moisture permeable bag.

Materials and Methods: A total of 16 beef loins (8 pairs), from Nellore intact males, were collected at a commercial plant and sent to the meat lab. Each pair was cut in 8 equal parts and used to one of each treatment combination (two RH: 65% or 85%; two aging times: 21 or 42 days; unpackaged and packaged). The aging chambers were set to the desired RH and the temperature was set at 2ºC. Samples were deboned and packaged samples were put in dry aging bags (Tublin® 10, TUB-EX ApS, Denmark) using vacuum to seal the bags to get contact between the bag and the meat. Samples were weighed and position within the aging chamber was rotated every three days. Aging loss (evaporation and trimming), moisture content and surface water activity, were determined. The statistical analysis was performed using a factorial ANOVA, and means (±SEM) were tested by Tukey test at 5% significance.

Results: At 21 days of aging it was verified the presence of a bad smell and slime on samples aged without bag at 85% of RH. These samples were analyzed, however the same treatment (unpackaged), assigned to 42 days, were discarded. At 65% of RH, a greater evaporation loss (P<0.05) was found for samples aged without bag compared with packaged samples. At 21 days 85% RH there was no effect on evaporation loss for samples aged with or without bag (P>0.05). Evaporation loss of packaged samples at 42 days / 85% RH was 19.2±0.4%. At 21 days, evaporation loss of samples at 85% RH was lower (P<0.05) than at 65% RH, in both packaged and unpackaged. There was an interaction (P<0.05) between aging type and relative humidity for trimming loss (crust removal). Trimming was not affected (P>0.05) by type or time of aging of samples aged at 65% RH. On the other hand, at 21 days / 85% RH, non-packaged samples had higher (P<0.05) trimming than samples in a bag, mainly due to the presence of slime that was removed. The moisture content was lower (P<0.05) on samples aged in a bag for 42 days at 65% RH than at 85% RH and on samples aged without bag for 21 days at 65% RH than 85% RH. The increase in aging time decreased (P<0.05) moisture content of samples aged at 65% RH with or without bag, with no effect (P>0.05) on packaged samples aged at 85% RH. A lower surface water activity was verified for samples aged at 65% RH, independent of time or type of aging, when compared with samples aged at 85% RH (P<0.05). At 65% RH, non-packaged samples had lower (P<0.05) water activity than packaged samples, at 21 and 42 days. At 21 days / 85% RH, water activity was not affected by the type of aging (P>0.05). The increase of aging time decreased water activity of samples aged at 65% RH without bag, as well as for samples aged at 85% RH with bag (P<0.05), with no effect (P>0.05) on packaged samples aged at 65% RH.

Conclusion: The higher relative humidity used in this experiment (85%) was unable to produce a viable dry aged beef, mainly without the use of a permeable bag. The use of an aging bag can increase yield, however the surface water activity is higher, so the microbiological growth needs to be studied.

Keywords: aging condition, relative humidity, special bag
Meat and Poultry Quality

111- IMPACT OF EXTENDED AGING TIME AND FREEZING ON TENDERNESS OF BEEF TOP SIRLOIN STEAKS

S. B. Tindel 1,*, A. R. Murray 1, A. N. Arnold 1, R. K. Miller 1, D. B. Griffin 1, K. B. Gehring 1, J. W. Savell 1
1Animal Science, Texas A&M University, College Station, United States
a.arnold@tamu.edu

Objectives: The beef top sirloin steak is a popular cut among cost-conscious consumers, yet often does not deliver a desirable eating experience when compared to other cuts from the rib and loin. The objectives of this study were to 1) assess whether extended aging periods for the top sirloin were necessary to improve tenderness, and 2) evaluate the impact of freezing top sirloin butts during subprimal storage to see if quality attributes of resulting steaks would be enhanced.

Materials and Methods: Paired USDA Choice top sirloin butts (n = 40) were collected from 20 carcasses and divided equally among two experiments: 1) left sides 14- versus right sides 35-day refrigerated aging (all subprimals stored ~ -1 °C for the assigned number of days), and 2) right sides refrigerated aging (aged under refrigeration for 35 days before cutting into steaks) versus left sides frozen aging (aged under refrigeration for 14 days, frozen for 14 days, and then placed back in refrigeration for 7 days before cutting into steaks). Consumers (n = 80 per experiment) evaluated four samples for sensory testing to determine if they could discern a difference in tenderness, flavor, juiciness, and overall likeability between treatments. Steaks also were subjected to Warner-Bratzler Shear (WBS) force for objective tenderness evaluation.

Results: Comparisons for both objective and subjective tenderness evaluations showed no (P > 0.05) treatment differences in either experiment (Table 1). Results of the 14- versus 35-day refrigerated aging treatments indicated that top sirloin butts do not require extending-aging periods to increase tenderness. The lack of differences in consumer panel ratings between refrigerated and frozen treatments reflect an absence of consumer preference for either treatment.

Conclusion: Regardless of treatment, there were no differences in subjective or objective evaluations indicating that purveyors have options and flexibility in inventory control for top sirloin butts.

Keywords: aging, beef, consumer panels, freezing, Warner-Bratzler shear force

---

Table 1. Paired t-tests for sensory panel ratings and WBS force values for steaks from subprimals subjected to different aging treatments.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>n a</th>
<th>Overall</th>
<th>Tenderness</th>
<th>Flavor</th>
<th>Juiciness</th>
<th>Warner-Bratzler shear force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 d</td>
<td>10</td>
<td>6.0</td>
<td>5.6</td>
<td>6.3</td>
<td>5.6</td>
<td>30.7</td>
</tr>
<tr>
<td>35 d</td>
<td>10</td>
<td>6.1</td>
<td>6.0</td>
<td>6.1</td>
<td>5.9</td>
<td>27.5</td>
</tr>
<tr>
<td>SE</td>
<td></td>
<td>0.25</td>
<td>0.29</td>
<td>0.20</td>
<td>0.28</td>
<td>1.81</td>
</tr>
<tr>
<td>Prob &gt; t</td>
<td></td>
<td>0.6321</td>
<td>0.1868</td>
<td>0.3795</td>
<td>0.2948</td>
<td>0.1215</td>
</tr>
<tr>
<td>Refrigerated</td>
<td>10</td>
<td>6.3</td>
<td>6.0</td>
<td>6.4</td>
<td>5.8</td>
<td>26.7</td>
</tr>
<tr>
<td>Frozen</td>
<td>10</td>
<td>6.1</td>
<td>5.8</td>
<td>6.2</td>
<td>6.1</td>
<td>30.7</td>
</tr>
<tr>
<td>SE</td>
<td></td>
<td>0.14</td>
<td>0.21</td>
<td>0.11</td>
<td>0.26</td>
<td>1.97</td>
</tr>
<tr>
<td>Prob &gt; t</td>
<td></td>
<td>0.0946</td>
<td>0.3017</td>
<td>0.1005</td>
<td>0.2870</td>
<td>0.0733</td>
</tr>
</tbody>
</table>

a Number of subprimals per treatment.
b Sensory panel ratings: 9 = like extremely; 1 = dislike extremely.
c Experiment 1: 14 d = top sirloin butts aged for 14 days under refrigeration before cutting into steaks; 35 d = top sirloin butts aged for 35 days under refrigeration before cutting into steaks.
d Experiment 2: Refrigerated = top sirloin butts aged under refrigeration for 35 days before cutting into steaks; Frozen = top sirloin butts aged under refrigeration for 14 days, frozen for 14 days, and then placed back in refrigeration for 7 days before cutting into steaks.
Meat and Poultry Quality

112- BROILER GENETIC STRAIN AND DIET ON THE INCIDENCE OF WOODY BREAST MEAT
X. Zhang 1,*, J. D. Hendrix 1, M. D. Byron 1, S. Mukherjee 1, Y. L. Campbell 1, W. Zhai 2, W. Schilling 1
1Food Science, Nutrition, and Health Promotion, 2Department of Poultry Science, Mississippi State University, Mississippi State, United States
xz206@msstate.edu

Objectives: Woody breast (WB) is characterized by pale, hardened areas and muscle rigidity in the Pectoralis major muscle of broilers. Although WB incidence is related to increased growth rate and breast meat yield, the exact causes are still unknown. The objectives of this study were to investigate the effect of genetic strain and diet on the incidence of WB.

Materials and Methods: All experimental procedures were approved by the Institutional Animal Care and Use Committee of Mississippi State University (IACUC-16-542). Five strains of mixed-sex broilers (A1-3, B1-2; n = 240 per strain) were fed with commercial or reduced essential amino acid diets (20% reduction of digestible lysine, total sulfur amino acids, and threonine). A 5 (breeds) × 2 (diets) factorial arrangement within a randomized complete block design with 8 blocks (10 pens per block) and 8 replicate pens (15 chicks per pen) of each treatment was utilized. At 8 weeks of age, 4 broilers from each pen were randomly selected and harvested in a lab scale commercial processing facility. A total of 32 broilers from each treatment were evaluated for live weight, carcass weight, breast weight, breast pH, and breast color. The WB severity of chicken breasts was evaluated where 0 = normal, 1 = slight, 2 = moderate, and 3 = severe. The pH was measured at 15 min and 24 h post processing, and color was measured 24 h post processing. Cook loss and shear force were also evaluated.

Results: B1 broilers that were fed with the control diet expressed the WB condition with an average of 2.34, which was greater (P<0.05) than all other treatments with the exception of the A1 reduced diet treatment (P<0.05). Feeding broilers with the reduced diet led to less WB incidence in B breeds (P<0.05) but had minimal impact (P>0.05) in the A breeds. This indicates that WB incidence was impacted predominantly by genetics in both cases, but that diet had a greater impact on woody breast incidence in B in comparison to A genetic strains. There was greater than 25% severe WB in the A1 and B1 control diet treatments and the A1 reduced diet treatment. Feeding a reduced diet to B1 decreased incidence from 88% to 28% for moderate and severe WB.

After 15 min of processing, A1 broilers had greater (P<0.05) pH (6.53-6.54) than B1 and B2 reduced diet treatments, but did not differ (P>0.05) from other treatments. The pH declined after 24 h of processing, and B1 fed with control diet had a greater (P<0.05) pH (5.96) than all other treatments (5.77-5.87). Differences existed among treatments (P<0.05) with respect to cooking loss and shear force, but all samples were tender (<45 N) and cooking loss was similar to values reported in literature.

Feeding the reduced diet to B decreased (P<0.05) carcass weight when compared to control treatments; but feeding the reduced diet to A led to no difference (P>0.05) in carcass weight. For the control diet, B1 had a greater breast weight (P<0.05) than all other treatments. Feeding the reduced diet decreased (P<0.05) breast weight for all breeds with the exception of A1.

Conclusion: A1 and B1 breeds had the greatest WB incidence. Feeding a reduced diet led to greater reductions in WB incidence and breast meat weight in B genetic strains when compared to A genetic strains.

Keywords: woody breast incidence, broiler, breast weight, reduced essential amino acid diet
Assessment of 1,3-Dibromo-5,5-Dimethylhydantoin as a Final Wash for Reducing Microbial Contamination on Beef Carcasses

A. A. Reyes 1,*, B. R. Bullard 1, I. Geornaras 1, R. J. Delmore 1, D. R. Woerner 1, J. N. Martin 1, K. E. Belk 1
1Center for Meat Safety & Quality, Department of Animal Sciences, Colorado State University, Fort Collins Colorado, United States
areyes23@colostate.edu

Objectives: The objective of this study was to evaluate the effect of a bromine-based antimicrobial (1,3-dibromo-5,5-dimethylhydantoin; DBDMH) in a food safety control system to eliminate hot water wash, against inoculated populations of E. coli biotype I surrogates on beef carcasses.

Materials and Methods: The surrogates consisted of a five-strain mixture of non-pathogenic E. coli biotype I. The external surfaces of the carcasses were inoculated within 4 10×10cm areas. The inoculation level was approximately 6 log CFU/cm². Inoculated carcasses were allowed a 10 min attachment period. Three food safety systems were evaluated. On each sampling day, 3 inoculated carcasses (6 sides) received a hot water (HW; 204.8°F) wash and were sampled immediately. Carcasses then received a lactic acid spray treatment (3.8%), were sampled again, and chilled for 36h with a 10h DBDMH spray chill treatment (106.4ppm) before the final samples were collected (A). A second set of 6 sides received a DBDMH (467ppm) treatment in a final wash cabinet and were sampled immediately. Those carcasses received the same remaining interventions (lactic acid spray; DBDMH spray chill; B). The third set, another 6 sides received all interventions: DBDMH final wash, HW, lactic acid spray, and DBDMH spray chill (C). All three systems were repeated on a second production day. Inoculated samples were analyzed for Enterobacteriaceae (EB) populations. Appropriate dilutions were plated in duplicate to enumerate EB (3M Petrifilm Enterobacteriaceae) populations for all sponge samples. Colonies on EB Petrifilm plates were enumerated following 24-hour incubation at 37°C. This study was designed as a randomized complete block, with production day serving as the block. Bacterial populations recovered were analyzed using the Mixed Procedure of SAS version 9.4 and data expressed as least squares means.

Results: The results for this study are found in Table 1. For system A, the HW reduced (P<0.05) inoculated surrogate populations from 6.6 log CFU/cm² to 3.2 log CFU/cm². Additionally, following a lactic acid spray, the combined effect of the HW and lactic acid spray reduced (P<0.05) the microbial populations to 3.0 log CFU/cm² and after DBDMH spray chill, the remaining populations were <1.2 log CFU/cm². The initial inoculated surrogate populations were 6.6 log CFU/cm² prior to application of system B (DBDMH final wash, lactic acid spray, DBDMH spray chill). Following DBDMH application in a final wash, surrogate populations were reduced (P<0.05) to 4.9 log CFU/cm². The combined effect of the DBDMH final wash and the lactic acid spray treatment reduced (P<0.05) the initial surrogate populations by 1.8 log CFU/cm² and ultimately, after the DBDMH spray chill, the remaining surrogate populations were 3.8 log CFU/cm². Lastly, system C interventions (DBDMH final wash, HW, lactic acid, and a DBDMH spray chill) decreased (P<0.05) initial populations from 6.6 log CFU/cm² to <0.5 log CFU/cm². Overall, all systems were effective (P<0.05) against the inoculated E. coli biotype I, surrogates for pathogenic E. coli and Salmonella, on beef carcasses.
Conclusion: In conclusion system C with all the intervention, provided the greatest potential for control against the inoculated *E. coli* biotype I surrogates when compared to the other two systems evaluated in this study.

**Keywords:** Antimicrobial intervention, bromine
**Meat and Poultry Safety**

**114-REDUCTION OF SALMONELLA IN POST-HARVEST HOT CARCASS PORK USING MULTIPLE INTERVENTIONS**

A. N. Orange 1,*, M. M. Brashears 1,2, M. F. Miller 1, A. Echeverry 1

1Animal and Food Science, 2International Center for Food Industry Excellence, Texas Tech University, Lubbock, United States

ashley.n.orange@ttu.edu

**Objectives:** Salmonella continues to be a leading cause of morbidity due to foodborne illness in the United States, accounting for 11% of the total annual foodborne illness cases (> 1 million) as well as 35% of hospitalizations and 28% of deaths related to foodborne disease. Pork is known to carry Salmonella, and it is critical that interventions be validated in simulated industry settings to effectively demonstrate the reductions of this pathogen. The purpose of this study was to determine the efficacy of various FSIS approved interventions on the reduction of Salmonella on post-harvest hot carcass pork.

**Materials and Methods:** Fresh pork skin, that was warmed and held at pre-rigor temperatures of 37°C, was inoculated with a 5-strain cocktail of Rifampicin Resistant Salmonella strains (S. Newport T1-473, S. Typhimurium R1-089, S. Enteritidis T1-496, S. Montevideo 11TTU382B, and S. Anatum 11TTU158B). Pork samples were dipped into a Salmonella solution of 7.00 Log_{10} CFU/ml for a final concentration of 5.00 Log_{10} CFU/cm² on the pork surfaces. Interventions tested in this study included: 1) Sulfuric acid and sodium sulfate (pH 1.3), 2) peracetic acid (350 ppm), 3) lactic acid (3%), 4) citric acid (1.3%), 5) hypobromous acid (300 ppm), and 6) lauramide arginine ethyl ester (200 ppm), 7) peracetic acid (400 ppm) with 2% acetic acid, and 8) sulfuric acid and sodium sulfate (pH 1.3) combined with peracetic acid (350 ppm). Treatments were prepared according to manufacturers’ recommendations to desired concentrations and confirmed using a pH meter, chemical titration and test kits specified for each intervention chemical prior to treatment of the pork meat. A commercial CHAD cabinet (CHAD Equipment LLC., Olathe, KS., United States) was used to apply treatments held at ambient temperature (21°C) at a speed of 30.4 cm/2.5 sec at a pressure of 257.8 kPa. Salmonella on the pork was enumerated before treatments, and 5 minutes and 24 hours after treatment. Salmonella was enumerated on Tryptic Soy Agar modified to have a concentration of 100 mcg/mL of rifampicin within the agar solution. Each experiment was replicated three times and statistically analyzed using ANOVA and pairwise T-tests.

**Results:** To measure significance, a $P$-value of 0.1 was used during statistical analysis. Five-minute post treatment Salmonella reductions showed significant reduction with the application of lauramide arginine ethyl ester with a 1.31 Log_{10} CFU/cm² reduction ($P = 0.006$) and hypobromous acid with a 1.66 Log_{10} CFU/cm² reduction ($P = 0.07$). Salmonella reductions 24 H post treatment showed significant reductions with the application of hypobromous acid (2.06 Log_{10} CFU/cm² reduction; $P = 0.07$), sulfuric acid and sodium sulfate (1.81 Log_{10} CFU/cm² reduction; $P < 0.001$), sulfuric acid and sodium sulfate combined with peracetic acid (1.73 Log_{10} CFU/cm² reduction; $P < 0.001$), and lauramide arginine ethyl ester (1.56 Log_{10} CFU/cm² reduction; $P < 0.001$).

**Conclusion:** It is pivotal for the industry to validate the efficacy of antimicrobial interventions to demonstrate that the process achieves pathogen reductions. The results of this study indicate that the application of a hypobromous acid, sulfuric acid and sodium sulfate, sulfuric acid and sodium sulfate combined with peracetic acid or lauramide arginine ethyl ester as an intervention significantly reduces Salmonella in pork from initial inoculated loads.

**Keywords:** Intervention, organic acids, pork, Salmonella
**Meat and Poultry Safety**

**115- REDUCTION OF SALMONELLA IN POST-HARVEST CHILLED PORK HEAD MEAT USING MULTIPLE INTERVENTIONS**

A. N. Orange 1,*, M. M. Brashears 1,2, M. F. Miller 1, A. Echeverry 1

1Animal and Food Science, 2International Center for Food Industry Excellence, Texas Tech University, Lubbock, United States

ashley.n.orange@ttu.edu

**Objectives:** *Salmonella* continues to be a leading cause of morbidity due to foodborne illness in the United States, accounting for 11% of the total annual foodborne illness cases (> 1 million). Pork is known to carry *Salmonella*, and it is critical that interventions be validated in simulated industry settings to demonstrate effective reductions of this pathogen. The purpose of this study was to determine the efficacy of various FSIS approved interventions on the reduction of *Salmonella* on post-harvest chilled pork head meat.

**Materials and Methods:** Fresh pork cheek meat, that was chilled to 4°C, was inoculated with a 5-strain cocktail of Rifampicin Resistant *Salmonella* strains (S. Newport T1-473, S. Typhimurium R1-089, S. Enteritidis T1-496, S. Montevideo 11TTU382B, and S. Anatum 11TTU158B). Pork samples were dipped into a *Salmonella* solution of approximately 7.00 Log 10 CFU/ml for a final inoculated concentration of nearly 5.00 Log 10 CFU/cm² on the pork surfaces. Interventions tested in this study included: 1) Sulfuric acid and sodium sulfate (pH 1.3), 2) Peracetic acid (350 ppm), 3) Lactic acid (3%), 4) Citric acid (1.3%), 5) Hypobromous acid (300 ppm), 6) Lauramide arginine ethyl ester (200 ppm), 7) Peracetic acid (400 ppm) with 2% acetic acid, and 8) Sulfuric acid and sodium sulfate (pH 1.3) combined with peracetic acid (350 ppm). Treatments were prepared according to manufacturers’ recommendations to desired concentrations and confirmed using a pH meter, chemical titration and test kits specified for each intervention prior to treatment of the pork meat. A commercial CHAD cabinet (CHAD Equipment LLC., Olathe, KS., United Sates) was used to apply individual treatments at ambient temperature (21°C) at a speed of 30.5 cm/2.5 sec at a pressure of 275.8 kPa. *Salmonella* on the pork was enumerated before treatments, and 5 minutes and 24 hours after treatment. *Salmonella* was enumerated on Tryptic Soy Agar modified to have a concentration of 100 mcg/mL of rifampicin within agar solution. Each experiment was replicated three times and statistically analyzed using ANOVA and pairwise T-tests.

**Results:** A P-value of 0.1 was used to determine significance during statistical analysis. Five-minute post treatment *Salmonella* reductions showed significant reduction with the application of sulfuric acid and sodium sulfate combined with peracetic acid with a 1.71 Log 10 CFU/cm² reduction (P = 0.07). 24 H post treatment showed significant *Salmonella* reductions with sulfuric acid and sodium sulfate combined with peracetic acid (3.98 Log 10 CFU/cm² reduction; P <0.001), peracetic acid (3.43 Log 10 CFU/cm² reduction; P <0.001), lactic acid (3.06 Log 10 CFU/cm² reduction; P <0.001), sulfuric acid and sodium sulfate (2.83 Log 10 CFU/cm² reduction; P <0.001), water (2.06 Log 10 CFU/cm² reduction; P <0.001), lauramide arginine ethyl ester (1.71 Log 10 CFU/cm² reduction; P <0.001), hypobromous acid (1.69 Log 10 CFU/cm² reduction; P <0.001), and citric acid (1.64 Log 10 CFU/cm² reduction; P <0.001).

**Conclusion:** It is pivotal for the industry to validate the efficacy of antimicrobial interventions in an industry setting to demonstrate their effectiveness. The results of this study indicate that the application of sulfuric acid and sodium sulfate combined with peracetic acid reduce *Salmonella* significantly in chilled pork and could improve the safety of pork products.

**Keywords:** Intervention, organic acids, pork, *Salmonella*
**Meat and Poultry Safety**

116- **SALMONELLA PREVALENCE IN LYMPH NODES OF SOWS AND MARKET HOGS IN THE UNITED STATES**

B. C. Bessire ¹, *, M. Thomas ², K. B. Gehring ¹, J. W. Savell ¹, D. B. Griffin ¹, T. M. Taylor ¹, W. B. Mikel ³, J. A. Campbell ⁴, A. N. Arnold ¹, J. Scaria ²

¹Animal Science, Texas A&M University, College Station, ²Veterinary & Biomedical Sciences, South Dakota State University, Brookings, ³WPF Technical Services, Louisville, ⁴Animal Science, Penn State University, University Park, United States

a.arnold@tamu.edu

**Objectives:** Antimicrobial interventions are applied to carcass surfaces to mitigate pathogens transferred during harvest. While highly effective, carcass surface interventions are unable to reduce pathogens located within fat-encased lymph nodes (LNs). For this reason, LNs have been identified as a potential cause of *Salmonella* in beef and pork products. The objectives of this study were to (1) establish a baseline for *Salmonella* prevalence in LNs of sows and market hogs in the United States, and (2) to determine the impact of carcass chilling methods on *Salmonella* prevalence in surveyed LNs.

**Materials and Methods:** A total of 21 commercial pork harvest facilities were categorized by region and hog type (n = 8 northern market hog, n = 4 northern sow, n = 4 southern market hog, and n = 5 southern sow). As processing volumes allowed, twenty-five carcasses were selected from each establishment. From each carcass, left and right superficial inguinal LNs were removed, pooled (n = 507 total LN samples), and subjected to *Salmonella* prevalence determination. Additionally, type of carcass chilling method (conventional, blast chill, or other) used at each facility was recorded.

**Results:** *Salmonella* prevalence rates differed (P < 0.05) between hog types in both regions. Specifically, 6.4% of market hog and 37.0% of sow LN samples were found to be *Salmonella*-positive in the northern region; in the southern region, 13.0% of market hog and 4.8% of sow samples were *Salmonella*-positive. There was a difference (P < 0.05) in prevalence rates between regions (northern and southern) for sows, but not market hogs (P > 0.05). In the northern region, prevalence rates of *Salmonella* across chilling types were as follows: 20.0, 2.7, and 1.3% positive for conventional, other, and blast chill methods, respectively. Additionally, in the southern region, there were 20.0% positive samples for conventional, 0.0% for blast chill, and 12.0% for other chill methods. In both regions, samples from conventionally chilled carcasses returned more (P < 0.017) positive results than any other chill method.

**Image:**

Prevalence of *Salmonella*-positive lymph node (LNs) samples by hog type, region and chilling method

<table>
<thead>
<tr>
<th>Hog type</th>
<th>Region</th>
<th>Northern</th>
<th>Southern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market hog</td>
<td>6.4 (13/202) A, X</td>
<td>13.0 (13/100) A, X</td>
<td></td>
</tr>
<tr>
<td>Sow</td>
<td>37.0 (37/100) B, X</td>
<td>4.8 (5/105) B, Y</td>
<td></td>
</tr>
<tr>
<td>Chill type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>20.0 (10/50) A</td>
<td>20.0 (10/50) A</td>
<td></td>
</tr>
<tr>
<td>Blast chill</td>
<td>1.3 (1/77) B</td>
<td>0.0 (0/25) A</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.7 (2/75) B</td>
<td>12.0 (3/25) A</td>
<td></td>
</tr>
</tbody>
</table>

A: Values within a column lacking a common letter differ (P < 0.05).
X: Values within a row lacking a common letter differ (P < 0.05).

Market hogs or sows were harvested and left and right superficial inguinal LNs (n = 1014 LNs) were removed. Within animal, left and right LNs were pooled (n = 507 total samples).

Carcass chilling methods were defined as: (1) conventional – standard cold storage unit without forced air circulation or water spray; (2) blast chill – cold storage unit with forced air circulation and without water spray; or (3) other – conventional or blast chill with water spray or other quick chill system. Carcass chilling methods were only documented for establishments harvesting market hogs, as all sow carcasses were hot-boned.

**Conclusion:** The higher rate of *Salmonella* prevalence in northern sows warrants further investigation. Members of the pork industry would benefit from the identification of subsequent research needs or possible process improvements to address the presence of *Salmonella* in porcine LNs.

**Keywords:** lymph nodes, market hogs, prevalence, Salmonella, sows
Meat and Poultry Safety

117- POST-HARVEST APPLICATION OF BACTERIOPHAGES ON BEEF AS A NATURAL INTERVENTION AGAINST E. COLI O157
B. De Vegt 1,*, J. Van Mierlo 1, S. Klamert 1, S. Witte 1
1Micreos Food Safety, Micreos, Wageningen, Netherlands
b.devegt@micreos.com

Objectives: Despite the use of chemical interventions in a multi-hurdle approach against *Escherichia coli* O157, this pathogen remains a great concern for the beef industry. Bacteriophages are the natural enemy of bacteria, and able to specifically kill *E. coli* O157, for example. Together with the fact that phages are harmless to human, phages have the potential to form an additional safe and effective intervention against *E. coli* O157.

The objective of this study was to determine the efficacy of bacteriophages as natural intervention against *Escherichia coli* O157 on refrigerated beef.

Materials and Methods: Bacteriophages were isolated from sewage water, after which lysis activity of the isolated phages was assessed by spotting serial dilutions on 88 *E. coli* O157 strains. For efficacy assays on beef, two cold (4 °C/39.2 °F) beef cuts of 9 cm² were contaminated per treatment with *E. coli* O157 at a rate of 1 x 10⁵ cfu/cm². Subsequently, samples were treated with 3 x 10⁷ or 3 x 10⁸ Plaque Forming Units (PFU)/cm² by applying 5 µL/cm² of a cocktail containing two selected phages. Controls were treated with similar volumes of tap water. Beef samples were then incubated for 24 hours at 4 °C, after which bacteria were retrieved for enumeration. Bacterial reductions on phage treated samples were calculated relative to tap water treated controls. Reductions of four different *E. coli* O157 strains obtained in three independent experiments were used for statistical analysis (Unpaired t-test).

Two separate time trials were done in which beef samples were contaminated and treated as described above. In one time trial, beef samples were stored at 4 °C during the complete experiment. In the second time trial, all samples were initially stored at 4 °C for 24 hours, after which all remaining samples were transferred to an abusive temperature of 20 °C (68.0 °F) for the remainder of the experiment. For both time trials, two beef samples per treatment were retrieved for bacterial enumeration at 2, 6, 24, 30, 48, and 54 hours post phage treatment. Results were confirmed in three independent experiments on which statistical analysis per time point was done (Unpaired t-test).

Results: After assessing the lysis activity of the isolated phages on 88 *E. coli* O157 strains, two phages were selected that showed a complementing hostrange activity, lysing 90% of all *E. coli* O157 strains tested. A cocktail of the two selected phages showed bacterial reductions between 1.5 - 1.9 log₁₀(P<0.05) when cold beef was treated with 3 x 10⁸ PFU/cm², while 0.8 – 1.5 log₁₀(P<0.05) reductions were observed with 3 x 10⁷ PFU/cm². In both time trials, we observed that the maximum reduction was already achieved 6 hours post phage application. Furthermore, in the first time trial at 4 °C, we observed no further reduction in bacterial load after the 6 hours time point (1.25 – 2.25 Log₁₀ reduction at all time points, P<0.05). Transferring the treated samples to an abusive temperature of 20 °C, resulted in outgrowth of the remaining *E. coli* O157 at a similar rate as the non-treated controls.

Conclusion: The two phage cocktail described above significantly reduces *E. coli* O157 on refrigerated beef. Furthermore, the time trials show that phages work fast on cold beef, and that they can be regarded as processing aid. All in all, we show that bacteriophages provide a natural, safe, and effective intervention for the beef industry to fight *E. coli* O157.

Keywords: Bacteriophage, Beef, *E. coli* O157, Intervention, Phage
118-SYNERGISTIC EFFECT OF PHAGES AND ORGANIC ACID SALTS ON LISTERIA CONTAMINATED READY TO EAT TURKEY HAM

G. Eraclio 1, B. De Vegt 1,*, J. van Mierlo 1, S. Sirdesai 1, R. Peterson 1
1Micreos Food Safety, Micreos, Wageningen, Netherlands
b.devegt@micreos.com

Objectives: Ready To Eat (RTE) are foods that have already been cooked and needs no further heating, making it easy and fast for consumers to prepare meals. For this reason that most RTE do not undergo any lethality steps at consumer level before consumption, companies must care to deliver “Listeria-free” foods.

In this study ability of PhageGuard Listex (a natural bacteriophage solution against Listeria) in combination with buffered vinegar or a commercially available solution comprising potassium lactate (72.8%) and sodium diacetate (5.2%), to control Listeria during the shelf-life (120 days) of sliced RTE turkey meat was assessed.

Materials and Methods: Cooked turkey slices were inoculated with a cocktail of four Listeria monocytogenes strains at 1 Log cfu/cm² (duplicate sample per treatment). Contaminated samples were treated by spraying either only PhageGuard Listex (2x10⁷ PFU (Plaque Forming Units)/cm²), PhageGuard Listex plus buffered vinegar and PhageGuard Listex plus potassium lactate/sodium diacetate on the surface of the turkey slices. Other samples were sequentially treated with just either of the organic acids and tap water (untreated) and were used as negative controls. Subsequently, all samples were vacuum packed and stored at 40°F/4°C. During the shelf-life of 120 days, samples were retrieved in peptone buffered water to detect and enumerate Listeria.

Results: When applied on artificially contaminated turkey ham, the phage solution or buffered vinegar alone kept Listeria concentration below detection limit for 20 and 30 days respectively (mean value of two individual experiments). However, when a combination of phages with buffered vinegar was applied, Listeria was kept below detection limit for 120 days (mean value of two individual experiments). A similar though less strong, effect was observed when turkey slices were sequentially treated with a combination of phages and potassium lactate/sodium diacetate. In this case, Listeria was not detected for 30 days (mean value of two individual experiments) and Listeria was kept below 2 logs outgrowth (compared to the initial contamination) for 70 days (mean value of two individual experiments). Application of just potassium lactate/sodium diacetate alone resulted in more than 2 logs outgrowth after 40 days.

Conclusion: A clear synergistic effect was observed when combining a bacteriophage product against Listeria with two different organic acid solutions on Listeria contaminated cooked turkey slices. Results showed combining phages with buffered vinegar, Listeria levels were kept below detection limits for an additional 90 days when compared to buffered vinegar alone. Combining such Listeria-specific phage product with these organic acids has the added beneficial effect of inhibiting the outgrowth of spoilage bacteria.

All in all, these results establish the combined effect of PhageGuard Listex and organic acids as an effective anti-listeria hurdle during processing of RTE meals, leading to an increase in consumer safety.

Keywords: Listeria, organic acids, phage, RTE, turkey ham
Objectives: Two studies were conducted to evaluate the antimicrobial effects of blends of peroxyacetic acid (PAA) acidified with various acids against inoculated populations of nonpathogenic *Escherichia coli* biotype I surrogates for pathogenic *E. coli* and *Salmonella* on warm, prerigor beef carcass surface brisket tissue.

Materials and Methods: In phase I, 10 × 10 cm pieces (n = 10) of warm, prerigor beef carcass surface brisket tissue were inoculated (6-7 log CFU/cm²) with a five-strain mixture of nonpathogenic *E. coli* biotype I surrogates. Samples were either left untreated (control) or were immersed for 10 s in PAA (400 ppm) acidified with lactic acid (3.5%), PAA (400 ppm) acidified with acetic acid (2%), PAA (400 ppm) acidified with citric acid (1%), PAA (400 ppm) acidified with a sulfuric acid and sodium sulfate blend (pH 1.2 and pH 1.8; SSS), and PAA (300 ppm) acidified with SSS (pH 1.2). All samples were analyzed five minutes post-treatment for surviving *Enterobacteriaceae* populations. In phase II, 10 × 10 cm pieces (n = 10) of prerigor beef tissue inoculated (6-7 log CFU/cm²) with the same five-strain mixture of nonpathogenic *E. coli* surrogates were either left untreated or were spray-treated (10 s) with water, PAA (350 ppm), PAA (400 ppm), PAA (400 ppm) acidified with acetic acid (2%), PAA (400 ppm) acidified with SSS (pH 1.2), or PAA (350 ppm) acidified with SSS (pH 1.2). Untreated and treated beef tissue samples were analyzed five minutes post-treatment for *E. coli* counts. Data were analyzed using the lsmeans package in R (Rstudio, 2015, Boston, MA) with antimicrobial treatment (including surfactant treatments) as the independent variable. Least-squares means were separated using a significance level of α = 0.05.

Results: All immersion treatments evaluated in phase I effectively (*P < 0.05*) reduced inoculated *E. coli* populations on the prerigor beef carcass surface tissue by at least 2.3 log CFU/cm². The 400 ppm PAA treatments acidified with lactic acid, SSS (pH 1.2), or acetic acid were the most (*P < 0.05*) effective treatments, lowering inoculated bacterial counts from 6.2 log CFU/cm² to 3.4, 3.4, and 3.7 log CFU/cm², respectively. In phase II, all of the tested antimicrobial spray treatments effectively (*P < 0.05*) lowered initial inoculated *E. coli* counts (6.4 log CFU/cm²) by 1.7 to 1.9 log CFU/cm². No (*P ≥ 0.05*) differences in efficacy were observed between the five antimicrobial treatments.

Conclusion: Since acidifying PAA with acetic acid or SSS is comparable to utilizing PAA, this could provide the industry with alternative antimicrobial intervention systems. Alternating the use of antimicrobials in a multiple-hurdle system could aid in the prevention of antimicrobial resistance.

Keywords: Antimicrobial intervention, Beef, *Escherichia coli*
**Meat and Poultry Safety**

120- **EFFECT OF HIGH PRESSURE PROCESSING AND WATER ACTIVITY ON THE SURVIVAL OF LISTERIA MONOCYTOGENES ON READY-TO-EAT SHELF-STABLE TURKEY-BASED MEAT BARS**

B. R. Bullard 1,*, R. J. Delmore 1, I. Geornaras 1, D. R. Woerner 1, J. N. Martin 1, K. E. Belk 1

1Department of Animal Sciences, Colorado State University, Fort Collins, United States
brittney.scott@colostate.edu

**Objectives:** A study was conducted to evaluate the effects of product water activity (a_w) and a post-processing HPP (high pressure processing) treatment on the survival of inoculated *Listeria monocytogenes* populations on shelf-stable vacuum-packaged meat bars stored at 25°C.

**Materials and Methods:** The study was repeated on separate start days and cooked batches (two a_w levels: ≤0.91, ≤0.85) of turkey-based bars for each trial. Ingredients included turkey, fruit, vegetables, seeds, nuts, rice and spices. Following processing, bars of both a_w were surface-inoculated with a mixture of *L. monocytogenes* (LM101, LM108, LM310, V7, Scott A) to a target level of ca. 3 or 6 log CFU/g. Inoculated bars were individually vacuum packaged. Approximately 18-20 h post-inoculation, half the bars from each a_w and inoculation level received HPP treatment (586 MPa, 180 s, 5°C) while the remaining half were not HPP treated (control). HPP-treated and control vacuum-packaged bars were stored at 25°C for up to 50 d and analyzed for pathogen counts (PALCAM agar). The study was designed as a 2x2 factorial, with factors of a_w (≤0.91, ≤0.85) and post-processing treatment (control, HPP) for two pathogen inoculation levels (3 and 6 log CFU/g). The Mixed Procedures of SAS version 9.4 was used to assess differences between treatments (a=0.05). Surviving pathogen counts were fitted with the Baranyi and Roberts mathematical model (DMFit version 3.5, ComBase) to assess shoulder periods (the time in days where the levels of the pathogen remain at the level of inoculation) and inactivation rates (log CFU/g/day).

**Results:** Storage day affected (P<0.05) the *L. monocytogenes* populations recovered from bars inoculated at both levels; populations tended to decrease over time. Additionally, irrespective of inoculation level, a_w (≤0.91, ≤0.85) and post-processing treatment (control, HPP) significantly affected *L. monocytogenes* populations during storage. For the 6 log CFU/g inoculation level, a_w was a significant effect for shoulder period and inactivation rate of the pathogen in each of the treatment combinations during storage; there were no significant effects observed for bars inoculated at 3 log CFU/g. The HPP treatment didn’t affect the survival of *L. monocytogenes*; it only reduced (P<0.05) the initial and/or end of storage counts. Initial pathogen reductions obtained with HPP ranged from 0.2-0.6 log CFU/g (6 log CFU/g inoculation) and 0.5-1.0 log CFU/g (3 log CFU/g inoculation). When inoculated to 6 log CFU/g, bars with a_w ≤0.91 had longer (P<0.05) shoulder periods (6.5 and 8.8 days) compared to bars dried to a_w ≤0.85 (1.9, 1.8 days). Likewise, bars dried to a_w ≤0.91 had slower (P<0.05) pathogen inactivation rates (-0.06, -0.08 log CFU/g/day) compared to bars dried to a_w ≤0.85 (-0.12, -0.10 log CFU/g/day). Regardless of treatment, *L. monocytogenes* populations were still recovered from all bars following 40 or 50 d of storage at 25°C.

**Conclusion:** High pressure processing of bars with a_w ≤0.85 showed the greatest potential for increased control of *L. monocytogenes* presence starting with 3 log CFU/g of post-processing contamination. The a_w impacted pathogen inactivation and surviving counts on shelf-stable meat bars. Parameters of HPP should be further investigated to better understand the most effective time and temperature to increase inactivation of *L. monocytogenes* on meat bars.

**Keywords:** high pressure processing, *Listeria monocytogenes*, shelf-stable
121- EVALUATION OF ANTIMICROBIAL INTERVENTIONS APPLIED TO BOB VEAL CARCASSES INOCULATED WITH SHIGA TOXIN-PRODUCING ESCHERICHIA COLI (STEC) SURROGATES BEFORE AND AFTER CHILLING

C. L. Thomas 1*, H. Thippareddi 2, S. Kumar 2, M. Rigdon 1, R. Mckee 1, A. Stelzleni 1
1Animal and Dairy Science, 2Poultry Science, University of Georgia, Athens, United States
chevisethomas@yahoo.com

Objectives: The United States Department of Agriculture Food Safety Inspection Service reported greater prevalence of Shiga toxin producing E. coli (STEC) on veal carcasses and ground veal. Ruminants are natural reservoir of STEC and the microorganisms can easily be transferred to carcasses during the conversion of animals to meat, especially for veal. Literature on efficacy of antimicrobial interventions in reducing STEC populations on veal carcasses is limited. Three experiments were conducted to evaluate lactic acid (4%; LA), peroxyacetic acid (300 ppm; PAA), and hot water (80°C; HW), for their individual and/or combined ability to reduce STEC surrogates on bob veal carcasses pre- and post-chill, and through fabrication.

Materials and Methods: In experiment 1, hot carcasses (n=9) were inoculated with a 5-strain cocktail (ca. 8 log CFU/ml) containing rifampicin-resistant surrogate Escherichia coli (E. coli; BAA-1427, BAA-1428, BAA-1429, BAA-1430, and BAA-1431) to simulate carcass contamination during slaughter and then treated with HW, LA, or PAA. Carcasses were chilled (0±1°C) for 24 h, split in halves and each side was treated with LA or PAA. In experiment 2, hot carcasses (n=3) were inoculated with the 5-strain cocktail and chilled for 24 h. After chilling, carcasses were split and each side was treated with either LA or PAA. For experiment 3, carcasses (n=3) where chilled for 24 h, split, and then inoculated (simulating post-slaughter contamination) and treated with either LA or PAA. Inoculated carcasses were allowed to rest for 15 min for attachment. Three individual replications were performed, on different days, for all experiments. Experiment 1 was designed as a randomized split-plot with carcass as the whole plot and side as the sub-plot. Experiments 2 and 3 were completely randomized designs with side as the experimental unit. For each experiment, E. coli population (log CFU/cm²) was analyzed using PROC GLM (SAS V.9.4) for the main effects of antimicrobial treatment, sampling time point, and their interaction, when applicable. Means were considered different at α≤0.05.

Results: Results from experiment one, showed that of the six treatment combinations, the collective reductions achieved from; HW+LA, and HW+PAA were 2.88 and 2.07 log CFU/cm², respectively; LA+LA and LA+PAA were 3.48 and 2.20 log CFU/cm², respectively; and PAA+LA and PAA+PAA were 1.32 and 0.99 log CFU/cm², respectively. Of the six combinations, LA+LA was the most effective (P≤0.05) treatment in reducing surrogate E. coli on veal. For experiment 2, application of LA and PAA on the chilled carcasses resulted in 0.91 and 0.24 log CFU/cm² reductions. Again, LA resulted in greater (P≤0.05) reductions compared to PAA. However, in experiment 3, there was no difference (P>0.05) between LA and PAA in reducing surrogate E. coli when applied to veal carcasses. Measurements on cut surfaces for translocation during fabrication showed that all antimicrobial treatments resulted in undetectable levels (<0.3 log CFU/cm²) of surrogate E. coli for experiment 1 and 2, and low levels (1.66 and 0.97 log CFU/cm² for LA and PAA, respectively) for experiment 3.

Conclusion: Of the antimicrobial interventions utilized, lactic acid was more effective in reducing STEC surrogate populations on veal carcasses, pre- and/or post-chill.

Keywords: Antimicrobial intervention, Bob veal, Escherichia coli, STEC surrogates
Meat and Poultry Safety

122- CHANGES IN PRESENCE OF SHIGA TOXIN-PRODUCING ESCHERICHIA COLI (STEC) AND SALMONELLA SPP. IN VERY SMALL HONDURAN BEEF PROCESSING PLANTS AFTER PERSONNEL TRAINING IN FOOD SAFETY PRACTICES

D. E. Casas 1,∗, M. Bueso 1, A. Calle 1, N. Huerta-Leidenz 1, M. F. Miller 1, M. M. Brashears 1
1Animal and Food Sciences, Texas Tech University, Lubbock, United States
diego.casas@ttu.edu

Objectives: To evaluate reduction of STEC and Salmonella in two small beef processing plants in Honduras after training and implementation of SSOP and GMP.

Materials and Methods: Changes in pathogen presence were monitored in two small Honduran beef processing plants. Plants processed 140 and 25 heads of cattle per week. Initially, neither plant had food safety programs in place. Swab samples of plant A (n=160) and plant B (n=78) were taken from direct and indirect food contact surfaces on January, May, June and July for plant A and January March June and July for plant B. After each sampling month, SSOP for equipment and surfaces with positive pathogen presence were provided to the plants. Additionally, employees underwent comprehensive SSOP, GMP and HACCP training. Swab samples were analyzed by BAX RT Salmonella and STEC screening and confirmed using immunomagnetic separation, selective media and latex agglutination. Fisher’s exact tests for equality of proportions were used in R (v3.4.4) statistical package to compare pathogen presence among sampling months.

Results: In Plant A, STEC occurred in 10%, 12.5%, 0% and 5% of the environmental samples respective to each month, indicating a significant reduction of STEC (p<0.10) by the third sampling month. This coincided with the completion of GMP, SSOP and HACCP training, providing customized GMP manuals, and the use of SSOP for disinfection of targeted equipment, surfaces, and utensils found with positive pathogen presence in previous sampling dates. In plant A, after implementation of SSOPs for targeted positive sampling areas, samples were not positive in subsequent sampling months, indicating effectiveness of recommended SSOPs. In Plant A, Salmonella environmental presence was at 0% except at one sampling interval and thus was not adequate to validate effective implementation of interventions. Salmonella environmental presence for each month in Plant B was of 5.6%, 6.3%, 27.3% and 0.0% respectively. In plant B, persistence of Salmonella was observed in the stuffer, where confirmed Salmonella isolates were found in January and March. After second positive sample was found, in-plant training of stuffer SSOP was made, resulting in absence of Salmonella in the stuffer in June. The highest Salmonella presence was observed by the fourth sampling month. Therefore, additional actions were taken to reinforce implementation of SSOP and GMP manual instructions, and verification procedures, which collectively resulted in a Salmonella reduction to 0% (p<0.10) by the fourth sampling month. STEC presence in this plant was too low to be an indication of validation of the effectiveness of implementation of interventions.

Conclusion: These experiences demonstrate the feasibility of fully implementing SSOP with verification procedures and compliance with the instructions of a customized GMP manual. Trained employees are more involved in cleaning and disinfection procedures before and after processing. In addition, evisceration and other dressing procedures are performed with more caution. In summary, the ongoing training of plant personnel increases awareness of food safety. Consequently, the presence of STEC and Salmonella can be significantly reduced in this type of facility.

Keywords: Environmental sample, GMP, Salmonella, Shiga toxin-producing Escherichia coli, SSOP
123- INHIBITION OF LISTERIA MONOCYTOGENES AND SPOILAGE BACTERIA ON CURED READY-TO-EAT MEATS BY SODIUM-FREE AND CLEAN-LABEL ANTIMICROBIAL INGREDIENTS

E. Heintz 1,*, L. Vega 2, G. Jahr 2
1 Innovation, Niacet, Tiel, Netherlands, 2 Innovation, Niacet, Niagara falls, United States
eelco.heintz@niacet.nl

Objectives: To compare the inhibitory properties of a standard potassium acetate and diacetate blend (Provian®K) and a natural fermented and neutralized dry vinegar product (Provian®NDV) on the growth of both Listeria monocytogenes and lactic acid bacteria in cured RTE meats.

Materials and Methods: Five treatments of cured deli-style ham (72-74% moisture, 1.75±0.1% salt, and pH 6.2-6.4, 156 mg/kg sodium nitrite and 547 mg/kg sodium erythorbate) where tested, including a control without antimicrobials and different concentrations of Provian® K (0.5% and 0.75%) and Provian® NDV (0.5%, 0.65%). Cooked products were surface-inoculated with 3-log10 CFU/g of a cocktail of 5 strains of Listeria monocytogenes (including serotypes 4b, 1/2a and 1/2b) or a mixture of two lactic acid bacteria (LAB) strains including Carnobacterium divergens and Leuconostoc mesenteroides, both isolated from spoiled cooked meat products. Inoculated slices (100g/package) were vacuum-packaged and stored at different temperatures for up to 4 and 8 weeks, for LAB and L. monocytogenes, respectively. Triplicate samples per treatment were assayed by enumerating twice on modified Oxford Agar for L. monocytogenes and on Plate Count agar (30°C, 48 h) and APT agar with bromocresol purple (27°C, 48 h) for LAB. The study was conducted twice.

Results: Results on Listeria inhibition: Control Ham supported >1 log increase of L. monocytogenes at 4 and 2 weeks storage at 4°C and 7°C, respectively. In contrast, hams supplemented with 0.5 or 0.75% Provian®K or 0.65% NDV inhibited the Listeria growth for 12 and 8 weeks at 4 and 7°C, respectively. Inhibition of Listeria on ham supplemented with 0.5% NDV was further affected by pH and moisture. Ham supplemented with 0.5% Provian®NDV in the trial 1 (71.5% moisture, pH 6.2) delayed Listeria for 12 weeks storage at 4°C, whereas individual samples of trial 1 (72.9% moisture, pH 6.3) supported growth (>1 log increase) at 8 weeks. Similar trends were observed at 7°C.

Results on Lactic Acid Bacteria inhibition: The Control Ham supported the increase of Lactic acid bacteria to spoilage level (>6 Logs) at 3 and 2 weeks storage at 4°C and 7°C, respectively. In contrast, hams supplemented with 0.5% Provian®K or 0.8% Provian®NDV showed complete inhibition of LAB for 4 weeks. For complete inhibition at 7°C slight higher concentrations of 0.75% and 1% were needed of Provian®K and Provian®NDV, respectively.

Image:
Conclusion: The results of this study show the inhibitive effect of a natural fermented vinegar product on the growth of *Listeria monocytogenes* and Lactic acid bacteria in a cured ready-to-eat ham. In order to have a comparable efficacy with neutralized natural vinegar as with a standard acetate-diacetate product, the dosage of the vinegar based product should be increased by approximately 10%. This can be explained by the lower amount of undissociated acid in the product.

**Keywords:** Food Safety, Listeria Control, Natural Preservation, Shelflife Extension, Sodium Reduction
Objectives: The objective is to find effective measures to control or inhibit growth of *E. coli* O157:H7, non-O157:H7 and *Salmonella* species in ground beef through exploring the effectiveness of antimicrobial properties of lauric arginate, peroxyacetic acid and buffered sulfuric acid, applied through an electrostatic spray system on inoculated trimmings.

Materials and Methods: Inoculums were prepared from frozen (-80°C) stock cultures of *Escherichia coli* O157:H7, O145, O121, O111, O103, O45, O26 and *Salmonella typhimurium* DT 104 and *newport* MDR-AmpC. *E. coli* was maintained by brain heart infusion (BHI) broth and *S. typhimurium* and *newport* were maintained by BHI broth containing nalidixic acid. The cocktail was pooled (420 mL *E. coli* and 420 mL *Salmonella* log 10^4 CFU/mL). The cocktail was hand mixed in a sterile bag with thawed beef trimmings and allowed to attach, then meat was drained and separated into 4 batches and placed in a cooler for 14 h. Inoculated beef trimmings were sprayed (~0.3 mL/g; 3 replicates/treatment) with either 5% lauric arginate (LA), 0.02% peroxyacetic acid (PA) or buffered sulfuric acid (pH=3; SA) and ground twice using a Hobart Grinder (3.2 mm plate) along with an unsprayed control (C). Ground beef was divided, packaged on styrofoam trays with absorbent pads overwrapped with polyvinyl chloride film and stored in a display case under retail conditions. 25g microbial samples taken on display days 0, 1, 2, 3, and 5 were placed in sterile stomacher bags with 225 mL of 0.1% BPW and homogenized for 2 min. Serial 10-fold dilutions were done and plated on Petrifilm aerobic plate count (APC), EMB, and SS in duplicates. After 24 h of incubation (37°C), EMB plates were counted and after 48 h APC and SS plates were counted. Counts were converted to log_{10} and recorded as colony forming units per g of meat (CFU/g). Instrumental color was evaluated (CIE L*, a*, b*; 630/580 nm; hue angle; saturation in dex) on display days 0, 1, 2, 3, and 5 of simulated retail display using a Hunter Lab MiniScan EZ Spectrocolorimeter (A/10°). Analysis used MIXED procedure of SAS in a 4x5 factorial arrangement with main effects spray treatment, display days and their interaction.

Results: The three treatments had no effect on APC (P=0.85), *E. coli* (P=0.54) and *Salmonella* (P=0.55) growth. Display day had an effect (P<0.05) on APC, *E. coli* and *Salmonella* growth. Display day 5 had increased growth for APC, *E. coli* and *Salmonella*, followed by display day 3, and 2. There was an interaction for APC with LA, PA and C having increased growth on display day 7 but SA had decreased growth on display day 5. There was also an interaction for *E. coli* growth with LA, PA and C having increased growth on display day 5 but SA had decreased growth on display day 5. PA and SA treatments were darker (lower L*; P<0.05) than LA and C treatments. PA and SA treatments were redder (greater a*; P<0.05) than LA and C treatments. Hue angle was greater (P<0.05) for LA and C treatments compared to PA and SA. Chroma was greatest (P<0.05) in SA and lowest in LA with PA and C being intermediate. PA and SA had the highest (P<0.05) oxymyoglobin ratio followed by C and then LA.

Conclusion: SA was the only effective spray treatment but only by display day 5 for APC and *E. coli*. Spray treatments also have an impact on display color of ground beef.

Keywords: Antimicrobial, Color, Display, Ground beef
VALIDATION OF NOVEL CULTURED CANE SUGAR AND VINEGAR POWDER TO EXTEND SHELF LIFE IN FRESH TURKEY SAUSAGE.
G. McCoy, S. LaSuer, D. Unruh, S. Kumar, T. Rourke
1Corbion Purac America, Lenexa, United States
garrett.mccoy@corbion.com

Objectives: The objective of this study was to assess the antimicrobial efficacy of Verdad® Opti Powder N70 (CSV- P) on inhibition of aerobic plate counts, lactic acid bacteria, and Enterobacteriaceae growth kinetics in fresh turkey sausage formulation for 24 days of storage at 40 °F.

Materials and Methods: Fresh turkey sausage formulation containing turkey thigh and skin, water, sea salt, and different levels of natural antimicrobial interventions: (A) Control, (B) 1.55% CSV-P, (C) 2.1% CSV-P (D) 2.5% CSV-P. Each treatment was prepared independently, ground, mixed, vacuum stuffed, clipped, and incubated at 40 °F.

Table 1 outlines the treatment structure, proximate values for the treatments and the different microorganisms outgrowth data. The samples were enumerated for aerobic plate counts (APC), lactic acid bacteria (LAB), Enterobacteriaceae (in duplicate), at 6 regular intervals for 24 days of incubation, using Tryptic Soy Agar plate, MRS and VRBG Agar, respectively. Proximate analyses were performed for all the treatments.

Results: Treatments containing CSV-P in general, had lower a_w values in comparison to control. Water activity is a major factor influencing the outgrowth of lactic acid bacteria strains, thereby preventing early spoilage. The antimicrobial treatments had no major impact on the ionic strength of the formulations as evidenced by similar pH values. The use of CSV-P at 1.55%, 2.10% and 2.50%, showed control of APC outgrowth. CSV-P treatments at all use level also delayed the outgrowth of LAB and Enterobacteriaceae counts compared to the control treatment. The 8 log_{10}CFU/g limit for APC and LAB bacteria outgrowth was reached in 7 and 6 days, for control treatment, respectively. The 8 log_{10}CFU/g limit for APC and LAB outgrowth was reached for 1.55% CSV-P in 9 and 7 days, 2.10% CSV-P in 12 and 12 days, and 2.50% CSV-P in 14 and 13 days, respectively. Enterobacteriaceae counts did not exceed 1 log_{10}CFU/g increase during 21 days of incubation for any treatments containing CSV-P.

Conclusion: The research validates the antimicrobial efficacy of cultured cane sugar and vinegar powder to control the outgrowth of APC, LAB and Enterobacteriaceae, thus providing the industry with an effective natural and clean label antimicrobial solution to improve shelf life and food safety in fresh poultry sausage.

Keywords: Antimicrobial Intervention, Natural Preservation, Shelf Life Extention, Turkey
VALIDATION OF INTERVENTIONS ON RAW GROUND BEEF COMPONENTS; CHEEK MEAT AND WEASAND.
I. Katawal 1,*, M. M. Brashears 1, A. Echeverry 1, A. Calle 1, M. F. Miller 1
1Department of Food Science, Texas-tech University, Lubbock, United States
ishwar.katawal@ttu.edu

Objectives: Interventions are commonly used to treat carcasses to reduce microbial loads, but little information is available on the use of these interventions on cheek meat and weasand, which can be used as raw ground beef components. Due to their anatomical location, they could have a high risk of contamination. The objective of this study was to determine the efficacy of two antimicrobial interventions strategies; 4 % lactic acid (LA), and 1000 ppm Acidified Sodium Chlorite (ASC), to reduce pathogens in raw ground beef components; cheek meat and weasand.

Materials and Methods: The experiment was a randomized complete split-plot design with individual Cheek meat (N=36) and Weasand (N=36), defined as experimental units. The two components were challenged with a three-strain cocktail mixture of each of the pathogen; Escherichia coli O157: H7 (Strains 944, 966 and 922) STECS (nonO157 STEC serogroups; 045, 0145 and 0121) and Salmonella (Typhimurium, Enteriditis, and Newport) 7.1, 7.2 and 6.8 \log_{10} CFU/ml respectively, for 20 minutes. All the strains were obtained from the Texas Tech University Food Microbiology Laboratory stock collection (Lubbock). For every pathogen, a total of 12 units of each component were used. The units of each component inoculated with a pathogen were further divided into 4 subgroups, each group consisting of 3 pieces; i) Inoculated but nontreated (used to determine recovery of pathogens), ii) Ambient water (CTRL), iii) 4 % lactic acid (LA) and iv) Acidified Sodium Chlorite (ASC). On Day 0, the interventions consisting; Ambient water (pH=6.87), 4 % lactic acid (pH= 2.03) and Acidified Sodium Chlorite (pH=2.91, 1000 ppm). were sprayed onto the surface of the product at room temperature, as they move down the belt, inside a six-nozzle trim-sanitizing spray. Following treatment, 50 cm$^2$ of each sample was swabbed by using 10 ml Buffered Peptone Water (BPW) swabs and sterile template and subjected to bacterial enumeration on thin-overlaid selective media. These samples were held at 4 °C, for 24 hours, separate area was swabbed and enumerated. Data were analyzed in R-Studio (version 3.3.1).

Results: On day 0, LA reduced E. coli, STECS and Salmonella in cheek meat and weasand on average by 0.90, 0.93 and 0.89 \log_{10}CFU/cm$^2$ respectively, when compared with the initial level of the pathogens in inoculated and non-treated samples. Similarly, ASC reduced pathogens on average by 0.79, 0.87 and 0.78 \log_{10} CFU/cm$^2$ respectively. Samples treated with ambient water gave lower surface counts of the pathogens when compared to untreated samples, however, the reduction was not significant. Both LA and ASC treatment maintained bacterial reduction even after 24 hours.

Conclusion: LA and ASC treatments can be used as intervention alternatives for cheek meat and weasand, as these components can potentially become a high-risk source of contamination.

Keywords: Acidified Sodium Chlorite, Intervention, lactic Acid
Meat and Poultry Safety

128- PULSED UV LIGHT AS A MICROBIAL REDUCTION INTERVENTION FOR BONELESS/SKINLESS CHICKEN THIGH MEAT

J. R. Cassar 1,*, E. W. Mills 1, J. Campbell 1, A. Demirci 2
1Animal Science, 2Agricultural & Biological Engineering, The Pennsylvania State University, State College, United States
jrc5659@psu.edu

Objectives: Salmonella, E. coli and Campylobacter are pathogens of concern in poultry processing. Pulsed Ultra Violet (PUV) light is an effective antimicrobial treatment with limited use in the food industry. Research using PUV light has established that it can be a more effective antimicrobial treatment than conventional UV light. The germicidal, UV-C wavelengths fall between 100 – 280nm with the optimum germicidal effect at 254nm. PUV light includes a much broader spectrum, 100 – 1100nm, with 50% of the energy deriving from the UV region. Unlike the continuous, low intensity output of conventional UV light, PUV light is emitted in short bursts of very high intensity light. The objective of this work is to investigate application of PUV light for destruction of Salmonella, E. coli and Campylobacter on chicken thigh meat.

Materials and Methods: Lean and skin surface chicken thighs, acquired from a commercial poultry integrator, were inoculated to a 6-7 log CFU/cm² concentration before exposure to PUV light in separate trials for each of the above mentioned pathogens. Treatment variables included the distance from the quartz window of the PUV light (8 and 13 cm) and application time (5, 15, 30, and 45 seconds). Inoculated control samples were not exposed to PUV light. Nine thighs were used for each distance by time treatment combination for each bacterial species. After treatment, samples were stomached in buffered peptone water and the suspensions were serially plated on selective agars. Comparison of treated samples to control samples allowed for quantification of microbial reduction due to PUV light treatment. The main effects, distance and treatment time and their interaction, were evaluated in a 2-way ANOVA. When needed, a Tukey multiple comparison test was used to detect significant differences (p<0.05) among treatment means.

Results: For lean and skin surface samples, the distance by treatment time interaction was not significant (P>0.05) for microbial reduction of E. coli, Campylobacter or Salmonella. Distance from the PUV light did not affect lean surface microbial reduction for E. coli, Campylobacter or Salmonella (p>0.05). Lean surface microbial reduction increased (p<0.05) with PUV light exposure time for E. coli, Campylobacter and Salmonella. Exposure to PUV light for 5 and 45 seconds on lean surface thighs resulted in log₁₀ reductions of 1.5A and 2.0B for E.coli, 1.2A and 2.2B for Campylobacter, and 1.5A and 2.4B for Salmonella, respectively. Distance from the PUV light did not affect skin surface microbial reduction for Campylobacter (p>0.05). Skin surface microbial reduction for E. coli and Salmonella was increased (p<0.05) with closer proximity to the PUV light source. Skin surface microbial reduction increased (p<0.05) with PUV light exposure time for E. coli, Campylobacter and Salmonella. PUV light exposure for 5 and 45 seconds on skin surface thighs resulted in log₁₀ reductions of 1.1A and 2.0B for E.coli, 1.2A and 1.9B for Campylobacter, and 0.9A and 1.8B for Salmonella, respectively.

Conclusion: This study clearly demonstrated the potential of using PUV light as a microbial reduction intervention on chicken meat.

Keywords: Campylobacter, chicken, E. coli, pulsed ultra-violet light, Salmonella
Objectives: *Escherichia coli* O157:H7 poses a significant health risk due to its ability to cause foodborne illness. It has been identified as the causative agent in numerous foodborne illness outbreaks linked to ground beef. As part of the commensal microflora of cattle, *E. coli* O157:H7 could easily contaminate beef carcasses, despite various decontamination treatments in place. Trims are commonly used in ground beef processing, which could result in increased risk of pathogen contamination. Furthermore, temperature abuse (>5°C) of contaminated ground beef during retail could also influence pathogen growth. To lower contamination and consumer health risk, some ground beef processors have started using beef trim wash as an added intervention. Adding an intervention to existing production practices could increase the cost of production significantly. Quantitative Microbial Risk Assessment (QMRA), which assesses the risk of foodborne illness from current production practices and predicts the effectiveness of proposed interventions, without actual implementation, could help processors make an informed decision. Utilizing QMRA to choose interventions, therefore, would be more economic and efficient. The objective of the study was to use QMRA as a decision-making tool for predicting the impact of various beef trim interventions on the reduction of foodborne illness risk from ground beef consumption.

Materials and Methods: Experiments were conducted in triplicates to determine the efficacy of various beef trim interventions. Beef trim samples, inoculated with a cocktail of *E. coli* O157:H7 (6 log_{10} CFU/g), were used. Following bacterial attachment, the trims were spray-washed (20 ml) with either lactic acid (5%), peracetic acid (400 ppm), sterile distilled water or *E. coli* O157:H7 specific bacteriophage cocktail (9 log_{10} PFU/ml). Untreated positive (inoculated) and negative (non-inoculated) controls were also used. Treated samples and controls were ground and stored in PVC-wrapped styrofoam trays. To simulate refrigerated and abuse retail storage conditions, samples were stored at 4 and 8°C, respectively for 4 days. Pathogen survival in stored ground beef was determined on day 0, 1, 2, and 3. The data were modeled and incorporated in an established QMRA framework from the literature. The QMRA involved scenario analysis of beef trim interventions, retail-storage, and cooking-preference (rare, medium, and well-done). For each scenario, 100,000 iterations were simulated using Montecarlo simulations, employing @Risk-software.

Results: Experimental results revealed that at 4°C, there were no significant differences among treatments. However, at 8°C, the most effective treatment was found to be the phage cocktail. The QMRA predicted the baseline probability of illness from rare-cooked ground beef, stored at 4°C, to be nearly 3 illnesses in 1 million. At 4°C, the organic acids and phages were successful in reducing the probability of illness by 98%. At 8°C, only phage treatment reduced the risk by 98%. It was also revealed that if ground beef is well-done, beef-trim interventions are not required.

Conclusion: The findings recommend beef trim interventions as a necessary step to reduce the risk of foodborne illness from undercooked ground beef. The study also demonstrates usage of QMRA as a cost-effective method to plan and compare intervention strategies.

Keywords: *E. coli*, Food Safety Risk, Ground Beef, Intervention, Retail Storage
Meat and Poultry Safety

130- EFFECT OF LACTIC ACID TREATMENT ON E. COLI AND COLIFORM GROWTH IN GROUND BEEF AFTER DIFFERENT STORAGE PERIODS AND RETAIL DISPLAY DAYS

K. Rodriguez 1,*, K. Cerjan 1, E. Mahalitc 1, A. Calle 1, M. Brashears 1, M. Miller 1
1Animal And Food Science, Texas Tech University, Lubbock, United States
karla-melissa.rodriguez@ttu.edu

Objectives: The study evaluated the changes in of Escherichia coli and coliforms counts in ground beef prepared from beef trimmings stored either 24 or 48 h after treatment with a 2-3% lactic acid dip (LA) for three storage periods of 7, 14, or 21 d after grinding.

Materials and Methods: Two sets of beef trimmings were dipped with 2-3% LA and stored for either 24 or 48 h prior to grinding. Additionally, two untreated sets were included as controls (CON), and were not treated with LA. Samples from each of the 4 sets of trim (n = 84; 4.54 kg) were ground, vacuum packaged, and further stored and sampled at 7, 14, or 21 d. After storage period was over, samples were re-ground using a 3.175 mm disk and a 25 g sample was collected to represent retail day 0. Three 454 g portions of each sample were placed on a polystyrene tray overwrapped with low-barrier polyvinylchloride film to represent retail day 1, 2, and 3. Packages were displayed in a coffin-style retail case maintained at 2-3 °C. Packages were respectively sampled every 24 h according to its designated retail display day. A 25 g sample was collected, placed into a filter bag, and 225 ml of buffered peptone water (BPW) was aseptically added. The bag was stomached for 2 min at 230 RPM. Serial dilutions were made from meat rinse in 9 ml tubes of BPW. One ml from the bag or appropriate tube was plated to each EC petrifilm in duplicate. Both coliforms and E. coli petrifilm plates were incubated at 36 °C ±1°C. Counts were made at 24 h for coliforms and 48 h for E. coli. Counts and duplicate plates were averaged and converted to log CFU/g of ground beef prior to statistical analysis. Data were analyzed using statistical procedures of a two-way ANOVA. A split-plot design was used with a whole plot as a 2 × 2 factorial of trim age and treatment and subplot of post-grind age.

Results: The Statistical Analysis showed that the coliform concentration increased in function of the storage period 7, 14, 21 days for 24-48 h LA treatments and 24-48 h control (P<0.01). The average concentration (for coliforms at 7, 14 and 21 days was 2.57, 4.99 and 5.65 log CFU/g respectively. For E. coli the concentration increases at 14 days stored and diminish at 21 days for 24-48 h LA treatments and 24-48 h control (P<0.01). The average concentration for E. coli at 7, 14 and 21 days was 1.47, 1.68 and 1.24 log CFU/g respectively. Coliforms and E. coli concentration increased in function of the retail display (0, 1, 2 and 3 days) on both the LA treatment and the control (P>0.05).

Conclusion: Based on the results, E. coli was not reduced in the samples treated with LA at 2-3% prior grinding after 7 and 14 days stored. However, an E. coli reduction was observed over a period of 21 days. Similarly, coliforms counts were not reduced with the chemical treatment during the storage periods.

Keywords: Trims, Beef, Coliforms, Dilutions, Petrifilms
MEAT AND POULTRY SAFETY

131 - SALMONELLA PREVALENCE IN LYMPH NODES OF U.S. AND MEXICAN CATTLE PRESENTED FOR SLAUGHTER DURING TWO SEASONS IN TEXAS

K. J. Nickelson 1,*, T. M. Taylor 1, D. B. Griffin 1, J. W. Savell 1, K. B. Gehring 1, A. N. Arnold 1
1Animal Science, Texas A&M University, College Station, United States
a.arnold@tamu.edu

Objectives: Due to the generalized nature of the lymphatic system, lymph nodes (LNs) have been identified as a potential source of Salmonella contamination in ground beef products. The objectives of this study were to determine if Salmonella prevalence differs (1) between cattle of Mexican and U.S. origins when exposed to the same feedlot environment and (2) between warm and cool seasons.

Materials and Methods: Paired subiliac LNs (n = 800 LNs) were collected from 100 carcasses per origin (Mexico and U.S.), per season (warm and cool). Per animal, left and right LNs were pooled yielding n = 400 total LN samples. LNs were aseptically trimmed of fat and pulverized before microbiological analysis. Salmonella presence/absence was determined by following the USDA-FSIS Microbiological Laboratory Guidebook (MLG) 4.08.

Results: Overall, Salmonella prevalence in LN samples was 52.0% (208/400; data not presented in tabular form). No difference (P = 0.4836) was seen in Salmonella prevalence as a function of country of origin, with 54.0% (108/200) and 50.0% (100/200) Salmonella-positive samples from cattle of Mexican and U.S. origin, respectively. Salmonella prevalence differed (P = 0.0354) between seasons, with 46.5% (93/200) and 57.5% (115/200) Salmonella-positive samples from cool and warm seasons, respectively (data not presented in tabular form). Interestingly, Salmonella prevalence in samples of U.S. origin differed by season (P = 0.0160), unlike those of Mexican origin. No difference (P = 0.6705) was seen between seasons in samples of Mexican origin, with 52.0% (52/100), and 56.0% (56/100) Salmonella prevalence for cool and warm seasons, respectively. For samples from beef carcasses of U.S. origin, Salmonella prevalence rates of 41.0% (41/100) and 59.0% (59/100) were seen for cool and warm seasons, respectively (Table 1). Serotyping of PCR-confirmed positive samples resulted in fourteen different serovars with Cerro (21.6%), Anatum (19.7%), Muenchen (17.8%), Montevideo (14.4%), and Kentucky (12.0%) comprising the majority.

Conclusion: These findings dispel previous concerns that Mexican cattle have a higher prevalence rate of Salmonella than U.S. cattle. These results also suggest that environmental factors may play a large role in the Salmonella prevalence rate in bovine LNs, and that additional research is needed to fully understand factors that influence Salmonella prevalence in bovine LNs.

Keywords: bovine, country of origin, lymph nodes, Salmonella, seasonality

<table>
<thead>
<tr>
<th>Season</th>
<th>% (no. positive/no. tested) Salmonella-positive LNs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mexico</td>
</tr>
<tr>
<td>Cool</td>
<td>52.0 (52/100) A, X</td>
</tr>
<tr>
<td>Warm</td>
<td>56.0 (56/100) A, X</td>
</tr>
</tbody>
</table>

A, B: Values within a column lacking a common letter differ (P < 0.05).
X, Y: Values within a row lacking a common letter differ (P < 0.05).

*a* Salmonella was isolated following protocols described by Microbiology Laboratory Guidebook 4.08. Three presumptive positive colonies were selected for confirmation by PCR. One confirmed positive colony for each LN sample was selected for serotyping (n = 208). These colonies were revived in Tryptone Soya Broth and then stored on nutrient agar slants for shipping to NVSL (Ames, IA).

*b* Left and right subiliac LNs (n = 800 LNs) were collected and pooled by animal (n = 400 total LN samples).

*c* Sample collection seasons were defined as: warm (May to August) or cool (December to February).

Image:

TABLE 1. Prevalence of Salmonella-positive lymph nodes (LNs) stratified by season and origin

<table>
<thead>
<tr>
<th>Season</th>
<th>% (no. positive/no. tested) Salmonella-positive LNs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mexico</td>
</tr>
<tr>
<td>Cool</td>
<td>52.0 (52/100) A, X</td>
</tr>
<tr>
<td>Warm</td>
<td>56.0 (56/100) A, X</td>
</tr>
</tbody>
</table>
A COMPARISON OF THE RESISTOME BETWEEN NATURAL AND CONVENTIONAL RETAIL GROUND BEEF PRODUCTS


1Animal Sciences, 2Clinical Sciences, Colorado State University, Fort Collins, 3U. S. Meat Animal Research Center, Agricultural Research Service, USDA, Clay Center, United States
kevin.thomas@colostate.edu

Objectives: The threat of antimicrobial resistance (AMR) in beef products is an emerging health issue and a driving force in consumer purchasing decisions. Analyzing retail ground beef products using culture-independent techniques allows for the investigation of AMR prior to consumption. The objective of this study was to characterize the resistome of retail ground beef products processed from conventionally and naturally raised cattle using whole-genome sequencing.

Materials and Methods: Samples of natural (n=50, raised without antibiotics) and conventional ground beef products (n=50) were purchased from various retailers throughout Fort Collins, CO. All samples were of different brands, packaging types, and lean points. Samples were processed 48 hours following collection. 30g aliquots of ground beef were washed with 100 mL phosphate-buffered saline (PBS) and the supernatant was centrifuged for 10 min at 10,000 x g. DNA was isolated using QIAGEN PowerFecal kit. A 515F/806R primer pair was used to amplify the V4 region of the 16S rRNA gene region of the isolated DNA. A subset of 16 samples (n=8) from the original 100 were selected for resistome analysis. Libraries were built for the 16 samples using a customized bait-pulldown system (Agilent, SureSelect XT HS) targeting specific AMR genes within the MegaRes database. All libraries and 16S amplicons were sequenced on a HiSeq 4000 (Illumina) platform with 2 x 125 bp paired-end reads and sequenced across 8 lanes.

Results: Of the 100 samples subjected to 16S rRNA gene sequencing, 96 passed quality checks and were analyzed. Shannon’s Diversity Index was used to compare alpha diversity between treatment groups and found no difference in microbiome alpha diversity (PERMANOVA, P=0.13). Weighted UniFrac was used to compare beta-diversity between treatment groups and samples of varying packaging types. Differences in beta-diversity between conventional and natural products were found to be significant (PERMANOVA, P=0.001). Furthermore, pairwise PERMANOVA comparisons suggest the microbial community of chub packaging differs from tray-overwrapped, vacuum sealed, and store ground product (P=0.002, 0.001, 0.001, respectively). Similarly, tray-overwrapped product also differed from vacuum sealed samples (PERMANOVA, P=0.003).
The 16 samples of ground beef collectively had hits to 12 classes, 23 mechanisms, 23 groups, and 105 gene accessions associated with antimicrobial resistance. An ANOVA test comparing resistance gene counts in natural and conventional products suggested no differences in AMR gene counts (P = 0.361). Furthermore, an Analysis of Similarity, which considers the ratio of alpha and beta diversity of the samples, suggested that the resistome in natural and conventional retail products were similar to each other (ANOSIM, R = -0.0079). Among the gene accessions detected, the majority was associated with tetracycline resistance (84%). Other resistance gene accessions detected included macrolide-lincosamide-streptogramin (8%), elfamycin (2%), beta-lactam (1.5%), rifampin (1%), and multi-drug (2%).

Conclusion: Among the two treatments, it appears that packaging type is the driving force behind the differences seen in the microbiome. The resistome of conventional and natural products were similar, suggesting that differences in production practices have little influence on contribution to antimicrobial resistance in retail ground beef products.

Keywords: metagenomics, beef, retail, resistance
Meat and Poultry Safety

133- GROWTH OF AEROBIC AND PSYCHROTROPHIC BACTERIA IN GROUND BEEF PREPARED FROM LACTIC ACID TREATED TRIMMINGS AND SUBJECTED TO CHUB STORAGE TIME

K. L. Cerjan 1,*, M. Miller 1, M. Brashears 2, E. Mahaltic 1, K. Rodriguez 1

1Animal Science, 2Food Microbiology, Texas Tech University, Lubbock, United States
kimberly.cerjan@ttu.edu

Objectives: The objective of this study was to evaluate the impact of lactic acid applied as an intervention (submersion) on beef trim on aerobic and psychrotrophic bacterial counts in ground beef throughout retail display storage.

Materials and Methods: Ground beef (n = 84; 4.54 kg) produced with trim stored 24 h (24TRIM) or 48 h (48TRIM) after either submersion treatments with 2-4% lactic acid (LA) or control (CON) was collected and further aged as a ground product for 7, 14, or 21 days. Process day (D0) consisted of regrinding and placing three 454 g samples on polystyrene trays with overwrap to represent the 3 day retail display. Chiller materials were cleaned between treatment group. Packages were arranged in a coffin-style retail case held at 2-3 °C. All sample collections consisted of weighing 25 g of ground beef from each treatment group and placed in a 55 oz. filtered stomacher bag. Day 0 was sampled prior to packaging, and the previously designated packages were sampled at 24 h (D1), 48 h (D2), and 72 h (D3) in retail display. A 225 mL measurement of buffered peptone water (BPW) was added to each filter bag and stomached at 230 RPM for 2 min. Dilutions were made with 9 mL BPW tubes. Dilutions were vortexed prior to plating 1.0 mL of sample duplicate on aerobic bacteria petrifilm for both aerobic (APC) and psychrotrophic bacteria (PSY). Petrifilms for APC were incubated at 35 °C ± 1°C and counted after 48 h ± 3 h, while PSY were incubated at 7 °C ± 1°C and counted after 7 d ± 6 h. Microbial data was analyzed using the GLM method of SAS 9.4 and reported in log CFU/g. Statistical significance was determined at P ≤ 0.05.

Results: The aerobic bacterial counts differed across storage times, with both LA and CON 7 and 14 day storage treatments showing a similar (P > 0.05) increase in bacterial count from 24 to 48 h. No differences in APC were determined among LA and CON for 21-day storage. However, when examining psychrotrophic bacteria, the LA and CON 7 day storage resulted (P > 0.05) in lower bacterial growth than the 14 and 21-day again; which showed a similar increase (P > 0.05) in log CFU/g for both 24 to 48 h treatments. Through evaluation, an overall trend was determined with an increase in bacterial growth from D0 to D4, and APC and PSY counts increased for 7 and 21-day storage periods.

Conclusion: From these results, it is fit to conclude LA treated and CON ground beef displayed similar increases in bacterial counts across 7, 14, and 21 day storage, as well as an increase in bacterial counts from D0 to D4.

Keywords: aerobic, bacteria, lactic acid, microorganism, psychrotroph
**Objective:** Antibiotic resistant bacteria are a significant global public health threat. The presence of Methicillin-resistant *Staphylococcus aureus* (MRSA) is a substantial concern in not only human medicine, but also food production. As the mechanisms which promote antimicrobial resistance are better understood, the development of novel strategies to mitigate the presence of resistant bacteria is a priority. Specific to food production, there has been a significant increase in the investigation of solutions which are considered “natural.” The objective of this study was to determine the inhibitory effects of a commercially available *Lactobacillus* cocktail against MRSA.

**Materials and Methods:** Two concentrations of a commercial available probiotic cocktail and two concentrations of a three-strain MRSA cocktail were combined in Brain Heart Infusion broth and stored at two temperatures for five days. Three ATCC strains of MRSA (from clinical isolates, community acquired isolates, and hospital acquired isolates) were grown from frozen stocks on Brain Heart Infusion (BHI), combined, and purified to make a MRSA cocktail with a final concentration of $10^9$ CFU/mL. Similarly, four dehydrated *Lactobacillus* strains were rehydrated in BHI broth and combined in proprietary ratios to formulate a probiotic cocktail with a concentration of $10^{10}$ CFU/mL. Cocktail One was prepared with $10^9$ CFU/mL of probiotic and $10^4$ CFU/mL of MRSA; Cocktail Two was prepared with $10^7$ CFU/mL of probiotic and $10^2$ CFU/mL of MRSA. Both cocktails were stored at either $25 \pm 1^\circ C$ or $37 \pm 1^\circ C$. Populations of MRSA and probiotic were monitored regularly over a five-day period. At each 24-hour interval during incubation, samples were removed from each cocktail (One and Two) and storage temperature $(25 \pm 1^\circ C$ or $37 \pm 1^\circ C$) combination, serially diluted, and plated in duplicate onto two selective agars--Baird Parker Agar (BPA) for the quantification of MRSA and De Man, Rogosa, and Sharp Agar (MRS) for quantifying the probiotic. Plates were aerobically incubated at $37^\circ C$ for 24 hours (BPA) or anaerobically incubated at the same temperature for 72 hours (MRS). As the selective media for the probiotic (MRS) also supports the growth of *Staphylococcus*, the MRS agar was modified with 0.05% cysteine and 0.002% bromophenol blue. The trial was replicated on three separate occasions. Analysis was completed using two-way, mixed-effects ANOVA models fit separately for each cocktail and each agar; least square means were separated with an alpha level of 0.05.

**Results:** MRSA populations decreased ($P < 0.05$) in Cocktail One, regardless of storage temperature, and were undetectable after five days of storage at $37^\circ C$. Conversely, MRSA populations increased ($P < 0.05$) by up to 3 log CFU/mL in Cocktail Two at both temperatures. Probiotic populations in Cocktail One decreased ($P < 0.05$) by up to 2 log CFU/mL over the storage period at either temperature; probiotic populations in Cocktail Two increased ($P < 0.05$) up to 1.5 log CFU/mL.

**Conclusion:** Mitigating the presence of MRSA in the environment and in food production facilities can have a significant impact on public health. These results suggest that probiotics could be used as effective inhibitors of MRSA. Additional research is needed to evaluate the efficacy of this probiotic cocktail on the presence of MRSA in an applied setting.

**Keywords:** competitive inhibition, MRSA, probiotic
CHARACTERIZATION OF ANTIBIOTIC RESISTANCE TRANSMISSION IN THE BEEF PRODUCTION SYSTEM

M. Weinroth 1,*, P. Rovira 2, X. Yang 3, J. Parker 1, P. S. Morley 1, K. E. Belk 1
1Colorado State University, Fort Collins, United States, 2Instituto Nacional de Investigación Agropecuaria, Treinta y Tres, Uruguay, 3University of California Davis, Davis, United States
weinroth@rams.colostate.edu

Objectives: Antibiotic resistance (AMR) associated with food animals is a public health concern. While many studies have evaluated AMR through culture-based techniques, shotgun metagenomics for AMR allows for development of an ecological perspective within an entire microbial community, rather than focusing on selected organisms. The objective of this study was to characterize AMR genes throughout a conventional beef production system using targeted shotgun metagenomics approach.

Materials and Methods: Eighty composite samples from several stages of beef production were collected in such a manner as to follow the same cohorts of cattle: fecal samples (n = 21), meat trim samples (n = 19), and soil samples, where composted feces were applied as amendments for crops (n = 18). In the same timeframe, samples from a nearby human wastewater treatment plant (n = 14) and soil where treated waste was applied for crops (n = 7) were collected. Collected samples were shipped to Colorado State University and stored at -80°C. Entire microbial DNA was isolated from each sample (aliquots of samples were used in DNA extraction except for meat which was sampled as a rinsate), and a customized target enrichment system (Agilent, SureSelect XT) was used to build DNA libraries enriched for AMR gene sequences. Libraries were sequenced on a HiSeq 4000 (Illumina; 2 × 125 bp paired-end) at a depth of 4 to 20 samples per lane depending on the expected microbial abundance and amount of off-target background DNA.

Results: Across all samples, 18 classes, 69 mechanisms, 250 groups, and 1327 gene accessions associated with AMR were identified. Using this AMR gene target enrichment system, AMR genes were identified in samples from all stages of beef production that were sampled. Human wastewater contained greater numbers of unique gene accessions (richness) compared to other sample matrices, with an average of 621 unique gene accessions per sample. Trim rinsates had the lowest richness (mean = 27 unique gene accessions per sample). Composition of the resistome differed among sample matrices. Fecal resistomes were predominantly associated with tetracycline resistance (74% of hits), while resistome from trim was more diverse; the trim resistome was comprised of 32% elfamycin, 25% betalactam, and 22% rifampin resistance. Additionally, soil samples where composted cattle feces and treated human waste were applied contained similar resistomes: approximately half of sequencing hits related to rifampin resistance and 25% for elfamysin resistance. Finally, treated human waste predominately (36%) contained hits of AMR gene accessions that are resistant to the macrolide, lincosamide, and streptogramin (MLS) class.

Conclusion: Diversity of AMR genes by location in the beef production system suggested that AMR gene dissemination was not linear throughout production and that there are many factors affecting transmission to humans. Using these data, differing interventions can be designed and implemented based on the specific step in production being targeted to mitigate AMR in and around the beef production system.

Keywords: AMR, beef, metagenomics
Objectives: To compare and characterize the antimicrobial resistance and multidrug resistance patterns of *Salmonella* isolates obtained from Honduras based on the source of isolation.

Materials and Methods: A total of 134 *Salmonella* isolates from Honduras were subjected to phenotypical antimicrobial resistance analysis for 14 antibiotics from nine different antibiotic classes. The isolates were collected from different sources, including beef cattle during harvesting (n=78), poultry (n=26) and retail beef (n=30). Antimicrobial resistance (AMR) analysis was conducted following the National Antimicrobial Resistance Monitoring System (NARMS) protocol. Minimum inhibitory concentrations (MIC) were obtained using the Sensititre® OptiRead™ system and Sensititre® software SWIN® (V3.3). Results were categorized as susceptible, intermediate or resistant according to the revised Clinical and Laboratory Standards Institute (CLSI) breakpoints.

Results: A total of 22% (30/134) of the isolates were multidrug-resistant (MDR), which indicates resistance to at least three or more classes of antibiotics. Antibiotic resistance patterns of all *Salmonella* isolates were analyzed detecting difference among antibiotics (*p*<0.05). The results indicate that *Salmonella* had higher resistance (*p*<0.05) to cefoxitin antibiotic with 25% (34/134), followed by amoxicillin-clavulanic acid at 23% (31/134), ampicillin, gentamicin and streptomycin with 19% (25/134), and ciprofloxacin with 16% (21/134). Moreover, *Salmonella* showed 13% (18/134) resistance to trimethoprim-sulfamethoxazole, 12% (16/134) to nalidixic acid, 10% (14/134) to tetracycline, and 8% (11/134) to azithromycin. Furthermore, resistance of 4% (6/134) was found for ceftiofur, ceftriaxone, and chloramphenicol. In contrast, all *Salmonella* isolates exhibited susceptibility to the sulfisoxazole antibiotic. MDR patterns were found to be significantly different (*p*< 0.05) among isolate source. *Salmonella* isolates from retail beef trim had the highest multidrug resistance patterns (*p*<0.05) with 57% (17/30), followed by beef cattle during harvesting 15% (12/78) and poultry sources with 4% (1/26).

Conclusion: High levels of MDR were found in retail meat products originated from Honduras, suggesting a risk and public health concern to consumers. Resistant pathogens and resistance genes could potentially be transmitted from the final products to humans and bacteria using several transmission routes. Cross contamination in wet markets could result in transfer and spreading of MDR *Salmonella* among consumers. The reduction of antibiotic use in the Honduran animal industry may reduce and limit *Salmonella* antibiotic resistance patterns in animal products.

Keywords: cefoxitin, multidrug resistance
Meat and Poultry Safety

137- EFFECT OF CULTURED CANE SUGAR AND VINEGAR IN COMPARISON TO VINEGAR POWDER ON LISTERIA MONOCYTOGENES INHIBITION IN NATURAL CURED DELI TURKEY BREAST.

P. Sijtsema 1,*, S. Kumar 2, G. McCoy 2, T. Rourke 2
1Corbion Purac America, Lenexa, Netherlands, 2Corbion Purac America, Lenexa, United States
garrett.mccoy@corbion.com

Objectives: The objective of this study was to assess the antimicrobial efficacy of Verdad® Opti. Powder™ N70 cultured cane sugar and vinegar powder (CSV-P) versus vinegar powder solution (DV) on the inhibition of \textit{L. monocytogenes} growth potential in natural cured ready to eat (RTE) Turkey breast formulation for 150 days of storage at 40°F.

Materials and Methods: Ground turkey breast, water, sea salt, cane sugar, fermented celery juice powder and different levels of natural interventions, were mixed, vacuum tumbled, placed in a cooking bag and mold, and cooked in a steam cabinet to an internal temperature of 162°F.

Table 1 outlines the treatment structure, water activity, pH, and moisture for the treatments as well as the \textit{L. monocytogenes} outgrowth data.

Each of treatment was independently inoculated with a 5 strain cocktail of \textit{L. monocytogenes}, vacuum packaged, and incubated at 40°F. The inoculated samples were enumerated for \textit{L. monocytogenes} (in duplicate set), at 12 regular intervals for 150 days of incubation, using selective Palcam media. Water activity, pH, and moisture were analyzed for all the treatments.

Results: The water activity values were relatively lower for CSV-P treatments in comparison to using dried vinegar treatments. The shelf life determined by the outgrowth of lactic acid bacteria is significantly influenced by water activity. Lower water activity values correspond to lower growth rate of lactic acid bacteria strains, thereby preventing spoilage.

The use of treatments 0.7% DV, 0.9% DV, 1.8% CSV-P and 1.8% CSV-P showed higher inhibitory control of the outgrowth of \textit{L. monocytogenes} compared to the control treatment. The 1 and 2 log\textsubscript{10} CFU/g outgrowth for \textit{L. monocytogenes} were reached in 10 and 12 days for control treatment, respectively. The 1 and 2 log\textsubscript{10} CFU/g outgrowth of \textit{L. monocytogenes} was reached at 30 and 40 days for 0.7% DV and 35 and 60 days for 0.9% DV, respectively.

Conclusion: This research substantiates the antimicrobial efficacy of Verdad® Opti. Powder™ N70 cultured cane sugar and vinegar powder in RTE turkey breast to control \textit{L. monocytogenes} outgrowth and provides the industry with an effective, natural, and clean label ingredient solution to improve food safety and extend shelf life in sensitive meat formulations.

Keywords: Antimicrobial intervention, Cooked Processed Meat, Natural Preservation, Shelf Life Extension, Turkey
ANTIMICROBIAL EFFICACY COMPARISON OF CULTURED CANE SUGAR AND VINEGAR POWDER AGAINST VINEGAR POWDER ON LISTERIA MONOCYTOGENES INHIBITION IN HAM.

P. Sijtsema 1, S. Kumar 1, G. McCoy 1, R. Thomas 1
1Corbion Purac America, Lenexa, United States
garrett.mccoy@corbion.com

Objectives: The objective of this study was to evaluate the antimicrobial efficacy of Verdad® Opti. Powder™ N60 cultured sugar and vinegar (CSV-P) versus vinegar powder solution (DV) in ham formulation. The efficacy was evaluated on L. monocytogenes growth inhibition in different product treatments incubated at 40°F for 140 days.

Materials and Methods: Pork semimembranosus was injected at 33% pump level of brine solution containing water, sea salt, cane sugar, sodium nitrite, and varying levels of antimicrobial interventions. Each treatment was macerated independently, tumbled, stuffed, and cooked in a steam cabinet to an internal temperature of 162°F. Table 1 outlines the treatment structure, proximate values for the treatments and the L. monocytogenes outgrowth data. Each of these treatments were independently inoculated with a 5 strain cocktail of L. monocytogenes, vacuum packaged, and incubated at 40°F. The treatments were sampled in duplicate at regular time intervals, enumerated for L. monocytogenes using selective Palcam media. Water activity, pH, and moisture content analysis was performed for all the treatments.

Results: The water activity values for CSV-P treatments were generally lower than control treatment and dried vinegar treatments. The lactic acid bacteria outgrowth is significantly influenced by water activity values and lower aw values correspond to lower growth rate of lactic acid bacteria strains, thereby preventing early spoilage by providing an additional preservation hurdle. The pH values show similar results for different antimicrobial treatments indicating no major impact on ionic strength of the formulations.

The use of 0.5% DV, 0.7% DV, 1.5% CSV-P and 1.8% CSV-P enhanced control in outgrowth of L. monocytogenes compared to the control treatment. The 1 and 2 log_{10} CFU/g outgrowth for L. monocytogenes was reached in 7 and 12 days for control treatment, respectively. Addition of 0.5% DV treatment reduced the L. monocytogenes outgrowth to less than 2 log_{10} CFU/g until 50 days. Increasing the DV concentration to 0.7% further reduced the L. monocytogenes outgrowth to less than 2 log_{10} CFU/g until 125 days. For the other 2 treatments (1.5% and 1.8% CSV-P), an inhibition (<1 log outgrowth) of L. monocytogenes was observed during 140 days of incubation, respectively.

Image:

Table 1: Water activity, pH, moisture and Listeria monocytogenes outgrowth kinetics details for different antimicrobial treatments

<table>
<thead>
<tr>
<th>Treatment details</th>
<th>aw</th>
<th>pH</th>
<th>Moisture (%)</th>
<th>Time for 1 log_{10} CFU/g outgrowth of L. monocytogenes (days)</th>
<th>Time for 2 log_{10} CFU/g outgrowth of L. monocytogenes (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.980</td>
<td>6.10</td>
<td>75</td>
<td>7d</td>
<td>12d</td>
</tr>
<tr>
<td>0.5% DV</td>
<td>0.979</td>
<td>6.10</td>
<td>74</td>
<td>30d</td>
<td>50d</td>
</tr>
<tr>
<td>0.7% DV</td>
<td>0.978</td>
<td>6.05</td>
<td>74</td>
<td>55d</td>
<td>125d</td>
</tr>
<tr>
<td>1.5% CSV-P</td>
<td>0.974</td>
<td>6.10</td>
<td>73</td>
<td>&gt; 140d</td>
<td>&gt; 140d</td>
</tr>
<tr>
<td>1.8% CSV-P</td>
<td>0.973</td>
<td>6.10</td>
<td>73</td>
<td>&gt; 140d</td>
<td>&gt; 140d</td>
</tr>
</tbody>
</table>

Conclusion: This research verifies the antimicrobial efficacy of Verdad® Opti. Powder™ N60 cultured cane sugar and vinegar powder in ham to control L. monocytogenes outgrowth and provides the industry with an effective, natural, and clean label ingredient solution to enhance the food safety and shelf life in sensitive meat formulations.

Keywords: Antimicrobial Intervention, Cooked Processed Meat, Ham, Natural Preservation, Shelf Life Extension
Efficacy of a Commercial Phage Cocktail in Reducing Salmonella Contamination on Poultry Products - Laboratory Data and Industrial Trial Data

S. Hagens 1, B. de Vegt 2, R. Peterson 3,*
1R&D, 2Micareos BV, Wageningen, Netherlands, 3Micareos BV, Atlanta, United States
s.hagens@micareos.com

Objectives: We endeavored to test the efficacy of two phages that show an extremely broad host range in in vitro studies on poultry products using a) artificial contamination studies and b) by assessing their usefulness in factory settings with naturally contaminated products.

Materials and Methods: The commercial Salmonella phage product PhageGuard S was used in these experiments. For the artificial contamination, poultry products (skin-on and skinless) were purchased from local stores. A streptomycin resistant Salmonella Enteritidis strain was used to contaminate both products with ~10^4 CFU/cm^2. Phage was applied at 1 and 2 x10^7 pfu/cm^2 after 30 min. Bacteria were retrieved from treated and control samples after 24, 48 and 144 hours. Duplicate samples were used and experiments were repeated twice. After stomaching dilutions were spread on Salmonella selective agar plates supplemented with streptomycin to further reduce background flora. In the tests in industrial trials phages were applied by dipping the products in phage solutions containing 1-4% of the phage product resulting in similar numbers of phages as used in the artificial contamination studies. All food products were tested twice. Experiments were performed off-line allowing comparison with regular non-treated product. In these trials absence/presence in a given sample was recorded using the detection methods preferred by the respective establishment. Different poultry producers were involved in the trials which were performed on-site. In short chicken livers, necks and breasts as well as turkey backs were treated and absence/presence of Salmonella was established according to the establishments (USDA-approved) testing method and compared to an equal number of untreated control samples (180, 120, 450 and 74 tested samples in total respectively).

Results: Both on skinless and skin-on poultry products phage application resulted in >1 log reductions for both phage concentrations used. The reduction in cells did not increase after 24 hours indicating that phage are active for a short period of time. In the industrial trials 19/90 untreated chicken liver samples were positive (21%) whereas in the treated group 1/90 samples was (~1%). 50/60 untreated neck samples were found to be positive (83%) whereas in the treated samples 21 were positive. In the chicken breast trial 49% of the control samples (94/190) were positive and 13% of treated samples were (33/260). For the turkey backs all 37 control samples were positive whereas only 8 on the treated samples were. This translates in reduction of positive samples by 94%, 58%, 80% and 88% respectively. Analysis using Fischers' exact test shows that the differences are statistically significant.

Conclusion: The results from the artificial contamination experiments show that phage can significantly reduce Salmonella on poultry products. The results from the industry trials show that this translates into meaningful reductions in real life and that phages offer a valuable new tool to enhance food safety.

Keywords: Bio-control, Field trials, Phage, Salmonella
Meat and Poultry Safety

140- EFFICIENCY OF PHAGE INTERVENTION ON SALMONELLA KILL ON LEAN PORK, PORK TRIM AND BACON
S. Sirdesai 1, G. Eraciio 1, R. Peterson 1,*, J. van Mierlo 1, B. De Vegt 1
1Micreos Food Safety, Micreos, Wageningen, Netherlands
b.devegt@micreos.com

Objectives: Raw Pork Products Exploratory Sampling Program (2015) by FSIS, USDA aims to estimate the prevalence and levels of Salmonella in various fresh pork cuts and products. The results of this ongoing baseline sampling program will provide direction to FSIS and the Agency to develop a better risk profile and refine the present food safety guidelines for pork products. New impending regulatory standards will likely prompt establishments to seek interventions that can help in reducing the prevalence and most probable number of Salmonella in their products. Bacteriophages are ubiquitous antibacterial agents that can invade and kill specific target pathogenic bacteria in foods. PhageGuard S, is a commercial salmonella based phage cocktail consisting of 2 phages, FO1a and S16. Having been found in nature, these phages are a natural and organic way to kill salmonella and reduce risk in various types of food products. Phage have a number of other added benefits over traditional chemical processing aids as well. There is no impact to the sensorial properties of foods and no impact on worker safety, wastewater or processing equipment. As such, the use of Salmonella-phages as a biocontrol agent for Salmonella can be an interesting avenue to explore for the meat industry. This study determines the efficacy of a commercially available phage product, PhageGuard S, for Salmonella kill on several types of pork including – lean meat, bacon and pork trim.

Materials and Methods: Overnight culture of Salmonella Se13 streptomycin resistant strain was diluted and inoculated at a concentration of 2x10^4 CFU/cm^2 or CFU/g on lean pork, bacon or pork trims (duplicate samples per treatment). Subsequently, contaminated samples were treated with either of the following phage concentrations (5x10^6, 1x10^7, 2x10^7 or 5x10^7 PFU/cm^2 or PFU/g) or water (control). After treatment, samples were stored at 40 °F (4 °C) for 18 hours before retrieval and enumeration of bacteria on selective agar plates.

Results: The application of phages 10^7 and 5x10^7 PFU (Plaque Forming Unit)/cm^2 on lean pork resulted in 1.1 log_{10} CFU/cm^2 and 1.6 log_{10} CFU/cm^2 reduction of Salmonella respectively (mean value of two individual experiments). On Bacon, the highest phage concentration resulted in 0.8 log_{10} CFU/cm^2 reduction (mean value of two individual experiments). When applied on pork trim, phage concentration 2x10^7 and 5x10^7 PFU/g showed Salmonella kill of 1.3 log_{10} CFU/g and 1.7 log_{10} CFU/g respectively. Overall, a dose response was observed where increasing phage concentration resulted in an increasing Salmonella kill on different pork meat.

Conclusion: Phage technology is an easy, safe intervention and an alternative to chemicals and antibiotics in controlling of Salmonella in slaughter and processing environments. The above results indicate that the commercially available phage solution, PhageGuard S, can reduce Salmonella contamination on pork by 1.3 to 1.7 log_{10}. Therefore, making it an effective Salmonella intervention for processors to reduce risks and allow for increase in consumer safety.

Keywords: bacon, Bacteriophage, pork, Salmonella, trim
Objectives: Manufacturing dry-cured, whole muscle meat products without a thermal lethality step is a growing trend for charcuterie companies in the United States. The USDA-FSIS requires that hazards for ready-to-eat meat products be addressed with a scientifically valid HACCP system. Since little literature exists for validation of these “old world” products, an experiment was designed to validate the safety of beef bresaola. The objectives of this study were to validate the safety of dry-cured, beef bresaola and to investigate a bresaola manufacturing process by attempting to achieve a 5 \( \log_{10} \) (CFU/cm\(^2\)) reduction of \( E. \ coli \) O157:H7, \( Salmonella \) spp., and \( Listeria \ monocytogenes \).

Materials and Methods: Prior to curing, whole beef eye rounds (n=6) were inoculated with a mixed culture bath containing three strains each of \( E. \ coli \) O157:H7, \( Salmonella \) spp., and \( Listeria \ monocytogenes \), allowed to air dry (30 min @ 23°C), sprayed with a 2.5% Beefxide\(^{R} \) antimicrobial treatment (lactic and citric acid) on all surfaces and allowed to sit overnight in a walk-in cooler (2-4°C). Cure (NaNO\(_3\) & NaNO\(_2\)) and salt were applied to the beef surface 24 hours after the antimicrobial treatment, and the beef was allowed to cured for 28 days (2-4°C). Following curing, a proprietary spice mixture was applied to the surface of the beef, and each piece was stuffed into beef casings (115-130mm). The stuffed bresaola pieces were hung and allowed to dry for 44 days to a target water activity <0.92 (13.63±2°C; rH 68% ± 7%). Pathogen populations and \( a_w \) were analyzed at days 0, 1, 2, and then once a week until day 72 of the study. Individual comparisons using a Generalized Linear Model were used to determine significant differences (p < 0.05) of pathogen concentrations between days.

Results: A 5 \( \log_{10} \) (CFU/cm\(^2\)) reduction was achieved for all three pathogens. A reduction of 5.52 \( \log_{10} \) (CFU/cm\(^2\)) (p < 0.0001) for \( E. \ coli \) was achieved on Day 44. A reduction of 5.72 \( \log_{10} \) (CFU/cm\(^2\)) (p < 0.0001) for \( Salmonella \) ssp. was achieved on Day 44. A reduction of 5.21 \( \log_{10} \) (CFU/cm\(^2\)) (p < 0.0001) for \( Listeria \ monocytogenes \) was achieved on Day 37. Final reductions of 5.97, 5.98, and 5.44 \( \log_{10} \) (CFU/cm\(^2\)) (p < 0.0001) were achieved on Day 65 for \( E. \ coli \), \( Salmonella \) ssp., and \( Listeria \ monocytogenes \), respectively. During the entire curing and drying process, populations of each species never increased by more than 0.5 \( \log_{10} \) (CFU/cm\(^2\)).

Conclusion: The critical parameters used to treat, cure (3.5% salt), and dry this product are sufficient to achieve the minimum 5 \( \log_{10} \) (CFU/cm\(^2\)) reduction of each pathogen as required by FSIS to validate process safety.

Keywords: Bresaola, \( E. \ coli \) O157:H7, \( Listeria \ monocytogenes \), \( Salmonella \)
Objectives: The objective of this study was to assess the antimicrobial efficacy of fumaric, phosphoric acid and lactic acid at different concentrations and pH points in rendered chicken fat against a *Salmonella* cocktail at room temperature.

Materials and Methods: Fresh rendered chicken fat was obtained from a commercial facility, divided into 1L bottles and autoclaved in order to remove any background microbial flora. Chicken fat was allowed to cool to room temp. A three strain *Salmonella* cocktail consisting of *Salmonella* enterica serovars Enteritidis, Typhimurium and Heidelberg was added to each individual tube of chicken fat treatment to obtain 7 log CFU/g starting counts. The chicken fat was homogenized, weighed into sterile centrifuge tubes, treatments were applied, and the tubes were vortexed. Application rates of fumaric, phosphoric, and lactic acid treatments are detailed in Table 1. The plating was done after 20 min delay post addition of acid and mixing. Spread plating was done using TSA with an XLT4 agar overlay using the thin agar layer method. The plates were then incubated at 35°C for 24 hours.

Results: The *Salmonella* counts (Table 1.) show that fumaric and phosphoric acid were unable to provide lethality with use rates up to 0.60%. However, lactic acid had a bactericidal effect, providing *Salmonella* lethality, in application rates as low as 0.20%.

Image:

### Table 1. *Salmonella* counts for the different organic and inorganic acid treatments

<table>
<thead>
<tr>
<th>Fumaric acid (Strong acid)</th>
<th>Log$_{10}$ CFU/g</th>
<th>Phosphoric acid (Strong acid)</th>
<th>Log$_{10}$ CFU/g</th>
<th>Lactic acid (Weak acid)</th>
<th>Log$_{10}$ CFU/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>6.89</td>
<td>Control</td>
<td>6.93</td>
<td>Control</td>
<td>6.93</td>
</tr>
<tr>
<td>0.05%</td>
<td>6.96</td>
<td>0.05%</td>
<td>6.96</td>
<td>0.10%</td>
<td>6.03</td>
</tr>
<tr>
<td>0.10%</td>
<td>6.87</td>
<td>0.10%</td>
<td>6.56</td>
<td>0.20%</td>
<td>4.00</td>
</tr>
<tr>
<td>0.15%</td>
<td>6.90</td>
<td>0.15%</td>
<td>6.71</td>
<td>0.30%</td>
<td>1.00</td>
</tr>
<tr>
<td>0.20%</td>
<td>7.00</td>
<td>0.20%</td>
<td>6.20</td>
<td>0.40%</td>
<td>1.00</td>
</tr>
<tr>
<td>0.25%</td>
<td>6.93</td>
<td>0.25%</td>
<td>5.88</td>
<td>0.50%</td>
<td>1.74</td>
</tr>
<tr>
<td>0.35%</td>
<td>6.87</td>
<td>0.35%</td>
<td>6.14</td>
<td>0.70%</td>
<td>1.00</td>
</tr>
<tr>
<td>0.40%</td>
<td>6.56</td>
<td>0.40%</td>
<td>5.46</td>
<td>0.80%</td>
<td>1.00</td>
</tr>
<tr>
<td>0.45%</td>
<td>7.40</td>
<td>0.45%</td>
<td>6.24</td>
<td>0.90%</td>
<td>1.00</td>
</tr>
<tr>
<td>0.50%</td>
<td>7.27</td>
<td>0.50%</td>
<td>5.95</td>
<td>1.0%</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.60%</td>
<td>6.57</td>
<td>1.50%</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Conclusion: This research verifies the antimicrobial efficacy of lactic acid over inorganic acids such as fumaric and phosphoric acid. Thus providing the pet food industry with a natural antimicrobial to provide *Salmonella* lethality in the rendered chicken fat and protecting pet food.

Keywords: Chicken, Lactic Acid, Pathogen Control, Pet Food, Salmonella
Meat and Poultry Safety

143- SHIGA-TOXIN PRODUCING ESCHERICHIA COLI AND SALMONELLA SPP. PREVALENCE ON SHEEP HIDES COLLECTED THROUGHOUT THE HARVESTING CHAIN IN VARIOUS HONDURAN SLAUGHTER FACILITIES.

S. Forgey 1,*, A. K. Englishbey 1, D. E. Casas 1, S. P. Jackson 1, M. M. Miller 1, M. Brashears 1

1Animal and Food Sciences, Texas Tech University, Lubbock, United States
savannah.forgey@ttu.edu

Objectives: This objective of this study was to create a baseline of STEC O157:H7, non-O157:H7, and Salmonella spp. prevalence observed on Honduran sheep hides.

Materials and Methods: Sample collection from 68 sheep in Honduran slaughter facilities was performed aseptically, with pre-hydrated, sterile sponge swabs from 100 cm² section of the brisket-foreshank region on the hide immediately following exsanguination. Microbial detection of presumptive STEC serogroups and Salmonella spp. was performed using the BAX Real-Time PCR system. Presumptive positive STEC serogroups were confirmed through latex agglutination. Additionally, presumptive positive Salmonella spp. was confirmed using both, latex agglutination and Real-Time PCR.

Results: Shiga-Toxin producing Escherichia coli was observed on 24 out of 68 hides. Serogroups detected on hides included; O26, O45, O145, and O157. Moreover, serogroups O26 and O45 were the most prevalent with 54.17 and 41.67%, respectively. However, only one isolate was detected for serogroups O157 and O145. Furthermore, zero presumptive positive STEC isolates contained O103, O111, or O121 serogroups. Additionally, Salmonella spp. was 20.58% less prevalent on hides than STEC. From the observed baseline contamination prevalence of STEC and Salmonella spp. on sheep hides in Honduras, additional critical control points, standard operating procedures, and antimicrobial interventions should be implemented to regulate initial pathogen prevalence. Therefore, proper sanitation and hygiene throughout the harvesting chain should be implemented to reduce and mitigate STEC and Salmonella spp. contamination on hides.

Conclusion: Implementation of sanitary measures while de-hiding the animal will reduce pathogen contamination from hides to sheep carcasses. Overall, STEC and Salmonella spp. prevalence on hides need to have microbial interventions implemented, therefore, creating a safer and more wholesome product for consumers.

Keywords: Salmonella, Shiga toxin-producing Escherichia coli
Translocation of Orally Inoculated Salmonella Following Mild Immunosuppression in Dairy Calves

S. Wilkerson 1*, P. R. Broadway 2, J. A. Carroll 2, N. C. B. Sanchez 2, D. A. Tigue 1, J. G. Rehm 1, T. R. Callaway 3, C. L. Bratcher 1

1Animal Science, Auburn University, AUBURN, 2Livestock Issues Research Unit, USDA-ARS, Lubbock, 3Animal and Dairy Science, University of Georgia, Athens, United States

srw0023@auburn.edu

Objectives: Salmonella (SAL) is a foodborne pathogen of increasing concern in the U.S. as foodborne infection rates remain high and legislative action against foods containing this pathogen is being crafted. Salmonella in beef may be harbored within peripheral tissues that are not reached by topical pathogen interventions; however, the mechanisms by which enteric SAL translocate to atypical locations are not well understood. Therefore, the objective of this study was to determine if immunosuppression via daily dexamethasone (DEX) infusion altered SAL translocation from the GI tract.

Materials and Methods: Weaned Holstein steer calves (n=20; BW=102±2.7 kg) received DEX (n=10; 0.5mg/kg BW) or saline (CON; n=10; 0.5mg/kg BW) for 4 d (from d -1 to d 2) via a jugular catheter prior to oral inoculation of a nalidixic acid resistant Salmonella Typhimurium (3.4x10^6 CFU/animal) via milk replacer on d 0. Fecal swabs for SAL shedding were obtained daily. Upon harvest (d 5), the ileum, cecal content, lymph nodes (ileocecal, mandibular, popliteal and prescapular), and synovial (stifle, coxofemoral and shoulder) swabs were collected for the isolation and quantification of the inoculated strain of SAL.

Results: Following the inoculation, 100% of DEX calves shed the experimental strain of SAL for 5 d, 90% of CON calves shed from d 1 to 3, and 100% of CON calves shed from d 4 to 5. A treatment by tissue interaction (P=0.0016) was observed when evaluating SAL concentrations in tissues collected at harvest. Greater concentrations of SAL were quantified from the cecum of DEX calves (3.86±0.37 log_{10} CFU) when compared to CON cecum (1.37± 0.37 log_{10} CFU; P <0.001). However, there was no difference in SAL concentrations between DEX and CON calves when evaluating ileal tissue (P=0.067), nor amongst ileocecal (P=0.569), mandibular (P=0.122), popliteal (P=0.992), or prescapular (P=0.834) lymph nodes. Salmonella was isolated from the stifle joint of one calf in the CON group; however, SAL was not isolated from any other joint fluids sampled (i.e., coxofemoral or shoulder). This is important to note as it was 3.3% of joint fluid swabs collected from the CON group and there is a high likelihood of the stifle joint fluid to come in contact with meat during hind quarter fabrication. While there were numerical increases in SAL concentrations in DEX calves, it does not appear that daily dexamethasone administration drastically altered SAL colonization or translocation in mildly immunosuppressed calves.

Conclusion: While more research is needed to elucidate the interactions of immunosuppression and pathogen migration patterns, these data confirm that orally inoculated SAL can translocate from the G.I. and be harbored in peripheral lymph nodes and synovial fluid which represents a food safety risk.

Keywords: Food Safety, Ground beef, lymph nodes, Salmonella, Synovial Fluid
Objectives: As the number of students with an agricultural background declines, it is imperative to implement teaching methods that aid in understanding and retaining material. Experiential and hands-on learning strategies are often used to meet these objectives. In that light, a foodborne illness investigation scenario was developed for an undergraduate meat safety class at Colorado State University. The impact of the hands-on experience on retention of information related to foodborne pathogens and their role in the meat industry was assessed by surveying students prior to and following the case-study.

Materials and Methods: A foodborne illness investigation scenario was developed based on modules from the Centers for Diseases Control and Prevention (CDC). Students were divided into groups and one student per group was selected as the “patient” while the other group members formed the “investigation team”. A list of symptoms was provided, and students were challenged with diagnosing the illness, identifying the causative organism, and confirming the source using CDC guidelines. To accomplish these objectives, students formulated hypotheses naming plausible pathogens and vectors, and followed appropriate diagnostic techniques to confirm or reject their hypotheses. Students then presented their findings and outlined strategies which could mitigate future illnesses. Prior to initiation and after completion of the project, students were surveyed to determine their knowledge of foodborne illnesses, perception of risk the meat industry poses with regard to foodborne illness, and their expectations for the project.

Results: All students were under 25 years of age and represented the sophomore (6%), junior (26%) and senior (68%) baccalaureate ranks. The majority of the class was female (74%) and most (87%) were Animal Science majors. Pre-project surveys indicated 59% of students had little knowledge of foodborne illnesses and 7% had no previous knowledge. Many students indicated they were unfamiliar with the procedures utilized to diagnose a foodborne illness or the complexity of the investigation itself. The primary student expectations regarding the scenario were to understand the steps of a foodborne illness investigation and practice the diagnostic methods used in such investigations. Notably, one primary student objective was to learn how to convey information regarding foodborne illnesses and the meat industry to others. When asked of the risk the meat industry poses to foodborne illness, 15% and 44% of the students indicated the industry posed significant or moderate risk, respectively. The remaining 41% of students considered the meat industry to pose minimal risk.

Conclusion: Retention of information that is applicable in future careers is a significant challenge in higher education. Traditional methods for instruction relative to foodborne illness, pathogens, and the meat industry may inhibit information retention or limit the applicability to practical scenarios. Empowering students to take a more active role in their education through experiential learning has shown positive results in other classroom settings. When utilized in this class, the approach had positive impacts on not only student retention and potential application, but also aided in the development of critical thinking skills and student independence—skills which will serve the students in multiple capacities.

Keywords: education, experiential learning
Objectives: The objective of this study was to evaluate the effectiveness of the SDSU Beef 2020 program on increasing participant knowledge and impacting production practices. Unlike the pork or poultry industries, the US beef industry is not vertically integrated and as a result the beef supply is managed by producers in a variety of roles. While these producers are knowledgeable about their specific sector, some may not be as familiar with the other aspects of beef production. South Dakota State University hosts an Extension program entitled Beef 2020 with the goal of bridging this knowledge gap.

Materials and Methods: Beef 2020 was a 3-day Extension program that was targeted to cattle producers, beef purveyors and allied industry representatives and addressed the management factors that influence beef carcass traits. Topics included live market cattle evaluation, health and disposition in relation to carcass quality, genetics, feeding and management, and a presentation on new value-added beef cuts. Beef 2020 also provided the opportunity for participants to view market animals live and participate in a mock auction to determine the purchase price. They observed the harvest process and then participated in a hands-on fabrication of their beef carcass. Information gathered from fabrication was used to calculate the value of the carcass they purchased. We hypothesized that the program improved participant knowledge of the beef industry and resulted in changes in participants’ operations to improve carcass quality. Participants (n = 113) were asked to complete a survey at the conclusion of the program where they rated each topic session, indicated their knowledge of the industry before and after the program, and answered other open-ended questions intended to improve the program year after year. Session ratings were scored on a scale of 1 (not valuable) to 10 (highly valuable). Prior and post program knowledge was evaluated on a Likert scale of 1 (none) to 10 (highly knowledgeable). Data were compiled from survey responses from 2013 to 2018. Statistical analysis was conducted on participant previous and post industry knowledge using a one tailed t-test and significance was indicated at $\alpha < 0.05$. Mean ratings and standard deviations were reported for all other data.

Results: Participation in Beef 2020 improved participant knowledge by 2.3 points (5.4 vs 7.7, $P < 0.0001$). Participants also indicated that sessions were valuable with average scores ranging from 7.2 ± 2.1 (Natural and Organic Production) to 8.9 ± 1.2 (Pre and Post Weaning Strategies to Improve Carcass Traits). Additionally, 84% of the respondents indicated they will implement strategies presented during the program in their own operations, while another 11% indicated they may implement new strategies. Participants also indicated the program was beneficial (9.5 ± 1.1) and it should be conducted again (9.6 ± 1.2).

Conclusion: Beef 2020 effectively improved participant knowledge of the management factors that influence value differences in beef cattle, which resulted in improved marketing opportunities and carcass value for their operations.

Keywords: Beef, Education, Marketing, Meat Quality, Production
Objectives: Using the NDSU BBQ Boot Camp Model we evaluated consumer perception of production agriculture and sustainability, while teaching outdoor cooking methods with meat as the focus in North Dakota cities over a 5-year period.

Materials and Methods: A pre- and post-test of attendees (n=3,112) was used to evaluate the effectiveness of the BBQ Boot Camp educational program and to obtain demographic information. The test had eleven multiple choice questions “A, B, C, D” and five “Yes” or “No” questions that asked attendee’s basic information about food, food safety, and cooking. The last six questions collected participant’s perceptions of food, livestock stewardship, and tools educators use to communicate food and agriculture information and rank each question on a Likert, 5-point scale, 1 = not important, 5 = very important.

Results: Boot Camp attendees scored a 15 percent improvement in test scores after completion of the program (pre-test average score = 67%; post-test average score = 82%, P<0.002). We observed that younger North Dakotans ages 18 – 29 were less concerned about where their food was produced compared to older attendees. More concern was placed on food production as the group age increased to the 40 + age group (P<0.05). Food safety was more of a concern for women as they aged compared to aging men (age x gender interaction; P < 0.048).

Conclusion: The data collected over the five year period provides insight into people’s attitude in North Dakota on food and agriculture production. The mission of Extension Outreach is to enhance the lives of people through research, education and community and BBQ Boot Camp encompasses all three of those core values. The use of barbecue as a means to educate consumers about agriculture and food has proven to be successful. The success can be seen where female participants scored lower than male participants in the pre-test, but recieved higher scores in the post-test.

Keywords: Consumer, Demographics, Education, Extension
148- ASSESSING CONSUMER FOOD SAFETY KNOWLEDGE AND PRACTICE AT TEMPORARY EVENTS

M. Yavelak 1, J. B. Luchansky 2, A. C. Porto-Fett 2, J. J. Hochstein 3, J. A. Campbell 4, D. J. Hanson 1, C. Warren 5, A. Schollenberger 6, B. J. Chapman 7
1Food, Bioprocessing, and Nutrition Sciences, North Carolina State University, Raleigh, 2United States Department of Agriculture Agricultural Research Service, Wyndmoor, 3University of Nebraska Lincoln, Lincoln, 4Animal Science, Pennsylvania State University, State College, 5Souderton Area High School, Souderton, 6PennState 4-H, State College, 7Agricultural and Human Sciences, North Carolina State University, Raleigh, United States
mkyavela@ncsu.edu

Objectives: Meat and poultry products are implicated as the likely source in 29% of reported foodborne illnesses and 22% of foodborne illness-linked deaths. A subset of meat-related foodborne illnesses occur at temporary events (TEs) such as sporting events or large social gatherings. This is likely due to their lack of food safety infrastructure, trained food preparers, and conventional food preparation facilities. Previous studies suggest that most food preparers at pre-game tailgate events (66%) do not use thermometers when cooking. The literature has limited data that evaluates attitudes and behaviors of people who attend these types of events. The purpose of this study was to determine if an in-person, hands-on food safety intervention is an effective approach in changing sustained self-reported behaviors of consumers.

Materials and Methods: Trained instructors provided information on handwashing, cleaning and sanitizing, thermometer use, and indicating meat doneness to customers (n=107) of the Penn State University Meat Lab. Instructors used a semi-structured script and group-based learning to deliver consistent information while leaving room for more personalized dialogue and questions. Four educational stations were utilized in order to conduct hands-on demonstrations and empower participants while they applied newly acquired skills. Self-reported food safety behavior data was collected prior to providing food safety information and one and four months following the intervention.

Results: 50.8% of participants reported thermometer use when cooking meat prior to being presented with information for home thermometer use (n=107). Of the participants that responded after one month (n=41), 77.4% reported using temperature to determine doneness for meat preparation. A paired t-test on thermometer use frequency revealed a significant increase (p<0.05) in frequency pre and one month post intervention (n=41), and no significant change (p>0.05) between one and four months post intervention (n=32). Retention of knowledge was measured on a 1 (not knowledgeable) to 5 (very knowledgeable) Likert scale. A paired t-test of participants from the pre and one month post assessment showed knowledge significantly increased (p<0.05) for lessons addressing cross-contamination, cleaning and sanitizing, and handwashing (n=41). A similar test showed sustained knowledge (p>0.05) between one and four months for cross contamination and cleaning and sanitizing (n=32).

After one month, 92.7% of participants reported changing food safety behaviors as a result of the intervention (n=41). Improvements were reported in the following areas: cleaning and sanitizing (39.5% of participants), using a food thermometer (36.8%), handwashing (13.2%), cooking to the proper temperature (13.2%), preventing cross contamination (10.5%), other (10.5%), and unspecified (2.6%) (n=41).

Conclusion: Results from this training indicate that hands-on stations centered around TE-specific risk factors can significantly increase knowledge and self-reported safe practices of TE participants and sustain them through four months. As many food preparers at TEs have not received professional food safety training, education and skill-building that leads to proper food safety behaviors is crucial in reducing the amount of improper food safety behaviors at TEs. The practicality and effectiveness of this intervention makes it an ideal option for educating future TE-specific audiences.

Keywords: Food Safety, Intervention, Knowledge, Temporary Event
Objectives: The National Market Cow and Bull Beef Quality Audit (NMCBBQA) has been conducted four times: 1994, 1999, 2007 and 2016. Following the original audit attention was drawn to injection-site lesions and the need to further assess the frequency and severity. The 2016 audit reported a major decline in presence of surface knots or injection-site lesions compared with previous audits. The presence of lesions was discussed in detail at the strategy workshop held as the third phase of the 2016 NMCBBQA. Further processors expressed extreme concern of loss and the need to once again evaluate lesions as they had been evaluated in 1998, 1999, and 2000. Therefore, the objective of this study was to evaluate the frequency and presence of injection-site lesions in the outside round muscles of cows.

Materials and Methods: Audits were conducted in 2017 on 1,300 rounds from dairy and beef cows. Audits were conducted in seven locations throughout the U.S. Outside round muscles were butterfly cut into 1.25-cm slices and if present lesions were counted, measured and categorized. The outside round consisted of 4 quadrants: Q1 identified as the most caudal end, closest to the shank, while Q4 identified as the most cranial end, included the biceps femoris muscle. Q2 and Q3 were evenly split between Q1 and Q4. Q1, Q2, and Q3 included both muscles. The depth of each lesion was measured from the outside surface (fat trimmed) to the innermost (center) of the lesion. The diameter was measured using the lengths of the lesion throughout the muscles. The lesions were classified using the 5-point system: classification 1: clear, lesion contains primarily clear connective tissue; classification 2: woody, lesion contains organized connective tissue and fat; classification 3: nodular, lesion contains nodules, a central foci, and granulomatous inflammation; classification 4: metallic, lesion contains mineralized remnants of muscle cells, typically bloody color; or classification 5: cystic, lesion contains fluid.

Results: Of the beef and dairy rounds evaluated 7 and 15%, respectively, had injection-site lesion(s) present. These frequencies were significantly decreased in 2017 from the 2000 audit where beef rounds were 13 percentage points higher and dairy rounds were 20 percentage points higher. The decline was even more significant from the 1998 audit where beef rounds were 24 percentage points higher and dairy rounds were 45 percentage points higher. The most common location of injection-site lesions was quadrant 2 and 3, which contained both the biceps femoris and semitendinosus muscles. Injection-site lesions were more frequent (P < 0.05) in the biceps femoris for both beef and dairy rounds. Clear and metallic lesions were the most common. Clear lesions accounted for 57% of injection-sites in both beef and dairy rounds while metallic lesions made up 23% of the total in beef and 25% in dairy.

Conclusion: Overall, there was a dramatic decline in the frequency (P < 0.05) of injection-site lesions since the 1998, 1999 and 2000 audits. Educational programs, such as Beef Quality Assurance, have increased improvements in management practices for both the beef and dairy industries.

Keywords: audit, beef, dairy, injection-site lesion
Objectives: The objective of the South Dakota State University (SDSU) BBQ Bootcamp program is to increase consumer’s knowledge of retail cuts of meat, methods to prepare the cuts at home, and proper food handling. In recent years, beef consumption per capita has declined by 7.7%, while pork and poultry consumption have increased by 19.7 and 76.7%, respectively. Changes in consumption can be attributed to price, convenience, and knowledge of cuts and cookery methods. In addition to meat selection, whether or not consumers opt to prepare food at home or dine out has been linked to convenience, value, speed of preparation, and taste preferences. SDSU BBQ Bootcamp aims to address these areas of consumer preferences by addressing value cuts, methods of preparation, and flavoring.

Materials and Methods: SDSU BBQ Bootcamp programs combined presentations and demonstrations that address four knowledge areas: 1) meat selection and retail cuts; 2) grilling, smoking, and barbequing; 3) food safety and degrees of doneness; and 4) spices, rubs, and marinades. Speakers discussed selection of known retail cuts, but emphasized the selection and preparation of new value cuts and participants are offered samples of these cuts. In addition, participants are offered the opportunity to sample products of different degrees of doneness, as well as samples prepared with various spices and marinades. The courses were approximately 2.5 hours in duration and were generally presented to an audience of 25 to 35 participants. At the end each program participants were provided a meal of the demonstrated meats along with side dishes, and a dessert prepared using a grill or smoker, followed by a question and answer session. At the end of each course, participants were asked to complete an evaluation of the program using a Likert scale where 1 = not valuable, absolutely not, and no knowledge and 10 = highly valuable, absolutely, and expert knowledge with regard to presentation effectiveness, speaker explanations, and knowledge level before and after the program, respectively. Additional open-ended questions were asked on surveys to improve future BBQ Bootcamp programs hosted by SDSU personnel. Data of pre- and post-knowledge was analyzed using a paired T-test.

Results: Twenty-eight SDSU BBQ Bootcamp programs have been presented reaching over 900 consumers from 2012 to 2017. Of the respondents (n=357; 39.7% respondent rate), the average rating for pre-knowledge of meat-related topics was 5.90 and post-knowledge was 8.11 (P < 0.05), demonstrating the effectiveness of the materials and demonstrations utilized in the program. Overall, 94.3% of participants responded that the course was beneficial and 93.2% responded that the course improved their understanding about food safety and proper cooking temperatures.

Conclusion: The majority of participants responded that the BBQ Bootcamp improved their knowledge of meat selection and preparation. Results indicate that the SDSU BBQ Bootcamp demonstration-based extension program focusing on meat selection and preparation can increase consumer knowledge about meat products and at-home preparation.

Keywords: education, meat preparation, meat selection
Objectives: Animal-sourced foods (ASFs), including meat, provide nutrients that are beneficial for physical and cognitive development, especially in developing countries. Ethiopia is home to the largest livestock inventory in Africa, but inefficiencies in livestock and meat industries contribute to low-per capita domestic consumption of meat. The combination of extensive periods of fasting from ASFs, knowledge gaps in hygienic handling and sanitation, lack of infrastructure, and weakly enforced food safety regulations provide food safety risks in an already protein-deficient population. The objective of this study is to identify pathways to improve safety of the Ethiopian domestic meat supply chain and utilize a training of trainers (ToT) program to initiate these changes.

Materials and Methods: In October of 2016, a needs assessment was conducted to identify pathways for improvement along the supply-chain to prevent or reduce contamination of meat. Site visits and interviews were conducted at abattoirs and butchers. As a result of the assessment, it was determined that building the educational capacity of abattoir and butchery workers would have a large influence on improving food safety. The results of the needs assessment were used to develop training concepts and materials. In August of 2017, a four-day ToT program was administered to 20 participants (18 men, 2 women) who represented multiple facets and regions of the meat supply chain. Trainees participated in classroom training, which focused on adult learning and training principles, common food safety hazards, and general hygiene and sanitation concepts. Trainees participated in field evaluations of an abattoir and butchery and presented observations to the group. Based on their evaluations, trainees planned and presented their training objectives for abattoir and butchery workers. Trainees were also given a Pre- and Post-Test to assess initial knowledge and knowledge increases.

Results: Eighteen butcher shops were observed in Addis Ababa, Ethiopia in October 2016. The assessment identified all 18 butchers sold meat for raw consumption, only two (11.11%) sold further processed meat. Despite having refrigerators for beverages, only eight (44.44%) refrigerated meat. A handwashing sink was available in 17 (94.44%) butcher shops, but accessibility varied greatly. Frocks were used in all 18 (100%) butcher shops, but few butchers used head coverings, and many allowed jewelry. The needs assessment also indicated that no worker trainings had been conducted and ground maintenance was needed in all facilities. Pre- and post-tests were conducted prior to and after TOT. Using a paired t-test, test scores were compared and indicated a 9.62% (P=0.0001) increase in knowledge between Pre- (73.29%) and Post- (82.31%) tests. As a result of the ToT program, 166 people (152 men, 14 women) representing 42 Woredas (districts in Ethiopia) have been trained in meat hygiene and food safety concepts.

Conclusion: The needs assessment and ToT programs was successful in determining key areas of improvement and building the capacity and of trainers. The knowledge is currently being successfully disseminated to abattoir and butchery workers throughout Ethiopia.

Keywords: Africa, Animal-sourced foods, Food Safety, Food Safety Risk
Muscle and Lipid Biology and Biochemistry

152- NOVEL OBSERVATIONS OF PEROXIREDOXIN-2 PROFILE AND PROTEIN OXIDATION IN SKELETAL MUSCLE FROM PIGS THAT DIFFER IN RESIDUAL FEED INTAKE AND HEALTH STATUS

B. M. Patterson 1*, A. C. Outhouse 1, E. T. Helm 1, J. C. M. Dekkers 1, K. J. Schwartz 2, N. K. Gabler 1, S. M. Lonergan 1, E. Huff-Lonergan 1
1Department of Animal Science, 2School of Veterinary Medicine, Iowa State University, Ames, United States
bmp@iastate.edu

Objectives: Efficiency of pork production is critical as demand for animal protein rises with increases in global populations and income. Feed efficiency and response to disease challenge are affected by stressors that increase reactive oxygen species in muscle. Reactive oxygen species are detrimental to growth, as they require the expenditure of energy for tissue repair that could be used for weight gain. Peroxiredoxin-2 (Prdx-2) is an antioxidant enzyme that converts hydrogen peroxide to water using reactive cysteines, thus mitigating oxidation. Prdx-2 can exist in multiple oxidation states (reduced, oxidized, and hyperoxidized) and quaternary structures (dimer and decamer). Prdx-2 concentration is greater in more color stable muscles and may be an indicator of tenderness. The objective of this study was to determine differences in Prdx-2 profile and protein oxidation between pigs that differed in feed efficiency and health status.

Materials and Methods: Pigs selected for differing feed efficiency based on residual feed intake (RFI) were used in a 2*2 factorial design for this study. At 50±7 kg in body weight, high RFI (less efficient) and low RFI (more efficient) barrows were distributed between two rooms in the same building. One room was inoculated with a dual respiratory/enteric bacterial health challenge. At 21 days post-infection (projected peak of illness), pigs were necropsied (total=24, n=6 per group) and longissimus muscle samples were collected. Reduced and nonreduced sarcoplasmic protein samples (β-mercaptoethanol) were used for western blot analyses. Reduced samples were used to quantify total Prdx-2, while nonreduced samples were used to evaluate hyperoxidized peroxiredoxin. Prdx-2 decamer, and Prdx-2 profile in nonreducing gels (two distinct bands analyzed). Carbonyl content and diagonal gel electrophoresis were performed on sarcoplasmic protein samples to determine protein oxidation. Statistical analysis was performed using SAS v. 9.4 with fixed effects of RFI line, infection status, and RFI line*infection status interaction. Gel repetition and necropsy day were included as random effects.

Results: Infection status was significant for the Prdx-2 band comparison in nonreducing gels (P=0.014) indicating potential differences in posttranslational modifications. Compared to low RFI pigs, high RFI pigs had greater total Prdx-2 (P=0.035), greater Prdx-2 decamer (P=0.0007), greater Prdx-2 in the second band of nonreducing gels (P=0.0006), and less hyperoxidized peroxiredoxin relative to the total immunoreactive protein (P=0.028). An interaction existed between RFI line and infection status for the Prdx-2 band comparison (P=0.02), with high RFI challenged pigs having greater ratios, and high RFI control pigs having lesser ratios relative to low RFI pigs. Visual analysis of diagonal gels showed more proteins with intermolecular disulfide formation in low RFI muscle samples. No significant difference was seen for carbonyl content.

Conclusion: Differences exist in Prdx-2 profile based on RFI line and infection status. High and low RFI pigs may respond differently to health challenges at the molecular level based on differences in antioxidant protein response. By defining Prdx-2 in livestock muscle, we may be better able to manage animals to meet demand for meat without increasing inputs.

Keywords: Feed Efficiency, Health Challenge Response, Oxidative Stress, Peroxiredoxin-2, Protein Oxidation
IMPACT OF PRRS CHALLENGE ON CALPAIN AND CALPASTATIN ACTIVITY IN SKELETAL MUSCLE OF YOUNG PIGS

E. A. Zuber, N. K. Gabler, E. T. Helm, C. M. De Mille, M. C. Schulte, B. M. Patterson, E. Huff-Lonergan, S. Lonergan

Animal Science, Iowa State University, Ames, United States

Objectives: Porcine Reproductive and Respiratory Syndrome (PRRS) virus challenges in growing pigs are known to negatively affect growth performance. One hypothesis to explain this observation is that an increase in calpain system initiated protein degradation in muscle contributes to the reduction of muscle protein accretion. Calpain-1 and -2 are calcium dependent cysteine proteinases that are regulated by an endogenous inhibitor, calpastatin. The objective of this experiment was to define the extent to which PRRS challenge influences skeletal muscle calpain and calpastatin activity at two stages of infection (viremia and seroconversion).

Materials and Methods: Thirty-three pigs (11.3±1.54 kg body weight (BW), approximately 6 weeks of age) were assigned to a contemporary group (3 pigs per group) based on age and weight. Pigs were housed in individual pens in separate rooms depending on treatment. One pig per group was assigned to one of three treatments, 1) PRRS (PRRS challenged with ORF5 RFLP1-3-4 isolate (n=11)), 2) Pair-fed (Non-challenged, daily feed intake matched to challenged pigs (n=11)), and 3) Ad-lib (Non-challenged, Ad libitum fed (n=11)). Weekly BW, feed disappearance, and feed efficiency were assessed over each period. At days post inoculation (dpi) 9-10 (7 groups; viremia period) and 16-17 (4 groups; seroconversion period), pigs were euthanized and a 50 g sample of longissimus muscle was collected and homogenized in pre-rigor extraction buffer (100 mM Tris-HCl pH 8.3, 10 mM EDTA, 100 mg/L trypsin inhibitor, 2 μM E-64, and 0.1% 2-mercaptoethanol). Calpains and calpastatins were separated using anion exchange chromatography and quantified using casein as a substrate. Data from each time period were analyzed as a separate experiment. Data were analyzed using the mixed procedure in JMP Pro version 13.1 with fixed effects of treatment and a random effect of contemporary group. Means separations were conducted via Student T-test with P<0.05 considered significantly different.

Results: At both time points, PRRS pigs had reduced ADG and G:F compared with Ad-lib and Pair-fed pigs (P<0.01). Additionally, ADFI was reduced in PRRS and Pair-fed pigs compared with Ad-lib pigs (P<0.001). At dpi 9-10, PRRS challenge resulted in greater calpastatin-2 (1.04) and total calpastatin (1.70) activity compared with the Pair-fed pigs (0.58, 1.06 respectively; P<0.05). By contrast, at dpi 16-17, PRRS challenge resulted in greater calpastatin-1 (1.08) and total calpastatin activity (1.98) compared with Pair-fed controls (0.54, 0.89, respectively; P<0.05). Calpain-1 and -2 were not significantly altered by treatment at either time point. The ratio of calpain-2 to total calpastatin activity was significantly (P<0.05) less in muscle from PRRS challenged pigs (1.16) compared with muscle from the Pair-fed (2.47), but not the Ad-lib pigs (1.58).

Conclusion: The results demonstrate that a decline in voluntary feed intake was not singularly responsible for the observed response to PRRS challenge. These results are counter to the hypothesis that PRRS challenge would decrease calpastatin activity. Moreover, the results of this study indicate a difference in calpastatin response to PRRS challenge, notably that PRRS challenge increased calpastatin-2 activity at dpi 9-10 and calpastatin-1 activity at dpi 16-17. The switch indicates a temporal response in skeletal muscle proteolysis due to PRRS virus challenge.

Keywords: calpain, calpastatin, proteolysis, PRRS
SARCOPLASMIC RETICULUM MEMBRANE INSTABILITY CAUSED BY DIETARY FAT SOURCE MAY AFFECT EARLY POSTMORTEM TENDERIZATION OF BEEF

F. A. Ribeiro, K. Domenech-Perez, N. Herrera, K. Hart, C. Calkins

University of Nebraska, Lincoln, United States
felipegea@hotmail.com

Objectives: We hypothesize that high concentrations of polyunsaturated fatty acids (PUFA) in the sarcoplasmic reticulum (SR) membrane could cause the membrane to quickly lose integrity due to increased oxidation potential, leading to early postmortem release of previously sequestered calcium. The free calcium could then interact with calpains and accelerate early postmortem protein degradation, making meat more tender. Therefore, this research was conducted to determine if a shift in dietary fat source could affect the beef tenderization mechanism early post-mortem.

Materials and Methods: Steers (n=320) were fed for 134 d on either corn, or a diet containing 40% full-fat modified distillers grains plus solubles (MDGS), 40% de-oiled MDGS, or 38% de-oiled MDGS plus 2% corn oil. Twenty-four USDA Choice carcasses (3 head/pen) were selected within each dietary treatment (n=96) and strip loins (Longissimus lumborum) from both sides were collected and aged for 2, 9, 16, or 23 d. Steaks from each aging period were placed under retail display (RD) conditions for 0 and 7 d and Warner-Bratzler shear force was evaluated. Sarcomere length (via laser diffraction), SR membrane fatty acids (via gas chromatography), free calcium concentration (via inductively coupled plasma spectroscopy), and troponin-T degradation (via immunoblotting) were analyzed only at d 2 postmortem with no RD exposition. Tenderness data were analyzed as a split-plot design with dietary fat source as the whole-plot and aging period as the split-plot. All other variables evaluated at d 2 postmortem were analyzed as a completely randomized design. Pen was considered the experimental unit and data were analyzed using the PROC GLIMMIX procedure of SAS. All means were separated with the LS MEANS and DIFF functions (α = 0.05).

Results: No differences in marbling scores were found among dietary treatments (P = 0.78). Feeding MDGS decreased (P < 0.05) concentrations of 18:1V, increased (P < 0.05) concentrations of linoleic acid (18:2) and tended to increase (P = 0.06) total PUFA in the sarcoplasmic reticulum (SR) membrane. Steaks from cattle fed MDGS had greater free calcium concentration than steaks from cattle fed corn 2 d postmortem (P = 0.05). Steaks from steers fed de-oiled MDGS and de-oiled MDGS plus corn oil had lower Warner-Bratzler shear force values (P = 0.03) than steaks from cattle fed corn at 2 d of aging with 0 d RD. However, no differences in WBSF values among dietary treatments were found within aging periods when RD time was extended to 7 d (P > 0.05). Extended aging beyond 2 d mitigated the tenderness effects, as there were no significant differences in tenderness among dietary treatments on samples aged for 9 (P = 0.38), 16 (P = 0.73) or 23 d (P = 0.96). There were no differences among dietary treatments for sarcomere length (P = 0.92) and troponin-T degradation 2 d postmortem (P = 0.60).

Conclusion: Results suggest that feeding de-oiled and de-oiled plus oil MDGS may increase early post-mortem release of free calcium due to increased 18:2 and PUFA concentration in the SR membrane, which could result in increased beef tenderness at 2 d postmortem when compared to cattle fed corn.

Keywords: calcium flux, distillers grains, fatty acids
EFFECT OF HIGH OXYGEN PARTIAL PRESSURE ON 4-HYDROXY-2-NONENAL INDUCED MYOGLOBIN OXIDATION, OXIDATION-REDUCTION POTENTIAL, AND MYOGLOBIN UNFOLDING

F. Kiyimba 1,*, M. N. Nair 2, G. Mafi 1, D. VanOverbeke 1, R. Ranjith 1
1Animal Science, Oklahoma State University, Stillwater, 2Animal Science, Colorado State University, Fort Collins, United States
frank.kiyimba@okstate.edu

Objectives: High oxygen modified atmosphere packaging (MAP) is often employed by the meat industry to enhance the appearance of fresh meat. 4-hydroxy-2-nonenal (HNE) is an alpha-, beta-unsaturated aldehyde derived from the oxidation of ll6–polyunsaturated fatty acids. Previous research has examined the effect of HNE on oxymyoglobin oxidation at atmospheric oxygen partial pressure (20%). However, limited knowledge is currently available on the effects of HNE on myoglobin redox stability under high oxygen conditions. Therefore, the objective of this study was to examine the effect of high partial pressure of oxygen on HNE induced myoglobin oxidation.

Materials and Methods: Oxymyglobin (0.15 mM; pH 5.6) prepared via hydrosulfite-mediated reduction was mixed with HNE (1.05 mM; dissolved in water), whereas controls received an equal volume of water. Following mixing, both samples were assigned to either high oxygen partial pressure (78%) or atmospheric oxygen partial pressure packaging. The samples were incubated either in a coffin-style display case maintained at 2 ± 1 °C (under continuous lighting) for 0, 2 or 6 days, or in an incubator for 0, 1, 2, or 3 h at 25°C. Metmyoglobin formation, oxidation-reduction potential, and myoglobin unfolding were evaluated on each of the storage time points. The experiments were replicated three times (n = 3) and the data were analyzed using the Mixed Procedure of SAS.

Results: Myoglobin oxidation, oxidation-reduction potential, and protein unfolding properties were not different (P > 0.05) between treatments on time 0 for samples incubated at 4 and 25°C. On days 2 and 6, the high oxygen partial pressure treatment resulted in increased metmyoglobin formation and protein unfolding (P < 0.05) than the atmospheric oxygen partial pressure samples. Moreover, atmospheric oxygen partial pressure treatment had greater oxidation-reduction potential than high oxygen partial pressure treatment. At 25 °C, high oxygen partial pressure treatments exhibited greater myoglobin oxidation from 1 to 3 h of incubation (P < 0.05) than atmospheric conditions.

Conclusion: The results suggest that high oxygen partial pressure accelerated HNE induced oxidation irrespective of temperature. Further research using molecular protein biomarkers may provide an understanding of the underlying mechanistic steps involved in the interaction of HNE with the myoglobin at higher oxygen partial pressure.

Keywords: HNE, Myoglobin oxidation, oxygen partial pressure, protein unfolding
Objectives: Berkshire pigs produce meat that is darker and redder in color and contains a greater abundance of intramuscular fat compared to some commercial crossbred pigs. This phenotypic superiority may be attributed to a mutation that occurs in the AMP-activated protein kinase (AMPK). This mutation arises from a valine to isoleucine substitution in the γ3 subunit which is thought to dysregulate the function of AMPK. Because the Berkshire breed carries this mutation with high frequency, the objective of this experiment was to characterize the effects of the AMPK γ3V199I mutation on carcass traits, meat quality, and postmortem metabolism in Berkshire pigs.

Materials and Methods: Homozygous mutant Berkshires (BERK-II, n = 9 consisting of 5 gilts and 4 barrows), heterozygous Berkshires (BERK-VI, n = 10, consisting of 5 gilts and 5 barrows), homozygous wild-type Berkshires (BERK-VV, n = 5, consisting of 2 gilts and 3 barrows) and commercial crossbred pigs (CROSS-VV, n = 7, consisting of 3 gilts and 4 barrows) were harvested under commercial processing conditions at the Ohio State University Meat Science Laboratory. Longissimus thoracis et lumborum muscle samples were collected from the right side of the carcasses at 0, 0.5, 1, 2, 4, and 24 hr postmortem and frozen in liquid nitrogen. At 24 hr postmortem, the left side of the carcasses were ribbed between the 10th and 11th rib where meat quality characteristics were evaluated (backfat thickness, loineye area, percent fat-free lean, and CIELAB color (L*, a*, and b*)). The carcass data were analyzed with two separate mixed models in JMP. First, the three AMPK genotypes were analyzed among Berkshire pigs. The model included the main effects of AMPK genotype, sex, and their two-way interaction. The second model compared the BERK-VV animals to the CROSS-VV to evaluate breed differences of the same AMPK genotype. This model included the main effects of breed, sex, and their two-way interaction. In both models, differences between LS means were evaluated using a student’s t-test and considered significant at P ≤ 0.05.

Results: In the first evaluation, there was no difference in live weight between Berkshire AMPK genotypes for sex (P = 0.29) or genotype (P = 0.79) groups. Barrows exhibited increased backfat thickness and decreased fat-free lean (%) (P = 0.03) compared to gilts. However, no carcass or meat quality differences were detected between AMPK genotypes. In the second analysis, there was no difference in live weight between the BERK-VV and CROSS-VV groups for sex (P = 0.81) or genotype (P = 0.63). However, the BERK-VV pigs exhibited increased backfat (P = 0.009), decreased lightness (L*; P = 0.034), and increased redness (a*; P = 0.018) compared to the CROSS-VV pigs.

Conclusion: The data suggest that the AMPK γ3V199I mutation does not affect carcass traits or meat quality within the Berkshire breed. However, previous data from our lab indicated differences in postmortem glycolysis and pH decline between the BERK-II and BERK-VI populations. These data also suggest that the BERK-VV animals produce pork with superior color compared to the CROSS-VV animals. Future analysis of pH decline and biochemical metabolites will occur to assess the rate and extent of postmortem glycolysis.

Keywords: AMPK, Berkshire, pork quality
Muscle and Lipid Biology and Biochemistry

157- A β3-ADRENERGIC AGONIST INCREASES GLUCOSE METABOLISM IN BOVINE MUSCLE INCUBATED IN VITRO
J. Jobe 1, 2, J. Hwang 1, S. B. Smith 1
1Texas A&M University, College Staion, United States
jobe8@tamu.edu

Objectives: The objective of this study was to determine the extent to which a β3-adrenergic agonist influences the ability of insulin to regulate metabolism in bovine longissimus muscle.

Materials and Methods: Four Angus or Angus-cross steers were used in this study. One steer was slaughtered once per week for 4 wk. Immediately after exsanguination, the M. longissimus lumborum (LL) muscle, stretching from approximately the 9th to 11th rib was removed from each carcass for muscle tissue samples. LL muscles were transported to the laboratory in Krebs-Hensleit buffer (KHB) (pH 7.4), containing 5 mM glucose, warmed to 37°C. Once at the laboratory, muscle strips were cut from the LL using sterile scalpels and forceps. Flasks were set up in a shaking water bath. Each flask contained 3 mL of KHB, 5 mM glucose, and held a single muscle strip. Flasks were capped with rubber stoppers containing a hanging center well. A piece of folded filter paper, saturated with 2 N NaOH to react with CO2. After a 90 min incubation period, muscle strips were removed from each flask, and 0.5 mL of 2 N H2SO4 was injected to stop metabolic reactions. Muscle strips were placed in 15-mL screwcap test tubes and mixed with 0.5 mL of water and 3 mL of 75% ethanol, to dilute [U-14C]glucose and produce a glycogen pellet. Pellets were added to scintillation vials, along with 1 mL distilled H2O, and 10 mL scintillation cocktail. Recovery of radioabeled glucose carbon was measured using a scintillation counter.

The original flask media was subjected to an additional 60 min incubation period. CO2 was trapped as H2CO3 in NaOH-soaked filter paper. Filter paper was placed in scintillation vials, along with 1 mL distilled H2O and 10 mL scintillation cocktail. Recovery of radioabeled glucose was measured as dpm using a scintillation counter.

Media was placed in separate 15 mL screwcap test tubes and Lactate Assay Kits will be purchased from Eton Bioscience (Eton Bioscience, Inc., San Diego, CA). Media from flasks was neutralized between pH 7.4 and 8. Media samples were placed in 96-well plates, using a BioTek Epoch plate reader to measure absorbancy at 490 nm.

Data were analyzed as a two-factor design, with insulin concentration and treatment as main effects.

Results: There were no insulin x treatment interactions for CO2 (P = 0.40), or lactate (P = 0.51). The insulin x treatment interaction for glycogen tended to be significant (P = 0.10); insulin increased glycogen synthesis in the absence of the β3-AA. There were significant treatment main effects for glycogen (P = 0.05), CO2 (P = 0.009), and lactate (P = 0.03) production. The β3-AA depressed glycogen synthesis from to 3.6 to 1.5 nmol/(100 mg per 90 min), but increased CO2 from 193 to 401 nmol/(100 mg per 90 min) and increased lactate production from 637 to 895 nmol/(100 mg per 90 min), which is consistent with the effects of β- AA.

Conclusion: The insensitivity of bovine muscle to insulin in vitro is consistent with overall insulin resistance observed in feedlot cattle. The results of this study provide strong evidence for a β3-adrenergic receptor in bovine muscle. Additionally, the strong effect of the β3-AA on CO2 and lactate production suggests that the use of a β3-AA in feedlot cattle could attenuate insulin resistance.

Keywords: Bovine, Metabolism, Muscle
PROTEOLYSIS AND TENDERIZATION IN ANGUS, BRAHMAN AND BRANGUS IS RELATED TO PH DECLINE AND CALPAIN-1 AUTOLYSIS

P. Ramos¹, J. Scheffler¹, M. Elzo¹, C. Carr¹, T. Scheffler¹
¹Animal Sciences, UNIVERSITY OF FLORIDA, Gainesville, United States
jmscheff@ufl.edu

Objectives: Early postmortem muscle pH decline influences protease activation and therefore tenderization. Brahman often shows slower proteolysis and less extended tenderization. The objective of this study was to determine pH decline, calpain-1 autolysis and protein degradation from Angus, Brahman and Brangus beef aged to 14d.

Materials and Methods: Steers used in this study were part of a long-term genetic study involving Angus, Brahman, and Angus-Brahman crossbreeding. Three genetic groups were used: Angus (A; 0.8-1), Brahman (B; 0.8-1) and Brangus (A 0.625; B 0.375). Steers (n = 6 per breed group) were harvested and the pH decline was assessed in the Longissimus lumborum at 1, 3, 6, 9 and 24h postmortem. Longissimus lumborum muscle samples were collected at 1, 3, 6 and 24h and 7 and 14d postmortem. Western blotting was performed to evaluate calpain-1 autolysis and troponin-T degradation (TnT). Tenderization was assessed in aged steaks using Warner-Bratzler shear force (WBSF; 7 and 14d) and sensory analysis by a trained panel (14d). Data were analyzed using SAS and the model included the fixed effects of breed, time and their interaction. Time was considered a repeated measure (pH, calpain-1 and troponin-T). Means were compared using Tukey-test.

Results: Breed affected pH decline (P = 0.049). Brahman showed higher pH than Brangus, particularly within the first 6h postmortem. Rate of autolysis tended to be different between breeds (breed x time, P =0.06). At 24h postmortem, Brangus showed greater calpain-1 autolysis compared to Brahman. Similarly, breed influenced the rate of TnT degradation during the aging period (breed x time, P = 0.001). At 24h, Brahman had less TnT degradation compared to Brangus, but not Angus. However, after 7d aging, Brahman had less TnT degradation than Angus; and at 14d, Brahman showed less TnT degradation compared to both Angus and Brangus. No differences were found for WBSF-7d (P = 0.092) or WBSF-14d (P = 0.292) between breeds, but breed affected (P = 0.004) sensory tenderness.

Conclusion: Longissimus from Brahman exhibited slower rate of pH decline that coincided with slower tenderization, evidenced by reduced calpain-1 autolysis at 24h postmortem and less troponin-T degradation. Although breed did not affect WBSF, it decreased sensory tenderness, with Brahman beef considered slightly tough after 14d aging. The slower rate of acidification in Brahman indicates ATP levels are maintained longer; this may prolong calcium uptake by the sarcoplasmic reticulum and mitochondria, thereby delaying calpain activation and tenderization.

Keywords: acidification, aging, beef, degradation, tenderness
Objective: Mechanically separated pork (MSP) is an underused low value by-product that is produced by applying pressure to separate soft muscle tissue from bones. It demonstrates poor gelation properties despite similar chemical composition to hand deboned pork. The objectives of this study were to explore the physicochemical, biochemical, and gelation properties of MSP and the effect of freezing rate on quality of MSP during frozen storage.

Materials and Methods: The MSP was produced from pork picnic bones one day after slaughter using a ProTEN linear press (Marel, Iceland) and BAADER soft separator (Germany). The MSP (17.0% protein, 18.9% fat) was frozen in a blast freezer (in 25 kg waxed boxes) to -20 °C at three different rates: held at 4 °C for 4 hr before blast freezing (MSP-DL: MSP delay), blast frozen immediately (MSP-STD: MSP standard), or pre-chilled by a heat exchanger before packing and blast freezing (MSP-PC: MSP pre-chill). Meats were collected on 3 production days as replicates. For each replicate, 2 boxes of MSPs were sliced and stored at -18 °C. Boneless pork picnic (PP, 18.0% protein and 14.6% fat) from the same production day was coarsely ground, vacuum packed and stored at -30 °C. Lipid oxidation and protein solubility were determined. Samples were also prepared and imaged by transmission electron microscopy (TEM). Natural actomyosin (NAM) was extracted (20 mg/g) for SDS-PAGE and dynamic rheological profiles (heating cycle: 25 to 85 °C at 1 °C/min) following 1, 4, 7 months of frozen storage with complete set of data shown from rep 1. Data was analysed using a mixed model with storage time as a repeated measurement.

Results: After pre-chilling, the temperature of MSP-PC was ~1 °C, while MSP-DL or STD packed directly after deboning were at ~8 °C. TEM imaging revealed that PP tissue had well preserved sarcomere structure with closely packed actin-myoosin filaments bundles. But MSP showed randomly oriented, curved and twisted actin-myoosin filaments indicating high level of ultrastructural disruption. The percentage of soluble myofibrillar protein for PP was 53% of total protein, and significantly higher ($P < 0.05$) than that of MSP-DL, STD, and PC with 44, 46, 45% respectively at 1 month storage. Soluble myofibrillar protein significantly decreased ($P < 0.05$) for all samples during frozen storage (42, 33, 33 and 34%, respectively after 4 months).

The NAM electrophoresis profile showed that the intensity of the myosin heavy chain band from MSPs was only about 65% of that of PP following 4 to 7 months of frozen storage. Multiple additional bands from 130 to 150 kDa and new 9 kDa and 17 kDa bands were observed in NAM from MSPs indicating degradation. During rheological analysis, the slope of storage modulus ($G'$) of NAM from MSPs was much lower than that of PP after 58 °C, showing the lower elasticity of gel, and poorer development of a 3-D network. The MSP-PC had slightly lower lipid oxidation (~0.8 mg malondialdehyde (MDA)/kg meat) compared with MSP-DL and STD (~1.1 mg MDA/kg meat) during 1 to 7 months of storage period, with values remaining quite stable during storage.

Conclusion: The results showed that gelation ability of MSPs was decreased by the mechanical separation process, not only because of the decrease in extractable myofibrillar protein, but also the degradation of myosin heavy chain. The initial freezing rate didn’t play a major role in gelation behaviour.

Keywords: Actomyosin, Mechanically deboned pork, Rheology, SDS-PAGE, Transmission electron microscopy
Objectives: The rising consumer preference for bacon as a center-of-the-plate item is associated with an increased demand for its food service applications. Maintaining flavor stability is critical where freezing without any oxygen barrier and a high variability in fat content and unsaturation of pork bellies can influence lipid oxidation and limit product shelf-life. Interest in natural cure ingredients is largely due to rising consumer demand for processed meats with clean label solutions. Rosemary and green tea extracts are naturally sourced antioxidants that could mitigate product quality issues while providing consumer-friendly labels. This research evaluated the effect of adding rosemary and green tea extracts on the keeping quality and shelf life of bacon using natural cure or conventional cure when stored in food service style packaging.

Materials and Methods: Pork bellies were manufactured into bacon under commercial conditions according to industry standards at the Michigan State University Meat Laboratory. Bellies were injected with a base formulation of 1.5% salt, 0.8% sugar, and water. The treatments include: (i) Conventional Cure (phosphates; sodium nitrite; sodium erythorbate; Control), (ii) Conventional Cure + 0.1% Herbalox® (Rosemary Extract; CCR), (iii) Natural Cure (half the sodium nitrite content of the Control from pre-converted vegetable juice powder, PVJP; 500 ppm ascorbic acid from cherry powder; NC) + 0.1% Herbalox® (Rosemary Extract; NCR), and (iv) Natural Cure (half the sodium nitrite content of the Control from PVJP; 200 ppm ascorbic acid from cherry powder; NC) + 0.2% Duralox® (Rosemary/Green Tea Extracts blend; NCRT). After smoking (94.3-98.6% yield) and chilling, sliced bacon slabs were packaged to simulate food service conditions (oxygen-permeable polyvinyl lined boxes layered on wax-cored lined paper, frozen at -20 °C) and stored for 45 or 90 days in the dark. Visual evaluation, lipid oxidation (hexanal, pentanal, heptanal) and descriptive sensory analysis were determined at the end of the respective storage times.

Results: Lipid oxidation, measured as secondary oxidation products, increased in all treatments as storage time progressed. However, the addition of rosemary extract in conventionally cured bacon samples (CCR) improved oxidative stability as evidenced by lower concentrations of secondary oxidation markers after 45 and 90 days of frozen storage than the Control. Results of secondary oxidation products in naturally cured bacon samples (NCR, NCRT) have shown their comparable oxidative stability with the Control following 90 days of storage. Saltiness, Musty and Caramelized aromas and flavors assessed by a trained sensory panel were highest (P < 0.05) in CCR while Brown/Grilled Meat, Smoky, Fatty, Herbal, Sweet and Aftertaste descriptors were similar (P > 0.05) among all treatments following 90 days of frozen storage. Visual evaluation results showed all treatments to be acceptable across all storage periods.

Conclusion: Addition of rosemary and green tea extracts can enhance the shelf-life of bacon throughout 90 days of frozen storage and help maintain their keeping quality during food service packaging conditions. It provides the meat industry with a highly effective alternative to replace synthetic preservatives so processors can meet consumer demand for clean label products without compromising product shelf-life and quality.

Keywords: Bacon, Clean label, Food service, Green tea, Rosemary
**Objectives:** Myoglobin is the primary sarcoplasmic protein responsible for beef color. However, hemoglobin and cytochrome c also contribute to a lesser extent. The redox form of myoglobin can influence beef color. For example, the presence of predominant oxymyoglobin form can impart bright red color while deoxymyoglobin can give dark-red color. The oxidation of deoxy- and oxymyoglobin can result in brown metmyoglobin. Previous research has noted that oxidation processes in meat can accelerate protein and lipid oxidation. However, limited studies have compared oxidation properties of all three proteins that can contribute to beef color. Therefore, the goal of this study was to determine hemoglobin, myoglobin, and cytochrome c oxidation in-vitro.

**Materials and Methods:** Equine myoglobin, bovine hemoglobin, and bovine cytochrome c (0.15 mM) were reduced separately by sodium hydrosulfite. Following reduction, all three proteins were passed through PD-10 desalting columns to remove residual hydrosulfite. The concentration of myoglobin, hemoglobin, and cytochrome c was confirmed using absorbance at 525 nm. Oxyhemoglobin, oxymyoglobin, and reduced cytochrome c were incubated at 4 and 25 °C, and the oxidation properties of proteins were recorded on d 0, 1, 2, 3, 4, and 5 at 4 °C, while reading was taken 12 h interval for 96 h at 25 °C. Samples were scanned using a UV-Vis spectrophotometer at specific incubation times from 400 to 700 nm using a Shimadzu spectrophotometer. Since all three proteins differ in their oxidation-reduction peaks, the ratio of oxidation to reduction was calculated to compare oxidation. The experiment was replicated three times and the data were analyzed using the Mixed Procedure of SAS.

**Results:** At both temperatures, there were differences ($P < 0.05$) in oxidation properties between hemoglobin, myoglobin, and cytochrome c. Myoglobin had greater oxidation, followed by hemoglobin and cytochrome c (myoglobin > hemoglobin > cytochrome c; $P < 0.05$). Cytochrome c was very stable to oxidation compared with other two proteins.

**Conclusion:** The results suggest that redox stability of myoglobin, hemoglobin, and cytochrome c are different. Future research determining the inter-relationship between protein oxidation will help to understand beef discoloration.

**Keywords:** beef color, Cytochrome C, Hemoglobin, Myoglobin, Oxidation
Objectives: The goal of this study was to evaluate the impact of four packaging types and two retail lighting systems on objective measures of microbial growth and muscle color of beef Longissimus lumborum steaks.

Materials and Methods: Beef strip loins (n=8), USDA Choice, were collected and fabricated (7d postmortem) into seventeen 1.27-cm thick steaks. Steaks (n=16) were assigned into 4 packaging treatments: high oxygen MAP (80% O₂, 20% CO₂) (HIOX), overwrapped packages in a motherbag flushed with carbon monoxide (0.4% CO, 30% CO₂, 69.6% N₂) (CO), vacuum rollstock (VAC), and traditional overwrap (OW), which were held in vacuum packaging, then placed onto foam trays and sealed with polyvinyl chloride film immediately before display. Microbial sampling occurred for each treatment at 7d (packaging), 20d (before display), and 23d (post display) postmortem. Each package type was sorted into 3 lighting treatments: darkness (DARK) (put in a box and held in cold storage), or a refrigerated open multi-deck retail display case with either light emitting diode (LED) or fluorescent (FL) lighting for 72h. Instrumental color (L*, a*, b*) was measured, and chroma calculated, at 0h and 72h of display using a Hunter Colorimeter. Aerobic Plate Counts (APC) and Psychrotrophic Plate Counts (PPC) were evaluated at packaging day, 0h and 72h retail display. Bacterial load was determined by swabbing a 50 cm² area of the steak. Serial dilutions were plated, in duplicate, onto APC petrifilm for mesophilic incubation, and standard methods agar plates for psychrotrophic incubation. Bacterial counts were reported as log_{10} CFU/50 cm². Microbial data were analyzed using the GLM procedure of SAS 9.4, and color analysis performed using the GLM procedure with repeated measures to account for beginning and end of retail display. Statistical significance was determined at P ≤ 0.05.

Results: There were no interactions between lighting and packaging type for APC or PPC (P > 0.05). Mean APC differed by sampling time, from 0.77 log_{10} CFU/50cm² on packaging day to 3.79 log_{10} CFU/50cm² at the end of retail display (P < 0.0001) across all packaging types. At the end of display, mean APC from OW were greater than HIOX packages, 3.83 and 3.05 log_{10} CFU/50cm² respectively (P < 0.05). Lighting did not impact APC counts at the end of display across any packaging type (P = 0.84). Lighting across all packaging types did not significantly (P = 0.07) impact PPC. Psychrotrophic means differed among VAC, CO, OW and HIOX (P < 0.05) ranging from 5.52 to 6.87 log_{10} CFU/50cm², with HIOX and CO being the only two packaging types that were not different (P > 0.05.) At the end of display, across all packaging types, L* values differed (P < 0.05) between FL display (34.20) and DARK (36.69) packages. Calculated chroma, a* and b* did not vary (P > 0.05) between lighting treatments across package types at the end of retail display.

Conclusion: This study provides evidence that packaging type has more of an effect on bacteria than lighting conditions, and variability in the lighting conditions does not have an impact on calculated chroma, b* or a* values, but does affect brightness (L*). Overall, OW packages had greater APC and PPC. These results imply packaging type may be used as a way to improve shelf life via control of spoilage bacteria. Moreover, this study indicates lighting systems may be used interchangeably when considering growth of spoilage organisms.

Keywords: Beef, Color, Lighting, Packaging, Spoilage
Undergraduate Research Competition

163- Efficiency of Environmentally Isolated Bacteriophages Against the ‘Big Six’ and O157:H7 STECs in Ground Beef
E. L. Shebs 1,*, E. S. Torres 1, Y. Yeh-Parker 1, A. S. De Mello 1
1Department of Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, United States
amilton@cabnr.unr.edu

Objectives: Phages targeting E. coli O157:H7 are approved by the FSIS (directive 7120.1) for application on beef trim. This study was conducted to evaluate the efficiency of seven environmentally isolated phages against “Big Six” and O157:H7 strains in vitro and in ground beef.

Materials and Methods: Seven phages (MS1-157:H7, MS1-145, MS1-121, MS1-111, MS1-103, MS1-45, and MS1-26) targeting individual non-O157:H7 and O157:H7 STECs were isolated from raw sewage using ATCC strains recovered from outbreaks. Phages were purified and amplified to 10^8-10^9 PFU/ml. Individual killing efficiency was determined by plating each strain with and without its respective phage on LB agar. For ground beef, forty (n=40) 100 g samples of 80% lean trim were randomly assigned to 8 treatments including I-6-25 (Inoculated, 6 h of lysing time at 25°C), I-30-25 (Inoculated, 30 min of lysing time at 25°C), I-6-7 (Inoculated, 6 h of lysing time at 7°C), I-30-7 (Inoculated, 30 min of lysing time at 7°C), P-6-25 (Phage treated, 6 h of lysing time at 25°C), P-30-25 (Phage treated, 30 min of lysing time at 25°C), P-6-7 (Phage treated, 6 h of lysing time at 7°C), and P-30-7 (Phage treated, 30 min of lysing time at 7°C). After bacterial attachment of 30 min at 7°C, samples were treated with the phage cocktail solution at 10^9 PFU/ml. Phages were allowed to lyse bacteria for 30 min and 6 h at 7°C and 25°C. Subsequently, trim was ground and an aliquot of 25 g was stomached in BPW. The pellet was resuspended in BPW and serially diluted before plating on LB agar. Plates were incubated at 37°C for 24 h and colonies were enumerated. Data were analyzed using SAS as a completely randomized design and contrasts between phage treatment, lysing time, and temperature were evaluated.

Results: Killing efficiency of each phage isolated for specific strain was: 99.9%, 99.6%, 96.6%, 99.4%, 98.6%, 96.2%, and 99.9% for O157:H7, O145, O121, O111, O103, O45, and O26, respectively. Inoculated meat samples yielded approximately 4 log CFU/g in the ground product. Overall, a significant decrease of approximately 1.5 log was observed when comparing I-6-25 (4.28 log CFU/g) versus P-6-7 (2.80 log CFU/g) treatments. The contrast analysis revealed significant effects of phage application (P = 0.003) and temperature (P = 0.03). Within same temperature conditions, phage applications led to a significant 0.70 log reduction when lysing time was 30 min at 7°C and 0.77 log reduction when lysing time was 30 min at 25°C.

Conclusion: Application of a cocktail of phages targeting all adulterant strains on trim prior to grinding decreased STEC populations in ground beef. Metabolic rates of STECs and phages are affected by temperature where bacteria replication and phage lysing activity seem to increase proportionally with temperature. Overall, phages that target adulterant STECs including O157:H7 and “Big Six” strains, could provide an additional barrier against these pathogens in robust food safety systems.

Keywords: Bacteriophage, Beef, Big Six, E. coli, O157:H7
**164- SUPPLEMENTING BEEF STEERS WITH RUMINAL BYPASS ARGININE IMPROVES OXIDATIVE STABILITY OF AGED BEEF LOINS**

J. Tuell 1,*, H.-W. Kim 1, J. Guedes 1, J.-K. Seo 1, J. Schoonmaker 2, Y. H. B. Kim 1

1Meat Science and Muscle Biology Lab., Department of Animal Sciences, 2Department of Animal Sciences, Purdue University, West Lafayette, United States
tuell@purdue.edu

**Objectives:** Supplementation of ruminal bypass amino acids, such as arginine (Arg) and lysine (Lys), in beef cattle rations has been suggested to improve growth performance, feed efficiency and carcass composition. However, its impacts on meat quality characteristics have not been fully investigated. Previous studies have indicated supplementation of Arg may have an antioxidative effect on skeletal muscle. Postmortem aging is widely practiced in the beef industry to improve eating quality characteristics, but extended aging period has been shown to adversely affect oxidative stability, resulting in rapid discoloration and/or off-flavor development. Hence, this study was conducted to evaluate the effects of ruminal bypass Arg and Lys supplementation on meat quality and oxidative stability of beef loins with 14 and 28 d aging times.

**Materials and Methods:** Forty cattle fed four different diets for 180 d (control - basal diet; additional supplementation of metabolizable treatments (10 g/day) of each Arg, Lys, and ArgLys, respectively) were harvested. At 1 d postmortem, paired loins (M. Longissimus lumborum) were separated from each carcass, vacuum-packaged, and assigned to 14 and 28 d aging at 2 °C. After each assigned aging time, three beef steaks (2-cm thick) were made from each loin to measure meat quality attributes, such as pH, water-holding capacity (WHC) and Warner-Bratzler shear force. One steak was overwrap-packaged with polyvinylchloride film and displayed for 7 d at 2 °C under fluorescent light (1,450 lx) for instrumental and trained panel color evaluation. Oxidative stability was determined by measuring total reducing activity (TRA) and 2-thiobarbituric acid reactive substances (TBARS). The experimental design was a split-plot design with diet effect as whole plot and aging time as sub-plot. All data were analyzed using the PROC MIXED procedure of SAS version 9.4, and means were separated by least significant differences (P<0.05).

**Results:** No significant diet impacts on pH, WHC, and shear force were found (P>0.05). An increase in aging duration decreased shear force (P<0.05) and improved WHC of steaks as indicated by decreased cooking loss and display weight loss (P<0.05). Extended aging for 28 d, however, negatively impacted color and oxidative stability of beef steaks over the display period, where steaks from 28 d had greater surface discoloration and TBARS values compared to steaks from 14 d (P<0.05). However, Arg supplementation improved color stability of steaks during display regardless of aging period, shown by higher a* values, lower hue angle values and least sensory discoloration scores compared to other treatments (P<0.05). Steaks from ArgLys had higher TRA and lower TBARS values compared to steaks from Arg and Lys (P<0.05), but no differences between Arg and Lys were found (P>0.05). This could indicate a synergistic ArgLys combination impact on oxidative stability of beef samples.

**Conclusion:** The results of this study suggest that Arg supplementation could be an effective strategy to improve color stability of beef loins with extended aging. Further studies to elucidate the mechanism through which Arg mitigates the negative effects of extended aging storage on color and oxidative stabilities are highly warranted. In particular, the influence of Arg supplementation on the synthesis of nitric oxide (NO) via the L-arginine-NO pathway in aged beef loins is under investigation.

**Keywords:** aging, arginine, beef quality, lysine, oxidative stability
Undergraduate Research Competition

165- COMPARISON OF NEUTRALIZING BUFFER AND SAMPLING SPONGES ON HOT BEEF CARCASSES
J. Marsh 1,*, S. Mijares 1, B. R. Bullard 1, M. Weinroth 1, I. Geornaras 1, R. J. Delmore 1, K. E. Belk 1
1Colorado State University, Fort Collins, United States
jmmarsh@rams.colostate.edu

Objectives: This study was conducted to investigate the capabilities of two sampling sponge types in neutralizing samples and recovering bacterial cells obtained from beef carcasses following antimicrobial interventions. A cellulose sponge hydrated with Dey-Engley (D/E) and a polyurethane sponge hydrated with High Capacity (Hi-Cap) neutralizing buffer were compared.

Materials and Methods: Samples were evaluated on pH and bacterial cell recovery to determine neutralizing capabilities. Sampling was conducted over two days at a commercial beef slaughter plant. For pH analysis, (n = 30) D/E and Hi-Cap sponges were used to swab beef carcasses following antimicrobial acid treatment. The pH samples were obtained by swabbing on the allotted area for a total of 15 samples per sponge type, per day. Cell recovery was tested with over two days (n = 70, 35 of each sample type a day). Both pH and cell recovery samples were obtained by swabbing a 100 cm² area (10 x 10 cm). To standardize samples, 10 horizontal passes were taken then the sponge was flipped and 10 vertical passes were made. Samples were transported in an insulated cooler to the Colorado State University Food Safety Laboratory for immediate plating and analysis. The pH samples were homogenized using a Stomacher Paddle Blender. A pH probe was then used to obtain pH readings for the neutralized solution in each sample. Prior to microbiological analysis, Butterfield’s diluent was added to the sampling bags for a total of 20 ml diluent, including each of the tested buffers, and subsequently homogenized. Samples were then serially diluted 10-fold in 0.1% buffered peptone water and surface plated on tryptic soy agar (TSA) to enumerate total plate counts. Plates were incubated for 72 hours at 25°C, then counted. All plate counts were log converted and differences were assessed using the PROC Mixed Procedures in SAS version 9.4; difference were reported at \( P < 0.05 \).

Results: D/E neutralized samples to an average pH of 6.83 and Hi-Cap to an average of 5.90. Though D/E did have a statistically \( P < 0.05 \) higher neutralizing ability, both sponge types had a neutralizing effect raising the pH above 5.4-5.8, the average pH of beef carcasses. Furthermore, there was no difference \( (P = 0.34) \) in cell recovery between D/E and Hi-Cap buffered sponges.

Conclusion: Both D/E and Hi-Cap had similar cell recovery and successful neutralization pH above the average pH of a beef carcass. Either sponge is appropriate for plant testing of acidic antimicrobial interventions and subsequent transport to an off-site laboratory for further processing and analysis.

Keywords: beef carcass, D/E, Hi-Cap, validation
Objectives: The objective of this study was to compare the use of dual-energy x-ray absorptiometry (DEXA) and chemical analyses for the prediction of carcass lean yield. This was done in order to decrease the total amount of time utilized in analyzing carcass composition. The scanning of carcasses on a DEXA takes approximately 2 minutes per carcass compared to chemical analyses that can take days of work in the lab.

Materials and Methods: Suffolk wethers (n=44) were put on a high-energy diet and then finished to 59kg or d185 post weaning. At this point the wethers were slaughtered. Hot carcass weight was obtained and the hot carcass was scanned using DEXA to measure carcass fat and lean composition. At 24h postmortem, the carcasses were scanned again using the DEXA. Carcass data were collected and the right side of the carcass was fabricated manually to obtain total lean and fat mass, and then ground. Samples of the ground lamb were taken and a total lipid analysis was performed.

Results: A linear regression model was used then to compare carcass fat composition estimated from the total lipid analysis versus total carcass fat estimated by the DEXA. Each method was compared on a percent total lipid basis and a total lipid mass basis. Values received from both hot and cold scans of the carcasses were used. Regression analyses found that DEXA scans on the cold carcass for total fat mass had the best agreement with the total lipid mass estimated from total lipid analyses ($r^2=0.75$). When compared on a percentage basis, the percent fat estimated from DEXA compared to percentage of total lipid from chemical analyses had lower agreement ($r^2=0.49$). The DEXA scans from the hot carcasses did not yield results with as high of agreement with chemical analyses for total lipid mass basis ($r^2=0.47$) or a total percent fat basis ($r^2=0.13$.) Stepwise regression was used to develop prediction equations for carcass fat mass or lean meat yield estimated from DEXA scans or chemical analyses using hot carcass weight, carcass traits or muscle weights. For DEXA fat mass, an equation including the variables for hot carcass weight (HCWg) and ribeye area (REAc) were deemed most significant ($r^2=0.7673$, $r^2=0.7915$). The equation for DEXA percent fat mass used the same variables, HCWg and REAc but with less agreement than DEXA fat mass ($r^2=0.2310$, $r^2=0.3079$).

Conclusion: The data collected from the DEXA scans on the cold carcasses for total fat mass can be utilized in predicting total carcass composition. These findings can help in time management and overall human resources when conducting a large-scale animal carcass study.

Keywords: Composition, DEXA, Lamb
Objectives: Meat color has a substantial influential in purchasing decisions as consumers associate color with freshness. Discoloration of beef at retail has resulted in a loss of about $1 billion annually. Many additives, including antioxidants, have been utilized in products such as ground beef to increase their shelf life. Therefore, the overall goal of this study was to evaluate the effects of pomegranate rind extract on ground beef color stability and lipid oxidation.

Materials and Methods: The pomegranate rind extract was prepared by mixing dried ground rind powder in boiling water. The mixture was centrifuged to extract the pomegranate rind extract. Course ground beef (80% lean) was mixed with 0, 1, and 1.5% of pomegranate rind extract. The pomegranate rind extract was included into the sample, reground and then formed into a 100 g patty, utilizing the adjust-a-burger patty press. Patties from each treatment were then assigned to four different packaging types: PVC, Hi-Ox, CO, and vacuum. Patties packaged in CO and vacuum bags were stored in dark storage 5 d prior to display. The vacuum patties were removed form the bags, packaged in PVC and allowed 1 h to bloom prior to evaluation. Patties packaged in PVC, CO and vacuum were on display for 3 d while patties packaged in Hi-Ox were left on display for 5 d. Patties were evaluated each day by trained color panelists (6 members). Patties were evaluated for display color and surface discoloration. Thiobarbituric acid values were used to indicate lipid oxidation. Lipid oxidation was measured on the control patties on d 0 and then evaluated on all treatments at the end of their assigned display time. The experiments were replicated six times (n = 6). The data were analyzed using the Mixed Procedure of SAS, and considered significant at a level of $P < 0.05$.

Results: Display color was brighter cherry red for samples with pomegranate solution compared to the control samples ($P < 0.05$). Similarly, surface discoloration decreased for patties with the addition of pomegranate solution compared to the controls ($P < 0.05$). Patties packaged in Hi-Ox maintained color stability longer ($P < 0.05$) than patties packaged in PVC, CO, and vacuum. There were decreases ($P < 0.05$) in the lipid oxidation levels of the patties enhanced with 1.0 and 1.5% pomegranate solution compared to the control patties, for all packaging types. Samples enhanced with 1.5% pomegranate solution in vacuum and PVC packaging had 50% less lipid oxidation after display than the control. Similarly, samples with 1.5% pomegranate solution packaged in CO had 65% and Hi-Ox had 75% less lipid oxidation compared to the controls.

Conclusion: The use of pomegranate as an antioxidant in ground beef patties had major positive impacts on both color stability and overall freshness (lipid oxidation). The addition of pomegranate will increase the shelf life of ground beef and ultimately decrease the economical loss that results from discoloration of meat.

Keywords: Antioxidants, ground beef, pomegranate