**Objective:** 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

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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
Meat and Poultry Quality

52: IMPACT OF LIGHTING TECHNOLOGIES ON BEEF STEAKS FROM THE SEMIMEMBRANOSUS; A COLOR STABLE MUSCLE

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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 (MMb) content increased over retail display with LED treated steaks having greater (P < 0.05) amounts of MMb than steaks treated with HFLO and FLO light sources. By day 7 of retail display, HFLO treated steaks had less (P < 0.05) MMb 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
Objective: 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
Meat and Poultry Quality

54: MUSCLE-SPECIFIC COLOR STABILITY IN SPRINGBOK MEAT

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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


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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 differed from SUPP 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
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
Objectives: Bison meat color is dark, consistently unstable and discolors 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**

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

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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 2ºC 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 2ºC. 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 73.9ºC, vacuum-packaged, and stored for 30, 60, 90, and 120 d at 4ºC. 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 -80ºC 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 10º 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
Meat and Poultry Quality

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

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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±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 TC700MC). 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
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/cm² 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.
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

Table 1. Least square means (standard error) for traits of control and RCI treated beef samples during storage time.

<table>
<thead>
<tr>
<th>Traits¹</th>
<th>Treatment²</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>TBARS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>53.17&lt;sup&gt;y&lt;/sup&gt; (2.81)</td>
<td>24.95&lt;sup&gt;x&lt;/sup&gt;(1.36)</td>
<td>20.19&lt;sup&gt;x&lt;/sup&gt;(0.35)</td>
<td>0.19(0.06)</td>
</tr>
<tr>
<td></td>
<td>RCI</td>
<td>55.19&lt;sup&gt;x&lt;/sup&gt;(2.81)</td>
<td>24.67(1.36)</td>
<td>21.09&lt;sup&gt;x&lt;/sup&gt;(0.35)</td>
<td>0.19(0.06)</td>
</tr>
<tr>
<td>Storage Time</td>
<td>0h</td>
<td>51.15&lt;sup&gt;c&lt;/sup&gt;(2.84)</td>
<td>24.54&lt;sup&gt;b&lt;/sup&gt;(1.46)</td>
<td>18.40&lt;sup&gt;c&lt;/sup&gt;(0.50)</td>
<td>0.12&lt;sup&gt;c&lt;/sup&gt;(0.06)</td>
</tr>
<tr>
<td></td>
<td>24h</td>
<td>53.08&lt;sup&gt;b&lt;/sup&gt;(2.84)</td>
<td>26.53&lt;sup&gt;a&lt;/sup&gt;(1.46)</td>
<td>21.31&lt;sup&gt;b&lt;/sup&gt;(0.50)</td>
<td>0.17&lt;sup&gt;b&lt;/sup&gt;(0.06)</td>
</tr>
<tr>
<td></td>
<td>Day 3</td>
<td>58.44&lt;sup&gt;a&lt;/sup&gt;(2.84)</td>
<td>25.49&lt;sup&gt;ab&lt;/sup&gt;(1.46)</td>
<td>21.44&lt;sup&gt;ab&lt;/sup&gt;(0.50)</td>
<td>0.15&lt;sup&gt;b,c&lt;/sup&gt;(0.06)</td>
</tr>
<tr>
<td></td>
<td>Day 7</td>
<td>54.38&lt;sup&gt;b&lt;/sup&gt;(2.84)</td>
<td>27.09&lt;sup&gt;a&lt;/sup&gt;(1.46)</td>
<td>22.69&lt;sup&gt;a&lt;/sup&gt;(0.50)</td>
<td>0.18&lt;sup&gt;b&lt;/sup&gt;(0.06)</td>
</tr>
<tr>
<td></td>
<td>Day 14</td>
<td>53.86&lt;sup&gt;b&lt;/sup&gt;(2.84)</td>
<td>20.40&lt;sup&gt;c&lt;/sup&gt;(1.46)</td>
<td>19.37&lt;sup&gt;c&lt;/sup&gt;(0.50)</td>
<td>0.33&lt;sup&gt;c&lt;/sup&gt;(0.06)</td>
</tr>
</tbody>
</table>

<sup>x,y a,b,c</sup> For main effect of treatment/storage time, least square means for each trait within a column with different superscripts differ (P < 0.05).

¹ L* reflects the lightness of meat color, a* reflects the redness, and b* reflects the yellowness; TBARS = thiobarbituric acid reactive substances, is expressed as mg malondialdehyde (MDA)/kg

² RCI = radiant catalytic ionization

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

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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

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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 ºC blast freezer, whereas fast-freezing was performed in a liquid nitrogen cabinet (-80 ºC). Aging of the loin section in a vacuum bag was conducted in a 1 ºC cooler for 19 days. Once assigned initial freezing was completed (either slow or fast), the loin section were stored in the -20 ºC freezer for 6 weeks, and thawed in the 1 ºC 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
Meat and Poultry Quality

65: TENDERNESS AND SENSORY ATTRIBUTES OF ELEVEN MUSCLES FROM CARCASSES WITHIN THE CANADIAN CULL COW GRADES

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

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Objectives: Freezing is an effective preservation method to extend the shelf life of meat products. Despite of 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

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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 OFT (Doric Scientific). Each steak was cut into 1 cm×1 cm×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

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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 ≤ 0.05.

Results: Barrows were heavier, fatter, and had loins that were lighter as a percentage of HCW compared with gilts (P ≤ 0.01). One d postmortem pH was correlated (P ≤ 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 ≥ 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 ≥ 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
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**

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**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 (\(\leq 16:0\)) were reduced (\(P \leq 0.03\)) compared to stearic acid (18:0). Meanwhile, increases (\(P < 0.05\)) of trans-octadecenoic acid (18:1 \textit{trans}) and decreases (\(P < 0.05\)) of \textit{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 (\(P \leq 0.03\)) 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 (\(P \leq 0.04\)) 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

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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/cooking 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/cooking of pork patties.

Keywords: Cooking method, Freezing rate, Freezing temperature, Frozen pork patty, Thawing method
**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 α=0.05.

**Results:** The majority of quantitated volatile compounds were impacted by a three-way interaction of E×QG×DOD (P ≤ 0.05). Thirteen Maillard reaction compounds had three way E×QG×DOD interactions (P ≤ 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 ≤ 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.

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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

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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

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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 × 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 IIIB 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 IIIB fiber size and proportion of type I-IIA fibers.

Keywords: cold storage, muscle fiber characteristics, pork, quality change
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78: A CASE-CONTROL GENOME-WIDE ASSOCIATION STUDY OF DARK-CUTTING IN TWO BEEF CATTLE POPULATIONS

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

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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 (Modest 100-Moderate 100 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 2.54 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 be 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
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80: NUTRIENT COMPOSITION OF WILD TURKEY AND DOMESTIC TURKEY FOR THE USDA FOOD COMPOSITION DATABASE

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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 1.8mg, 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

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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-primals 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
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83: EFFECTS OF SIRE LINE, SLAUGHTER WEIGHT, AND GENDER ON PORK QUALITY AND YIELD CHARACTERISTICS

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

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


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

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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, LDCO 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

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

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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 reaserch 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

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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

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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
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

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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 -40°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*, and 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 < 0.001) 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 d simulated retail display.

Keywords: bacon, oxidized oil, pork, shelf-life
Meat and Poultry Quality

93: RELATIONSHIP BETWEEN HEIFER CARCASS MATURITY AND BEEF PALATABILITY


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Objectives: 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.

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Objectives: It is well understood that aging fresh pork loins will improve tenderness. The explanation for this phenomenon is degradation 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
Meat and Poultry Quality

95: THE MICROBIAL QUALITY OF PORK CARCASS DURING STORAGE

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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
Meat and Poultry Quality

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

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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 1 of 4 antimicrobial treatments or a negative control in 6 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
**Meat and Poultry Quality**

**97: THE EFFECTS OF RACTOPAMINE AND HORMONAL GROWTH PROMOTANTS ON GROWTH AND MEAT QUALITY OF CROSSBRED ANGUS STEERS**

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**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 $\beta$-adrenergic agonists ($\beta$-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 2x2x2 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 feed 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 $\beta$-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