Objectives: Captive bolt stunning is a standard and effective method of rendering cattle unconscious for slaughter. An unrecoverable penetrating stun is ensured by correct placement of the captive bolt stunner. The purpose of this study was to determine the effect of different bolt lengths on sustained brain damage and presence of specified risk materials (SRM) in blood of Holstein and non-Holstein cattle. It was hypothesized that brain damage and SRM dispersion would not differ based on bolt length or breed type.

Materials and Methods: The study was designed as a randomized unbalanced block design. Test day served as a block and the experimental unit was animal. Data were analyzed with SAS (SAS Inc., Cary, NC) using a paired t-test. Each collection was assigned one of three lengths; control (CON; 15.2 cm), medium (MED; 16.5 cm), or long (LON; 17.8 cm). All animals sampled were less than 30 months of age. Blood was randomly sampled immediately following the start of exsanguination from 33 animals per treatment, with an equal split of Holstein and non-Holstein breed type. Blood samples were sent to IEH-Warren Analytical Laboratory (IEH, Greeley, CO) where the Colorado State University fluorescent enzyme-linked immunosorbent assay (F-ELISA) was conducted for detection of glial proteins. For brain damage assessment, 292 heads were randomly sampled across three collection periods, with an equal split between non-Holstein and Holstein breed type. Heads were collected, chilled, and brought to the Necropsy Laboratory (Colorado State University, Veterinary Teaching Hospital, Fort Collins, CO) for splitting and damage analysis. Skulls were split with a bandsaw through the median plane of the captive bolt penetration tract. Brains were photographed and assessed for damage to the frontal lobe (FL), parietal lobe (PL), occipital lobe (OL), olfactory bulb (OB), hypothalamus (HYP), corpus callosum (CC), fornix (FOR), and the thalamus (THAL). Brain structure disruption was determined with a graphic overlay along the median plane; each structure was recorded as either damaged or non-damaged. Additionally, evidence of double knocking (DK) or skull plate fragments in the brain tissue (BC) were recorded.

Results: The Colorado State University F-ELISA found that 97% of the CON blood samples were negative, 94% of the MED blood samples were negative, and 100% of the LON blood samples were negative. The level of brain damage did not differ between breed type for any structure measured ($P = 0.607$). The amount of brain damage was statistically different between CON and LON for FL, OL, and THAL ($P = 0.004, P = 0.025$, and $P = 0.002$, respectively). The FL, OL, CC, and THAL differed between MED and LON ($P = 0.022, P = 0.043, P = 0.043$, and $P = 0.002$, respectively). Comparisons between CON and MED showed that only FL damage differed ($P = 0.033$). The percentage of DK and BC in brain tissue did not differ based on treatment or breed type ($P = 0.399, P = 0.311$). The brainstem was not disrupted for any of the treatments.

Conclusion: There was sufficient evidence that differing bolt lengths affect the amount of brain damage to the skull and brain structures. Additionally, there was minimal evidence to support that changes in SRM dispersal occurred due to bolt length. Further work is required to determine how bolt length could affect SRM transmission in older animals.

Keywords: Beef, Brain Damage, Captive Bolt
**Objectives:** Maintaining optimal litter conditions is essential to minimizing disease in broiler houses. Ultimately, flux in welfare standards will alter management practices. Antibiotic-free (AF) broilers raise concerns regarding flock health, because of the limitations regarding disease treatment. In the study, we evaluated flock performance parameters and yield of AF broilers as it relates to stocking density.

**Materials and Methods:** Commercially available rapidly growing broilers were raised at a high stocking density (697 cm$^2$ per bird) and a low stocking density (836 cm$^2$ per bird). Four flocks, each with 19,740 straight run broilers, were housed in an industry standard facility located at California State University, Fresno. The broiler production barn was subdivided into four equal-sized pens, which run the length of the barn. These pens served as alternating stocking density treatments during each flock. Body weight, litter moisture, percent mortality, and coccidiosis in litter were measured every week for six weeks, while feed conversion was measured at the end of the flock. Body weight, litter moisture, percent mortality, and coccidiosis counts in litter were analyzed using Student’s t-tests. At the processing facility carcass weights were obtained and yield was calculated. Yield data was analyzed using the ANOVA procedure of SAS.

**Results:** No significant differences were detected in body weight between stocking densities or in weekly percent mortality. As expected, litter moisture was greatest in high-stocking densities in weeks 1, 2, 3, 4, and 6. Yet, there were no statistical differences in coccidiosis counts in the litter. Feed conversion efficiency was less (p < 0.05) in birds reared at the high- than low-stocking density (1.66 ± 0.06 vs 1.81 ± 0.04), but birds reared at the low-stocking density tended to have greater (p = 0.07) carcass yields than those reared at the high-stocking density (68 vs 66%).

**Conclusion:** The results confirm that lower stocking densities equate to a lower litter moisture, which reduces the potential of disease spread. However, no differences in coccidiosis counts in the litter. Interestingly, the increase in feed conversion present in low stocking densities represents an increase in feed costs.

**Keywords:** Antibiotic free, broilers, stocking density
Objectives: Fed cattle slaughter facilities often have cattle delivered to the facility with the intention to hold the cattle overnight. As required by USDA FSIS, cattle that are held overnight at the harvest facility are required to have lying space in pens. The current guideline in industry is 1.86 m$^2$ per animal at an estimated live weight of 544.31 kg. However, cattle weights have increased over time while the space to lie down has remained constant.

Materials and Methods: This field observation was designed to determine if 1.86 m$^2$ is enough space for a Bos taurus steer or heifer, with no Bos indicus or Holstein influence, to lie down, with an assumed live weight of 544.31 kg. This field observation evaluated space requirements for cattle that varied in average weight from 521.63 kg to 717.13 kg. It was hypothesized that the pen space requirements would not differ based on average live weight of the cattle. This field observation utilized a random incomplete design over a five day period. Pens were selected for adequate lighting, distance away unloading docks, and distance away from entrance to the harvest facility. The pen dimensions were measured before daily production began and average weights of the cattle were obtained from the harvest facility scale house. Once the selected overnight pens were filled with a mixture of British and continental bred cattle, cameras were placed on the catwalk to capture video and photographs of the cattle lying down between 0200 h and 0400 h each day. Video and photographs were taken with a remote control so that the cattle were not disturbed by individuals on the catwalk.

Results: In this field observation, 1,584 cattle were observed and it was determined that as the weight of the cattle increased the space allocation needed to be increased to have enough space for all cattle to lie down. The space allocations estimated were a 544.31 kg animal required 1.86 m$^2$ per animal, a 589.67 kg animal required 1.95 m$^2$ per animal, a 635.03 kg animal required 2.04 m$^2$ per animal, and a 680.39 kg animal required 2.14 m$^2$ per animal. Space requirements did differ as average weight of the cattle increased.

Conclusion: Further observations are needed to fully determine the effect that average live weight has on pen space requirements of cattle at slaughter facilities.

Keywords: Cattle, Lairage, Pen Capacity, Slaughter, Weight
4: IDENTIFYING CONSUMER PREFERENCE FOR BEEF RAISED WITH DIFFERENT PRODUCTION SYSTEMS

M. J. Webb 1*, D. L. Pendell 2, A. A. Harty 1, R. R. Salverson 1, C. A. Rotz 3, K. R. Underwood 1, K. C. Olson 1, A. D. Blair 1
1Animal Science, South Dakota State University, Brookings, 2Department of Agricultural Economics, Kansas State University, Manhattan, 3Agricultural Research Service, United States Department of Agriculture, University Park, United States

Objectives: Objectives of this study were to 1) evaluate meat quality characteristics, and 2) identify consumer palatability and label preferences for beef raised in different production systems.

Materials and Methods: Beef striploins (n=72) were collected from cattle raised using four different production systems: 1) no technology (NA; no antibiotics or growth promotants); 2) non-hormone treated (NHTC; NA plus therapeutic antibiotics); 3) implant (IMPL; NHTC plus implants); and 4) implant plus a beta-agonist (IMBA; IMPL plus ractopamine-HCl). Cattle were slaughtered at a commercial facility and marbling scores were obtained prior to striploin collection. During fabrication the anterior end of striploins were squared off and the slice removed was frozen for analysis of percent crude fat. Steaks (2.54 cm) were fabricated from striploins, vacuum packaged, aged 14 d, and designated for WBSF and consumer panel analysis. To determine the influence of production information on consumer preferences, untrained consumer panelists (n=105) were recruited from the surrounding areas of St Paul, MN for three consecutive panels: Blind (Panel 1; samples provided with no production information); Disclosed without Meat (Panel 2; only the production description provided); and Disclosed with Meat (Panel 3; samples and production description provided). Panelists were fed repeated samples of each of the four treatments and were instructed to identify their most and least preferred sample. The relative preference of each sample was analyzed to determine percent share of preference (SOP) per treatment for comparison using a percentage scale.

Results: The marbling score and ether extractable fat percentage of NA and NHTC did not differ (P > 0.05) but were greater (P ≤ 0.05) than IMPL and IMBA, which were similar (P > 0.05). Steaks from NA and NHTC treatments did not differ (P > 0.05) for WBSF though were more tender (P ≤ 0.05) than IMPL and IMBA, which were not different (P > 0.05). Percent cook loss was reduced (P ≤ 0.05) for NHTC versus IMPL and IMBA which were not different (P > 0.05). Further, a reduction (P ≤ 0.05) in percent cook loss was detected for NA compared to IMPL but did not differ (P > 0.05) from IMBA. In Panel 1, when no information was provided, NA was most preferred (P ≤ 0.05) and IMBA was least preferred (P ≤ 0.05) while NHTC and IMPL were intermediate and similar (P > 0.05). When asked to select the most and least preferred production descriptions in Panel 2, all SOP differed (P ≤ 0.05) with NA most preferred followed by NHTC, IMPL, and IMBA. All samples differed (P ≤ 0.05) when information was disclosed and meat was consumed in Panel 3 but NHTC was most preferred followed by NA, IMPL and IMBA. Pairwise comparisons between Panel 1 and 3 revealed that disclosing production information resulted in a lift (P ≤ 0.05) in SOP for NA and NHTC and a decline (P ≤ 0.05) for IMPL and IMBA.

Conclusion: Treatments utilizing growth promoting implants with and without beta-agonist increased WBSF, which may be detectable by untrained consumer panelists as natural treatments captured greater SOP in both blind and disclosed panels. When production information was disclosed and palatability was assessed, NHTC was the most preferred followed by NA, indicating that when information is provided consumers are accepting of meat from an animal that may have been treated with an antibiotic in the event of illness.

Keywords: beef, consumer, meat quality, shares of preference, technology
Consumer Topics

5: EFFECTS OF MARBLING TEXTURE ON CONSUMER PALATABILITY RATINGS OF BEEF STRIP LOIN STEAKS

K. Vierck 1,*, J. Gonzalez 1, T. Houser 1, E. Boyle 1, T. O’Quinn 1
1Animal Sciences and Industry, Kansas State University, Manhattan, United States

Objectives: To determine the effect of marbling texture (fine, medium, and coarse) on consumer sensory and visual ratings of beef strip loin steaks of three USDA quality grades.

Materials and Methods: Beef strip loins (n = 117; 39/grade) were selected to equally represent three marbling texture categories (fine, medium, and coarse) within three quality grades [Top Choice (Modest00 – Moderate100 marbling), Low Choice, and Select] based on visual appraisal of marbling texture. For selection, 75% of the marbling in the ribeye had to meet the USDA-AMS-LS-SB-02 marbling texture reference for the texture category. Prior to analysis, each strip loin was aged for 21 d and fabricated into 2.5 cm steaks, vacuum packaged, and frozen at -20°C. Each steak was cooked to 71°C on clamshell grills for consumer panel analysis. After cooking, each steak was cut into 2.5×1×1 cm cubes and two cubes were served to each panelist. Untrained consumer panelists (n = 104) evaluated nine samples, one from each treatment, for tenderness, juiciness, flavor liking, and overall liking on 100 mm line scale, and rated each trait as acceptable or unacceptable. Each consumer was also asked to visually rate the appearance of a steak from each treatment using a digital survey on an electronic tablet. Pictures of each steak were edited to 2.5×6.4 cm dimensions of the center of the steak to remove any external fat or muscling differences. Consumers rated their preferences for the appearance of each steak as well as how likely they were to purchase the steak pictured on line scales with verbal anchors at each end and midpoints. Data were analyzed as a completely randomized design with a 3×3 factorial arrangement with marbling texture, quality grade, and their interaction as fixed effects.

Results: There were no marbling texture × quality grade interactions (P > 0.05) for all traits evaluated. Additionally, marbling texture had no effect (P > 0.05) on palatability traits, as consumers rated all texture groups (fine, medium, and coarse) similar for tenderness, juiciness, and flavor. When asked if samples were acceptable for each trait, consumers rated a similar (P > 0.05) percentage of samples from each texture treatment as acceptable. Likewise, marbling texture did not affect (P > 0.05) the percentage of strip loin steaks rated as unsatisfactory, everyday, better than everyday, or premium quality. When asked to visually rate the steaks, consumers rated all marbling texture treatments similar (P > 0.05) for the desirability of the appearance of the steak as well as for purchase intent. Low Choice steaks were rated higher (P < 0.05) than Select steaks for tenderness, flavor liking, and overall liking. Consumers rated Low Choice steaks similar (P > 0.05) to Top Choice steaks for all palatability traits evaluated. When asked to rate samples as acceptable or unacceptable for tenderness, juiciness, and overall liking, there were no differences (P > 0.05) between quality grade treatments; however, a lower percentage of Select samples were rated as acceptable (P < 0.05) for flavor than either Top or Low Choice steaks.

Conclusion: These results indicate marbling texture does not impact consumer ratings of tenderness, juiciness, flavor liking or overall liking of beef strip loin steaks from the evaluated quality grades. Moreover, consumers did not exhibit a visual preference for steaks of differing marbling texture or marbling levels.

Keywords: Beef, Consumer, Marbling texture, Palatability, Quality grade
6: FREEZING TEMPERATURE AND THAWING METHODS IN SENSORY QUALITY OF BEEF STRIP LOIN STEAKS

C. L. Gomes¹, T. J. Silva², G. B. Silva², F. M. Ferreira², R. J. Valderrama², S. B. Pflanzer²,⁎, H. M. Bolini¹
¹Department of Food and Nutrition, ²Department of Food Technology, University of Campinas, Campinas, Brazil

Objectives: Freezing is one of the most important methods to preserve meat and meat products. However, it may affect some of the quality traits, depending on freezing rate, frozen storage conditions and thawing methods. For this reason, the objective of this study was to investigate the descriptive sensory profile (QDA) of beef strip loin steaks stored at -10°C or -20°C and thawed after 1 month by refrigerator temperature (4°C/~24 hours), ambient temperature (20°C/~4 hours) or microwave, comparing to non-frozen samples.

Materials and Methods: Each strip loin (n = 3) was cut in 2.5cm thick steaks and destined for one of the seven treatments. Steaks were weighed before freezing and after thawing, as well after cooking to calculate weight losses. After thawing (considered 4°C) or for fresh meat, the samples were cooked in an electric oven until reaching 71°C. Eleven trained assessors were selected and evaluated the samples in monadic form and according to a complete balanced block design. The intensity of sixteen descriptors chosen during the training sessions was evaluated using a linear scale of 9 cm (unstructured), anchored at the extremities by weak, little or none to the left and strong and much to the right. The data were analyzed using the GLM procedure and the means were compared by the Tukey test with the aid of the SAS software.

Results: Microwave thawed samples, independent of freezing temperature storage, showed the highest values of thawing loss (P<0.05; ~11%), while thawing at 4°C or 20°C had similar losses (P>0.05; ~2%). There was no difference in weight losses during cooking between either for temperature of storage or thawing method (P>0.05; ~21%). For the appearance attributes (internal brown color, degree of doneness, apparent juiciness and crumbling) only the apparent juiciness was affected (P<0.05) by the treatments, where samples thawed by microwave presented a drier appearance (2.70 and 3.13 at -10°C and -20°C, respectively). There were no differences (P>0.05) between treatments for aroma attributes (roast beef, cooked beef, metallic and rancid). For flavor attributes (roast beef, cooked beef, metallic and rancid) the assessors found less rancidity (P<0.05; 0.16) for samples frozen at -20°C and thawed in refrigeration (4°C), when compared to the other treatments (~0.65). The assessors verified a difference (P<0.05) between the treatments for fibrosity, one of the texture attributes (initial tenderness, initial juiciness, chewiness and fibrosity), where the non-frozen sample had the highest values (4.45), while the samples frozen at -10°C and thawed at ambient temperature and refrigeration showed the lowest values (2.81 and 3.12, respectively).

Conclusion: The results indicate that the frozen storage temperature, as well the methods used in the thawing can affect some sensory attributes, however they would not be able to compromise the overall quality of beef.

Keywords: Beef flavor, frozen storage, Microwave cooking, Quantitative Descriptive Analysis, sensory analysis
**Consumer Topics**

7: THE FLAVOR AND TEXTURE ATTRIBUTES OF GROUND BEEF

H. Laird 1*, R. K. Miller 1, C. R. Kerth 1, E. Chambers 2

1Animal Science, Texas A&M University, College Station, 2Food, Nutrition, Dietetics and Health, Kansas State University, Manhattan, United States

**Objectives:** Ground beef comprises between 50 and 60% of the beef consumed in the United States and is manufactured from beef trimmings from either commodity, grain-fed beef or lean trimmings from older, mature cows and bulls. Examining the impact of final grind, forming, fat/source content, patty thickness, cooking, and holding on ground beef patty descriptive flavor and texture attributes and aromatic volatile chemical compounds provides a method for understanding factors that drive ground beef flavor and texture differences.

**Materials and Methods:** Ground beef from grain-fed and mature cattle were selected at two different fat levels. The ground beef was coarse ground and then segmented into 3 final grinds treatments (bowl chopped, 0.95 cm grind, 0.64 cm grind) and then formed into patties by hand or by machine at either 0.64 cm or 2.54 cm thickness. The patties were cooked using a dry heat cooking method (a flat solid) or a steam cooking method (clam-shell grill) to an internal cook temperature endpoint of 70°C. Hold time was also evaluated at 0, 1, and 3 hours in a steam table. Two trained descriptive sensory attribute panels from Texas A&M University (n = 288) and Kansas State University (n = 218) evaluated patties for flavor and texture descriptive attributes.

**Results:** Patty thickness impacted flavor attributes with thicker patties having more (P < 0.05) beef identity, overall sweet, brown/roasted, fat like flavor attributes; umami, salty, bitter and sweet basic tastes; and particle size, and initial juiciness texture attributes than thinner patties. Ground beef patties with higher fat content, 20 versus 5% lipid, had higher (P < 0.05) levels of beef identity flavor attribute and umami basic taste and ground beef patties manufactured using grain-fed beef versus mature beef had more (P < 0.05) beef identity, and brown/roasted flavor attributes. Grind size impacted patty flavor and texture attributes but not to as great of an extent as patty thickness and meat source. Ground beef patties that were ground to either 0.64 cm or 0.95 cm final grind size had more (P < 0.05) fat-like flavor attributes. The bowl chopped and final grind size of 0.95 cm were (P < 0.05) more springy and harder. Cooking impacted flavor and texture attributes. Patties cooked on the George Foreman grill had more (P < 0.05) oxidized flavors, which were magnified when 0.64 cm thick patties were cooked, than patties cooked on a flat grill. Hand formed patties had more (P < 0.05) beef identity, brown/roasted, bloody serumy, fat-like flavor attributes and umami and sweet basic tastes than machine formed patties. Holding patties in a steam table for up to 3 h mainly affected oxidative flavors, but had minimal effects on flavor and texture attributes across all treatments (P < 0.05). In a partial least square regression bi-plot, thick ground beef patties from commercial grain-fed sources with 20% fat and bowl chopped or fine ground were more closely clustered with the positive flavor attributes including beef identity, brown/roasted, buttery, and fat-like flavor attributes; initial juiciness; and sweet, salty and umami basic tastes than the other treatments.

**Conclusion:** Selecting specific ground beef patty manufacturing and cooking methods can be used to improve the flavor traits of patties and should be used to maximize consumer acceptance.

**Keywords:** Beef flavor, ground beef, Sensory
Consumer Topics

8: CONSUMER PERCEPTION OF BEEF PALATABILITY ALTERED BY BRAND RECOGNITION

H. Voegele 1,*, O. S. Ron 1, A. J. Garmyn 1, T. G. O'Quinn 2, J. C. Brooks 1, M. F. Miller 1

1Animal & Food Science - Meat Science, Texas Tech University, Lubbock, 2Animal Sciences and Industry, Kansas State University, Manhattan, United States

Objectives: The objective of this study was to evaluate the differences of beef palatability trait scores when consumers were made aware of brands representing various production systems.

Materials and Methods: Strip loins were selected to represent a Grain-Fed Natural (Natural), Certified Angus Beef (CAB), Local Grass Fed (LGF), USDA Select (Select), and USDA Certified Organic (Organic) production systems. After 21 d of storage, strip loins were cut into 2.5 cm thick steaks and stored at -20°C until analysis. Thawed samples were cooked on a belt grill to a medium degree of doneness (71°C) and evaluated by consumers (n = 120) for tenderness, juiciness, flavor liking, and overall liking. Each trait was rated on a 100 mm verbally anchored line scale. Each panelist was served two, 1 cm x 1 cm, pieces per sample. Panelists were served steaks representing the five production system treatments without any knowledge of their identity (blind). Next, panelists were served five samples but were read a short description of each production system treatment before each sample (known). Differences between the results from the blind group responses and the known responses were calculated for the various palatability traits. Data were analyzed using the GLIMMIX procedure of SAS (version 9.4) with treatment as the fixed effect and panel as the random effect ($\alpha$ = 0.05).

Results: During the blind panels, differences were found among production system treatments for tenderness, flavor and overall liking ($P < 0.01$). Natural and CAB samples were scored higher than all other treatments for tenderness, flavor and overall liking ($P < 0.05$). Organic was scored less for tenderness than both Select and LGF (46.25 vs. 52.83 and 52.52, respectively; $P < 0.05$), while both LGF and Organic were rated higher than Select for flavor and overall liking ($P < 0.05$). After treatment descriptions were read to the panelists, panelists increased their scores for all palatability traits for Natural and CAB, with each treatment scoring higher than any other production system. Additionally, LGF and Select rated higher in tenderness, flavor and overall liking than Organic ($P < 0.05$). When consumers were aware of the production system of the beef they were consuming, scores for tenderness and juiciness did not fluctuate from the blind panels ($P = 0.39$ and $P = 0.23$, respectively). However, CAB was rated 11.9 and 11.3 units greater ($P < 0.01$) for flavor liking and overall liking, respectively, when the treatments were known. Likewise, consumers scored LGF 6.0 and 7.0 units greater ($P < 0.05$) for flavor liking and overall liking, respectively. Moreover, scores for Natural overall liking increased ($P < 0.05$) by 5.8 units when consumers knew the treatments.

Conclusion: These results indicate brand recognition may have significant impact on consumer perception of beef palatability. Most notably, Natural and CAB rated the highest among treatments during the blind panel, and benefited the most from treatment disclosure. Overall, verbal descriptions tended to increase consumer acceptability, particularly for flavor and overall liking. The Select treatment group was the only treatment with negative impacts.

Keywords: beef, brands, consumer preference, sensory analysis
Consumer Topics

9: EFFECTS OF LABELING AND CONSUMER HEALTH TRENDS ON PREFERRED GROUND BEEF COLOR CHARACTERISTICS, FAT CONTENT, AND PALATABILITY IN SIMULATED RETAIL DISPLAY.

F. W. Pohlman II 1,*, F. W. Pohlman1, N. B. Anthony2, F. L. Yang1
1Animal Science, 2Poultry Science, University of Arkansas, Fayetteville, United States

Objectives: Nutritional concerns and attempts to limit fat in the diet over the past decades have impacted the protein market, decreasing red meat consumption as well as prompting the advent of lean and extra lean ground beef. Such lean blends of ground beef may suffer in palatability, however, resulting in less satisfied consumers turning to other protein sources. While consumers are demanding lean ground beef, fatter blends may be more palatable. This study seeks to bridge the gap between perceived health and palatability by evaluating preferred fat content and instrumental color characteristics between labeled and unlabeled packages of ground beef in simulated retail display and comparing this data to preferred palatability characteristics in taste sampling.

Materials and Methods: Participants were asked to identify the relative importance of characteristics commonly used in purchasing ground beef (color, label, fat content, company, and price) and select a preferred package of ground beef from labeled and unlabeled sections consisting of 4%, 10%, 20%, and 27% fat content. Instrumental color data (CIE L*, a*, b*, hue, and chroma) and their main drivers (oxymyoglobin proportion) were also collected. Participants then completed a blind taste sampling of ground beef with variable fat contents as previously described and were asked to evaluate samples on juiciness, bind, beef flavor, off flavor, and overall impression. Data were evaluated through the Mixed Model procedure of SAS, version 9.4.

Results: Color, fat, and price were found to be significantly more important ($P < 0.05$) than label, which was significantly more important than company for package preference. No trend towards fatter or leaner blends was found between labeled and unlabeled selections, with 62.64% of participants selecting identical packages between the two sections. The 20% fat treatment was the most frequently selected product in both labeled and unlabeled sections, however the two leaner blends combined garnered more preferred selections than the two fatter blends (56.67% vs. 43.33%, respectively). Instrumental color data found significant trends towards a lighter product and increasing L* value with increasing fat content as well as decreasing oxymyoglobin proportion with increasing fat content. No significant differences were found between the blends for any trait in sensory taste evaluation.

Conclusion: These results suggest that while consumers have specific preferences when purchasing ground beef that can be replicated without a label using visual inspection alone, they are less discerning between cooked ground beef of different fat contents. This may explain the continued demand for lean ground beef, as consumers in this study found no significant differences in palatability between ground beef differing in fat content from 4% to 27%. Continued research comparing preferred fat content of ground beef in retail display with preferred fat content for palatability is encouraged to expand upon the findings of this study.

Keywords: color, consumer, fat content, ground beef, sensory
Consumer Topics

10: FRESH BEEF STEAK PURCHASING MOTIVATION IS AFFECTED BY DEMOGRAPHICS AND BEEF PREFERENCES OF CONSUMERS

L. W. Lucherk 1,*, T. G. O’Quinn 2, J. F. Legako 1, J. C. Brooks 1, M. F. Miller 1
1Department of Animal and Food Sciences, Texas Tech University, Lubbock, 2Department of Animal Sciences and Industry, Kansas State University, Manhattan, United States

Objectives: A consumer study was conducted to measure the impact of demographics and beef preferences on purchasing motivators of fresh beef steaks.

Materials and Methods: Panelists were recruited in conjunction with a beef consumer panel in four cities in the United States. Consumers (n = 480; 120/city) were evenly distributed in Lubbock, Texas; Manhattan, Kansas; San Francisco, California; and Gainesville, Florida. Consumers were asked to evaluate the importance of purchasing motivators when buying fresh beef steaks on a 10-cm, verbally anchored line scale. The motivators included animal welfare (WEL); antibiotic use in the animal (ANT); brand of product (BRAND); color; diet of animal (corn, grass, vegetarian fed) (DIET); eating satisfaction claims (ex: guaranteed tender) (CLAIM); familiarity with cut (CUT); growth hormone use in the animal (HORM); local; natural or organic claims (NATORG); nutrient content (NUTR); packaging type (PACK); price; size, weight and thickness; and USDA grade (marbling). Demographics obtained included gender, household size, marital status, age, ethnic origin, annual household income and education level. Beef preferences identified included weekly beef consumption, most important palatability trait when eating beef, degree of doneness (DOD) preferred when eating beef, and meat product preferred for flavor. 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 α = 0.05.

Results: Traits including WEL, ANT, BRAND, color, DIET, HORM, local, NATORG, NUTR, PACK and price were of more (P < 0.05) importance to females than males. Married consumers put greater (P < 0.05) purchasing emphasis on ANT, DIET, CLAIM, CUT, HORM and local than single consumers. Californians had higher (P < 0.05) average ratings for WEL, ANT, color, DIET, HORM, local and NATORG, than all other states. Household sizes of >5 people placed more (P < 0.05) importance on BRAND, DIET, and NUTR than consumers from smaller households. Consumers with 1-2 people per household placed less (P < 0.05) importance on ANT and local purchasing motivators compared to larger households. Antibiotics, DIET, HORM, local and NATORG were more (P < 0.05) important to consumers over 60 years old than to consumers under 29 years old. Caucasian/White consumers placed less (P < 0.05) importance on BRAND, HORM, local and NUTR than other ethnicities. As household income increased, consumers were more (P < 0.05) concerned about ANT and HORM. Heavy beef eaters (4 or more times/week) were less (P < 0.05) influenced by WEL, ANT, color, DIET, HORM, local, NATORG, and NUTR, but more (P < 0.05) influenced by USDA grade than light beef eaters (0-3 times/week). In general, as DOD preference increased from rare to well-done, importance of WEL, ANT, DIET, HORM, local, NATORG, and NUTR increased. Consumers who preferred flavor of beef viewed WEL, ANT, HORM, NATORG, NUTR, PACK, and price less (P < 0.05) concerning than consumers who prefer flavor of other meat proteins.

Conclusion: Gender, marital status, geographic location, household size, age, ethnic origin, annual household income, weekly beef consumption, DOD preference, and flavor preference affected many beef purchasing motivators of consumers. It is important to consider the demographics and preferences of consumers when marketing fresh beef steaks.

Keywords: beef, consumer, demographics, motivation, purchasing
11: TRENDS IN CONSUMER DEMOGRAPHICS AND WILLINGNESS TO PAY FOR PERCEIVED EATING QUALITY LEVELS OF LAMB

C. Shannon 1,*, A. Garmyn 1, M. Miller 1

1Texas Tech University, Lubbock, United States

Objectives: The relationships between the demographics of lamb consumers and their willingness-to-pay (WTP) for four eating quality (EQ) levels were anylazed for this study.

Materials and Methods: The study was conducted in five areas across the United States: Ohio (OH), Florida (FL), Texas (TX), Colorado (CO), and California (CA). A demographic questionnaire was distributed to consumers (n=1,440) during a lamb tasting session to acquire the following variables: gender (GEN), age, education (EDU), occupation (OCC), heritage (HER), income (INC), number of adults in household (NOA), number of children (NOC), consumption (CON), preferred degree of doneness (DOD). Additionally, the state in which the consumer participated was used as a factor that could affect WTP. At the conclusion of a tasting session, which consisted of 7 lamb samples representing various muscles, genders, breeds, weights, fatness levels, and pH levels, consumers were asked how much they would pay for each of the four quality levels [Unsatisfactory (UNS), Good, Better than everyday (BTE), and Premium (PREM)], using line scales anchored from $0/lb. to $40/lb. WTP of each EQ level was analyzed using the GLIMMIX procedure of SAS with each of the aforementioned demographic traits considered as fixed effects. Differences in LS means were determined (α=0.05).

Results: Heritage and consumption affected (P<0.05) WTP at each EQ level. African Americans were willing to pay more than White and Native Americans for UNS, Good, and PREM EQ levels. Additionally, consumers who said they consumed lamb daily were willing to pay the least for all EQ levels. Furthermore, state impacted (P<0.05) WTP for BTE and PREM EQ levels, with OH and CO consumers willing to pay less than consumers from TX. Additionally, there was an influence of OCC on WTP (P<0.05) of UNS and Good EQ levels; consumers who worked in sales and service or as a laborer were willing to pay more than homemakers at both EQ levels. Income only had an influence (P<0.05) on WTP of PREM EQ, with consumers whose household income was $50-75,000 USD paying the least. Preferred DOD impacted (P<0.05) WTP for all perceived quality levels except for BTE; consumers who preferred blue rare would pay the least for UNS and Good quality lamb, but would pay more per pound than consumers whose preferred DOD was rare for PREM quality lamb. Gender only influenced (P<0.05) WTP for UNS lamb with males willing to pay more than females. Moreover, age influenced (P<0.05) WTP; consumers under 20 would pay more for BTE quality lamb than people over the age of 40, and would pay more than people over the age 50 for PREM quality lamb. NOC influenced (P<0.05) WTP, with consumers who had more than 6 children willing to pay the least for UNS. Lastly, number of NOA and EDU had no impact (P>0.05) on consumer WTP, regardless of EQ level.

Conclusion: Based on these results, HER and CON had a significant impact on WTP for each EQ level, but NOA and EDU had no influence on WTP at any EQ level. Preferred DOD influenced the WTP of 3 out 4 EQ levels. State where the test was conducted and increasing age only influenced the top two EQ levels, while OCC only had an impact only on the lower two EQ levels. Finally, gender and NOC played little role in WTP, as each trait only impacted WTP of UNS lamb. Likewise, income had little impact on WTP, although it did influence WTP of PREM quality lamb.

Keywords: consumer preference, lamb, willingness to pay
Consumer Topics

12: THE CONTRIBUTION OF TENDERNESS, JUICINESS, AND FLAVOR TO OVERALL CONSUMER BEEF EATING EXPERIENCE

L. N. Drey1,*, J. F. Legako2, J. C. Brooks2, M. F. Miller2, T. G. O'Quinn1

1Animal Sciences and Industry, Kansas State University, Manhattan, 2Animal and Food Sciences, Texas Tech University, Lubbock, United States

Objectives: To combine consumer palatability data from studies conducted within the past five years to evaluate the contribution of tenderness, juiciness, and flavor to overall consumer eating satisfaction.

Materials and Methods: Eleven consumer studies conducted within the last five years were used to determine a beef palatability model. Each study used the same 100 mm lines scales for consumer evaluation of steak tenderness, juiciness, flavor, and overall liking. Moreover, consumers rated each trait as either acceptable or unacceptable. Samples in all studies were cooked using similar dry-heat grilling procedures. Collectively, these studies resulted in more than 12,000 individual consumer observations. The raw data from all studies were compiled as a single dataset with the average sensory score for each palatability trait determined for each sample by averaging across the individual consumer ratings for the sample. The relative contribution of tenderness, juiciness, and flavor to consumer overall liking scores were determined by creating a multivariate regression model using sample means. The odds and relative risk of an unacceptable overall eating experience were determined based on the acceptability of the three individual sensory traits.

Results: The final beef palatability model determined was: Consumer overall liking = (0.42 × tenderness) + (0.07 × juiciness) + (0.48 × flavor). The model accounted for more than 99% of the variation ($R^2 > 0.99$) in consumer overall liking scores and indicates flavor contributes the most (49.4%), followed by tenderness (43.4%), and juiciness (7.4%). The interaction terms among the traits were not significant ($P > 0.05$) and therefore were excluded from the model. The odds of overall palatability failing when tenderness was acceptable were 1 in 10 (10%) but increased to 2.2 to 1 (69%) when tenderness was unacceptable. When flavor was acceptable, only 1 in 15 (6.7% chance) steaks failed for overall palatability, but this increased to 3.3 to 1 (76% chance) when flavor was unacceptable. For juiciness, 1 in every 9 steaks (11% chance) failed for overall palatability when juiciness was acceptable, however this increased to close to 2 out of every 3 (66% chance) when juiciness was unacceptable. The odds ratios for overall palatability failure were 20.8, 17.1, and 49.0 for tenderness, juiciness, and flavor, respectively, with the risk of overall palatability failing 7.2, 6.5, and 12.3 times more likely if tenderness, juiciness or flavor, respectively failed. If multiple palatability traits failed, the odds of overall palatability failure increased to 86% to 96%. With respect to USDA quality grade of longissimus lumborum steaks, the odds of palatability failure increased ($P < 0.05$) as quality grade decreased from Prime (8.6% failure rate), to Average and High Choice (13.2% failure rate) to Low Choice (16.9% failure rate) to Select (25.3% failure rate) and Standard (28.0% failure rate).

Conclusion: These results indicate the relative contribution of tenderness, juiciness, and flavor to overall beef palatability. They indicate that the failure of even a single palatability trait dramatically increases the likelihood of overall palatability failure, indicating that no single palatability trait is most important, as beef palatability is dependent upon the acceptance of all three traits: tenderness, juiciness and flavor.

Keywords: beef, flavor, juiciness, Palatability, tenderness
13: EVALUATION OF LAMB CARCASS QUALITY CHARACTERISTICS IN RELATION TO CONSUMER SENSORY SCORES

M. R. Phelps¹*, A. J. Garmyn¹, J. C. Brooks¹, M. F. Miller¹
¹Animal and Food Sciences, Texas Tech University, Lubbock, United States

**Objectives:** Flank streakings and confirmation drive lamb quality grading, but in beef, quality is based on marbling in the ribeye. However, little to no research has been conducted linking flank streaking to lamb eating quality. The objective of this study was to determine the relationship between carcass fat indicator traits, intramuscular fat percentage (IMF), and the palatability traits of tenderness (TEN), juiciness (JUIC), flavor liking (FLAV) and overall liking (OALL), as rated by U.S. consumers.

**Materials and Methods:** Carcasses (n=180; 60/treatment) were selected at a commercial lamb processor in Greeley, CO based on pork marbling standards (PMS) as low (PMS 1), intermediate (PMS 2) or high (PMS 3+), with marbling score and flank streaking (FS) being determined within seconds of carcass ribbing. Full lamb loins (IMPS 232; 1 × 1in) representing the 3 targeted marbling levels [LOW, Medium (MED), HIGH] were obtained, vacuum packaged, shipped to Texas Tech University, and stored under refrigeration (2–4°C) until fabrication. On d 21 postmortem, loins were removed from packaging, and marbling (MB) was assessed following a 10-minute bloom period. Loins were fabricated, leaving only the Longissimus dorsi, then manually sliced into 2.5 cm thick chops, vacuum packaged, and either frozen immediately or stored at 2°C until 42 d postmortem, then frozen. Untrained consumers (n=360) from Lubbock, TX; Hicksville, OH; Clemson, SC; Logan, UT; and Stillwater, OK rated TEN, JUIC, FLAV and OALL on 100-mm line scales. Data for fat measures (FS, 21d MB, and IMF) were analyzed as complete randomized design using the GLIMMIX procedure of SAS 9.4 with fixed effects of target marbling level. Treatment LS means were separated with the PDIFF option of SAS (α=0.05). Pearson correlation coefficients were determined using the CORR procedure of SAS.

**Results:** FS, MB, and IMF were all influenced (P<0.01) by target marbling level in a linear fashion. As expected, HIGH had the highest values (FS: Mt54, MB: Md59, and 6.2% IMF), MED were intermediate (FS:Sm71, MB: Sm56, and 4.4% IMF), and LOW had the lowest values (FS:Sl53, MB: Sl41, and 3.7% IMF). With flank streaking being commonly used to evaluate lamb quality, a strong positive correlation would be expected with marbling level and IMF. Within the eating quality traits, FLAV was most strongly correlated (r=0.93; P<0.01) to OALL, followed by JUIC (r=0.63) and tenderness (r=0.62). TEN and JUIC scores were also strongly related (r=0.75; P<0.01) to each other. There were strong relationships (P<0.01) between MB and IMF (r=0.70), as well as between FS with MB and IMF (r=0.60, 0.44, respectively). When examining the relationships between FS with the palatability traits, only JUIC had a correlation (r=0.07; P=0.01) with FS. MB was correlated (P<0.01) with TEN, JUIC, FLAV, and OALL, (r=0.09, 0.13, 0.09, and 0.09, respectively). However, IMF was only related (P<0.01) to TEN (r=0.08) and JUIC (r=0.09).

**Conclusion:** Increasing MB, more so than FS, was positively linked to increasing eating quality scores. Fortunately, FS and MB were strongly associated; however, neither FS nor MB had strong linear correlations with lamb eating quality. Also, tenderness, juiciness and flavor liking are major drivers for consumer sensory scores for overall liking, with flavor liking having the biggest impact on overall liking of lamb.

**Keywords:** consumer, correlation, lamb, marbling
**Objectives:** Although lamb is consumed in low volumes in the U.S., especially when compared to high lamb consumption countries such as Australia (AUS) and New Zealand (NZ), U.S. consumers have three main options when choosing lamb in the U.S.: domestic, imported from AUS, or imported from NZ. Based on previous research with beef, palatability differences in lamb are expected when comparing country origins and muscle types. The objective of this study was to evaluate the effects of country-of-origin and muscle type on palatability of lamb loin and leg chops as determined by U.S. consumers.

**Materials and Methods:** The U.S. lamb (n = 70 carcasses) was obtained from a commercial lamb processor in Colorado; full lamb loins (IMPS 232; 1 × 1) and paired lamb legs (IMPS 233A) were retained from those carcasses, vacuum packaged and shipped to Texas. Full lamb loins and lamb legs from AUS and NZ were procured from food distributors. Loins were fabricated to obtain only the *longissimus lumborum*, by removing tenderloins, bone, flank and all other secondary muscles. Legs were fabricated to obtain the *semimembranosus* with adductor. Loins and legs were trimmed of any visible external fat and connective tissue, manually fabricated into 2.5 cm thick chops, vacuum packaged, stored at 2°C, and frozen at 21 d postmortem. Untrained consumers (n = 360) from Lubbock, TX; State College, PA; Gainesville, FL; Fort Collins, CO; and Fresno, CA rated tenderness, juiciness, flavor liking and overall liking on 100 mm line scales. Data for sensory attributes were analyzed as a 2 × 3 factorial design using the GLIMMIX procedure SAS (Version 9.4; SAS Inst. Inc., Cary, NC) with fixed effects of country, muscle and their interaction. Location and consumer within testing night were included as random effects. Treatment least squares means were separated with the PDIFF option of SAS at a significance level of *P* < 0.05.

**Results:** The interaction between country and muscle was detected for tenderness, flavor, and overall liking (*P* < 0.05). U.S. loins were more tender (*P* < 0.05) than all other treatments, followed by AUS and NZ loins, which did not differ (*P* > 0.05). Next, U.S. legs were more tender than legs from AUS or NZ, which did not differ (*P* > 0.05). Consumers preferred the flavor of U.S. loins more (*P* < 0.05) than all other treatments. Next, U.S. legs and AUS loins were similarly liked more than NZ loins, but consumers liked the flavor of legs from NZ and AUS less than any other treatment. Overall liking followed the exact same trend as flavor liking. Both country and muscle impacted (*P* < 0.01) juiciness scores. U.S. loin chops were juicier than AUS or NZ loin chops, regardless of muscle, and consumers rated loin chops juicier than legs chops, regardless of country (*P* < 0.05).

**Conclusion:** Consumers found palatability differences in lamb between country origins and muscle types. U.S. consumers prefer domestically sourced lamb over AUS and NZ when comparing tenderness, juiciness, flavor and overall liking. Loin chops were preferred over leg chops for all palatability traits. It is recommended that U.S. consumers purchase U.S. lamb and lamb loin for a better eating experience.

**Keywords:** Australia, consumer, lamb, New Zealand
15: CONSUMER EVALUATION OF NINE DIFFERENT BEEF CUTS FROM THREE USDA QUALITY GRADES

L. N. Drey 1*, K. M. Nyquist 2, J. F. Legako 2, J. M. Gonzalez 1, T. A. Houser 1, E. A. Boyle 1, T. G. O'Quinn 1

1Animal Sciences and Industry, Kansas State University, Manhattan, 2Animal and Food Sciences, Texas Tech University, Lubbock, United States

Objectives: To determine consumer perceptions of nine cuts including strip steaks and eight Beef Innovation cuts of varying quality grades.

Materials and Methods: Beef strip loins (IMPS #180), inside rounds (IMPS #169), bottom rounds (IMPS #171), shoulder clods (IMPS #114), and chuck rolls (IMPS #116A) were selected from 3 USDA quality grades (Prime, Low Choice, Select; n = 10/quality grade). Sub-primals were vacuum packaged and aged 21d at 2 to 4°C. Sub-primals were fabricated into 2.54 cm steaks to represent eight Beef Innovation cuts (San Antonio, Western Griller, Delmonico, Flat Iron, Tucson, Denver, Ranch, and Shoulder Petite Tender steaks) as well as strip loin steaks. Steaks were cooked to 71°C on an electric clamshell grill (Cuisiart Griddler Deluxe, model GR-150, East Windsor, NJ) with temperatures monitored using thermocouples connected to a Doric Mini-trend Data logger 205 B-1-c OFT (Doric Scientific, San Diego, CA). Consumers (n = 210) were fed 9 samples representing differences in muscle and quality grade in a random order. Consumers evaluated steaks for juiciness, tenderness, flavor, and overall liking on continuous line scales. Additionally, consumers rated each trait either acceptable or unacceptable. Consumers also rated each sample as unsatisfactory, everyday, better than everyday or premium quality. Data were analyzed as a 9 × 3 factorial with a model that included the fixed effects of cut, grade, and their interaction and the random effect of panel and steak peak temperature as a covariate.

Results: There were no muscle × quality grade interactions for all traits evaluated (P > 0.05). The Delmonico, Flat Iron, and Denver steaks were rated the highest (P < 0.05) for juiciness while strip loin steaks were rated similar (P > 0.05) to Ranch steaks. The Delmonico and Flat Iron were rated more tender (P < 0.05) than Denver steaks, which were more tender (P < 0.05) than all other cuts. The strip loin was rated similar (P > 0.05) in tenderness to the Shoulder Petite Tender and Ranch steak. The Western Griller was the toughest (P < 0.05) when compared to all other muscles, except the Tucson steak. The Delmonico and Flat Iron steaks were rated the highest for flavor (P < 0.05). The San Antonio, Western Griller and Tucson had the lowest (P < 0.05) overall liking ratings while the Delmonico had the highest percentage (P < 0.05) of steaks rated acceptable for tenderness. The Delmonico had the highest percentage (P < 0.05) of steaks rated acceptable for overall liking. The Delmonico had the highest percentage (P < 0.05) of steaks rated as premium quality whereas the San Antonio, Western Griller and Tucson had the highest percentage (P < 0.05) of steaks rated as unsatisfactory. For all muscles, Prime was rated the highest (P < 0.05) for all traits evaluated and had the highest percentage (P < 0.05) of steaks rated acceptable for juiciness, tenderness, flavor and overall liking.

Conclusion: The Delmonico, Flat Iron, and Denver steaks had a better eating quality than strip steaks. This represents an opportunity for retailers and foodservice to market these more affordable cuts and still deliver a high level of eating satisfaction to customers. Moreover, the positive impact of increased quality grade was consistent across all cuts.

Keywords: beef, consumer, Innovation Cuts, palatability, Quality grade
Consumer Topics

16: GRILLING TEMPERATURE EFFECTS ON TENDERNESS, JUICINESS, AND FLAVOR OF RIBEYE, TOP LOIN AND TOP SIRLOIN STEAKS

K. Wall ¹, C. Kerth ¹, R. Miller ¹
¹Animal Science, Texas A&M University, College Station, TX, United States

Objectives: The objective of this study was to characterize the impact grilling temperature has on tenderness, juiciness and flavor of ribeye, top loin and top sirloin beef steaks.

Materials and Methods: Beef subprimals (n = 16 each; 48 total) were purchased from a local meat supplier. After aging 21 d post-processing, 2.54 cm thick steaks were hand cut and randomly assigned a grilling temperature treatment: 177°C, 205°C, or 232°C. Steaks were vacuum-packaged and frozen at -10°C until testing. Prior to testing, steaks were individually selected and thawed at 4°C 12-18 hours prior to analysis. Steaks were grilled to an internal temperature of 71°C on a commercial flat top grill set at 177°C, 205°C, or 232°C. Consumers (n = 80) were served nine samples representative of each treatment combination and prompted to rate their liking of overall, tenderness, juiciness, appearance, and flavor on a 9-point hedonic scale. The ends used to square off the sample were used to take color readings of the center of each cooked steak. Steaks selected for Warner-Bratzler Shear Force were held over night at 4°C before obtaining six 1.3 cm diameter cores from each steak. Samples from the steaks after cooking were quickly frozen in liquid nitrogen and stored at -80°C for GC/MS – Olfactory analysis. Results were analyzed as a 3x3 factorial random block design using analysis of variance. Date of consumer session and order were included as random effects in the consumer model. Weight of the sample was included as a covariate in the GC/MS model.

Results: No differences (P > 0.05) in consumer overall, tenderness, juiciness, appearance, and flavor liking were detected between steak type or grill temperature. The center color of ribeye steaks was redder (a*; P < 0.05) than top loin and top sirloin steaks. The ribeye steaks also had a greater (P < 0.05) hue angle than top sirloin steaks. Top loin steaks required 0.27 kg less peak shear force (P < 0.05) than ribeye and top sirloin steaks. Of the volatiles present during aroma analysis (n = 68), trimethyl-pyrazine (raw, musty, potato), 2-ethyl-5-methyl-pyrazine (coffee, nutty), 2-ethyl-6-methyl-pyrazine, 2,3-dimethyl pyrazine (meaty, musty, potato, cocoa), 3-butyl-2,5-dimethyl-pyrazine, and sulfur dioxide were greatest (P < 0.05) in total ion count when the grill surface was set to 177°C. 2,5-dimethyl pyrazine (a musty or potato aroma) was determined to have the greatest (P < 0.05) presence when the grill was set to 232°C and least at 177°C. 3-(methylthio)-propanal, known to have a cooked potato-like aroma, was least (P < 0.05) in ribeye steaks compared to top sirloin and strip loin steaks. Furthermore, 2,3-butanedione (buttery), 3-hydroxy-2-butanone (buttery, creamy), acetaldehyde (fresh, green), decanal (orange, citrus), dimethyl sulfide (asparagus, putrid), dodecanal (soapy, citrus), nonanal, sulfur dioxide, phenyl acetaldehyde (sweet, honey, rose), and thiobis-methane (sulfureous, tomato, creamy) were greatest (P < 0.05) for top sirloin cuts; whereas, 2,3-octanediene was greatest (P < 0.05) for ribeye steaks.

Conclusion: The tenderness and juiciness of beef steaks grilled at differing temperatures were not perceived to be different by consumers; however, grilling temperature impacts the time the steak is exposed to the grill and, thus, the volatile flavor aroma compounds of the final product.

Keywords: flavor, grill temperature, tenderness
Consumer Topics

17: CONSUMER SENSORY EVALUATION OF GRASS-FED, ANGUS, AND COMMODITY GROUND BEEF

F. Najar 1,*, E. Boyle 1, T. O’Quinn 1, R. Danler 1, T. Houser 1, J. Gonzalez 1, S. Stroda 1, L. Drey 1, K. Vierck 1, G. McCoy 1

1Animal Science and Industry, KANSAS STATE UNIVERSITY, Manhattan, United States

Objectives: Ground beef is one of the major sources of animal protein in the U.S., accounting for approximately 40% of beef consumption per capita. Several studies have looked at the flavor profile between grass-fed and grain-fed beef to identify if omega-3 fatty acids found in grass-fed ground beef play a key role in consumer flavor acceptability. Consumer sensory evaluation was conducted to evaluate consumer palatability ratings of grass-fed ground beef in comparison to Angus and commodity ground beef.

Materials and Methods: Grass-fed, Angus, and commodity 80/20 ground beef was obtained from local retail stores and a commercial meat processing facility. For each treatment 14 different production lots were used, and each lot contained 2.26 kg of ground beef. Ground beef patties were manually formed into 113 g patties using a template, crust frozen, vacuum packaged with 2 patties per package, and stored at -40°C for approximately 8 d. The remaining product was vacuum packaged and frozen at -40°C for consumer evaluation and moisture, fat, protein, and pH determination. Frozen ground beef patties were thawed for 24 h prior to consumer sensory analysis. Patties were cooked to 71°C initial internal temperature using a clamshell grill (Cuisinart, East Windsor, NJ) and held for approximately 5 min to allow a post-cook temperature rise to 74°C. Cooked ground beef patties were cut into 4 wedge-shaped pieces, and immediately served to panelists. A total of 98 consumers were recruited from Manhattan, KS. and adjacent areas and rated the samples using 100-point continuous line scales with anchors at both ends and the midpoint on electronic tablets. Patties were rated for tenderness, juiciness, flavor liking, texture liking, and overall liking, and each sample was rated as acceptable or unacceptable for each palatability trait.

Results: Moisture, fat, and protein content of commodity, grass-fed, and Angus ground beef used in this study were similar (P>0.05). Commodity ground beef had a pH that was higher (P<0.05) than Angus and grass-fed ground beef by 2.6% and 6.8%, respectively, which may have been contributed the result of lean finely textured beef as a component of this treatment. Consumers tended to rate grass-fed ground beef 4% and 6% lower (P=0.06) for flavor and texture liking, respectively than Angus and commodity ground beef. Angus and commodity ground beef were rated higher (P<0.01) for overall liking compared to grass-fed ground beef. Consumers found tenderness and juiciness similar (P>0.05) for all three types of ground beef. Overall, Angus ground beef was preferred (P<0.05) to grass-fed ground beef with an overall acceptability of 94.9% vs 82.5%, while commodity ground beef had a similar (P>0.05) overall acceptability to Angus and grass-fed ground beef. Consumers indicated no difference (P>0.05) for tenderness acceptability, juiciness acceptability, and texture acceptability among the three ground beef treatments. Commodity ground beef had the highest (P<0.05) flavor acceptability, while Angus and grass-fed ground beef had similar (P>0.05) acceptability percentages for flavor.

Conclusion: Consumers rated grass-fed, Angus, and commodity ground beef similar for all palatability traits, except overall liking, in which consumers preferred Angus and commodity over grass-fed ground beef.

Keywords: Consumer, ground beef, Palatability
**Objectives:** Beef fajitas are an extremely popular dish served in Mexican-themed restaurants in the US. Pre-marinated fajitas are also widely available as case-ready retail items. One fajita-producing company approached our research group about performing consumer discriminative testing to determine if two new proprietary fajita ingredient formulations differed from their current formulation. Therefore, the objective of this study was to determine if the current beef fajita formula differs from either of the two alternative beef fajita formulas.

**Materials and Methods:** Frozen vacuum packages of pre-processed/marinated fajitas (inside skirt steaks) were shipped to Texas Tech University. All processes/ingredient formulations are proprietary. Treatments included: treatment A beef fajita (A), treatment B beef fajita (B), and current beef fajita (C). Samples (whole muscle) were thawed overnight and cooked to a medium degree of doneness (71°C/160°F) monitored using a digital thermapen (Super-Fast Thermapen, ThermoWorks, American Fork, Utah). All samples were cooked on a clamshell grill (George Foreman) that was preheated to 375°F. After cooking, samples were sliced into ½” strips served warm to consumers (different sets of knives and cutting tables were used for each treatment). A triangle sensory test procedure was performed in a local supermarket in Lubbock (TX) using untrained consumers (n = 120). Each consumer received two rounds representing each difference test (A vs. C or B vs. C), but the sampling order varied for each consumer. Round 1 was designed to determine if consumers could detect a difference between treatment A and the control (C) and round 2 was designed to determine if consumers could detect a difference between treatment B and the control (C). Consumers were instructed to taste samples from left to right. Two were the same, and they had to determine which was the odd sample. Consumers were also asked to complete a brief demographic questionnaire. Sensory ballots were tallied for each treatment separately to determine the number of correct and incorrect responses. Using a statistical table (pg. 433 of Meilgaard et al., 2007), we determined if consumers were able to detect a difference between the new fajitas and the original formulation. The hypothesis of “no difference” was rejected if the number of correct responses was greater than or equal to the tabled value for a 120 observations (α=0.05). The minimum number of correct responses required for significance was 50.

**Results:** Demographical information collected from the 120 consumers showed that a majority of participants eat beef either daily or weekly (24.2% and 64.2% respectively). Most participants were either Caucasian or Hispanic (59.2% and 26.7% respectively), which is very representative of the population in Lubbock, TX. For the treatment A, 53 of 120 consumers correctly identified the sample that was different. For treatment B, 49 out of 120 consumers correctly identified the sample that was different. According to the statistical table for the critical number of correct responses in a triangle test, there was a difference (P < 0.05) between treatment A and C, but the consumers fail to distinguish difference between the treatment B and C.

**Conclusion:** According to the results, the consumers were unable to detect the difference between the current fajita formula and the treatment B.

**Keywords:** Beef fajita, Consumer, Triangle sensory test
19: QUALITY EVALUATION OF PIGS FED POUlTRY BY PRODUCTS IN THEIR DIET.

P. O. Fakolade 1,*, E. T. Oluwasola 1, T. R. Akinloye 1, S. A. Adeoye 1
1Animal Science, Osun State University, Osogbo, Nigeria

Objectives: The effect of consuming solely animal products in pig diet is the focus of this study. Thirty – six male Large White pig of 6weeks old of ages of 5.7 – 7.5 kg old were fed boiled poultry by products (poultry dead birds and hatchery waste) and compared with the conventional feed from plant source, P.K.C (Palm Kernel Cake)

Materials and Methods: Pigs were reared for 10 weeks, allotted into 3 treatments of 12 pigs per treatment, replicated three times, to evaluate for chemical composition, performance and digestibility studies, carcass and organ evaluation, serum and haematological parameters, physico – chemical analysis and palatability study, in a completely randomized design. Boiled dead birds BDB (T3) and Boiled hatchery waste BHW (T2) were compared with the conventional pig food PKC (T1).

**TABLE 1**

<table>
<thead>
<tr>
<th>SERUM BIOCHEMISTRY PARAMETER OF PIGS FED POULTY – BY – PRODUCTS IN THEIR DIET.</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (mg/dl)</td>
<td>84.92 a</td>
<td>80.22 a</td>
<td>66.63 b</td>
<td>5.22</td>
</tr>
<tr>
<td>As(t)u/l</td>
<td>13.64</td>
<td>11.50</td>
<td>14.90</td>
<td>3.64</td>
</tr>
<tr>
<td>Alt</td>
<td>2.48 b</td>
<td>3.68 a</td>
<td>4.24 a</td>
<td>0.25</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td>123.88 b</td>
<td>336.76 a</td>
<td>106.80 c</td>
<td>58.76</td>
</tr>
<tr>
<td>Total Protein (g/dl)</td>
<td>9.28 b</td>
<td>7.73 c</td>
<td>13.37 a</td>
<td>0.68</td>
</tr>
<tr>
<td>Albumin (g/dl)</td>
<td>5.32 a</td>
<td>3.96 b</td>
<td>5.40 a</td>
<td>0.83</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>4.99 a</td>
<td>1.83 b</td>
<td>1.50 c</td>
<td>1.03</td>
</tr>
<tr>
<td>Urea (g/dl)</td>
<td>44.06</td>
<td>55.38</td>
<td>52.32</td>
<td>9.54</td>
</tr>
</tbody>
</table>

Means on the same row are significantly different (P<0.05)

**Results:** T1 had significant highest values for fasted, bled, rib, thigh, shoulder, caecum, lungs, spleen, kidney, heart and intestinal weight compared to T2 and T3, but liver weight was significantly highest in T3 follows by T2. Daily weight gain, daily feed intake and body weight gain had highest (P<0.05) values of 107.45g, 105.31g and 4513.00g for T1 compared to T2 (37.52g, 63.39g and 1580.00g) and T3 (60.00g, 63.30g and 2500.00g) respectively. Feed Conversion Ratio was observed with the lowest (P<0.05) for T1 (0.98), follows by T3 (1.06) and then T2 (1.68). For apparent digestibility, crude fibre, ether extract, dry matter and NFE were (P<0.05) highest for T3 follows by T2, but lower for crude protein. T3 perform best in physico – chemical evaluation having the lowest (P<0.05) for thermal and cold shortening, cooking loss and thaw rigor but highest (P<0.05) value for water holding capacity than for T1 and T2. Lymphocyte values and white blood cell performed best for T3 while T1 had the highest in monophils. T3 had the lowest significant cholesterol value (106.80 mg/dl), than T2 (336.76 mg/dl) and T1 (123.88 mg/dl) while T1 did best (P<0.05) in glucose content (84.92 mg/dl), compared to T2 (80.22 md/dl) and T1 (66.63 mg/dl). Protein content had the highest values (P<0.05) in T3 followed by T2 in fresh muscle while the revi was observed for ether extract. T2 and T3 made the highest (P<0.05) different for palatability score when the muscle were boiled, for flavor, tenderness, juiciness, texture and overall acceptability than T1.

**Conclusion:** T3 performed best, having the highest value for palatability scored, performance quality, physico – chemical analysis, lowest cholesterol and glucose content.

**Keywords:** Boiled Hatchery Waste (BHW), Boiled Dead Bird (BDB), Pigs, and Diets.
Education and Extension Tools

20: GENERAL PUBLIC EDUCATION OF FOOD MYTHS AND URBAN LEGENDS: HORMONES, ANTIBIOTICS AND GMOS

D. A. Tigue 1,*, L. Kriese-Anderson 1, R. Pacumbaba 2

1Department of Animal Science, Auburn University/Alabama Cooperative Extension System, Auburn University, Alabama A&M University/Alabama Cooperative Extension System, Normal, AL, United States

Objectives: Approximately 1% of the American population produces food and fiber for the remaining U.S. population. Most Americans are currently three or more generations removed from the farm and no longer have first hand knowledge of how food and fiber are produced. Additionally, food production has developed into several different breeding and growing methods, all of which compete for market share. This has led to confusion as to the nutrition, health and safety of many food products. The Alabama Cooperative Extension System initiated a Food Myths program in 2014. In 2014, it was geared toward education of how meat is produced in the U.S. for extension agents. In 2015, the program was expanded to explain GMO plants used in food production. The target audience changed as well to all consumers of food and fiber. The objective of these meetings is to educate consumers on how food is produced and help them decipher all of the choices they face when purchasing food.

Materials and Methods: Currently, the Food Myths program is 2 hours in length and explains the various ways food and fiber are produced in the U.S. Participants are encouraged to ask questions throughout the program in order to make the best food and fiber choices for their families. All information presented is research based and presented by extension educators with first hand knowledge of breeding and growing methods used in plant- and animal-based U.S. agriculture.

Results: Through program surveys, 82% of participants indicate their knowledge has increased as a result of attending the Food Myth meetings. Interestingly, though, 70% or more of participants indicated that they would not change their consumption of various types of food after attending the meetings. 47% of participants did indicate that they would read packaging and labels more closely as a result of these trainings.

Conclusion: Food production is a highly debated topic amongst consumers and science-based information is often not part of the conversation. Through these series of meetings, consumers from all sides of the food debate were able to learn the truth about how food is produced and what years of research have proven about different production methods. While the major of these consumers indicated that they learned at these meetings, relatively few indicated that they would change their behavior as a result, showing that these beliefs are deeply rooted and not easily changed.

Keywords: antibiotics, hormones, meat myths
21: PREDICTING BEEF TENDERNESS AND JUICINESS

H. Henderson¹,* and H.L Laird, T. Luckemeyer, R.K. Miller, C.R. Kerth, and K. Adhikari,
¹Texas A&M University, College station, United States

Objectives: The objective of this study was to predict overall consumer liking (OLike) or Warner-Bratzler shear force (WBSF) using either consumer tenderness (OTend) and juiciness (OJuice), trained descriptive tenderness (Tend) and juiciness (Juice) attributes, or WBSF.

Materials and Methods: Data where consumer sensory, trained meat descriptive tenderness and juiciness attributes, and Warner-Bratzler shear force were used. Study 1 used top loin steaks cooked to 58°C or 80°C utilizing a George Forman grill (191°C) or a flat food-service grill (232°C). A second study used Choice beef top loin steaks cooked to 58 or 80°C on a flat electric grill (176°C). Companion steaks were cooked for WBSF (kg). A third study used 60 top loin steaks cooked on an open hearth electric grill (176°C) and served to a trained meat descriptive attribute panel. For study 1, consumers (n=80 per city) were recruited in Portland, OR; Olathe, KS; State College, PA; and study 2 recruited 120 consumers per city from Olathe, KS; State College, PA; Portland, OR; and Griffin, GA.

Results: Consumer ratings (n=3,228), Warner-Bratzler shear force values, and 400 trained descriptive attribute values (n=400) were used to develop 13 equations (Table 1). Equation 1 used Tend ratings to account for 24.6% of the variation in WBSF. Inclusion of Juice and their interaction did not appreciably increase the amount of variation accounted for by Equation 3 (R²=0.25) compared to Equation 1. Equations to predict OLike using Tend, Juice or WBSF had very low R². OTend and OJuice were better predictors of OLike (R²=0.500, 0.492, 0.554 for Equations 10, 11 and 12, respectively) than when Juice, Tender or WBSF were used.

Conclusion: WBSF is more highly related to trained descriptive tenderness ratings than to consumer tenderness liking values. Overall consumer liking is difficult to predict using trained descriptive attribute and WBSF values and is most highly related to consumer sensory liking ratings for tenderness and juiciness. Juiciness ratings, either trained or consumer, did not appreciably improve predictability of regression equations to predict either WBSF or consumer overall liking.

Keywords: juiciness, tenderness
Objectives: Objectives of this study were to 1) evaluate growth performance and carcass characteristics, and 2) determine environmental and economic impacts of cattle raised with different levels of growth promoting technology.

Materials and Methods: Angus x Simmental crossbred steer calves (n=120) of a single source were stratified by dam age, birth date, birth weight, and randomly assigned to four treatments with increasing levels of growth promoting technology: 1) no technology (NA; no antibiotics or growth promotants); 2) non-hormone treated (NHTC; NA plus therapeutic antibiotics, tylosin and monensin during finishing); 3) implant (IMPL; NHTC plus 3 implants [suckling, initial finishing, and mid-finishing]); and 4) beta-agonist (IMBA; IMPL plus ractopamine-HCl for 31 d before harvest). At weaning, steers were transported to a backgrounding lot and blocked by initial feedyard body weight to 3 pen replicates per treatment resulting in a randomized complete block design. Following backgrounding, steers were finished in a GrowSafe® feeding system and individual performance data (ADG, DMI, and G:F) were recorded. At harvest, hot carcass weight (HCW) and standard carcass measures were used to obtain USDA Yield Grade (YG) and Quality Grade (QG). To evaluate environmental impact of each treatment, input parameters recorded from three production stages (cow-calf, backgrounding, and finishing) were represented in a Life Cycle Assessment using the USDA-ARS, Integrated Farm System Model to determine greenhouse gas emissions, energy use, water use, and reactive nitrogen loss. Production costs and carcass values were used to determine economic impacts of each treatment.

Results: Steers in the IMPL and IMBA treatment had heavier (P < 0.01) final calculated body weight and HCW than NA and NHTC. Steers in IMPL and IMBA had greater (P < 0.01) DMI than NA, which was greater (P < 0.01) than NHTC. Steers in the IMPL treatment had the greatest overall ADG, followed by IMBA, and NA and NHTC had the lowest ADG (2.11, 1.79, 1.54 and 1.45 kg/d respectively; P < 0.01). Gain to feed was greatest (P < 0.01) for IMPL while IMBA, NHTC, and NA were similar (P > 0.05). There were no differences among treatments for YG. Treatments with less technology (NA and NHTC) had greater (P < 0.01) marbling scores than IMPL and IMBA however, there was no difference (P > 0.05) in the distribution of carcasses in each QG category. Compared to NA, IMPL reduced carbon footprint (CO₂e/kg HCW) by 8%, energy use (MJ/kg HCW) by 6%, water use (kg H₂O/kg HCW) by 4%, and reactive nitrogen loss (g N/kg HCW) by 8%. Compared to NA, IMBA reduced carbon footprint by 1%, energy use by 3%, and reactive nitrogen loss by 2%. The NA and NHTC treatments were similar in environmental outputs and resource utilization. Total cost of gain ($/kg) was greater (P < 0.01) for NA and NHTC than IMPL and IMBA. When branded carcass premiums were applied, NA and IMPL had a higher value than NHTC and IMBA (P < 0.01). Net return was greatest (P < 0.01) for NA. Steers in the IMPL had a greater (P < 0.01) net return than NHTC, which was greater (P < 0.01) than IMBA.

Conclusion: Treatments utilizing growth promotant implants with and without beta-agonist produced heavier and more environmentally sustainable carcasses. Economic data suggests carcass premiums associated with NA and NHTC may offer producers greater profitability.

Keywords: beef, feedlot performance, growth promotant, life cycle assessment, technology
Objectives: More than 50% of the goat meat consumed in the U.S. is imported due to the increased demand for goat meat. More meat from each animal could be made available by increasing the current slaughter weight of kid goats. The objective of this research was to compare live, carcass and goat meat properties of Spanish and Savannah-Spanish crossbred kid goats fed on concentrate and hay diets to 27, 36, and 45 kg live weight.

Materials and Methods: Spanish (n = 30) and Savannah-Spanish (n = 30) male kid goats (bucklings) were obtained from two commercial herds and assigned to 10 pens based on weight and breed with ad libitum access to concentrate feed and hay with 15.8 crude protein and 75.36 calculated total digestible nutrients on an as-fed basis. Goats were weighed weekly and linear dimensions were measured prior to overnight fasting and humane slaughter when goats reached 27 kg, 36 kg, or 45 kg. Temperature and pH of the M. Semimembranosus were measured after hide removal and 1 h, 3 h and 24 h after stunning. Carcasses were chilled overnight at 2°C before determination of carcass characteristics (McMillin and Pinkerton, 2008). Loin eye area and body wall thickness were measured on carcasses after ribbing at the 13th rib. After splitting carcasses into sides, L*, a*, and b* color were measured on the Rectus abdominis flank muscle. Right sides were fabricated into USDA IMPS food service style cuts with an additional transverse cut between the 4th and 5th ribs. The Semimembranosus and Longissimus dorsi muscles were vacuum packaged and held at 4°C for 7 days before grilling on a conveyor oven to an internal temperature of 75°C. Cook yield was determined as proportion of cooked weight and raw weight. Three 1.27-cm cores were removed parallel to the muscle grain for Warner-Bratzler shear force. Data were analyzed with Statistical Analysis System 9.4 Proc Mixed procedures with separation of least squares means and significance set at P < 0.05.

Results: Spanish goats averaged 5.73 kg heavier at the start of the feeding trial, but with 0.09 kg/d average daily gain (P = 0.001) did not grow as rapidly as the Savannah-Spanish crossbred goats (0.13 kg/d). Carcass dressing percentage was higher (P = 0.05) at heavier weights. Percentage of carcass shrink from overnight chilling was 2.93% for carcasses from Spanish and 2.32% for Savannah-Spanish goats (P > 0.05). Carcasses at 27 kg slaughter weight had decreased (P = 0.001) external fat scores of 1.46 compared to the other two weights (2.27 and 2.10). Additionally, the Savannah goats had decreased actual kidney, pelvic and heart fat percentage (P = 0.048) of 2.91% when compared to the Spanish goats at 3.36%. Carcass conformation (P = 0.0008) and loin eye area increased (P < 0.0001) with increased weight. Boneless lean yield and Semimembranosus shear force did not vary (P > 0.05) with breed or weight at slaughter.

Conclusion: There were no major differences between the two breeds except for growth rate and length of feeding to reach one of the target slaughter weights. Weight at slaughter affected dressing percentage, fatness and muscling, but not boneless meat yields or shear force.


Keywords: Goat meat
Objectives: The objective of this study was to analyze the carcass composition of lambs produced from different mating systems.

Materials and Methods: Lambs (n = 1,237) were produced by a multi-sire mating of three maternal lines (Katahdin (KN), Polypay (PP), and Easycare (EZ)) in two mating systems: a purebred mating system, in which each maternal line was mated with rams of the same genetic line, and a terminal mating system, in which ewes were mated with Texel (TL) rams. Lambs were born (late May/Early June) in a pasture-lambing, low-input production system. Lambs were weaned at about 9 wk of age, moved to feedlot pens, weighed, and transitioned to finishing rations using feedstuffs high in fermentable fiber. When lambs were about 24 wk of age, they were weighed and assigned to one of four slaughter groups with an equal number of lambs in each slaughter group and with the goal of maximizing the number of lambs that produced carcasses with acceptable carcass weights. The four groups of lambs (308 to 310 head per group), ranked from heaviest to lightest, were fed an additional 21, 49, 77, and 103 d, weighed, transported 645 km to a commercial packing plant, held overnight, and harvested. The commercial packing plant uses the VSS 2000 lamb carcass imaging system to evaluate each carcass as the hot carcasses move from the harvest floor to the chiller. Valid VSS data was obtained for 1,108 of the carcasses. Data were analyzed with PROC GLIMIX using dam line, mating system, and sex as fixed effects with hot carcass weight included in the model as a covariate.

Results: Lambs born from EZ ewes had a lighter (P < 0.05) body weight than those from PP ewes, and a greater proportion of EZ lambs were assigned to later marketing groups. Consequently, lambs from EZ ewes were older (P < 0.05) at time of slaughter, had a lower (P < 0.05) dressing percentage and had a lower (P < 0.05) HCW. Relative to the purebred mating system, terminal crossing improved (P < 0.0001) the yield grade (i.e., reduced fat thickness) of lambs produced from EZ (2.99 vs 3.20) and KN (2.79 vs 3.11) ewes. However, terminal crossing did not (P > 0.05) affect the yield grade (2.83 vs 2.87) of lambs produced from PP ewes, which had lower yield grade than purebred KN, purebred EZ and TL × EZ lambs. Indicative of greater muscularity, terminal crossing with TL rams increased (P < 0.0001) conformation scores of lambs produced from all maternal lines and conformation scores differed (P < 0.05) among each breed combination (TL × EZ = 388 > TL × KN = 385 > TL × PP = 382 > EZ = 377 > KN = 373 > PP = 360). The increased prolificacy of EZ ewes relative to PP and KH, in the low-input production system, offset the reduction in growthiness and leanness of EZ as more (P < 0.01) pounds of carcass was produced per ewe exposed for breeding for EZ (38.7 kg/ewe exposed) than PP (30.9 kg) and KN (28.5 kg).

Conclusion: Use of TL rams in a terminal mating system improved growthiness, carcass leanness and carcass conformation of lambs from EZ ewes; however, complementarity of sire breed for other growth and carcass traits should be investigated further.

Keywords: camera grading, lamb, mating system
Environment, Production Systems

25: EVALUATION OF WARM-SEASON ANNUAL GRASSES FOR SOUTHERN FORAGE-FINISHED BEEF SYSTEMS

R. W. McKee 1,*, D. D. Harmon 2, A. M. Stelzleni 1, R. L. Stewart, Jr. 1, D. Hancock 2

1Animal and Dairy Science, 2Crop and Soil Sciences, University of Georgia, Athens, United States

Objectives: In the southeastern United States, long growing seasons allow for near year-round forage production but high summer temperatures and drought can negatively impact forage production, nutritive value, and, consequently, performance of grazing animals. Warm-season annual grasses are typically higher in nutritive value than common warm-season perennial forages in the Southeast. Drought tolerant warm-season annuals may provide forage-finished beef producers with alternative options during the summer months. The objective of this research was to evaluate and compare drought tolerant warm-season annual grasses for beef forage-fishing systems in the Southeast across a 3-yr grazing trial in central Georgia (2014-2016).

Materials and Methods: Sixteen 0.81-ha paddocks were blocked by previous land management and randomly assigned to 1 of 4 forage treatments with 4 replications. Treatments included: ‘Tifleaf 3’ pearl millet (PM), ‘Tifleaf 3’ pearl millet plus ‘Red River’ crabgrass (PMCG), ‘Sugar Grazer II’ sorghum sudangrass (SS), and ‘Surpass’ brown mid-rib sorghum sudangrass (BMR) which were planted in mid to late spring of each year. Each year 32 previously stockered Angus crossbred steers (434±19 kg) were stratified by weight, paired, and randomly assigned to treatment paddocks. Paddocks were split into two sub-paddocks for rotational grazing. Additional steers and heifers were used as “put-and-take” animals to maintain forages in a vegetative stage. All treatment steers were weighed after an 8-h fast at the beginning, mid-point, and end of the grazing period, and average daily gain (ADG) and total body weight gain (BWG) were calculated. Steers were slaughtered under USDA inspection in September of 2014, 2015, and 2016 after 70, 63, and 56 d on treatment, respectively. Carcass quality and yield data were collected 24-h post-mortem and boneless strip loin (longissimus lumborum) sub-primals were removed from the right side of each carcass, vacuum packaged, boxed, and allowed to age (0±2°C) for 21 d. After aging, steaks (2.54-cm) were fabricated from each strip loin starting at the anterior end and allocated to proximate analysis, Warner-Bratzler shear force (WBSF), and trained sensory analysis. Data were analyzed using PROC GLIMMIX (SAS v9.4). Pasture served as the experimental unit with steer as the observational unit. Year was included as a fixed effect, while block and pasture were included as random effects. Means were separated using the PDIFF option of LSmeans at α ≤ 0.05.

Results: No differences (P > 0.05) were observed among treatments for ADG, BWG, dressing percent, subjective lean and fat color, fat L*, a*, and b*, lean L*, marbling, lean and skeletal maturity, fat thickness, adjusted fat thickness, kidney pelvic and heart (KPH) fat, yield grade, percent lipid, protein, and moisture, WBSF, beef flavor intensity, or off-flavor intensity. Treatment effects (P < 0.05) were observed for lean a*, lean b*, ribeye area (REA), percent ash, and juiciness, however, these differences were small in magnitude. Differences (P < 0.05) in initial and sustained tenderness were observed among treatments in 2014 only. Differences were observed across years for most variables, which were attributed to variability in weather conditions for the given year.

Conclusion: This data shows that PM, PMCG, SS, and BMR are viable warm-season annual options for beef forage-fishing systems in the southeastern United States.

Keywords: Beef, Forage-Finished, quality, tenderness
Objectives: This study was performed to evaluate the quality characteristics of low-fat pork sausage (LFPS, <3%) containing paprika powder (PP) to partially replace with sodium nitrite (NaNO2).

Materials and Methods: LFPSs were prepared commercially with or without NaNO2 (37.5 ppm) and paprika powder (0.05~0.1): Control (CTL-37.5 ppm, NaNO2), Reference (REF-150 ppm, NaNO2), TRT1-37.5 ppm, NaNO2 +0.05 % PP; TRT2-37.5 ppm+0.1% PP). After the sausages were cooked by boiling (75 °C/30 min) or smoking (72oC), physicochemical and textural properties were measured. Sensory evaluation was performed with 7 semi-trained pannels with 8 point- hedonic test. Experimental design of this study is one-way analysis of variance (ANOVA) with three replications.

Results: The addition of PP into sausage mixture increased redness values (a*) similar to those of REF. Boiled sausages with 37.5 ppm NaNO2 and 0.05% PP (TRT 1), and smoked sausages with 37.5 ppm NaNO2 with both 0.05 and 0.1% were most similar to those with REF. However, the physicochemical and textural properties of LFPS were not different with the addition of PP. TRT1 in boiling sausage and TRT2 in smoked sausage showed highest in overall sensory evaluation.

Conclusion: Thus, the addition of PP into the sausage mixture increased redness values and sensory evaluation, regardless of cooking method, and might be useful to partially replace with NaNO2.

Keywords: low-fat pork sausages, paprika powder, quality characteristics, sodium nitrite
Meat and Poultry Processing, Ingredient Technology and Packaging

27: HIGH PRESSURE PROCESSING (HPP) DOES NOT AFFECT TEXTURE AND SENSORY ATTRIBUTES OF SMOKED HAMS CURED BY CONVENTIONAL AND ALTERNATIVE METHODS

Y. Yeh 1,*, H. Thippareddi 2, A. S. De Mello 1
1 Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, 2 Poultry Science, University of Georgia, Athens, United States

Objectives: High Pressure Processing (HPP) is a post-lethality treatment applied on RTE meats to reduce or eliminate Listeria monocytogenes. Previous research showed that HPP can affect texture and sensory attributes by modifying the myofibrillar structure and inducing lipid oxidation. Additionally, the increasing demand for natural and organic products created niche markets for uncured and alternatively cured hams. This experiment evaluated the effects of HPP on texture profile, WBSF, and sensory attributes of uncured, and conventionally and alternatively cured hams.

Materials and Methods: Thirty-two boneless pork top rounds (m. semimembranosus and m. adductor) were obtained from a commercial USDA inspected plant. Eight samples were assigned to one of four curing treatments. Treatments included conventional curing with nitrite (TRT1), alternative curing with celery powder (TRT2), uncured with apple cider, wine, and garlic (TRT3), and alternative curing with celery powder and buffered vinegar (TRT4). Samples were injected to 110% of green weight with a brine solution, immersed for 3 days, and smoked for 10 h at 107 °C until the final product reached at least 71.1 °C at the geometric center. From each sample, a total of four 2.54 cm thick slices were obtained. Two were treated with HPP at 87,000 psi for 3 min (HPP) and two were assigned as HPP control (NOHPP). Textural profile analysis (TPA) was performed on three cubes (2.54 cm) from each slice and WBSF was analyzed from six 1.27 cm cores. A consumer sensory panel (480 panelists, 16 sessions, 30 panelists per session) evaluated color, odor, flavor, texture, and overall desirability by using a numerical scale (1=Dislike extremely and 9=Like extremely). Panelists also scored off-flavor intensity from 1=No off-flavor to 9=Off-flavor extremely intense. Data was analyzed by using PROC GLIMMIX of SAS as a split plot design where curing treatment was the whole plot and HPP the sub plot.

Results: HPP did not affect hardness, adhesiveness, springiness, gumminess, chewiness and WBSF of smoked hams. However, a significant effect of HPP was observed for cohesiveness (0.38 for NOHPP and 0.34 for HPP; P<0.0001). No interaction between TRT and HPP was observed for any texture profile attributes. Curing treatment only affected springiness (6.21a, 6.28a, 5.78b, and 5.90ab, for TRT1, 2, 3, and 4, respectively; P=0.03). For sensory analysis, interaction between TRT and HPP main effects were observed on odor (P=0.02) and off-flavor (P=0.006). No single effect of HPP was observed on other sensory attributes. Curing treatment affected color, flavor, texture, and overall desirability (P<0.0001). Overall TRT1 and TRT4 had better scores when compared to TRT2 and TRT3.

Conclusion: HPP did not affect texture and WBSF of smoked hams cured by conventional and alternative methods. Hams cured conventionally and alternatively with celery powder and buffered vinegar had better color, flavor, and overall desirability. Uncured hams had the lowest overall desirability when compared to cured hams.

Keywords: Celery powder, Ham, High Pressure Processing, Nitrite
Objectives: Sliced fermented salami sausages packaged in modified atmospheres (MA) are prone to discoloration by a combination of residual O₂ in the headspace and light at retail display. To avoid discoloration, packages of uncooked salami should be stored in darkness until all O₂ is removed by internal processes in the product, usually within a few days. The aim of this study was to determine if the color of salami could return from brown to red by extended illuminated display in packages with MA’s, in which residual O₂ was present in the early, but not the later stage of display.

Materials and Methods: Dry fermented raw salami was produced with pork, pork fat, beef, starter culture, salt, sugars and 120 ppm sodium nitrite. Packages with 150 g sliced salami were inserted with air and CO₂ through self-sealing septas to contain ca. 5 % O₂, 50 % CO₂ and 45 % N₂ with a gas to product ratio of 1.1 to 1. The lower and upper films for the packages were laminates with EVOH as O₂ barrier. The transparent packages were exposed to continuous LED light type 68 W 830 (Glamox AS, Oslo, Norway) of 3.5 W/m² (1100 lux) for 10 days at 20 °C. Concentrations of O₂ in the packages were measured at the time of packaging and days 1, 2, 3 and 4 of display with a Checkmate 3 instrument (Dansensor, Ringsted, Denmark). CIE L*a*b* values (lightness, redness and yellowness) were analyzed through the packaging films at days 0, 1, 2, 3, 4, 7 and 10 of display with a Minolta Chroma Meter CR-400 (Konica Minolta Inc., Tokyo, Japan). The experiment included 3 batches of salami with 5 packages per batch. Analysis of variance was performed for all data using a general linear model in Minitab 17 Statistical Software (Minitab Inc., State College, PA, USA), and means were separated by Tukey’s multiple comparison test.

Results: Concentrations of O₂ were reduced from the initial 5 % to 0 % at day 4 of display. The initial a* values of sausages from the 3 batches were ca. 16, which is fully red. Within 2 days of display, a* values were substantially reduced to 9-10 (P <0.05), with a distinct browning or discoloration. By end of display at day 10, a* values were slightly higher at 10-11 (P <0.05), but sausages were still clearly discolored. L* and b* values were not affected by residual O₂ and light display (P>0.05). Packages from one of the 3 batches had higher O₂ concentrations at days 2 and 3, consistent with slightly lower a* values of the sausages at the middle and late period of display than the other 2 batches (P <0.05).

Conclusion: Illuminated display of salami slices in MA’s with initial high residual O₂ resulted in a non-reversible discoloration of the product, despite that it was kept under anaerobic conditions for the middle and late display. A subsequent and minimal increase in a* value at this time of display would not be noticed by consumers.

Keywords: discoloration, light, residual oxygen, salami
Meat and Poultry Processing, Ingredient Technology and Packaging

29: EFFECTS OF ACETIC ACID ON 'DARK CUTTING' BEEF QUALITY CHARACTERISTICS

D. Griffing 1,*, C. Christjohn 1, C. Bratcher 1
1Animal Sciences, Auburn University, Auburn, United States

Objectives: Lean color is a driving factor in beef retail acceptance and likelihood of purchase. Dark, firm, and dry (DFD) lean otherwise known as “dark cutting” meat is characterized by an apparent dark purplish-red color as a result of a pH greater than 5.7 due to a depletion of muscle glycogen prior to harvest resulting in minimal conversion to lactic acid. Lean from a DFD carcass is used for ground beef production. Innovative research focusing on adding value in terms of lean color appeal to the loin of DFD carcasses using previously under-utilized Generally Recognized as Safe ingredients could be of value to the industry by increasing the bottom line and increasing consumer and food service satisfaction. The experimental objective was to evaluate the effects of buffered acetic acid on meat quality attributes of dark cutting beef strip loins.

Materials and Methods: Following a Latin square design, four injection treatments (0.0%, 0.4%, 1.2%, and 1.6% acetic acid) were applied to sectioned (n = 4 per strip loin) no-roll DFD striploins (n = 16) for a total of 64 pieces and compared to USDA Select strip loins (RFN) (n = 2) to evaluate meat quality. Pre-treatment, initial color and pH was evaluated. After injection, strip loin sections were vacuum packaged and stored at 4 ± 2°C for three days. Prior to analysis, all sections were cut into three individual 2.54 cm steaks (n = 192). Final color and pH were obtained. Sensory analysis was performed following the American Meat Science Association sensory evaluation research guidelines. Data were analyzed using the PROC Mixed procedure of SAS.

Results: A difference was seen ($P < 0.05$) for initial pH comparing DFD loins and RFN loins; 6.04 and 5.59 respectively. Final pH values did not differ between the DFD and RFN loins; however, there was a difference between treatments ($P < 0.05$). No differences were seen regarding cook loss. DFD loins yielded a lower drip loss percentage ($P < 0.05$). Warner-Bratzler shear force (WBSF) values did not differ for treatment or between DFD and RFN loins. Initial $L^*$ values were greater for RFN loins compared to DFD loins ($P < 0.05$). A difference was observed in initial $b^*$ values between DFD and RFN loins ($P < 0.05$). Final $L^*$, final $a^*$, and final $b^*$ values were different ($P < 0.05$) between treatment levels in the DFD loins. Final $b^*$ values were greater ($P < 0.05$) for RFN loins compared to DFD loins; 15.12 and 12.78, respectively. No difference was observed in cooked internal in $L^*$ values. However, cooked internal $a^*$ values differed ($P < 0.05$) between DFD and RFN loins; 7.88 and 6.56, respectively. Thiobarbituric Acid Reactive Substances (TBARS) values did not differ between DFD and RFN loins. Treatment, location, and loin type had no effect on the following sensory traits: initial juiciness, sustained juiciness, initial tenderness, sustained tenderness, and beef flavor intensity.

Conclusion: Buffered vinegar was only sufficient at altering the final raw color and pH to a level that closely represents a USDA Select strip loin and did not have a substantial effect on cook loss, WBSF, TBARS, and cooked internal color. Results do suggest that it could be valuable to investigate the use of buffered vinegar in conjunction with an antioxidant and/or a functional ingredient used for binding water for synergistic effects possibly resulting in improved raw and cooked color as well as increased water holding capacity in the raw product while reducing cook loss.

Keywords: acetic acid, beef, color, quality
Objectives: Until recently, rice bran, a by-product of rice milling was considered unfit for human consumption after prolonged storage. Due to recently developed stabilizing technology to inactivate the enzyme lipase, rice bran is no longer used as waste material. Stabilized Rice Bran (SRB) is an allergen-free functional ingredient which can replace some or all of the traditional binders in meat products. SRB can be used to replace lean meat to provide cost savings. In June 2008, SRB was approved as "rice bran" by the USDA as a binder/extender in comminuted meat and poultry products. Approved products where SRB can be used includes products such as sausages, chicken patties, meatballs, meatloaf and meat patties where binders are permitted. The objective of this study was to evaluate quality characteristics of beef and binder product by utilizing stabilized rice bran (SRB) or defatted rice bran (DRB) to replace soy protein concentrate (SPC) or meat.

Materials and Methods: Five treatments of beef and binder product were formulated: Control with 2.70% SPC, TRT 2: 2.7% SRB replacing 2.7% SPC, TRT 3: 2.7% DRB replacing 2.7% SPC, TRT 4: 2% SRB replacing beef 80s and TRT 5: 2% DRB replacing beef 80s.

Beef 80's with 20% fat was ground through a 5mm plate. Textured wheat protein was hydrated with ½ the formulation water and held for 10 min. Beef 80s, salt, spices, textured wheat protein, the remaining dry ingredients and the rest of the water/ice were mixed in a paddle mixer and mixed for no more than 3 minutes. The mixture was reground through a 2 mm plate, then stuffed into 12 cm diameter fibrous casing and cooked in a smokehouse under steam to an internal temperature of 71.7C. The chubs were stabilized following USDA Appendix B guidelines, sliced and vacuum packaged and stored in a cooler at 4C. The different treatments were evaluated for cook yield by difference in weight before and after cooking/chilling, sliceability (number of intact slices 1.5 mm thick using a Bizerba high speed tabletop slicer set at full speed 2/3 stroke), firmness using a Texture Analyzer equipped with a 1 cm diameter stainless steel probe and a compression cycle set at 30% of the height of a 2.54 cm thick slice and a test speed of 2mm/s. Purge was measured over 12 weeks of refrigerated storage on vacuum-packaged slices. Statistical analysis was performed using ANOVA (P<0.05) with StatView for Windows on three replications.

Results: Cook yields were significantly (P<0.05) higher for TRT 3, TRT 4 and TRT 5 compared to the control. Slicing yields were significantly (P<0.05) higher for TRT 3, TRT 4 and TRT 5 compared to the control. The firmness values were significantly (P<0.05) higher for TRT 3, but not significantly (P>0.05) different for TRT 4 and TRT 5 compared to the control. Number of intact slices were significantly higher (P<0.05) for TRT 2 and TRT 3 compared to the control. Purge was significantly (P<0.05) lower for all treatments after week 2 and week 4 compared to the control.

Conclusion: SRB is a cost-effective, functional, non-GMO, non-allergen, minimally processed ingredient that can replace SPC or meat while improving yield, sliceability and reducing purge in a beef and binder product. SRB offers a more friendly recognizable label compared to other binders that are approved for use in meat products.

Keywords: stabilized rice bran, defatted rice bran, soy replacement, meat replacement
31: EFFECT OF INITIAL FREEZING RATE AND REPEATED FREEZING/THAWING ON QUALITY AND PHYSICOCHEMICAL CHARACTERISTICS OF PORK PATTIES

J. K. Seo1,2,*, H. W. Kim1, Y. H. B. Kim1
1Meat and Muscle Biology Lab, Department of Animal Sciences, Purdue university, West Lafayette, United States, 2Animal Science Food Processing Lab, Division of Applied Life Science (BK 21 plus), Gyeongsang National University, Jinju-si, Korea, Republic Of

Objectives: Freezing is one of the most effective methods for meat storage. However, repeated freezing/thawing during meat processing could lead to detrimental impacts on quality attributes of final meat products. Fast freezing has been known to reduce quality defects of frozen/thawed meat by minimizing structural damage to muscle related to ice crystal formation during freezing. However, little information is available on how the initial freezing rate would affect the final quality attributes of meat products undergone repeated freezing/thawing process. Therefore, the objective of this study was to evaluate the effect of initial freezing rate of sub-primals and subsequent freezing/thawing on quality characteristics of ground pork patties.

Materials and Methods: At 8 days postmortem, pork ham muscles from each side of pork carcasses (n=6) were removed, cut into four sections, assigned to three initial freezing rates (operating temperatures at -20 °C (slow), -30 °C (medium) or -80 °C (fast)) and unfrozen control, and stored at -18 °C for 3 weeks. After thawing, the ham muscle sections were ground and manufactured for ground patties using a hand-held patty maker. The pork patties were then randomly assigned to three subsequent freezing conditions (unfrozen, air-freezer (-20 °C) or blast freezer (-30 °C)) and stored in -18 °C for 3 weeks. Once patties were thawed in a cooler at 2°C, water-holding capacity, moisture, pH, color (CIE L*, a* and b*), texture profile analysis, 2-thiobarbituric acid reactive substances (TBARS) and thiol content were evaluated. The experimental design was a split-plot design with initial freezing rate (whole-plot) and subsequent freezing condition of patties (sub-plot) with three independent batches. All data were analyzed using the PROC MIXED procedure of SAS.

Results: Both initial freezing rate and subsequent freezing conditions significantly affected thawing, cooking and total losses of frozen pork patties. Pork patties prepared with the sub-primal section assigned to slow freezing (-20 °C) showed the highest total loss (P < 0.05), regardless of subsequent freezing conditions. The initial freezing rate and/or subsequent freezing condition had no impacts on pH, moisture and texture of frozen/thawed pork patties (P > 0.05). The pork patties formulated with the sub-primal section assigned to slow freezing (-20 °C) exhibited higher TBARS value but lower thiol content compared to patties made with the muscle sections assigned to medium or fast freezing (P < 0.05). Frozen/thawed patties had lower L*, a* and b* values compared to the unfrozen control patties, irrespective of freezing rate and/or subsequent freezing conditions (P < 0.05).

Conclusion: This study shows that initial freezing of sub-primals at -20 °C (slow freezing) resulted in increases in total water loss and lipid/protein oxidation of further processed pork patties, regardless of repeated freezing condition of patties. Thus, our findings indicate that the initial freezing rate of sub-primal sections could have a dominant impact on quality attributes of final meat products when undergone subsequent freezing/thawing. Further studies determining effects of different thawing conditions coupled with different freezing rate on meat quality would be warranted.

Keywords: freezing rate, physicochemical characteristics, pork patty
Objectives: Protein ingredients are primarily used in meat products to decrease formulation costs, improve product texture, increase cook yield or enhance product flavor. In 2010, a functional protein known as dehydrated pork stock (DPS) was approved by USDA in comminuted and whole muscle meat products such as sausages, meatballs, meatloaf, meat patties and hams. DPS is an allergen-free, functional ingredient which can replace some or all of the traditional binders and allergens in meat products. It contains over 90% protein and can be used to replace meat to provide cost savings. DPS is not considered a "binder" by USDA hence meat processors are able to make "no binder no filler" claims.

The objective of this study was to evaluate quality characteristics of low cost bologna by utilizing DPS to replace meat.

Materials and Methods: Three treatments of bologna were formulated as shown in the table below.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>TRT. 1</th>
<th>TRT. 2</th>
<th>TRT. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork 20s</td>
<td>22.23</td>
<td>14.23</td>
<td>15.23</td>
</tr>
<tr>
<td>Mechanically Separated Turkey</td>
<td>60.00</td>
<td>60.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Water</td>
<td>8.10</td>
<td>15.10</td>
<td>14.10</td>
</tr>
<tr>
<td>Salt</td>
<td>1.49</td>
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<td>1.49</td>
</tr>
<tr>
<td>DPS 941</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>DPS 941/DPS 1075</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Corn Syrup</td>
<td>5.25</td>
<td>5.25</td>
<td>5.25</td>
</tr>
<tr>
<td>Potassium Lactate/Sodium Diacetate</td>
<td>1.04</td>
<td>1.04</td>
<td>1.04</td>
</tr>
<tr>
<td>Sodium Nitrite</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Spice with Sodium Phosphate</td>
<td>1.88</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
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</tbody>
</table>

Mechanically separated turkey, salt, sodium phosphate, sodium erythorbate and sodium nitrite and half the water/ice was chopped in a bowl chopper to a temperature of 6C. Pork 20s trim and the rest of the dry ingredients and the remaining water were added to the bowl chopper and chopped until the temperature reached 12C. The emulsion was stuffed into a 12 cm diameter fibrous casing and cooked in a smokehouse to an internal temperature of 71.6C. The bologna was chilled following USDA Appendix B guidelines, sliced, vacuum packaged and stored in a cooler at 4C.

Bologna was evaluated for cook yield by difference in weight before cooking/chilling. Firmness was measured on 2.54-cm thick bologna slices using a Texture Analyzer equipped with a 1-cm stainless steel cylindrical probe set to 30% compression and 2mm/s test speed. Interior color was measured using a handheld Hunterlab color reflectance meter set to a D65 light source. Sliceability was measured by the number of intact slices (out of 30) when the bologna was sliced to 1.5 mm thickness using a Bizerba table top automatic slicer set to full speed, 2/3 stroke. Purge was measured over 8 weeks of refrigerated storage on sliced vacuum packaged bologna by measuring the amount of free liquid in the package. Statistical analysis was performed using ANOVA (P<0.05) with StatView for Windows on three replications.

Results: Cook yields were not significantly (P>0.05) different for Trt. 2 and Trt. 3 compared to control. Firmness values were significantly (P<0.05) higher for Trt. 2, but not significantly (P>0.05) different for Trt. 3
compared to control. Hunterlab interior color (L, a and b) values were not significantly (P>0.05) different for any of the treatments. Sliceability was significantly (P<0.05) improved for both test treatments compared to control. Purge was significantly (P<0.05) lower for both test treatments compared to control over 8 weeks of refrigerated storage.

**Conclusion:** DPS is a cost-effective, functional, allergen-free protein ingredient which can be used in bologna to increase cook yields, improve texture, sliceability and reduce purge while providing significant cost savings. DPS can be used in modification of current and development of next generation meat products.

**Keywords:** dehydrated pork stock, natural, functional protein, non-binder
Objectives: Meat retail space throughout the US is an ever-changing area of the modern supermarket. The objective of this survey was to further investigate the retail trends of the fresh meat case across the US.

Materials and Methods: National and regional supermarkets and club stores (n=114) were surveyed from April to August 2015. Two trained auditors visited each store between the hours of 9 AM and 7 PM, with the typical audit lasting 2 hours. Retail self-service cases were evaluated for the percentage of space allocated to fresh meat of various species (whole muscle beef, ground beef, pork, veal, lamb, chicken, and turkey). Five regions were represented across the U.S.: northeast (NE), southeast (SE), midwest (MW), southwest (SW), west coast (WC). The following traits were recorded for each stock keeping unit (SKU): Species, Region, Natural (NAT), Organic (ORG), Case Ready (CR), and packaging type. NAT, ORG, and CR were recorded as either yes or no, based on the presence of NAT or ORG labeling, or the presence of a USDA mark of inspection containing an establishment number indicating CR. Data were summarized using R: A language and environment for statistical computing (version: “Fire Safety” 3.2.2)

Results: Across the United States 15,136 SKU were evaluated. Thirty percent of SKU’s was represented by beef, and chicken was the second most prevalent at 22%. The SW region had the highest percentage (34.4%) of beef in the case, while the MW had the lowest prevalence (28.3%) of beef. Chicken presence was very consistent across the MW, SE, and SW (22.3%, 22.2%, and 22.0%, respectively) with the NE higher at 25.0% and the WC on the lower end at 20.2%. Ground beef prevalence was more variable, with a range from 9.4% in the NE and 13.35 in the MW. There was nearly a 5% difference from the greatest pork presence in a region (SE, 24.7%) to the lowest (SW, 20.1%).

Natural labeling varied by species across the US. Over 50% of chicken and turkey SKU’s were labeled as NAT (62.6% and 51.7%, respectively). The majority of beef, ground beef, and pork packaging did not carry a natural labeling claim (89.4%, 67.6%, and 77.2%, respectively). Organic labeling claims were much less prevalent than NAT. Of the species audited, ORG labeling was observed most often in chicken (7.8%), followed by ground beef (5.4%). Case ready was most common with poultry products, as 93% of chicken and 97.2% of turkey was CR. Ground beef was also commonly found packaged as CR (71.7%). The only species that had a majority of store packaged product was fresh beef cuts (64.0%).

Packaging type was another trait evaluated at all stores. PVC overwrap with a foam tray was the most common (42.2%) packaging type across the US. Most chicken (58.6%) was packaged in SSD/SES packages which contributed to 15.5% SKU’s evaluated. Rollstock packaging was the third most used (12.3%) packaging type in the US. Rollstock was most commonly used for pork packaging rollstock (17%).

Conclusion: The data in this study in a small snapshot of retailers’ stocking trends. Overall the data is suggesting that an increasing amount of meat in self-service retail cases is case ready. The level of organic products remain below 4% on average, but has still made substantial gains since the last audit. PVC overwrap still remains the preferred package by retailers, but varies by species. More research and education needs to be completed to improve the efficiency of this packaging type to help reduce product waste.

Keywords: Labelling, Packaging, Retail
34: EVALUATION OF AN ALTERNATIVE SKIN-ON GOAT HARVESTING METHOD ON MEAT YIELD AND PROCESSING TIME

P. Garcia 1,* , M. Chao 1
1College of Agriculture, California State University-Chico, Chico, United States

Objectives: Many Asian cultures such as Taiwanese, Korean and Chinese enjoy bone-in goat meat cubes with skin attached because of the skin’s unique texture. With the growing Asian population in the U.S., there is potential to grow the goat meat market to meet the new demand. The high demand for skin-on goat meat is currently not met domestically because of the absence of cultural knowledge of the niche market and the technological knowledge to produce a high-quality skin-on goat meat product. The objective of this study was to develop a standard procedure for the alternative skin-on goat harvest and fabrication process, along with comparing the processing yields and time efficiency between the alternative skin-on and traditional skin-off harvest and fabrication processes.

Materials and Methods: A total of 17 Boer/dairy crossbred goats averaging 26.28 kg and 4 months of age were harvested in two different harvesting techniques: nine with skin left on the carcasses (skin-on) and eight with skin removed (skin-off). In skin-on harvest group, carcasses were scalded and dehaired at 61 °C for three minutes to remove most of the hair after stunning and exsanguination. The skin-off harvest group was harvested the same as the traditional lamb harvest, using the fisting technique. All carcasses were fabricated using a bandsaw and cut into 2 in. x 2 in. cubes after 24 hours of postmortem chilling at 2 °C. Cubes from each carcass were placed in individual lug and assessed for consistent quality. Any cube with excessive fat or bones was removed from the batch. Live weight, hot carcass weight, dressing %, chilled carcass weight, and final retail product weight were recorded throughout the harvest and fabrication processes. The harvest time (time spent from stunning to entering the cooler) and the fabrication time (time spent on the bandsaw and removal of inedible products) were also recorded.

Results: The skin-on treatment group had greater dressing % (61.00% vs. 48.38%; P<0.01), % chilling loss (6.53% vs. 3.15%; P=0.01) and % total yield (50.16% vs. 41.36%; P<0.01) compared to the skin-off treatment group. It is interesting to note that the skin-off treatment tended to have greater % retail product yield (P=0.07). This is likely due to the skin-on retail product tended to have more cubes with just skin and fat, which were removed from the batch during the quality check. There were no differences between treatments for harvest time (P= 0.79), fabrication time (P= 0.27), and total processing time (P= 0.55).

Conclusion: The results are encouraging to goat producers and processors who are interested in this ethnic niche of the goat market as the skin-on process requires similar inputs, but generates additional outputs in comparison to the traditional skin-off harvesting. Additional research on consumers’ willingness-to-pay and economic analysis for domestic skin-on goat meat product is needed to confirm the sustainability of this product.

Keywords: carcass fabrication, Goat meat, skin-on harvesting, yield
Meat and Poultry Processing, Ingredient Technology and Packaging

35: POTENTIAL FOR RICE BRAN WAX AND SOYBEAN OIL OLEOGELS AS A PORK FAT REPLACEMENT IN FRANKFURTERS

T. L. Wolfer1*, N. C. Acevedo2, K. J. Prusa1 2, J. G. Sebranek1 2, R. Tarte1

1Animal Science, 2Food Science and Human Nutrition, Iowa State University, Ames, United States

Objectives: The objective of this study was to evaluate the potential of rice bran wax/soybean oil oleogels as pork fat replacements in frankfurters.

Materials and Methods: Frankfurters almost entirely devoid of animal fat were produced using the following lipid replacement strategies: 1) soybean oil (SBO); 2) oleogel made with soybean oil and 2.5% rice bran wax (2.5 RBW); 3) oleogel made with soybean oil and 10% rice bran wax (10 RBW); and 4) oleogel made with soybean oil and 2.5% rice bran wax added later in the chopping step of the frankfurter batter (RBW/LS). Frankfurters produced with pork backfat were used as a control (PF), and all five treatments were targeted to 21% lipid.

Results: Replacing pork fat did not influence emulsion stability or cook/chill yield of the frankfurters. Color L*, a*, and b* values revealed PF to be significantly darker ($P < 0.05$) than SBO, 2.5 RBW, and 10 RBW, and significantly redder ($P < 0.05$) than all other treatments. Texture Profile Analysis showed that PF and oleogel-containing treatments were similar in firmness and springiness, but SBO was significantly different ($P < 0.05$) from PF in these attributes. PF offered less resistance to puncture than all other treatments ($P < 0.05$), as measured by an incisor probe. According to a trained sensory panel, cured frankfurter aroma was not affected by pork fat replacement, but cured frankfurter flavor was significantly reduced ($P < 0.05$) when pork fat was substituted. 10 RBW had higher lipid oxidation values, but these remained consistently low throughout the entire study and were not detected by the sensory panel. Microstructural image analysis revealed that PF and 10 RBW both had a significantly greater ($P < 0.05$) proportion of fat globules larger than 100 μm² when compared to all other treatments, indicating that a stronger oleogel may be necessary in order to more closely resemble pork fat after frankfurter processing.

Conclusion: In conclusion, rice bran wax/soybean oil oleogels have potential to produce frankfurters with similar technological quality, instrumental texture values, oxidative stability, and microstructural features as those made with pork fat. Future research should focus on optimizing this technology by examining the behavior of different types of oleogels under different comminution conditions.

Keywords: Fat replacement, Frankfurter, Oleogel, Rice bran wax, Soybean oil
Meat and Poultry Processing, Ingredient Technology and Packaging

36: EVALUATION OF PORK SKIN GELATIN ON RHEOLOGICAL PROPERTIES OF PORK MYOFIBRILLAR PROTEIN GEL AT DIFFERENT SALT CONCENTRATIONS

C. Lee 1,*, K. B. Chin 1

1Department of Animal Science, Chonnam national university, Gwangju, Korea, Republic Of

Objectives: The aim of this study was to evaluate the pork skin gelatin on rheological properties of myofibrillar protein gel as affected by different salt concentrations.

Materials and Methods: Myofibrillar protein (MP) mixtures were prepared with or without 1.0% of gelatin powder at different salt concentrations (0.15, 0.30, 0.45 M). Gelatin powder was provided by Gel-Tech (Model #Gelatin-G, Busan, Korea). This gelatin powder had 209 bloom of jelly strength and 8 mesh of particle size. Cooking yield (%), gel strength (gf), shear stress (Pa), sodium dodecyl sulfate-poly acrylamide gel electrophoresis (SDS-PAGE), scanning electron microscopy (SEM), fourier transform infrared spectroscopy (%T), sulfhydryl group (A415), and surface hydrophobicity (μg) were measured. The experimental design was 2-way (2x3) analysis of variance and each experiment were performed in triplicate (Table 1).

Results: The addition of gelatin powder increased cooking yield and shear stress, and MP at salt concentration of 0.45 M had higher values of cooking yield and shear stress than the other lower salt concentrations (0.15, 0.30 M). Although gel strength was not affected by adding gelatin (p>0.05), MP gel at the salt concentration of 0.45 M increased gel strength as compared to those at 0.15 and 0.30 M (p<0.05). Protein bands of SDS-PAGE did not differ among the treatments, regardless of addition of gelatin. In microstructure, MP gels with increasing salt concentration showed compact and wet structures. 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. Increasing salt concentration showed low content of sulfhydryl groups. Myofibrillar protein mixtures with gelatin at 0.45 M was lower content of sulfhydryl groups than those without gelatin (p<0.05). Surface hydrophobicity of MP at 0.45 M were higher than those of low salt concentrations (p<0.05). At 0.15 M and 0.45 M, MP mixtures with gelatin was higher than those without gelatin (p<0.05).

Conclusion: These results suggested that MP gel at the salt concentration of 0.45 M was optimum condition for the application of the gelatin in MP systems.

Table 1. Experimental design of this study

<table>
<thead>
<tr>
<th>Ingredients</th>
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<th>Gelatin</th>
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</thead>
<tbody>
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<td>Myofibrillar protein</td>
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</tr>
<tr>
<td></td>
<td>0.30 M</td>
<td>0.30 M</td>
</tr>
<tr>
<td></td>
<td>0.45 M</td>
<td>0.45 M</td>
</tr>
<tr>
<td>Buffer solution</td>
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</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td>10.0</td>
<td>9.50</td>
</tr>
<tr>
<td>Gelatin</td>
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<tr>
<td></td>
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<tr>
<td></td>
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Keywords: FTIR, Gelatin, Myofibrillar protein, Salt concentration
Meat and Poultry Processing, Ingredient Technology and Packaging

37: CARCASS CHILLING METHOD EFFECTS ON TEXTURE AND CURED COLOR DEVELOPMENT OF COOKED SOW SAUSAGE

V. A. Soendjaja 1*, M. A. Mickelson 1, J. R. Claus 1
1Animal Sciences, University of Wisconsin, Madison, United States

Objectives: To determine the effect of carcass Rinse&Chill® on texture and cured color development of cooked sow sausage in comparison to conventional chilling.

Materials and Methods: Two chilling methods were implemented on carcasses (average hot carcass weight 237.0 kg) from 30-month old sows. Six carcasses were conventionally chilled (C) and six were chilled with Rinse&Chill® technology (RC; MPSC Inc.). RC involved vascular rinsing of residual blood using a cold (3°C) isotonic substrate solution (98.5% water; balance: glucose, polyphosphates, glycerine, and maltose). Carcasses were deboned (30 min postmortem) to obtain lean from each of the three anatomical locations (shoulder, loin, ham) with each location separately ground, salted (1%, w/w), mixed with dry ice, vacuum packaged, and stored (24 h) before being reground. Samples were vacuum packaged, frozen, and stored (-20°C). Thawed samples were mixed with non-meat ingredients (0.5% seasoning, 0.25% sugar, 10% water, 156 ppm sodium nitrite, additional salt 1%), stuffed into cellulose casings (32 mm), and cooked on an electric grill (endpoint 76.6°C). Color measurements included CIE L*a*b* and reflectance estimators of myoglobin chemical states (deoxymyoglobin, DMb, %R474nm/%R525nm; nitrosylhemochrome, NITHEM, %R650nm / %R570nm). Cooked sausage links were cut (12 mm length, 25 mm diameter) for texture profile analysis (compressed twice, 60%). Cooking loss and pH were also determined. Data were analyzed with PROC MIXED model of SAS (SAS institute) and animal (replication, N=6) served as the RANDOM term.

Results: RC did not affect (P>0.05) cook loss, cooked pH, NITHEM, DMb, or instrumental texture. RC resulted (P<0.05) in lighter (CIE L*, 57.1) and less red (CIE a*, 16.7) cured cooked sausage than C (CIE L* 55.9; CIE a* 17.2). Sausage manufactured from the shoulder lean had the highest pH (P<0.05; 6.26) with no difference between the loin and ham (6.02, 6.01; respectively). Those from the loin had the lowest (P<0.05) cooking loss. Sausages that used shoulder lean had the highest (P<0.05) reflectance estimator of NITHEM, while sausage from the ham had the highest (P<0.05) reflectance estimator of DMb. Sausage from the shoulder and loin were different (P<0.05) in yellowness with the ham being intermediate. Sausage from the loin was the most firm (P<0.05) followed by the ham and shoulder. The shoulder produced the least cohesive (P<0.05) sausage with no difference between loin and ham. Sausages varied (P<0.05) in springiness associated with each anatomical location of the lean (ham>0.05) between carcass chilling treatment and anatomical location.

Conclusion: Rinse&Chill® technology produced lighter, less red cooked cured sausage with no other influence on the chemical and physical properties. The lower redness presumably was associated with the removal of more residual hemoglobin. However, this technology did not affect the development of the cured meat pink pigment. Of future value would be to determine the cured color stability of sausages made from carcasses processed with Rinse&Chill technology with respect to the potential impact of differences in myoglobin and hemoglobin content.

Keywords: Carcass chilling method, Color, Sausage, Sow, Texture
EFFECTS OF TEMPERATURE ABUSE ON SHELF LIFE AND COLOR STABILITY ON BEEF PRODUCTS

M. M. Pfeiffer 1,*, D. L. VanOverbeke 1, R. M. Mitacek 1, G. G. Mafi 1, R. Ramanathan 1

1Animal Science, Oklahoma State University, Stillwater, United States

Objectives: Meat color is the single most influential purchasing decision for consumers, as they associate freshness and wholesomeness with discoloration. Surface discoloration results in about 15% of retail beef being discounted and about $1 billion in annual revenue loss. Although several factors can influence beef color, limited information is currently available on the effect of temperature abuse on beef color. Therefore, the overall goal of this study was to evaluate the effects of temperature abuse on shelf-life and color stability in beef products.

Materials and Methods: All master bags (0.4% carbon monoxide, 30% carbon dioxide, and 69.6% nitrogen) were kept in dark storage for 15 d before display at a temperature of -2 – 0ºC. Four different treatments were utilized during the 5 d display study: (1) case at -1 – 1ºC, 5 d display; (2) case at 3 – 5ºC, 5 d display, (3) 8 h temperature abuse at 10ºC then 5 d display, case at -1 – 1ºC; and (4) 8 h temperature abuse at 10ºC and 5 d display, case at 3 – 5ºC. Seven trays of strip loin steaks (n = 28) and top sirloin steaks (n = 28) were utilized for each treatment and were randomly assigned to a retail case. Surface color, biochemical, and microbiological qualities were determined during display time. Each sample was visually evaluated for lean color, surface discoloration, and overall acceptability over 5 d by a 6 member trained color panel. For the biochemical analysis, pH, metmyoglobin reducing activity, and oxygen consumption were determined on the steaks before display. At the conclusion of color evaluation, two samples from each treatment were utilized for total aerobic plate count. The data were analyzed using the Mixed Procedure of SAS, and considered significant at a level of P < 0.05.

Results: Lean color and overall acceptability were not different (P > 0.05) for strip loin and sirloin steaks that were temperature abused prior to display, but lean color and overall acceptability were lower for steaks in warmer retail cases (P < 0.05). Sirloin steak discolored more rapidly (P < 0.05) than strip loin steaks in all treatments. The total plate counts showed no differences between treatments for sirloin steaks. However, a greater total plate count was noted in strip loin steaks that had not been temperature abused but displayed in a warmer temperature. Oxygen consumption rate, metmyoglobin reducing activity, and pH were not different between treatments.

Conclusion: Temperature abuse prior to retail display had no effect on the lean color, discoloration, or overall acceptability of the product. However, a warmer retail case had significant effect on surface color and overall acceptability of steaks. Temperature abuse prior to display combined with a warmer display case leads to shorter shelf-life.

Keywords: meat color, packaging, spoilage, temperature abuse
Objectives: Consumer demand for clean ingredient labels has led to research into natural alternatives to synthetically derived functional ingredients. Phosphates, including sodium tripolyphosphate, have been reported as an undesirable additive in meat products by some consumers. Phosphates are used by meat processors to increase yields, improve texture, and protect flavor. The objective of this research was to determine if the addition of phosphate substitutes including oat fiber, oat fiber with dried vinegar, and whey protein concentrate are viable natural alternatives to phosphate in ready-to-eat (RTE) marinated chicken breast.

Materials and Methods: Broiler breast meat (0.19-0.25 kg per fillet) was marinated with formulations containing 1.0% NaCl and 0.4% sodium tripolyphosphate or a phosphate substitute treatment and water. The treatment variables consisted of positive phosphate, negative phosphate, whey protein concentrate (WPC), oat fiber, or oat fiber with dry vinegar. Treatments were vacuum tumbled at 25 mm hg for 30 min at 8 rpm with 0.91 kg of brine solution and 7.8 kg of chicken breast. Samples were measured for percent pick-up of brine, cooking loss, pH, color, and instrumental tenderness. Sensory evaluation was conducted (n=180 total panelists) to evaluate the appearance, aroma, texture, flavor and overall acceptability of chicken breast treatments. A randomized complete block design with three replications was used to test the effect of adding whey protein concentrate, oat fiber, and oat fiber DV on quality parameters and sensory acceptability of chicken breast. Duncan’s multiple range test was utilized to separate the treatment means when significant differences occurred (P<0.05).

Results: Phosphate treatments yielded breast meat with less (P<0.05) cooking loss and a greater pH than the negative control and phosphate substitute treatments. No differences existed (P>0.05) among treatments with respect to brine pick up and shear force. On average, no differences existed (P>0.05) in consumer acceptability for appearance, texture and overall acceptability, with all mean values between like slightly and like moderately on the 9 point hedonic scale. Furthermore, 82% of panelists rated the positive phosphate treatment at least like slightly. The oat fiber treatment was liked slightly or greater by 77% of panelists, while 74% of panelists rated the whey protein concentrate treatment at least like slightly or greater. Both the oat fiber with dry vinegar and negative phosphate treatments were like slightly or greater by 68% of panelists. This indicates that formulating whey protein concentrate, and oat fiber into chicken marinades can effectively increase the percentage of panelists that like chicken breast as compared to the negative phosphate treatment.

Conclusion: Whey protein concentrate and oat fiber have potential as phosphate alternatives in marinated chicken breast. Future research should be explored to determine ingredients that can increase negative charges on myofibrillar proteins to maximize yield and functionality for use in conjunction with oat fiber and whey protein concentrate as a potential phosphate replacer in meat systems.

Keywords: Phosphate, natural ingredients, marinated chicken breast.
Objectives: Enhancement has been known to improve eating quality of fresh beef, in particular, with low marbled beef or from not fattened cattle. The objectives of this study was to determine the optimal enhancement processing condition to improve the eating quality of freshly prepared steaks with application of tumbling and calcium lactate.

Materials and Methods: The Longissimus lumborum muscles of 12 Luxi × Simmental cattle, 18 ~ 24 months (no fattening), were selected and aged for 48 h (pH 24 was 5.56 ± 0.03). The muscles were cut into steaks of 3 cm, and tumbled with a brine (1% sodium chloride, 0.4% sugar, 0.4% phosphate and different concentrations (0.016 M, 0.05 M, 0.1M, 0.15M and 0.184 M) of calcium lactate (CAL)), then tray-packaged with the PVC film and stored at 4°C for 7 days. The SF was measured according to the methods of Luo, Zhu, and Zhou (2008).

Purge loss (%) = [(tumbling weight – post storage weight) / tumbling weight] × 100
Cooking loss (%) = [(uncooked weight – cooked weight) / uncooked weight] × 100
% Yield = (final cooked weight / green steak weight) × 100

Response surface methodology was applied to optimize the processing parameters. The design consisted of 20 sets of experiments with 3 replications, and with 5 levels of each independent variable which were coded as -1.682, -1, 0, 1 and 1.682 (Table 1). The range of the experiment and its center point were based on preliminary trials. A central composite rotatable design was used to evaluate the relevance of the three independent variables of tumbling time (X1), marinade volumes (X2), and CAL concentration (X3). The dependent variables were purge loss (Y1), cooking loss (Y2), yield (Y3) and shear force (Y4). Software SAS 9.2 was used for data analysis.

Table 1 Critical factors in Response Surface Methodology analysis.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Symbol coded</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumbling time (min)</td>
<td>X1</td>
<td>-1.682, -1, 0, 1, 1.682</td>
</tr>
<tr>
<td>Marinade volume (% , v/w)</td>
<td>X2</td>
<td>3.3, 6, 1, 14, 16.7</td>
</tr>
<tr>
<td>Calcium lactate concentration (M)</td>
<td>X3</td>
<td>0.016, 0.0, 0.1, 0.18</td>
</tr>
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</table>

Results: Based on the analysis of the effects of variables on purge loss, cooking loss, yield and SF, the optimum condition was determined by superimposing the contour plots of 4 responses. The optimum condition constraints were set as purge loss < 0.6 %, cooking loss < 25 %, yield > 84 %, 3.9 kg < SF < 4.2 kg. The results indicated that the best tumbling time was 60-73 min and the best CAL concentration was 0.15 M. The tumbling time 60 min and 0.15 M CAL was then put into the model which showed the best marinade volume to be 8%.

Conclusion: The optimum process conditions for freshly prepared steaks was: tumbling for 60 min, 8% (v/w) marinade and 0.15M CAL. In these conditions, the SF was 3.94 kg, and the purge loss, cooking loss, yield was 0.40%, 22.76% and 83.56%, respectively, which are well in agreement with the values predicted by the model. The eating quality was much better that other CAL concentrations. This investigation could help meat industries to produce high quality chilled freshly prepared steak.

Keywords: calcium lactate, freshly prepared steak, tenderness, tumbling, water holding capability
Objectives: The impact of the photosensitizer chlorophyll $a$ (chl $a$) was examined in three independent pre-rigor pork sausage experiments. The objective was to determine the threshold level of chl $a$ that accelerated color loss, and to ascertain whether synthetic antioxidants, natural plant extracts, or a combination of both would help delay color loss.

Materials and Methods: In each experiment, 3% water and 0.8% salt were added to pre-rigor pork trim (6 hours post-mortem). In experiment 1, different levels of parsley (0, 513, 1026, 2051, and 3077 ppm) were added to the pork, equivalent to 500, 1000, 2000, and 3000 ppb chl $a$. Chl $a$ was measured by UV-Vis spectrophotometer. In experiment 2, each batch of meat was treated with 0.3% FORTIUM® RGT12 Plus Dry (rosemary and green tea extracts). The three treatment conditions were no added sage, 0.0075% oleoresin sage, and 0.15% rubbed sage, to study the impact of chl $a$ delivered by sage used in breakfast sausage. In experiment 3, 1539 ppm of ground parsley (1500 ppb chl $a$) was added to each batch of meat, and the treatments were untreated, a synthetic antioxidant blend (0.01% butylated hydroxyanisole (BHA), 0.01% propyl gallate (PG), and 0.01% citric acid (CA)), 0.3% FORTIUM RGT12 Plus Dry (RGT), and 0.3% RGT plus BHA/PG/CA. All of the treatments were replicated ($n=2$). The treatments were mixed with the pork for one minute, ground through a 4.8 mm plate, and shaped into 150 g patties. The patties were placed on foam trays and covered with oxygen permeable overwrap. They were frozen for 11 days ($-18 \, ^\circ C$) followed by 12-17 days of simulated retail display ($3\pm1 \, ^\circ C$, 1200-1400 lux fluorescent lighting). Instrumental redness ($a^*$) and photographs were taken periodically during the lighted display period to monitor changes.

Results: The results revealed significant effects of time and treatment ($p<0.05$) for each experiment. In experiment 1, the patties with 2000 and 3000 ppb chl $a$ had lower $a^*$ values ($p<0.05$) than the 0, 500 ppb, and 1000 ppb chl $a$ treatments. The 1000 ppb chl $a$ patties had lower $a^*$ values ($p<0.05$) than the 500 ppb patties, and there was no significant difference between the mean $a^*$ values of the 500 ppb patties and the patties with no added parsley. In experiment 2, the patties with rubbed sage (778 ppb chl $a$) had lower $a^*$ values ($p<0.05$) than the patties with no sage or oleoresin sage, and there was no significant difference between the mean $a^*$ values of the patties with no sage and oleoresin sage (36 ppb chl $a$). In experiment 3, the patties demonstrated color instability when chl $a$ was present at 1500 ppb, even in the presence of natural plant extract and antioxidant ingredients. RGT and RGT + BHA/PG/CA had higher $a^*$ values than untreated ($p<0.05$), while BHA/PG/CA $a^*$ values were not higher than untreated ($p>0.05$). RGT $a^*$ values were neither significantly higher than BHA/PG/CA nor significantly lower than RGT + BHA/PG/CA ($p>0.05$).

Conclusion: This study suggested that pre-rigor pork sausage color stability was moderately affected by chl $a$ levels between 500-1000 ppb, and it was significantly affected when chl $a$ exceeded 1000 ppb. Although minimizing chl $a$ in seasoning blends and limiting light exposure could help extend color life, the use of 0.3% FORTIUM RGT12 Plus Dry extended the simulated retail color life of pre-rigor ground pork containing the level of chl $a$ typically found in commercial seasonings.

Keywords: chlorophyll, color, green tea extract, pork, rosemary extract
EVALUATION OF CITRUS FIBER AS A NATURAL ALTERNATIVE TO SODIUM TRIPOLYPHOSPHATE IN ALTERNATIVELY CURED BOLOGNA

M. J. Powell 1,*, K. J. Prusa 2, J. G. Sebranek 3, R. Tarte 1

1Animal Science, 2Food Science and Human Nutrition, 3Animal Science, Food Science and Human Nutrition, Iowa State University, Ames, United States

Objectives: Consumers are currently driving the demand for “clean labels” and the elimination of ingredients from their further processed foods that are perceived as unnatural or unhealthy. The meat industry is not exempt from these growing trends and is one of the major industries attempting to meet the consumers’ demand. Most of the focus has been on eliminating nitrite/nitrate, ascorbate/erythorbate, and phosphates from processed meat. It is well established that cultured celery juice powder and cherry powder can serve as natural alternatives to sodium nitrite and sodium ascorbate/erythorbate, respectively. However, little research has been published on a natural alternative to conventional phosphate in processed meat products. The objective of this research was to evaluate the functionality of citrus fiber as a natural alternative to sodium tri polyphosphate in alternatively cured bologna.

Materials and Methods: Effects of citrus fiber on cook and chill yield, rancidity (TBARS), texture (simplified TPA measuring hardness, adhesiveness, resilience, cohesion, springiness, gumminess, chewiness), color (Hunter L, a, b, on samples in both lighted, simulated retail display (RD) and samples with no light exposure), and sensory properties of an alternatively cured, all-pork-bologna throughout a 98-day shelf life (1°C) was investigated. The bologna (target fat ~27%) was assigned to one of five treatments: positive control (phosphate), negative control (no phosphate/no citrus fiber), 0.50% citrus fiber treatment, 0.75% citrus fiber treatment, or 1.00% citrus fiber treatment. All treatments were replicated three times. Proximate analysis was conducted once for each replication. All other parameters were analyzed at days 0, 14, 42, 70, and 98. Statistical analysis was conducted in SAS using the mixed procedure.

Results: Cook and chill yields, TBARS, Hunter a, L (RD), a (RD), adhesiveness, gumminess, chewiness, bologna aroma, bologna flavor, off flavor, and sensory color (light to dark) were not significantly different across treatments (P > 0.05). Hunter L values were significantly different (P < 0.05) between the negative control and the 0.50% citrus fiber treatment. The 0.50% citrus fiber samples were slightly darker than the no phosphate control. All three citrus fiber treatments had higher Hunter b and b (RD) values and were significantly different (P < 0.05) from the positive and negative controls. This is most likely due to the yellow coloring of the citrus fiber. The hardness of the 1.00% citrus fiber treatment was significantly higher (P < 0.05) than all other treatments. Resilience and cohesion for all citrus fiber treatments and springiness for the 0.50% citrus fiber treatment were significantly lower (P < 0.05) compared to the positive control. The positive and negative controls were significantly higher than the citrus fiber treatments for moistness (P < 0.05) and the positive control had significantly higher texture scores, were firmer, than the other treatments (P < 0.05).

Conclusion: Overall, citrus fiber did not negatively affect the physical, chemical, or sensory characteristics of the alternatively cured bologna. These results indicate that citrus fiber has potential to serve as a natural alternative to phosphate in processed meat products.

Keywords: Phosphate, citrus fiber, bologna, sensory
Meat and Poultry Processing, Ingredient Technology and Packaging

43: EFFECTS OF GROUND CARDAMOM ON THE FUNCTIONAL PROPERTIES OF RESTRUCTURED GROUND TURKEY

A. Clarke 1,*, T. Harper 1, A. Bond 2
1 Food Science, University of Missouri, 2 Food Science, Rock Bridge H.S., Columbia, United States

Objectives: The objectives of this study were to determine the effects of 0, 1.0, 1.5, and 2.0% ground cardamom in a restructured turkey product. The aim was to determine if this ingredient affected the function of an alginate binding system regarding cook yield, pH, texture, water activity, moisture percentage, and water holding capacity.

Materials and Methods: Each treatment contained one pound (454g) raw turkey, 0.6% sodium alginate, 0.6% encapsulated lactic acid, 0.3% calcium carbonate, and 5.0% distilled water. Samples were prepared and stuffed into polypropylene centrifuge tubes within 20 min at 23º C and given at least 12 hours to set in a 4º C refrigerator. Samples were then cooked to an internal temperature of 72º C via water bath and the experiment was replicated three times. The binding strength of each treatment was determined using a Stevens-LFRA Texture Analyzer fitted with a spherical probe to penetrate 1-cm discs of product. One-way ANOVA was used to analyze the data with P<0.05 as the significance level and a Tukey multiple range test was used to separate means.

Results: The addition of ground cardamom within the binding system did affect pH, water holding capacity, and cooking yield of each treatment. As ground cardamom increased, the pH decreased from 6.35 to 6.10 and the cook yield increased by 4% (P<0.05). The 2.0% ground cardamom sample had the highest cooking yield (72.7%) and lowest pH value (6.10). A decreased value in pH across all ground cardamom samples correlated to a decreased value in water holding capacity. This may be explained by competitive interactions between the ground cardamom and the calcium alginate binding system. The cardamom fiber absorbed water adequately to increase cook yield, but did not possess the same water holding capacity as turkey meat bound by calcium alginate. Water activity and moisture percentage appeared to have minimal differences (P>0.05) of up to 0.003 units and up to 2.8%, respectively, across all four treatments. It was observed that 2.0% ground cardamom (166 g) had significantly higher (P<0.05) binding strength than the 1.0% ground cardamom (146 g) treatment.

Conclusion: Overall, this study indicated that adding a fiber-rich spice source enhanced the cooking yield of the product while minimally influencing other characteristics. However, no sensory evaluation was performed to determine whether the differences were desirable. Further research can be performed with sensory evaluation to determine if ground cardamom at different levels affects the appearance, flavor, and overall acceptability of a restructured turkey product.

Keywords: calcium alginate, fiber, meat extender
**Meat and Poultry Processing, Ingredient Technology and Packaging**

**44: TEXTURE AND CONSUMER ACCEPTABILITY OF GOAT SAUSAGES MADE WITH BEEF FAT FROM VARIOUS LOCATIONS ON A CARCASS**

L. Venzor¹,*, E. G. Holmes¹, R. M. Harp², J. Waddell¹, L. A. Kinman¹

¹Animal Science and Veterinary Technology, Tarleton State University, Stephenville, ²School of Agriculture, Texas A&M - Commerce, Commerce, United States

**Objectives:** Chevon is a globally produced lean protein source. However, Western consumers are not accustomed to the effects of 4-ethyloctanoic acid which gives Caprinae meat its musky flavor. Mono-unsaturated fatty acids found at higher ratios in the brisket than in other beef carcase fat depots, produce a brothy beef flavor, while saturated fatty acids form less stable emulsions. Therefore, value-added goat meat products using beef fat have potential of increase palatability and texture for Western markets. The objective of this study was to evaluate the texture profile and consumer acceptability of goat sausages formulated with beef fat from various locations.

**Materials and Methods:** Subcutaneous fat was obtained from beef carcases at three different locations: brisket (BF), plate (PF), and round (RF). Goat meat and beef fat were initially course ground using a 12.5mm grinder plate. Sausage formulations consisted of 17.01kg goat meat, 3.40kg beef fat, 907.18ml water, 0.22kg ice, seasoning blend, and curing salts (6.25% sodium nitrite). The control sausage consisted of 1.13kg of beef fat from each beef fat location. Each formulation mixed for 4 minutes and then finely ground using a 9.5mm grinder plate. Meat batter was stuffed into natural hog casing, linked and thermally processed to 71°C. Sausages were chilled for 24h, vacuum packaged and frozen. Frozen sausages were thawed at 5.5°C and assigned a random identification number. Sausages were then reheated to 71°C and cut into 2.54cm pieces. Two pieces were placed in Styrofoam cups and served to 100 panelists. Each panelist evaluated samples for aroma, color, overall opinion, texture of exterior and interior, greasiness, juiciness, and flavor using a 9-point hedonic scale (1=dislike extremely to 9=like extremely). Likelihood of purchasing was rated using a 5-point hedonic scale (1= definitely would not buy to 5=definitely would buy). Texture profile analysis (TPA) variables were evaluated using model TA.XT2. The following variables were determined: hardness, springiness, cohesiveness, chewiness, and resilience.

**Results:** The consumer panel data indicated a difference (p<0.05) in greasiness. Sausages that contained BF and PF were slightly disliked (4.84 and 4.97) more than sausages made with RF (5.58). The consumer panelists found no differences in other variables evaluated between the treatment groups. The TPA analysis indicated that sausages formulated with RF (6.12kg and 3.61kg) and the control (6.18kg and 3.77kg) were significantly harder and chewier than BF (4.78kg and 2.87kg) or PF (5.14kg and 3.11kg) treatments. Sausages made with BF (86.1%) or PF (86.1%) were also springier than control sausages (85.5%). Sausages made with RF were found to be less cohesive and resilient (68.8% and 36.4%) compared to the other sausages.

**Conclusion:** The purpose of this study was to expand options in the goat meat market without sacrificing quality by evaluating consumer acceptability and texture profile analysis for goat sausages formulated with beef fat from various locations on a carcass. According to the consumer panel, sausages made with PF and BF were slightly disliked due to greasiness. Texture profile analysis indicated that sausages formulated with RF were found to be harder, chewier, less cohesive and resilient, while sausages made with BF or PF were found to be springier.

**Keywords:** acceptability, goat, Sausage
Objective: Inconsistencies within the boxed beef supply have led to increased cost and variability for consumers. Our goal was to quantify adherence to Institutional Meat Purchase Specifications (IMPS) guidelines and differences in quality and yield parameters including marbling score (MARB), retail yield (RY, %), and Warner-Bratzler shear force (WBSF, kg).

Materials and Methods: Five boxes each of USDA Choice (CH), custom sorted (CS), and Certified Angus Beef (CAB) subprimals (SUB) were utilized: IMPS 112A Lip-On Ribeye Roll, 120 Deckle-Off Brisket, 180 Strip Loin, and 184 Top Sirloin Butt. Six days’ of USDA video image analysis data was collected one week prior to CS carcass selection and used to calculate selection criteria ranges for hot carcass weight, calculated yield grade, MARB, ribeye area, and backfat thickness of 790–887 lbs., 2.31–3.22, 316.60–437.73, and 11.24–14.85 in², respectively. Each SUB was cut into 2.54-cm thick steaks, weighed, assessed for adherence to IMPS, trimmed to spec if needed, and reweighed post trimming to calculate RY.

Results: Means of ribeye box weight (BW), SUB weight (SUBW), MARB and WBSF differed across groups (\( P \leq 0.01 \)), with RY being similar (\( P = 0.24 \)). Differences in BW and SUBW indicated CH and CAB were heavier than CS (\( P < 0.05 \)), with CS also having the least MARB (\( P < 0.01 \)). Results indicated WBSF for CH was improved compared to CS (\( P < 0.05 \)). Number of retail cuts and specifications for tail length, subcutaneous fat thickness (SFT), and presence of bone, ligamentum nuchae, scoring and intercostal meat (IM) were different across groups (\( P < 0.01 \)). Means of brisket SUBW, MARB, and WBSF differed (\( P \leq 0.04 \)), with BW and RY being similar (\( P = 0.13 \)). Differences in SUBW indicated CAB was heavier than CS (\( P = 0.04 \)). All groups differed in MARB (\( P \leq 0.01 \)), with CS having improved WBSF compared to CH (\( P = 0.03 \)). Specifications including visibility of the muscle seam, and presence of the deckle, bone, and scoring differed (\( P < 0.01 \)). Means of striploin BW, RY, MARB, and WBSF differed (\( P < 0.04 \)), with a SUBW trend calculated (\( P = 0.08 \)). Differences in BW indicated CS was heavier than CH and CAB (\( P < 0.05 \)). All groups differed in MARB (\( P < 0.01 \)), with CS exhibiting improved WBSF compared to CH and CAB (\( P < 0.01 \)). Although RY differed amongst all groups (\( P = 0.04 \)), only CH and CAB tended to be different (\( P = 0.07 \)). Number of retail cuts and specifications for tail length, SFT, and presence of bone, scoring, and IM were different across groups (\( P < 0.01 \)). Means of Sirloin BW, SUBW, gluteus medius MARB, biceps femoris weight and MARB, and total RY were different across groups (\( P < 0.05 \)), with gluteus medius weight exhibiting a calculated trend (\( P = 0.06 \)). There were no differences in gluteus medius WBSF, or biceps femoris WBSF (\( P > 0.15 \)). Differences in BW and SUBW indicated CH and CS were heavier than CAB (\( P < 0.02 \)), with all groups being different for total RY. Means of gluteus medius MARB indicated CH was improved compared to CS (\( P = 0.02 \)) with a tendency for improvement compared to CAB (\( P = 0.07 \)). Biceps femoris MARB for CH and CAB was greater than CS (\( P < 0.01 \)). Number of retail cuts and specifications for non-square cuts at the cranial or caudal ends, gluteus medius exposure, SFT and presence of scoring were different across groups (\( P < 0.01 \)).

Conclusion: These results indicate a potential for carcasses to be sorted into more homogenous groups to improve uniformity and adherence to IMPS.

Keywords: Boxed Beef, Marbling, Retail Yield, Uniformity, WBSF
**Meat and Poultry Processing, Ingredient Technology and Packaging**

**46: COLOR CHANGES IN HIGH PRESSURE PROCESSED GROUND BEEF WITH DIFFERENT NITROSYLMYOGLOBIN STATES AND WITH OR WITHOUT ADDED REDUCING COMPOUNDS**

J. Gupta¹, C. G. Bower²*, G. A. Cavender³, G. A. Sullivan²

¹Department of Food Science and Technology, ²Department of Animal Science, University of Nebraska-Lincoln, Lincoln, ³Department of Food Science and Technology, University of Georgia, Athens, United States

**Objectives:** A major challenge of ground beef processors is the control of *E. coli* O157:H7 and other Shiga toxin producing *E. coli*. High pressure processing (HPP) has emerged as an effective non-thermal pasteurization technique. The use of HPP in raw meat is limited due to color changes. The state of myoglobin and bound ligand can influence myoglobin stability and reducing compounds can improve the color stability of fresh meat. The objective was to determine effects of myoglobin (nitrosyl or nitrosylmet) state and reducing compounds on color stability in HPP treated ground beef.

**Materials and Methods:** Boneless USDA Select beef top rounds were ground and mixed with cure ingredients, such as, sodium nitrite or celery juice powder and packed under vacuum (VP) or oxygen permeable wrap (OPW) to achieve nitrosylmyoglobin or nitrosylmetmyoglobin. Additionally, reducing compounds (sodium erythorbate or cherry powder) were added to selective treatments.  
T1: Sodium nitrite 156 ppm / VP  
T2: Sodium nitrite 156 ppm + sodium erythorbate 547 ppm / VP  
T3: Celery juice powder (equivalent to 100 ppm nitrite) / VP  
T4: Celery juice powder (equivalent to 100 ppm nitrite) + cherry powder (equivalent to 469 ppm ascorbic acid) / VP  
T5: Sodium nitrite 156 ppm / OPW  
T6: Sodium nitrite 156 ppm + sodium erythorbate 547 ppm / OPW.

After 48 hours, T5 and T6 were VP just prior to HPP treatment. To each of the treatments above, patties were subjected to HPP treatments: no HPP treatment, 600 MPa for 3 minutes, 600 MPa for 6 minutes, and 450 MPa for 3 minutes. Patties placed in dark stored at 4°C throughout the study. Color was measured (CIE L*, a*, b*, DE) through the vacuum pouch before HPP and on days 3, 7, 12, 14, 19, and 21 storage after HPP. Three independent replications were manufactured on separate days. Statistical analysis (SAS GLIMMIX) was run to see the main effects of ingredient treatment and HPP treatment and their interactions within each day of storage. Means separation was conducted for significant effects (*P* < 0.05) using the Tukey adjustment.

**Results:** Regardless of ingredient treatment (T1-T6), HPP had a detrimental effect on the color of the beef patties with all three pressure and time combinations. Lightness (L*) increased (*P*<0.001), a* decreased (*P*<0.001), b* increased (*P*<0.001) after HPP. Color change (DE) with respect to non-HPP treated samples was similar for all three HPP treatments. The effect remained the same throughout the course of the study. However, the redness after HPP was retained better by samples treated with reducing agents (T2, T4, T6) than those without reducing agents (T1, T3, T5). Both inorganic and natural sources of nitrite and reducing agents (T1 vs T3 and T2 vs T4) performed similarly to maintain the redness (*P* > 0.05). Nitrosylmetmyoglobin states (T5 and T6) had less change in redness (*P*<0.001) as compared to nitrosylmyoglobin states (T1 and T2) and this pattern became more profound during storage.

**Conclusion:** While the addition of nitrite compounds to ground beef did not stabilize color during HPP treatment, reducing compounds may lessen the color change associated with HPP treatment of ground beef.

**Keywords:** Colorimetry, High pressure processing, Raw ground beef
Meat and Poultry Processing, Ingredient Technology and Packaging

47: IMPROVEMENT OF RAW MEAT QUALITY AND PROTEIN FUNCTIONALITY USING HOT-BONED, QUARTER-SECTIONED AND CRUST-FREEZE-AIR-CHILLING(HB-¼CFAC) AND COLD-BATTER MINCING TECHNOLOGY

H. C. Lee1 2,*, P. Singh2, M. M. Metheny1, G. Strasburg2, B. P. Marks3, I. Kang1
1Animal Science, California Polytechnic State University, San Luis Obispo, 2Food Science and Human Nutrition, 3Biosystems Engineering, Michigan State University, East Lansing, United States

Objectives: Cold-batter mincing is an emerging technology that can be used to extract muscle protein without loss of protein functionality. The purpose of this study was to evaluate the combined effects of cold batter mincing and hot-boning, quarter sectioning and crust-freeze air chilling (¼CFAC) on raw meat quality and protein functionality of turkey breast fillets (Pectoralis major). The fillets of ¼CFAC were obtained after air chilling the fillets (hot-boned and quarter sectioned) in a freezing room at -12oC.

Materials and Methods: For each of 4 replications, 48 toms were processed traditionally at Michigan State University Meat Processing Center. After evisceration, the turkeys were subjected to: 1) water immersion chilling (WIC), chill boning (CB), and conventional mincing 2) WIC, CB, and cold-batter mincing after ¼CFAC at -12oC (CB-¼CFAC), and 3) hot-boning, quarter-sectioning, and cold-batter mincing after ¼CFAC (HB-¼CFAC). Statistical analysis was conducted using three factorial design (2 x 2 x 3). Data were pooled due to no interaction among factors. Muscle pH was measured after homogenizing 2.5 g meat in 25 ml of iodoacetate solution and R-value was measured using perchloric acid and phosphate buffer solution. Rheological properties was assessed by oscillatory measurements (storage modulus, G') using the ARES rheometer (TA instrument) with 25 mm diameter parallel plate.

Results: After chilling, the pH and R-value of turkey fillets in HB-¼CFAC were higher and lower, respectively, than those of fillets in CB (P < 0.05). During cold-batter mixing in a bowl chopper at 4,000 rpm, the batter temperature started at sub-zero (-1.5 to 2.1oC), reached 1.5 to 14oC at 6 to 12 min mincing, and ended with 26 to 31oC at 24 min, with high temperatures observed for 2% salt batter than 1% salt batter. During traditional mincing, the batter temperature started at 3 to 4oC, increased by ~10oC every 6 min, and ended with 32 to 35oC with higher temperature seen for 2% salt batter again. Dynamic rheological properties of meat batters indicated that the cold-batter mincing showed elevated G' than traditional mincing regardless of mixing time, indicating that gel-setting temperature was reduced in the cold-batter mincing over the conventional mincing potentially due to the less protein denaturation or protein structural change in a different way. After cooking, higher cooking yield and better protein functionality were observed in the cold-batter mincing especially at 6 min (P < 0.05).

Conclusion: These results indicated that the technology of HB-¼CFAC produced superior raw meat quality and the combination of cold batter mincing and HB-¼CFAC technologies improved protein gelation at 6 min where the batter temperature was not higher than 1.5oC.

Keywords: Cold-batter-mincing, Crust-freezing-air-chilling, Hot-boning, Meat quality and protein functionality, Quarter-sectioning
Objectives: There is increasingly a demand for affordable, all-natural products in the food service industry. The objective of this study is to evaluate a blend of clean label functional ingredients for use in an affordable smoked sausage for food service.

Materials and Methods: Researchers at Auburn University used texture profile analysis (TPA) and consumer sensory panels to evaluate sausages made with three blends of oat fiber (OF) and modified corn starch (MCS) over 4 weeks of storage. All sausages were made with mechanically separated chicken (MSC; 0.0625% NaNO₂, 1.75% salt) in a hog intestine casing. Treatments included a positive control (0.43% sodium phosphate), negative control (no sodium phosphate, OF, or MCS), 90:10 blend (3.15% OF, 0.35% MCS), 50:50 blend (1.75% OF, 1.75% MCS), and 10:90 blend (0.35% OF, 3.15% MCS). All treatments included 18% water, 1.7% seasoning, 1.3% vinegar, and 0.5% salt. Two trials were conducted to evaluate the treatments. Sausages were formulated and then cooked in a smokehouse in two batches, dividing by trial, in which every treatment was equally represented and uniformly positioned. Five sausages were selected randomly from each treatment for each trail for sensory and 1 sausage was randomly selected for TPA. Following cooking and chilling, sausages were vacuum sealed and stored at 1°C ± 2°C in a cardboard box. Three sensory sausages were reheated in an oven to 79.4°C, cut into 2.54 cm segments, and cut in half lengthwise for sensory analysis while the remaining two were evaluated for objective color and pH using a Hunter Colorimeter and a pH Stab probe. Treatments were given a unique, random 3-digit code. Thirty consumer sensory panelist evaluated juiciness, cohesiveness, flavor, texture, and overall acceptability on a 9-point rating scale. TPA analysis indicates numerous significant (P≤0.05) week by treatment interactions for OF:MCS blends for all parameters measured. All treatments experienced an increase in pH between weeks 0 and 1 and a decrease between weeks 2 and 3. No differences (P>0.05) were observed for a* over weeks. L* and b* showed differences (P≤0.05) over weeks.

Conclusion: Sensory properties of the 90:10 and 50:50 blend were lower than other treatments, but the 50:50 blend performed that best for TPA analysis. Further research evaluating the sensory, texture, pH, and color parameters is needed across an additional 9 weeks of product storage in order to make recommendations on the best blend of OF:MCS for an optimal product.

Keywords: Mechanically Separated Chicken, Modified Corn Starch, Oat Fiber
Objectives: Low cost Bologna type product reaches high production volumes in Brazil and is marketed at ambient temperature. Previous studies including challenge test with Clostridium sporogenes PA 3679 indicated that water activity (aw) up to 0.96 prevented spores germination. The objective of this study was to evaluate the efficacy of potassium sorbate addition (0.25%) on limiting germination of Clostridium sporogenes PA 3679 in low cost Bologna type product formulated with aw 0.96 and 0.965 during 90 days storage at 27°C.

Materials and Methods: The experiment comprised four treatments formulated with mechanically deboned chicken meat (60%), edible offal (2%), pork skin (8%), 80/20 pork trimmings (15%), water (4%), texturized soy protein (3.5%), tapioca starch (5%), 150ppm ingoing sodium nitrite, 500ppm sodium isocorbate, 0.15% sodium acid pyrophosphate and 0.35% sodium tripolyphosphate. The amount of sodium chloride varied in order to achieve the desired aw (0.96 and 0.965). Potassium sorbate was added at 0.25% in the final product. Raw material was comminuted in a bowl chopper. The raw batter was vacuum stuffed in 60mm PVDC impermeable casing. The samples were cooked in a cooking chamber with direct steam until 75°C was reached in the center of the product. Cooling was performed in running tap water until 27°C and the samples were kept in a chamber at 27°C (±2°C) during 90 days. Lactic acid bacteria, Enterobacteriaceae, mesophilic aerobic, sulphite-reducing clostridia (spores and vegetative cells) counts, residual nitrite and pH value were evaluated in three samples of each treatment 24h after processing and at 15, 30, 60 and 90 days. Data (log CFU/g, residual sodium nitrite and pH value) were analyzed using GLM model procedure of SAS as a 2 aw (0.96, 0.965) X 2 potassium sorbate amounts (0, 0.25%) X 5 storage time (0, 15, 30, 60, 90) factorial design with repeated measurements. Interactions and main effects were considered significant at p<0.05. Least square means for significant effects (p<0.05) were separated by Tukey’s test.

Results: Lactic acid bacteria and Enterobacteriaceae counts were below 1 Log CFU/g during shelf life for all treatments. There was a significant effect (p<0.05) of the interaction aw X sorbate X storage on mesophilic aerobic and sulphite-reducing counts (spores and total) and residual nitrite concentration. It was observed that sorbate addition prevented mesophilic aerobes growth and sulphite-reducing clostridia spores germination during 90 days storage at aw 0.96 and during 60 days at aw 0.965. Regarding residual nitrite, the addition of potassium sorbate decreased nitrite depletion at both water activities until 30 days and marked difference has been perceived at 0.965.

Conclusion: Addition of potassium sorbate may enhance microbial stability of this type of emulsified product and prevent spores germination during storage at ambient temperature. The amount of sodium in the product due to its high amount of sodium chloride required to reach 0.95 may be reviewed especially after other experiments including other shelf life enhancers such as sodium or potassium lactate which are effective at inhibiting different microorganisms.

Keywords: Bologna, Clostridium sporogenes PA3679, Residual nitrite, Sorbate
Objectives: A need exists for a better on-line evaluation method for pork quality. Raman spectroscopy evaluates structure and composition of food samples, with advantage of being portable, non-invasive and insensitive to water. The objectives of this study were to evaluate the correlation between Raman spectral (RS) data measured from fresh and aged pork with sensory characteristics and slice shear force (SSF), to develop classification models for prediction of fresh pork sensory.

Materials and Methods: Eight hundred pork loins, from 4 plants, were removed from the carcass at 24 h postmortem and selected based on color and marbling. Six hundred loins from 3 plants were subjected to onsite RS measurements in which the ventral side of each loin was scanned with RS for 6 seconds. All loins were then transported to USMARC and held for 14 days at 0˚C. The aged loins were cut into 2.54 cm chops for RS, SSF and sensory analysis. For the sensory analysis only 75 loins from each plant were chosen. One chop for RS measurements and two for sensory were vacuum packed and transported to ISU Labs. At 14 d, the chops (cross section) were scanned under same conditions. SSF on 800 samples was determined following Wheeler et al., 2005. Sensory tenderness was evaluated by a trained sensory panel (n=10). All spectral data were analyzed using R and Matlab. Support Vector Machine was used to develop the classification model, where 300 pork loin samples were divided into groups according to the percentile (25%) of values of sensory tenderness or SSF.

Results: A weak correlation ($R^2=0.20$) between SSF and sensory tenderness was obtained using a least square regression model. The prediction accuracies for d15 postmortem samples are significantly higher than that for d1 postmortem samples, both for tenderness scores and SSF values (Table 1). These observations strongly suggest that aging of the meat samples from day 1 to 15 has significantly affected their chemical properties that are directly correlated to their tenderness. For d15 postmortem samples however, a substantial improvement in classification accuracies for the four quality grade groups was observed. In general, pork samples that belong to the medium quality category are more difficult to predict based on their Raman spectroscopic characteristics.

Table 1. The average accuracies for classifying pork Raman spectra into 4 groups based on percentiles.

<table>
<thead>
<tr>
<th>Grouping</th>
<th>1st 25% percentile</th>
<th>2nd 25% percentile</th>
<th>3rd 25% percentile</th>
<th>4th 25% percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 postmortem tenderness</td>
<td>76.3%</td>
<td>62.4%</td>
<td>67.7%</td>
<td>68.6%</td>
</tr>
<tr>
<td>D15 postmortem tenderness</td>
<td>93.5%</td>
<td>90.1%</td>
<td>92.2%</td>
<td>95.5%</td>
</tr>
<tr>
<td>D1 postmortem SSF</td>
<td>76.1%</td>
<td>73.5%</td>
<td>72.6%</td>
<td>69.9%</td>
</tr>
<tr>
<td>D15 postmortem SSF</td>
<td>92.8%</td>
<td>93.1%</td>
<td>96.7%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Conclusion: It was demonstrated that sensory attributes of pork loins are moderately correlated to their Raman spectroscopic characteristics. The classification model developed yielded moderate performance in identifying pork loins that belong to extreme categories of sensory quality (i.e., superior and inferior) in freshly cut loins. The spectra obtained from aged samples showed a more
accurate classification. Raman spectroscopy, in combination with performance-enhancing data processing and multivariate statistical discriminant modeling, has the potential to become a rapid on-line screening tool for the pork producers to quickly select meats with superior quality and/or poor quality to better serve customers. This project was funded in parts by a grant from the National Pork Board. The scholarship for the first author was granted by CNPq-Brazil.

**Keywords:** on-line data collection, pork quality, Raman spectral, support vector machine, tenderness prediction
Meat and Poultry Quality

51: IMPACT OF LIGHT EMITTING DIODES (LED) ON BEEF STEAKS FROM THE TRICEPS BRACHII; A COLOR LABILE MUSCLE

J. V. Cooper1,*, S. P. Suman2, B. R. Wiegand1, Z. D. Callahan1, L. Schumacher3, C. L. Lorenzen1

1Division of Animal Sciences, University of Missouri, Columbia, 2Department of Animal and Food Sciences, University of Kentucky, Lexington, 3Agricultural Systems Management, University of Missouri, Columbia, United States

Objectives: Color of fresh beef is one of the economically important attributes and purchasing decision factors for consumers in a retail setting. The objectives of this study were to evaluate the impact of modern light sources on surface color and lipid oxidation of fresh beef steaks from the Triceps brachii (TB) over retail display time.

Materials and Methods: Steaks from the TB [low oxidative and color stabilities] (n=20) were packaged on Styrofoam trays and overwrapped with oxygen permeable polyvinyl chloride. Steaks were then assigned to one of three lighting treatments (High UV fluorescent [HFLO], low UV fluorescent [FLO], and light emitting diode [LED]) within temperature controlled deli cases between 2 - 3 °C. Steaks were removed on retail display days 1, 3, 5, and 7 for objective color determination, surface myoglobin redox forms, metmyoglobin reducing activity, and lipid oxidation levels. Objective color (L*, a*, and b*) values were determined utilizing a Hunter MiniScan. Following objective color determination, relative proportions of myoglobin redox forms were determined as a measure of myoglobin oxidation. Total myoglobin concentration and metmyoglobin reducing activity (MRA) assays were performed on fresh meat samples. In addition, lipid oxidation was determined by quantification of thiobarbituric acid reactive substances (TBARS). Statistical analysis was analyzed using the GLIMMIX function of SAS.

Results: Objective color measurements for redness, as indicated by a* values decreased daily (P < 0.05) for steaks produced from the TB with values of 22.14, 17.73, 15.72, and 13.49 for days 1, 3, 5, and 7 respectively. Light treatment also changed a* values for steaks with HFLO treated steaks having higher (P < 0.05) a* values than steaks treated with both FLO and LED light sources. Surface oxymyoglobin (MbO2) contents were higher (P < 0.05) for steaks from the TB treated with HFLO lights than those treated with FLO (days 3 and 7) or LED (days 5 and 7) lights. Steaks treated with HFLO lights had less (P < 0.05) metmyoglobin (MMb) than those treated with both FLO and LED lights on retail display days 5 and 7. On day 7 of retail display, steaks treated with HFLO light sources had lower (P< 0.05) TBARS values than those treated with FLO or LED light sources.

Conclusion: Data indicate that muscles with low oxidative and color stabilities, such as TB, are impacted by modern lighting technologies such as LED light sources.

Keywords: color, light, myoglobin, oxidation, triceps brachii
Objectives: Consumer beef purchasing decisions are heavily influenced by color, which is used as an indicator of fresh meat quality in a retail setting. The objectives of this study were to evaluate the impact of different light sources on surface color and lipid oxidation of fresh beef steaks from the Semimembranosus (SM; beef muscle with high oxidative and color stabilities) over retail display time.

Materials and Methods: Steaks from the SM (n=20) were packaged on Styrofoam trays and overwrapped with oxygen permeable polyvinyl chloride. Steaks were then assigned to one of three lighting treatments (High UV fluorescent [HFLO], low UV fluorescent [FLO], and light emitting diode [LED]) within temperature controlled deli cases between 2 - 3 °C. Steaks were removed on retail display days 1, 3, 5, and 7 for objective color determination, myoglobin concentrations, metmyoglobin reducing abilities, and lipid oxidation levels. Objective color ($L^*$, $a^*$, and $b^*$) values were determined utilizing a Hunter MiniScan. Following objective color determination, relative proportions of myoglobin redox forms on the surface were determined as a measure of myoglobin oxidation. Total myoglobin concentration and metmyoglobin reducing activity (MRA) assays were performed on fresh meat samples. In addition, lipid oxidation was determined by quantification of thiobarbituric acid reactive substances (TBARS). Statistical analysis was analyzed using the GLIMMIX function of SAS.

Results: Redness, as indicated by $a^*$ values differed (P < 0.05) for steaks treated with all light sources, with HFLO > FLO > LED. The $a^*$ values decreased (P < 0.05) over retail display days. These data indicated that HFLO treated steaks retained greater amounts of redness compared FLO and LED treated steaks and that loss of redness occurs over retail display. Steaks treated with both HFLO and FLO light sources had greater (P < 0.05) surface oxymyoglobin (MbO$_2$) contents than those treated with LED lights, indicating that LED treated steaks exhibited a less desirable color than its HFLO and FLO counterparts. Values for MbO$_2$ were lower (P < 0.05) on day 7 of retail display indicating that steaks produced from the SM discolored as retail display time increased. Metmyoglobin (MbM) content increased over retail display with LED treated steaks having greater (P < 0.05) amounts of MbM than steaks treated with HFLO and FLO light sources. By day 7 of retail display, HFLO treated steaks had less (P < 0.05) MbM than both FLO and LED treated steaks. Light source did not influence lipid oxidation in SM steaks. On the other hand, TBARS increased (P < 0.05) daily during the retail display indicating that increased retail display time increases lipid oxidation.

Conclusion: The findings suggested that the use of HFLO bulbs for retail display of SM steaks increases the bright red color retention compared to FLO and LED lighting.

Keywords: color, light, myoglobin, oxidation, semimembranosus
Objectives: Mixed pastures containing grass and legumes provide higher nutritional values to steers when compared to grass only. Additionally, cattle finished on pasture with grain supplementation show improved growth performance and better carcass traits when compared to grass-fed finished cattle. In this study we evaluated the effects of finishing diets based on legume and grass mixed pasture, mixed pasture and corn supplementation, and only corn on carcass traits of steers.

Materials and Methods: A total of 18 British and Zebu cross steers were randomly assigned to one of three dietary treatments consisting of grazing in pasture of oats, ryegrass, white and red clover (PAST); grazing in PAST plus whole corn grain supplementation (1.4% of body weight, SUPP); and feedlot-finishing with whole corn grain (2.8% of body weight, whereas 85% was corn and 15% protein-mineral-vitamin supplement, GRAIN). Steers finished on PAST and SUPP were individually allocated in 12 paddocks whereas steers finished on GRAIN were assigned to 6 individual pens. Steers were fed for 91 d before harvesting at a commercial abattoir. Data collected in this experiment included body weight at slaughter (kg), hot carcass weight (kg), carcass shrink (%), dressing percentage (%), KPH (%), fat thickness between the 12th and 13th ribs (mm), ribeye area (cm²), and marbling score (1=devoid and 10=abundant). Carcass sides were fabricated into 3 primals including the forequarter with 5 ribs (FOR), pistola hindquarter, which included the round and loin (PIH), and a combination of cuts (FRNB) including flank, lateral portion ribs, end portion of the navel, and brisket. Data was analyzed as CRD by using PROC GLM of SAS.

Results: Dietary treatments did not affect body weight at slaughter ($P = 0.165$), hot carcass weight ($P = 0.169$), carcass shrink ($P = 0.329$), dressing percentage ($P = 0.730$) and ribeye area ($P = 0.630$). Values of fat thickness and KPH were significant higher in carcasses from steers finished on GRAIN when compared to steers finished on PAST (5.95 mm and 4.11 mm; and 2.32% and 1.53%, for GRAIN and PAST, respectively). Treatments GRAIN and SUPP provided better marbling deposition on the ribeye when compared to PAST ($P = 0.023$). No significant differences were observed for yields of FOR and PIH ($P = 0.654$ and $P = 0.476$, respectively). However, carcasses from steers fed GRAIN showed higher yield values for FRNB when compared to carcasses from steers fed PAST (16.71% and 14.92%, respectively; $P = 0.017$).

Conclusion: Finishing steers on legume and grass pastures with corn supplementation (SUPP) leads to similar marbling deposition on ribeyes when compared to feedlot finishing with corn (GRAIN). Overall, finishing steers on legume and grass pastures (PAST) led to similar yields of end and middle cuts when compared to SUPP and GRAIN. Although SUPP and GRAIN diets provided better marbling deposition, finishing steers on legume and grass pastures still provide carcass yields that are acceptable for the Brazilian market.

Keywords: Carcass traits, Corn-fed, Grass-fed, Legume, Mixed pasture
Objectives: Fresh meat color critically influences the consumers’ purchase decisions at the point of sale. Color and color stability of fresh red meats are muscle-dependent. While muscle-specific color stability has been studied extensively in livestock, scientific information on this aspect is non-existent in game species. Springbok (*Antidorcas marsupialis*) is a prominent South African game species that has significant potential in meat production. Our objective was to characterize the color stability of three economically important muscles (i.e., infraspinatus, IS; longissimus lumborum, LL; and biceps femoris, BF) in springbok carcasses.

Materials and Methods: The muscles (IS, LL, and BF) were removed from both sides of six (n = 6) male springbok carcasses 24 h post-mortem, vacuum-packaged, and stored at 2°C. After 48 h, each muscle was fabricated into 2.5-cm steaks. The steaks were placed in trays, aerobically over-wrapped, and stored at 2°C for eight days. Meat pH, instrumental color (*L*, *,a*, and *,b* values), color stability (R630/580; ratio of reflectance at 630 nm and at 580 nm), surface myoglobin redox forms, metmyoglobin reducing activity (MRA), and lipid oxidation (TBARS) were measured on 0, 1, 2, 4, 6, and 8 days. Data were analyzed using mixed model repeated measures ANOVA, with carcass as random effect, and muscle and storage time as fixed effects.

Results: Throughout the storage, the IS steaks demonstrated greater (*P* < 0.05) pH than the LL and BF steaks. IS exhibited the greatest (*P* < 0.05) *L* values (lightness), whereas LL had the lowest (*P* < 0.05) *L* values. IS also exhibited greater (*P* < 0.05) *a* values (redness) than LL and BF throughout the storage. While IS steaks exhibited no changes (*P* > 0.05) in *a* values during the storage, LL and BF demonstrated a decline (*P* < 0.05) in *a* values. In addition, IS demonstrated greater (*P* < 0.05) *b* values (yellowness), R630/580, and MRA, than the LL and BF counterparts. Furthermore, surface metmyoglobin content and lipid oxidation were lower (*P* < 0.05) in IS than in LL and BF.

Conclusion: The results suggested that springbok IS muscle is more color-stable than their LL and BF counterparts. The game meat industry may employ muscle-specific strategies for processing and marketing fresh meat from springbok.

Keywords: Color stability, Game meat, Springbok
Meat and Poultry Quality

55: FATTY ACIDS PROFILE AND QUALITY ATTRIBUTES OF BEEF FROM STEERS FINISHED ON LEGUME AND GRASS PASTURE

A. P. B. Fruet 1,*, F. S. Stefanello 1, F. Trombetta 1, A. N. Motta de Souza 2, A. G. Rosado, Jr. 3, C. J. Tonetto 3, A. S. De Mello 4, J. L. Nörnberg 1

1Science and Food Technology, 2Polytechnic School, Federal University of Santa Maria, Santa Maria, 3Farroupilha Federal Institute, São Vicente do Sul, Brazil, 4Agriculture, Nutrition, and Veterinary Sciences, University of Nevada, Reno, United States

Objectives: Feeding legume and grass can alter fatty acids profile and quality characteristics of pasture-finished beef. Therefore, the objective of this study was to compare finishing beef steers on mixed legume-grass pastures to feeding a high-energy supplement to grazing steers and feeding a high-concentrate diet on fat content, fatty acids profile, lipid oxidation, objective color, texture, and WBSF of beef.

Materials and Methods: British x zebu-cross steers (n=18) were assigned randomly to 1 of 3 dietary treatments: 1) grazing pastures comprised of oats, ryegrass, white and red clover (PAST); 2) grazing the mixed legume-grass pastures and supplementing steers (1.4% BW) with whole corn (SUPP); or 3) limit-feeding (2.8% BW) an 85% whole corn finishing diet (GRAIN). All steers were slaughtered after the 91-d feeding trial, and boneless ribeye rolls were removed from left sides 24 h of chilling, and subsequently cut into 2.54-cm-thick steaks that were individually vacuum packaged and frozen at -20°C for 20d. Analyses included proximate composition (g/100g), cholesterol (g/100g), fatty acids profile (g/100g FAME), cooking loss (%), shear force (N), and texture profile. Five steaks were thawed and displayed at 4 °C for 13 days to evaluate objective color (L*, a*, b*). TBARS (mg MDA/kg meat) were quantified on days 1, 4, 7, 10, and 13 d. Data were analyzed as a CRD. Days of display and oxidation were analyzed as repeated measures. MIXED and GLM procedures of SAS were used and when significance (P ≤ 0.05) was identified by ANOVA.

Results: Finishing steers on GRAIN led to higher fat content (P = 0.002) and lower moisture values (P < 0.001) when compared to PAST. Dietary treatments did not affect crude protein (P = 0.99) and cholesterol values (P = 0.13). The LT from PAST- and SUPP-fed steers had greater proportions of n-3 PUFA and 18:2cis-9, trans-11 CLA than the LT from GRAIN-fed steers; however, LT of GRAIN steers had greater (P < 0.001) n-6/n-3 ratio (8.86%) than the LT from either SUPP-fed (2.65%) or PAST-fed steers (1.91%). Although steers fed GRAIN had greater (P = 0.002) proportions of MUFA than PAST, proportions of PUFA and SFA were similar (P > 0.05) among dietary treatments.

No treatment effect was observed for L*, cooking loss, WBSF, and texture profile attributes, except for cohesiveness (higher from PAST and SUPP samples than for GRAIN samples, P = 0.002). Lipid oxidation was significant higher on beef from steers fed GRAIN than beef from SUPP and PAST (P < 0.001). Steaks from steers fed PAST and SUPP were redder after 10 and 13d of display than steaks from GRAIN-fed steers, and steaks from PAST and SUPP differed after 13d of display (P < 0.001). Although yellowness decreased during retail display (P < 0.001), dietary treatments did not influence b* values (P = 0.051).

Conclusion: Beef finished on GRAIN had higher values of n-6/n-3 ratio and increased lipid oxidation. Higher proportions of PUFA found in beef from steers finished on mixed pasture (PAST) and supplemented with corn (SUPP) did not affect lipid and color stability of beef, possibly due to natural antioxidants found in legume-grass mixtures. Dietary treatments did not influence texture, tenderness, and cholesterol values. Beef from steers finished on legume and grass pasture (PAST) showed similar attributes when compared to beef from steers finished with corn supplementation (SUPP).

Keywords: Beef color, Fatty acids, Legume, Lipid oxidation, Pasture
Objectives: A major challenge facing the turkey industry continues to be the Pale Soft Exudative (PSE) syndrome. The PSE turkey meat problem is most evident as poor protein extractability and gelation in processed meat products. PSE development is generally thought to result from an unusually high rate of postmortem glycolysis causing a rapid drop of pH while the temperature is still warm, resulting in denaturation of meat proteins. However, the specific mechanism underlying the accelerated postmortem metabolism is still poorly understood. Recent studies from our laboratory have shown that expression of the pyruvate dehydrogenase kinase isozyme 4 (PDK4) gene and the PDK4 protein are dramatically downregulated in PSE turkey. PDK4 serves as a modulator of glycolytic metabolism by regulating pyruvate dehydrogenase (PDH) activity. Phosphorylation of PDH by PDK4 results in inactivation of PDH with a shift to anaerobic metabolism and lactate production. A crucial first step in defining the specific mechanism by which PDK4 expression could affect development of PSE muscle is the quantification of PDH levels in normal and PSE samples. In this study, we test the hypothesis that PDH levels are not different between meat samples characterized as normal or PSE.

Materials and Methods: Randombred Control Line 2 turkeys (n=20), representing the turkey of the 1960s maintained without selection pressure were raised to 22 weeks of age, and slaughtered and processed according to industry standards. Muscle samples from pectoralis major were collected at 5 min postmortem, cut into small pieces, snap frozen in liquid nitrogen and stored at -80°C until further use. Breast muscle samples were classified as normal or PSE based on marinade uptake at 24h postmortem, with high uptake for normal and low uptakes for PSE. To quantify PDH levels, frozen muscle samples (6 normal and 6 PSE) were pulverized and extracted with cell lysis buffer supplemented with protease and phosphatase inhibitors. Following centrifugation to remove insoluble material, proteins of the supernatants were separated by SDS-PAGE and analyzed by western blotting using a polyclonal antibody for human E1 component subunit alpha-PDH, and a monoclonal antibody to chicken beta-actin was used as a loading control. Following immunoblotting, the membrane was analyzed using the Odyssey Imaging System (Licor) using fluorescent secondary antibodies.

Results: Imaging of the membrane revealed that there was no significant difference (P=0.24) in PDH abundance between normal and PSE meat samples.

Conclusion: These results suggest that variation in PDH abundance does not contribute to the development of PSE meat. Taken together with the previous observation that PDK4 levels are decreased in PSE muscle, the results suggest that the phosphorylation state of PDH may be a determinant of whether a muscle is likely to become PSE.

Keywords: PSE, Pyruvate Dehydrogenase, Pyruvate Dehydrogenase Kinase 4, Turkey
Meat and Poultry Quality

57: THE EFFECT OF ANIMAL AGE ON COOKED LAMB FLAVOR AND OFF FLAVOR INTENSITY IN THE LONGISSIMUS DORSI, GLUTEUS MEDIUS, AND GROUND SHOULDER PATTIES FROM WETHER LAMBS

H. Garza 1, J. R. Jaborek 1, L. G. Garcia 1
1Animal Science, Ohio State University, Columbus, United States

Objectives: Consumer acceptance of meat is dependent on three main factors: tenderness, flavor and juiciness. In 2017, lamb flavor continues to be seen by many American consumers to be unpleasant due to the species specific flavor profile of cooked lamb meat. As animals age and fat levels increase, flavors intensify. Would comparing younger lambs to older lambs, within the same lamb group (< 12 mo.) be more beneficial in regards to flavor intensities in lamb? Therefore, the objective of this study is to clearly define lamb flavor, and off flavor intensities of three ovine muscle cuts by studying age at time of harvest from wether lambs.

Materials and Methods: The Longissimus dorsi thoracis (LD), Gluteus medius (GM) and boneless square cut shoulder were collected from light weight five month old (n=8; 32.3 kg), and heavy weight twelve month old (n=8; 58.4 kg) wether lambs. Color values: L* (lightness), a* (redness), and b* (yellowness) were measured on Longissimus dorsi thoracis chops using a Minolta colorimeter. Muscle pH values was determined from a sample of the LD with the use of a bench top pH probe. Percent lipid concentration of the LD and ground shoulder were determined by similar procedures used by Fisher et al. (2013) with the use of soxhlet extraction. Muscle cuts were cooked using a clam shell grill, reaching an end temperature 65 °C, while ground shoulder patties were cooked to 71.1 °C. Consumer panelists were asked to rate lamb flavor and off flavors intensity for each sample using a 0-100 scale, with 0 being mild flavor and 100 being very intense flavor. Data was analyzed using a PROC MIXED model and LS means in SAS. Data was considered significant at P < 0.05.

Results: Lambs at twelve months of age had heavier carcass weights (P < 0.01) than lambs at five months of age. Twelve month heavy weight lambs possessed a larger ribeye (P < 0.05) and had an increase in back fat and body wall thicknesses (P < 0.01) when compared to five month, light weight lambs resulting in higher yield grades. No color differences (P > 0.05) were observed between treatments. Twelve month old lambs had greater total lipid concentrations (P < 0.05) in the Longissimus dorsi thoracis (P < 0.01) and ground shoulder samples (P < 0.05) than five month old light weight lambs. Consumer panelists reported a more intense lamb flavor (P < 0.05) and off flavor (P < 0.05) in the Longissimus dorsi thoracis from twelve month old lambs when compared with five month old lambs. However, there were no differences (P > 0.05) between five and twelve month old lamb flavor and off flavor intensities in Gluteus medius and shoulder patty samples.

Conclusion: Upon reviewing the data, it is speculated that lambs harvested at twelve months of age possessed greater lamb and off flavor intensities when compared with five month old lambs. Therefore, consumers who desire a more mild flavor lamb product should attempt to purchase younger lambs, while consumers who prefer more intense lamb flavor would choose older lamb. However, further investigations are required to prove this.

Keywords: eating quality, lamb flavor, lamb off flavor
Meat and Poultry Quality

58: IMPROVING SHELF LIFE OF FRESH BISON STEAKS TREATED WITH OREGANO AND ROSEMARY ESSENTIAL OILS

V. Sood1,*, W. Tian1, C. Narváez-Bravo1, S. D. Arntfield1, A. Rodas-González1

1Department of Food Science, University of Manitoba, Winnipeg, Canada

Objectives: Bison meat color is dark, consistently unstable and discolours rapidly under aerobic packaging during retail display. Consequently, it is important to explore available technologies for use in bison meat which might be successful in improving shelf-life attributes. This study was conducted to examine the effects of essential oils (rosemary and oregano) on color and oxidative stability of bison strip loins in retail display conditions.

Materials and Methods: Strip loins (n=10) from grade A1 bison carcasses were obtained and aged for 7 d at 4 °C. Before injecting the subprimal with essential oils (at 7 d postmortem), an initial steak (2.5 cm thick) was cut from each strip loin for metmyoglobin reducing activity (MRA) and oxygen consumption (OC) analysis. The rest of the loin was cut into three equal portions. Each portion was weighed, pH and temperature were determined and then allotted to 1 out of 3 treatments with essential oils (non-enhanced, 0.05 % rosemary extract and 0.08% oregano extract in the final product at a 10% pump level). Treatments were evaluated for pH, drip loss, MRA, OC, lipid oxidation (TBARS) and color stability (based on instrumental and sensory color measurements) on steaks which were PVC-overwrapped and placed in retail cabinets for five days at 3 °C under LED (light emitting diodes) with intensity 1240 lx.

Results: The pH values were not different among treatments at d 0 and d 4 (P > 0.05); however, the pH of all samples decreased (P < 0.05) by the end of the retail display period. The drip loss was higher in oregano and rosemary than control steaks (P < 0.05). Oregano steaks presented lower OC and higher MRA values than the control and rosemary steaks (P < 0.05), but no difference between the control and rosemary steaks was detected (P > 0.05). Oregano steaks presented a stable red color with less discoloration during the retail display period than the control and rosemary steaks (P < 0.05). These results were in accordance with lightness (L*), chroma (C) and hue (H) results obtained in the instrumental color analysis. With respect to TBARS values, oregano steaks decreased lipid oxidation compared to the control and rosemary steaks (P < 0.05).

Conclusion: These results indicated that the essential oil from oregano can considerably improve color stability of bison steaks due to its antioxidants properties and ability to increase MRA capacity in the bison meat.

Keywords: Bison, Color stability, Essential oils, Oregano, Rosemary
**Meat and Poultry Quality**

59: EFFECTS OF SUPPLEMENTAL DIETARY GLUTAMINE AND ARGININE ON BROILER LIVE PERFORMANCE, BLOOD CHEMISTRY, AND INCIDENCE OF WHITE STRIPING AND WOODEN BREAST

C. Wu¹, G. K. Walker¹, M. Livingston¹, K. Flores¹, M. F. Warren¹, J. Cabanas¹, K. A. Livingston¹

¹Prestage Department of Poultry Science, Raleigh, United States

**Objectives:** The broiler industry has been recently plagued with muscle myopathies, namely wooden breast (WB) and white striping (WS). These myopathies negatively affect the most valuable cut of a broiler, the pectoralis major muscle, whereby there is reduced protein content and increased fat and collagen content, resulting in reduced meat quality and consumer preference. The current cause of WB and WS in broilers is yet to be fully elucidated. One theory is that increased corn prices, availability of distiller’s dry grains with solubles, and other food industry co-products have led to less soybean meal and more synthetic amino acids in broiler diets can result in marginal dietary levels of glutamine (Gln) and amino acids such as arginine (Arg). It was hypothesized that increasing intracellular Gln and Arg may relate to an increased rate of protein synthesis, decreased inflammatory immune responses, a reduction of muscle proteolysis, and consequently a reduced incidence of WB and WS.

**Materials and Methods:** A total of 288 male broiler chicks were allocated to 1 of 4 diets that had 0 or 1% supplemental Gln or 0 or 0.25% supplemental Arg to complete a 2x2 factorial design. Chicks were housed in Alternative Design cages with 8 chicks/cage and 9 replicates/treatment. Individual body weights (BW) were recorded weekly, blood chemistry was analyzed at 28 and 41 d using iStat, and 2 birds/pen were scored for WB and WS after being harvested at 42 d of age. Shear force, drip loss, cook loss, and meat pH were then evaluated. Data were analyzed using PROC GLM and PROC MIXED on SAS ®.

**Results:** There were no differences among feed conversion ratio, BW, or WS. Total carbon dioxide, partial pressure of oxygen, and pH of the blood at 28 d were reduced by supplementing Gln at 1% (P<0.05). Similarly, the base excess extracellular fluid and potassium of the blood at 28 d were reduced by supplementing Gln at 1% (P<0.01). Broilers fed diets with Arg or Gln alone exhibited significantly greater WB incidence when compared to those fed the control (0% Gln and 0% Arg) or combined interaction levels of 1% Gln and 0.25% Arg (P<0.05).

**Conclusion:** These data demonstrated that Gln and Arg were able to reduce the incidence of WB when supplemented simultaneously as opposed to individually in broiler diets.

**Keywords:** amino acids, blood, broilers, meat quality, Wooden breast
Meat and Poultry Quality

60: EFFECTS OF PRE-RIGOR DEBONING AND VACUUM STORAGE ON SENSORY ATTRIBUTES OF COOKED BEEF SAUSAGE

A. Theradiyl Sukumaran1,*, A. J. Holtcamp1, Y. L. Campbell2, M. Wes Schilling2, T. T. N. Dinh1

1Animal and Dairy Sciences, 2Food Science, Nutrition, and Health Promotion, Mississippi State University, Starkville, United States

Objectives: The objective of this study was to evaluate effects of pre-rigor deboning and vacuum storage on quality characteristics of sausage batter and cooked beef sausage.

Materials and Methods: Five 24-month-old Holstein steers were slaughtered and the left chuck primals were deboned, coarsely ground through 1.25-cm plate, chilled to 2°C within 15 min of deboning, and salted (1.5%) within 2 h post-mortem (pre-rigor treatment – PRE); whereas the right chuck primals were deboned at 72 h post-mortem (post-rigor treatment – POST), coarsely ground, and stored at 2°C. Ground beef was pre-blended with 0.25% phosphate and other ingredients before being processed into sausage batter on d 6 post-mortem, during which POST meat was salted separately from batter formulation. Sausage batter was stuffed into 32-mm edible collagen casings (DeWied International Inc., San Antonio, TX) and sausage links were cooked to an internal temperature of 73.9°C, vacuum-packaged, and stored for 30, 60, 90, and 120 d at 4°C. Samples of coarsely ground lean (GB), salted lean (SB), batter (BB), and sausage at the end of storage periods were collected, frozen in liquid nitrogen, homogenized into fine powder, and stored at -80°C for chemical analysis. Proximate analysis was conducted using NIR spectrophotometer (FoodScan™ Pro/Lab, Type 7880; Foss, Eden Prairie, MN). Myoglobin forms and surface color were determined by reflectance spectroscopy with illuminant A at 10° angle (MiniScan EZ 4500L, Hunter Associates Laboratory, Inc., Reston, VA). Metmyoglobin reducing activity (µM of metmyoglobin reduced/min/g of muscle) was determined by reacting extracted muscle reductases with equine skeletal metmyoglobin and measuring deoxymyoglobin at 580 nm. Descriptive sensory attributes of cooked sausages were also evaluated. A randomized complete block design with a split-plot in time was analyzed by the GLIMMIX procedure of SAS (SAS Institute Inc., Cary, NC) with 0.05 level of significance unless otherwise noted.

Results: Deboning time had no effect on chemical attributes of sausages, except for pH, which was greater (P < 0.001) for PRE GB (6.8) than for POST GB (5.8). Lightness of BB (52.7) was greater (P = 0.005) than that of GB (47.6); whereas redness was greater (P < 0.001) for GB (27.8) than that for BB (15.3). Percentage of metmyoglobin was greater (P < 0.001) in BB (47.1) than that in GB (31.2); whereas those of deoxymyoglobin and oxymyoglobin were greater (P ≤ 0.007) in GB (8.2 and 60.6) than those in BB (1.5 and 51.3), respectively. Trained panelists did not detect any treatment difference in all sensory attributes, except for saltiness, which was greater (P = 0.053) in POST sausage than in PRE sausage. However, aroma intensity and chewiness were increased (P ≤ 0.019) on d 90 and 120 compared with d 30 and 60; whereas beef complex and umami flavor were decreased (P ≤ 0.060) on d 90 and 120 compared to d 30 and 60. Sweetness and juiciness of sausages were decreased on d 60, 90, and 120 compared with d 30 (P ≤ 0.012). Off-odor intensity and sourness were increased (P ≤ 0.019) on d 90 and 120 compared with d 30 and 60.

Conclusion: These findings indicated that, despite having a greater pH, pre-rigor beef provide no technological advantage to cooked sausage when phosphate was used. Moreover, cooked sausages can be refrigerated in vacuum-package for up to 60 d without deterioration of sensory quality.

Keywords: beef, cooked sausage, descriptive sensory, prerigor
Meat and Poultry Quality

61: THE EFFECTS OF NOVEL ANTIMICROBIALS ON QUALITY AND SHELF-LIFE CHARACTERISTICS OF BLADE TENDERIZED BEEF STRIP LOINS

C. L. Thomas 1,*, A. Stelzleni 1, Y.-C. Hung 2

1Animal and Dairy Science, University of Georgia, Athens, 2Food Science and Technology, University of Georgia, Griffin, United States

Objectives: Beef tenderness is an important palatability attribute relating to consumer satisfaction. To enhance tenderness, and consumer satisfaction, blade tenderization (BT) is commonly employed; however, foodborne outbreaks have been associated with BT products. Application of antimicrobial interventions prior to BT is commonly employed by the meat industry to reduce the inherent risk of BT. As new antimicrobial technologies arise, they must also be tested to ensure quality and shelf life is not compromised. The objectives of this study were to investigate the effects of pulse ultra-violet light (PUV), 5% levulinic acid + 0.5% sodium dodecyl sulfate (LVA+SDS), and electrolyzed oxidizing water (EOW; 50 ppm Cl), on beef strip loin (SL) subprimals prior to BT, and assess their effects on shelf life and sensory characteristics compared to SL treated with 4.5% lactic acid (LA), and no antimicrobial intervention (CON).

Materials and Methods: Whole USDA Choice beef SL (n = 75) of known date were assigned randomly to antimicrobial interventions across three replicates. Pulse UV samples were treated for 15 s at 5.754 J/cm² 6±2 cm from the quartz window. All other treatments were applied to subprimals using a six-nozzle sanitizing cabinet (0.42 L/nozzle·min⁻¹ at 275.79 kPa). After treatment, all SL made a single pass, lean side up, through a mechanical tenderizer (Ross TC700 MC). After BT, SL were vacuum packaged, boxed, and stored (0±1°C) for 7 d. Following storage, subprimals were squared and 2 steaks (2.54 cm) were cut from the anterior face with one designated for Warner-Bratzler shear force and the other for trained sensory analysis. Pulse UV samples were not included in sensory analysis due to the PUV equipment being previously utilized in pathogen studies. After steak removal, roasts (5 cm) were cut for shelf life analysis, packaged in Styrofoam trays with PVC overwrap and randomly assigned to 0, 1, 2, 3, 5, or 7 d of display in open top coffin display cases (0±1.5ºC, two defrost cycle every 24 h) and 24 h lighting (1600 - 2100 lux; 30000K). On each day objective color was measured on d 7 roasts for L*, a*, b*, hue, chroma, and ΔE. Aerobic plate count (APC) and thiobarbituric acid reactive substance analysis (TBARS) were also quantified on d 0, 1, 2, 3, 5, and 7 roasts. Data were analyzed using Proc Mixed (V9.4, SAS Inst.) as a randomized split-plot where subprimal was the whole plot and steak or roast was the subplot. The PDIFF option of least squares means was utilized to test for differences (α≤0.05).

Results: Antimicrobial treatment prior to BT did not (P>0.05) affect objective color measures. However, as display progressed L*, a*, b*, and chroma decreased (P<0.05), while hue and ΔE values increased (P<0.05). As expected, APC increased (P<0.05) with extended display, and, even though APC were similar (P>0.05) among CON (5.64 log CFU/cm²), PUV (5.20 log CFU/cm²), and EOW (5.78 log CFU/cm²), both LVA+SDS- and LA-treated roast had lower (P<0.05) APC than all other treatments (3.49 and 4.33 log CFU/cm² respectively). However, antimicrobial treatments did not (P>0.05) affect lipid oxidation, WBSF, or sensory characteristics.

Conclusion: The results from this study suggest that LVA+SDS could be used as an antimicrobial prior to SL BT without compromising quality or sensory characteristics.

Keywords: Antimicrobial intervention; Blade tenderized; Beef; Shelf life; Tenderness
Meat and Poultry Quality

62: EFFECT OF RADIANT CATALYTIC IONIZATION ON LEAN COLOR AND LIPID OXIDATION OF BEEF

X. Yang 1,*, N. Kalchayanand 2, K. Belk 3, T. Wheeler 2
1Animal Science, University of California Davis, Davis, 2USDA-ARS, Clay Center, 3Colorado State University, Fort Collins, United States

Objectives: The radiant catalytic ionization (RCI) technology utilizes a combination of UV light and low-level oxidizers such as ozone, hydroxyl radicals, and hydrogen peroxide to cause antimicrobial action. There is a potential to use this technology as an antimicrobial intervention against foodborne pathogens for meat. However, the use of UV light and oxidizers may accelerate the oxidation of pigments and lipid components of meat. Thus, the objective of this study was to evaluate the effect of RCI technology on the lean color and lipid oxidation of beef during storage period.

Materials and Methods: A total of 24 pieces of beef flanks (10 x 10 cm) were collected and surface-trimmed for lean color measurement, and another set of 24 pieces of beef flanks (10 x 10) were collected without being trimmed (external fat was left on) for lipid oxidation measurement. Half of each set of samples were exposed to RCI (UV intensity: 0.0042 J/cm^2 x exposure time in seconds, ozone level: 0.2 to 0.3 ppm, hydrogen peroxide: 0.15 to 0.2 ppm) for 75 seconds and the untreated samples were set as control. Samples were stored in Whirl-Pak bags at 4°C in the dark. Objective color and thiobarbituric acids reactive substances (TBARS) analyses were made on 0h, 24h, Day 3, Day 7 and Day 14 of storage on the same pieces of meat. Only lean color were measured, and only surface fat of each meat sample was excised and tested for TBARS analysis.

Results: No interactive effect of treatment and storage time was identified (P > 0.05) on lean color and lipid oxidation. When averaged over all storage times, the lean L* and b* values were higher (P < 0.05) for RCI treated samples than for control samples, indicating that lean of RCI treated samples had a lighter, more yellow appearance. However, no difference (P > 0.05) was detected on lean a* value, suggesting that both control and treated samples appeared to have similar red color. In terms of lipid oxidation, the TBARS values did not differ (P > 0.05) for control and treated samples. Across all samples, the TBARS values increased (P < 0.05) as storage time increased, although the average TBARS value for samples on Day 14 was 0.33 (±0.06) mg malondialdehyde (MDA)/kg, which was lower than the minimal TBARS value for strong off-odor development to reject beef at 2 mg MDA/kg. No interactive effect of treatment and storage time was identified (P > 0.05) on lean color and lipid oxidation. Over all storage times, the lean L* and b* values were higher (P < 0.05) for RCI treated samples than for control samples, indicating that lean of RCI samples had a lighter, more yellow appearance. However, no difference (P > 0.05) was detected on lean a* value, suggesting that both control and treated samples appeared to be similar red color. In terms of lipid oxidation, the TBARS values did not differ (P > 0.05) for control and treated samples. Across all samples, the TBARS values increased (P < 0.05) as storage time increased, although the average TBARS value for samples on Day 14 was 0.33 (±0.06) mg malondialdehyde (MDA)/kg, which was lower than the minimal TBARS value for strong off-odor development to reject beef at 2 mg MDA/kg.
Conclusion: In conclusion, the use of RCI technology under current settings as an antimicrobial treatment, will not cause adverse effect on lean red color or accelerate the lipid oxidation of beef.

Keywords: Beef color, Lipid oxidation, Radiant catalytic ionization
Meat and Poultry Quality

63: EFFECT OF FREEZING (TIME AND TEMPERATURE) AND METHODS OF THAWING IN THE PHYSICOCHEMICAL QUALITY OF BEEF

T. J. Silva 1, C. L. Gomes 2, G. B. Silva 1, H. M. Bolini 2, S. B. Pflanzer 1,*

1Department of Food Technology, 2Food and Nutrition Department, University of Campinas, Campinas, Brazil

Objectives: The aim of this study was to evaluate the effects of freezing temperature and storage time (-10°C or -20°C either by 1 or 3 months) and thawing methods (microwave, 20°C and 4°C) on the physicochemical characteristics of beef.

Materials and Methods: A total of 6 pieces of striploin (3 for each time of storage) were collected directly from the slaughterhouse and sent to the meat lab (48 hours after slaughter). Each piece was cut in 7 steaks of 2.5cm and 7 steaks of 1cm thick. One steak of each thickness was destined for one of 7 treatments: without freezing, plus treatments formed by the combination of two freezing temperatures and 3 thawing methods. Before freezing samples were weighed, vacuum packed and aged 14 days. Samples were frozen until reaching a desired temperature (-10°C or -20°C). The thawing was performed, after 1 or 3 months of storage, in microwave (800W), ambient temperature (20°C) or in refrigerator (4°C), until the samples reached 4°C. After thawing, the samples (2.5cm thick) were analyzed for thawing loss (TL), instrumental color (L*, a*, b*), cooking loss (CL) and shear force (WBSF). The 1.0cm steaks were destined to lipid oxidation (TBAR), moisture and fat contents. Statistical analyses were performed by GLM, with a completely randomized design, in order to determine if there were significant interactions between treatments. The means (±SEM) were tested by Duncan test at 5% significance.

Results: There were no interactions (P>0.05) between sources of variation for any of the traits. The TL (~3.26±0.38%) and lightness (L*) (~37.02±0.70) were not affected neither by the time nor freezing temperature (P>0.05). However, microwave (4.90±0.46%) had greater TL than other thawing methods (~2.44±0.22%), and fresh steaks had higher L* (41.15±1.11) than steaks that received some of the freezing/thawing treatments (~37.02±0.86; P<0.05). Freezing, independent of the temperature and method of thawing, decreased the a* values (18.66±0.55) when compared to fresh meat (23.01±0.55), and lower values were observed for samples stored by 3 months (17.67±0.59) in relation of those stored by 1 month (19.48±0.34). In the same hand, higher time of storage decrease de b* values (19.48±0.34 and 17.35±0.42 for 1 and 3 months, respectively). The moisture content was not affected by freezing time or temperature (P>0.05), but the samples thawed in microwave (72.63±0.38%) presented lower values than other methods (~73.71±0.29, P<0.05). TBAR content of fresh meat (0.06±0.01mgMDA/g) was lower when compared to samples that were frozen/thawed (0.26±0.02mgMDA/g). It was verified that the longer storage time increased the values of TBAR (0.19±0.01 and 0.32±0.01 mgMDA/g, for 1 and 3 months, respectively). CL was not affected neither by time nor temperature of freezing (P>0.05). However, CL was higher in samples thawed at 20°C (22.32±0.34%) and lower in samples thawed in microwave (20.52±0.40%). The fat content (2.65±0.40%) and shear force (3.50±0.14kg) showed no difference between the storage time, freezing temperature and thawing methods. However, fresh meat was tougher (4.33±0.29kg, P <0.05) than all others frozen/thawed samples.

Conclusion: The procedure of freezing/thawing, in general, improved meat tenderness, however, it negatively affected color, and increased the levels of lipid oxidation with longer storage periods. Microwave would not be recommended for thawing due to higher values of exudation.

Keywords: color, freezing time, Lipid oxidation, meat quality, Microwave cooking
Meat and Poultry Quality

64: IMPACTS OF AGING SEQUENCE AND FREEZING RATE ON QUALITY ATTRIBUTES AND OXIDATIVE STABILITY OF FROZEN/THAWED PORK LOINS


1Department of Animal Sciences, Purdue University, West Lafayette, United States, 2Department of Food Science & Biotechnology of Animal Resources, Konkuk University, Seoul, 3Division of Applied Life Science (BK21 Plus), Gyeongsang National University, Jinju, Korea, Republic Of

Objectives: Aging is known to improve quality attributes of frozen/thawed meat by minimizing quality defects, such as purge/drip loss, texture and/or color. In frozen/thawed meat, the extent of quality deterioration is considerably influenced by freezing rate, as it impacts on the size, distribution, and/or location of ice crystals. This, in turn, results in the physicochemical and structural damages to muscle tissue. However, there have been no available literatures on the effect of aging sequence (between aging and freezing/thawing) and freezing rate on frozen/thawed meat quality attributes. Therefore, the objective of this study was to evaluate the combined effects of aging sequence and freezing rate on quality attribute and oxidative stability of frozen/thawed pork loins.

Materials and Methods: At 1 day postmortem, pork loins (M. longissimus dorsi) were removed from one side of 6 carcasses. Each loin was cut into 6 equal-length sections and vacuum-packaged. Then, six treatments, comprised of 3 aging/freezing sequences (freezing/thawing without aging, aging prior to freezing/thawing, or freezing before thaw/aging) and 2 freezing rates (slow vs. fast), were randomly assigned to the loin sections. Slow-freezing was conducted in a commercial -20 °C blast freezer, whereas fast-freezing was performed in a liquid nitrogen cabinet (-80 °C). Aging of the loin section in a vacuum bag was conducted in a 1 °C cooler for 19 days. Once assigned initial freezing was completed (either slow or fast), the loin section were stored in the -20 °C freezer for 6 weeks, and thawed in the 1 °C chilling cooler for 2 days. Purge/thaw loss, cooking loss, shear force, color (CIE L*, a* and b*), 2-thiobarbituric acid reactive substances (TBARS), carbonyl content and histology of thawed pork loins were determined. The PROC MIXED of SAS was used for data analysis (P < 0.05) by using least significant differences.

Results: No interactions between aging sequence and freezing rate on purge/thaw loss and cooking loss were observed (P > 0.05). The highest purge/thaw loss was found in the loin section assigned to frozen first then thaw/aged (12.4%) compared to frozen/thawed only (8.5%) or aged/frozen/thawed (7.8%) samples (P = 0.0003). This result indicates the importance of aging and aging sequence for WHC of frozen/thawed meat. No difference in cooking loss of pork loins between treatments was found (P > 0.05). Aged/frozen/thawed pork loins had a lower shear force than frozen/thawed only pork loins (P = 0.0223). Further, slow-frozen then thaw/aged loin had the lowest shear force among treatments (P < 0.0001). Aging tended to increase initial L* (lightness), regardless of its combination sequence with freezing/thawing (P < 0.05). No differences in the TBARS value and carbonyl content of frozen/thawed pork loins were found between treatments (P > 0.05). Based on histological analysis, severe structural damages were observed in the slow-frozen then thaw/aged loin section.

Conclusion: The results of the current study found that the sequence of aging prior to freezing play a significant role in affecting the WHC and texture of frozen/thawed pork loins. Moreover, this study confirms that fast-freezing could be an effective process to improve WHC of frozen/thawed meat products, regardless of aging combination and/or its sequence.

Keywords: aging, freezing rate, frozen meat, oxidative stability, pork loin
Objectives: The objective of this research was to benchmark palatability attributes for muscles from carcasses assigned grades within the Canadian grading standards for cows compared to youthful carcasses.

Materials and Methods: Eleven muscles (psoas major, infraspinatus, longissimus thoracis, longissimus lumborum, triceps brachii, rectus femoris, gluteus medius, semitendinosus, semimembranosus, biceps femoris and teres major) were obtained from mature graded carcasses with >50% ossification (D1, D2, D3 and D4; n=84) and youthful carcasses with <50% ossification A/AA grades youthful carcasses (over [OTM]; n=18, and under [UTM] 30 months of age; n=18, based on dentition but < 50% ossification); these muscles were aged 14 d prior to sensory and shear force evaluation. Steaks were thawed and grilled to an endpoint temperature of 71°C. Peak shear force was determined on each core perpendicular to the fibre grain using a texture analyzer equipped with a Warner-Bratzler cell (crosshead speed of 200 mm.min⁻¹). For the sensory evaluation, each sample was evaluated by a six-member trained panel for initial tenderness, overall tenderness, amount of perceptible connective tissue, juiciness, and beef flavour intensity using an eight-point descriptive scale.

Results: The results suggest that while most meat from cow graded carcasses becomes less tender, within these carcasses, some muscles did not become tougher. For example, the PM from mature graded carcasses remains tender and had higher juiciness, suggesting this muscle is still valuable from the perspective of eating quality; similar results were observed in tenderness comparisons made between USDA select and grain-finished beef cull cows. Additionally, several muscles received lower scores for overall tenderness, but did not have a significantly higher shear force. This may indicate the extent of toughening for these muscles was not large. While overall tenderness for most muscles across the mature grades decreases, other sensory attributes were often similar to those of youthful carcasses. In some instances, juiciness or beef flavour intensity were higher in the mature carcasses than in the youthful carcasses. As such, many cuts from mature carcasses would likely have acceptable eating quality with tenderness interventions such as blade tenderization or brine injection applied.

Differences in meat quality exist between the mature quality grades. The largest decreases in tenderness occurred in the D3 carcasses, which are graded as such due to poor muscling. The present results appear to be consistent with tenderness measures obtained from non-finished beef cows. Quality differences between mature grades suggest that classification of mature carcasses based on muscling and fat depth does serve to partially differentiate carcasses in a manner that relates to meat quality.

Conclusion: The changes to eating quality attributes differed between the mature grades; as such, processors could potentially use the information presented here as a guide for utilizing cuts which retain high eating quality and separating those which may require tenderness intervention to reach consumer acceptability.

Keywords: Cull cow, Grade, Palatability
Meat and Poultry Quality

66: EFFECTS OF FAST FREEZING FIRST THEN THAW-AGING ON QUALITY AND CHEMICAL ATTRIBUTES OF BEEF MUSCLES

D. Setyabrata 1,*, Y. H. B. Kim 1

1 Meat Science and Muscle Biology Lab. Department of Animal Sciences, Purdue University, West Lafayette, United States

Objectives: Freezing is an effective preservation method to extend the shelf life of meat products. Despite the benefits, quality deteriorations associated with freezing, such as decreases in water holding capacity (WHC) and/or oxidative stability have been well documented. Fast freezing is known to enhance the quality of frozen/thawed meat by inducing the formation of intracellular small ice crystal formation, and thus reducing muscle damage. Aging prior to freezing is a common process to improve the quality of the frozen meat. As positive aging impacts can be shown after freezing/thawing, we hypothesized that fast freezing first then thaw-aging would result in equivalent or better meat quality attributes compared to the conventionally aged/frozen beef products. The objective of this study was to evaluate the effect of different freezing rate and aging/freezing sequence on quality and physicochemical attributes of beef loins.

Materials and Methods: Both loin (Longissimus lumborum) and eye of round (Semitendinosus) muscles from one side of 10 beef carcasses were obtained at 3d postmortem, cut into 4 sections and vacuum packaged. The sections were randomly assigned to four different combinations of aging/freezing - (Aging Only (AO), Slow Freezing then Thaw-Aging (SFTA), Fast Freezing then Thaw-Aging (FFTA), or Aging first then Slow Freezing (ASF)). Aging was conducted at 2ºC for 2 weeks. Frozen samples were stored at -20ºC for 3 weeks. Fast freezing was conducted using a liquid nitrogen freezing cabinet set at -75ºC. Conventional blast freezer set at -20ºC was used for slow freezing. Frozen samples were thawed at 2ºC until the internal temperature reached -1.5ºC. Meat quality measurements such as shear force, WHC by assessing purge/thaw loss, drip loss and cook loss, and color stability were conducted. For display color, steaks were overwrapped with PVC film and displayed for 7d under light, and instrumental and visual color evaluations were performed. Other chemical analyses including 2-thiobarbituric acid reactive substance (TBARS), non-heme iron (NHI) content and histology for muscle micro-structure analysis were performed. All data were analyzed using the PROC MIXED of SAS.

Results: FFTA samples took less than 3 hours to reach -20ºC of internal temperature, while SFTA samples took almost 3 days. Both FFTA and SFTA samples exhibited a higher total moisture loss (P<0.05) when compared to the other treatments. No significant difference in shear force was found between the treatments, although the steak samples from FFTA showed numerically lowest shear force values compared to the others (P=0.12). AO samples maintained the highest a* value during the entire display between the treatments. Rapid increase in discoloration was observed in steak samples from SFTA, followed by FFTA and ASF after 4 d display. Higher TBARS and NHI contents were observed on all frozen/thawed samples compared to non-frozen AO after display (P<0.05).

Conclusion: We found that fast freezing first then thaw-aging did not result in positive impacts on the overall quality characteristics of frozen/thawed meat products. The results also indicate that the order of aging/freezing/thawing sequence could be an overriding factor affecting quality attributes of frozen/thawed meat over freezing rate. Further studies involving various thawing and freezing rate combined with different aging/freezing/thawing sequence would be warranted.

Keywords: aging sequence, Beef, freezing rate, Oxidative stability
Meat and Poultry Quality

67: TRAINED SENSORY PANEL EVALUATION OF NINE BEEF CUTS FROM THREE USDA QUALITY GRADES

O. Khatri 1,*, L. Drey 1, K. Nyquist 2, J. Legako 2, J. Gonzalez 1, E. Boyle 1, T. Houser 1, T. O’Quinn 1
1Department of Animal Sciences and Industry, Kansas State University, Manhattan, 2Department of Animal and Food Sciences, Texas Tech University, Lubbock, United States

Objectives: To determine the palatability characteristics of nine beef cuts from three USDA quality grades.

Materials and Methods: Beef strip loins (IMPS #180), inside rounds (IMPS #169), bottom rounds (IMPS #171), shoulder clods (IMPS #114), and chuck rolls (IMPS #116A) were selected from three quality grades (Prime, Choice and Select), vacuum packaged, and aged for 21 days at 4°C. The sub-primals were fabricated into nine beef cuts (Delmonico, Flat Iron, Denver, Ranch, Shoulder Petite Tender, San Antonio, Western Griller, Tucson and Strip). Cuts were fabricated to 2.54 cm steaks and frozen at -20°C prior to analysis. Steaks were cooked on an electric clamshell grill (Cuisiart Griddler Deluxe model GR-150) to 71°C. The temperature was measured using a thermocouple connected to a Doric Mini-trend Data Logger 205 B-1-c ORF (Doric Scientific). Each steak was cut into 1 cm x 1 cm x steak thickness samples and immediately served to trained sensory panelists. Each panelist was trained per the AMSA guidelines for Sensory Evaluation (2016). The samples presented to the panelists were evaluated for initial juiciness, sustained juiciness, myofibrillar tenderness, connective tissue amount, beef flavor intensity, off flavor intensity, and overall tenderness on continuous line scales with verbal anchors at end (0=extremely dry/tough/none/bland, 100=extremely juicy/tender/abundant/intense) and midpoints.

Results: For all traits evaluated other than overall tenderness, there was no quality grade × cut interaction (P > 0.05). Initial juiciness, myofibrillar tenderness, and beef flavor intensity rated higher (P < 0.05) for Prime than Choice and Select, which were rated similar (P > 0.05). Select steaks had a greater (P < 0.05) amount of connective tissue than both Choice and Prime steaks. Panelists rated Delmonico, Flat Iron and Denver steaks highest (P < 0.05) for initial and sustained juiciness, while the San Antonio and Tucson cuts rated lowest (P < 0.05). For myofibrillar tenderness, the Delmonico and Flat Iron cuts rated highest (P < 0.05), followed by Strip Loin and Denver steaks. The Tucson cut was the toughest (P < 0.05) myofibrillary. Western Griller steaks had the greatest (P < 0.05) amount of connective tissue, followed by the Tucson cut, which had a greater (P < 0.05) amount of connective tissue than all other cuts. For beef flavor intensity, the Denver cut rated the highest (P < 0.05), with the Delmonico and Flat Iron steaks rating higher (P < 0.05) than all other cuts.

There was an interaction (P < 0.05) between quality grade and cut for overall tenderness. Within Prime, Delmonico steaks were rated most (P < 0.05) tender, and no difference (P > 0.05) was found among Strip Loin, Flat Iron, Denver, and Shoulder Petite Tender steaks. Whereas within Choice and Select, Delmonico steaks were similar (P > 0.05) to Flat Iron and Shoulder Petite Tender steaks for overall tenderness. Additionally, within Prime, no difference in overall tenderness was found among Western Griller, San Antonio, and Tucson steaks. However, San Antonio steaks were more tender (P < 0.05) than both Western Griller and Tucson steaks in both Choice and Select.

Conclusion: The results, from the trained panel, indicate that for all traits other than overall tenderness, quality grade had a similar impact on the palatability traits of the evaluated muscles. Also, these results show the Delmonico, Flat Iron, and Denver steaks were favored over strip loin steaks.

Keywords: Beef, Innovation Cuts, Palatability, Quality grade, Sensory
Meat and Poultry Quality

68: RELATIONSHIPS BETWEEN EARLY POSTMORTEM AND AGED PORK LOIN QUALITY CHARACTERISTICS OF BARROWS AND GILTS

J. Lowell 1,*, M. Overholt 1, B. Harsh 1, C. Stahl 2, A. Dilger 1, D. Boler 1
1Animal Science, University of Illinois, Urbana, 2Choice Genetics USA, West Des Moines, United States

Objectives: Pork loins are often sorted during fabrication of carcasses based on visual appraisals of color, marbling and firmness, but it is unclear whether these early postmortem traits are related to quality traits observed by consumers. Furthermore, it is also unknown whether the relationships between early and aged postmortem quality differ between barrows and gilts. The objectives were to 1) determine correlations between early postmortem loin quality characteristics and aged loin quality characteristics, and 2) determine if those relationships differed between barrows and gilts.

Materials and Methods: Early and aged loin quality evaluations were collected on 133 barrows and 195 gilts killed on 3 different days. Pigs were transported approximately 195 km to a commercial slaughter facility and held in lairage for a minimum of 3 h. Pigs were immobilized via carbon dioxide gas, and carcasses were blast chilled for 90 min. Loin pH and back fat thickness were measured at the midline of the 10th rib. Early quality measures (1 d postmortem) included 1 d postmortem pH, instrumental color (L*, a*, b*), and subjective color, marbling, and firmness from the ventral surface of boneless loins. Loins were vacuum-packaged and aged 14 d at 4°C. Then, 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 25 mm thick chops, allowed to bloom, and color measurements were taken from the chop-face. Chops were cooked to an internal temperature of 68°C for Warner Bratzler shear force (WBSF) and cook loss. Pooled correlations between sexes for early postmortem and aged quality characteristics were calculated using the CORR procedure of SAS. To assess differences in relationships between barrows and gilts, comparison of independent correlation coefficients was conducted. Correlations were considered different from 0 and relationships between barrows and gilts were considered different at $P \leq 0.05$.

Results: Barrows were heavier, fatter, and had loins that were lighter as a percentage of HCW compared with gilts ($P \leq 0.01$). One d postmortem pH was correlated ($P \leq 0.01$) with aged ventral color ($r=0.46$), aged chop color ($r=0.42$), cook loss ($r=-0.33$) and WBSF ($r=0.16$). However, these relationships did not differ ($P \geq 0.11$) between barrows and gilts. Early ventral L* was correlated to aged ventral L* ($r=0.55$) and WBSF ($r=-0.24$), but not with chop L* ($r=-0.06$) or cook loss ($r=0.05$). Early ventral a* was correlated to aged ventral a* ($r=0.17$), chop a* ($r=0.28$), and cook loss ($r=-0.25$), but not with WBSF ($r=-0.04$). None of these relationships differed ($P \geq 0.41$) between barrows and gilts.

Conclusion: One d postmortem pH was correlated with color, water-holding capacity, and tenderness. Early ventral color measurements were correlated with aged ventral color measurements and tenderness, but not with chop color. Therefore, 1 d postmortem pH, L*, and a* could be used as indicators of aged color and tenderness. Given that there were no differences in early and aged postmortem relationships between barrows and gilts, sex does not need to be accounted for when using these early quality traits to predict aged quality.

Keywords: aged loin quality, correlation, loin quality, pork, sex
Meat and Poultry Quality

69: EVALUATING THE RELATIONSHIP OF ANIMAL WELL-BEING AND TEMPERAMENT TO CARCASS CHARACTERISTICS

F. L. Yang 1*, F. W. Pohlman 1, K. S. Anschutz 1, J. J. Ball 1, P. Hornsby 1, J. L. Reynolds 1

1Department of Animal Science, University of Arkansas, Fayetteville, United States

Objectives: While much effort has been put forth dealing with extrinsic factors influencing animal well-being, less is known and therefore less effort has been conducted in dealing with intrinsic factors affecting animal comfort and well-being. Animals are unique and each cope with stress in their own unique way. Therefore, it is not uncommon to have a group of cattle, each in the same truck, pen, handling facility and environment, but have quite different responses to stress. In a given group some cattle may remain calm with regard to their surrounding and handling while others may become excited. The differing response of these cattle can lead to individuals that respond well and thrive in the environment to those who do not cope at all. The lack of the ability to remain calm and adapt to their environment can lead to poor performance, illness and even death. Docility can impact feedlot profitability and carcass characteristics. The purpose of this study was to compare carcass characteristics between steers with different docile chute scores.

Materials and Methods: Incoming calves were weighed, processed, and scored for docility/temperament in the chute (1-docile, 2-restless, 3-nervous, 4-flighty, 5-aggressive, 6-very aggressive) by one person. Docility scores 5 and 6 were not observed and group 3 and 4 were combined. There was a total of 49 steers, 19 in the docile group, 18 in the restless group, and 12 in the nervous-flighty group. Steers were housed with access to pastures for two months then transferred to research feedlots where they remained until harvest. Finished steers were processed when they reached a minimum 1.27 cm back-fat thickness and carcass data collected.

Results: The incoming weight and the final body weight were similar (P>0.05) among temperament groups. The nervous-flighty group had a lower (P<0.05) hot carcass weight than the docile and restless groups. All three groups were similar (P>0.05) in back-fat thickness, ribeye area, yield grade, marbling score, dressing percent, and percent kidney, pelvic, and heart fat.

Conclusion: There were very little differences in carcass characteristics of steers with different temperament.

Keywords: carcass performance, docility, temperament
Meat and Poultry Quality

70: CHARACTERIZATION OF FRESH AND DRY-AGED GROUND BEEF PATTIES

D. A. Gredell 1*, J. H. McHenry 1, D. R. Woerner 1, J. F. Legako 2, T. E. Engle 1, J. C. Brooks 2, J. D. Tatum 1, K. E. Belk 1
1Animal Sciences, Colorado State University, Fort Collins, 2Animal and Food Sciences, Texas Tech University, Lubbock, United States

Objectives: Consumers have varied preferences for beef flavor and it is known that dry-aging changes the flavor profile of beef. Therefore, the objective of this study was to characterize flavor differences and compositional changes of ground beef blends with varying levels of dry-aged beef.

Materials and Methods: Beef shoulder clods were collected from a commercial processing facility and ground to create 3 treatments: 100% fresh beef, 100% dry-aged beef, and a 50% fresh and 50% dry-aged ground beef blend. Clods used for dry-aged beef were vacuum packaged for 21 d, then opened and aged for an additional 21 d exposed to oxygen. Clods for fresh beef were held in plastic lined combos for 4 d postmortem. Upon completion of its aging protocol, each clod was trimmed and randomly assigned to 1 of 3 treatments. Five batches of each treatment were made to include equal numbers of clods and contain 15% fat. Each batch was ground and formed into 151 g patties. Panelists were trained to evaluate samples for standard beef flavor and textural attributes on a 10 cm line scale. Patties for descriptive sensory were cooked to 71°C on griddle pans over open gas burners. Cooked patties were cut into 8 wedge-shaped pieces for evaluation. Total lipid fatty acids were analyzed from 1 g of homogenized raw sample. Fatty acid methyl esters (FAME) were quantified via gas chromatography, with each individual FAME being reported as a percentage of the total amount of FAME identified. Volatile flavor compounds were measured from cooked patties. Immediately after cooking, sample was placed in a capped glass vial. Volatiles were collected from the headspace via a solid phase microextraction fiber. Quantification was carried out using a 7-point internal standard method and compounds were identified from authentic external standards. Treatment comparisons for all analyses were tested for significance using the general linear model procedure of SAS.

Results: Samples comprised of 100% dry-aged beef were rated greatest (P < 0.01) for browned/grilled, earthy/mushroom, and nutty/roasted nut flavors; however, panelists also found more intense (P ≤ 0.01) sour/acidic and bitter flavors. Dry-aged beef also increased (P < 0.01) hardness and reduced (P < 0.01) tenderness. Dry-aging caused a shift in saturated fatty acids (SFA), as shorter chain SFA (≤ 16:0) were reduced (P ≤ 0.03) compared to stearic acid (18:0). Meanwhile, increases (P < 0.05) of trans-octadecenoic acid (18:1 trans) and decreases (P < 0.05) of cis monounsaturated fatty acids were seen in dry-aged beef. Concentrations of 18:2 conjugated linoleic isomers were greatest (P < 0.01) in fresh beef and decreased with the addition of dry-aged beef. Several lipid-derived volatile compounds were greater (P < 0.05) in dry-aged beef compared with fresh beef. Dry-aged beef showed increases (P ≤ 0.03) of 3- and 2-methyl butanal, both of which are amino acid-derived Strecker aldehydes. Additionally, 2,3-butanedione and 3-hydroxy-2-butanone, which can be byproducts of spoilage organisms, were greatest (P ≤ 0.04) in dry-aged beef. Alterations of fatty acids and volatile compounds with dry-aging were determined to be related with intensity of individual flavor attributes.

Conclusion: The inclusion of dry-aged trimmings impacts the flavor profile of ground beef, altering the composition of fatty acids and volatile compounds. This supports the idea that dry-aging may be utilized to impart a more intense beef flavor experience.

Keywords: Fatty acids, flavor, sensory, Texture, Volatile compounds
Meat and Poultry Quality

71: COMBINED EFFECTS OF FREEZING RATE AND THAWING/COOKING METHODS ON PHYSICOCHEMICAL AND TEXTURAL PROPERTIES OF PORK PATTIES

J.-H. Kim1 2*, H.-W. Kim1, Y. H. B. Kim1

1Department of Animal Sciences, Purdue University, West Lafayette, United States, 2Department of Food Science & Biotechnology of Animal Resources, Konkuk University, Seoul, Korea, Republic Of

Objectives: Quality defects associated with frozen/thawed patties have been well documented. Freezing rate is known to affect water-holding capacity (WHC), texture and possibly oxidative stability of frozen/thawed patties. In addition, different thawing/cooking conditions could influence the quality attributes of frozen/thawed meat. However, there has been little to no available information on the effects of initial freezing temperature coupled with different thawing/cooking methods on quality and physicochemical attributes of frozen/thawed patties. Therefore, the objective of this study was to evaluate the combined effects of different freezing rates with various thawing/cooking methods on physicochemical and textural properties of cooked pork patties.

Materials and Methods: At 2 days postmortem, pork ham muscles (M. biceps femoris) from one side of six carcasses were removed and ground (two carcasses per each batch). A total of 72 patties (80 g and 10.5 cm in diameter) was manufactured in each batch using the ground pork only. The patties (24 patties per each freezing temperature) were randomly assigned into slow freezing (-20 °C in a conventional freezer), fast freezing (-50 °C in a liquid nitrogen chamber) and ultra-fast freezing (-80 °C in the same chamber), vacuum-packaged, and stored at -20 °C for 3 weeks. The frozen patties were thawed/cooked at three different conditions; immediately cooking without thawing, slow thawing (2 °C in a refrigerator) and fast thawing (25 °C in a water bath). Cooking process was conducted on an electric grill 150 °C to reach at 72 °C of core temperature. The pH, color (CIE L*, a* and b*), WHC (freezing, thawing, cooking, and total losses), textural properties and lipid oxidation (2-thiobarbituric acid reactive substances, TBARS) of pork patties were evaluated. Experimental design was a completely randomized design with three independent batches (n=3). All data were analyzed using the PROC MIXED procedure of SPSS, and Tukey’s multiple range test (P < 0.05) was used to separate differences between treatment means.

Results: No interactions between freezing temperature and thawing/cooking method on pH, color, WHC, textural properties (hardness, springiness and cohesiveness) and TBARS were found (P > 0.05). Fast and ultra-fast frozen pork patties had significantly lower total losses (the sum of freezing/thawing/cooking losses) compared to the slow frozen pork patties. In addition, direct cooking without thawing reduced cooking and total losses of patties compared to other treatments (P < 0.05). Freezing rate had no impacts on textural properties (P > 0.05), except for hardness. However, fast thawing resulted in lower hardness, springiness, cohesiveness, gumminess and chewiness compared to slow thawing (P < 0.05). Fast thawing slightly reduced TBARS value of pork patties compared to the others thawing/cooking methods (P < 0.05).

Conclusion: The results of this current study indicate that fast freezing could be an effective way to reduce weight losses associated with freezing/thawing/cooling process. We also found that different thawing/cooking methods had greater impacts on textural properties and lipid oxidation of pork patties, rather than initial freezing rate. This study suggests that fast freezing coupled with fast thawing would be the most effective way to minimize quality defects associated with freezing/thawing/cooling of pork patties.

Keywords: Cooking method, Freezing rate, Freezing temperature, Frozen pork patty, Thawing method
Meat and Poultry Quality

72: VOLATILE COMPOUNDS FROM ENHANCED AND NON-ENHANCED BEEF STRIP STEAKS OF THREE USDA QUALITY GRADES COOKED TO MULTIPLE DEGREES-OF-DONENESS

S. Mallick 1,*, T. G. O’Quinn 2, J. C. Brooks 1, M. F. Miller 1, J. F. Legako 1
1Department of Animal and Food Science, Texas Tech University, Lubbock, 2Department of Animal Sciences and Industry, Kansas State University, Manhattan, United States

Objectives: Beef palatability is greatly influenced by flavor. This study was conducted to determine the impact of enhancement (E) with a brine solution on generation of volatile compounds in three USDA quality grades (QG) of beef steaks cooked to different degrees of doneness (DOD).

Materials and Methods: Paired beef strip loins representing USDA Prime(n=24), Low Choice(n=24), and Low Select QG(n=24), were collected at a commercial beef processing facility and maintained in vacuum packaging and refrigeration (2°C) until further processing. All treatments, both enhanced and unenhanced were aged for 21 days. However, after 14 days of aging, half of the paired strip loins from each QG (n = 12) were enhanced with a solution (0.35% salt and 0.40% sodium phosphate) at a target of 8% additional weight within the end product. Strip loins weights were recorded before and 15 minutes after injection to determine actual percentage pump. Enhanced strip loins were then vacuum packaged and stored at 2°C for an additional 7 days. Strip loins that were not chosen for enhancement were aged for 21 days under vacuum at 2°C. Steaks of 2.5 cm thickness were produced and assigned to one of the three DOD (Rare: 60°C; Medium: 71°C; Well-Done: 82°C). Experiments were set up with 12 replicates per treatment and a split-plot ANOVA was used with a factorial arrangement of QG and E as the whole plot and DOD as the sub-plot. All comparisons were tested at a significance level of \( \alpha = 0.05 \).

Results: The majority of quantitated volatile compounds were impacted by a three-way interaction of E×QG×DOD (\( P \leq 0.05 \)). Thirteen Maillard reaction compounds had three way E×QG×DOD interactions (\( P \leq 0.048 \)). Among Maillard products, Strecker aldehydes, pyrazines, and sulfur compounds differentiated in concentration (\( P < 0.05 \)) for well-done non-enhanced steaks with USDA Prime QG having the highest concentration for all compounds. However, concentrations did not differ (\( P > 0.05 \)) at lower degree of doneness within non-enhanced steaks. Among enhanced steaks there was no differentiation (\( P > 0.05 \)) due to QG. Fifteen lipid derived compounds quantitated had a three way E×QG×DOD interaction (\( P \leq 0.038 \)). Among lipid derived compounds, hexanal concentrations were greater (\( P < 0.05 \)) in rare, Prime non-enhanced and enhanced steaks compared with their well-done counterparts. The same was not apparent for Low Choice or Low Select among both non-enhanced and enhanced beef, where Low Select of each enhancement group were similar (\( P > 0.05 \)) between rare and well-done steaks. Meanwhile, Low Choice non-enhanced increased (\( P < 0.05 \)) in quantity of hexanal from rare to well-done, and Low Choice enhanced decreased (\( P < 0.05 \)) in quantity of hexanal from rare to well-done. Interestingly, within medium and well-done, non-enhanced and enhanced steaks hexanal quantity was inversely related with quality grade, where Prime was lower (\( P < 0.05 \)) than both Low Choice and Low Select.

Conclusion: Enhancement of beef steaks influence both Maillard reaction and lipid derived volatile compounds. The greatest impact of enhancement seems to have occurred with Maillard products where variation of Maillard compounds was reduced within enhanced product.

Keywords: Degree of Doneness, Enhancement, USDA quality grade, Volatile compounds
Meat and Poultry Quality

73: DETERMINATION OF OBJECTIVE ANALYSIS OF JUICINESS AMONG MULTIPLE BEEF MUSCLES AND QUALITY GRADES.

K. M. Nyquist¹, L. N. Drey², L. W. Lucherk¹, J. C. Brooks¹, M. F. Miller¹, T. G. O’Quinn², J. F. Legako¹

¹Animal and Food Science, Texas Tech University, Lubbock, TX, ²Animal Sciences and Industry, Kansas State University, Manhattan, KS, United States

Objectives: The purpose of this study was to use a developed objective juiciness analyses including corresponding tenderness measurements to determine the juiciness among multiple beef muscles of various quality grades.

Materials and Methods: Treatments were obtained from five different beef sub-primals: Strip loins (IMPS #180), inside rounds (IMPS #169), bottom rounds (IMPS #171B), shoulder clods (IMPS #114), and chuck rolls (IMPS #116). Sub-primals were also represented by three different USDA quality grades: Prime, Low Choice and Select; (n=10/quality grade). All sub-primals were vacuum packaged, aged for 21d then fabricated into 2.5 cm thick steaks from respective cuts: Adductor (AD), Biceps femoris (BF), Chuck Eye (CE), Infraspinatus (IF), Semimembranosus (SM), Serratus ventralis (SV), Longissimus lumborum (LD), and Triceps brachii (TB). The steaks were frozen (-20°C) until subsequent analyses. Several objective measures of juiciness and tenderness were evaluated on raw and cooked samples. Analysis techniques measured on raw samples included: pH and percentage fat, moisture, protein and collagen. Cooked techniques evaluated included: Warner-Bratzler shear force (WBSF), slice shear force (SSF), cook loss, and pressed juice percentage (PJP). For cooked analysis, each steak was cooked on a clam-shell grill to a medium degree of doneness (71°C), and the fiber orientation (45 or 90°) was determined before sampling. Analysis of PJP was evaluated using a compression-based juiciness method. Following SSF, a 1cm thick PJP slice was removed parallel with predetermined muscle fiber orientation (45 or 90°) and compressed on filter paper at 8g for 30s. Data were analyzed using the GLIMMIX procedure of SAS (α =0.05). Subprimal was experimental unit, and muscle, quality grade, muscle × quality grade were used as fixed effects. Carcass was used as a random effect.

Results: A muscle × quality grade interaction (P < 0.05) was detected for each chemical proximate measurement, as well as pH. Fat percentage for SV was greater (P < 0.05) than all other cuts in all quality grades, but similar (P > 0.05) to IF in the Select grade. Within Prime and Low Choice, moisture was greatest (P < 0.05) for TB and similar (P > 0.05) to AD. The pH was lowest (P < 0.05) for AD in all grades. The IF was highest (P < 0.05) in Choice and Select, but similar (P > 0.05) to Choice TB, LD and Select TB. A muscle × grade interaction (P < 0.05) was found for SSF. The BF across all quality grades was the toughest (P < 0.05). The SV was the most tender (P < 0.05) in Prime, however few differences were found in all other quality grades between muscles of AD, IF, LD, and SV. Quality grade and muscle affected (P < 0.05) WBSF and PJP. As quality grade increased, WBSF values decreased (P < 0.05). The SV and CE were more tender (P < 0.05) than AD, TB, and IF. The PJP was less (P < 0.05) for Prime and Choice than Select, while TB and SM were greater (P < 0.05) than IF and AD for the same trait.

Conclusion: Objective juiciness and tenderness measures among different beef cuts and quality grades cooked to the same degree of doneness indicated that there is a difference in the amount of juice that is released from various beef muscles.

Keywords: Beef, muscles, juiciness, quality grade, slice shear force, Warner-Bratzler
Objectives: Irradiation is well-known for its sterilization impacts on meat products. However, some oxidation related quality defects have been identified as one of major problems associated with irradiated meat products. While various irradiation source and/or dose level could result in different extents of oxidation, little information is available on how different irradiation sources and dose levels affect antioxidant enzyme activities and subsequent oxidative stability of meat products. Therefore, the objective of this study was to determine the effects of irradiation source/dose level on endogenous antioxidant enzyme activity and lipid oxidation of ground pork.

Materials and Methods: Pork ham muscles (M. biceps femoris, semitendinosus and semimembranosus) from six carcasses at 1 day postmortem were trimmed, ground, and divided into seven groups. The irradiation treatments, comprised of 3 irradiation sources (gamma-ray, electron-beam (e-beam) and X-ray) and 2 irradiation dose levels (3 and 7 kGy) with non-irradiated control, were randomly assigned to the ground pork groups. Ground pork in vacuum-packaged bags was irradiated at target dose levels with each ionizing source at the ambient temperature (22°C). Catalase (CAT), glutathione peroxidase (GSH-Px), and superoxide dismutase (SOD) activities were determined on the day of irradiation. To determine lipid oxidative stability, conjugated diene (CD), peroxide value (POV) and 2-thiobarbituric acid reactive substances (TBARS) were measured during 20 days of refrigerated storage (4 ºC). The experimental design was completely randomized block with three independent replicates. The ANOVA procedure was performed on all the variables measured using the GLM procedure with SPSS. When significant differences were found (P < 0.05), Duncan’s multiple-range test was used to separate the mean differences between treatments.

Results: The ground pork irradiated with X-ray showed lower POV but higher TBARS values compared to the ground pork assigned to other irradiation sources (P < 0.05). X-ray irradiation significantly decreased total SOD activities as compared to the other irradiation sources. Regarding the impact of irradiation dose level, ground pork irradiated at 7 kGy had higher CD and TBARS values than that irradiated at 3 kGy. E-beam irradiation at 7 kGy significantly decreased CAT activity when compared to non-irradiated control. GSH-Px was unaffected by either irradiation source or dose level (P > 0.05).

Conclusion: The results from the present study suggest that the extent of lipid oxidation in ground pork induced by irradiation could be dependent upon irradiation source/dose level. The decrease in total SOD activity in X-ray irradiated ground pork could result in accelerated formation of secondary oxidation products such as malondialdehyde. Further studies to develop a practical strategy to minimize irradiation-induced oxidative quality defects of meat products (e.g. incorporation of antioxidants or different packaging conditions) would be warranted.

Keywords: catalase, glutathione peroxidase, irradiation, lipid oxidation, superoxide dismutase
Meat and Poultry Quality

75: TEMPERATURE AND TIME EFFECTS OF SOUS VIDE ON TENDERNESS IN BEEF SEMITENDINOUS MUSCLES

V. R. Trbovich 1,*, H. Garza 1, L. G. Garcia 1
1Department of Animal Sciences, The Ohio State University, Columbus, United States

Objectives: To determine the time and temperature combination required to improve tenderness in undervalued cuts of beef while maintaining quality attributes; and to understand the biochemical effects of sous vide cooking and how it might be advantageous to tough cuts of meat.

Materials and Methods: Whole beef semitendinosus muscles (IMPS #171C) were purchased from 2 beef groups: fed beef (< 30 mo. of age; n = 20) and cow carcasses (> 42 mo. of age; n =20). Beef muscles were portioned into 6 cm roasts using a template. Roasts were randomly assigned to one of two cook times: 2 or 8 hours at two different temperature treatments: 55°C and 70°C. Percent cook loss, objective color (L*a*b*, Minolta), and Warner-Bratzler shear force (WBSF, kg) were analyzed. Purge accumulated in the cook-in bag was saved and analyzed to determine soluble and total protein concentrations. Soluble protein concentrations were determined using a ThermoFisher Scientific BCA assay and total protein concentrations were determined using a Bio-Rad RC DC assay. Data were analyzed with a mixed model in JMP. The LSMeans were compared within an age classification using a Student’s t-test and considered significant at P ≤ 0.05.

Results: WBSF values decreased as time increased for roasts representing the cow group when cooked at 55°C (P < 0.0144). However, roasts representing the fed group resulted in a decrease in WBSF values when temperature was increased from 55°C to 70°C (P < 0.002). Lightness values (L*) increased in both groups as time and temperature increased (P < 0.0611); whereas, redness values (a*) significantly decreased across all cooking treatments (P < 0.0145). Additionally, percent cook loss significantly increased as cooking temperature and time increased in both groups (P < 0.0322). Total protein concentrations in the purge significantly decreased as temperature and time increased in both groups (P < 0.0287). Cooking loss could be correlated to the decrease in total protein concentrations. As cooking temperature and time increase the amount of water expelled from the muscle (purge) could increase, resulting in a dilution of protein concentration. Soluble protein concentration in both age groups significantly decreased as cooking temperature and time increased (P < 0.0266).

Conclusion: Through the application of sous vide cooking we can improve tenderness in tough cuts of beef, especially undervalued beef cuts originating from cows. In order to capitalize on value in dealing with cow meat cuts, cooking to an internal degree of doneness of 55°C (rare) for 8+ hours may be the most suitable.

Keywords: beef quality, sous vide, tenderness
Objectives: The purpose of this study was to compare meat quality and taste profile of steaks from longissimus dorsi with different temperament.

Materials and Methods: Calves were processed and scored for docility/temperament in the chute (1-docile, 2-restless, 3-nervous, 4-flighty, 5-aggressive, 6-very aggressive). Groups 5 and 6 were not observed and groups 3 and 4 were combined. Steers were housed with access to pastures then transferred to research feedlots until harvest and processed when back-fat reached a minimum of 1.27 cm. Carcasses were aged for 14 days before the 6-12 rib section were removed, frozen, cut into 2.54 cm steaks, and individually packed. For simulated retail display and instrumental color analysis, steaks were thawed overnight at 6°C and placed on polystyrene foam trays with absorbent pads and overwrapped with poly-vinyl chloride film, then placed in a commercial chest type display case at 2°C under deluxe warm white fluorescent lighting. Instrumental color was measured on days 0, 1, 2, 3, 5, and 7 of simulated retail display using a Hunter-Lab MiniScan SE spectrophotometer. Samples were read using illuminant A/10° observer, evaluated for CIE (L*, a*, and b*) color values, reflectance measurements from 400 to 700 nm to estimate oxymyoglobin, and hue angle and saturation index values were calculated. For sensory panel analysis, steaks were thawed overnight at 6°C and cooked on an electric griddle set at 205°C to an internal temperature of 70°C. A 6 member trained panel evaluated steak samples over 4 days under sodium color neutralizing lights for myofibrillar tenderness, connective tissue amount, overall tenderness, juiciness, and beef flavor intensity on an 8-point scale. Color was analyzed as a 3x6 factorial arrangement with docile group, display day, and docility score and display day interaction as the main effects. Sensory panel data was analyzed with docility score group as the main effects with panelist and taste day as random effects.

Results: Docile groups affected color with groups 1 and 2 being lighter (L*; P<0.05), and group 2 being yellower (b*; P<0.05) and greater (P<0.05) hue angle than the other groups. There was no difference (P>0.05) between docile groups for redness (a*), saturation index, and oxymyoglobin ratio. Display days affected color with day 0 being redder (a*; P<0.05), yellower (b*; P<0.05), greater (P<0.05) saturation index, and greater (P<0.05) oxymyoglobin ratio. There were no differences (P>0.05) in lightness between display days and there was no interaction (P>0.05) for any of the color attributes measured. For taste panel, docile groups 1 and 2 were more tender (P<0.05) in myofibrillar tenderness, less (P<0.05) connective tissue, overall more tender (P<0.05), and more (P<0.05) juicy than group 3-4. Group 2 was more (P<0.05) intense in beef flavor with group 3-4 being least intense in beef flavor and group 1 being intermediate. There was no difference (P>0.05) in off-flavor between the docile groups.

Conclusion: Docility affected lightness, yellowness, and hue angle. Docility also affected taste with the nervous-flighty group having negative impact on taste.

Keywords: color, display, meat quality, sensory, steak
Meat and Poultry Quality

77: RELATIONSHIPS BETWEEN MUSCLE FIBER CHARACTERISTICS AND CHANGES OF PORK LOIN QUALITY DURING 14 DAYS OF COLD STORAGE

G.-D. Kim1,2,*, M. F. Overholt1, B. J. Klehm1, B. Fields3, A. A. Sosnicki3, D. D. Boler1, A. C. Dilger1

1Department of Animal Sciences, University of Illinois at Urbana-Champaign, Urbana, United States; 2Institute of Agriculture & Life Science, Gyeongsang National University, Jinju, Korea, Republic Of; 3Genus PIC, Hendersonville, United States

Objectives: Most studies investigating the relationship between muscle fiber characteristics and pork loin quality have focused on early postmortem characteristics. However, the influence of muscle fiber characteristics on aged pork loin quality or changes in pork loin quality during storage have not been fully investigated. Therefore, the present study was conducted to investigate the relationships between muscle fiber characteristics and changes of pork quality during 14 days of cold storage.

Materials and Methods: Pigs (PIC 280 boar x Camborough sow, n = 22, HCW = 93.4±7.1 kg) used in this study were randomly selected from a single lot that were slaughtered at a commercial abattoir. Loins (longissimus dorsi) were removed from pork carcasses at 24 h postmortem (PM), vacuum-packaged, and transported to the University of Illinois. At 36 h postmortem, a 2.54 cm thick chop was cut from the 8th-10th thoracic vertebra region to be used for immunohistochemistry. An additional chop was used to evaluate 36 h pH, instrumental color, National Pork Producers Council (NPPC) color, cooking loss and Warner-Bratzler shear force (WBSF). The rest of loin was vacuum-packaged and stored at 4 °C until 14 d PM. After 14 d of storage, pork quality characteristics were evaluated again. Differences (Δ) of pork quality between the two storage points were calculated as the value at 14 d minus the value at 36 h PM. Four pure fiber types (I, IIA, IIX and IIB) and 3 hybrid fiber types (I-IIA, IIXA and IIXB) were classified using four monoclonal antibodies (BA-D5, SC-71, BF-35 and BF-F3, DSHB, IA). Relative fiber number (%) and area (%) and cross-sectional area (CSA) were analyzed from approximately 500 fibers per sample. Data were analyzed using a paired t-test to compare loin quality at 36 h and 14 d PM. Pearson correlation coefficients were determined for the relationships between muscle fiber characteristics and changes of loin quality traits during storage. Both differences and correlation coefficients were considered significant at P ≤ 0.05.

Results: Muscle fiber type IIB had the highest proportion (55.06% relative number and 66.31% relative area; P<0.0001) and the largest size (5949.0 µm²; P<0.0001) among the fiber types; whereas, the proportion of type I was the lowest (9.38% relative number and 6.15% relative area; P<0.0001) among the pure types. NPPC color score decreased (Δ=-0.55; P<0.0001) and WBSF decreased (Δ=-0.90; P<0.01) during cold storage; whereas, CIE L* (Δ=3.55; P<0.0001), a* (Δ=0.86; P<0.01) and b* (Δ=2.35; P<0.0001), and cooking loss (Δ=2.11; P<0.05) increased during cold storage. Relative number and area of type I fibers were positively correlated (r = 0.52, r = 0.46, respectively; P<0.05) with Δ cooking loss, and CSA of type I was positively correlated (r = 0.48; P<0.05) with Δ CIE a*. The relative number and area of type I-IIA fibers were negatively correlated (r = -0.47; r = -0.46; P<0.05) with Δ CIE a*. Relative number and area of type I-IIA fibers were also negatively correlated (r = -0.52; r = -0.55; P<0.05) with Δ NPPC color. Relative area and CSA of type IIB fibers were positively correlated (r = 0.44; r = 0.47; P<0.05) with NPPC color.

Conclusion: Muscle fiber characteristics are related with changes of pork quality during cold storage. In particular, the rate of discoloration is closely related with type IIB fiber size and proportion of type I-IIA fibers.

Keywords: cold storage, muscle fiber characteristics, pork, quality change
Meat and Poultry Quality

78: A CASE-CONTROL GENOME-WIDE ASSOCIATION STUDY OF DARK-CUTTING IN TWO BEEF CATTLE POPULATIONS

H. Lei1*, T. Yang1, S. Mahmood1, B. C. Roy1, C. Li2, G. S. Plastow1, H. L. Bruce 1
1University of Alberta, 2Agriculture and Agri-Food Canada, Edmonton, Canada

Objectives: Dark-cutting beef carcasses are graded Canada B4 in the Canadian Beef Grading System, resulting in economic loss for beef producers. Dark-cutting beef is caused by depletion of muscle glycogen before slaughtering, which may also be affected by animal genetics. This study aimed to identify possible single nucleotide polymorphisms (SNPs) associated with dark-cutting through a case-control genome-wide association study (GWAS) and explore the biological relevance of these SNPs to the formation of dark cutting beef.

Materials and Methods: Two cattle populations were used in this study, population Ⅰ had 64 beef cattle, of which 40 were graded Canada B4 (dark-cutters, treated as cases), and population Ⅱ had 837 beef cattle, of which 30 were graded Canada B4. The two populations were genotyped using GeneSeek Genomic Profiler for Beef Cattle-HD (GGP-HD) of 76,783 SNPs and Illumina BovineSNP50v2 BeadChip of 54,609 SNPs, respectively. All SNPs with a call rate lower than 90% or a minor allele frequency (MAF) lower than 5% were removed in quality control. Association analyses were conducted using Plink 1.9 and dark-cutting beef was analyzed as a binary trait (cases versus controls) through a logistic regression model under an additive model. UCSC Genome Browser RefSeq genes harboring (1 Mb window) the top 50 SNPs with lowest raw \( P \) values in each population were used for GO (Gene Ontology) analysis through DAVID (Database for Annotation, Visualization and Integrated Discovery).

Results: In total, 418 SNPs were detected in population Ⅰ, 383 SNPs in population Ⅱ and 267 SNPs in the combined data with a less stringent significance level \( (P < 0.01) \); 12 SNPs in population Ⅰ, 30 SNPs in population Ⅱ and 22 SNPs in the combined data with a significance level \( (P < 0.001) \); 2 SNPs in population Ⅱ and 2 SNPs in the combined data with a relatively stringent significance level \( (P < 0.0001) \). These detected SNPs showed suggestive association with dark-cutting beef. GO analysis revealed that genes (717 in total) harboring top-scoring variants (150 SNPs in total) were involved in molecular functions like poly (A) RNA binding, and calcium ion and GTP binding which are related to energy metabolism.

Conclusion: Based on our association study with a relatively small sample size, no evidence was found for a large genetic effect for beef dark-cutting, the trait may therefore be polygenic. Significant SNPs showed suggestive association with dark-cutting beef. Although the detected SNP associations require validation in a larger dataset, the results suggested the possibility in the future for marker-assisted selection or genomic selection in beef cattle to reduce dark cutting.

Keywords: Beef cattle; Case-control; Dark cutters; Genome-wide association study
Meat and Poultry Quality

79: THE IMPACT OF MARBLING TEXTURE ON TRAINED SENSORY PANEL RATINGS OF BEEF STRIP LOIN STEAKS

A. L. Williamson 1,*, K. Vierck 1, J. Gonzalez 1, T. Houser 1, E. Boyle 1, T. O’Quinn 1

1Department of Animal Sciences and Industry, Kansas State University, Manhattan, United States

Objectives: Analyze effects of three marbling textures (fine, medium, and coarse) on trained sensory panel ratings of beef steaks from three quality grades.

Materials and Methods: Beef strip loins (IMPS #180) from 3 quality grades: Top Choice (Modest00-Moderate100 marbling), Low Choice (Small marbling), and Select (n = 117;39/quality grade) were visually sorted at the 12th 13th rib interface into 3 texture groups: fine, medium, and coarse using the USDA Marbling Texture reference card (USDA-AMS-LS-SB-02). Within each ribeye, 75% of the marbling had to meet the standard to qualify. After transport to Kansas State University Meat Lab, strip loins were fabricated into 2.5 cm steaks, and vacuum packaged. Steaks were aged for 21 d postmortem at 2-4°C before freezing at -20°C. Twenty-four h prior to each sensory panel session, steaks were thawed at 2-4°C. After thawing, steaks were cooked on clamshell grills (Cuisinart Griddler Deluxe, East Windsor, NJ) to 71°C. After cooking, each steak was sliced into 2.5 cm×1 cm×1 cm cubes. Eight sensory panelists, trained per AMSA guidelines, were served 2 cubes of each steak and asked to evaluate initial and sustained juiciness, myofibrillar tenderness, amount of connective tissue, overall tenderness, beef flavor intensity, and off-flavor intensity on continuous line scales on electronic tablets (Toshiba Encore 2, Toshiba, Tokyo, Japan) using a digital survey (Qualtrics, Provo, UT). Each line scale was anchored at both ends with descriptive terms (0=extremely dry/tough/none/unbeef-like/bland, 100=extremely juicy/tender/abundant/beef-like/intense) and mid-points with descriptive terms (50 = neither dry/tough/none/unbeef-like/bland or juicy/tender/abundant/beef-like/intense). Data were analyzed as a 3×3 factorial, with marbling texture, quality grade, and their interaction serving as fixed effects.

Results: There were no marbling texture group × quality grade interactions (P > 0.05) for all traits evaluated. Coarse steaks were rated higher than medium steaks (P < 0.05) for initial juiciness, but similar to fine steaks (P > 0.05) for the same trait. Coarse steaks were also rated higher (P < 0.05) for sustained juiciness and beef flavor intensity than fine or medium marbled steaks. No differences (P > 0.05) were found between fine and medium steaks for sustained juiciness and beef flavor intensity. All marbling texture treatments were rated similar (P < 0.05) for connective tissue amount, myofibrillar tenderness, overall tenderness, and off-flavor intensity. Top Choice steaks were rated higher for both initial and sustained juiciness (P < 0.05) than Select steaks, but were similar to Low Choice steaks (P > 0.05) for both traits. All quality grades were similar (P > 0.05) for myofibrillar tenderness, amount of connective tissue, overall tenderness, and off-flavor intensity. Top Choice and Low Choice steaks were similar (P > 0.05) and greater (P < 0.05) in beef flavor intensity than the Select steaks, respectively.

Conclusion: These results indicate steaks with coarse textured marbling were more flavorful and were juicier when compared to steaks with fine and medium textured marbling when evaluated by trained sensory panelists. This research indicates beef with coarse marbling should not discriminated against at marketing, as trained panelists reported better ratings compared to fine and medium marbling textures for two attributes important to establishing steak palatability.

Keywords: Juiciness, Marbling texture, Palatability, sensory, USDA quality grade
Meat and Poultry Quality

80: NUTRIENT COMPOSITION OF WILD TURKEY AND DOMESTIC TURKEY FOR THE USDA FOOD COMPOSITION DATABASE


1Nutrient Data Laboratory, USDA, Beltsville, 2Animal Sciences, Texas Tech University, Lubbock, 3Cornell University Cooperative extension, Cornell university, Ithaca, United States

Objectives: Background: Cornell University conducts research into leveraging the local food movement for popular wild game and fish species, including Eastern wild turkey (Meleagris gallopavo silvestris). Wild turkeys are omnivores who consume a wide variety of vegetation, fruits, seeds, small vertebrates and insects, resulting in lean meat. A collaborative study between Cornell University, Texas Tech, and USDA was established to acquire wild turkey nutrient data for the USDA food composition database. Objective: The objective of this study was to compare analytical nutrient data (proximates, minerals and cholesterol) for (a) raw vs. cooked wild turkey and (b) wild turkey vs. domestically-raised turkey.

Materials and Methods: Materials and Methods: Wild turkey were obtained (n=6 males) during the spring or fall hunting season in New York, Tennessee, Georgia and Wisconsin to obtain samples representing typical geographical areas for this species. Collection protocols were provided to the hunters who were National Wild Turkey Federation biologists. Carcasses were wrapped well in plastic bags, frozen intact and sent on dry ice to the lab. After thawing, dressing and feather removal turkeys were roasted in a preheated oven to internal temperature of 165°F, held for 30 minutes at room temperature, then final weights were obtained. Turkeys were dissected into parts (drumstick, wing, thigh, back, and breast) and components (skin, meat, refuse). Meat and skin from raw and cooked turkeys were homogenized separately to form composites of light and dark meat for analysis (n= 6 for proximates and fatty acids; n=1 for minerals; n=1 for cholesterol). In a separate study, domestically-raised turkeys which contained no commercially-added solutions or preservatives (n=4) were purchased from local retail outlets. The same cooking and dissecting procedures were used to obtain analytical composites (n= 8 for proximates, fatty acids, minerals, and cholesterol). Nutrient composition was determined by commercial laboratories using validated AOAC methodologies. Quality assurance was monitored using in-house materials and random duplicates.

Results: Results: Per 100 grams of lean tissue, fat content was lower in wild turkey (cooked 3.3 ± 0.36g, raw 2.1± 0.12g) than domestic (cooked 7.4 ± 0.77g, raw 5.6 ± 0.20g). Likewise, polyunsaturated, monounsaturated, and saturated fatty acids were lower in wild than domestic turkey. Protein was higher in wild cooked (30.4 ± 1.19 g) compared to wild raw (24.2 ± 0.31g), domestic cooked (28.6 ± 0.97g) and raw (21.6 ± 0.68g). Cholesterol was lowest in wild raw (63mg) and highest in domestic cooked turkey (109 ± 0.29mg). Sodium was lowest in wild (raw 72mg, cooked 79mg) compared to domestic turkey (raw 112 ± 6.0mg, cooked 103 ± 7.2mg). Magnesium was highest in domestic cooked (30 ± 1.09mg) compared to others (domestic raw 25 ± 0.98mg; wild cooked 25mg and raw 24mg). Iron content was higher in wild (raw 1.5mg, cooked 2.4 mg) than domestic (raw 0.9 ± 0.09mg, cooked 1.1 ± 0.14mg) turkeys.

Conclusion: Conclusion: Fat and sodium were substantially lower in wild than domestic turkeys. Protein, iron, and zinc were higher in wild turkey while cholesterol and magnesium were lower, compared to their domestic raw and cooked counterparts. These data serve as a foundation for building nutrient profiles for making informed decisions about nutrient content of unique foods like game meat.

Keywords: Wild Turkey, Domestic Turkey, Nutrient data, Food composition,
Meat and Poultry Quality

82: DRY-AGING IMPROVES EATING QUALITY ATTRIBUTES OF LOW MARBLED GRASS-FED BEEF LOINS

Y. H. B. Kim 1, J. Berger 1,*, J. Lee 2, H.-W. Kim 1, S. Martini 2, J. Legako 2, S. Zuelly 1, P. Ebner 3
1Meat Science and Muscle Biology Lab, Department of Animal Sciences, Purdue University, West Lafayette, 2Department of Nutrition, Dietetics, and Food Science, Utah State University, Logan, 3Microbiology Lab, Department of Animal Sciences, Purdue University, West Lafayette, United States

Objectives: Inferior meat flavor and/or inconsistent tenderness associated with grass-fed beef has frequently been identified as a major quality problem mainly due to its low marbling content. Considering the emerging consumer demand for high quality and locally raised grass-finished beef, this presents a potentially profitable and sustainable marketing issue for this segment of the beef industry nationwide. Dry-aging, a traditional butchery process storing unpackaged sub-prrimals in a controlled cooler, has been known to improve palatability attributes. While these positive impacts of dry-aging have been mostly seen in highly marbled grain-fed cattle, there is little to no published research looking at how low marbled grass-fed beef is affected by dry-aging. Therefore, the objective of this study was to evaluate the effect of dry-aging on eating quality, chemical and microbiological attributes of grass-fed beef loins with a low degree of marbling.

Materials and Methods: At 7 d postmortem, eighteen bone-in strip loins (M. longissimus lumborum) from 9 beef carcasses (USDA Select grade; grass-fed) were obtained. Each loin was cut in half yielding a total of 36 sections, which were assigned to three aging methods; wet-aging in vacuum packages (WA), dry-aging (DA) and dry-aging in a water permeable bag (DW; UMAi Dry® Short Loin, Wayzata, MN), according to the pre-allocated balanced incomplete block design (n=12/treatment). All treatments were aged in the same condition at 78% RH, 2°C and air speed of 0.2 m/s for 28 days. After aging, DA and DW sections were trimmed of dehydrated surface. The pH, proximate composition, shear force, lipid (2-thiobabituric acid reactive substances, TBARS) and protein oxidation (carbonyl content), fatty acid (FA) profiling, microbial properties (aerobic plate count (APC), lactic acid bacteria (LAB), and yeast and mold (YM) counts) and consumer sensory evaluation (120 panelists; 10 panelists x 12 sessions; IRB #7315) of final retail products were determined. All data were analyzed using the PROC MIXED procedure of SAS, and least squares means for all traits were separated (F test, P<0.05) by using least significant differences.

Results: Different aging methods had no impacts on pH and fat content of grass-fed beef loins (P>0.05). However, WA had a significantly higher moisture content, but relatively lower protein and ash contents compared to DA and DW (P<0.05). Similar shear force and carbonyl content of grass-fed beef loins were observed regardless of aging methods (P>0.05). The TBARS value of DA and DW was slightly higher than that of WA (<0.1 mg MDA/kg difference; P<0.05). FA analysis revealed no major differences in FA profiles between the treatments. DA had the lowest APC and LAB levels (P<0.05). Significant differences in eating quality attributes were found, where DA steaks had higher flavor and tenderness preferences compared to the WA counterpart. DW resulted in a significantly higher juiciness of steaks compared to those of DA or WA (P<0.05).

Conclusion: Our findings indicate that dry-aging could improve eating quality attributes of low marbled/grass-fed beef without any adverse impacts on oxidation stability and microbial shelf-life. Hence, dry-aging could be a natural/value-adding post-harvest process to improve eating quality attributes of grass-fed beef. Further studies identifying chemical compounds associated dry-aging flavor of low marbled beef are highly warranted.

Keywords: beef, dry-aging, dry-aging in bag, grass-fed, meat quality
Objectives: The U.S. swine industry has placed a premium on lean growth in order to meet growing consumer demand for lean, affordable pork products. At the same time, growing global demand for pork as well as increased penetration of pork into the foodservice market has led to emphasis on genetic lines of pigs that produce high quality pork products. As the U.S. pork industry continues to grow it is important to understand how slaughter weight impacts carcass value in lines of pigs selected for lean growth and those selected for meat quality.

Materials and Methods: In this study, lean yield line (LYL) and meat quality line (MQL) boars were mated to PIC C-42 females to determine the effects of sire line, gender, and slaughter endpoint on carcass quality and yield attributes. Three pigs within a litter and gender category were randomly assigned to slaughter weights of 113, 136, and 159 kg. Upon reaching their assigned weight, pigs were slaughtered under inspection. A total of 108 offspring from 18 litters were evaluated. After slaughter, loin pH was measured and carcasses were chilled at -2°C. After 24 h, loin pHu, carcass muscle score (CMS), carcass length, tenth rib back fat (TRBF), last rib back fat (LRBF), loin eye area (LEA), NPPC color and marbling scores, and Hunter L*, a*, b* were measured in the longissimus muscle. Carcasses were fabricated, and primal and subprimal weights were recorded. After fabrication, samples were removed from the loin for proximate composition, drip loss, and Warner Bratzler and slice shear force (14 d aged) determination. Skinless belly dimensions (length, width, and depth) and firmness were recorded. Data were analyzed using GLM procedures with the main effects and interactions of sire line, gender, and slaughter endpoint and LSMEANS were separated using LSD.

Results: The LYL had higher \( P<0.01 \) CMS than the MQL, but the MQL had longer \( P=0.01 \) carcasses than the LYL. The MQL had more \( P<0.01 \) TRBF and LRBF than the LYL. LEA and LRBF increased as weight increased \( P<0.01 \), along with an increase \( P<0.01 \) in TRBF from 113 to 136 kg. The LYL gilts had darker \( P<0.05 \) loin color scores than the MQL gilts. As expected, the MQL had higher \( P<0.01 \) marbling scores than the LYL, with no differences \( P=0.29 \) noted across slaughter endpoints. Hot carcass weight was heavier \( P<0.01 \) for the MQL vs LYL. Primal weights and boneless cut yield increased \( P<0.01 \) as slaughter weight increased. The LYL exhibited greater \( P<0.03 \) cut yields when expressed as a percentage of side weight than the MQL for the lean cuts; however, the MQL exhibited greater \( P<0.05 \) cut yields than the LYL for the fatter cuts. The LYL and gilts had a higher \( P<0.01 \) percent fat free lean than the MQL and barrows, respectively. Lipid content was higher \( P<0.01 \) in the longissimus from the MQL vs LYL and barrows vs gilts. Slice shear values were lower \( P=0.01 \) for the LYL than the MQL, but Warner Bratzler shear did not differ.

Conclusion: Consistent advantages in lean yield existed in the LYL compared to the MQL. Increasing slaughter weight increased the pounds of boneless cuts; however, due to fat accumulation, increasing slaughter weight negatively impacted lean yield for both lines. No quality differences were found as carcass weight increased; however the MQL carcasses had higher marbling scores than the LYL. Advantages in meat quality were not as consistent across sire lines as were advantages in yield.

Keywords: genetics, pork, quality, yield
Meat and Poultry Quality

84: APPLICATION OF FOOD-GRADE INGREDIENTS INFUSED NETS TO CONTROL MITE INFESTATION ON DRY CURED HAM

X. Zhang 1,*, M. D. Byron 2, J. Goddard 3, T. W. Phillips 3, Y. L. Campbell 1, J. Hendrix 1, S. Abbar 3, W. Schilling 1

1Food Science, Nutrition, and Health Promotion, 2Biochemistry, Molecular Biology, Entomology, and Plant Pathology, Mississippi State University, Mississippi State, 3Entomology, Kansas State University, Manhattan, United States

Objectives: *Tyrophagus putrescentiae* (Schrank) (Sarcoptiformes: Acaridae), the most common arthropod pest of dry-cured ham, is controlled in the U.S. dry cured ham industry with methyl bromide (MB) fumigation. However, MB fumigation will be phased out of use since it is an ozone depleting substance. The objective of this research was to evaluate ham nets that were infused with food-grade ingredients for their efficacy at controlling mite infestations on dry cured ham.

Materials and Methods: Ham nets were infused with low or medium concentrations of patent pending formulations of food-grade propylene glycol (PG) and lard, and/or gums. The gums that were used include xanthan gum (XG) and the combination of carrageenan (CG) and propylene glycol alginate (PGA). Three sets of experiments were conducted. The netting formulations in the first set included 100% lard, lard + low PG, and lard + medium PG; the second set included XG + low/medium lard + low/medium PG; and the third set included CG + PGA + low/medium lard + low/medium PG. Control hams cubes were not covered with nets, while net control ham cubes were wrapped with untreated nets. Dry cured ham cubes (2.5 × 2.5 × 2.5 cm³) were covered in untreated or treated nets and placed in ventilated glass jars. Each cube was inoculated with 20 large adult mites and incubated in a dark cabinet that was controlled at room temperature (20-25 °C) and relative humidity of 80 ± 5 %. In order to evaluate the long-term effectiveness of treated nets at controlling mite infestations, two batches of samples were prepared and each batch was inoculated with adult mites on the first day of storage and at 4 weeks of storage, respectively. After two weeks of incubation, the total number of moving mites were counted under a microscope. Randomized complete block designs with two replications (n=10) were utilized for each set of experiments, and Tukey’s Honestly Significant Difference Test (P<0.05) was used to separate treatment means.

Results: Fewer *T. putrescentiae* (P<0.05) were on ham cubes with treated nets that contained PG when compared to the number of mites on ham cubes with untreated nets over six weeks of storage. In comparison to the net control (123-163 mites on average), lard and low- or medium-PG infused net treatments had only 19-44 mites. However, lard infused nets without PG did not decrease the mite population (P>0.05). XG + lard + PG infused nets had fewer mites (2-39 mites) (P<0.05) when compared to the net control (77-146 mites). Similarly, CG + PGA + lard + PG infused nets also had fewer mites (0-22 mites) (P<0.05) than the net control (88-123 mites), and medium PG treatments had only a few mites present. Nets slowed the growth and reproduction of *T. putrescentiae* since net controls had fewer mites (P<0.05) than controls without nets (133-437 mites). Molds were not present on ham cubes that were treated with PG-containing nets over 6 weeks of storage, with the exception of XG + low lard + low PG and CG + PGA + low lard + low PG treatments that were inoculated at 4 weeks of storage.

Conclusion: Lard and XG, or CG + PGA treated nets containing the medium concentration of PG effectively inhibited mite reproduction and mold growth on dry cured ham and could potentially be used in an integrated pest management program to control mites on dry cured ham.

Keywords: mite reproduction, propylene glycol, lard, dry cured ham
Meat and Poultry Quality

85: THE IMPACT OF SELECTION USING RESIDUAL AVERAGE DAILY GAIN AND MARBLING EPDS ON GROWTH PERFORMANCE AND CARCASS TRAITS IN ANGUS CATTLE


1Animal and Dairy Science, University of Georgia, Athens, United States

Objectives: Angus steers (n = 191) over a 3-yr period were used to compare growth performance, feed efficiency, body composition, and carcass characteristics from bulls divergently selected for feed efficiency. Angus sires were selected with high and low residual average daily gain (RADG) EPDs and high and average marbling (MARB) EPDs.

Materials and Methods: Steer weight and body composition, via ultrasound, were measured at weaning and yearling ages. Steers entered the feedlot at 454 d of age and completed a 70-d GrowSafe™ Beef test to determine DMI, ADG, and RFI. Steers were then slaughtered under federal inspection as they reached a backfat thickness of 1.3 cm. Carcasses were chilled for 48 h at 2°C, ribbed, and USDA yield and quality grade data were collected. The right side of the carcass was fabricated and primal and subprimal weights were collected. A 2.5-cm longissimus steak was removed, vacuum-packaged, aged for 14 d, and frozen for slice shear force determination. Additionally, a 1.3 cm longissimus steak was removed from year 3 steers for proximate analysis. The GLM procedure of SAS was used and the main effects of RADG and MARB and their interaction were tested by SIRE(RADG*MARB). Year was evaluated as a replicate.

Results: Steer weaning and yearling weights and ultrasound body composition were not affected (P ≥ 0.30) by RADG selection, except for the Lo RADG steers having higher (P ≤ 0.02) IMF values than the Hi RADG steers at both measurement times. For MARB selection, weaning weight, backfat and REA were higher (P ≤ 0.05) in the Hi vs Lo MARB steers; however, no differences in weight or composition were noted at yearling. Feedlot gain, ADG, DMI and daily DMI were not affected (P > 0.20) by selection using RADG or MARB EPDs. However, feed efficiency measured by RFI (P = 0.05) and DM Gain:Feed (P = 0.11) was improved in the Hi RADG steers compared to their Lo RADG counterparts. Selection for increased marbling did not significantly affect feed efficiency measures. Slaughter and hot carcass weights were heavier (P ≤ 0.03) in the Hi vs Lo RADG groups; however, no other carcass traits were impacted (P ≥ 0.14). Marbling score and adjusted 12th rib backfat tended to be higher (P = 0.10) in the Hi vs Avg MARB groups. An interaction (P = 0.05) between RADG and MARB selection was found for marbling score, with the Lo RADG/Hi MARB steers having significantly higher marbling scores than all other groups which did not differ (P > 0.05) from each other. The distribution of quality grades across MARB groups revealed a higher percentage of low and average Prime carcasses in the Hi MARB group and a higher percentage of low Choice carcasses in the Avg MARB groups. No major differences were observed across the RADG and MARB groups in primal and subprimal yields or meat tenderness. Longissimus proximate composition from year 3 steers showed that lipid content was higher in the Hi MARB and Lo RADG groups compared to the Lo MARB and Hi RADG groups, respectively.

Conclusion: These findings suggest that selection using RADG or MARB EPDs has minimal impact on carcass yield, and positive selection pressure placed on these genetic values can potentially improve efficiency and carcass quality, respectively. Furthermore, it appears that improvements in feed efficiency can be attained without negatively impacting beef carcass merit, especially USDA quality grade.

Keywords: Angus, carcass, marbling, residual feed intake, steers
Meat and Poultry Quality

86: CONSUMER SENSORY EVALUATION OF BEEF FOLLOWING DISPLAY IN VARIED PACKAGING TYPES

J. Ponce 1*, J. C. Brooks 1, J. Legako 1
1Animal and Food Science, Texas Tech University, Lubbock, United States

Objectives: This study aimed to determine the impact of packaging systems and muscle type on consumer sensory perception.

Materials and Methods: Paired strip loins and top sirloin butts collected from USDA Choice, “A” maturity beef carcasses (n = 10), were used in a 2x5 factorial arrangement to determine the effects of muscle and packaging type on beef flavor. All subprimals were packaged under vacuum and aged for 14d. After initial aging, all subprimals were fabricated to produce Gluteus medius (GM) or Longissimus dorsi (LD) steaks. At 14d steaks were randomly assigned to 1 of 5 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 and non-forming films, ROLL), vacuum packaging without retail display (VAC), and traditional overwrap (OW) which remained under vacuum prior to being placed on foam trays and sealed with polyvinyl chloride film. All were stored in darkness an additional 7d prior to display. At 21d postmortem, HIOX, OW, CO, and ROLL packages were removed from dark storage and displayed in retail cases (0-2˚C) for 48hrs under continuous fluorescent lighting, while VAC steaks remained in dark storage. After 48hrs, all steaks were individually vacuum packaged and frozen (-20˚C). Consumer panels (n=5 panels with 20 consumers/panel; 100 consumers total) were conducted in Lubbock, TX. Cooked steaks (71.6 ± 1.39˚C) were evaluated for overall liking (OALL), liking of flavor (LFLAV), tenderness (TEN), and juiciness (JUIC). All attributes were measured on a 100-mm line scale with Not Present/Dislike Extremely representing 0 and Very Present/Like Extremely representing 100. Acceptability was determined by asking a yes or no question for overall acceptability (OACC), flavor (FLAVACC), tenderness (TENDACC), and juiciness (JUICACC). Each panelist was served one, 1.5 cm x 1.5 cm piece per steak, evaluating a total of 10 steaks representing all possible muscle x packaging combinations. Data were analyzed using GLIMMIX proc in SAS (9.4).

Results: A muscle x packaging interaction (P=0.02) was determined for OALL, for all other dependent variables only main effects are discussed as no muscle x packaging interactions (P ≥ 0.08) were found. The GMHIOX and LDHIOX had the lowest (P<0.05) scores for OALL compared with LDROLL, GMROLL, GMCO, LDVAC, GMVAC, and LDOW. However, LDCO and GMOW were considered similar (P>0.05) with the 2 HIOX muscles. In two cases OALL differed within packaging types between muscles, LDOW was rated lower (P<0.05) than GMCO. Additionally, LDOW was rated higher (P<0.05) than GMOW. Both, LDVAC and GMVAC did not differ in OALL (P>0.05), were similar (P>0.05) with all other muscle and packaging combinations, but were rated higher than HIOX steaks (P<0.05). The HIOX packaging type influenced LFLAV (P<0.001) and TEND (P<0.001) without interaction with muscle, and ROLL was rated higher (P<0.001) than VAC, CO, OW, and HIOX for LFLAV. The HIOX treatment resulted in a lower (P<0.05) occurrence of OALL (P<0.001), FLAV (P<0.001), and TEND (P<0.030) acceptability. The LD had greater (P<0.05) juiciness compared with the GM.

Conclusion: The results of this consumer study indicate that high-oxygen package systems have a detrimental effect on palatability. Meanwhile, vacuum type or low oxygen packaging has clear advantages with regards to delivering product with greater flavor liking.

Keywords: beef, flavor, packaging, Palatability
Meat and Poultry Quality

87: EFFECTS OF EXPOSURE TO A HIGH-CONCENTRATE OR PASTURE BASED DIET FOR VARIED TIME PERIODS ON CARCASS CHARACTERISTICS AND QUANTITATIVE ANALYSES OF COMPOSITION AND TENDERNESS OF BEEF STRIP LOIN STEAKS OF EARLY FED STEERS

J. T. Milopoulos 1,*, B. M. Koch 2, A. J. Garmyn 1, J. F. Legako 1, S. K. Duckett 2, M. F. Miller 1
1Animal and Food Science, Texas Tech University, Lubbock, 2Animal and Veterinary Science, Clemson University, Clemson, United States

Objectives: It is generally accepted that exposure to a high concentrate diet promotes improved carcass characteristics in cattle, but less has been done to explore carcass effects of early exposure to concentrate post-weaning across serial fed periods. The objective of this study was to assess carcass quality, composition, and tenderness of beef strip loin steaks from steers finished early post-weaning on either a pasture-based diet or various time periods on a high concentrate diet, followed by pasture finishing.

Materials and Methods: Following a live feeding trial at Clemson University (Clemson, SC), 47 steers were harvested on 2 dates at a commercial slaughterhouse (either 308 or 354 total days on trial), and carcass data were collected, including hot carcass weight (HCW), ribeye area (REA), 12th rib backfat thickness (FT), KPH, marbling score, and skeletal maturity. Steers were blocked by initial shrunk body weight (SBW) and assigned to diet treatment groups following weaning. Weight blocks were: light, middle, and heavy (214±9 kg, 229±9 kg, 250±10 kg, respectively; n=4/treatment/block). Animals were individually fed, and treatment groups included: all pasture (P; n=12), 40 d high concentrate feed (40d; n=12), 80 d high concentrate feed (80d; n=11), 120 d high concentrate feed (120d; n=12), followed by pasture finishing to a mean final SBW of 465±29 kg. Loins were separated from the carcass 1 d post-harvest and stored at 0–4°C until 21 d postmortem. After aging, loins were frozen (-20°C) until further processing. Subprimals were fabricated into 2.5 cm steaks while still frozen and vacuum packaged for storage. The anterior-most steak was used for proximate analysis, conducted using a near infrared spectrophotometer; pH was measured subsequently using a slurry of ground product from the same steak. WBSF was conducted using the second most anterior steak. Data were analyzed using Proc GLIMMIX of SAS 9.4 with treatment as the fixed effect. Carcass data were analyzed with block and harvest date as random effects. Cooking loss was included as a covariate (P<0.01) in the analysis of WBSF.

Results: No differences were detected in full SBW or shrunk dressing percentage (P=0.41, P=0.07, respectively), though HCW did differ between treatments (P=0.03). Marbling score was also influenced by diet (P<0.01), as was FT (P=0.04). In all three cases, 120d differed from other treatments, having a heavier HCW, greater marbling scores, and greater FT compared to the remaining diets. Skeletal maturity was not influenced by diet (P=0.65), and no differences were detected for REA (P=0.08), KPH (P=0.17), or calculated yield grade (P=0.57). Percent lipid content differed between treatments in proximate analysis (P=0.01) with 120d having the greatest fat content. Consequently, moisture differed between treatments (P=0.03), though percent protein and collagen did not (P=0.34, P=0.07, respectively). The pH was similar between treatments (P=0.64), as was WBSF value (P=0.98).

Conclusion: While varied lengths of exposure to high-concentrate diet early post-weaning had little effect on yield grade and dressing percentage, these data suggest that early exposure to a high-concentrate diet for 120 d increased fat deposition, and therefore backfat thickness, marbling, and percent fat in muscle composition.

Keywords: composition, grain, meat quality, pasture, tenderness
**Meat and Poultry Quality**

**88: ASSOCIATION OF A SINGLE NUCLEOTIDE POLYMORPHISM IN M-CALPAIN GENE WITH WARNER-BRATZLER SHEAR FORCE IN A CROSSBRED BRAHMAN-ANGUS POPULATION**


1Animal Sciences, University of Florida, Gainesville, United States

**Objectives:** Tenderness is a major factor influencing consumer satisfaction of beef products. The calpain-calpastatin system influences tenderness through the proteolysis of structural proteins. The purpose of this study was to investigate the impact of a Single Nucleotide Polymorphism (SNP) in the calpain gene, on beef tenderness. A SNP is a genetic marker with a known location on a chromosome, where a single nucleotide is replaced with another in some individuals.

**Materials and Methods:** In this study, steaks were taken from the longissimus dorsi of 623 crossbred Angus-Brahman steers. The steaks were aged for 14 days and tenderness was determined by Warner-Bratzler shear force (WBSF). DNA was extracted from a blood sample collected at slaughter, using the Qiagen DNeasy Blood & Tissue Kit. The SNP was genotyped by real-time PCR and high resolution melt curve analysis. The allelic and genotypic frequencies were calculated using Proc Frec procedure of SAS. An association analysis was performed using the general linear model procedure in SAS, to determine the association between the genotypes and WBSF values. Year, breed group, cooking loss, and genotypes for the SNP were used as fixed effects in the model.

**Results:** The CAPN4751 SNP was polymorphic in the multibreed population with genotypic frequencies of 23.2% CC, 71.2% CT and 5.6% TT. The genotypes for CAPN4751 was not significantly associated with Warner Bratzler Shear Force values in this population. Breed group, year and cooking loss were highly significant. The mean WBSF for purebred Angus was 3.9, 75% Angus 4.09, 50% Angus was 4.05, Brangus was 4.15, 25% Angus was 4.5, and purebred Brahman was 4.4.

**Conclusion:** Although CAPN4751 was not significant in this study, consistent with previous research a trend between higher Warner Bratzler Shear Force Values and a higher percent Brahman was found, indicating that Brahman tend to have tougher meat.

**Keywords:** Calpain, tenderness prediction
Meat and Poultry Quality

89: HONDURAN CONSUMER PERCEPTION OF PALATABILITY OF ENHANCED AND NON-ENHANCED BEEF FROM VARIOUS FINISHING DIETS

N. Hardcastle 1,*, A. J. Garmyn 1, J. F. Legako 1, M. M. Brashears 1, M. F. Miller 1
1Animal and Food Science, Texas Tech University, Lubbock, United States

Objectives: Honduran consumers traditionally prefer beef cooked to a well-done degree of doneness, which can reduce palatability. Increasing an animal’s plane of nutrition can improve meat palatability, and enhancing beef can enrich eating quality. Our objective was to determine the effects of finishing diet and enhancement on eating quality and value of steaks.

Materials and Methods: Regionally available feedstuffs were added into 7 finishing diets: grass-finished control (CON), distillers dry grain (DDG), palm kernel meal (PKM), PKM replication (PKMR), soybean meal (SB), SB with poultry litter (SBPL) and sugar cane (SC). Paired strip loins (n=210; 30/diet) were collected, so one loin could be enhanced (E) with water, salt, and sodium tripolyphosphate to 12% of the green weight, while the other loin remained non-enhanced (N). Strip loins were fabricated into 2.5-cm steaks and frozen at 21 d postmortem. Thawed steaks were cooked on clamshell grills to 77°C, portioned and served warm to 3 consumers (n=288). Panelists evaluated each sample for tenderness, juiciness, flavor and overall liking on 100-mm lines scales, as well as acceptability of each trait (TACC, JACC, FACC, and OACC). Willingness to pay (WTP) was rated in Honduran Lempira (Lps) on a line scale anchored from 0/lb. to 400/lb. Each consumer evaluated 8 samples, consisting of CON-E and CON-N along with 6 other treatments arranged in a prearranged, balanced order. Sensory data were analyzed using the GLIMMIX procedure of SAS as a split plot design with diet as a whole plot fixed effect, enhancement as a subplot fixed effect, and panelists as a random effect (α=0.05).

Results: Diet and enhancement interacted (P<0.01) to influence all palatability traits, WTP and acceptability of all traits. In general enhancement improved (P<0.05) all palatability traits, acceptability, and WTP compared to their non-enhanced counterparts for all treatments, except CON. CON-N and CON-E had similar (P>0.05) scores for tenderness and overall liking, as well as similar WTP, TACC, JACC, FACC, and OACC. Enhancement did not improve (P>0.05) JACC for PKM, PKMR, and SC. DDG-E was more tender (P<0.05) than all other treatment combinations, except PKMR-E, while consumers rated SB-N and SC-N less tender than all other treatments. This same trend was observed for TACC. Aside from DDG-E and SB-E, PKM-E beef was juicier (P<0.05) than other treatments, and SB-N was less juicy than all other treatments except for SC-N. The flavor of DDG-E, PKM-E, PKMR-E, SB-E and SBPL-E was liked more (P<0.05) by consumers than all other treatments; a greater percentage of consumers found those same treatments more acceptable for flavor. Meanwhile, the flavor of SB-N and SC-N was liked less (P<0.05) compared to all other treatments. Overall consumers liked DDG-E, PKM-E, PKMR-E, SB-E and SBPL-E more (P<0.05) and SB-N and SC-N less than all other treatments. OACC followed the same trend as scores for overall liking. PKMR-E, DDG-E, SBPL-E, and PKM-E had greater (P<0.05) WTP than all other treatments except SB-E, while SB-N had lower WTP than all other treatments except SC-N, indicating that enhancement greatly improved the WTP of SB samples.

Conclusion: Results from this study indicate the use of high-energy diets and enhancement of steaks can improve Honduran consumer’s perception and acceptance of palatability traits and garner a higher WTP when used singularly or in combination.

Keywords: beef, consumers, Enhancement, finishing diet, Honduras
Meat and Poultry Quality

90: RUMEN PROTECTED LONG CHAIN FATTY ACID SUPPLEMENTATION EFFECTS ON BEEF CARCASS TRAITS AND COMPOSITION

C. Fehrman 1,*, H. Rode 1, J. Grubbs 1, A. Blair 2, K. Underwood 1

1Animal Science, South Dakota State University, Brookings, 2Animal Science, South Dakota State University, Rapid City, United States

Objectives: Marbling is one of the most important indicators of beef quality. Greater amounts of intramuscular fat are associated with increased palatability. Previous research has shown the activation of peroxisome proliferator activated receptor gamma (PPARγ) is related to marbling development in growing beef cattle, and long chain fatty acids are known activators of PPARγ. The objective of this study was to determine if supplementation of long chain fatty acids, which are known activators of PPARγ, will increase marbling development of beef cattle.

Materials and Methods: Angus steer calves (n=99) were backgrounded for 77 days with a target weight gain of 1.2 kg/day and received a Synovex-S implant during this period. Upon completion of backgrounding, the steers were divided into 12 pens with 8-9 head/pen. Steers received a transition diet for 21 days prior to being fed a high concentrate diet containing high moisture ear corn, corn silage, dry rolled corn, soybean meal, and a liquid supplement containing monensin. Megalac®-R was fed to 6 pens at 2% of the diet dry matter (LCFA). Control pens (CON; n = 6) received an additional 2% of diet dry matter as dry rolled corn. The final finishing diet NEg for LCFA and CON treatments was 63.70 and 60.50 Mcal/cwt respectively. At day 28 of the finishing phase, cattle received a Revalor-S implant. Steers were weighed every 28 days. Growth performance data including ADG and G:F were calculated monthly and averaged across the feeding period for cumulative data. After a 147-day finishing phase, steers were transported to a commercial abattoir for slaughter. After a 24-hour chilling period, standard carcass data were obtained by trained personnel. A subset of carcasses (n=24, 2 per pen) were selected for carcass composition analysis using 9-10-11 rib dissections and analyzed using equations from Hankens and Howe (1946). Live and carcass data were analyzed using Proc GLM of SAS and rib composition data were analyzed using PROC Mixed of SAS. Both used pen as the experimental unit. Significance was determined at a P-value ≤ 0.05 and a trend at a P-value < 0.10.

Results: Final live weights tended (P =0.06) to be greater for LCFA than CON cattle (596±1.51 vs. 586±2.86 kg). There was a tendency for cumulative ADG to be increased (1.60±0.01 vs. 1.54±0.02 kg; P =0.08) while cumulative G:F was decreased (0.07±0.02 vs. 0.08±0.02 kg; P =0.04) for LCFA cattle. Hot carcass weight, REA, Backfat, %KPH, Marbling Score, Quality Grade, and Yield Grade did not differ (P > 0.05) between treatments. Composition of the 9-10-11 rib sections revealed no differences in ash (P =0.25), moisture (P =0.16), or fat (P =0.12). Protein was greater (15.3±0.22 vs. 14.6±0.09%; P =0.01) for CON cattle. Predicted percent carcass fat was increased for LCFA cattle (25.5±0.39 vs. 23.9±0.60%; P <0.05). In contrast, predicted percent carcass protein (13.8±0.13 vs. 13.6±0.05%; P =0.07) and bone (14.6±0.21 vs. 13.8±0.33%; P =0.06) tended to be greater for CON cattle.

Conclusion: Long chain fatty acid supplementation during the finishing phase did not increase marbling scores of the steers in this study, but predicted total body fat was increased. Supplementation of LCFA at earlier growth stages or for longer durations are of interest for future work to determine if marbling scores can be increased.

Keywords: beef, carcass composition, meat quality
Meat and Poultry Quality

91: QUALITY AND SHELF LIFE OF GROUND BEEF FROM CATTLE FED DISTILLERS GRAINS MANUFACTURED TO CONTAIN DIFFERENT AMOUNTS OF OIL

F. D. Rasmussen1,*, C. G. Bower1, G. A. Sullivan1
1Department of Animal Science, University of Nebraska-Lincoln, Lincoln, United States

Objectives: Ethanol processors have begun removing a portion of the free oil from distillers grains during the manufacturing process. Therefore the purpose of this study was to determine the effect of feeding modified distillers grains (MDGS) containing different amounts of oil on the fatty acid content and quality characteristics of raw and cooked ground beef.

Materials and Methods: Steers (n=256) were finished (134 d) on one of four diets: 1) corn control, 2) 40% full-fat MDGS, 3) 40% de-oiled MDGS, or 4) 40% de-oiled MDGS with oil added back in proportion to the oil removed during the de-oiling process. From each pen (N=32; 8 pens per diet with 8 steers per pen), the shoulder clod from 1 USDA low Choice carcass was collected. Shoulder clods were stored at 4°C until processing. On day 14 postmortem, about 100g of lean tissue (triceps brachii) and 30g of subcutaneous fat was collected from the ventral end of each shoulder clod for fatty acid analysis and the remaining portion was ground. A ground composite sample was collected for fatty acid analysis. Raw patties (113g) and cooked beef links (containing 0.75% salt and 0.25% sodium phosphate) were manufactured from each ground clod. The raw patties covered in oxygen permeable film were placed in a simulated retail display for 7 days at 4°C. The raw patties were analyzed for objective color (L*, a*, b*; Minolta CR-400), percentage discoloration by a five-person panel, and lipid oxidation by the thiobarbituric acid reactive substances (TBARS) protocol during retail display storage. Cooked beef links were stored at 4°C for 18 days and 0°C for 196 days, and were analyzed for lipid oxidation throughout storage. Data were analyzed for main effects of diet, and when appropriate, data were analyzed for main effects of diet, time, and their interaction using GLIMMIX procedure of SAS (v.9.4). Storage time was considered a repeated measure. When significant effects were identified (P ≤ 0.05), LS means separation was conducted using a Tukey adjustment.

Results: Inclusion of any modified distillers grains increased the content of C18:2 in lean, subcutaneous fat, and ground composite samples, and the concentration of polyunsaturated fatty acids (PUFA) in subcutaneous fat and composite samples (P ≤ 0.01). Diet did not impact objective color measures (P = 0.827), discoloration (P = 0.872), or lipid oxidation in raw beef patties (P =0.289). Lipid oxidation and discoloration of raw patties increased throughout simulated retail display (P < 0.001). Similarly, finishing diet had no effect on lipid oxidation of cooked beef links in refrigerated (P = 0.342) or frozen storage (P = 0.948) but lipid oxidation did increase with increased refrigerated or frozen storage time (P < 0.001).

Conclusion: Feeding modified distillers grains manufactured to contained different amounts of lipid content to cattle increased the amount of C18:2 and PUFA in beef but did not have negative effects on the quality and shelf life of raw ground beef patties or cooked beef links.

Keywords: Cooked ground beef, Distillers grains, Fatty acid composition, Lipid oxidation, Raw ground beef
Meat and Poultry Quality

92: EFFECTS OF FEEDING PEROXIDIZED SOYBEAN OIL TO FINISHING BARROWS ON THE SHELF-LIFE OF BACON AND LOIN CHOPS

M. F. Overholt 1,*, G. D. Kim 1,2, B. J. Kerr 3, D. D. Boler 1, A. C. Dilger 1

1Department of Animal Science, University of Illinois, Urbana, United States, 2Institute of Agriculture & Life Science, Gyeongsang National University, Jinju, Korea, Republic Of, 3USDA, ARS, Ames, United States

Objectives: Peroxidized lipids are, at times, used in finishing pig diets and have been shown to induce oxidative stress and reduce growth performance. The effects of feeding peroxidized lipids on the shelf-life of pork products is not as clear, as previous research has reported contradictory results. Therefore, the objective of this study was to test the effect of feeding soybean oil (SO) subjected to varying degrees of thermal abuse to finishing pigs on lipid oxidation and sensory attributes of commercially manufactured bacon during 90 d of simulated food-service-style storage; and the color stability and lipid oxidation of pork loin chops during 11 d of simulated retail display.

Materials and Methods: Fifty-five individually housed barrows were randomly allotted to 1 of 4 diets containing 10% SO: 1.) not heated (CON), or heated at 2.) 45°C for 288 h (45C/288h), 3.) 90°C for 72 h (90C/72h), or 4.) 180°C for 6 h (180C/6h), and fed for 81 d. Barrows were slaughtered on d 82 at the University of Illinois. At 24 h postmortem, bellies (NAMP 408) and Canadian back loins (NAMP 414) were removed from carcasses. Two 2.54 cm thick chops were cut from the Canadian back loin and used to determining color stability and thiobarbituric acid reactive substances (TBARS) during simulated retail display. Bellies were skinned (NAMP 409) then processed into sliced bacon at a commercial facility. Bacon was stored at -4°C without an atmosphere barrier to simulate food service storage conditions. Samples were removed on d 0, 30, 60, and 90 for sensory evaluation by 6 trained panelists and analysis of TBARS. Loins were packaged 1 d postmortem in foam trays covered in oxygen permeable overwrap and subjected to an 11 d simulated retail display at 4°C with full exposure to fluorescent light. Loins were evaluated for CIE L*, a*, b*, reflectance ratio, and visual discoloration daily. Loin samples were analyzed for TBARS on d 1 and d 10 of display. Data were analyzed as a complete randomized design repeated in time with fixed effects of oil treatment and storage day. Storage location (shelf) served as a random effect for analysis of loin shelf-life. Bacon sensory data were analyzed as a partially balanced incomplete block design repeated in time, with fixed effects of oil treatment and storage time, and sensory session serving as a random effect.

Results: There was no effect of oil treatment on TBARS (P > 0.90), oxidized odor (P = 0.63), or oxidized flavor (P = 0.79) of bacon. As expected lipid oxidation, oxidized odor, and oxidized flavor increased (P < 0.0001) over the 90 d storage period. There was no effect (P > 0.51) of oil treatment on L*, hue angle, or TBARS of loin chops subjected to a 10 d simulated retail display. However, chops from pigs fed 45C/288h oil were more red (greater a*; P < 0.01) and more yellow (greater b*; P < 0.01) than the other three treatments. Chroma and reflectance were also greater (P < 0.03) greater for these same chops; however, the 45C/288h chops were the most (P < 0.01) discolored after 10 d of simulated retail display.

Conclusion: Feeding peroxidized soybean oil did not affect lipid oxidation in either food-service packaged bacon or fresh loin chops. However, feeding the 45C/288h oil (mild thermal abuse) resulted in chops that were more red had more intense color, but also were the most discolored at the conclusion of an 11 day simulated retail display.

Keywords: bacon, oxidized oil, pork, shelf-life
Objective: Our objective was to determine the relationship between carcass maturity and beef palatability of strip loin and outside round steaks.

Materials and Methods: Left sides of A (n=30), B (n=30), and C (n=30) maturity heifer carcasses under 30 months of age by dentition were used. Average skeletal maturities of the groups were A 67, B 49, and C 48. Carcasses were selected to ensure similar marbling scores across maturity groups, and average marbling scores were Sm 94, Mt 02, and Mt 01 for A, B, and C maturity carcasses, respectively. Beef strip loins (IMPS 180) and outside (bottom) rounds (IMPS 171B) obtained from these carcasses were purchased from AB Foods (Toppenish, WA) and transported to the University of Idaho Meat Science Laboratory. Following a 14-day aging period, wholesale cuts were removed from vacuum packaging and ischiatic heads were removed from outside rounds to produce trimmed flats. Two 2.54 cm-thick steaks were cut from the trimmed flats and anterior ends of strip loins. Steaks were used to measure Warner-Bratzler shear force (WBSF), cook loss, insoluble and total collagen, and consumer sensory attributes. Steaks used for WBSF were weighed, cooked on open hearth broilers to an internal temperature of 40°C, then turned and cooked to a final internal temperature of 71°C. Cooked steaks were re-weighed to determine cook loss and cooled to 4°C. Six cores (1.27-cm diameter) were then removed from each steak parallel with the muscle fibers and then sheared perpendicular to muscle fiber orientation using a Warner-Bratzler shear machine (GR Manufacturing, Manhattan, KS). Samples from cooked steaks were frozen at -20°C and used to determine insoluble and total collagen. Sensory panel steaks were frozen at -20°C after aging, and allowed to thaw at 4°C for 24 hours prior to the consumer panel. Steaks were cooked as previously described and four 1.27-cm x 1.27-cm x steak thickness cubes were obtained from each steak. Separate sensory panels were conducted for strip loin and outside round steaks. Consumers (n=72 panelists per panel) evaluated cooked samples for overall acceptability, tenderness, juiciness, and flavor using a 9-point scale (9 = like extremely, 1 = dislike extremely). Using an incomplete block design, panelists evaluated 5 samples from the 3 maturity groups. Data were analyzed using the Mixed Model procedure of the Statistical Analysis System (SAS Institute, Inc., Cary, NC). Significance was determined at P < 0.05 and data were considered trending at P < 0.10.

Results: Heifer carcass maturity did not significantly affect WBSF or cook loss for either outside round or strip loin steaks (P > 0.23). Likewise, insoluble and total collagen were not different for either steak type from A, B, or C maturity carcasses (P > 0.89). Strip loin steaks from C maturity carcasses tended to have higher overall acceptability (P = 0.08) and juiciness (P = 0.09) than steaks from B maturity carcasses, but steaks from B and C maturity carcasses did not differ from strip loin steaks obtained from A maturity carcasses (P > 0.11). No differences in tenderness or flavor were observed due to maturity (P > 0.24). Similarly, maturity had no effect on sensory characteristics of outside round steaks (P > 0.30).

Conclusion: In conclusion, advanced skeletal maturity does not decrease palatability of carcasses from cattle under 30 months of age.

Keywords: Beef, Carcass, Heifer, Maturity, Palatability
Meat and Poultry Quality

94: INFLUENCE OF POSTMORTEM AGING OF FRESH PORK LOIN ON INSTRUMENTAL TENDERNESS AND ABUNDANCE OF A SOLUBLE DESMIN DEGRADATION PRODUCT.

A. C. Outhouse 1, K. J. Prusa 2, C. A. Fedler 2, E. M. Steadham 1, M. D. Schulte 1*, E. Huff-Lonergan 1, S. M. Lonergan 1

1Department of Animal Science, 2Department of Food Science and Human Nutrition, Iowa State University, Ames, United States

Objectives: It is well understood that aging fresh pork loins will improve tenderness. The explanation for this phenomenon is degredation of myofibrillar, cytoskeletal, and intermediate filament proteins by endogenous proteolytic enzymes. Recently, the abundance of a desmin fragment in the sarcoplasmic fraction of aged pork has been linked to differences in pork tenderness. The objective of this experiment was to document the abundance of this desmin degradation product in the sarcoplasmic fraction during aging of fresh pork loin and determine its relationship to fresh pork tenderness.

Materials and Methods: Loins (n = 20) were collected 1 day postmortem at a commercial processing facility. Criteria for inclusion in the study was an average pH between 5.70 and 5.85 and a visual color score (National Pork Board) between 3 and 4. Two loin chops containing only the longissimus muscle (2.54 cm and adjacent 1 cm chop) from each loin were aged 1, 3, 7, or 14 d. Upon completion of aging, 2.54 cm chops (never frozen) were used to determine Hunter L, a, b, pH, color scores, and marbling scores. These chops were then cooked to 68 °C and evaluated for cook loss and star probe (kg). The 1 cm thick chops were frozen and homogenized in liquid nitrogen at the end of each aging period. Proteins were fractionated to isolate proteins soluble in a low ionic strength buffer (40 mM Tris, 1 mM EDTA, pH 8.0). Abundance of a desmin degradation product (34 kDa) in the sarcoplasmic fraction was determined by immunoblotting and normalized to the abundance of a reference sample on each gel. Data were analyzed with a fixed effect of days of aging, and a random effect of loin. Pearson correlations for the quality variables were calculated.

Results: Star probe values declined with aging (7.9 kg, 6.4 kg, 5.6 kg, and 5.1 kg after aging 1, 3, 7, and 14 d respectively). Each aging period showed a significant decline in star probe (P<0.05). The abundance of the desmin degradation product in the sarcoplasmic fraction significantly increased between 1, 3, and 7 d aging (P<0.01). No difference in desmin fragment abundance was observed in a comparison of samples aged 7 and 14 d. Across all days of aging, star probe was positively correlated with cook loss (r = 0.59), and weakly correlated with pH measured on the day of aging (r = 0.29). Across all aging periods, desmin degradation product abundance was significantly negatively correlated (r = -0.49) with star probe values. Abundance of the desmin degradation product in the sarcoplasmic fraction measured after aging 1 d postmortem was significantly negatively correlated with star probe measured 3,7, and 14 d postmortem (r = -0.46, -0.44, and -0.45 respectively). Presence of soluble desmin in early postmortem pork may aid in predicting pork loin tenderness after aging.

Conclusion: Therefore, results of this study demonstrate promise of using the abundance of a desmin degradation product in the sarcoplasmic fraction of early postmortem pork to predict fresh pork tenderness.

Keywords: desmin, pork, proteolysis, tenderness
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95: THE MICROBIAL QUALITY OF PORK CARCASS DURING STORAGE

F. Najar 1,*, E. Boyle 1, T. Houser 1, R. Phebus 1, C. Vahl 1, J. Wolf 1, J. Gonzalez 1, T. O’Quinn 1, J. Acuff 1, D. Vega 1
1Animal Science and Industry, KANSAS STATE UNIVERSITY, Manhattan, United States

Objectives: To assess the microbial quality of pork carcasses held for up to 21 days prior to fabrication.

Materials and Methods: The right sides of 20 freshly harvested pork carcasses were held in a carcass cooler for 21 d. Cooler temperature was measured every hour using a data logger. Three carcass locations (flank, shoulder, and jowl) were surface sampled on days 1, 7, 14, and 21 after slaughter using a stainless-steel meat corer. A 21.6 cm² area corer was used to obtain flank and shoulder samples, and a 9.6 cm² area corer was used to collect jowl samples. Each location had four sites that were randomly assigned for each sampling day. Meat sample cores were placed in sterile stomacher bags with 50 ml peptone water for microbiological analysis. An additional sample immediately adjacent to the shoulder incised sample was collected using the 9.6 cm² area corer for moisture determination. The carcass pH was determined using a pH probe inserted 1.5 cm deep into the shoulder. Aerobic plate count (APC), Enterobacteriaceae (EB), yeast, and mold populations were enumerated in duplicate on petrifilm™. APC data was analyzed as a randomized complete block design with repeated measures. The carcass side was considered to be a random blocking factor. Moisture and pH were analyzed as repeated measures over time with carcass side as the subject. Because the majority of observations for EB, yeast, and mold were below the detection limit (DL), these variables were analyzed as binary responses (1 = above DL and 0 = below DL) using Fisher’s exact test in SAS Proc FREQ.

Results: The carcass cooler temperature averaged -0.7 °C over the 21 d hanging period. The carcass surface moisture content declined (P<0.05) from 65.1% on day 1 to 50.5% by day 21. The pH was 5.7 to 5.9 over 21 days, and the pH on days 1 and 7 was higher (P<0.05) than day 21. There was no carcass sampling location by day interaction (P>0.05) for APC. There was no day effect (P>0.05) for APC; however, there was a location effect (P<0.01). The jowl had the highest (P<0.05) APC population with 1.2 log CFU/cm² compared to the flank and shoulder with 0.772 and 0.761 log CFU/cm², respectively. There was no location or day effect (P>0.05) for EB or mold populations, but there was a location (P<0.01) and day (P<0.01) effect for yeast populations. The DL for EB and yeast and mold populations was 0.062 log CFU/cm² for the shoulder and flank and 0.414 log CFU/cm² for the jowl. Over 97.5% and 96.5% of EB and mold populations, respectively, for all locations and days, were below the DL. For yeast populations, 63.8, 37.5, and 45.0% were higher than the DL for the jowl, flank, and shoulder, respectively. On day 1, 60.0% of yeast populations were above the DL and by day 21 only 26.6% (P>0.05) were above the DL.

Conclusion: Pork carcass sides could be held in a carcass cooler for up 21 d at -0.7 °C without compromising microbial quality.

Keywords: aerobic bacteria, pork, quality, storage
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96: THE EFFECT OF DIPPING IN ORGANIC ACIDS FOR SHORT OR EXTENDED TIMES ON QUALITY ATTRIBUTES OF GROUND BEEF FROM SECTIONS OF BEEF SHOULDERS CLODS

A. McCoy, D. Burson, G. Sullivan

Objectives: The objective of this study was to evaluate the effect of short or extended antimicrobial dip times on various shelf life and quality characteristics of ground beef from beef shoulder clod sections.

Materials and Methods: Beef clod slices (5.44 kg) were treated with one of four antimicrobial treatments or a negative control in six replications. Pieces of beef shoulder clod were dipped in 4.5% lactic acid or 380 ppm peroxyacetic acid for 15 seconds (s) or 3 minutes (m) at 22.2°C. Samples were then ground and formed into 454g blocks before being overwrapped in oxygen permeable film and placed in retail display at 2.7°C for 7 days (d). On d 0, 1, 3, 5, and 7, samples (25g) were taken for Total Plate Count (TPC) and 150g for lipid oxidation and pH analysis. Percent discoloration and L*a*b* were measured daily. Data were analyzed using GLIMMIX 9.2 of SAS with model including treatment, day of retail display, and the interaction. LS means were calculated and separated (P<0.05) using Tukey’s adjustment.

Results: TPC, lipid oxidation, pH, and discoloration% all had a significant interaction of treatment by day of display (P<0.0001). For TPC, lactic acid 3m had lower (P<0.05) Colony Forming Units (3.4 CFU/g) than control (4.2 CFU/g) on d 3 of display. Also, d 5 and 7 of display showed lower (P<0.05) CFU/g for lactic acid 3m than control. Lipid oxidation was lower (P<0.05) on d 3 for peroxyacetic acid 3m and 15s (1.5, 1.8 mg malonaldehyde/kg tissue, respectively) than lactic acid 15s, 3m, and control (2.7, 3.6, 2.0 mg malonaldehyde/kg tissue). On d 5, lipid oxidation values were higher (P<0.05) for lactic acid 3m (4.8 mg malonaldehyde/kg tissue) than control (2.7 mg malonaldehyde/kg tissue). Analysis of pH on d 1 and 3 showed lactic acid 3m was lower (P<0.05) than all other treatments, including control. In general, % discoloration scores increased rapidly from d 3 to 5. On d 3, lactic acid 3m % discoloration scores were higher (P<0.05) than peroxyacetic acid 3m (32.2%, and 8.5%, respectively). Additionally, on d 4, lactic acid 3m was no different than control and higher (P<0.05) than peroxyacetic acid 3m. This continued on d 5 when lactic acid 3m (90.9%) was higher (P<0.05) than peroxyacetic acid 3m (68.3%) but not different than control. L* values were higher (P<0.05) for lactic acid 3m (51.38) than control (49.7) and peroxyacetic acid 15s (49.55). In a* values, peroxyacetic acid 3m and 15s were more red (P<0.05) than control. Lactic acid 3m and 15s had higher (P<0.05) b* values when compared to peroxyacetic acid 3m, 15s, and control.

Conclusion: While lactic acid 3m reduced TPC, quality characteristics such as discoloration, pH, and lipid oxidation all showed negative impacts that could lead to reduced shelf life. In addition, peroxyacetic acid showed an increase in redness, but remained similar to control in TPC, lipid oxidation, and pH analysis. When processors use an organic dip for control of Shiga Toxin-producing E. coli (STEC), both the organic acid type and length of exposure can influence ground beef quality and shelf life.

Keywords: beef, Lactic Acid, organic acids, Peroxyacetic acid, quality attributes
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97: THE EFFECTS OF RACTOPAMINE AND HORMONAL GROWTH PROMOTANTS ON GROWTH AND MEAT QUALITY OF CROSSBRED ANGUS STEERS

P. Coleman 1,*, B. C. Roy 1, H. L. Bruce 1

1 Agricultural, Food and Nutritional Sciences, University of Alberta, EDMONTON, Canada

Objectives: Meat tenderness is an important quality parameter that influences consumer preference. The cattle industry has over the years seen the emergence of feed additives and hormonal growth promotants in the form of β-adrenergic agonists (β-AA) and steroids respectively. The objective of this study was to analyze the effect of hormonal growth implants and ractopamine on slaughter weight and meat quality parameters of steers selected for high (inefficient) and low (efficient) residual feed intake (RFI) performance.

Materials and Methods: Forty-eight crossbred Angus steers identified from individual GrowSafe data as high (n=21) or low (n=27) RFI cattle were randomly assigned to pens according to treatment (n=12). Treatments included control (no ractopamine hydrochloride (RAC)/no steroids), RAC and steroids, steroids only, and RAC only in a 2x2 factorial design. Steers on steroid treatment received a first implant (200mg progesterone, 20mg estradiol benzoate and 29mg tylosin tartrate) at about 350 days of age and 450kg live weight and a terminal implant (120mg trenbolone acetate and 24mg estradiol) at about 100 days before slaughter. RAC was fed to the appropriate group 28 days before slaughter at a rate of 200mg head−1 day−1. Cattle were slaughtered at about 16 months of age over 6 consecutive weeks by weight and back fat, with 1 animal per treatment represented in each kil for a total of 8 animals slaughtered per week. Hot carcass weights (HCW) were recorded. Gluteus medius (GM) muscles were obtained from the carcasses 3 days post mortem and halved for ageing, with one half aged a further 12 days under vacuum. After ageing at 4°C, muscle halves were assessed for pH, colour, drip loss and Warner-Bratzler shear force (WBSF). For all data the experimental unit was the steer as the effect of ageing was not considered. Data was analyzed using the General Linear Model procedure in SAS with RFI, steroids, RAC and their interactions as fixed factors with slaughter day used as a covariate. Mean differences were determined using Least Square Means and Tukey’s multiple comparisons.

Results: Results revealed no effect (P>0.05) of RFI and RAC on slaughter weight (SW) but steroids increased (P<0.0001) SW of steers. An interaction effect (P=0.0381) was seen between RFI, steroids and RAC on HCW, where high RFI steers that were implanted with steroids and fed RAC had a higher HCW at 389.64±8.70 kg than low RFI steers that were neither implanted nor fed RAC (325.68±7.05kg). An interaction between RFI, steroids and RAC (P=0.045) for drip loss was observed on muscles aged for 12 days, where high RFI steers that were implanted but not fed RAC had a higher drip loss (1.93±0.23 g) than low RFI steers that were not implanted but fed RAC (0.63±0.19g). Muscles from implanted steers had a higher mean WBSF value than muscles from non-implanted steers on day 12 post-mortem (P=0.039), while high RFI steers that received RAC had the lowest mean WBSF (P=0.015).

Conclusion: Results indicated that steroids compromised the development of tenderness during post mortem ageing in the GM. This suggests that the benefit of steroid use on slaughter and hot carcass weights will compromise tenderness of this muscle. Additional post mortem ageing beyond 12 days may be required. Conversely, the use of the β-AA RAC showed potential for decreasing cooked GM toughness in high RFI steers regardless of the ageing period.

Keywords: ractopamine, residual feed intake, steroids, meat quality
Objectives: Aroma and flavor are important sensory attributes for roasted beef and can influence consumers’ acceptance, beyond tenderness. Beef quality can be affected by several factors such as breed, age, gender, finishing system and diet. Finishing system affects growth performance, fat deposition and fatty acid composition, which leads to different lipid oxidation and aroma precursors such as oleic and linoleic acid. These precursors form different aldehydes, ketones and other compounds responsible for roasted beef aroma. As there are few studies of beef aroma compounds from animals finished on feedlot or pasture on Brazilian conditions, this study aimed verify the effects of finishing system, sire breed, cow genetic group and gender on the chemical profile of the main volatile compounds in Brazilian beef.

Materials and Methods: Beef (longissimus thoracis muscle) from animals of four genetic groups, bulls and heifers, the offspring of Angus or Limousin bulls and ½ Angus + ½ Nellore or ½ Simmental + ½ Nellore cows, finished on feedlot or pasture were analyzed. Beef samples of 2.5 cm were roasted in a electric oven, pre-heated at 180°C, until the sample reach an internal temperature of 75°C and ground. Solid-phase microextraction technique was used for volatile compounds extraction, using a CAR/PDMS (Carboxen/polydimethylsiloxane) fiber as stationary phase. Gas Chromatography coupled to Mass Spectrometry (GC-MS) was used to separate and identify the beef volatile compounds. Specific compounds of each volatile compound was selected, transformed to log10 and analyzed by Analysis of Variance (ANOVA) by GLM procedure, where production system/diet, sire breed, cow genetic group and gender were considered as fixed effects. Means were compared by Tukey test at 5% significance level. Principal component analysis was also applied to see if there was any separation between groups within the studied effects based on the volatile compounds.

Results: Ninety-four compounds were detected and thirty-seven were selected as they were associated to beef characteristic aroma. All the studied effects affected the qualitative profile of volatile compounds on beef, being the finishing system (feedlot or pasture) and sire breed (Angus or Limousin) the major ones. For finishing system, octanal, nonanal, 1-heptanol and 3-hydroxi-2-butanone were affected. Beef from feedlot-finished animals was characterized by the presence of volatile compounds from lipid oxidation, as nonanal, octanal, octanoic and nonanoic acids, 3-hydroxi-2-butanone e 1-octen-3-ol while pasture-finished animals presented 4-heptanal, 1-pentanol, 2-methyl-pyridine, 2-ethyl-thiophene and pentanoic acid. There was no clear separation between feedlot and pasture-finished animals as expected in PCA and it can be due the fact that feedlot animals were confined for a short period of time (90 days). Sire breed presented the higher number of volatile compounds with significant difference (p<0.05) between the treatments: octanal, nonanal, 2-nonenal, 3-hydroxibutanone, 2-heptanone, 3-octanone, 2-n-butylfuran, 2-pentylfuran, octanoic and nonanoic acids, 1-octen-3-ol and benzaldehyde. In PCA for sire breed, a clear separation was found. Cow genetic group and gender also affected the beef volatile profile, but in minor proportion.

Conclusion: Sire breed affected more the volatile compounds profile than production system. Cow genetic group and gender had minor effect.

Keywords: Angus, aroma, GC-MS, Limousin, SPME
Meat and Poultry Quality and Composition – Measurement and Prediction

99: PROPOSAL OF A VALUE-BASED GRADING SYSTEM FOR THE COMMERCIAL BEEF INDUSTRY IN THE DOMINICAN REPUBLIC

B. M. Bohrer 1,*, M. A. Tavárez 2

1Department of Food Science, University of Guelph, Guelph, Canada, 2Department of Food Technology, Universidad ISA, Santiago de los Caballeros, Dominican Republic

Objectives: Management conditions of beef cattle is very different in the Central American/Caribbean region when compared with other regions in the world. Consequently, a beef grading scheme different than the one used in other regions of the world and unique to the cattle in that region is justified. Objectives of the current study were 1) to determine marketing systems used for beef cattle in the Dominican Republic, 2) to propose a value-based beef marketing system offering incentive to beef producers for providing packers with a high quality, consumer preferred product, and 3) to provide the industry with more information pertaining to possible measurable components related to beef quality.

Materials and Methods: Quality was evaluated in 96 cattle sourced from 3 commercial producers. Cattle were slaughtered under federal inspection at a commercial processing facility in the Dominican Republic. Quality characteristics measured included subcutaneous fat color (1 indicated white color; 2 indicated cream color; and 3 indicated yellow color), subcutaneous fat uniformity (1 indicated fat not evident or uniform; 2 indicated fat evident, but not uniform; and 3 indicated fat evident and uniform), muscling (1 indicated heavy muscle; 2 indicated moderate muscling; 3 indicated light muscling; and 4 indicated very light muscling), and number of permanent incisor teeth (ranging from 0 to 8) as an indicator of maturity. A proposed value-based grading grid was used with the combined score of subcutaneous fat color, subcutaneous fat uniformity, and muscling on the y-axis (3 to 10) and the number of permanent incisor teeth (0 to 8) on the x-axis. The grid was then used to assign quality scores (listed in ascending order of highest quality to lowest quality: AAA, AA, A, B, and C). Statistical analysis included determining descriptive statistics with the MEANS procedure of SAS, determining the fixed effect of producer using a multi-variance model with the MIXED procedure of SAS, and summarization with frequency distributions based on calculations with the proposed value-based grading grid.

Results: The average for each characteristic was the following: fat color was 1.81 ± 0.05, fat uniformity was 1.01 ± 0.01, muscling was 1.60 ± 0.05, and the number of permanent incisor teeth was 3.27 ± 0.14. Based on the proposed value-based grading grid, 31% of carcasses graded AAA, 16% of carcasses graded AA, 44% of carcasses graded A, 7% of carcasses graded B, and 2% of carcasses graded C. Beef carcasses from producer 1, producer 2, and producer 3 had fat color scores of 1.90 ± 0.10, 1.73 ± 0.07, and 1.86 ± 0.07; fat uniformity scores of 1.00 ± 0.02, 1.00 ± 0.02, and 1.02 ± 0.02; muscling scores of 1.85 ± 0.08, 1.17 ± 0.06, and 1.88 ± 0.06; average permanent incisor teeth of 3.50 ± 0.31, 3.28 ± 0.23, and 3.15 ± 0.22; and an average value-based grade of A 30, A 83, and A 70, respectively.

Conclusion: The proposed value-based grading grid was successful in differentiating beef carcasses in the Dominican Republic based on fat color, fat uniformity, muscling, and the number of permanent incisor teeth. If adopted, this grading system provides a unique system that could work for the Dominican Republic; as well as, an incentive for beef producers to produce a higher quality and more consistent product. More research is warranted in developing relationships between carcass characteristics measured in this study and consumer acceptance.

Keywords: beef, beef grading, Dominican Republic, value-based marketing
Objectives: Dry cured hams are susceptible to mite infestations which are currently controlled in the U.S. dry cured ham industry via fumigation with methyl bromide. Since methyl bromide is an ozone depleting substance, food grade ingredient infused nets have been researched as an alternative to control mite infestations on dry cured hams. Mite infestations and mold growth vary on dry cured ham in untreated and treated nets due to environmental changes in relative humidity (RH) and temperature. Therefore, the objective of this research was to evaluate the effect of RH and infused nets on mite infestations and mold growth on dry cured hams.

Materials and Methods: Patent pending food grade coating formulations consisting of 1) xanthan gum (XG) and propylene glycol (PG) and 2) carrageenan (CG), propylene glycol alginate (PGA), and PG were infused into ham nets. Dry cured ham cubes (2.5 cm³) and slices (2.5 cm x 9.0 cm x 15.5 cm) were wrapped with untreated (control) and two types of treated (infused) nets (XG + PG and CG + PGA + PG) and stored in ventilated glass jars. Three cubes and slices from each treatment were inoculated with 20 and 50 adult mites respectively, and stored in an environmental chamber for 14 days at 24 °C and 65±2, 75±2, and 85±2 % RH. Mite infestation was determined by counting the mobile mites on ham cubes, slices, and nets using a microscope. Nine trained panelists rated the moldiness of ham slice surfaces on a 0 to 100 % scale. A 3x3 factorial structure within a completely randomized design was used to determine the impact of RH and net treatment on mite infestations and mold growth. The least square means method was applied to separate treatment means.

Results: At 65% and 75% RH, samples with treated nets had fewer (P<0.05) mites than the control, but there were no differences (P>0.05) between treated and control nets at 85% RH. On average, across net treatments, there were fewer mites (P<0.05) at 75 and 85 % RH in comparison to 65 % RH. In addition, when averaged over RH, samples in XG and CG coated nets had fewer (P<0.05) mites on ham slices compared to samples in untreated nets. Though there was no difference between XG and CG (P>0.05) with respect to the number of mites on ham slices, the CG treatments were effective at controlling mites at all RHs. In contrast, the XG treatment did not control mites at 65 % RH. There was a strong correlation (r=0.98) between percentage of the ham slices covered with mold and number of mites present. Mold growth was greater (P<0.05) at 65 % RH in comparison to 75 and 85 %, and XG and CG treatments had less mold growth than the control treatments, with the CG treatment completely inhibiting the presence of visual mold.

Conclusion: Treated nets inhibited mite infestations and mold growth on ham cubes at 65% and 75% RH and on ham slices at 65% RH. Results indicate that 75 and 85 % RH would be more desirable in the ham industry if hams were aged at 24°C. Further testing will be performed to observe the impact of temperature on mite infestations and mold growth on ham cubes and slices at various RHs to optimize aging conditions that can used to help control mite infestations.

Keywords: Dry cured hams, Food Grade Coated Nets, Mite Infestations, Relative Humidity
101: PREDICTION EQUATIONS TO ESTIMATE CUTABILITY FROM BEEF CARCASSES PRODUCED IN COSTA RICA

N. Huerta-Leidenz 1,*, O. Atencio-Valladares 2, G. Vargas 3, N. Jerez-Timaure 2, A. R. Rodas-Gonzalez 4

1Animal and Food Sciences, Texas Tech University, Lubbock, United States, 2Facultad de Agronomía, Universidad del Zulia, Maracaibo, Venezuela, Bolivarian Republic Of, 3Corporación Ganadera, San Jose, Costa Rica, 4Animal Science, University of Manitoba, Winnipeg, Canada

Objectives: For years the Livestock Corporation of Costa Rica (Corporacion Ganadera, CORFOGA) has been gathering extensive cut-out data with an aim to establish a primary segregation of carcasses by sex class and then by yield grades. Despite the efforts of CORFOGA and associated academic groups, no reports were found on prediction equations for estimating cutability of Costa Rican beef carcasses. Hence, data from 292 carcasses, representing cattle produced in different regions of Costa Rica under similar extensive conditions (fed pasture/forage-based diets) representing different Bos indicus-influenced breed types and two sex classes (156 bulls, 136 heifers or cows) were used to develop equations to estimate yield of fabrication products (bone-in and boneless cuts) and co-products (bone and fat trimmings).

Materials and Methods: The independent variables (predictors) considered for the regression analysis were: carcass weight (CWEIGHT), kidney fat (KIDNEY), carcass length (CLENGTH) leg perimeter (LEGPER), back fat thickness (BACKFAT), external fat amount and distribution score (FINISH), loin eye area (LEA), and Achilles tendon length (LTENDON). Models were developed to predict total closely-trimmed, valuable boneless cuts (TVC) in kg [TVCKG] and percentages [TVC%]; total closely-trimmed, bone-in and boneless cuts (TC) in kg [TCKG] and percentages [TC%]), bone yield percentage (PBONE), and fat trim yield percentage (PFAT). Statistical analyses included descriptive tests, correlations, residual and multiple linear regression.

Results: Unexpectedly, fatness indicators (FINISH AND BACKFAT) were not significantly associated with TVC or TC yields, probably due to the usual hot fat trimming applied during carcass dressing at the Costa Rica harvesting plant. Sex class had low (ca. 2%) to moderate (ca. 66%) influence on TVC (in kg or %), TC (in kg or %), PBONE and PFAT. Most of the variation (50% or more) in TVC, TC, BONE, and FAT could not be explained by its simple linear regression over any of the 13 carcass traits considered as potential predictors. None of the equations for predicting percentages of TVC, TC BONE and FAT showed R² coefficients with high numerical values. The equations which explained the highest proportion of the variability in yield of products and co-products were:

- TVC%: 44.375-1.067(KIDNEY)-0.052(CLENGTH)+0.069(LEGPER) (R² 0.259; Mallow’s-Cp: 3.19; CME 17.36).
- TVCKG: 18.741+0.414(CWEIGHT)-3.254(KIDNEY)+0.835(LTENDON) (R² 0.953; Mallow’s-Cp: 4.00; CME 17.36).
- TC%: 70.551+0.663(LEA) (R² 0.286; Mallow’s-Cp: 4.00; CME 2.78).
- TCKG: -0.167+0.058(LEGPER)+0.567(FINISH)-0.148(LTENDON) (R² 0.190; Mallow’s-Cp: 4.00; CME 1.58).

Conclusion: Given that the equations to predict percentages of TVC, TC, BONE and FAT did not show sufficient predictive capacity, future studies should consider to avoid the lack of variation in fatness indicators because of the carcass fat trimming procedure occurring in several Costa Rican packing plants. Although an eventual Costa Rican beef carcass grading program could consider the yield of cuts in absolute terms (kg) it is not recommended given the overwhelming, biased influence of carcass weight.

Keywords: Beef carcass, Beef subprimals, Cut-out yield, Prediction equation
102: DUAL ENERGY X-RAY ABSORPTIOMETRY AS A RAPID AND NON-DESTRUCTIVE METHOD FOR DETERMINATION OF LEAN, FAT AND BONE CONTENT IN LIVESTOCK

O. Lopez-Campos¹, M. Juárez¹*, I. Larsen¹, N. Prieto¹, J. Roberts¹, M. Dugan¹, J. Aalhus¹
¹Agriculture and Agri-Food Canada, Lacombe, Canada

Objectives: In order to implement dual energy x-ray absorptiometry (DXA) as a platform technology, calibrations and development of robust equations to attain precision and accuracy are required before using for routine predictions of carcass yields in livestock. This manuscript summarized results of ongoing research where DXA has been used to estimate lean, fat, and bone carcass composition in beef, pork and lamb.

Materials and Methods: From a wide range of carcasses, a total of 334 beef (230 crossbred finished steers and 104 cows), 212 pork and 155 lamb carcasses were used to build calibration equations within each population. Left carcass sides were scanned with a Lunar iDXA unit and then dissected into lean, fat, and bone and weighed. Partial least square regression was used to carry out the prediction equations for lean, fat and bone values from primal cuts scans (independent) and actual lean, fat and bone obtained through the full dissection (dependent). The predictive ability of the models was evaluated in terms of coefficient of determination ($R^2$) and root mean square error of calibration (RMSE).

Results: The PLSR results between actual and DXA estimated lean and fat values showed high relationship ($R^2>0.97$) across all the species. Within beef, the present results suggest that DXA capacity to estimate carcass composition is independent of maturity. With regard to the bone predictions, PLSR analyses also improved the relationship for bone predictions compared to simple regression models previously developed at this institution or single pass scans for pork and lamb. Observed $R^2$ values for predicting bone were slightly lower than those for lean and fat estimations, particularly in those carcasses with smaller bone sizes such as pork ($R^2=0.889$) and lamb ($R^2=0.870$).

Conclusion: The results suggest that DXA technology can reliably estimate carcass composition in livestock, particularly for lean and fat estimations. Using PLSR analyses, suitable models for research have been developed from main primal scan data. However, further studies to externally validate the prediction accuracy and to obtain calibration curves for specific retail cuts or carcass cut-outs specifications are needed. Prediction accuracies for industry applications using single pass scans will also be needed.

Keywords: beef, carcass, DEXA, lamb, pork
Meat and Poultry Quality and Composition – Measurement and Prediction

103: COMPARISON OF SENSORY CHARACTERISTICS, FATTY ACID PROFILES, PROXIMATE ANALYSIS, AND SHELF-LIFE STABILITY OF AKAUSHI BEEF, COMMODITY PRIME BEEF, AND TOP CHOICE BRANDED BEEF

L. Weinheimer¹*, A. Reyes¹, R. Cope¹, E. Behrends¹, L. Branham¹
¹Department of Agriculture, Angelo State University, San Angelo, United States

Objectives: The objective for this study was to compare Akaushi beef with commodity prime beef and top choice branded beef (TCB) looking at trained sensory panel attributes, tenderness, nutritional composition and shelf-life.

Materials and Methods: Striploins (n=106) were collected from two commercial beef plants. Beef type served as treatment (Akaushi top choice (Akaushi) (n=36), top choice branded (TCB) (n=36), and USDA low prime (prime) (n=34)). Striploins were selected with marbling scores of Mt to Md for the top choice products and SLAB marbling for the prime product. Striploins were fabricated into 2.54-cm steaks and assigned to various laboratory analysis after 21, 28, and 35 days of wet ageing at 4°C. Steaks from the posterior end of the striploin were displayed for four days in an atmosphere consistent with a commercial retail case lighting and temperature and were then utilized for TBARS analysis. A trained sensory panel was used to evaluate common sensory attributes. Steak types were evaluated for tenderness using Warner-Bratzler Shear Force (WBSF), proximate analysis using a Foss® Foodscan™ (Eden Prairie, MN), and fatty acid composition using gas chromatography. Differences between beef types and ageing treatments were analyzed using the mixed models procedure of SAS.

Results: Akaushi (21.8%) and prime (21.7 %) had lower protein percentage compared to TCB (22.6%) (P<0.0001). TCB had the highest moisture percentage, followed by Akaushi, and prime (67.9, 67.1, and 64.3%, respectively) (P<0.0001). TCB (47.4) had the highest percent of composite saturated fatty acids, followed by prime (46.6) and Akaushi (42.8) (P<0.0001). When assessing composite monounsaturated fatty acid percentages, Akaushi (53.8) was the highest, followed by prime (49.7), and TCB (48.3) (P<0.0001). TCB (4.4) had the highest percent of composite polyunsaturated fatty acids followed by prime (3.7) and Akaushi (3.4) (P<0.0001). Akaushi had the highest lipid oxidation followed by TCB, and prime (P<0.0001) averaging 0.5, 0.4, and 0.3 mg mal/kg of meat, respectively. Additionally, there was a difference among ageing treatments, (P<0.0001), with 21d (0.4) and 28d (0.4) being similar, while 35d (0.5) was more oxidized. Akaushi and prime were similar for juiciness scoring 6.0 and 6.0 (P<0.0001), with 21d (0.4) and 28d (0.4) being similar, while 35d (0.5) was more oxidized. Akaushi and prime were similar for juiciness scoring 6.0 and 6.0 (P<0.0001), with 21d (0.4) and 28d (0.4) being similar, while 35d (0.5) was more oxidized.

Conclusion: Results show that while there were differences, all three beef types would be considered very acceptable to consumers when analyzing organoleptic properties. The fatty acid profile element was diverse, as TCB had the highest percentage of polyunsaturated fatty acids, and Akaushi had the highest percentage of monounsaturated fatty acids. Akaushi beef compares well to Prime and TCB when evaluating sensory and fatty acid profile attributes; this could benefit Akaushi producers if other factors do not impede economical beef production.

Keywords: Akaushi, Beef, Fatty acids, Quality, Sensory
Meat and Poultry Quality and Composition – Measurement and Prediction

104: PREDICT BEEF TENDERNESS USING IMAGE TEXTURE FEATURES

W. Ogdahl¹, A. Ward¹, E. Knutson¹, J. Liu¹, S. Wirt¹, E. Berg¹, X. Sun¹,*
¹Animal Sciences Department, North Dakota State University, FARGO, United States

Objectives: The aim of this study was to investigate the usefulness of image texture features extracted by computer image processing techniques to predict beef tenderness.

Materials and Methods: Fifty-eight strip loins from commercial Angus × Simmental steers were used to evaluate the effectiveness of image texture features on the predictability of beef tenderness. The average marbling score of these samples was 539.5, marbling score ranged from 360 to 820. The strip loins were vacuum packed and aged for 2 weeks under 0°C. Upon aging, 2.5-cm 13th rib steaks were cut from the center section of each loin. After blooming 10-15 mins, images were acquired using a laboratory-based color camera (NI 1776C, National Instruments, USA) with a controlled illumination system. Image background segmentation, lean/fat area separation was performed after the image acquisition (Figure 1). Image texture features, which including 88 gray level co-occurrence, 81 fast Fourier transform, and 48 Gabor wavelet filter texture features were extracted from the fresh beef strip loin steak images. After cooking, steaks were placed on a metal tray to allow to cool to room temperature. Steaks were analyzed for tenderness by the Warner-Bratzler shear force (WBSF) method. First, steaks were cooked to a final temperature of 71°C with a clamshell-style grill and cooled to room temperature, six 1.3-cm cores were removed and sheared from each steak parallel to the muscle fiber orientation. Steak samples were segregated into tougher and tender classification groups based on WBSF values whereby a WBSF of 2.0 kg or less was considered tender. A STEPWISE regression model was established to test the prediction model. Two hundred and seventeen image texture features were input as indicators for beef tenderness attributes. The subsequent textural feature selection method was analyzed by the STEPWISE method.

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**Results:** The STEPWISE model regression summary result of classified tenderness according to WBSF value was shown in Table 1. STEPWISE method generated 12 useful models to predict beef tenderness through image texture features. The best model’s coefficient of determination value was 0.82, which means image texture features were able to explain 82% of the variation in strip steak tenderness as determined by WBSF value.

**Image:**

![Image](image_url)

**Figure 1** Image processing procedure for steak texture feature extraction

**Conclusion:** This study shows the potential of image texture analysis, in combination with image processing analysis, for prediction of fresh beef tenderness.

**Keywords:** Beef Tenderness, Image Texture, STEPWISE
Objectives: The objective of this study was to use ion exchange chromatography to measure hemoglobin (Hb) and myoglobin (Mb) content in ground and salted pork lean obtained from early post-mortem sow carcasses treated with Rinse&Chill® (RC) technology (MPSC Inc., Hudson, WI) and evaluate its efficacy to decrease blood content in the muscle, when compared to a conventional treatment.

Materials and Methods: RC technology involved vascular rinsing the carcass early postmortem using a chilled (3 °C) isotonic solution (98.5% water; balance: glucose, polyphosphates, glycerine, and maltose). Sows were electrically stunned (550 V) prior to exsanguination. Six sows were used as the conventional treatment and 6 sows received the RC process. At 30-60 minutes post-mortem, the Boston butt and picnic shoulder were deboned, ground (9.5 mm diameter plate) and mixed with 1% NaCl (w/w). Samples (~100 g) were vacuum-packaged and stored at -80°C until analysis. After thawing, samples were frozen with liquid nitrogen and ground into a fine powder for extraction and determination of total heme, Mb, and Hb. Total heme was extracted with acid acetone and determined spectrophotometrically ($\varepsilon_{640\text{nm}}=4.80 \text{ mM}^{-1}\text{cm}^{-1}$). Mb and Hb were extracted with 0.01 M PBS buffer (pH 7.4) and after exchange into a 0.01 M Tris buffer (pH 8.6), the heme pigments were separated by ion exchange chromatography in a diethylaminoethyl cellulose (DE52 resin, 2 g) column. Mb was eluted with 0.05 M Tris buffer (pH 8.0) and Hb with 0.5 M NaCl solution. The amount of Mb and Hb in the corresponding eluates was determined spectrophotometrically ($\varepsilon_{418\text{nm}}=125 \text{ mM}^{-1}\text{cm}^{-1}$ for Mb and $\varepsilon_{414\text{nm}}=128 \text{ mM}^{-1}\text{cm}^{-1}$ for Hb). ESI-MS was used to measure the mass of polypeptides in the Mb and Hb fractions. Total heme, Mb, and Hb content in muscle extracts from the two treatments were compared using an unpaired student t-test.

Results: ESI-MS analysis of the Mb fraction indicated a mass of 16,954 Da which was consistent with the mass of pig Mb without its heme moiety. The Hb fraction had masses of 15,040 and 16,036 Da which was consistent with the mass of the alpha and beta chain of pig Hb, respectively, without their heme moiety. These results indicated that the chromatographic separation was satisfactory. Heme and Mb content in the muscle extracts were statistically similar, when comparing conventional to RC process. The corresponding means for heme content were 187.5 and 209.2 μmol/kg muscle and for Mb, 151.9 and 168.1 μmol/kg muscle. Hb content in the RC treatment was significantly lower, 39.6% on average, than that for the conventional treatment. The percentages of Mb and Hb by weight (relative to each other) in the conventional treatment were 80.9% and 19.1%, respectively. For the RC treatment, Mb was 86.4% and Hb was 13.6%.

Conclusion: The ion exchange chromatography method presented here allowed the measurement of Mb and Hb in pork lean with a satisfactory recovery compared to the total heme determination. Using Hb content in muscle extracts as a measure of blood content suggested that the RC method removed 40% more blood from the muscle compared to the conventional method, leaving still about 60% of the blood in the muscle of RC-treated pigs. The possibility to quantify Hb and Mb separately offers a method to quantitatively assess blood content in muscle.

Keywords: blood removal, hemoglobin, ion exchange chromatography, pork
106: NUTRIENT VALUES FOR DIFFERENT TYPES OF SAUSAGE, FROM USDA RESEARCH STUDIES

Q. Nguyen 1*, J. Roseland 1, J. Williams 1
1USDA, Beltsville, United States

Objectives: USDA’s Nutrient Data Laboratory (NDL) analyzes, evaluates and reports the nutrient content for a wide variety of different foods available in the US, based on research and consumer priorities. Representative samples and analytical data are obtained through the National Food and Nutrient Analysis Program (NFNAP). Data are publicly released in the USDA food composition database.

The objective of this study was to obtain current analytical nutrient values including proximates, vitamins and minerals for 3 different types of sausage which are highly consumed and available in the United States retail market (chorizo, beef hot dog, and Italian sausage), to update the USDA database, and to make nutrient comparisons among these products.

Materials and Methods: Nationally representative samples were collected for each type of sausage including 2 or 3 leading national brands and several store brands per type, from 12 different US locations through NFNAP. Chorizo and Italian sausage were pan-fried and beef hotdog was precooked (unheated) by the manufacturer. Samples were composited using standardized methods and analyzed for proximate nutrients (protein, moisture, fat, carbohydrates and ash), minerals and cholesterol (n= 5-17) at qualified commercial laboratories using approved AOAC’s methodologies and quality control procedures such as certified reference material. Nutrient values were reported per 100 grams basis. The nutrient values were first compared using one-way ANOVA and t test for significant differences between the three types of sausage, a pairwise comparison (t-test) with the Bonferroni correction was used.

Results: Protein was lowest for beef hot dog (11.7±0.13g) compared to Italian sausage (18.2±0.54g; p<0.05) and chorizo (19.3±1.60g; p<0.05). Total fat ranged from 26.4±1.1g to 28.2±0.36g, showing no significant difference among the three products. Sodium value was significantly lower for Italian sausage (766±33.4mg) compared to chorizo (983±50.4mg; p<0.05) and for Italian sausage compared to beef hot dog (872±21.5mg; p<0.05). For calcium, iron and phosphorus, chorizo had significantly higher values than beef hot dog (p<0.05) and Italian sausage (p<0.05). Zinc was higher in Italian sausage (2.4±0.06 mg) than beef hot dog (2.1±0.08mg; p<0.05. Magnesium (range 12-30mg) and moisture (range 46-55g) differed between the three types (p<0.05).

Conclusion: Nutrient differences varied among the product types, especially for protein, moisture and magnesium, due to processing and ingredients used. Overall, comparing these sausages allows researchers and consumers to see the differences in nutrient values. Meat scientists, nutritionists, and consumers can use meat nutrient data for research, nutrition policy, and food purchase decisions. Full nutrient profiles for these products using data from these assays, as well as data for other processed meats, are available publicly at http://www.ars.usda.gov/ba/bhnrc/ndl.

Keywords: Nutrient, Sausage, USDA
Meat and Poultry Quality and Composition – Measurement and Prediction

107: MEAT QUALITY ASSESSMENT OF PORK FROM PIGS FED POULTRY FAT, FLAXSEED OIL, AND SUPPLEMENTED WITH VITAMIN E

W. E. Magee1,*, C. Huang2, J. Smith1,2,3, L. I. Chiba1,2,3, C. L. Bratcher1,2,3
1Animal Science, 2Animal Sciences, Auburn University, Auburn, United States, 3Auburn University, Auburn, -

Objectives: The objective of this project was to determine the meat quality characteristics of pork from pigs fed a combination of poultry fat, flaxseed oil, and supplemented with vitamin E.

Materials and Methods: Yorkshire pigs (N=96) weighing approximately 50 kg were allocated to pens based on weight and sex, over two trials. Pigs within each trial were born in the same farrowing groups and each pen was allotted two gilts or two barrows. Each pen was randomly assigned to one of 8 dietary treatments in a 4 x 2 factorial. Corn-soybean meal finisher diets (N=2; 1: 50 to 80 kg, 2: 80 to 110 kg) were formulated to contain 0, 2, 4 or 6% lipids and 11 (NRC, 2012) or 220 IU Vitamin E/kg. Flaxseed oil was included at 1% and the remaining lipids supplied by poultry fat. Pigs were harvested (N=8 groups) at an average pen weight of 110 ± 3 kg. Following harvest, hot carcass weight (HCW) was recorded. At 24 hours post mortem carcasses were evaluated for last rib fat thickness (LRFT), tenth rib fat thickness (TRFT), loin eye area (LEA), muscle score (MS), percent fat free lean (%FFL), color values (L*, a*, b*), ultimate pH of the ham (pHH) and loin (pHL), and National Pork Producers Council (NPPC) color (NPPCCol) and marbling score (NPPCMar). TRFT, LEA, L*, a*, b*, pHH, NPPCCol, and NPPCMar were determined on the loin eye at the 10th/11th rib interface after chilling, prior to carcass fabrication. Eight 2.54-cm thick pork chops were fabricated, individually vacuum packaged, and frozen (-20±2°C) for further analysis. Belly firmness, skin-side up (SSU) skin-side down (SSD), and thickness (BT) were determined after fabrication. Chops were thawed at 4±2°C for analysis of drip loss (DL), vacuum purge loss (VP), marinade uptake (MU), marinade cook loss (MCL), cook loss (CL), Warner-Bratzler Shear Force (WBS), proximate analysis (PA), and thiobarbituric acid reactive substances (TBARS). Sensory evaluation was performed. Statistical analysis was conducted using the GLM procedure in SAS (2002). Carcass was the experimental unit.

Results: The main effect(s) of lipid content, vitamin E concentration, and sex had no effect (P>0.05) on, HCW, LEA, %FFL, a*, b*, NPPCCol, pHH, pHL, MS, SSD, SSU, BT, DL, VP, MU, MCL, WBS, % fat, % moisture, % collagen, % protein, % salt, and TBARS. Vitamin E affected (P<0.05) LRFT, TRFT, and NPPCMar; values for LRFT (23.19 vs 21.41), TRFT (21.62 vs 19.26), and NPPCMar (1.87 vs 1.41) were greater for 220 IU vitamin E. Sex had an effect (P<0.05) on L* and CL; males had a greater L* (61.50 vs 58.86) and CL (17.14 vs 14.89). There was a Lipid x Vitamin E interaction for TRFT (P=0.0015), %FFL (P=0.0028). A Trial x Vitamin E interaction was present for TRFT (P=0.03), %FFL (P=0.0350), MS (P=0.0304), SSD (P=0.0042), SSU (P=0.0079), DL (P=0.0490), VP (P=0.0418), and Collagen % (P=0.0225). There was a Trial x Sex interaction for LRFT (P=0.0034), VP (P=0.0286), and % Moisture (P=0.0390). A lipid x sex interaction for LRFT (P=0.0031), %FFL (P=0.0164), MS (P=0.0362), and SSU (P=0.0335) and a sex by vitamin E for LRFT (P=0.0206), SSD (P=0.0003), and SSU (P=0.0018).

Conclusion: A feeding program utilizing poultry fat in combination with flaxseed oil, and Vitamin E at these levels will not negatively affect the variables for carcass composition or meat quality assessed in the project. Further analysis of fatty acid composition assessment is needed.

Keywords: Flaxseed oil, Meat Quality, Pork, Poultry fat, Vitamin E
Objectives: The objective of this study was to evaluate the sources of potential error in determination of longissimus muscle area (LMA) between the 12th and 13th ribs of carcasses from heifers fed with or without zilpaterol hydrochloride (ZH).

Materials and Methods: There are two primary potential sources of error when determining LMA. First is the location of the cut between the 12th and 13th ribs. Second is the deviation of the cut from 90 degrees perpendicular to the long axis of the longissimus muscle. An additional potential source of error could come from feeding ZH. To evaluate the relative importance of each error source, rib-loin sections were cut caudal to the 13th rib and cranial to the 11th rib from 10 carcasses: 5 from heifers supplemented with ZH (8.33 mg/kg of dry matter) and 5 from heifers not supplemented with ZH (controls). Consecutive slices (3-4 mm thick) from each rib-loin section were cut at 90 degrees to the long axis of the longissimus muscle on a band saw. To ensure structural integrity, the sections were frozen and tempered so that the muscles remained firm during cutting. Each slice was placed on a stationary platform below a camera stand and images were captured using a digital Nikon D5100 camera (Lens: Nikon AF-S DX VR Zoom-Nikkor 55-200mm f/4.5-5.6G IF-ED). An image of a USDA beef ribeye grid was also obtained to ensure accurate calibration of LMA. The LMA was traced using a tablet computer, allowing image magnification to ensure accurate tracings were made. The LMA were determined for those slices that were cranial to the 13th rib and caudal to the 12th rib.

Results: Mean LMA was 99.4 sq. cm. The mean range in LMA between the 12th and 13th ribs was 8.9 sq. cm. There were no differences in the mean or range of LMA among carcasses from heifers fed ZH and controls ($P > 0.10$). Depending upon the location of the cut between the 12th and 13th ribs, the LMA could be overestimated by as much as 9.0%. This equates to approximately 0.4 yield grade units. That is, a carcass that should receive a yield grade of 3.2 could present a LMA supporting a grade of 2.8. Additional inaccuracy could occur by cutting at a sharper angle than that described by the USDA. An angle of 68 degrees (22 degrees from the desired 90 degree angle) can be created by closely following the curvature of the 13th rib, potentially overestimating LMA by 7.9%. In this study, an incorrect cutting angle could overestimate LMA as much as 7.8 sq. cm, an additional 0.4 yield grade units. Collectively, both sources of error could alter LMA as much as 16.7 sq. cm (16.9%), the equivalent of 0.8 yield grade units.

Conclusion: These data reinforce the written directions of the USDA to separate the longissimus muscle between the 12th and 13th ribs by a cut as close to 90 degrees as possible. Failure to do so could result in an overestimation of LMA by as much as 16.9%. Feeding ZH to heifers had no effect on LMA variation between the 12th and 13th ribs.

Disclosure of Interest: None Declared

Keywords: beef, longissimus, ribeye area, yield grade, zilpaterol hydrochloride
Objectives: Typically, commercial slicing yield and shelf-life of bacon is thought to be reduced as the iodine value (IV) of fat increases, but little data exists to substantiate that hypothesis. Therefore, the objectives were to establish the relationship of IV with slicing yields and the development of lipid oxidation in bacon during 90 d of storage under food-service-style conditions.

Materials and Methods: Bellies (N=84) were selected from two populations of pigs fed diets formulated to induce a large range of IV. Bellies were then allotted to 1 of 4 treatments based on IV: Low (IV 60 to 70, $\bar{x}$=66.11, n=24), Med (71 to 80, $\bar{x}$=74.64, n=24), Hi (81 to 90, $\bar{x}$=85.74, n=16), VeryHi (91 to 100, $\bar{x}$=94.24, n=20). Fresh bellies were evaluated for initial weight, length, width, thickness, and flop, and a sample of adipose tissue was excised from the belly to evaluate IV. Bellies were manufactured into bacon and sliced at a commercial processing facility. Sliced bacon was transported to the University of Illinois. Sliced bacon slabs were weighed to calculate slicing yield. Center slices from each slab were randomly allotted to storage times of 0, 30, 60, or 90 d. Sliced bacon was stored at -40° C without an atmosphere barrier to simulate food service storage conditions. Uncooked bacon slices were evaluated for thiobarbituric acid reactive substances (TBARS) and cooked samples were rated by trained sensory panelists for oxidized odor and flavor at each time point. Shelf life data were analyzed as a one-way ANOVA repeated in time; whereas, step-wise regression was used to predict bacon slicing yield based using non-invasive measures of belly quality.

Results: Iodine value ranged from 61.7 to 98.6 in this population. Commercial bacon slicing yields decreased linearly ($P < 0.0001$; 90.4%, 83.6%, 67.6%, 60.0%) concomitant with a linear increase in IV from the Low to the VeryHi treatment ($P < 0.0001$). The step-wise regression equation to predict bacon slicing yield calculated from initial weight was: yield = $230.24 - (0.502 \times \text{length, cm}) - (1.025 \times \text{width, cm}) - (1.125 \times \text{IV})$; and explained 62.5% ($P < 0.0001$) of the variability in commercial bacon slicing yield. In this equation, IV alone accounted for 60% of the variation in slicing yield. Lipid oxidation did not differ between Low and Med at any time ($P > 0.22$), though Hi and VeryHi had greater ($P < 0.05$) TBARS than Low and Med at 30 d and thereafter. There was no difference in TBARS between Hi and VeryHi until 90 d, where VeryHi had 0.7 mg/kg-MDA less ($P < 0.01$) than VeryHi. Panelists’ evaluation of oxidized odor and flavor both followed a similar pattern to TBARS, with Hi and VeryHi having greater ($P < 0.05$) oxidized odor than Low and Med at 30 d and thereafter, but Low and Med did not differ ($P > 0.05$) at any time, nor did Hi and VeryHi differ ($P > 0.65$). Oxidized flavor of Hi and VeryHi were greater ($P < 0.03$) than Low and Med at all time points, but did not differ ($P > 0.11$) from each other. Med had greater ($P < 0.04$) oxidized flavor than Low at 60 d and 90 d.

Conclusion: Non-invasive measures of belly quality were able to predict 62.5% of variability in slicing yield and increasing IV resulted in discernable differences in lipid oxidation during 90 d of food-service-style storage. Overall, IV and fresh belly characteristics may be effective predictors of the shelf-life and slicing yield of commercially processed bacon.

Keywords: Bacon, iodine value, shelf-life, slicing yield
Objectives: The continued objective was to further investigate the potential development of nutritionally complete diets using local feedstuffs and to develop replicable management strategies.

Materials and Methods: Diets were designed to assess the gain potential of beef cattle in confined feeding systems across Honduras and the viability of local feedstuffs, rather than the intent of diet comparison. Three finishing diets were formulated using local Honduran feedstuffs such as palm kernel meal, poultry litter, and sugar cane for bulls in confinement. Diets were formulated on DM basis and targeted a positive balance of ruminal degradable protein. Management included vaccination, individual identification, implantation, and treatment of parasites upon arrival to the feeding facilities. Additionally, monensin (Monsigran; Monensin Sodium 20; Brazil) was added to all diets. Treatments HM6 through HM11 were fed in the southwest region and HM12 was fed in the central region of Honduras. Cattle were Bos indicus crossed with Bos taurus and dairy type. Bulls were fed between 68-145 d with an average of 112 d. Initial BW ranged from 231-479 kg with an average of 363 kg. Bulls were fed to a minimum end point of 400 kg (unshrunk live final BW). Descriptive analyses were performed using UNIVARIATE procedure of SAS with pen within site as the experimental unit.

Results: Considering all diets, dry matter intake ranged from 9.98 to 12.27 kg/d with an average of 10.73 kg/d. Average daily gain ranged from 0.40 to 2.41 kg with an average of 1.03 kg. Final BW averaged 482 kg with a modest variability (CV = 9.33%). Gain to feed followed similarly to ADG averaging 0.096. Hot carcass weight ranged from 197 to 347 kg with an average of 267 kg. Dressing percent reported an interval of 45.25% to 61.60% averaging 55.26% with low variability (CV = 4.77%).

Conclusion: All diets were viable options for Honduran producers to finish beef cattle depending on feedstuff or byproduct availability. Local byproducts have been effectively blended with other more traditional feedstuffs such as corn to reach sufficient protein and energy. The role byproducts can have within Honduran beef finishing systems has been demonstrated through multiple diets, in various locations across Honduras. More consistent management practices have led to increased dressing percent driven by increased carcass weight. As dressing percent and carcass weight increase, the role of byproduct use to increase beef production are verified. Subsequently, the continued development of better management practices and increased information can be utilized to conduct more intensive research on local feedstuffs and diets across Honduras.

Keywords: Beef cattle, byproducts, Honduras
Meat and Poultry Quality and Composition – Measurement and Prediction

111: EFFECT OF RESIDUAL FEED INTAKE STATUS, BREED AND POST MORTEM AGING ON CONSUMER PERCEPTION OF AND PREFERENCE FOR BEEF RIBEYE STEAKS

Z. Jiu on behalf of University of Alberta, W. V. Wismer, M. Juárez, H. Nguyen, C. Fitzsimmons, C. Li, H. L. Bruce

AFNS, University of Alberta, Edmonton, Agriculture and Agri-Food Canada, Lacombe, Livestock Gentec, Agriculture and Agri-Food Canada, Edmonton, Canada

Objectives: The effect of selection for efficient animals using residual feed intake (RFI) on meat sensory quality and consumer preference has had limited study. The objective of this study was to determine the effects of breed, RFI and aging on consumer sensory preference and attributes perception of beef rib-eye steaks.

Materials and Methods: Thirty-six steers were used in a 3 breed (Angus, Charolais, and Kinsella Composite) × 2 RFI level (high and low) factorial design experiment. Two aging times (4 and 18 days) were also included in the experiment. Perceived and ideal tenderness, juiciness, flavor intensity and overall acceptance of ribeye steaks were evaluated by 24 consumers prescreened to ensure that they regularly consumed high-quality steaks. Analysis of variance (ANOVA), Generalized Procrustes Analysis (GPA) and preference mapping were used to analyze consumer sensory data.

Results: Results from the ANOVA showed that consumers found no significant effect of any main factor on beef flavor intensity (P > 0.05). Breed significantly affected juiciness (P = 0.0070) and overall acceptance of steaks (P = 0.0149), with steaks from Angus and Charolais receiving similar juiciness and acceptance ratings. Steaks aged 18 days were slightly juicier (P = 0.0832) and more acceptable (P = 0.0075) than steaks aged 4 days. No RFI effect was observed for any sensory attribute and acceptance of steaks (P > 0.05). The comparison between consumers’ ideal ribeye steaks and assessed samples found that sensory attributes of steaks from some treatments were different from consumers’ ideal products (P < 0.05). About 80% of the total variation was explained by the first two dimensions of the GPA consensus configuration. GPA differentiated meat clearly by aging, with samples aged for 18 days and ideal ribeye steaks characterized as juicier, more tender and as having more intense beef flavor than samples aged for 4 days. Following GPA analysis, preference mapping was performed to correlate sensory attribute perception and consumer preference. Combined with the contour plot, results of preference mapping showed that steaks from carcasses of Angus and Kinsella Composite steers with high RFI received more appreciation from consumers than steaks from carcasses of steers with low RFI. This result suggested a negative influence of selection for efficient animals using RFI on consumer preference of ribeye steaks in some breeds.

Conclusion: Therefore, RFI can be a beneficial tool in selecting efficient animals because of its limited influence on meat sensory quality, but its possible adverse influence on consumer preference should be monitored during the selection process.

Keywords: consumer sensory analysis, feed efficiency, Generalized Procrustes Analysis, meat quality, preference mapping
112: COMPARISON OF PROTEOMIC CHANGES AND MEAT QUALITY BETWEEN FRESH AND FREEZE-THAWED PORK LOINS

J.-Y. Jeong1,*, J.-K. Seo1, H.-W. Yum1, H.-S. Yang1,2, G.-D. Kim2,3
1Division of Applied Life Science (BK21 plus); 2Institute of Agriculture & Life Science, Gyeongsang National University, Jinju, Korea, Republic Of; 3Department of Animal Sciences, University of Illinois at Urbana-Champaign, Urbana, United States

Objectives: Proteomic studies help us to understand various biochemical changes in meat and meat products. In the present study, a comparison of proteomic changes between fresh and freeze-thawed pork loins were carried out to identify protein markers that relate to pork quality.

Materials and Methods: Longissimus thoracis m. (n = 10, the 6th-12th thoracic vertebrae) were taken from pigs (Yorkshire×Landrace×Duroc, 82.2±4.3 kg carcass weight) in a commercial slaughterhouse at 24 h postmortem. The loins were cut into three pieces of 3.0 cm thickness each and randomly allocated to three treatments: FR0 (no storage); FR5 (5 days of cold storage at 0 ºC); and FT5 (frozen at -20 ºC for 4 days and thawed at 0 ºC for 1 day). All the chops were vacuum packed in plastic bags. Meat quality characteristics such as pH, meat color (CIE L*, a*, b*, chroma and hue), drip loss and Warner-Bratzler shear force (WBSF) were analyzed. The proteins extracted from the pork loin chops were digested with trypsin, and the digested peptides were separated using LC-ESI/MS (Thermo Fisher Scientific, MA). To quantify the MS/MS spectra, MaxQuant software (ver. 1.5, Max Planck Institute of Biochemistry, Germany) was run with normalization of MS spectra followed by the label-free quantification (LFQ). Peptides and proteins were derived from the SwissProt database (Sus scrofa; 66493 sequences). The LFQ intensities were compared between the treatments, and significant differences were accepted at \(-10\times\log(P\text{-value}) > 13.0\). The meat quality data were analyzed with an ANOVA in SAS software (ver. 9.4), and differences among the treatments were considered to be significant at \(P < 0.05\).

Results: The values of CIE L* decreased from 54.30 (FR0) to 49.98 (FT5; \(P < 0.01\)) by freeze-thawing, whereas pork loins stored at 0 ºC were not different from those in the FR0 treatment (\(P > 0.05\)). In contrast, the value of CIE a* did not change by freeze-thawing (\(P > 0.05\)), but the FR5 samples showed a higher CIE a* (7.08) value than the other treatments (\(P < 0.05\)). CIE b*, chroma and hue values were increased by both cold storage and freeze-thawing (\(P < 0.05\)). Both WBSF (3.65 kg/cm²) and drip loss (5.61 %) were increased by freeze-thawing (\(P < 0.05\)), but FR0 was not significantly (\(P > 0.05\)) different from FR5 in terms of WBSF (2.77 kg/cm²) or drip loss (2.77%). These results indicate that 5 days of cold storage affected the pork loin color intensity very slightly, but freeze-thawing reduced the lightness of the pork loin despite of 5 days of storage. Furthermore, freeze-thawing lowered the water-holding capacity and the tenderness. A total of 29 proteins were seen to be significantly different among the treatments (\(P < 0.05\)). Levels of metabolic enzymes such as glyceraldehyde-3-phosphate dehydrogenase, pyruvate kinase, fructose-bisphosphate aldolase A and adenylate kinase isoenzyme 1 decreased during storage regardless of the treatments (\(P < 0.05\)). Structural proteins such as actin, troponin T and desmin were also decreased in both FR5 and FT5, but the other structural proteins, including myosin-4 and troponin I, were decreased in FT5 only.

Conclusion: The deterioration of pork loin quality was observed at 5 days of cold storage and freeze-thawing. The levels of sarcoplasmic proteins including metabolic enzymes were decreased by cold storage or freeze-thawing; however, myofibrillar proteins such as myosin-4 and troponin I could be decreased by freeze-thawing.

Keywords: freeze-thawing, meat quality, pork, protein
Objectives: *Salmonella* is an emerging beef industry challenge. In order to reduce pathogen contamination of ground beef, major processing companies apply organic acids to beef trim before grinding. The objectives of this study were (1) to evaluate the efficacy of individual applications of lactic acid (LA), peroxyacetic acid (PAA), ultraviolet light (UVC) and bacteriophages (BA), and (2) to determine which combination provides the optimal control of *Salmonella* in ground beef.

Materials and Methods: A total of ninety-six (n=96) samples containing 100 g of 80% lean trim were randomly assigned to one of twelve treatments: Control not inoculated (CO), Control Inoculated (COI), LA, PAA, UVC, BA, LA+PAA, LA+UVC, LA+BA, PAA+UVC, PAA+BA, and UVC+BA. Samples were inoculated with a cocktail comprising 4 *Salmonella* strains to yield approximately 3 log CFU/g (COI=3.52 log CFU/g). Strains used in this study included: S. enterica (ATCC 51741), S. Heidelberg (ATCC 8326), S. Newport (ATCC 27869), and S. Enteritidis C (Se 13, streptomycin resistant). After inoculation samples were treated with LA at 5%, PAA at 400 ppm, UVC at 254 nm, and BA solution including S16 and FO1a phages at 10⁹ PFU/ml. LA, PAA, and BA solutions (5 ml) were uniformly pipetted onto trim surfaces whereas UVC was applied during tumbling for 2 min. Samples were ground and a 25 g aliquot stomached for 2 min in 225ml of sterile 0.1% BPW. The homogenate was centrifuged and the supernatant was discarded to avoid plating phages. Pellets were resuspended in BPW, vortexed, serially diluted in BPW, and plated onto XLD plates to evaluate *Salmonella* counts. Data were analyzed as a CRD by using the PROC GLIMMIX procedure of SAS®.

Results: No *Salmonella* growth was observed in plates from CO samples. Fixed effect of treatment was significant at \( P < 0.0001 \).

Individual applications of organic acids (LA and PAA) as well the combination of both (LA+PAA) did not significantly decrease *Salmonella* counts when compared to COI samples (COI = 3.52\(^A\), LA = 3.13\(^A\), PAA = 3.13\(^A\), and LA+PAA = 3.07\(^A\) log CFU/g).

When combined with UVC and BA, LA significantly reduced *Salmonella* loads in ground samples when compared to COI and organic acids-only treatments (LA+UVC = 2.28\(^B\) and LA+BA = 2.46\(^B\) log CFU/g). Similar results were observed for UVC and for the combination of PAA and UVC (UVC = 2.37\(^B\) and PAA+UVC = 2.20\(^B\) log CFU/g). Bacteriophage application (BA= 2.29\(^B\) log CFU/g) and its combination with PAA (PAA+BA = 2.07\(^B\) log CFU/g) led to similar *Salmonella* decrease when compared to UVC, UVC and organic acids, LA, and LA+BA. Combined application of UVC and BA provided the optimal reduction when compared to all other treatments. (UVC+BA = 1.55\(^C\) log CFU/g).

Conclusion: Application of lactic and peroxyacetic acids on trim prior to grinding did not affect populations of four different *Salmonella* strains in ground beef. When applied to beef trim, exposure of ultraviolet light at 254 nm combined with bacteriophage application led to lowest values of *Salmonella* loads in ground beef.

Keywords: bacteriophage, ground beef, organic acids, *Salmonella*, ultraviolet light
Meat and Poultry Safety

115: LEVEL OF POLYCYCLIC AROMATIC HYDROCARBON (PAHS) AND PHENOLS IN MEAT PRODUCTS DUE TO PROCESSING METHODS.

P. O. Fakolade 1,*, E. O. Ijiwade 1, P. A. Adeniyi 1
1Animal Science, Osun State University, Osogbo, Nigeria

Objectives: Health challenges may arise from eating meat products not properly processed. High temperature during smoking of meat products usually above 400 °C, could result in production of Polycyclic Aromatic Hydrocarbon (PAHs) and Phenols. (PAHs) which could exhibit cancerous substance affecting human health while Phenols produced could contribute to meat flavour, aroma, taste and overall acceptability.

Materials and Methods: Ten kg of raw semimembranosus muscles of 2 years old male White Fulani cattle was used and was differently cut into 2 kg each to produce Nigeria locally consumed meat products namely, Kundi, Kilishi, Balangu, Suya and Asun. Kundi products; meat was cut into 50 - 80g, oven-dried for 3 hours at 170 °C and smoked for 2 hours at 220 - 250 °C. Kilishi products; meat was cut into 20cm by 25cm of 100 to 150g, oven-dried for 5 hours at 170 °C and smoked dried for 2 hours at 220 - 250 °C. Suya products; meat was cut by 25cm of 100 – 150g, oven-dried for 1 hour at 170 °C and smoked dried for 30 minutes at 220 – 250 °C. Asun products; meat was sliced into 10cm by 12cm of 40 - 50g, oven-dried 45 minutes at 170 °C and smoke dried for 30 minutes at 220 - 250 °C. Balangu products; meat was sized into 10 - 12cm of 40 -50g, oven-dried for 45 minutes at 170 °C and smoke dried for 30 minutes at 220 - 250 °C. Final samples were evaluated and compared with the commercial product for PAHs, phenols, proximate composition and palatability status using a completely randomized design in a factorial experiment.

Table 1: The level of Polycyclic Aromatic Hydrocarbon (PAHs) status in Nigeria meat products. (µkg⁻¹)

<table>
<thead>
<tr>
<th>Method</th>
<th>Kundi (µkg⁻¹)</th>
<th>Kilishi (µkg⁻¹)</th>
<th>Balangu (µkg⁻¹)</th>
<th>Suya (µkg⁻¹)</th>
<th>Asun (µkg⁻¹)</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTM</td>
<td>8.00a</td>
<td>6.40b</td>
<td>2.50f</td>
<td>3.20e</td>
<td>2.10f</td>
<td>0.001</td>
</tr>
<tr>
<td>LOM</td>
<td>3.30e</td>
<td>5.30f</td>
<td>2.10f</td>
<td>2.20f</td>
<td>2.10f</td>
<td>0.001</td>
</tr>
<tr>
<td>CM</td>
<td>8.80a</td>
<td>8.60a</td>
<td>4.80f</td>
<td>3.80e</td>
<td>2.10f</td>
<td>0.001</td>
</tr>
</tbody>
</table>

abcdef means of different alphabet in both the column and row are significantly different (p<0.05).

Results: Kundi from LTM and CM, and Kilishi from CM had the highest PAHs level (8.00µkg⁻¹, 8.80µkg⁻¹, and 8.60µkg⁻¹) respectively, while the least (P<0.05) values (2.10µkg⁻¹) were observed in Asun products produced using all processing methods. Kilishi from CM had the highest phenols level of (1.30µg), and least value (0.10µg) was noticed in Asun products using all processing methods. Kundi products had the highest significantly (P<0.05) values in protein and ash content in all the processing methods. Balangu products had the highest (P<0.05) ether extract content, while moisture content was highest in Asun products. The panellists rated Balangu, Asun and Kilishi products highest (P<0.05) than Kundi and Suya products.

Conclusion: With higher temperature and duration of time used in smoking animal products, the higher the accumulation the nutrients composition, Phenols compound and the PAHs content (which could affect human health, when consumed).

Keywords: Kundi, Kilishi, Suya, Asun and Balangu
Meat and Poultry Safety

116: SEQUENCE-SPECIFIC REMOVAL OF SHIGA TOXIN-PRODUCING ESCHERICHIA COLI USING THE CRISPR-CAS9 SYSTEM

M. Jia1,*, I. Geornaras1, K. E. Belk1, H. Yang1

1Center for Meat Safety & Quality, Department of Animal Sciences, Colorado State University, Fort Collins, CO, United States

Objectives: The CRISPR-Cas system (clustered regularly interspaced short palindromic repeats and CRISPR associated genes) has emerged as a programmable and versatile tool for precise genome editing. The specificity of the CRISPR-Cas9 system is dictated by a 20-nucleotide CRISPR guide RNA. The Cas9 protein is a double-stranded DNA nuclease guided by guide RNA to sequence-specific sites. The interaction between the Cas9 protein and the target DNA sequences leads to lethal cleavage of double-stranded DNA. Objectives of this study were to design and clone a guide RNA targeting Shiga toxin in pCRISPR and use a two-plasmid platform to deliver this Shiga toxin specific CRISPR-Cas9 system into bacterial cells for specific killing of Shiga toxin-producing Escherichia coli.

Materials and Methods: The E. coli O157:H7 cells containing pCRISPR were cultured on tryptic soy agar (TSA) with 50 µg/ml of kanamycin, cells containing pCas9 were cultured on TSA with 50 µg/ml of chloramphenicol, and those containing both pCRISPR and pCas9 plasmids were cultured on TSA with 50 µg/ml of kanamycin and 50 µg/ml of chloramphenicol. Shiga toxin guide RNA was designed by screening Shiga toxin gene sequences for NGG on the 3’ side. The pCRISPR vector was digested with BsaI (10 units) and purified using a Monarch gel extraction kit (New England Biolabs). The designed guide RNA was ligated with the digested pCRISPR to create a new plasmid of pCRISPR w/stx. After ligation, the cloned region was sequenced by a Sanger Sequencing service (Genewiz). The pCas9 and pCRISPR w/stx were introduced into E. coli O157:H7 cells sequentially by electroporation: first the pCas9 was introduced into E. coli O157:H7 cells and then the pCRISPR w/stx was introduced into the recipient E. coli O157:H7 cells containing pCas9 plasmids. Briefly, E. coli O157:H7 cells were grown to a A600 of 0.4–0.6. Plasmids (around 100 ng each) were transformed into bacterial cells using 0.1 cm Gene Pulser® cuvettes (Bio-Rad) and the Electroporator 2510 (Eppendorf) set at 1800 V. In addition to pCRISPR w/stx, pCRISPR cloned with a piece of oligo that does not target any DNA sequences in E. coli O157:H7 cells (pCRISPR w/oligo) and the original pCRISPR were used as controls. After electroporation, cells were plated onto TSA plates containing appropriate antibiotics for quantification.

Results: Sanger sequencing confirmed that the guide RNA targeting Shiga toxin genes was successfully cloned in pCRISPR. When the newly created pCRISPR w/stx plasmid was introduced into the recipient E. coli O157:H7 cells containing pCas9 plasmids, an approximately 2 log lower concentration of E. coli O157:H7 cells was observed compared to that of the control plasmids of pCRISPR w/oligo and pCRISPR (Table 1).

Image:

Table 1: Log CFU/reaction after electroporation of pCRISPR w/stx, pCRISPR w/oligo and pCRISPR into the recipient E. coli O157:H7 cells containing pCas9 plasmids.

<table>
<thead>
<tr>
<th></th>
<th>pCRISPR w/stx</th>
<th>pCRISPR w/oligo</th>
<th>pCRISPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Log CFU/reaction)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeat 1</td>
<td>2.14</td>
<td>4.64</td>
<td>4.20</td>
</tr>
<tr>
<td>Repeat 2</td>
<td>2.05</td>
<td>3.84</td>
<td>4.05</td>
</tr>
</tbody>
</table>
**Conclusion:** This study provides proof-of-concept evidence that introduction of a CRISPR-Cas9 system that specifically cleaves Shiga toxin genes in bacterial cells leads to death of Shiga toxin-producing *E. coli*. The CRISPR-Cas system could be further explored for improving meat safety by sequence-specific removal of pathogens that harbor target virulence or antibiotic resistance genes.

**Keywords:** CRISPR-Cas9 system, sequence-specific antimicrobial, Shiga toxin-producing Escherichia coli
Meat and Poultry Safety

117: VALIDATION OF ANTIMICROBIAL INTERVENTIONS INCLUDING THE USE OF 1,3-DIBROMO-5,5-DIMETHYLYHDANTOIN APPLIED IN A FINAL CARCASS WASH IN A COMMERCIAL BEEF HARVEST OPERATION

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

1Department of Animal Sciences, Colorado State University, Fort Collins, United States

Objectives: A study was conducted to evaluate the ability of a bromine based antimicrobial (1,3-dibromo-5,5-dimethylhydantoin; DBDMH), applied in a final carcass wash, to reduce inoculated populations of nonpathogenic *Escherichia coli* biotype I, serving as surrogates for pathogenic *E. coli* and *Salmonella*, as well as natural microflora on beef carcasses in a commercial beef harvest operation. Additionally, the cumulative decontamination efficacy of the DBDMH treatment and three subsequent interventions applied to beef carcasses was evaluated.

Materials and Methods: The inoculum consisted of a five-strain mixture of *E. coli* biotype I. External carcass surfaces on the chuck were inoculated (6 log CFU/cm²) within three 10×10 cm² zones using sponges hydrated with 10 ml of the inoculum; these served as samples before and after treatment with DBDMH and then following the complete intervention system. Additional zones remained uninoculated to test the treatment effect against carcass natural microflora. Twenty carcasses (10/day) received a low concentration DBDMH treatment (280-350 ppm; treatment 1) in a final wash cabinet as well as all of the remaining intervention treatments going into fabrication (lactic acid spray [LA; 2.0-2.5%], peroxyacetic acid spray chill [PAA; 300-400 ppm] and post-chill LA spray [2.0-5.0%]). A different set of 20 carcasses received a high concentration DBDMH treatment (550-630 ppm; treatment 2) in the final wash followed by all of the same subsequent intervention treatments. Carcass zones were sampled before and after treatment exposure with sampling sponges. Inoculated samples were analyzed for *Enterobact*eriaceae (EB) populations while uninoculated samples were analyzed for aerobic plate counts (APC) and EB counts. The study was designed as a paired comparison replicated on two days, with day serving as a random variable. Surviving bacterial populations were analyzed using the Mixed Procedure of SAS; data were expressed as least squares means with differences reported using a significance level of α=0.05.

Results: Carcasses treated with 280-350 ppm DBDMH in the final wash cabinet and subsequent interventions prior to fabrication reduced (P<0.05) initial EB counts of 6.0 log CFU/cm² to 4.8 and <1.4 log CFU/cm², respectively (Table 1). Corresponding EB counts for carcasses that received the 550-630 ppm DBDMH treatment were 6.0 log CFU/cm² before treatment, and 4.5 (after final carcass wash) and <0.4 (after complete intervention system) log CFU/cm² following the antimicrobial treatments (Table 1). Surviving uninoculated APC and EB populations obtained from carcasses exposed to treatments 1 and 2 were less (P<0.05) than initial populations obtained from beef carcasses prior to antimicrobial treatments. The surviving inoculated and uninoculated populations obtained from carcasses subjected to treatment 2 were lower (P<0.05) than those subjected to treatment 1 (Table 1).
Table 1. Adjusted least squares (LS) mean *Enterobacteriaceae* plate counts (log CFU/cm²; [standard error]) for inoculated beef carcass zones before (untreated control) and after (treatments 1 and 2) application of antimicrobial interventions.

<table>
<thead>
<tr>
<th>Treatment - Intervention</th>
<th>Untreated Control</th>
<th>DBDMH-Final Wash</th>
<th>Complete Intervention System</th>
<th>% BDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – DBDMH (280 to 350 ppm)</td>
<td>6.0 a</td>
<td>4.8 a</td>
<td>&lt; 1.4 a</td>
<td>22.5</td>
</tr>
<tr>
<td>2 – DBDMH (550 to 630 ppm)</td>
<td>6.0 a</td>
<td>4.5 a</td>
<td>&lt; 0.4 a</td>
<td>47.5</td>
</tr>
<tr>
<td>Contrast P-Value</td>
<td>N/A</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>N/A</td>
</tr>
</tbody>
</table>

DBDMH: 1,3-dibromo-5,5-dimethylhydantoin.

a, b, c LSMeans bearing different superscript letters within the same row are different from the control ($P < 0.05$).

LSMeans with a less than symbol (<) indicate at least one-sample was below the detection limit (< -0.6 log CFU/cm²).

Contrast P-values < 0.05 are considered different within each column.

Additional interventions included in the complete system: LA = 2.0% to 5.0%, PAA spray chill (300 to 400 ppm), and post-chill LA = 2.0% to 5.0%.

“N/A” indicates that the P-value was not calculated.

% BDL: indicates the percent of samples below the analysis detection limit after the complete intervention system.

**Conclusion:** The use of DBDMH was effective at reducing inoculated and uninoculated microbial populations when applied as a carcass wash in a commercial beef operation, with the higher concentration being more effective. The series of interventions, including the use of DBDMH, LA and PAA, in a complete system was effective against inoculated and uninoculated microbial populations on beef carcasses in a commercial beef harvest operation.

**Keywords:** beef carcass, bromine, harvest validation, interventions
**Meat and Poultry Safety**

**118: EFFECTIVENESS OF 1,3-DIBROMO-5,5-DIMETHYLDANTOIN APPLIED IN A PRE-EVISCERATION WASH CABINET FOR REDUCING MICROBIAL CONTAMINATION ON BEEF CARCASSES**

A. A. Reyes¹, B. Bullard¹, I. Geornaras¹, R. J. Delmore¹, D. R. Woerner¹, J. N. Martin¹, K. E. Belk¹

¹Center for Meat Safety & Quality, Department of Animal Sciences, Colorado State University, Fort Collins Colorado, United States

**Objectives:** The objective of this study was to evaluate the effect of a bromine-based antimicrobial (1,3-dibromo-5,5-dimethylhydantoin; DBDMH), for use in a pre-evisceration carcass wash cabinet, against naturally occurring beef carcass associated microflora.

**Materials and Methods:** The study was conducted in a commercial beef harvest facility. Carcasses were randomly selected prior to the pre-evisceration wash cabinet for treatment application, which included two concentrations of DBDMH: low (280-350 ppm) and high (550-630 ppm). Prior to treatment application, carcasses were swabbed (10 x 10 cm²) on the ventral midline region with a sampling sponge hydrated with 10 ml Dey/Engley neutralizing broth, to serve as the initial counts (untreated control). After DBDMH was applied to the carcasses, a second sample was taken, to provide remaining bacterial populations after treatment. The two DBDMH treatments were replicated over two production days per treatment (N = 80; n = 40). All sponge samples were analyzed for aerobic plate counts (APC) and Enterobacteriaceae counts (EB) using Petrifilm Aerobic Count Plates and Petrifilm Enterobacteriaceae Count Plates, respectively. Bacterial populations for all samples were converted and expressed as log CFU/cm². The study was designed as a paired comparison conducted on two different test days per treatment (four total production days), for two DBDMH concentration levels. Day was treated as a fixed effect due to the unpredictable variation of the microbial conditions of carcasses on each production day. Data were analyzed using the Mixed Procedure of SAS and expressed as least squares means for log CFU/cm². Differences were reported with a significance level of α = 0.05.

**Results:** There were significant main effects of treatment and day for APC populations recovered from carcasses treated with DBDMH at 280-350 ppm (treatment: P < 0.0001; day P = 0.0181). Due to these main effects, APC results were separated by each production test day to evaluate efficacy of the treatment. The APC populations recovered from beef carcasses before treatment with the low concentration of DBDMH (280-350 ppm) were 3.4 and 2.8 log CFU/cm², from days 1 and 2, respectively (Table 1). Following DBDMH application, APC were 1.4 and 1.0 log CFU/cm² for days 1 and 2, respectively (Table 1). The EB populations obtained before and after treatment with the low DBDMH concentration were < 0.1 and < -0.6 log CFU/cm²; respectively (Table 1). For carcasses treated with DBDMH at 550-630 ppm, a significant interaction between treatment and day (P = 0.0028) was observed for the APC data; therefore, APC results were separated by each production test day. Prior to DBDMH application at 550-630 ppm, the APC were 2.7 and 2.8 log CFU/cm² for days 1 and 2, respectively (Table 1). The APC declined (P < 0.05) after DBDMH was applied, and APC of 1.1 and 2.2 log CFU/cm² for days 1 and 2, respectively, were obtained (Table 1). Corresponding EB populations before and after the high concentration treatment were < -0.1 and < -0.6 log CFU/cm², respectively (Table 1).
**Conclusion:** In conclusion, 1,3-dibromo-5,5-dimethylhydantoin was effective against naturally occurring microflora present on beef carcasses when applied in a pre-evisceration wash cabinet.

**Keywords:** antimicrobial, beef, bromine, intervention
Meat and Poultry Safety

119: SALMONELLA CONTAMINATION IN POULTRY—ARE WE MISSING A POTENTIAL VECTOR?

T. Sexton¹, I. Geornaras¹, D. Woerner¹, R. Delmore¹, K. Belk¹, J. Martin¹
¹Center for Meat Safety & Quality, Department of Animal Sciences, Colorado State University, Fort Collins, United States

Objectives: In the third quarter of 2015, USDA Salmonella prevalence in young chicken carcasses and chicken parts was 1.4% and 22.1%, respectively. These data indicate that efforts to control carcass contamination are effective; however, the relatively high prevalence in chicken parts suggests the pathogen is somehow evading carcass decontamination strategies. Thus, the objectives of this study were to assess the presence of Salmonella enterica in an alternative carcass location, namely joint synovial fluid, and further, to characterize any recovered Salmonella isolates.

Materials and Methods: The synovial fluid of three unique true joints (shoulder, coxofemoral, and stifle) of 500 broiler carcasses were individually sampled (1,500 total samples) and analyzed for Salmonella presence. Broiler carcasses were collected immediately post-chilling from three conventional and two antibiotic free broiler processing facilities located in the Southeast and Western United States. Each processing location was sampled twice during the study period. Broiler carcasses were subjected to a decontamination protocol to reduce the potential of cross-contamination of the joint synovial fluid from the carcass surface. The decontamination protocol included immersing the carcass in ethanol, flame sterilization, removing the carcass skin around the joint to be sampled and finally, immersion in boiling water (10 s). The joints to be sampled were then aseptically exposed using a sterile scalpel. The synovial fluid of the three joints was individually sampled, using a sterile swab, and the swab was enriched (35°C, 22 h) in buffered peptone water. Enriched synovial fluid samples from each bird (n = 3 joints per bird) were composited and subjected to rapid-based PCR Salmonella detection. If the composite sample was deemed a presumptive positive, the individual enriched synovial samples were further subjected to rapid based PCR Salmonella detection. Individual samples deemed a presumptive positive were subjected to secondary enrichment and selective agar plating (Brilliant Green Sulfadiazine Agar and XLT4 Agar) to facilitate isolation of Salmonella. Presumptive Salmonella isolates were serotyped prior to determination of antimicrobial susceptibility.

Results: Overall, the prevalence of presumptive positive Salmonella among all joints for all birds was 0.47% (7 out of 1,500 samples) with a 95% confidence interval of 0.20% to 1.00%. The prevalence of presumptive positive Salmonella among the antibiotic free and conventionally raised broilers was 0.17% and 0.67%, respectively. Among regions, presumptive positive Salmonella prevalence tended to be greater in the Southeast (0.83%) versus the Western region (0.22%). Among joint types, prevalence was greater in the shoulder joint (0.80%) when compared to the coxofemoral (0.40%) and stifle (0.20%) joints, respectively.

Conclusion: To our knowledge, no previous assessments of Salmonella in the synovial fluid of broilers exists. However, as the presence of Salmonella in ground poultry and poultry parts remains problematic, alternative vectors for Salmonella should be evaluated. These results suggest that Salmonella may be present in the synovial fluid of broilers. Although prevalence is relatively low, when extrapolated to the scale of broilers produced, this information provides valuable insight into potential poultry contamination pathways. Further evaluation of this pathway is warranted.

Keywords: Poultry, Salmonella, Synovial Fluid
Meat and Poultry Safety

120: VALIDATION OF VARIOUS ANTIMICROBIAL INTERVENTIONS FOR USE IN A BONE DUST CABINET IN A COMMERCIAL BEEF HARVEST FACILITY

M. Weinroth 1,*, C. Cashman 1, I. Geornaras 1, J. Martin 1, D. Woerner 1, R. Delmore 1, K. Belk 1

1Center for Meat Safety & Quality, Department of Animal Sciences, Colorado State University, Fort Collins, United States

Objectives: The objective of this study was to evaluate the efficacy of three antimicrobial spray interventions (peroxyacetic acid, PAA; lactic acid, LA; lactic/citric acid blend, LCA) in reducing inoculated populations of Shiga toxin-producing Escherichia coli (STEC) on pre-rigor beef tissue. A secondary objective was to validate E. coli biotype I to serve as surrogates for STEC.

Materials and Methods: The efficacy of each intervention was assessed using a 14-strain mixture of rifampicin-resistant STEC, comprised of two strains of E. coli O157:H7 and two strains each of E. coli serogroups O26, O45, O103, O111, O121, and O145. In addition, this study served to validate the utility for a non-pathogenic five-strain mixture of rifampicin-resistant E. coli biotype I to serve as surrogates for the aforementioned STEC mixture. For three sampling days, 90 tissue samples from pre-rigor plate subprimals were obtained from beef carcasses immediately following slaughter. The tissue samples were evenly split into two inoculation groups (n = 45 samples/group, 15/group/day): i) STEC, or ii) surrogate. Within each inoculation group, tissue samples were randomly assigned to one of nine treatments: i) 200 ppm PAA; ii) 1% LCA; iii) 1.5% LCA; iv) 2.5% LCA; v) 5% LA; vi) 8% LA; vii) 10% LA; viii) potable water; or ix) untreated control. Tissue external fat surfaces were spot inoculated (5-6 log CFU/cm²) with 100 μl of the STEC or surrogate inoculum and was spread over a 50 cm² area using a sterile plastic spreader. Within each inoculation group, treatments were applied using a custom-built, laboratory-scale spray cabinet (0.53 lpm, 137.9 kPA over eight nozzles). Tissue surfaces were sampled approximately 10 min after spray-treatment application, using sponges hydrated with D/E neutralizing broth, and analyzed for surviving STEC and surrogate populations on tryptic soy agar supplemented with rifampicin (100 μg/ml). This experiment was conducted as a randomized complete block design. Data were evaluated using the MIXED procedure of SAS. To compare surviving populations of the surrogates and STEC, data were analyzed using the MIXED Procedure in SAS with microbial population of the untreated control samples used as a covariate to adjust least-squares means to a common pre-treatment inoculated plate count.

Results: When applied as a spray treatment to pre-rigor beef tissue, LA applied as a 10% solution was more (P < 0.05) effective at reducing STEC and surrogate populations than water, PAA, 1, 1.5 or 2.5% LCA, and 5 and 8% LA (Table 1). Additionally, the 5, 8 and 10% LA treatments were more (P < 0.05) effective at reducing both inoculum types than water, PAA, or 1, 1.5 or 2.5% LCA. No differences (P ≥ 0.05) in surviving STEC populations were observed for tissue samples treated with PAA, 1.5% LCA or 2.5% LCA. Pairwise comparisons indicated surviving STEC and surrogate populations did not differ (P ≥ 0.05).

Image:
Conclusion: When all treatments were compared, LA, at 10%, was found to have the greatest effect against STEC populations. As evidenced by similar surviving populations of STEC and surrogate populations, the five-strain, non-pathogenic *E. coli* would effectively serve as a surrogate inoculum for the 14-strain STEC cocktail used in this study.

Keywords: Citric Acid, Lactic Acid, Peroxyacetic acid, Shiga toxin-producing *E. coli*, Surrogate
Meat and Poultry Safety

121: THE EFFECT OF TYLOSIN SUPPLEMENTATION AND TYLOSIN ALTERNATIVES ON LIVER ABSCESS PREVALENCE, BEEF TRIM MICROBIAL POPULATIONS, AND CARCASS CHARACTERISTICS FROM FEEDLOT CATTLE.

C. Weissend 1,*, K. L. Holzer 1, K. L. Huebner 2, J. L. Metcalf 1, I. Geornaras 1, J. K. Parker 2, K. E. Belk 1, P. S. Morley 2, J. N. Martin 1
1Animal Sciences, 2Clinical Sciences, Colorado State University, Fort Collins, United States

Objectives: Tylosin phosphate is a macrolide commonly used for the reduction and prevention of liver abscesses in feedlot cattle. As pressures to reduce antimicrobial use in livestock production rise, pressures to remove Tylosin from cattle feeding strategies continue to increase. This potential removal of Tylosin from cattle feeding could result in significant economic and food safety impacts on the beef industry. In light of this, a blinded, randomized, controlled field trial was conducted to evaluate the effect of Tylosin alternatives on beef trim microbial populations and carcass characteristics from feedlot cattle.

Materials and Methods: Commercial steers and heifers (n = 5,481 hd) were assigned to ten 4-pen blocks (n = 40 pens) at a commercial feedyard in Texas in the Spring of 2016. At placement, cattle were randomly assigned to one of four treatment groups including or excluding Tylosin. At the conclusion of the feeding period (Fall 2016), cattle were harvested at a commercial processing facility in Texas. At harvest, but prior to application of interventions, carcass swabs (n=15/pen) were taken from the plate, and livers abscess scores were recorded at evisceration. Individual carcasses were subjected to USDA yield and quality grading prior to fabrication. At fabrication, approximately 5kg of trim was collected from each pen directly from the trim belt at 3 points on the fabrication floor for a total of approximately 15kg. Trim was retrieved from the chuck, the loin, and the round of carcasses that graded USDA Choice. Trim samples were subjected to detection of generic E.coli and Salmonella enterica following the USDA Microbiology Laboratory Guidebook (MLG) guidelines. In addition, trim and carcass swab samples were analyzed using 16S rRNA gene sequencing to characterize their microbial communities.

Results: Cattle supplemented with Tylosin (Tyl) were 1.49 times less likely (P < 0.0001) to develop a liver abscess than cattle not supplemented with Tylosin (NTyl). Hot carcass weights (HCW), dressing percentage, ribeye area, and backfat thickness, did not differ among Tyl and NTyl treatment groups (P > 0.05). However, the percentage of cattle grading USDA Choice was greater for the Tyl group than the percentage grading choice from the NTyl feeding group (P = 0.034). Salmonella enterica was isolated from the trim collected from 10 pens. However, eight of these 10 trim samples were collected during one sampling day (i.e. 2 blocks).

Conclusion: Although previous data and results from the current study highlight the utility of Tylosin inclusion on the reduction of liver abscesses, investigating alternatives is a necessity as pressure to remove antimicrobial compounds from livestock production increases. As alternatives are investigated, understanding their influence on the microbial ecology of trim will not only aid in improving their efficacy, but also assuring the safety of the beef food chain. This understanding will be imperative for the future implementation of strategies aimed to mitigate liver abscesses and maintain the safety and economical production of beef.

Keywords: Beef trim, Carcass traits, E.coli, Salmonella, Tylosin
Meat and Poultry Safety

122: PATHOGEN REDUCTIONS DURING TRADITIONAL FERMENTATION AND DRYING OF PORK SALAMIS

S. McKinney 1,*, C. Cutter 2, J. Campbell 1
1Animal Science, 2Food Science, Penn State, University Park, United States

Objectives: Traditionally-processed meat products produced without thermal processing are common in European countries and are increasing in popularity in the United States. Processors are met with the challenge of creating these high-quality products while ensuring food safety. The purpose of this study was to validate the safety of a process to produce a traditional fermented and dried salami. This experiment investigated the impact of casing type and an antimicrobial intervention on the survival of foodborne pathogens in a salami product made with minimal ingredients.

Materials and Methods: Pork butts were cubed and experimentally-inoculated with ~8 log10 CFU/ml of three strains each of E. coli O157:H7 (EC), Salmonella spp. (S), and L. monocytogenes (LM). The cubes were either sprayed with water (CTRL) or a 2.5% antimicrobial solution (TRT) prior to grinding through a 6-mm plate. Dry ingredients and starter culture were thoroughly mixed into the ground pork before being stuffed into ~50 mm natural, collagen, and fibrous casings (N=192). The salamis were subjected to fermentation (72 h), drying (28 d), and packaging (28 d). Salami samples were collected every 24 h until the end of fermentation. During drying and packaging, salami samples were collected weekly.

Results: There was no significant difference between the CTRL and TRT sausages for bacteria populations for EC (p=0.1645), S (p=0.3746), or LM (p=0.1762) for the 60 d sampling period. There was also no significant difference in bacteria reductions between casings types within each treatment (p>0.05). Initial levels of pathogens were 8.36, 8.40, and 8.72 log10 CFU/g for EC, S, and LM respectively. Following the treatments, bacteria populations in CTRL sausages decreased by 3.20, 0.38, and 0.12 log10 CFU/g for EC, S, and LM respectively. Bacteria populations decreased in TRT sausages decreased by 2.40, 0.34, and 0.19 log10 CFU/g for EC, S, and LM respectively. Following fermentation and drying, EC populations decreased 1.50 to 3.19 log10 CFU/g; S populations decreased 3.03 to 3.45 log10 CFU/g; and LM populations decreased 2.69 to 4.56 log10 CFU/g in both CTRL and TRT sausages. A 5 log10 reduction was achieved for S and LM by the end of packaging, but a combination of treatment and casing type did not achieve a 5 log10 reduction of EC by the end of packaging.

Conclusion: This study validated the safety of a fermented pork salami manufactured without a heat treatment or additional lethality steps following fermentation and drying for salamis produced in collagen and fibrous casings.

Keywords: E. coli O157:H7, Fermented sausage, L. monocytogenes, Salami, Salmonella
Objectives: Population growth of ethnic cultures that readily consume goat meat has led to an increase in demand and consumption in the United States. Although foodborne disease outbreaks associated with meat from small ruminants have been limited, small ruminant animals such as goats are known reservoirs for Shiga toxin-producing Escherichia coli (STEC). As goat meat demand increases, it is critical to ensure pathogen reduction strategies for STEC are effective during the slaughter and chilling processes. The objectives of this research were to evaluate 4.5% lactic acid (LA), 400 ppm peroxyacetic acid (PAA), Citrilow™ (a proprietary blend of hydrochloric and citric acid; CL; pH 1.2), 5% levulinic acid plus 0.5% sodium dodecyl sulfate (LVA+SDS), and a non-treated control (CON) for their ability to reduce STEC surrogates and their effects on carcass color from slaughter through chilling.

Materials and Methods: A total of 15 goat carcasses (28±6 kg) across three replications were inoculated with a 5-strain cocktail (ca. 8 log CFU/ml) containing rifampicin-resistant Escherichia coli (E. coli; BAA-1427, BAA-1428, BAA-1429, BAA-1430, and BAA-1431), surrogates for STEC. The exterior of each carcass was evenly inoculated to achieve 6 log CFU/cm². After inoculation, the carcasses were held on the slaughter line for 30 min (25°C) for attachment prior to antimicrobial treatment application. Antimicrobial treatments were randomly assigned to each carcass and applied prerigor and 24 h post chill. Each carcass was sampled at five different points during processing 1) after inoculation with a 30-min attachment period, 2) after the standard water wash (55°C), 3) 5 min after the pre-chill carcass antimicrobial spray application, 4) post-24 h chilling, and 5) 5 min after the 24 h post-chill carcass antimicrobial spray application. One of five anatomical carcass locations was randomly assigned for sample collection on both sides of each carcass at each time point and then combined for analysis. Objective carcass color was measured below the hipbone on a surface that was not sampled for microbial analysis, at five different processing points: 1) pre-treatment (immediately prior to application of inoculum), 2) after pre-chill antimicrobial spray treatment, 3) post-1 h chill, 4) post-24 h chill, and 5) after the post-24 h chill antimicrobial spray application. E. coli population (log CFU/cm²) and color values were analyzed using PROC GLM (SAS V.9.4). E. coli population and color values were analyzed for the main effects of antimicrobial treatment, sampling time point, and their interaction. Least squares means were generated and separated using the PDIFF option. Means were considered different at α≤0.05.

Results: Mean log reductions (P<0.05) achieved after prerigor treatment with CL, LA, LVA+SDS, and PAA were 2.27, 2.00, 1.9, and 1.87 log CFU/cm², respectively. Antimicrobial treatment after the 24 h chilling period resulted in subsequent reductions (P<0.05) of surrogate E. coli by 1.89, 1.17, 1.03, and 0.47 log CFU/cm² for CL, LA, PAA, and LVA+SDS, respectively. Antimicrobial treatments did not have a large impact goat carcass objective color.

Conclusion: The antimicrobials tested in this study were effective at reducing E. coli populations on goat carcasses during pre- and post-chill applications without compromising carcass color.

Keywords: Antimicrobial intervention; Goat; Color; Escherichia coli
Meat and Poultry Safety

124: PRESENCE AND CHARACTERISTICS OF SALMONELLA ENTERICA RECOVERED FROM SUBILIAC LYMPH NODES OF BEEF FEEDLOT CATTLE ENROLLED IN A RANDOMIZED CLINICAL TRIAL OF DIETARY ADDITIVES.

K. Holzer 1,*, C. Weissenberg 1, K. Huebner 2, J. Metcalf 1, I. Geornaras 1, K. Belk 1, P. Morley 2, J. Martin 1

1Center for Meat Safety and Quality, 2Clinical Sciences, Colorado State University, Fort Collins, United States

Objectives: The presence of Salmonella enterica in the lymphatic system of beef cattle presents a potentially important food safety issue for consumers and a significant production challenge for the beef industry. An understanding of pre-harvest factors which may influence the presence of Salmonella enterica in beef lymph nodes is of importance and should be considered as new feeding strategies or treatment plans are adopted. The objectives of this project were to evaluate the influence of pre-harvest feeding strategies on the presence and characteristics of Salmonella enterica associated with subiliac lymph nodes (SLN) of feedlot beef cattle.

Materials and Methods: Commercial steers and heifers (n = 5481 hd) were sourced for enrollment in a feeding trial at a commercial feedyard in the panhandle of Texas. Upon arrival at the feedyard (Spring 2016), the cattle were randomly assigned to one of four treatment groups until ten pen blocks representing one pen of each treatment group (n= 10 pens/treatment). The four treatment groups reflected the inclusion of feed additives in finishing diets and specifically the inclusion and exclusion of Tylosin. Cattle were harvested at a commercial beef processing facility in Texas within a three-week period in the fall of 2016. Fifteen SLNs were collected from each pen (40 pens x 15 SLN = 600 SLN) at the time of slaughter for evaluation of Salmonella enterica presence. Salmonella isolated from the SLNs were further characterized by determining the serogroup and antibiotic susceptibility. Similarly, the microbial community of the SLN was assessed using the 16S rRNA gene of SLNs composited by pen.

Results: Overall, 84.6% of SLNs were positive for Salmonella enterica across the four treatment groups. Gross prevalence data suggests that treatment group had no impact on the number of SLNs that were positive for Salmonella enterica; however, the overall high prevalence agrees with previous studies which have demonstrated SLN Salmonella prevalence greater than 75% in feedlot cattle from the Southern region. Serogroup, susceptibility, and microbiome data will complement information related to Salmonella prevalence and provide further insight into the potential impact of pre-harvest feeding strategies on Salmonella enterica in the lymphatic system of feedlot cattle. The 16S rRNA microbiome analysis indicates that the top three phyla present in the composited SLNs were Proteobacteria (68.9%), Acidobacteria (8.9%), and Actinobacteria (8.8%). The microbiome did not differ among treatment groups (P > 0.05).

Image:

Table 1. The impact of pre-harvest feeding strategies on the prevalence of Salmonella enterica in the subiliac lymph nodes of feedlot beef cattle

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percentage (%) of Subiliac Lymph Nodes positive for Salmonella enterica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tylosin</td>
<td>86.00</td>
</tr>
<tr>
<td>No Tylosin</td>
<td>83.33</td>
</tr>
</tbody>
</table>

1 Percentage did not differ among treatment groups (P = 0.77).

Conclusion: As the beef cattle industry moves towards adapting feeding and treatment strategies to combat the development of antimicrobial resistance, the impact of such motives on meat quality and beef safety must be explored. Relative to beef safety, mitigation of Salmonella enterica presence in the lymphatic system—and subsequently beef trim—is a priority for the industry. This study, which is part of a larger effort to evaluate tylosin alternatives, will provide valuable information regarding the impact these feeding strategies have on Salmonella in SLNs. This understanding will be useful in determining the role such strategies can play in producing safe beef.

Keywords: Lymph Node, Microbiome, Salmonella, Tylosin
Meat and Poultry Safety

125: EVALUATION OF THE REDUCTION OF SALMONELLA SURROGATE IN BEEF STRIP LOINS AT TEMPERATURES LOWER THAN 54.4°C

B. Mendes¹, E. Krage¹, J. Henson¹, A. G. Mckeith¹
¹Animal Sciences and Agricultural Education, California State University, Fresno, Fresno, United States

Objectives: According to the CDC, Salmonella is a leading cause of gastroenteritis in humans and continues to be significant in relation to public health concerns for the food industry. This may be attributed to inadequate heating/cooking. According to Appendix A in order to achieve a 6.5-log₁₀ reduction in Salmonella the lowest time/temperature that can be utilized is 54.4°C for 112 min. To date there is limited research in utilizing lower temperatures for strip loins in order to increase juiciness and perceived tenderness. This study evaluated the reduction of Salmonella surrogate on strip loins cooked to internal temperatures of 54.4°C or lower to determine if temperatures less than 54.4°C would achieve a 6.5-log₁₀ reduction in accordance with Appendix A.

Materials and Methods: A local company provided their proprietary brine and rub ingredients and raw meat materials for the experiment. A cocktail of five strains of Escherichia coli (ATCC® BAA-1427, 1428, 1429, 1430, 1431) were utilized. These strains are approved by the USDA as surrogates for Salmonella for in plant verification studies. Inoculations were prepared by inoculating TSB with each E. coli strain and allowed to grow at 37°C for approximately 24 hr. Strip loins were dip inoculated with E. coli to achieve a 7.5-log₁₀ CFU/g inoculation level on the meat. Strip loins were pumped 15% with a brine solution and then rubbed with the rub. They were then placed into cook-in bags and vacuum-sealed. Packages were placed on a smokehouse trolley in the smokehouse. The combination of temperatures and times held were 54.4°C for 2 and 3 hr, 51.7°C for 3 and 5 hr, and 48.9°C for 10 and 12 hr. Times were determined utilizing a model from the North American Meat Institute. Internal temperatures were continuously monitored utilizing Type-K Thermocouples. Once removed from the smokehouse 1 kg samples were taken from each strip loin and were vacuum-packaged for Salmonella surrogate enumeration. Samples were taken to Food Safety Net Services for enumeration. MacConkey Sorbitol Agar was utilized to determine Salmonella surrogate survival. The experiment consisted of three replications with two samples per treatment per replication. Data were analyzed using excel to determine variance and the GLM procedure of SAS to obtain lsmeans with statistical differences set at p<0.05.

Results: No treatment was more effective at inactivating the Salmonella surrogate than another (p>0.05). However, there was a trend (p=0.08) that the temperature 54.4°C was more effective at inactivating the Salmonella surrogate than 48.9°C. Strip loins had a 6.2-log₁₀ reduction (var=0.3) at 54.4°C when held for 2 hr and a 6.4-log₁₀ reduction (var=0.07) when held for 3 hr. When held at an internal temperature of 51.7°C a 5.1-log₁₀ reduction (var=0.59) was achieved when held for 3 hr and a 5.5-log₁₀ reduction (var=0.59) when held for 5 hr. Strip loins that were cooked to 48.9°C and held for 10 hr resulted in a 4.8-log₁₀ reduction (var=3.23) and when held for 12 hr achieved a 4.9-log₁₀ reduction (var=1.28). Reduction from brine and rub will be presented on the poster.

Conclusion: Results suggest that lower temperatures may possibly achieve a 6.5-7.0-log₁₀ reduction in accordance with Appendix A if the product was held at the temperature for the correct time. This information is useful for companies that wish to use other temperature/time relationships than those stated in Appendix A.

Keywords: Appendix A, Beef, Salmonella
Meat and Poultry Safety

126: PREVALENCE AND ANTIMICROBIAL SUSCEPTIBILITY OF E. COLI AND SALMONELLA SPP. IN MARKET SHOW CATTLE AND SWINE

K. S. Werland 1,*, S. R. Robles 1, L. A. Branham 1
1 Department of Agriculture, Angelo State University, San Angelo, United States

Objectives: The objective of this study was to determine the prevalence and antimicrobial susceptibility of generic Escherichia coli and Salmonella spp. in feces of market show steers and hogs from a state wide livestock show.

Materials and Methods: Fecal samples were collected from market steers (n=84) and hogs (n=84) at a statewide livestock show, stored at 4°C and processed within 36 hours of collection. Fecal samples were processed using 3M E. coli/Coliform Count Plates® for enumeration and isolated onto MacConkey Agar for susceptibility testing. Salmonella prevalence was determined using selective enrichment in Rappaport Vassiliadis and Tetrathionate broths and selective plating on XLT4 agar. Salmonella spp. isolates, which were confirmed positive via latex agglutination, were utilized for antimicrobial susceptibility testing. Antimicrobial susceptibility testing was conducted with a microbroth dilution method using Sensititre® plates from Trek Diagnostic. Isolates were tested against 14 antimicrobial agents important to both human and animal health, including: Cefoxitin, Azithromycin, Chloramphenicol, Tetracycline, Ceftriaxone, Amoxicillin/Clavulanic Acid, Ciprofloxacin, Gentamicin, Nalidixic Acid, Ceftiofur, Sulfisoxazole, Trimethoprim/Sulfamethoxazole, Ampicillin, and Streptomycin. Resistance breakpoints used were published in the NARMS 2014 Human Isolates Surveillance Report. Data was analyzed using procedures of SAS (Cary, NC; Version 9.1.3).

Results: As E. coli can serve as a vehicle for resistance genetics, fecal samples were analyzed for its presence and antibiotic resistance. E. coli populations were higher in hogs with 6.12 log10 CFU/g of feces compared to steer samples at 5.57 log10 CFU/g (P<0.05). Of the 662 E. coli isolates, 98.18% (324 of 330 tested) of hog isolates and 63.25% (210 of 332 tested) of steer isolates exhibited resistance to at least one antimicrobial. Within isolates from hogs, the most common resistance was to Tetracycline, Sulfisoxazole, and Streptomycin with 96.67%, 69.70%, and 53.64% of isolates exhibiting resistance to the respective antimicrobial. Escherichia coli isolates from steers exhibited the most common resistance to Tetracycline, Streptomycin, and Sulfisoxazole with 55.12%, 32.53%, and 28.61% of isolates exhibiting resistance, respectively.

Salmonella was more prevalent in hog samples than steer samples (P<0.05) with 19.05% of hogs (16 of 84) and 3.61% steers (3 of 83) testing positive. Of the 18 Salmonella isolates from hog samples, 83.33% exhibited resistance to at least one antimicrobial. Isolates from market hogs exhibited the most common resistance to Tetracycline, Streptomycin, and Sulfisoxazole with 77.78%, 44.44% and 44.44% of isolates resistant to the respective antimicrobial. Conversely, none of the Salmonella isolates from steers exhibited clinical resistance to any of the antimicrobials.

Conclusion: Little research has been done on the antimicrobial susceptibility of bacteria in show animals. Results from this study indicate that market show hogs had higher levels of the bacteria of interest and isolates from hogs were consistently more resistant to the tested antimicrobial agents when compared to steers. While making up a small percentage of the overall industry, show animals that are designated “market livestock” will eventually be introduced to the human food supply and play a role in its safety.

Keywords: Antimicrobial susceptibility, Escherichia coli, Salmonella, Show Cattle, Show Hogs
Meat and Poultry Safety

127: GENOME SEQUENCING OF NON-PATHOGENIC E. COLI APPROVED AS PATHOGEN SURROGATES

D. A. Therrien 1*, M. Taylor 1, J. Gill 1, P. Riggs 1
1Animal Science, Texas A&M State University, College Station, United States

Objectives: For this study, the objectives were to produce whole genome sequence (WGS) data, and conduct sequence alignment, assembly, and analyses from DNA of non-pathogenic E. coli recognized as useful surrogates for STEC by the USDA-FSIS. In addition, a group of three rifampicin-resistant (RifR; 100 mg/L) mutants generated from parent isolates via a process of natural selection were also analyzed alongside the parent surrogate isolates.

Materials and Methods: Working stocks of the E. coli surrogates (5 wild type isolates and 3 RifR mutants) were revived from -80°C cryo-storage, prepared on nutrient agar slants, and layered with mineral oil to prevent oxidative stress during storage at 5°C. Each bacterium was streaked onto MacConkey agar (MAC) & MacConkey agar + rifampicin (100.0 mg/L; MACR) to verify that isolates exhibited E. coli-typical appearances on media surfaces, that antimicrobial resistance was detected in RifR mutants, and to isolate bacterial colonies for DNA extraction to submit for WGS. Following this the E. coli surrogates and RifR mutants were grown in Luria-Bertani (LB) broth (24 hrs, 35°C) and then streaked onto LB agar and incubated, where an individual colony was isolated and grown for DNA extraction. A phenol/chloroform DNA extraction protocol was used to extract and purify the bacterial genomic DNA for WGS. After bacterial DNA was purified, the samples were submitted to the Texas A&M University (TAMU) Institute for Genome Sciences and Society (TIGSS) laboratory to undergo WGS via the Illumina MiSeq® platform and the Oxford Nanopore MinION® genomic sequencers. Once samples were sequenced they were analyzed via the TAMU Center for Phage Technology (CPT) GALAXY program.

Results: Upon sequencing, E. coli sequence data were analyzed via a constructed online database using the TAMU CPT GALAXY program, comparing obtained sequences to a combination of previously formed database of sequences of known bacterial virulence factors and antibiotic resistance. Pathogen surrogates will be verified to determine whether or not they in fact possess key STEC pathogenesis elements, including the locus of enterocyte effacement (LEE), Shiga toxins, hemolysin, as well as other virulence factors previously identified in members of the STEC.

Conclusion: The move by the USDA-FSIS to initiate WGS analysis of obtained isolates, particularly isolates obtained during outbreak or recall investigations, will produce a need for regulatory officers to be capable of differentiating WGS datasets from non-pathogenic organisms from disease agents. Data collected here will supplement existing or new WGS datasets by providing sequence data of E. coli useful for process validation and verification, allowing processors and regulatory officers to differentiate these organisms from pathogenic STEC.

Keywords: Beef Safety, E. coli, Pathogen Surrogates, Whole Genome Sequencing
128: USE OF PREDICTIVE MODELING TO DETERMINE SAFE COOKING TIMES OF MECHANICALLY TENDERIZED BEEF STEAKS

J. Saha 1,*, R. Jadeja 1, J. Nelson 1, D. Jaroni 1
1Department of Animal Science, Oklahoma State University, Stillwater, United States

Objectives: Microbial food safety issues related to mechanically tenderized beef products are on the rise, evident from 6 outbreak reports from CDC identifying them as the leading cause of contamination. Mandatory labelling requirements, by the USDA-FSIS, for cooking instructions of mechanically tenderized beef products requires validation of safe cooking time. However, determination of safe cooking times and degree of doneness for individual steak cuts of different sizes and weights is tedious. At the same time, cooking validation studies involving multiple factors is costly and time consuming. Predictive modeling, using statistical approach, is a powerful and concise way to simulate real-time scenarios without undergoing repeatability of costly experimentation. Predictive modeling in meat processing can provide quick and inexpensive testing of “what if” scenarios, reducing operation and production costs.

The objective of the study was to utilize predictive modeling techniques to determine safe cooking times for a variety of mechanically tenderized steak cuts.

Materials and Methods: A total of 288 steak cuts of various types (n=4 each): Top Round, Knuckle, Top Sirloin, Sirloin Cap, Flap, Tri-Tip, Flank, and Ribeye, with 3 thicknesses: 1.27, 2.54 and 3.81 cm, were used. The weight of the steaks ranged from 117-567 g. Samples were tenderized and fabricated, vacuum-packaged and stored at 5-7 °C until cooking (< 7-day storage). The dimensions (width, thickness, and length) of the steaks were measured prior to each cooking experiment. Before cooking the steaks, a thermocouple, attached to a temperature data logger, was inserted into the probable geometrical center of the sample and temperature logged every 10 seconds. Temperature profiles obtained during cooking were used to determine cooking rate. Samples were cooked on a preheated (185°C) flat-top grill until they reached an internal temperature of 70-71°C. Samples were flipped when the first side reached 35–40°C and the end-point temperature was used as a measure of doneness.

Data generated through the experiment was used for model development. Model building started with correlation of factors that could determine cooking time. A Pearson’s correlation statistics was performed to identify variables governing cooking time. Factors (length, width, thickness, weight, and cooking rate) with a 60% or higher correlation with cooking time (P<0.01) were selected to build the multivariable regression model. Values were checked for multicollinearity. Each experiment was repeated three times and data analyzed and modeled using PROC REG at a significance level of P<0.01.

Results: A high correlation (>70%) between cooking time and the thickness, weight, and cooking rate of the steaks was observed. The length and width of the steaks did not affect the time it took to cook the steaks. No significant differences (P>0.01) were found between experimental and predicted values of cooking time. A regression coefficient (r2) of 0.80 indicated that the model was successful in determining cooking time for different steak products with 80% accuracy.

Conclusion: This method for predicting cooking time will help the food industry (specifically at processing, retail and in food-service sectors) formulate safe cooking times of various steak cuts, without repeatability of cooking validation studies. Its application could help eliminate use of thermocouples.

Keywords: Cooking, Mechanical Tenderization, Predictive Modeling, Steak
Meat and Poultry Safety

129: ANTIMICROBIAL RESISTANCE PATTERNS OF ENTEROCOCCUS ISOLATED FROM FEEDLOT CATTLE AFTER FEEDING DIRECT-FED MICROBIALS IN DIETS WITH AND WITHOUT TYLOSIN

A. English1,*, A. Echeverry 1, J. Sarturi 1, T. Opheim 1, K. Nightingale 1, M. Miller 1, M. Brashears 1
1Animal and Food Science, Texas Tech University, Lubbock, United States

Objectives: The purpose of this study was to determine the antimicrobial resistance patterns of Enterococcus isolated from feedlot cattle supplemented with either a direct-fed microbials (DFM) (L. salivarius, L28) or tylosin as part of their finishing diet.

Materials and Methods: L. salivarius L28 was used in this study, a newly isolated DFM. Three treatments based on conventional high concentrate diets were fed to finishing cattle for harvest: base (no DFM, tylosin or monensin), MonPro (DFM at a feeding rate of $10^7$ cfu/head/day, with monensin, but no tylosin), and a control (tylosin and monensin). A total of 36 composite fecal samples, from 3 animals per pen, were collected after 56 days of feeding. Samples were weighed, enriched and plated onto KF Streptococcus Agar supplemented with 1% TTC solution. Three typical isolates from each plate were randomly selected and streaked onto 5% sheep blood agar for antimicrobial resistance analysis using Sensititre™ susceptibility MIC plates, following the National Antimicrobial Resistance Monitoring System (NARMS) protocol. The data was analyzed using a Chi-Squared test to compare resistance patterns across treatment group with a significant value of $p < 0.05$.

Results: Enterococcus was isolated from 100% (n=36) of fecal samples collected. After 56 days of feeding, 100% (n=36) of the control group isolates were resistant to at least one antibiotic, and 66% (n=24) were multi-drug resistant (MDR) to 3 or more antibiotics. Isolates from the base treatment group on day 56 exhibited 97% (n=35) resistance to one drug and 28% (n=10) were MDR. Ninety-four percent (n=34) of isolates in the MonPro group showed resistance on day 56, and 47% (n=17) of isolates were MDR. The percent of isolates with MDR differed significantly between treatments ($p = 0.004$). Specific antibiotics of concern are listed in Table 1.

Conclusion: While the enterococci isolated in this study, in all 3 treatments, had resistance to at least one antibiotic, there were differences in the MDR. The most MDR was observed in the control groups. MDR in the isolates collected from cattle fed the base diet was similar to the isolates from cattle fed the MonPro diet. A total of 10 and 17 of the isolates were MDR, respectively. The supplementation of L28 instead of the tylosin resulted in fewer MDR enterococci. These results indicate that supplementation with a DFM, such as L28, may be effective in mitigating the presence of multi-drug resistance in feedlot cattle.

Keywords: antimicrobial resistance, direct-fed microbials, enterococcus

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>Daptomycin</th>
<th>Lincomycin</th>
<th>Erythromycin</th>
<th>Tylosin Tartrate</th>
<th>Tetracycline</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
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<tr>
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<td>94%</td>
<td>11%</td>
<td>44%</td>
<td>33%</td>
</tr>
<tr>
<td>MonPro</td>
<td>36</td>
<td>14%</td>
<td>94%</td>
<td>17%</td>
<td>44%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Image:

Table 1. Percentage of resistance for specific antibiotics across treatment.
Meat and Poultry Safety

130: PRESENCE OF SALMONELLA ON THE CARCASS, HIDE AND FECES OF GOATS AND LAMBS FROM MAJOR LIVESTOCK SHOWS IN TEXAS COLLECTED OVER 4 YEARS

K. E. Hanlon1,*, M. F. Miller1, M. M. Brashears1

1Department of Animal and Food Sciences, Texas Tech University, Lubbock, United States

Objectives: Goats and lambs raised for exhibition at major stock shows are subjected to different management techniques than animals raised for commercial production, often leading to increased stress, travel time and feeding techniques. While these stock show animals are not a primary concern relative to the U.S. lamb and goat meat supply, they are frequently raised by children, and have increased exposure to children and families at exhibitions. Ultimately these animals also end up in the food supply system. An understanding of the role of foodborne pathogens, such as Salmonella, in the feces, hide and carcasses of these animals is valuable to reducing the risk of human illness from exposure to goats and lambs. The objective of this study was to determine presence of Salmonella on the carcass, hide and feces from show goats and lambs over four years in Texas.

Materials and Methods: Animals in this study were goats or lambs exhibited at two large stock shows in Texas (late winter and early fall), and harvested at the Gordon W. Davis Meat Laboratory in Lubbock, Texas over a four-year period. Carcass swabs were taken at three time-points during the harvest process (pre-evisceration, post-evisceration, and after organic acid intervention was applied), and hide swabs were taken using a sterile pre-moistened sponge with 25 ml of Buffered Peptone Water. Fecal samples were collected by guiding fecal pellets from the descending colon, after evisceration, into a sterile collection cup. Carcass swabs were screened using a real-time polymerase chain reaction (PCR) platform, cultured for confirmation. Hide swabs and feces were enriched in selective media, cultured using a Xylose-Lysine-Tergitol 4 (XLT-4) agar, and subjected to latex agglutination for confirmation. Isolates from all positive samples were frozen and stored with 20% glycerol in -80°C for further analysis.

Results: From lambs (n=90) and goats (n=92), over four years, hide swabs (n=182), carcass swabs at pre-evisceration (n=182), post-evisceration (n=182) and post-intervention application (n=182), and fecal samples (n=182) were collected. Frequency of Salmonella detected from goat and lamb feces was similar (6.5% and 6.7% respectively), Salmonella on the hide was more frequently detected from lambs (16.7%) than goats (7.6%). Salmonella presence on small-ruminant (goat and lamb) carcasses was 1.1% at pre-evisceration, 3.3% at post-evisceration and 0.5% at post-intervention.

Conclusion: Salmonella was detected on the hide and from the feces of show goats and lambs, as well as on small-ruminant carcasses. This information confirms the presence of this pathogen, and provides data to substantiate the importance of hygiene and sanitation at livestock shows and exhibitions to protect visitors and ultimately reduce the risk of pathogen contamination on the carcasses of lambs and goats.

Keywords: carcass, Goat meat, hide, lamb, Salmonella
Meat and Poultry Safety

131: SHIGA TOXIN PRODUCING ESCHERICHIA COLI PRESENCE IN ENVIRONMENTAL SAMPLES COLLECTED FROM FOUR DIFFERENT MEAT PROCESSING PLANTS IN HONDURAS

D. E. Casas 1,*, A. Calle 1, M. Miller 1, M. Brashears 1
1Animal and Food Sciences, Texas Tech University, Lubbock, United States

Objectives: To create a baseline of Shiga toxin producing Escherichia coli (STEC) presence in meat processing facilities in Honduras.

Materials and Methods: Swab samples from tables, saws, equipment, knifes, aprons, walls, floors, drains, tubs, baskets, axes, boots, carts, hands, weighs and shelves were sampled in four different meat processing plants in Honduras. Plants A and B have an implemented HACCP system, while plants C and D have no food safety system in place. Surfaces were swabbed with pre-hydrated sponges, and all sponge samples were subjected to BAX STEC screening after enrichment. Presumptive positives underwent immunomagnetic separation for the serotype of interest and were plated onto modified Rainbow Agar. Individual colonies were confirmed through slide agglutination. Procedures of R (v3.3.2) were used for statistical analysis.

Results: There was no significant difference (P = 0.93) in the STEC presence among the four plants. The prevalence of STEC in environmental samples in plants A, B, C and D was 7.3% (4/55), 10.0% (4/40), 7.1% (1/14) and 11.1% (3/27) respectively. The use of HACCP as a food safety management system did not influence (P = 0.97) the prevalence of STEC in environmental samples.

Conclusion: The USDA-FSIS currently recommends that establishments test food contact surfaces for STEC (or virulence markers), and if the surface is found positive then the product that came in direct contact with those surfaces may be considered adulterated. Hence, it is crucial that meat plants maintain strict sanitation regimes for decontamination of environmental surfaces that may act as reservoirs for STEC. A reassessment of sanitation and HACCP plans in plants A and B is urgent, given that the system is not currently eliminating environmental STEC, while the development and implementation of food safety systems is needed in facilities C and D to protect public health in Honduras.

Keywords: beef processing, environmental surfaces, Honduras, STEC
132: AGING-INDUCED CHANGES IN SARCOPLASMIC PROTEOME OF THREE BEEF HINDQUARTER MUSCLES WITH DIFFERENTIAL COLOR STABILITY

M. Narayanan Nair¹ ¹, S. Li¹, C. Beach¹, G. Rentfrow¹, S. P. Suman¹
¹University of Kentucky, Lexington, United States

Objectives: Fresh beef color is critical to consumers’ purchase decisions. Beef color stability is muscle-specific, and the muscle-specific variations in sarcoplasmic proteome influence beef color. Post-mortem aging is a common practice employed by beef industry for improving beef tenderness and palatability. However, the color attributes and sarcoplasmic proteome of beef muscles undergo changes during aging. The objective of this study was to examine the changes in the sarcoplasmic proteome profile of three differentially color-stable muscles from beef hindquarters during postmortem aging.

Materials and Methods: Longissimus lumborum (LL), psoas major (PM), and semitendinosus (ST) muscles were obtained from both sides of eight (n = 8) beef carcasses (USDA Choice, 24 h post-mortem). Muscles were further divided into two equal-length sections and vacuum-packaged. The vacuum-packaged muscle sections were randomly assigned to aging at 2°C for either 0, 7, 14, or 21 days. On each aging period, muscle sections were fabricated into 2.5-cm thick steaks, individually over-wrapped, and allocated to refrigerated storage for 0, 3, or 6 days. Samples for proteome analysis obtained during fabrication were frozen at –80°C. On each storage day, lightness (L*), redness (a*), yellowness (b*), hue (trueness of red), chroma (saturation index), pH, and metmyoglobin reducing activity (MRA) were evaluated. The instrumental color, pH, and MRA data were analyzed using MIXED procedure in SAS. Sarcoplasmic proteome was analyzed using two-dimensional electrophoresis (pH 5–8; 13.5% acrylamide gels). The images of Coomassie Blue-stained gels were obtained and analyzed. Protein spots exhibiting 1.5-fold intensity difference (P < 0.05) were considered differentially abundant and were subjected to tryptic digestion and tandem mass spectrometry for identification.

Results: The results indicated that instrumental color attributes and biochemical parameters during storage were influenced by muscle source and aging (P < 0.05). LL and ST had greater (P < 0.05) surface redness (a* value) than PM, whereas the color stability (R630/580) followed the order: LL > ST > PM. Aging also influenced surface redness with 7-day aged steaks demonstrating greatest values (P < 0.05). Proteome analysis identified differentially abundant glycolytic enzymes between the treatments (muscle source and aging days; P < 0.05) indicating muscle-specific changes in sarcoplasmic proteins during aging. The glycolytic enzymes identified (triosephosphate isomerase, glyceraldehyde-3-phosphate dehydrogenase, enolase, and phosphoglomutase-1) were more abundant (P < 0.05) in color-stable LL and ST compared to color-labile PM.

Conclusion: Our results indicated that the color attributes and sarcoplasmic proteome profile of beef LL, PM, and ST were influenced by aging for 21 days. Furthermore, the aging-induced changes in the sarcoplasmic proteome profile and color traits were muscle-specific. The differentially abundant glycolytic enzymes could be used as biomarkers for beef color, and for developing muscle-specific processing strategies to improve beef color stability.

Keywords: Beef color, Muscle-specificity, Proteome, Wet-aging
Muscle and Lipid Biology and Biochemistry

133: RACTOPAMINE INFLUENCES MUSCLE PROTEOME PROFILE OF POSTMORTEM BEEF LONGISSIMUS LUMBORUM

H. M. Kim1,*, S. P. Suman1, S. Li1, M. N. Nair1, C. M. Beach1, B. M. Edenburn2, D. D. Boler2, A. C. Dilger2, T. L. Felix3
1University of Kentucky, Lexington, 2University of Illinois, Urbana, 3The Pennsylvania State University, State College, United States

Objectives: Ractopamine is a beta-adrenergic agonist approved for use in cattle and pigs as a repartitioning agent to increase muscle deposition and potentially limit fat deposition. While the effects of ractopamine on proteome profile of postmortem pork muscles have been examined recently, its influence on beef muscle proteome has not been evaluated. Therefore, the objective of this study was to examine the effects of ractopamine on muscle proteome of postmortem longissimus lumborum (LL) from beef cattle.

Materials and Methods: Crossbred steers housed in pens were fed either a corn-based basal diet (CON) or a diet top-dressed with Optaflexx 45 (Elanco Animal Health) to provide 400 mg of ractopamine hydrochloride/steer per day (RAC). Ractopamine was fed the last 28 days before slaughter. Steers were harvested, and carcasses were chilled. The LL muscle samples were obtained from the carcasses of nine (n = 9) RAC and CON steers 24 h postmortem. The muscle samples were individually vacuum-packaged and frozen at −80°C for proteome analysis. Whole-muscle proteome was analyzed using two-dimensional electrophoresis, and the digital gel images were analyzed. The protein spots exhibiting more than 1.5-fold intensity differences (P < 0.10) between RAC and CON were subjected to in-gel tryptic digestion and were identified by tandem mass spectrometry.

Results: Five differentially abundant protein spots identified were of greater (P < 0.10) abundance in LL samples from RAC compared to those from CON. The proteins identified were F-actin-capping protein subunit β2, PDZ and Lim domain protein-3, heat shock protein β-1, myoglobin, and L-lactate dehydrogenase A chain. The differentially abundant proteins belong to four functional groups; i.e., skeletal muscle organization (F-actin-capping protein subunit β2, and PDZ and LIM domain protein-3), chaperone activity (heat shock protein β-1), oxygen transportation (myoglobin), and energy metabolism (L-lactate dehydrogenase A chain). The over-abundance of F-actin-capping protein subunit β2 as well as PDZ and LIM domain protein-3 in RAC may be attributed to the increase in myofibrillar protein synthesis and increase in muscle mass as a result of ractopamine feeding. Heat shock protein β-1 is a chaperone that protects muscle proteins, and its increased abundance in RAC compared to CON may be due to the increased muscle protein synthesis. The over-abundance of myoglobin could possibly result from the increased oxygen consumption due to additional muscle mass accretion in RAC compared to CON, whereas the increased levels of L-lactate dehydrogenase A chain in RAC could potentially be due to the shift of muscle fiber type.

Conclusion: The findings indicated that feeding ractopamine to steers influences the abundance of proteins involved in skeletal muscle organization, chaperone activity, oxygen transportation, and energy metabolism in postmortem beef LL muscle.

Keywords: Longissimus lumborum, Muscle proteome, Ractopamine
Muscle and Lipid Biology and Biochemistry

134: EFFECT OF OIL SOURCE, COOKING METHOD, AND STORAGE TIME ON FATTY ACID COMPOSITION IN GROUND BEEF PATTIES FROM NELLORE CATTLE

1Animal Science, Texas A&M University, College Station, United States, 2Paulista Agency Agribusiness Technology, Sao Jose do Rio Preto, 3Animal Science, University of Sao Paulo/VMCZ, 4Animal Science, University of Sao Paulo/FZEA, Pirassununga, Brazil

Objectives: The aim of this study was to evaluate the effects of feeding vegetable oil sources (sunflower - SU; linseed - LO and soybean - SO) on fatty acids composition of raw and cooked beef patties stored for 0 and 90 d.

Materials and Methods: Ninety-six Nellore steers were fed diets containing 3.5% vegetable oils (DM basis). After 82 d on feed, animals were harvested and samples of Longissimus muscle and subcutaneous fat were collected to prepare hamburger patties (n=40 per treatment; 100g patty). Patties were prepared utilizing a commercial formulation (85.4% meat, 12% fat, 2% salt, 0.3% garlic and 0.3% emulsifier) and packaged in oxygen permeable plastic bags, then immediately frozen at −18°C and stored for 0 (fresh) and 90d. The patties were evaluated raw and cooked. The cooked patties were grilled at 170°C for 4 min on each side (internal temperature 70°C). Fatty acid composition was estimated using gas chromatography. The data was analyzed as a completely randomized design in a 4 × 2 × 2 factorial arrangement (3 oil sources plus control × 2 storage time × raw and cooked) using a mixed model (MIXED procedure of SAS), including the fixed effects of oil source, storage time, cooking method, and the interaction between the treatments where each patty was used as an experimental unit.

Results: There was an interaction between storage times, cooking methods and oil source (P<0.0001). There was a higher concentration of SFA for SU and SO compared to the other treatments for fresh raw samples (P<0.0001). The cooking process decreased SFA concentration of all the treatments with oil (P<0.0001). There was a higher concentration of SFA for the control samples compared to the treatments with oil source for cooked patties (P<0.0001). Both raw and cooked patties had a higher concentration of MUFA in the control treatment (P<0.0001). Cooking process did not affect MUFA concentration in any treatment (P=0.19). There was higher concentration of PUFA of LO, followed by SO (P<0.0001), while SU and control samples did not differ (P=0.16) for fresh raw patties. Cooked samples with oil had higher concentrations of PUFA than the control (P<0.0001). The cooking process did not affect the concentration of PUFA for control and LO, however it increased for SU (P<0.0001) and SO (P<0.0001). The raw patties had a higher PUFA:SFA ratio for LO treatments, whereas the cooked patties had a higher ratio for all the oil source treatments compared to control. There was an increase in the PUFA:SFA ratio after cooking for SU (P<0.0001) and SO (P<0.0001), whereas neither control (P=0.27) nor LO (P=0.38) were affected. Comparing the effect of storage time, the samples that were not stored had higher concentration of PUFA in LO especially for 18:3 n3, and SO for 18:2 n6, followed by SU and control. There was a decrease in the PUFA concentration when the patties were stored for 90 d for all the treatments (P<0.0001). The LO patties had a higher concentration of PUFA compared with patties from the other treatments (P<0.0001) stored for 90 d.

Conclusion: In conclusion, ground beef patties made from the LO and SO had higher concentrations in PUFA, the cooking process decreased the SFA for patties with oil and the storage for 90 d decreases the concentrations of PUFA.

Keywords: Bos indicus, linoleic acid, Linseed oil, vegetable oil
Muscle and Lipid Biology and Biochemistry

135: EFFECTS OF POSTMORTEM AGING ON SMALL HEAT SHOCK PROTEIN DEGRADATION OF THREE BOVINE MUSCLES

D. Ma 1*, Y. H. B. Kim 1
1Meat and Muscle Biology Lab, Department of Animal Sciences, Purdue University, West Lafayette, United States

Objectives: Meat tenderness is a result of enzymatic degradation of muscle structural proteins. Small heat shock proteins (HSPs) are a family of molecular chaperones that could be involved in postmortem meat tenderization through its protective role in programmed cell death, namely anti-apoptotic activity. The rate and extent of proteolytic enzyme activity (particularly calpain1) change and its subsequent impacts on myofibrillar protein degradation during aging have been well established. However, the impact of postmortem aging on small HSP degradation of different beef muscles has not been fully understood. Therefore, the objective of this study was to determine the effect of postmortem aging on small HSP dynamics and its relevance to meat quality attributes of different beef muscles.

Materials and Methods: At 1 day postmortem, three muscles (longissimus lumborum (LL), semimembranosus (SM), and psoas major (PM)) from 8 beef carcasses were divided into 5 sections, vacuum-packaged, and assigned for 1, 2, 9, 16, and 23 days of aging. Warner-Bratzler shear force (WBSF) and water-holding capacity (WHC) including drip loss, cook loss, and purge loss were determined at each aging point. Western blots were performed to determine the extent of myofibrillar protein degradation (desmin and troponin-T), calpain1 autolysis, and small HSPs including HSP27, HSP20, and αβ-crystallin intact/degradation. The experimental design was a split-plot design with muscle effect as whole plot and aging time as sub-plot. The data were analyzed by using PROC MIXED procedure of SAS. Spearman ranking correlations between protein dynamics and meat quality attributes were analyzed by using PROC CORR of SAS.

Results: Postmortem aging improved WHC of beef muscles indicated by decreased cook loss and drip loss of beef samples (P < 0.05). Shear force values decreased with aging as expected (P < 0.05). However, the different aging response for tenderness development was observed in a muscle specific manner, where PM exhibited the most rapid WBSF decrease, followed by LL and SM (P < 0.05). A significant decrease in intact desmin and troponin T along with increased degradation products of these proteins were found with prolonged aging (P < 0.05). Desmin and troponin T degradation were positively correlated with WHC, tenderness and degradation of HSP20, HSP27 and αβ-crystallin (P < 0.05). HSP20 and αβ-crystallin exhibited similar dynamics, where significant decreases of intact proteins were observed during aging (P < 0.05). An increase in HSP27 degradation product of all beef muscles was found with aging in general (P < 0.05), but LL showed the most degradation products, while PM showed the least HSP27 degradation (P < 0.05).

Conclusion: The result of the current study suggests that small HSP degradation of beef muscles increase with aging, but the extent of degradation would be different in a muscle-specific manner. A different degradation pattern of HSP in LL compared to PM could be coincided with greater myofibrillar degradation of LL compared to that of PM during aging. The increase in small HSP degradation could indicate loss of protective anti-apoptotic activity from delaying myofibrillar protein degradation. Further investigation of upper stream (mitochondrial) apoptotic factors and caspase system dynamics over aging and their relationship with HSP and meat tenderness development would be warranted.

Keywords: Muscle type, Postmortem aging, Small heat shock protein, Tenderness
Muscle and Lipid Biology and Biochemistry

136: GENE CO-EXPRESSION NETWORK ANALYSIS ASSOCIATED WITH CARCASS TRAITS IN NELLORE STEERS

B. S. Vignato¹, L. L. L. Coutinho², A. S. M. Cesar², M. D. Poleti², L. C. A. Regitano³, J. C. D. C. Balieiro⁴,*
¹Animal Science, Universidade de São Paulo, Pirassununga, ²Animal Science, Universidade de São Paulo, Piracicaba, ³CPPSE, EMBRAPA, São Carlos, ⁴Animal Nutrition and Production, Universidade de São Paulo, Pirassununga, Brazil

Objectives: Carcass traits are influenced by a complex network of gene interactions in muscle, so elucidating the relationships between genes and how these genes influence these traits is crucial for understanding the muscle development in animals. This study aimed to identify groups of co-expressed genes in the skeletal muscle of Nellore steers associated with ribeye area (REA) and backfat thickness (BFT), using RNA-Seq data.

Materials and Methods: Three hundred and ninety Nellore steers from the Brazilian Agricultural Research Corporation (EMBRAPA/Brazil), were raised in feedlots under identical nutrition and management conditions until slaughter at an average age of 25 months. Samples from Longissimus dorsi (LD) muscle located between the 12th and 13th ribs were collected in two time-points: at slaughter for RNA sequencing analysis to guarantee the RNA integrity, and 24 h after slaughtering for REA and BFT evaluations. A total of 43 animals were selected based on their extreme (highest (H) or lowest (L)) GEBVs (Genomic Estimated Breeding Values) for REA and BFT to define groups for differential expression analysis. RNA-Seq data was normalized by the Transcript per million (TPM) procedure. The gene co-expression network analyses was carried out using the “blockwiseModules” function, part of the WGCNA (Weighted Correlation Network Analysis) R package. Modules were merged based on the dissimilarity between their eigengenes, which is the first principal component of each module. For each module, a different color was assigned. Module-trait associations were estimated using the correlation between the eigengene module and the phenotype (REA and BFT). Genes from modules with significant module-trait associations (P < 0.1), for at least one trait, were assigned for functional enrichment analysis when their Module Membership (MM) values were greater than 0.7 (P<0.001). The functional enrichment analysis was performed by DAVID v6.7 (FDR<0.1).

Results: Thirty-seven modules were identified. Among the modules identified, the Blue (r=0.3), Dark Green (r=0.3) and Salmon (r=0.3) presented significant correlation (P < 0.10) with BFT. The Blue module was the largest one, presenting 953 genes (MM>0.7). The functional enrichment analysis of the 953 genes from the Blue module identified 101 Gene Ontology (GO) terms including biological processes, cellular component, and molecular function, and six KEGG pathways. Among the metabolic pathways identified for the Blue module, the Extracellular Matrix - receptor interaction (bta04512) was noteworthy. This pathway was related to GO terms such as proteinaceous extracellular matrix (GO:0005578), extracellular matrix (GO:0031012) and cell-matrix adhesion (GO:0007160). The extracellular matrix (ECM) is a substrate for cell adhesion, growth, and differentiation, which plays an important role in force transmission for muscle contraction, maintenance, and repair, emphasizing its importance for REA. In relation to BFT, ECM plays an important role in adipogenesis.

Conclusion: The approaches used in this study allowed us to identify co-expressed networks correlated with important economic traits, collaborating to better understand the biological processes involved in muscle development and fat deposition in beef cattle.

Keywords: backfat thickness, ribeye area, WGCNA
137: IDENTIFICATION OF GENOMIC REGIONS RELATED TO PH IN NELLORE BEEF CATTLE

E. C. Mattos¹,*, M. E. Carvalho¹, A. F. Rosa¹, R. V. Ventura², M. Bonin³, F. M. D. Rezende⁴, F. Baldi⁵, J. P. Eler¹, J. B. S. Ferraz¹

¹Veterinary Medicine, College of Animal Science and Food Engineering - University of Sao Paulo, Pirassununga, Brazil, ²Beef Improvement Opportunities, Guelph, Canada, ³Animal Production, Federal University of Mato Grosso do Sul, Campo Grande, ⁴Federal University of Uberlandia, Uberlândia, ⁵São Paulo State University, Jaboticabal, Brazil

Objectives: The aim of this study was to identify genomic regions that potentially have association with pH in Nellore cattle.

Materials and Methods: Post mortem muscle metabolism (pH) was measured on samples of Longissimus thoracis muscle collected 24 hours post mortem using a portable pH-meter (Hanna HI9963) from 1,208 feedlot Nellore steers slaughtered at two years of age. Genotypic data of all animals was used for genome wide association studies through the ssGWAS method. Those animals were genotyped with the Illumina Bovine beadchip HD® GGpi (74K). Based on another Nellore population genotyped for Illumina beadchip BovineHD® (777K), genotypes were imputed using the FImpute software. Analyses were performed using a pedigree composed by 6,276 animals. Single step analyses were performed using the Blupf90 family of programs considering windows of 10 markers to estimate the SNP effects. This procedure enables the identification of regions associated with pH along the chromosomes. After quality control (MAF <0.05%, call rate <90%), 463,995 SNPs in autosomal chromosomes were used in the association analyses.

Results: The current investigation revealed 15 regions located in 10 different chromosomes (2, 3, 4, 8, 9, 11, 12, 16, 17 and 21), which explained more than 1% of the additive variance (Figure 1). Gene identification was carried out using the BioMart do Ensembl Genome Browser tool (www.ensembl.org). The following genes were identified in six distinct regions: WD repeat, sterile alpha motif and U-box domain containing 1; palmdelphin; insulin like growth factor binding protein 1; Bos taurus charged multivesicular body protein 7; tumor necrosis factor receptor superfamily, member 10d, decoy with truncated death domain; rho-related BTB domain-containing protein 2; spectrin repeat containing nuclear envelope protein 1 e ubiquitin specific peptidase like 1.

Image:

![Variance explained by 10 adjacent SNP window](image-url)
Conclusion: The ssGWAS method, using high density panel, allowed the identification of regions and genes related to pH in Nellore beef cattle. Further investigation combining information of the reported genes and its biological pathways is required to better evaluate their importance for meat quality traits.

Keywords: Bos indicus, meat quality, pH, ssGWAS
Muscle and Lipid Biology and Biochemistry

138: INFLUENCE OF HEAT SHOCK PROTEIN ACTIVITY ON THE BEEF TENDERNESS DURING AGING

A. Rosa 1,*, C. Moncau 2, E. Mattos 1, M. Poleti 3, J. Balieiro 4, J. Eler 1
1Veterinary Medicine, 2Animal Production, College of Animal Science and Food Engineering, Pirassununga, 3Animal Production, Luiz de Queiroz College of Agriculture, Piracicaba, 4Animal Nutrition and Production, College of Veterinary Medicine and Animal Science, Pirassununga, Brazil

Objectives: The aim of this study was to evaluate aging effects on tenderness and Heat Shock Proteins activity of beef muscle.

Materials and Methods: Were evaluated 303 F1 immunocastrated steers cross cattle (Nellore x South African Simmental), aged 18.0 ±2.0 months and live weights at slaughter of 500 kg. After 24 hours post mortem, two 2.5 cm steaks were collected at the 12th and 13th ribs of the Longissimus muscle. The steaks were individually identified, vacuum packaged and aged for 1 and 14 days. Also, in each aging time, one piece of meat was cut and immediately frozen in liquid nitrogen for further Heat Shock Protein (HSP) analysis. The meat samples were analyzed for Warner Bratzler Shear Force (WBSF) according AMSA (1995) and the HSP quantification were determined by Bovine HSP 27 and HSP 70 ELISA kits (Mybiosource). The total of protein content was calculated by Bradford method. Beef samples were classified into two groups according WBSF values at 14 aging days: Tender (<4.0 kg) and Tough (>5.2 kg) and after then, were selected 20 samples from each group for HSP quantifications. Data were analyzed using GLM procedures of SAS, LS MEANS statement and the TUKEY adjustment were used for mean separation with an alpha level of 0.05 (Version 9.2, Cary, N.C., 2002 – 2008).

Results: As expected, WBSF values (n=300) at 14 aging days from Tender group were smaller (4.2 kg) than Tough group (5.3 kg; P<0.05). The HSP 27 values decreased from 1 to 14 aging days inside the Tender and Tough groups, but no differences were detected between groups at the same aging day. With respect of the HSP 70 values, were observed differences only inside the Tender group and instead of HSP 27, the values increased from 1 to 14 aging days (Table 1).

Table 1. Heat Shock 27 and 70 protein expression (pg/ mg protein) by aging time.

<table>
<thead>
<tr>
<th>Aging Time</th>
<th>1 day</th>
<th>14 days</th>
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<tr>
<td></td>
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<td>HSP 27</td>
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<tr>
<td>Tough</td>
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<td>9.53</td>
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<tr>
<td>Tender</td>
<td>21.40</td>
<td>1.87</td>
</tr>
<tr>
<td>Tough</td>
<td>25.72</td>
<td>1.87</td>
</tr>
</tbody>
</table>

Conclusion: In conclusion, there are no evidence of relationship between HSP 27 activity and meat tenderness but with respect to HSP 70 activity, more studies should be conducte for elucidate this question.

Keywords: HSP27, HSP70
Muscle and Lipid Biology and Biochemistry

139: AGING, ANTIOXIDANT-ENHANCEMENT, AND MODIFIED ATMOSPHERIC PACKAGING IMPROVES APPEARANCE OF DARK-CUTTING BEEF

K. Wills 1,*, R. Mitacek 1, M. Pfeiffer 1, G. Mafi 1, D. VanOverbeke 1, D. Jaroni 1, R. Ramanathan 1

1Animal Science, Oklahoma State University, Stillwater, United States

Objectives: Color is the most crucial component of a consumer’s decision when purchasing beef. Due to their dark appearance, dark-cutters will be discounted at the packing facility. Improving the appearance can increase the value of dark-cutting beef resulting in a greater profit for producers and retailers. The objective of this study was to evaluate the effects of wet-aging, antioxidant-enhancement, and modified atmospheric packaging on color of dark-cutting beef during simulated retail display.

Materials and Methods: No-roll dark cutting (pH > 6.0) strip loins (n = 12) and 10 USDA choice (pH range 5.45 – 5.55 ) strip loins (IMPS #180) were randomly selected from a commercial purveyor within 3 d post-harvest. Dark cutting loins were sectioned into two equal sections and assigned to one of three aging periods 7, 14, and 21 d, then cut into three equal sections and assigned to 1 of 3 treatments, control, 0.1% rosemary, and 0.2% rosemary. Choice loins were sectioned into three equal sections and randomly assigned to respective aging periods. Following aging, loins assigned to rosemary enhancement treatments were enhanced to 110% their green weight with a solution consisting of deionized water and 1.1% or 2.2% oleoresin rosemary (Kalsec Herbalox®). Following aging and enhancement, sections were sliced into 1.9-cm steaks and assigned to one of three packaging treatments; high-oxygen modified atmospheric packaging (HiOx-MAP; 80% O₂ & 20% CO₂), carbon-monoxide (CO-MAP; 0.4% CO, 69.6% N, & 30% CO₂) and polyvinyl chloride overwrap (PVC; 20% O₂). Steaks were on display under continuous fluorescent lighting for 5 d. The surface color was measured utilizing a HunterLab Miniscan XE Plus spectrophotometer each day of display. Lipid oxidation was determined on 0 and 5 d of display utilizing the thiobarbituric acid reactive substances (TBARS) assay. Data were analyzed using the Mixed Procedure of SAS and values were considered significant at P < 0.05. The experiment was replicated eight times (n = 8).

Results: The combination of aging, modified atmospheric packaging, and antioxidant-enhancement improved (P < 0.05) redness (a* values) and lightness (L* values) of dark-cutting beef compared with control dark-cutting beef. HiOx-MAP packaging was the most effective (P < 0.05) in improving surface color compared with CO-MAP and PVC packaging.

Conclusion: The results indicate that the combination of post-harvest technologies such as aging, antioxidant enhancement and packaging has potential to improve surface color and value of dark-cutting beef.

Keywords: aging, antioxidant, dark-cutter, enhancement, modified atmospheric packaging
Objectives: Administration of growth-promoting technologies (GP), such as implants and beta-agonists, to feedlot animals is known to positively impact feedlot performance, however these technologies can have a negative impact on meat tenderness. Rate and extent of post-mortem proteolysis determines meat tenderness. Heat shock proteins (HSP) may play a role in this process through the protective effects these molecules exhibit over myofibrillar proteins during the degradation process. The objective of this study was to determine the effect of different growth-promoting technologies (GP) on HSP abundance in Longissimus lumborum (LL) steaks during aging.

Materials and Methods: Steaks were collected from the LL of feedlot heifers that received one of three different treatments (n = 11 per treatment) during the feedlot phase: no anabolic implant or beta-agonist (CON), anabolic implant but no beta-agonist (IMP), or an anabolic implant and a beta-agonist (COMBO). Heifers designated to receive an implant were administered Component TE-200 and the COMBO group received 8.3 mg/kg of zilpaterol hydrochloride for the final 21 d of feeding followed by a 3-d withdrawal period. At approximately 72 h postmortem, 5.08-cm thick roasts were cut and aged for 3, 14 and 35 d. At the end of the assigned aging period, a 2.54 cm steak was cut, frozen in liquid nitrogen and stored for subsequent analysis. Protein was extracted using a modified RIPA buffer. Western blot analyses were completed to measure abundance of HSP70 (HSPA) and HSPβ1 using bovine specific primary antibodies from Cell Signaling Technologies®. Statistical analyses were completed using SAS version 9.4. The statistical model analyzed repeated measures with GP treatment as the fixed effect, individual steaks as a random effect, day of aging as the repeated measure, and individual steak as the experimental unit. Differences in HSP abundance due to GP treatment were considered significant at P ≤ 0.05.

Results: Abundance of HSPβ1 was different (P < 0.001) between steaks from the three different treatment groups, however there was no significant effect (P > 0.50) found in the interaction between treatment and day of aging. At both 3 d and 14 d of aging, there was increased (P < 0.05) abundance of HSPβ1 in IMP and COMBO when compared to CON steaks. At 35 d of aging, COMBO steaks had increased (P < 0.05) abundance of HSPβ1 when compared to CON steaks, however, abundance of HSPβ1 did not differ (P ≥ 0.26) between IMP steaks and the CON and COMBO treatments. There was no effect (P = 0.81) of treatment or the interaction between treatment and day on HSPA abundance during the aging period.

Conclusion: Provision of different GP to feedlot cattle alters abundance of HSPβ1 in LL steaks during the aging period when compared to LL steaks from animals that did not receive any GP. These data may provide new insights into the mechanism through which meat tenderness is altered when these GP are administered to feedlot cattle.

Keywords: aging, growth promotants, heat shock proteins, HSP β1, meat tenderness
141: IMPACTS OF BOVINE MATERNAL NUTRITION ON MIRNA EXPRESSION IN SKELETAL MUSCLE OF THE PROGENY DURING GROWTH

N. E. Ineck¹*, R. G. Christensen¹, S. M. Quarnberg², K. A. Rood¹, C. E. Carpenter², J. F. Legako³, K. J. Thornton¹

¹Animal, Dairy and Veterinary Sciences, ²Nutrition, Dietetics and Food Science, Utah State University, Logan, ³Animal and Food Science, Texas Tech University, Lubbock, United States

Objectives: Decreased gestational nutrition has been shown to alter deposition of adipose tissue in the offspring within several different livestock species. Currently, little is known pertaining to the cellular mechanism(s) that are responsible for these observed changes in adipose deposition and skeletal muscle growth. This study investigated whether progeny from cows with restricted nutrition during the second trimester had different expression of microRNA known to be involved in either skeletal muscle or adipose deposition in the skeletal muscle during growth when compared to progeny from non-restricted cows.

Materials and Methods: Cows were all bred by the same Angus sire, stratified by body weight (P=0.80) and body condition score (BCS) (P = 0.72) and allocated to one of two different treatment groups: maintenance (n = 16) or restricted (n = 18). Restricted cows (REST) were provided with lower forage biomass (1662 kg/ha, dry matter) in comparison with maintenance (MAINT) (2309 kg/ha, DM). Restricted cows had a mean BCS 1.55 lower (P = 0.001) than MAINT at the end of the period and a weight difference of 188 Kg (P = 0.024). After the second trimester all cows and their subsequent calves were treated similarly. At the beginning of the feedlot stage skeletal muscle biopsies were collected from the offspring from the biceps femoris (BF) and immediately snap frozen in liquid nitrogen. Additionally, samples were collected from the offpring from the longissimus lumborum (LD) within 20 min of harvest and snap frozen in liquid nitrogen. Expression of miR-1, -133a/b, -206, -181d, -27b, -424, -486, -214, and let-7g was analyzed using quantitative real-time PCR methods.

Results: Offspring from REST cows expressed more (P < 0.05) MiR-133a, -133b, -206, -214, -424 and -486 in the BF at the beginning of the feedlot phase when compared to offspring from MAINT cows. There was no difference (P ≥ 0.12) in expression of MiR-1, -27b, or -181d in the BF between the two treatment groups at this phase of growth. Furthermore, at harvest, offspring from REST cows expressed more (P < 0.05) MiR-133a and -486 in the LD than offspring from MAINT cows. Offspring from REST cows also have a tendency (P = 0.09) for increased expression of MiR-133b in the LD when compared to offspring from MAINT cows. No differences (P ≥ 0.44) in expression of MiR-1, -27b, -181d, -206, -214, -424, or -486 were detected in the LD immediately following harvest between offspring from either the REST or MAINT cows.

Conclusion: These data provide novel insight into alterations in microRNA expression in the skeletal muscle during growth from offspring born from cows with restricted nutrient intake in the second trimester. Offspring born from REST cows expressed more MiRNA involved in both adipose and skeletal muscle growth which is likely involved in the cellular mechanism(s) that ultimately determine meat quality through their effects on skeletal muscle growth and adipose deposition. However, further research needs to be completed to determine the exact role that these microRNA have in skeletal muscle growth and adipose deposition.

Keywords: fetal programming, growth, MiRNA, skeletal muscle
Muscle and Lipid Biology and Biochemistry

142: B-ADRENERGIC AGONIST MEDIATED CHANGES IN MUSCLE ENERGY METABOLISM IN AMPK γ3R200Q PIGS

C. Mason 1,*, D. Gerrard 2, S. W. El-Kadi 2, S. K. Matarneh 2, K. Young 2, C. Carr 1, J. M. Scheffler 1, T. Scheffler 1

1Animal Science, University of Florida, Gainesville, 2Animal Science and Poultry Science, Virginia Tech, Blacksburg, United States

Objectives: The β-adrenergic agonist Ractopamine (RAC) repartitions nutrients from adipose to skeletal muscle and enhances muscle accretion in a fast-fiber type specific manner. In contrast, muscles from pigs with a mutation in the key energy sensor, AMPK-activated protein kinase (AMPK), exhibit a slower, more oxidative phenotype and elevated glycogen. Our objective was to utilize RAC and AMPK-mutated pigs to investigate the cellular signaling pathways regulating energy metabolism.

Materials and Methods: At approximately 90 kg, wild type and AMPKγ3R200Q barrows (n=29) were assigned to control diet or diet supplemented with RAC (9 ppm; Elanco Animal Health) for 28 d. Pigs were harvested and muscle was collected from the longissimus lumborum (LL) immediately after exsanguination (t=0 min) and deep (red) and superficial (white) portions of the semitendinosus (RST and WST respectively) were collected at 15 min. Glycogen content and parameters of glycogen metabolism were analyzed, and muscle metabolic phenotype was assessed by measuring glycolytic and oxidative enzyme activities.

Results: Regardless of RAC or muscle, AMPKγ3R200Q increased glycogen (P<0.001) and glycolytic potential (P<0.001) compared to wild type. In the LL, RAC decreased glycolytic potential in AMPK but not wild type (genotype x diet, P<0.05). Dietary RAC decreased glucose in RST and LL (P<0.05) and WST (P=0.08). The glycolytic capacity, indicated by lactate dehydrogenase activity, was differentially influenced by RAC and genotype in WST (genotype x diet, P<0.02), whereas in the LL, lactate dehydrogenase was increased by RAC (P = 0.05). In contrast, oxidative capacity, assessed by citrate synthase activity, was increased (P<0.001) in AMPK regardless of RAC in both LL and STW.

Conclusion: While AMPKγ3R200Q is associated with altered glycogen storage and a more oxidative metabolism, RAC administration affects muscle metabolic characteristics and alters metabolites towards glycolytic usage in a muscle specific manner. These results indicate that AMPK and RAC influence glycogen storage and energy metabolism, which may ultimately impact capacity for muscle growth.

Keywords: AMP-activated protein kinase, B-adrenergic agonist, muscle metabolism
Objectives: Kiwi fruit contains the cysteine protease actinidin, which belongs to the same class of enzymes as papain and bromelain. Several studies have shown that meat becomes more tender when injected with these enzymes. The objective of this study was to evaluate the proteolytic effects of actinidin in bovine semitendinosus muscle at high (6.4) and low (5.5) pH conditions, by monitoring degradation of desmin and myosin light chain.

Materials and Methods: Kiwi fruit powder (OT-1005X), which contains the proteolytic enzyme actinidin, was obtained as a gift from the producer (Ingredient Resources Pty Ltd, Australia). Four different marinades (A-D) were prepared. Na_5P_3O_10 was used to obtain the high pH-marinades. Marinade A: 0.5% kiwi powder, 3% phosphate and 3% NaCl. Marinade B: 0.5% kiwi powder and 3% NaCl. Marinade C: 3 % phosphate and 3% NaCl. Marinade D: 3% NaCl. From a commercial abattoir M. Semitendinosus from 6 young bulls (Norwegian Red) were purchased. Four days post mortem the muscles were cut into 5 slices (approximately 3.5 cm thick), and pH was measured. One slice from each muscle was further cut into small pieces (approximately 2 mm wide). The other slices were injected to 110% weight with the A-D marinades and kept at 4⁰C in sealed plastic bags for 14 days. Then Warner-Bratzer (WB) shear force was measured on these muscle slices after cooking in water bath at 70⁰C for 50 minutes. The finely cut muscle samples, from the 5th slice, were mixed with marinades (A-D) and stored in tubes for either 3 hours, 3 days or 14 days. At the given times excess liquid was removed and muscle samples were frozen. Then the meat samples were homogenized in Tris-EDTA buffer. Degradation of desmin and myosin light chain were measured by Western blotting of SDS-PAGE gels. Protein bands were quantified with the Image Quant software (GE Healthcare). Analysis of variance (ANOVA) was performed with the software Minitab (Version 17.2.1).

Results: There was no difference (p>0.05) in the pH values, which was in the range 5.55 to 5.62 (s.d 0.04), of the six semitendinosus muscles used in this study. Marinade A and C had pH-values of 6.38 and 6.45 respectively after addition of muscle, which were higher (p<0.001) than the corresponding values for marinade B and D which were 5.49 and 5.52. The muscle slices injected with marinade A had 34.0 (s.d 8.8) N cm⁻² as average WB shear force value, which was lower (p<0.05) than slices injected with marinade D (49.0 N cm⁻², s.d 8.8). Average WB values for the samples injected with marinade B and C were 44.7 (s.d 10.4) and 40.3 (s.d 5.2) N cm⁻² respectively, and these were neither different from marinade A or D. Both desmin and myosin light chain were increasingly degraded with time (p<0.001), but no difference was found between the marinades A-D at each of the three time periods.

Conclusion: This study has shown that actinidin has a tenderizing effect on bovine semitendinosus muscles. The proteolytic activity seems to be higher when pH is around 6.4 than 5.5. Since no differences were seen in degradation rate of desmin and myosin light chain between the 4 marinades, the proteolytic activity of actinidin is limited against these proteins.

Keywords: actinidin, proteolysis, Warner-Bratzler shear force
Objectives: The objective of the study was to determine the effects of feeding endophyte-infected tall fescue seeds on mitochondrial fatty acid (FA) composition and phospholipid (PL) fractions and activity of superoxide dismutase (SOD) and metmyoglobin reductase (MRA) in beef longissimus muscle from Angus steers.

Materials and Methods: Twelve Angus steers were blocked by initial BW and randomly assigned to be fed with either KY32 (E- or control) or KY31 (E+ or treatment; approximately 20 µg of ergovaline per kg of BW) within a block. Steers were fed individually using Calan® gates in the first 70-d trial in the summer of 2015, followed by a 149-d withdrawal period and the second 64-d trial in the winter of 2016. After the second trial, steers were implanted with a dose of Ralgro®, finished for 66 d on summer perennial pastures, and slaughtered at approximately 500 kg of BW. Immediately after carcass decontamination, longissimus thoracis muscle was collected at the 12th rib on the left side of the carcasses, cubed, snap-frozen in liquid nitrogen, wrapped in aluminum foil, vacuum-packaged, and stored at -80°C for FA, PL, and SOD analyses. Strip loins were collected at 72 h post-mortem, aged for 14 d, trimmed to 0.3-cm backfat thickness, cut into 2.54-cm steaks, placed on black Styrofoam® trays, overwrapped with PVC film (O₂ permeability of 1.21 mL/cm²/d and water vapor permeability of 0.022 g/cm²/d; LINPAC Packaging-Filanco Inc., Aurora, OH), and placed under simulated retail display conditions (2 to 4°C, 900-lux fluorescent intensity, and 80% relative humidity) for 0, 1, 3, 5, and 7 d. One steak per animal per time point was collected for MRA analysis. Mitochondria were separated by ultracentrifugation and their lipids were extracted in 1:2 chloroform:methanol (v/v) and converted to fatty acid methyl esters to be analyzed by gas chromatography (Hewlett-Packard 6890 FID GC System; Agilent Technologies, Santa Clara, CA). Phospholipid classes were determined by thin-layer chromatography. Activity of SOD was determined by a colorimetric assay kit applicable for muscle (ab65354; Abcam, Cambridge, MA). Metmyoglobin reducing activity (µM of MMb reduced/min/g of muscle) was determined by reacting extracted muscle reductases with equine skeletal metmyoglobin and measuring deoxymyoglobin at 580 nm (Spectra max plus 384; Molecular Devices, Sunnyvale, CA). One steer with a large abscess, yielding pH of 6.35 and dark cuts, was excluded. Statistical analysis was performed by the GLIMMIX procedure of SAS 9.4 (SAS Institute Inc., Cary, NC) at 0.05 level of significance.

Results: Feeding endophyte-infected tall fescue seeds did not affect mitochondrial FA composition, PL fractions, and SOD activity (P ≥ 0.14). Metmyoglobin reducing activity of E+ steaks was 6.01 ± 0.37 µM/min/g, similar to that of E- steaks (6.92 ± 0.41 µM/min/g; P = 0.117). As expected, MRA was correlated with length of retail display (r = – 0.74; P < 0.001) and decreased from 9.54 ± 0.49 µM/min/g on d 0 to 2.29 ± 0.93 µM/min/g on d 7 (P < 0.001).

Conclusion: Endophyte-infected tall fescue may not affect the integrity of mitochondria and MRA. A decrease in color stability was well correlated with decreased activity of metmyoglobin reductase.

Keywords: tall fescue, beef, metmyoglobin reducing activity, mitochondria
Objectives: The purpose of this study was to determine the effect of steak location and postmortem aging on cooked meat tenderness and sarcomere length of steaks from the Semitendinosus (ST) and Longissimus lumborum (LL).

Materials and Methods: Forty crossbred steers were processed at a commercial facility, and from one side of each carcass, the ST and LL subprimal were collected. Each ST was divided into 5 locations (LOC) with LOC 1 being the most proximal and LOC 5 the most distal. Similarly, each LL was divided into 3 LOC with LOC 1 starting within the middle of the subprimal and LOC 3 being the most posterior. Within each subprimal location a 2.54-cm thick steak was fabricated for Warner-Bratzler shear force (WBSF) and sarcomere length analyses. Steaks from each LOC within the ST were randomly assigned to 7, 14, 28, 56, or 112 d of aging (DOA) and steaks from each LL LOC were randomly assigned to 7, 28, or 112 d of aging. After the appropriate aging period, WBSF and sarcomere steaks were cooked to 71°C and chilled overnight. Six cores were removed parallel to muscle fibers and were sheared perpendicular to the muscle fibers. Sheared cores were frozen and powdered for sarcomere length. The Z- and M-Lines were marked under a laser beam, and the equation established by Cross et al., (1981) was utilized to quantify sarcomere length. Data were analyzed as a randomized complete block design with repeated measures.

Results: There were no LOC × Day of aging interactions for ST or LL steaks for WBSF or sarcomere length (P > 0.25). Steaks from the ST had reduced WBSF values in LOC 4 compared to other LOC (P < 0.05). The ST steaks for LOC 1 and 2 had the greatest WBSF values compared to the more distal LOC (P <0.05). Sarcomere length was shorter for ST steaks from LOC 1 and 2, compared to LOC 4 and 5 (P < 0.05). Longer sarcomere lengths were found in the more distal LOC for ST steaks than in the proximal LOC (P < 0.05). The LL steaks were not different in WBSF values across LOC (P > 0.05). Additionally, sarcomere length of LL steaks was not different across LOC (P > 0.05). As day of aging increased, WBSF values decreased in ST steaks (P < 0.05). However, no differences (P > 0.05) were detected for sarcomere length in ST steaks as day of aging increased. In LL steaks, WBSF values decreased and sarcomere length increased (P < 0.05) as day of aging increased.

Conclusion: Semitendinosus steaks from the center portion of the subprimal were instrumentally more tender than proximal steaks, but LOC had no effect on instrumental tenderness for LL steaks. Increased day of aging resulted in more tender ST and LL steaks. To provide the highest eating satisfaction to consumers on a budget, extended aging and steak location should become most valued when selecting ST steaks. While loin steaks can be more consistent in tenderness, consumers can value quality over steak location.

Keywords: aging, beef, location, shear force, tenderness
Objectives: The aim was to evaluate the fatty acids (FA) composition of meat samples exposed to retail display conditions for three days from Nellore steers fed different oil sources during the feedlot finishing.

Materials and Methods: Ninety-six Nellore (Bos indicus) steers were fed for 81 days with diets containing different oil sources: soybean (SOY – 6.6% ether extract - EE), sunflower (SUN – 6.9% EE), linseed (LIN – 6.8% EE) and a diet control (CON - without addiction of oil - 3.5% EE). Diets were composed of 21% corn silage and 79% concentrate (dry corn grain, soybean meal, citrus pulp, urea, mineral nucleus and calcitic limestone) and inclusion of oils (3.5%) was made by partial substitution of corn grain. After 81 days of feeding, animals were slaughtered (507.5 ± 17.3 kg LW and 5.2 mm of backfat thickness) and samples of longissimus muscle (2.5 cm thick) were collected at 12th rib level after 48 hours postmortem. Steaks were placed on Polyfoam trays, overwrapped with an oxygen-permeable polyvinylchloride film and stored for three days under simulated retail display conditions of illumination (Halogen light; 2000 lx) and temperature (0 – 2 °C). After this period, steaks were frozen and analyzed for FA composition using the methods by Folch et al. (1957) and Kramer et al. (1997), and quantified using a gas chromatography. The experiment was set up as a completely randomized block (initial body weight) design and analyzed using the mixed model, considering diets as fixed effects.

Results: No effect (P > 0.05) of oil addiction in diet was observed for most FA percentage (average among all treatments): c9 t11 CLA (0.42% ± 0.04) and total concentrations of monounsaturated (45.17% ± 0.86), saturated (SFA) (41.13% ± 0.75), polyunsaturated (PUFA) (10.06% ± 0.85), n-3 (1.50% ± 0.20), n-6 (8.3% ± 0.70). The c6 18:1 concentration was higher (P = 0.04) in meat from steers fed LIN (0.36% ± 0.03) and SOY (0.37% ± 0.03), in comparison to CON (0.19% ± 0.04). This c6 18:1 increased concentration is seen as beneficial to human health because of cis positional configuration. Linolenic acid was in higher concentration (P = 0.01) in animals fed LIN (0.96% ± 0.05) compared to other treatments (0.46% ± 0.05), which would be expected due to the high concentration of 18:3 n-3 in linseed oil. This is a desirable result, because the goals of feeding LIN were to increase n-3 FA in the meat because of their benefits to human health. In consequence, meat from LIN fed animals had a high n-6:n-3 ratio (4.15 ± 0.55) which is close to the recommended ratio (4.0) by the World Health Organization – WHO (2003). The meat of animals fed SUN and SOY showed n-6:n-3 ratio of 8.75 and 7.66, respectively, which are higher than recommended by the WHO. Despite no differences among treatments for n-6 FA, the high n-6:n-3 ratio observed for SUN and SOY occurred probably due to the high amount of 18:2 n-6 in these oils. The PUFA:SFA (0.25 ± 0.02) ratio was not affected by diets (P > 0.05) and was below the recommended ratio which is greater than or equal to 0.4. The index of enzymes activity ∆9 desaturase C16 (11.05% ± 0.36), ∆9 desaturase C18 (72.07% ± 1.18) and elongase (65.48% ± 0.50) were not influenced by diets (P > 0.05).

Conclusion: The LIN diet provided meat with better FA composition considering the higher concentration of linolenic acid and adequate relation of n-6:n-3, which is positive for human health.

Keywords: beef, linolenic acid, longissimus muscle, vegetable oil
Muscle and Lipid Biology and Biochemistry

147: EXCESS GLYCOGEN DOES NOT RESOLVE HIGH ULTIMATE PH OF BEEF, LAMB, AND CHICKEN OXIDATIVE MUSCLE

S. S. Chauhan 1,*, M. N. LeMaster 1, M. K. Foster 1, C. E. Miller 1, E. M. England 1

1Department of Animal Sciences, The Ohio State University, Columbus, United States

Objectives: Glycogen is the main energy source during the conversion of muscle to meat. Lower glycogen levels of oxidative muscle ante-mortem were thought to contribute to a higher ultimate pH. However, excess glycogen did not resolve the high ultimate pH of porcine masseter (oxidative) muscle. To understand this phenomenon further in other species, we hypothesized that excess glycogen may not resolve the high ultimate pH of oxidative muscles in beef, lamb, and chicken.

Materials and Methods: Six market-weight beef cattle, lambs, and chickens were harvested at The Ohio State Meat Center under USDA-FSIS supervision. Cutaneous trunci (glycolytic) and masseter (oxidative) muscle samples from the ruminants, and pectoralis major (glycolytic) and sartorius (oxidative) muscle samples from the chickens were collected immediately after exsanguination. The samples were snap frozen in liquid nitrogen and stored at -80°C until further analysis. Muscle samples were powdered in liquid nitrogen and homogenized into an anaerobic glycolysis buffer containing 10 mM Na₂HPO₄ (pH 7.4), 5 mM MgCl₂, 60 mM KCl, 5 mM ATP, 0.5 mM ADP, 0.5 mM NAD⁺, 30 mM glycogen, 25 mM carnosine, 30 mM creatine, and 10 mM sodium acetate at 100 mg muscle/mL. Reaction vessels were placed in a dry heating block at 25°C and aliquots were removed at 0, 30, 60, 120, 240, and 1440 min for pH, glycogen, glucose 6-phosphate, glucose, and lactate analysis. Data were analyzed with a mixed model in JMP. Individual animals were recognized as an experimental unit and time-course data were analyzed with a split-plot design. The least squares means were evaluated with a Student’s t-test and considered significant at P ≤ 0.05.

Results: Glycogen content between muscle homogenates was similar at 0 min in all the species and decreased significantly (P < 0.001) with time. However, both glycolytic and oxidative muscle homogenates contained residual glycogen at 1440 min which indicated that glycogen was not completely depleted in all species tested. The muscle homogenate pH decreased (P < 0.001) with time in all species. However, the ultimate pH at 1440 min of the oxidative muscle homogenates was significantly (P ≤ 0.023) greater than the glycolytic muscle homogenates in all species tested. Lactate content increased (P < 0.001) with time in all muscles, but the oxidative muscle homogenates contained decreased (P ≤ 0.0231) lactate levels at 1440 min in all species tested. Glucose 6-phosphate content increased significantly (P < 0.001) from 0 to 30 min in both muscles of all species tested, followed by relatively consistent levels until 240 min. There was again a significant (P ≤ 0.023) increase in glucose 6-phosphate levels from 240 to 1440 min in all the muscles, however the levels were significantly (P ≤ 0.005) lower in oxidative muscles as compared to glycolytic muscles in all the species tested. These results are consistent with the previous findings in pigs.

Conclusion: Combined these data indicate that glycolysis and pH decline terminate prematurely in the presence of excess glycogen in postmortem oxidative muscles across livestock species.

Keywords: beef, chicken, glycogen, pork, ultimate pH
Objectives: Myosin heavy chain (MyHC) isoform composition is a primary determinant of contractile speed of muscle fibers. Current methods for assessing bovine MyHC isoforms involve time-consuming histochemical evaluation by immunofluorescence or ATPase activity. Alternatively, electrophoretic separation of MyHC isoforms is more rapid, and this technique has been utilized in mice, pigs, and other species. Therefore, our objective was to establish a reliable procedure for separating bovine MyHC isoforms (I, IIa, and IIx) using sodium-dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE), followed by validation with Western blotting and histochemical analyses.

Materials and Methods: Muscle samples were collected from beef carcasses within 1.5 h after exsanguination; samples were processed for SDS-PAGE and immunohistochemical determination of fiber type and size. Muscles were chosen to represent a variety of fiber type compositions, including masseter, superficial pectoral, longissimus lumborum, and cutaneous trunci. For SDS-PAGE, proteins were extracted using a sodium phosphate SDS buffer. To determine appropriate conditions for MyHC isoform separation, the following parameters were evaluated: percent acrylamide (7-9% for separating; 4-5% for stacking) and acrylamide to bis-acrylamide ratios (50:1 and 37.5:1), glycerol concentrations (30-45%), and electrophoresis running buffers. After SDS-PAGE, proteins were stained with Coomassie to validate all three isoforms were separated. Once conditions were established, MyHC composition was calculated using band intensity for each isoform relative to total intensity of all three types. In addition, Western blotting was used to confirm identity of MyHC isoforms. Primary antibodies (Developmental Studies Hybridoma Bank; Iowa City, IA) were of unique isotypes to detect a combination of MHC using 2 color detection. A primary antibody for all MHC types (MF 20; IgG2b) was used in conjunction with BF-32 (MHC I and IIa; IgM), A4.840 (MHC I; IgM), SC-71 (MHC IIa; IgG1), or 6H1 (MHC IIx; IgM). Primary antibody BA-F8 (MHC I; IgG2b) alone was also used. In conjunction, relative area of muscle fiber types was calculated using immunohistochemical determination of MyHC composition and cross sectional area. Muscle cross sections were incubated with primary antibodies (BA-F8 and BF-32), followed by AlexaFluor conjugated secondary antibodies; AlexaFluor 488 conjugate to wheat germ agglutinin was used to visualize muscle cell membranes. Fiber CSA and area were determined using ImageJ software.

Results: All three bovine MyHC isoforms were separated using a discontinuous gel system. The separating gel consisted of 37% glycerol, 8% acrylamide-bis (50:1), 0.2 M Tris (pH 8.8), 0.1 M glycine, and 0.4% SDS, and the separating gel was composed of 37% glycerol, 4% acrylamide-bis (50:1), 70 mM Tris, 4 mM EDTA, and 0.4% SDS. Ammonium persulfate and TEMED were used to initiate polymerization of separating and stacking gels. Electrophoresis was performed at 80V for approximately 40 hours at 4 C. Identity of isoforms was confirmed with Western blotting, and percent MyHC composition evaluated by SDS-PAGE was consistent with relative area determined by immunohistochemistry (P<0.05).

Conclusion: Modification to SDS-PAGE parameters results in clear and consistent separation of bovine MyHC isoforms, thereby providing a more rapid means for determining MyHC composition compared to histochemical methods.

Keywords: muscle fiber type, myosin heavy chain
Objectives: The Meat Science Lexicon was developed by AMSA to fill a void recently observed by various AMSA members and associated meat industry organizations. These included the observations that various health and nutrition organizations (e.g., IARC) have had great difficulty defining terms like ‘red and white’ meat and ‘processed’ meat. Consequently, there seemed to be a void in the understanding of meat science terms that could lead to future confusion in such research especially for consumers when trying to interpret dietary information.

Materials and Methods: A committee of ten AMSA members made up of professional and emeriti members was created in the early spring of 2016 to develop such a lexicon. Through the use of several face-to-face meetings, numerous conference calls, and with meetings with meat industry groups, the committee developed the lexicon.

Results: The lexicon defines several of the more difficult terms currently being used (red & white meat and processed meat) while also creating a rather complete taxonomic system of organizing meat and meat products. The document also includes a glossary of popular meat science terms that are used in the text of the Lexicon itself. The finished journal article has been submitted for publication in the AMSA Meat & Muscle Biology Journal.

Conclusion: The hope is that this new Meat Science Lexicon will be a starting place to use for the education of not only meat science professionals but also researchers involved in nutrition, medical, and cancer research to illustrate the diversity of consumer products created by the meat industry and that these cannot simply be described by a few simple terms.

Keywords: MEAT, MEAT SCIENCE LEXICON, OFFAL, PROCESSED MEAT, RED AND WHITE MEAT
150: EFFICACY OF ROSEMARY AND GREEN TEA EXTRACTS AS CLEAN LABEL ANTIOXIDANTS IN DRY-FERMENTED SAUSAGES

A. Pham-Mondala 1,*, A. Vanek 1, P. Joseph 1

1Kalsec, Kalamazoo, United States

Objectives: Increased interest in natural cure ingredients is largely due to rising consumer demand for processed meats with clean label solutions. Maintaining color and flavor stability is critical in dry-fermented type sausages, which are highly susceptible to oxidative changes especially when sliced and stored. Rosemary and green tea extracts are naturally-sourced antioxidants that could mitigate such 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 pepperoni formulations using natural cure or conventional cure.

Materials and Methods: Fresh pork shoulders (16% fat) were deboned and fine ground through a 0.32 cm plate. A base formulation of 2% salt, 1% dextrose, 1% water, oleoresin paprika and commercial starter culture was used. Treatment effects include: (i) Conventional Cure (150 ppm sodium nitrite; 400 ppm ascorbic acid; 60 ppm BHA/BHT; CC), (ii) Natural Cure (60 ppm sodium nitrite equivalent from pre-converted vegetable juice powder, PVJP; 400 ppm ascorbic acid from cherry powder; NC), (iii) Natural Cure + 0.2% Herbalox® (Rosemary Extract; NCR), (iv) Natural Cure + 0.2% Duralox® (Rosemary/Green Tea Extracts blend; NCRG), (v) Natural Cure (150 ppm sodium nitrite from PVJP) + 0.2% Duralox® (Rosemary/Green Tea Extracts blend; NCFNRG). Pepperoni formulations were stuffed, fermented (43-66°C, RH 65-85%, 26 h), dried down (20-21°C, MPR 2.0:1, pH 4.8), sliced, packed under vacuum or high oxygen modified atmosphere (80% O₂/20% CO₂, HiOx-MAP, to enhance oxidation) and stored (3±1°C, away from light) until analyses. Instrumental color, visual evaluation, secondary oxidation products (hexanal, pentanal, heptanal), gas composition and informal sensory evaluation were determined every 7 days (d) over a period of 28 d (HiOx-MAP) and 31 d (vacuum packaged). This study was replicated two times and statistical analysis was performed using Analysis of Variance (ANOVA, P < 0.05).

Results: HiOx-MAP pepperonis with NCFNRG, NCRG and NCR showed higher (P < 0.05) CIE \( a^* \) (redness) and chroma (saturation) values compared to CC and NC alone after 28 d of storage indicating slower red color deterioration. Redness and chroma values were also greater (P < 0.05) in vacuum packaged NCR pepperonis throughout 31 d of refrigerated storage. The addition of rosemary and green tea extracts to HiOx-MAP sliced pepperoni samples improved (P < 0.05) oxidative stability as evidenced by lower concentrations of secondary oxidation products and were not different from CC after 28 d of storage. Results of secondary oxidation products in vacuum packaged pepperonis have shown that NCR, NCRG and NCFNRG could significantly (P < 0.05) inhibit oxidation compared to NC alone. Informal sensory evaluation results showed all treatments to be acceptable across all storage periods except for NC alone where oxidized notes were detected after 7 d in HiOx-MAP and 31 d in vacuum packaged conditions.

Conclusion: This research shows the antioxidative efficacy of rosemary and green tea extracts in dry-fermented sausages by maintaining their color life and inhibiting oxidation during storage equal to BHA/BHT. 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: Clean label, Green tea, Pepperoni, Rosemary
Undergraduate Research Competition

151: CORRELATIONS BETWEEN MEASURES OF TENDERNESS IN BEEF STRIP STEAKS

M. J. Kapraun 1,*, B. N. Harsh 1, J. C. McCann 1, A. C. Dilger 1, D. D. Boler 1
1University of Illinois, Urbana, United States

Objectives: The tenderness of meat is instrumentally determined via Warner-Bratzler shear force (WBSF) and slice shear force (SSF) tests. These instrumental tenderness tools are frequently used as a means to predict sensory tenderness. Therefore, the objective was to determine the strength of relationships between WBSF, SSF and sensory evaluation.

Materials and Methods: Dietary treatments and different endpoint cooking temperatures were used a means of increasing variation in tenderness. Strip steaks were collected from 12 Angus × Simmental cross steers where half received a control diet (CON) and half were fed a diet including 400 mg·animal⁻¹·d⁻¹ RAC ractopamine hydrochloride (RAC, Actogain) for 35 d prior to slaughter. Carcasses were aged 14 d prior to removal of strip steaks posterior to the 12th–13th rib interface. Two 2.5-cm thick steaks per degree of doneness (DoD) treatment (63°C, medium-rare & 71°C, medium) were cut and assigned to SSF, WBSF, and trained sensory panel analyses. Steaks were weighed and cooked to an internal temperature of 63°C or 71°C. After cooking, steaks were allowed to equilibrate to 22°C before shear force tests were performed. Cook loss was calculated as [(weight of raw steak, g - weight of cooked steak, g) / weight of raw steak, g]×100. Trained panelists were asked to evaluate tenderness and juiciness of steak samples using a 15-cm anchored scale (0 = not tender or juicy and 15 = extremely tender or juicy). Data were analyzed as a 2 × 2 factorial, in split-plot design, using the MIXED procedure of SAS with diet as the whole-plot factor and DoD as the split-plot factor. Pearson correlation coefficients between SSF, WBSF, and sensory attributes were computed using the CORR procedure. Treatment differences were considered significant and correlations were considered different from 0 at P ≤ 0.05.

Results: The association between sensory tenderness and instrumental tenderness was substantiated by the correlation between panel tenderness and SSF (r = -0.66) and WBSF (r = -0.46). Sensory juiciness was also related to SSF (r = -0.42), however sensory juiciness was not related to WBSF (P ≥ 0.31). Despite differences between the correlations of SSF and WBSF with sensory analyses, the two instrumental tenderness measures were correlated (r = 0.47). Cook loss and panel juiciness were also correlated (r = -0.46). Steaks from RAC fed steers had greater SSF values (P = 0.05, 22.42 vs 18.28 kg) than from CON fed steers, however RAC had no effect on WBSF (P = 0.97, 2.97 vs 2.96 kg). Similar to WBSF, RAC usage had no effect (P = 0.13) on panel tenderness ratings. Steaks cooked to 63°C were more juicy (P ≤ 0.01, 7.24 vs 8.38) than those cooked to 71°C. Similar to panel ratings for juiciness, steaks cooked to 63°C had less cook loss (P ≤ 0.01, 18.64 vs 23.66) than steaks cooked to 71°C. However, DoD had no effect (P = 0.15) on panel tenderness ratings.

Conclusion: In a group of cattle that would generally be considered tender, decreasing cooking DoD did not further improve sensory tenderness. However, cooking steaks to a lower DoD did improve in sensory juiciness. In this study, SSF values were more closely related to panel tenderness and juiciness ratings than WBSF. Therefore, given the throughput advantages of SSF over WBSF, SSF is the favorable choice for instrumental tenderness evaluation under these experimental conditions.

Keywords: beef, correlation, Degree of Doneness, Ractopamine, sensory
Undergraduate Research Competition

152: EFFECTS OF VARIOUS LEVELS OF PROTEIN, LYSINE, FAT, AND FIBER ON SWINE GROWTH AND PORK QUALITY

H. Price¹, S. Williamson¹, J. Henson¹, A. G. McKeith¹
¹Animal Sciences and Agricultural Education, California State University, Fresno, Fresno, United States

Objectives: Efficient and profitable swine production depends upon an understanding of the concepts of genetics, environment, herd health, management, and nutrition (DeRouchey et al., 2007). Feed represents about 60 to 75 percent of the total cost of pork production; therefore, a thorough knowledge of the principles of swine nutrition is essential in order to maintain a profitable swine enterprise. Davey (1976) found that improvements in carcass composition are associated with the feeding of higher protein levels. Diets with higher protein content were associated with lower intramuscular fat content and less-tender (higher shear force value) meat. Therefore, the objective of this study was to determine how varying levels of protein, lysine, fat, and fiber in swine diets affected swine growth and pork quality.

Materials and Methods: The study was performed at the Fresno State Swine Unit where data was collected on a total of 12 crossbred barrows, 2 barrows per treatment per replication (3 replications), with littermates in each treatment in a replication. The barrows started at approximately 4 months of age (approximately 63.5 kg) and were fed specific diets for 56 d. Two different diets were used: a commercial hog feed (protein- min 14%, lysine- min 0.69%, fat- min 6.8%, fiber- max 8.7%) and a show hog feed (protein- min 22%, lysine- min 1.55%, fat- min 1.80%, fiber- max 2.6%). Weights were collected each week and average daily gain was calculated each week as well as overall. Carcass data was collected including hot carcass weight, NPPC color, NPPC firmness, NPPC marbling, loin eye area, tenth and last rib fat thickness. Dressing percentage and percent fat free lean were calculated and instrumental color (L*, a*, b*) on the loin eye was measured. Data were analyzed using the Proc ANONA procedure of SAS with statistical differences being set at p < 0.05.

Results: The results of this study determined there were minimal differences between the two diets when it came to weekly weights and pork quality. However, the show diet had a higher ADG for week one (1.21 kg vs 0.76 kg; p = 0.01). This is most likely due to compensatory gain from switching types of hog feed. Barrows fed the show feed had a higher dressing percentage (74.7% vs 71%; p = 0.0027) and more fat at the last rib (2.79 cm vs 2.03 cm; p = 0.03). Additionally, the show feed resulted in higher L* values (56.89 vs 53.89; p = 0.004) in the loin eye, yet no visual color differences were observed with NPPC Color. There was a trend for the barrows fed the show feed to have larger muscle scores (2.5 vs 2; p = 0.09 and larger loin eye areas (20.07 cm² vs 17.78 cm²; p = 0.07). All other measurements and calculations were not statistically different (p > 0.1). Show fed barrows resulted in observationally firmer fat than commercial fed barrows.

Conclusion: Results of this study indicate that diets higher in protein and lysine and in lower fat and fiber leads to a higher dressing percentage and that were lighter in color objectively. Therefore, carcasses should have more total pounds of product on them.

Keywords: fat, growth , lysine, pork quality, protein
Undergraduate Research Competition

153: A NEW PARADIGM FOR DRY-AGING: EFFECTS OF FAT DRY-AGING ON PHYSICOCHEMICAL AND TEXTURAL CHARACTERISTICS OF GROUND BEEF PATTIES

N. Bland¹, H. W. Kim¹, O. Ogbeifun¹, Y. H. B. Kim¹
¹Meat Science and Muscle Biology Lab, Department of Animal Sciences, Purdue University, West Lafayette, United States

Objectives: Dry-aging has been known to improve eating quality attributes of beef products (in particular unique flavor and/or juiciness). While fat plays an important role in flavor development of aged beef products, the current aging practice (including dry-aging) predominantly deals with whole muscle aging rather than separated fat aging. We hypothesized that dry-aging of beef fat would result in positive impacts on quality characteristics of ground beef patty. If successful, this would be a novel approach of value-adding process of beef fat as a naturally-enhanced flavor ingredient for manufacturing dry-aged ground beef. The objective of this present study was to determine the physicochemical and textural properties of ground beef patties formulated with wet-/dry-aged fat.

Materials and Methods: Beef round muscle (M. semimembranosus and semitendinosus) and backfat were collected from beef carcases at 7 days postmortem. Trimmed beef backfat was randomly assigned into five treatment groups as follows; unaged-fat (control), wet-aged fat for 2 weeks (2WA) or 4 weeks (4WA) and dry-aged fat for 2 weeks (2DA) or 4 weeks (4DA). Wet-aging of beef fat was performed in a vacuum bag in a chilling room (at 1 ºC; 80% relative humidity), whereas dry-aging was conducted without any packaging material in the same chilling condition. Beef patties were formulated with 80% round lean and 20% each assigned fat. Proximate composition, display weight loss, cooking loss and texture profile analysis were determined at each manufacturing day. Display color stability by measuring instrumental color and visual discoloration, pH and lipid oxidation (2-thiobarbituric acid reactive substances, TBARS) were performed at the initial and after 5 days of retail display. The experimental design was a completely randomized block design with three independent batches, and the PROC Mixed procedure of SAS was used for data analysis (P<0.05) by using least significant differences.

Results: The addition of aged-fat slightly decrease pH value of beef patties (P<0.05). Similar proximate composition (moisture, protein, lipid and ash) and cooking yield of beef patties were found between the treatments (P>0.05). The addition of aged-fat for 4 weeks (4DA or 4WA) resulted in significantly higher hardness, gumminess, and chewiness of beef patties than control. While CIE a* (redness) of beef patties with aged fat was decreased during display storage, beef patties with 4WA showed the most rapid decrease in redness during display (P<0.05). Similarly, beef patties made with wet-aged fat (2WA and 4WA) showed the most rapid discoloration, whereas beef patties with dry-aged fat maintained little to no discoloration. Furthermore, the highest TBARS value was observed at beef patties with 4WA between the treatments at the end of display (P<0.05).

Conclusion: These results indicate that the addition of dry-aged fat positively impact on color and lipid oxidative stability of beef patties, while resulting in little impact on chemical composition of beef patties. The addition of aged fat for 4 weeks increased hardness, gumminess and chewiness of beef patties, regardless of aging method. The follow up analyses including sensory attributes and flavor related chemical compounds would be highly warranted to determine the efficacy of fat dry-aging in meat flavor development.

Keywords: beef patty, Fat dry-aging, quality attributes
Undergraduate Research Competition

154: RATE AND EXTENT OF TROTONIN-T DEGRADATION IN LOINS FROM PIGS SELECTED FOR LOW AND HIGH RESIDUAL FEED INTAKE

E. Zuber 1,*, A. C. Outhouse 1, J. C. M. Dekkers 2, N. K. Gabler 2, E. Huff-Lonergan 2, S. M. Lonergan 2

1Animal Science, 2Iowa State University, Ames, United States

Objectives: It is well known that proteolysis of myofibrillar proteins such as troponin-T is linked to myofibrillar fragmentation and improvement of tenderness of fresh meat products. The objective of this research was to quantify the rate and extent of troponin-T degradation in chops, aged 1, 7, or 14 days, from the longissimus muscle (LM) of pigs selected for low residual feed intake (LRFI; more feed efficient) and high residual feed intake (HRFI; less feed efficient). Residual feed intake is defined as the difference between expected and observed feed intake based on ADG and backfat.

Materials and Methods: Lines of LRFI (n = 6) and HRFI (n = 6) pigs, from generation 11 of the Iowa State University RFI project, were used for this study. Pigs were fed a commercial corn and soybean diet and were harvested at approximately 125 kg using standard industry procedures. Loins were removed and chops (2.54 cm) were cut from the LM 1 day postmortem, vacuum packaged, and aged 14 days. At the completion of aging, fresh (never frozen) chops were used to determine subjective color and marbling, Hunter L, a, b, and pH. Chops were cooked to 68°C for cook loss and star probe (kg) evaluation. Chops, from the LM (1.27 cm), for biochemical analysis were vacuum packaged and aged 1, 7, or 14 days. Samples were frozen in liquid nitrogen and homogenized at the end of the assigned aging period. Proteins were solubilized using whole muscle extraction buffer (10 mM sodium phosphate, pH 7.0, and 2 % wt/vol sodium dodecyl sulfate). Densitometry analysis of immunoblots was used to quantify troponin-T degradation products (28-30 kDa) that were resolved in the extracts from the aged samples. Degradation product abundance was normalized to the abundance of a reference sample on each gel and data were analyzed with fixed effects of line and days of aging and random effect of gel.

Results: Hunter a and b values, pH, subjective color scores, and subjective marbling scores were not different between lines (P > 0.05). There was a tendency for chops from LRFI pigs to have less cook loss (19.2 %) than those from HRFI pigs (22.3 %; P = 0.07). Chops from LRFI animals exhibited lower Hunter L values (LRFI, 46.5; HRFI, 50.9; P < 0.01) and lower star probe values (LRFI, 5.70 kg; HRFI, 6.15 kg; P < 0.05). An explanation for lower star probe values in the chops from LRFI animals may be due to greater postmortem proteolysis of myofibrillar protein. Densitometry measurements showed significant effects of line, days aged, and a days aged x line interaction (P < 0.01). Troponin-T abundance was not different between lines in day 1 postmortem chops (P > 0.05). The degradation product was more abundant in chops from LRFI animals at days 7 (0.64) and 14 (0.92) postmortem when compared to HRFI counterparts at days 7 (0.41) and 14 (0.80; P < 0.01).

Conclusion: Selection for improved efficiency was not detrimental to fresh pork quality. The results suggest that the explanation for improved quality in the loin chops from LRFI pigs is a greater rate and extent of troponin-T degradation during postmortem storage.

Keywords: pork, proteolysis, residual feed intake, troponin-T
Undergraduate Research Competition

155: RELATIONSHIP OF MYOFIBRILLAR FRAGMENTATION INDEX TO WARNER-BRATZLER SHEAR FORCE AND PALATABILITY TENDERNESS OF LONGISSIMUS LUMBORUM AND SEMITENDINOSUS STEAKS

L. L. Prill¹, T. G. O’Quinn¹, K. J. Phelps¹, J. M. Gonzalez¹, T. A. Houser¹, E. A. E. Boyle¹
¹Animal Science, Kansas State University, Manhattan, United States

Objectives: The objective of this study was to determine the relationship between the myofibrillar fragmentation index (MFI) and the Warner-Bratzler shear force (WBSF) and sensory traits of longissimus lumborum (LL) and the semitendinosus (ST) steaks.

Materials and Methods: Forty beef strip loins (IMPS #180) and 40 eye of rounds (IMPS #171C) were collected from a Midwest beef processor and transported to the Kansas State University Meats Laboratory. Sub-primals were divided into anatomical location (anterior, medial, and posterior for strip loins; proximal and distal for eye of rounds) and cut into three 2.54 cm thick steaks and aged 14 d. Within location, steaks were randomly assigned to WBSF, trained sensory panel evaluation, or MFI analysis. Steaks utilized for WBSF and trained sensory panel were cooked to an internal temperature of 71°C on electric clamshell grills. Steaks used for WBSF were chilled overnight at 4°C, and six 1.27-cm cores were removed parallel to the orientation of the muscle fiber and sheared once through the center using an Instron testing machine with a Warner-Bratzler shear head. Sensory panel steaks were cut into 1 cm × 1 cm × 2.54 cm samples and immediately served to sensory panelists trained per AMSA guidelines for Sensory Evaluation (2016). Myofibrillar fragmentation index was determined using the procedures described by Culler et al. (1978). Data were analyzed as a completely randomized design with muscle as the fixed effect. Sub-primal location data were analyzed muscle independent and as a completely randomized design with location as the fixed effect.

Results: When comparing muscles, there were muscle differences for all variables measured (P < 0.05). Steaks from LL had smaller WBSF, sensory panel connective tissue ratings, and MFI values than ST steaks (P < 0.05). Additionally, LL steaks had greater myofibrillar and overall tenderness sensory panel ratings (P < 0.05). There were location effects for sensory and WBSF of both muscles (P < 0.05). Warner-Bratzler shear force values of all three locations within the LL were different from one another (P < 0.05). Panelists rated anterior steaks greater for myofibrillar and overall tenderness than middle and posterior steaks (P < 0.05), which were not different (P > 0.05) from each other. Panelist detected less connective tissue in anterior steaks when compared to middle and posterior steaks (P < 0.05), which were not different (P > 0.05) from each other. In the ST, proximal steaks had greater WBSF values and sensory connective tissue amounts than distal steaks (P < 0.05). Proximal steaks had less myofibrillar and overall tenderness than distal steaks (P < 0.05). Within each sub-primal, anatomical location had no effect on MFI value (P > 0.05). Myofibrillar fragmentation index was correlated (P < 0.05) to myofibrillar tenderness (r = -0.18), connective tissue (r = 0.11), and overall tenderness (r = -0.15); however, MFI was not correlated (P = 0.056) to WBSF.

Conclusion: As expected, the LL was rated more tender than the ST by sensory panelists and had smaller WBSF values. The ST had a higher MFI versus the LL. In both muscles, MFI was not dependent upon anatomical location. Moreover, the correlation between MFI, WBSF, and sensory measures of tenderness were weak, indicating MFI was not a reliable indicator of beef tenderness for the muscles evaluated.

Keywords: beef, myofibrillar fragmentation index, sensory, tenderness, Warner-Bratzler shear force
Objectives: Color is the most important factor that a consumer uses to perceive meat quality and freshness. Meat color is primarily imparted by myoglobin. When meat discolors, myoglobin oxidizes from a bright cherry red oxymyoglobin form to a dark-brown metmyoglobin form. However, meat has the ability to limit discoloration and reduce the ferric brown metmyoglobin to ferrous deoxymyoglobin. The ability of meat to undergo reduction has been considered as the most important indication of color stability. Previous research showed that as meat ages, color stability decreases throughout display; however, the role of metmyoglobin reducing activity on beef color stability is unclear. Therefore, the objective of this study was to determine the effect of aging on metmyoglobin reducing activity.

Materials and Methods: USDA choice strip loins (n=8) were sliced into 5 equal sections, vacuum packaged, and designated to 1 of 5 aging period treatments (0, 7, 14, 21, or 28 d). At each respective aging period, 2.54 cm steaks were sliced from each section. The first steak was packaged into PVC overwrap and stored in a simulated retail display for 6 d. The second steak was used to characterize day 0 metmyoglobin reducing activity (MRA) and NADH-dependent reductase activity. The surface color was measured every 24 h using a HunterLab colorimeter. Following surface color measurements, MRA was measured on 6 d of display. Data was analyzed using the Mixed Procedure of SAS and the results were considered significant at P < 0.05.

Results: Aging time decreased color stability of steaks during display. By the end of 6 d display, the redness reduced by 58% for 28 d aged steaks, compared to 0 d aged. On d 0 at each aging period, MRA showed no difference between aging periods (P > 0.05). However, on d 6 of display MRA decreased (P < 0.05) with an increase in the aging period. Interestingly there were no differences (P > 0.05) in NADH-dependent reductase activity on day 0 of each aging period.

Conclusion: In conclusion, as aging period increases, beef color stability decreases. There were no differences in MRA and NADH-dependent reductase activity before display at each aging period. However, combined effect of aging time and display time decreased MRA and color stability. The results suggest that oxidative stress during display time may deplete reducing equivalents for MRA faster than the aging time.

Keywords: Aging, Meat color, Metmyoglobin, Reductase
Undergraduate Research Competition

157: EFFECTS OF EXTENDED RETAIL DISPLAY ON METMYOglobIN REDUCING ACTIVITY IN GROUND BEEF MODEL

A. E. Schnedler 1,*, A. T. Sukumaran 1, A. J. Holtcamp 1, T. T. N. Dinh 1
1Animal and Dairy Sciences, Mississippi State University, Mississippi State, United States

Objectives: The objective of this study was to evaluate the effects of extended retail display on metmyoglobin reducing activity in ground beef model.

Materials and Methods: Two retail display trials were conducted using two ground beef batches with 91 and 93% lean. Thirty-six 454-g ground beef loaves per trial were produced, placed on black Styrofoam™ trays, overwrapped with PVC film (O2 permeability of 1.21 mL/cm²/d and water vapor permeability of 0.022 g/cm²/d; LINPAC Packaging-Filmco Inc., Aurora, OH), and displayed at 2°C under fluorescent light (900 lux) for up to 0, 4, 8, 12, 24, 36, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288, and 312 h (n = 4 per time point). Two randomly selected loaves per time point per trial were withdrawn for further analysis. The pH value was determined by placing 1 g of meat in 10 mL of D-water (Accumet AE150 pH Benchtop Meter; Fisher Scientific, Waltham, MA). Aerobic Plate Count (APC, log CFU/g) was determined using 3M™ APC Petrifilm™ (3M™ Corporation, St. Paul, MN). Lean redness and reflectance spectra (400 to 700 nm) were recorded with illuminant A at 10° angle (MiniScan EZ 4500L, Hunter Associates Laboratory, Inc., Reston, VA). Metmyoglobin reducing activity (MRA) was measured by reacting extracted reductases with horse skeletal metmyoglobin and measuring absorbance by deoxymyoglobin at 580 nm (Spectramax Plus 384; Molecular Devices, Sunnyvale, CA). Statistical analysis was performed by using the GLIMMIX procedure of SAS (SAS Institute Inc., Cary, NC) at 0.05 level of significance.

Results: The APC was increased by 0.7 log CFU/g from 0 to 168 h (P = 0.022), which coincided with an increase in pH from 5.61 to 5.88 (P < 0.001). As expected, redness was decreased from 30.83 (0 h) to 13.48 (96 h; P < 0.001), which coincided with 10.56% decrease in surface oxymyoglobin (P = 0.001). However, lean redness and surface oxymyoglobin was increased after 120 h up to 216 h (P < 0.001). Although MRA remained constant from 0 to 120 h of retail display (7.03 to 8.58 µM/min/g; P ≥ 0.220), it was increased up to 16.01 µM/min/g by 288 h (P ≤ 0.004), following a quadratic relationship that could be fit as MRA = 7.68 + 0.0001 × time² (R² = 0.67; P < 0.001).

Conclusion: These findings were in contrast with the conventional wisdom that beef color continues to deteriorate as retail display progresses. The current study indicated that microorganisms in meat might contribute to the increase in metmyoglobin reducing activity, which may be used as novel technology to maintain meat color stability.

Keywords: ground beef, meat color, metmyoglobin reducing activity, retail display
Undergraduate Research Competition

158: EVALUATION OF ALTERNATIVE FABRICATION SPECIFICATIONS TO INCREASE GROSS VALUE OF PORK CARCASSES

E. E. Bryan1,*, M. F. Overholt1, G. D. Kim1,2, A. C. Dilger1, D. D. Boler1
1Department of Animal Science, University of Illinois, Urbana, United States, 2Institute of Agriculture & Life Science, Gyeongsang National University, Jinju, Korea, Republic Of

Objectives: Modifying fabrication specifications in domestic processing facilities to reflect specifications in key export markets may increase demand for U.S. pork abroad. Changes in specifications may also yield value-added cuts to increase total domestic value. The objective was to evaluate differences in economic value of carcasses fabricated using either U.S cutting specifications, or specifications derived from those used in South Korea.

Materials and Methods: Paired sides (30 sides total; n=15) were weighed and fabricated into primals and subprimals according North American Meat Processors (NAMP) or Korean-style specifications. Korean carcasses were separated into shoulder (4th/5th rib separation), loin, belly, and ham (sirloin-on) primals. For Korean carcasses, the butt-tender was partially removed, and the ham was separated from the loin with a saw-cut through the last lumbar vertebrae, perpendicular to the long axis of the spine. The loin, belly, and ham of Korean carcasses were further fabricated into subprimals corresponding with NAMP specifications. Korean shoulders were fabricated into a cellar-trimmed (CT) butt, cushion, boneless picnic, and into a pork brisket (Kalbi). Individual primals and subprimals were weighed in order to calculate cutting yield. Fabricated carcass value was calculated using the AMS Carlot Report values from the week of 19 to 25 March, 2017. Value for the pork brisket was estimated based on relative value of the beef brisket compared to the beef shoulder clod primal resulting in a value of $112.83/cwt. Comparisons between yields and value of analogous primals and subprimals from each side and total carcass value were conducted using a Paired T-test. Means were considered different at P ≤ 0.05.

Results: Whole Bone-in (BI) loin yields of Korean carcasses were 6.23 units less (P < 0.0001) than NAMP carcasses, with 5.20, 1.62, 0.50, and 0.35 unit reductions (P < 0.01) in 1/4 trim BI loin, boneless (BNLS) strap-on, BNLS strap-off, and backrib yields, respectively. However, tenderloin and sirloin yields of Korean carcasses were increased (P < 0.01) by 0.14 and 0.82 units compared to NAMP carcasses. Similarly, yields of whole belly (spareribs-in), natural fall belly (rind-on), skinned natural fall, and trimmed and squared bellies of Korean carcasses were reduced compared with NAMP carcasses by 1.43, 1.10, and 0.83 units, respectively,. There was no effect (P > 0.08) of fabrication specifications on ham subprimals with the exception of inside hams where NAMP carcasses had 0.14 units greater (P = 0.04) yield than Korean carcasses. The pork brisket cut fabricated from the shoulder of Korean carcasses represented 3.97% of carcass weight and the CT butt represented 4.82% of carcass weight. Despite reductions in the yield of loin and belly subprimals, Korean carcasses had 2.7% more added value based on subprimal values reported in the Carlot Report.

Conclusion: Using Korean-style specifications reduced the yield, and therefore the value of the loin and belly, with minimal effect on the ham. However, added value from the pork brisket and CT butt adds sufficient value to the shoulder to offset lost value from the loin and belly. These data suggest that using fabrication methods based on Korean cutting specifications increases carcass value for export markets and may yield novel cuts like the pork brisket from the shoulder to increase the value of domestic pork sales.

Keywords: Cutability, Fabrication, Korean, pork
Objectives: Oxidation is a major contributor to degradation of color and flavor in ground beef. Mushrooms have been shown to inhibit lipid oxidation when added to meat products. One of the major components in mushrooms that acts as an antioxidant is Ergothioneine, a compound that works as a free radical scavenger. The objective of this study was to evaluate the impact of mushroom addition to ground beef patties on lipid and protein oxidation, cohesiveness, and color.

Materials and Methods: In addition to a control containing no mushrooms, four treatments were used; chopped, whole mushroom; dried mushroom powder; aqueous extract; and residue remaining after extraction. Half of the patties for each treatment were packaged in aerobic over-wrap packaging while the remaining patties were packaged using modified atmosphere packaging (MAP) containing 70% nitrogen, 30% CO2, and 0.4% carbon monoxide. Patties were stored in a cooler at approximately 36°F for 4 days, cooked, and tested by Thiobarbituric acid (TBA) assay for lipid oxidation, Dinitrophenyl hydrazine (DNPH) assay for protein oxidation, and resistance to tear (RTT) for cohesiveness. Patty color was measured daily during storage by Hunter L*a*b* using a colorimeter (Minolta CR-300 series). All statistical analyses were performed using Statistical Analysis Software (SAS).

Results: Lipid oxidation levels were significantly (p<0.05) lower for the aerobic and MAP whole, powder, and extract samples compared to the aerobic control. Patties with mushroom residue in both packaging treatments had significantly higher levels of lipid oxidation than other mushroom treatments and the control. After 4 days, MAP patties exhibited significantly lower a*(redness) values than those packaged aerobically with the exception of the aerobically packaged mushroom powder treatment, which also had significantly lower redness compared to the aerobic treatments. Although the results were not significant, a trend can be seen among the data showing that patties treated with whole mushroom or residue tend to have lower redness values. Free carbonyls and cohesiveness did not differ among mushroom or packaging treatments. There were no observed differences (p=0.4581) in protein oxidation among treatments, indicating mushrooms may preferentially inhibit pathways for lipid oxidation rather than protein oxidation. There were also no observed differences among treatments for patty cohesiveness (p=0.875).

Conclusion: In conclusion, adding whole, powdered or extracted mushroom inhibits lipid oxidation in ground beef patties, but does not significantly affect protein oxidation or cohesiveness. Although powdered mushroom effectively inhibits lipid oxidation, it triggers pigment oxidation causing patties to become an undesirable brown color rather. Among the treatments used, the most suitable for commercial production would be the mushroom extract because it significantly lowered lipid oxidation while allowing the patties to retain a bright cherry red color. In the future, sensory testing is needed to determine if consumer perception matches the laboratory results.

Keywords: color, ground beef patties, Lipid oxidation, mushroom, protein oxidation
**Undergraduate Research Competition**

**160: EFFECTS OF NITRITE SOURCE, REDUCING AGENTS, AND HOLDING TIME ON COLOR DEVELOPMENT IN A CURED MEAT MODEL SYSTEM**

J. A. Posthuma, F. D. Rasmussen, G. A. Sullivan

1Department of Animal Science, University of Nebraska-Lincoln, Lincoln, United States

**Objectives:** The objective of this study was to determine the effects of nitrite source, the addition of reducing agents, and holding times prior to cooking on color development in a cured meat model system.

**Materials and Methods:** Emulsified beef sausages were manufactured using four different combinations of nitrite sources and reducing agents: 1) sodium nitrite (SN; 156 ppm), 2) SN (156 ppm) and sodium erythorbate (SE; 495 ppm), 3) pre-converted celery juice powder (CJP; VegStable 504, Florida Food Products, Inc., Eustis, FL; providing 100 ppm of sodium nitrite), 4) CJP (providing 100 ppm of nitrite) and cherry powder (CP; VegStable 515, Florida Food Products, Inc., Eustis, FL; providing 440 ppm ascorbic acid). Beef, ice (20%), salt (2 %) and the appropriate amount of sodium nitrite and reducing agents were chopped for 1 minute in a food processor at 2000 rpm (Blixer 6V, Robot Coupe, Robot Coupe, Ridgeland, MS). For each treatment, the meat batter was placed in 5, 100 ml beakers, and held at 21° C for 5, 15, 30, 60, and 120 min prior to cooking. The emulsions were cooked in a water bath for 30 min at 40º C and 30 min at 80° C and then cooled for 30 min in an ice bath. Samples were then evaluated for objective color (Minolta CR400; L*, a*, b*), residual nitrite, total meat pigment, and cured meat pigment. Three independent replications were produced. Data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Cary, NC) using a 2 x 2 x 5 factorial arrangements with main effects of nitrite source, with or without reducing agents and holding time and their interactions. Means were separated using Tukey’s adjustment (P ≤ 0.05).

**Results:** A significant nitrite source by reducing agent interaction was identified for cured meat pigment and residual nitrite (P ≤ 0.006). The SN+SE samples had the greatest amount of cured meat pigment (130.9 ppm) followed by CJP+CH (127.8 ppm), SN (74.7 ppm), and CJP (51.9 ppm) where each treatment was different than all other treatments. Residual nitrite was greatest in SN (79.7 ppm), SN+SE (62.6 ppm) and CJP (59.3 ppm) were intermediate and similar, and CJP+CH (31.64 ppm) had the least. Treatments with reducing compounds (SE or CP) were more red (P < 0.001; a* 15.8) and less yellow (P = 0.016; b* 8.8) than those without reducing compounds (a*10.7; b* 9.2). Similarly, samples cured with SN were more red (P < 0.001; a* 13.9) and less yellow (P = 0.009; b* 8.8) than those cured with CJP (a* 12.6; b* 9.2) but the differences were not as great the effect of reducing agents. Total meat pigment (P > 0.06) and L* (P > 0.32) were not affected by nitrite source or reducing agents. Holding time was not included in any significant interactions (P > .349). The only significant main effect of holding time was for a* (P = 0.011) where sausages held for 120 min was more red than those held for 5, 15, and 30 min.

**Conclusion:** The addition of reducing agents (SE or CP) had the largest impact on cured meat color development and reduced the residual nitrite in a cured meat model system. Treatments with SN had slightly greater cured color development than CPJ treatments. Holding times prior to cooking had limited impact on cured meat color development.

**Keywords:** Alternative curing, Cured color development, Holding times, Reducing agents, Sodium nitrite
161: EFFECT OF PROBIOTIC FEEDING ON OXIDATIVE STABILITY AND MEAT QUALITY ATTRIBUTES OF BREAST MUSCLE FROM CHICKENS EXPOSED TO CHRONIC HEAT STRESS

Y. Chao 1,*, H.-W. Kim 1, T. Cramer 1, H.-W. Cheng 2, Y. H. B. Kim 1

1Meat Science and Muscle Biology Lab, Department of Animal Sciences, Purdue University, 2Livestock Behavior Research Unit, USDA-ARS, West Lafayette, United States

Objectives: Heat stress (HS) has long been known to reduce the productivity of broiler chicken, decreasing breast muscle size and protein content, as well as damage to various tissues including skeletal muscle. Recently, feeding a dietary probiotic supplement to broilers has been suggested to alleviate these negative impacts by improving their gut health and nutrient absorption. However, little research has been performed to determine the effect of probiotic feeding on meat quality of broilers exposed HS, especially concerning oxidative stability and meat quality attributes. Furthermore, heat shock proteins (HSPs), which are chaperon proteins produced in response to heat stress, could be potentially related to oxidation stability in skeletal muscle by interfering with apoptosis mechanism. Therefore, the objective of this study was to determine the impact of probiotic feeding on oxidative stability, HSP expression, and meat quality characteristics of breast muscle from heat-stressed chickens.

Materials and Methods: Two hundred forty male Ross 708 broilers were assigned to 48 pens in temperature-controlled rooms. Using a 2 x 2 factorial design, HS broilers were kept at either 32ºC or the thermoneutral room at 21ºC. Control fed broilers were fed a regular diet, while probiotics fed received Sporulin (250 ppm; containing three strains of B. subtilis). Forty-eight chickens (12 birds/treatment) were harvested at day 46. At 1 day postmortem, paired breast muscles (M. pectoralis) were collected for the meat quality analyses such as, drip loss, cook loss, Warner-Bratzler shear force, and display color. 2-thiobarbituric acid reactive substances (TBARS), phospholipid, and 2,2-diphenylpicrylhydrazyl (DPPH) were measured. Western blots for HSP70 and HSP27 were performed. Data were analyzed using the PROC MIXED procedure of SAS, and means were separated using least significant differences (P < 0.05).

Results: Probiotic feeding significantly decreased TBARS and phospholipid contents in HS chicken breast (P < 0.05). HS increased the DPPH radical scavenging activity in chicken breast (P < 0.0001). However, probiotic feeding had no impacts on the DPPH radical scavenging activity in HS chicken breast (P > 0.05). HS increased HSP70 in chicken breast (P=0.08), whereas probiotic feeding had no significant impact on HSP70. Based on the qualitative Western blot analysis of HSP27, HS increased HSP27 in the breast muscle compared to its counterpart. Neither HS nor probiotics had impacts on water-holding capacity, shear force, and color stability (P > 0.05).

Conclusion: The results of this study indicate that probiotic feeding could alleviate oxidative deterioration of breast muscle from broilers undergoing HS, possibly through the decrease in phospholipid and increase in antioxidant capacity of the muscle. Further studies elucidating the underlying mechanisms behind antioxidant property associated with probiotics supplementation and possible involvement of HSP activity would be highly warranted.

Keywords: broilers, heat stress, probiotics
Objectives: During the postmortem period, muscle cells are unable to maintain reducing conditions and this leads to oxidation of proteins that could affect function, solubility, and susceptibility to degradation. Compared to Bos taurus steers, Bos indicus influenced cattle exhibit differences in beef tenderness as well as muscle metabolic characteristics. Therefore, the objective of this study was to determine sarcoplasmic and myofibrillar protein solubility in beef during the aging period.

Materials and Methods: Bos taurus (Angus), Bos indicus (Brahman) and Brangus steers were harvested according to standard industry procedures (n=2 per breed group for 3 harvest days). Longissimus lumborum was collected at 24h and 14d. Sarcoplasmic protein solubility was determined by homogenizing triplicate 0.1 g muscle samples with 0.025 M potassium phosphate (pH 7.2) buffer. The homogenate was incubated overnight at 4 °C and then centrifuged at 1500 x g for 30 min. The supernatant was collected and protein concentrations were measured using the BCA protein assay. Total protein solubility was determined by homogenizing triplicate 0.1 g muscles samples with buffer containing 8M urea, 2M thiourea, and 3% SDS. The homogenate was incubated at 4 °C for 30 min and then centrifuged at 1500 x g for 30 min. The supernatant was collected and protein concentrations were measured using the Pierce 660 nm protein assay. Myofibrillar protein was calculated from the difference between total and sarcoplasmic protein solubility. Values are expressed as mg protein/g tissue. Data were analyzed using SAS JMP and the model included fixed effects of breed, time, breed × time, and harvest day.

Results: Sarcoplasmic protein solubility decreased from 24 h to 14 d (time, P < 0.05). Curiously, the decrease in sarcoplasmic protein solubility over time tended to be dependent on breed (breed × time, P <0.1); sarcoplasmic protein solubility decreased less in Brahman compared to Angus and Brangus. Breed did not influence myofibrillar protein solubility.

Conclusion: Breed-related changes in sarcoplasmic protein solubility suggest the cellular environment during the aging period may differ in longissimus muscle of Bos indicus compared to Bos taurus steers. Further work is needed to determine if protein oxidation or other cellular factors contribute to these protein solubility changes during aging.

Keywords: Bos indicus, Bos taurus, Protein Solubility