

Undergraduate Research Competition

151: CORRELATIONS BETWEEN MEASURES OF TENDERNESS IN BEEF STRIP STEAKS

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Objectives: The tenderness of meat is instrumentally determined via Warner-Bratzler shear force (WBSF) and slice shear force (SSF) tests. These instrumental tenderness tools are frequently used as a means to predict sensory tenderness. Therefore, the objective was to determine the strength of relationships between WBSF, SSF and sensory evaluation.

Materials and Methods: Dietary treatments and different endpoint cooking temperatures were used as a means of increasing variation in tenderness. Strip steaks were collected from 12 Angus × Simmental cross steers where half received a control diet (CON) and half were fed a diet including 400 mg·animal⁻¹·d⁻¹ RAC ractopamine hydrochloride (RAC, Actogain) for 35 d prior to slaughter. Carcasses were aged 14 d prior to removal of strip steaks posterior to the 12th-13th rib interface. Two 2.5-cm thick steaks per degree of doneness (DoD) treatment (63° C, medium-rare & 71° C, medium) were cut and assigned to SSF, WBSF, and trained sensory panel analyses. Steaks were weighed and cooked to an internal temperature of 63° C or 71° C. After cooking, steaks were allowed to equilibrate to 22° C before shear force tests were performed. Cook loss was calculated as [(weight of raw steak, g - weight of cooked steak, g) / weight of raw steak, g] × 100. Trained panelists were asked to evaluate tenderness and juiciness of steak samples using a 15-cm anchored scale (0 = not tender or juicy and 15 = extremely tender or juicy). Data were analyzed as a 2 × 2 factorial, in split-plot design, using the MIXED procedure of SAS with diet as the whole-plot factor and DoD as the split-plot factor. Pearson correlation coefficients between SSF, WBSF, and sensory attributes were computed using the CORR procedure. Treatment differences were considered significant and correlations were considered different from 0 at $P \leq 0.05$.

Results: The association between sensory tenderness and instrumental tenderness was substantiated by the correlation between panel tenderness and SSF ($r = -0.66$) and WBSF ($r = -0.46$). Sensory juiciness was also related to SSF ($r = -0.42$), however sensory juiciness was not related to WBSF ($P \geq 0.31$). Despite differences between the correlations of SSF and WBSF with sensory analyses, the two instrumental tenderness measures were correlated ($r = 0.47$). Cook loss and panel juiciness were also correlated ($r = -0.46$). Steaks from RAC fed steers had greater SSF values ($P = 0.05$, 22.42 vs 18.28 kg) than from CON fed steers, however RAC had no effect on WBSF ($P = 0.97$, 2.97 vs 2.96 kg). Similar to WBSF, RAC usage had no effect ($P = 0.13$) on panel tenderness ratings. Steaks cooked to 63° C were more juicy ($P \leq 0.01$, 7.24 vs 8.38) than those cooked to 71° C. Similar to panel ratings for juiciness, steaks cooked to 63° C had less cook loss ($P \leq 0.01$, 18.64 vs 23.66) than steaks cooked to 71° C. However, DoD had no effect ($P = 0.15$) on panel tenderness ratings.

Conclusion: In a group of cattle that would generally be considered tender, decreasing cooking DoD did not further improve sensory tenderness. However, cooking steaks to a lower DoD did improve in sensory juiciness. In this study, SSF values were more closely related to panel tenderness and juiciness ratings than WBSF. Therefore, given the throughput advantages of SSF over WBSF, SSF is the favorable choice for instrumental tenderness evaluation under these experimental conditions.

Keywords: beef, correlation, Degree of Doneness, Ractopamine, sensory

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152: EFFECTS OF VARIOUS LEVELS OF PROTEIN, LYSINE, FAT, AND FIBER ON SWINE GROWTH AND PORK QUALITY

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Objectives: Efficient and profitable swine production depends upon an understanding of the concepts of genetics, environment, herd health, management, and nutrition (DeRouchey et al., 2007). Feed represents about 60 to 75 percent of the total cost of pork production; therefore, a thorough knowledge of the principles of swine nutrition is essential in order to maintain a profitable swine enterprise. Davey (1976) found that improvements in carcass composition are associated with the feeding of higher protein levels. Diets with higher protein content were associated with lower intramuscular fat content and less-tender (higher shear force value) meat. Therefore, the objective of this study was to determine how varying levels of protein, lysine, fat, and fiber in swine diets affected swine growth and pork quality.

Materials and Methods: The study was performed at the Fresno State Swine Unit where data was collected on a total of 12 crossbred barrows, 2 barrows per treatment per replication (3 replications), with littermates in each treatment in a replication. The barrows started at approximately 4 months of age (approximately 63.5 kg) and were fed specific diets for 56 d. Two different diets were used: a commercial hog feed (protein- min 14%, lysine- min 0.69%, fat- min 6.8%, fiber- max 8.7%) and a show hog feed (protein- min 22%, lysine- min 1.55%, fat- min 1.80%, fiber- max 2.6%). Weights were collected each week and average daily gain was calculated each week as well as overall. Carcass data was collected including hot carcass weight, NPPC color, NPPC firmness, NPPC marbling, loin eye area, tenth and last rib fat thickness. Dressing percentage and percent fat free lean were calculated and instrumental color (L*, a*, b*) on the loin eye was measured. Data were analyzed using the Proc ANOVA procedure of SAS with statistical differences being set at $p < 0.05$.

Results: The results of this study determined there were minimal differences between the two diets when it came to weekly weights and pork quality. However, the show diet had a higher ADG for week one (1.21 kg vs 0.76 kg; $p = 0.01$). This is most likely due to compensatory gain from switching types of hog feed. Barrows fed the show feed had a higher dressing percentage (74.7% vs 71%; $p = 0.0027$) and more fat at the last rib (2.79 cm vs 2.03 cm; $p = 0.03$). Additionally, the show feed resulted in higher L* values (56.89 vs 53.89; $p = 0.004$) in the loin eye, yet no visual color differences were observed with NPPC Color. There was a trend for the barrows fed the show feed to have larger muscle scores (2.5 vs 2; $p = 0.09$) and larger loin eye areas (20.07 cm² vs 17.78 cm²; $p = 0.07$). All other measurements and calculations were not statistically different ($p > 0.1$). Show fed barrows resulted in observationally firmer fat than commercial fed barrows.

Conclusion: Results of this study indicate that diets higher in protein and lysine and in lower fat and fiber leads to a higher dressing percentage and that were lighter in color objectively. Therefore, carcasses should have more total pounds of product on them.

Keywords: fat, growth , lysine, pork quality, protein

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153: A NEW PARADIGM FOR DRY-AGING: EFFECTS OF FAT DRY-AGING ON PHYSICOCHEMICAL AND TEXTURAL CHARACTERISTICS OF GROUND BEEF PATTIES

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Objectives: Dry-aging has been known to improve eating quality attributes of beef products (in particular unique flavor and/or juiciness). While fat plays an important role in flavor development of aged beef products, the current aging practice (including dry-aging) predominantly deals with whole muscle aging rather than separated fat aging. We hypothesized that dry-aging of beef fat would result in positive impacts on quality characteristics of ground beef patty. If successful, this would be a novel approach of value-adding process of beef fat as a naturally-enhanced flavor ingredient for manufacturing dry-aged ground beef. The objective of this present study was to determine the physicochemical and textural properties of ground beef patties formulated with wet-/dry-aged fat.

Materials and Methods: Beef round muscle (*M. semimembranosus* and *semitendinosus*) and backfat were collected from beef carcasses at 7 days postmortem. Trimmed beef backfat was randomly assigned into five treatment groups as follows; unaged-fat (control), wet-aged fat for 2 weeks (2WA) or 4 weeks (4WA) and dry-aged fat for 2 weeks (2DA) or 4 weeks (4DA). Wet-aging of beef fat was performed in a vacuum bag in a chilling room (at 1 °C; 80% relative humidity), whereas dry-aging was conducted without any packaging material in the same chilling condition. Beef patties were formulated with 80% round lean and 20% each assigned fat. Proximate composition, display weight loss, cooking loss and texture profile analysis were determined at each manufacturing day. Display color stability by measuring instrumental color and visual discoloration, pH and lipid oxidation (2-thiobarbituric acid reactive substances, TBARS) were performed at the initial and after 5 days of retail display. The experimental design was a completely randomized block design with three independent batches, and the PROC Mixed procedure of SAS was used for data analysis (P<0.05) by using least significant differences.

Results: The addition of aged-fat slightly decrease pH value of beef patties (P<0.05). Similar proximate composition (moisture, protein, lipid and ash) and cooking yield of beef patties were found between the treatments (P>0.05). The addition of aged-fat for 4 weeks (4DA or 4WA) resulted in significantly higher hardness, gumminess, and chewiness of beef patties than control. While CIE a* (redness) of beef patties with aged fat was decreased during display storage, beef patties with 4WA showed the most rapid decrease in redness during display (P<0.05). Similarly, beef patties made with wet-aged fat (2WA and 4WA) showed the most rapid discoloration, whereas beef patties with dry-aged fat maintained little to no discoloration. Furthermore, the highest TBARS value was observed at beef patties with 4WA between the treatments at the end of display (P<0.05).

Conclusion: These results indicate that the addition of dry-aged fat positively impact on color and lipid oxidative stability of beef patties, while resulting in little impact on chemical composition of beef patties. The addition of aged fat for 4 weeks increased hardness, gumminess and chewiness of beef patties, regardless of aging method. The follow up analyses including sensory attributes and flavor related chemical compounds would be highly warranted to determine the efficacy of fat dry-aging in meat flavor development.

Keywords: beef patty, Fat dry-aging, quality attributes

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154: RATE AND EXTENT OF TROPONIN-T DEGRADATION IN LOINS FROM PIGS SELECTED FOR LOW AND HIGH RESIDUAL FEED INTAKE

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Objectives: It is well known that proteolysis of myofibrillar proteins such as troponin-T is linked to myofibrillar fragmentation and improvement of tenderness of fresh meat products. The objective of this research was to quantify the rate and extent of troponin-T degradation in chops, aged 1, 7, or 14 days, from the longissimus muscle (LM) of pigs selected for low residual feed intake (LRFI; more feed efficient) and high residual feed intake (HRFI; less feed efficient). Residual feed intake is defined as the difference between expected and observed feed intake based on ADG and backfat.

Materials and Methods: Lines of LRFI (n = 6) and HRFI (n = 6) pigs, from generation 11 of the Iowa State University RFI project, were used for this study. Pigs were fed a commercial corn and soybean diet and were harvested at approximately 125 kg using standard industry procedures. Loins were removed and chops (2.54 cm) were cut from the LM 1 day postmortem, vacuum packaged, and aged 14 days. At the completion of aging, fresh (never frozen) chops were used to determine subjective color and marbling, Hunter L, a, b, and pH. Chops were cooked to 68°C for cook loss and star probe (kg) evaluation. Chops, from the LM (1.27 cm), for biochemical analysis were vacuum packaged and aged 1, 7, or 14 days. Samples were frozen in liquid nitrogen and homogenized at the end of the assigned aging period. Proteins were solubilized using whole muscle extraction buffer (10 mM sodium phosphate, pH 7.0, and 2 % wt/vol sodium dodecyl sulfate). Densitometry analysis of immunoblots was used to quantify troponin-T degradation products (28-30 kDa) that were resolved in the extracts from the aged samples. Degradation product abundance was normalized to the abundance of a reference sample on each gel and data were analyzed with fixed effects of line and days of aging and random effect of gel.

Results: Hunter a and b values, pH, subjective color scores, and subjective marbling scores were not different between lines ($P > 0.05$). There was a tendency for chops from LRFI pigs to have less cook loss (19.2 %) than those from HRFI pigs (22.3 %; $P = 0.07$). Chops from LRFI animals exhibited lower Hunter L values (LRFI, 46.5; HRFI, 50.9; $P < 0.01$) and lower star probe values (LRFI, 5.70 kg; HRFI, 6.15 kg; $P < 0.05$). An explanation for lower star probe values in the chops from LRFI animals may be due to greater postmortem proteolysis of myofibrillar protein. Densitometry measurements showed significant effects of line, days aged, and a days aged x line interaction ($P < 0.01$). Troponin-T abundance was not different between lines in day 1 postmortem chops ($P > 0.05$). The degradation product was more abundant in chops from LRFI animals at days 7 (0.64) and 14 (0.92) postmortem when compared to HRFI counterparts at days 7 (0.41) and 14 (0.80; $P < 0.01$).

Conclusion: Selection for improved efficiency was not detrimental to fresh pork quality. The results suggest that the explanation for improved quality in the loin chops from LRFI pigs is a greater rate and extent of troponin-T degradation during postmortem storage.

Keywords: pork, proteolysis, residual feed intake, troponin-T

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155: RELATIONSHIP OF MYOFIBRILLAR FRAGMENTATION INDEX TO WARNER-BRATZLER SHEAR FORCE AND PALATABILITY TENDERNESS OF LONGISSIMUS LUMBORUM AND SEMITENDINOSUS STEAKS

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Objectives: The objective of this study was to determine the relationship between the myofibrillar fragmentation index (**MFI**) and the Warner-Bratzler shear force (**WBSF**) and sensory traits of longissimus lumborum (**LL**) and the semitendinosus (**ST**) steaks.

Materials and Methods: Forty beef strip loins (IMPS #180) and 40 eye of rounds (IMPS #171C) were collected from a Midwest beef processor and transported to the Kansas State University Meats Laboratory. Sub-primals were divided into anatomical location (anterior, medial, and posterior for strip loins; proximal and distal for eye of rounds) and cut into three 2.54 cm thick steaks and aged 14 d. Within location, steaks were randomly assigned to WBSF, trained sensory panel evaluation, or MFI analysis. Steaks utilized for WBSF and trained sensory panel were cooked to an internal temperature of 71°C on electric clamshell grills. Steaks used for WBSF were chilled overnight at 4°C, and six 1.27-cm cores were removed parallel to the orientation of the muscle fiber and sheared once through the center using an Instron testing machine with a Warner-Bratzler shear head. Sensory panel steaks were cut into 1 cm × 1 cm × 2.54 cm samples and immediately served to sensory panelists trained per AMSA guidelines for Sensory Evaluation (2016). Myofibrillar fragmentation index was determined using the procedures described by Culler et al. (1978). Data were analyzed as a completely randomized design with muscle as the fixed effect. Sub-primal location data were analyzed muscle independent and as a completely randomized design with location as the fixed effect.

Results: When comparing muscles, there were muscle differences for all variables measured ($P < 0.05$). Steaks from LL had smaller WBSF, sensory panel connective tissue ratings, and MFI values than ST steaks ($P < 0.05$). Additionally, LL steaks had greater myofibrillar and overall tenderness sensory panel ratings ($P < 0.05$). There were location effects for sensory and WBSF of both muscles ($P < 0.05$). Warner-Bratzler shear force values of all three locations within the LL were different from one another ($P < 0.05$). Panelists rated anterior steaks greater for myofibrillar and overall tenderness than middle and posterior steaks ($P < 0.05$), which were not different ($P > 0.05$) from each other. Panelist detected less connective tissue in anterior steaks when compared to middle and posterior steaks ($P < 0.05$), which were not different ($P > 0.05$) from each other. In the ST, proximal steaks had greater WBSF values and sensory connective tissue amounts than distal steaks ($P < 0.05$). Proximal steaks had less myofibrillar and overall tenderness than distal steaks ($P < 0.05$). Within each sub-primal, anatomical location had no effect on MFI value ($P > 0.05$). Myofibrillar fragmentation index was correlated ($P < 0.05$) to myofibrillar tenderness ($r = -0.18$), connective tissue ($r = 0.11$), and overall tenderness ($r = -0.15$); however, MFI was not correlated ($P = 0.056$) to WBSF.

Conclusion: As expected, the LL was rated more tender than the ST by sensory panelists and had smaller WBSF values. The ST had a higher MFI versus the LL. In both muscles, MFI was not dependent upon anatomical location. Moreover, the correlation between MFI, WBSF, and sensory measures of tenderness were weak, indicating MFI was not a reliable indicator of beef tenderness for the muscles evaluated.

Keywords: beef, myofibrillar fragmentation index, sensory, tenderness, Warner-Bratzler shear force

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156: THE EFFECT OF AGING TIME ON METMYOGLOBIN REDUCING ACTIVITY

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Objectives: Color is the most important factor that a consumer uses to perceive meat quality and freshness. Meat color is primarily imparted by myoglobin. When meat discolors, myoglobin oxidizes from a bright cherry red oxymyoglobin form to a dark-brown metmyoglobin form. However, meat has the ability to limit discoloration and reduce the ferric brown metmyoglobin to ferrous deoxymyoglobin. The ability of meat to undergo reduction has been considered as the most important indication of color stability. Previous research showed that as meat ages, color stability decreases throughout display; however, the role of metmyoglobin reducing activity on beef color stability is unclear. Therefore, the objective of this study was to determine the effect of aging on metmyoglobin reducing activity.

Materials and Methods: USDA choice strip loins (n=8) were sliced into 5 equal sections, vacuum packaged, and designated to 1 of 5 aging period treatments (0, 7, 14, 21, or 28 d). At each respective aging period, 2.54 cm steaks were sliced from each section. The first steak was packaged into PVC overwrap and stored in a simulated retail display for 6 d. The second steak was used to characterize day 0 metmyoglobin reducing activity (MRA) and NADH-dependent reductase activity. The surface color was measured every 24 h using a HunterLab colorimeter. Following surface color measurements, MRA was measured on 6 d of display. Data was analyzed using the Mixed Procedure of SAS and the results were considered significant at $P < 0.05$.

Results: Aging time decreased color stability of steaks during display. By the end of 6 d display, the redness reduced by 58% for 28 d aged steaks, compared to 0 d aged. On d 0 at each aging period, MRA showed no difference between aging periods ($P > 0.05$). However, on d 6 of display MRA decreased ($P < 0.05$) with an increase in the aging period. Interestingly there were no differences ($P > 0.05$) in NADH-dependent reductase activity on day 0 of each aging period.

Conclusion: In conclusion, as aging period increases, beef color stability decreases. There were no differences in MRA and NADH-dependent reductase activity before display at each aging period. However, combined effect of aging time and display time decreased MRA and color stability. The results suggest that oxidative stress during display time may deplete reducing equivalents for MRA faster than the aging time.

Keywords: Aging , Meat color, Metmyoglobin, Reductase

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157: EFFECTS OF EXTENDED RETAIL DISPLAY ON METMYOGLOBIN REDUCING ACTIVITY IN GROUND BEEF MODEL

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Objectives: The objective of this study was to evaluate the effects of extended retail display on metmyoglobin reducing activity in ground beef model.

Materials and Methods: Two retail display trials were conducted using two ground beef batches with 91 and 93% lean. Thirty-six 454-g ground beef loaves per trial were produced, placed on black Styrofoam™ trays, overwrapped with PVC film (O₂ permeability of 1.21 mL/cm²/d and water vapor permeability of 0.022 g/cm²/d; LINPAC Packaging-Filmco Inc., Aurora, OH), and displayed at 2°C under fluorescent light (900 lux) for up to 0, 4, 8, 12, 24, 36, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288, and 312 h (n = 4 per time point). Two randomly selected loaves per time point per trial were withdrawn for further analysis. The pH value was determined by placing 1 g of meat in 10 mL of D-water (Accumet AE150 pH Benchtop Meter; Fisher Scientific, Waltham, MA). Aerobic Plate Count (APC, log CFU/g) was determined using 3M™ APC Petrifilm™ (3M™ Corporation, St. Paul, MN). Lean redness and reflectance spectra (400 to 700 nm) were recorded with illuminant A at 10° angle (MiniScan EZ 4500L, Hunter Associates Laboratory, Inc., Reston, VA). Metmyoglobin reducing activity (MRA) was measured by reacting extracted reductases with horse skeletal metmyoglobin and measuring absorbance by deoxymyoglobin at 580 nm (Spectramax Plus 384; Molecular Devices, Sunnyvale, CA). Statistical analysis was performed by using the GLIMMIX procedure of SAS (SAS Institute Inc., Cary, NC) at 0.05 level of significance.

Results: The APC was increased by 0.7 log CFU/g from 0 to 168 h ($P = 0.022$), which coincided with an increase in pH from 5.61 to 5.88 ($P < 0.001$). As expected, redness was decreased from 30.83 (0 h) to 13.48 (96 h; $P < 0.001$), which coincided with 10.56% decrease in surface oxymyoglobin ($P = 0.001$). However, lean redness and surface oxymyoglobin was increased after 120 h up to 216 h ($P < 0.001$). Although MRA remained constant from 0 to 120 h of retail display (7.03 to 8.58 $\mu\text{M}/\text{min}/\text{g}$; $P \geq 0.220$), it was increased up to 16.01 $\mu\text{M}/\text{min}/\text{g}$ by 288 h ($P \leq 0.004$), following a quadratic relationship that could be fit as $\text{MRA} = 7.68 + 0.0001 \times \text{time}^2$ ($R^2 = 0.67$; $P < 0.001$).

Conclusion: These findings were in contrast with the conventional wisdom that beef color continues to deteriorate as retail display progresses. The current study indicated that microorganisms in meat might contribute to the increase in metmyoglobin reducing activity, which may be used as novel technology to maintain meat color stability.

Keywords: ground beef, meat color, metmyoglobin reducing activity, retail display

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158: EVALUATION OF ALTERNATIVE FABRICATION SPECIFICATIONS TO INCREASE GROSS VALUE OF PORK CARCASSES

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Objectives: Modifying fabrication specifications in domestic processing facilities to reflect specifications in key export markets may increase demand for U.S. pork abroad. Changes in specifications may also yield value-added cuts to increase total domestic value. The objective was to evaluate differences in economic value of carcasses fabricated using either U.S cutting specifications, or specifications derived from those used in South Korea.

Materials and Methods: Paired sides (30 sides total; n=15) were weighed and fabricated into primals and subprimals according North American Meat Processors (NAMP) or Korean-style specifications. Korean carcasses were separated into shoulder (4th/5th rib separation), loin, belly, and ham (sirloin-on) primals. For Korean carcasses, the butt-tender was partially removed, and the ham was separated from the loin with a saw-cut through the last lumbar vertebrae, perpendicular to the long axis of the spine. The loin, belly, and ham of Korean carcasses were further fabricated into subprimals corresponding with NAMP specifications. Korean shoulders were fabricated into a cellar-trimmed (CT) butt, cushion, boneless picnic, and into a pork brisket (Kalbi). Individual primals and subprimals were weighed in order to calculate cutting yield. Fabricated carcass value was calculated using the AMS Carlot Report values from the week of 19 to 25 March, 2017. Value for the pork brisket was estimated based on relative value of the beef brisket compared to the beef shoulder clod primal resulting in a value of \$112.83/cwt. Comparisons between yields and value of analogous primals and subprimals from each side and total carcass value were conducted using a Paired T-test. Means were considered different at $P \leq 0.05$.

Results: Whole Bone-in (BI) loin yields of Korean carcasses were 6.23 units less ($P < 0.0001$) than NAMP carcasses, with 5.20, 1.62, 0.50, and 0.35 unit reductions ($P < 0.01$) in 1/4 trim BI loin, boneless (BNLS) strap-on, BNLS strap-off, and backrib yields, respectively. However, tenderloin and sirloin yields of Korean carcasses were increased ($P < 0.01$) by 0.14 and 0.82 units compared to NAMP carcasses. Similarly, yields of whole belly (spareribs-in), natural fall belly (rind-on), skinned natural fall, and trimmed and squared bellies of Korean carcasses were reduced compared with NAMP carcasses by 1.43, 1.10, and 0.83 units, respectively,. There was no effect ($P > 0.08$) of fabrication specifications on ham subprimals with the exception of inside hams where NAMP carcasses had 0.14 units greater ($P = 0.04$) yield than Korean carcasses. The pork brisket cut fabricated from the shoulder of Korean carcasses represented 3.97% of carcass weight and the CT butt represented 4.82% of carcass weight. Despite reductions in the yield of loin and belly subprimals, Korean carcasses had 2.7% more added value based on subprimal values reported in the Carlot Report.

Conclusion: Using Korean-style specifications reduced the yield, and therefore the value of the loin and belly, with minimal effect on the ham. However, added value from the pork brisket and CT butt adds sufficient value to the shoulder to offset lost value from the loin and belly. These data suggest that using fabrication methods based on Korean cutting specifications increases carcass value for export markets and may yield novel cuts like the pork brisket from the shoulder to increase the value of domestic pork sales.

Keywords: Cutability, Fabrication, Korean, pork

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159: GROUND BEEF OXIDATION IS INHIBITED BY SOLUBLE FRACTION OF MUSHROOM

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Objectives: Oxidation is a major contributor to degradation of color and flavor in ground beef. Mushrooms have been shown to inhibit lipid oxidation when added to meat products. One of the major components in mushrooms that acts as an antioxidant is Ergothioneine, a compound that works as a free radical scavenger. The objective of this study was to evaluate the impact of mushroom addition to ground beef patties on lipid and protein oxidation, cohesiveness, and color.

Materials and Methods: In addition to a control containing no mushrooms, four treatments were used; chopped, whole mushroom; dried mushroom powder; aqueous extract; and residue remaining after extraction. Half of the patties for each treatment were packaged in aerobic over-wrap packaging while the remaining patties were packaged using modified atmosphere packaging (MAP) containing 70% nitrogen, 30% CO₂, and 0.4% carbon monoxide. Patties were stored in a cooler at approximately 36°F for 4 days, cooked, and tested by Thiobarbituric acid (TBA) assay for lipid oxidation, Dinitrophenyl hydrazine (DNPH) assay for protein oxidation, and resistance to tear (RTT) for cohesiveness. Patty color was measured daily during storage by Hunter L*a*b* using a colorimeter (Minolta CR-300 series). All statistical analyses were performed using Statistical Analysis Software (SAS).

Results: Lipid oxidation levels were significantly ($p < 0.05$) lower for the aerobic and MAP whole, powder, and extract samples compared to the aerobic control. Patties with mushroom residue in both packaging treatments had significantly higher levels of lipid oxidation than other mushroom treatments and the control. After 4 days, MAP patties exhibited significantly lower a*(redness) values than those packaged aerobically with the exception of the aerobically packaged mushroom powder treatment, which also had significantly lower redness compared to the aerobic treatments. Although the results were not significant, a trend can be seen among the data showing that patties treated with whole mushroom or residue tend to have lower redness values. Free carbonyls and cohesiveness did not differ among mushroom or packaging treatments. There were no observed differences ($p = 0.4581$) in protein oxidation among treatments, indicating mushrooms may preferentially inhibit pathways for lipid oxidation rather than protein oxidation. There were also no observed differences among treatments for patty cohesiveness ($p = 0.875$).

Conclusion: In conclusion, adding whole, powdered or extracted mushroom inhibits lipid oxidation in ground beef patties, but does not significantly affect protein oxidation or cohesiveness. Although powdered mushroom effectively inhibits lipid oxidation, it triggers pigment oxidation causing patties to become an undesirable brown color rather. Among the treatments used, the most suitable for commercial production would be the mushroom extract because it significantly lowered lipid oxidation while allowing the patties to retain a bright cherry red color. In the future, sensory testing is needed to determine if consumer perception matches the laboratory results.

Keywords: color, ground beef patties, Lipid oxidation, mushroom, protein oxidation

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160: EFFECTS OF NITRITE SOURCE, REDUCING AGENTS, AND HOLDING TIME ON COLOR DEVELOPMENT IN A CURED MEAT MODEL SYSTEM

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Objectives: The objective of this study was to determine the effects of nitrite source, the addition of reducing agents, and holding times prior to cooking on color development in a cured meat model system.

Materials and Methods: Emulsified beef sausages were manufactured using four different combinations of nitrite sources and reducing agents: 1) sodium nitrite (SN; 156 ppm), 2) SN (156 ppm) and sodium erythorbate (SE; 495 ppm), 3) pre-converted celery juice powder (CJP; VegStable 504, Florida Food Products, Inc., Eustis, FL; providing 100 ppm of sodium nitrite), 4) CJP (providing 100 ppm of nitrite) and cherry powder (CP; VegStable 515, Florida Food Products, Inc., Eustis, FL; providing 440 ppm ascorbic acid). Beef, ice (20%), salt (2 %) and the appropriate amount of sodium nitrite and reducing agents were chopped for 1 minute in a food processor at 2000 rpm (Blixer 6V, Robot Coupe, Robot Coupe, Ridgeland, MS). For each treatment, the meat batter was placed in 5, 100 ml beakers, and held at 21° C for 5, 15, 30, 60, and 120 min prior to cooking. The emulsions were cooked in a water bath for 30 min at 40° C and 30 min at 80° C and then cooled for 30 min in an ice bath. Samples were then evaluated for objective color (Minolta CR400; L*, a*, b*), residual nitrite, total meat pigment, and cured meat pigment. Three independent replications were produced. Data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Cary, NC) using a 2 x 2 x 5 factorial arrangements with main effects of nitrite source, with or without reducing agents and holding time and their interactions. Means were separated using Tukey's adjustment ($P \leq 0.05$).

Results: A significant nitrite source by reducing agent interaction was identified for cured meat pigment and residual nitrite ($P \leq 0.006$). The SN+SE samples had the greatest amount of cured meat pigment (130.9 ppm) followed by CJP+CH (127.8 ppm), SN (74.7 ppm), and CJP (51.9 ppm) where each treatment was different than all other treatments. Residual nitrite was greatest in SN (79.7 ppm), SN+SE (62.6 ppm) and CJP (59.3 ppm) were intermediate and similar, and CJP+CH (31.64 ppm) had the least. Treatments with reducing compounds (SE or CP) were more red ($P < 0.001$; a* 15.8) and less yellow ($P = 0.016$; b* 8.8) than those without reducing compounds (a*10.7; b* 9.2). Similarly, samples cured with SN were more red ($P < 0.001$; a* 13.9) and less yellow ($P = 0.009$; b* 8.8) than those cured with CJP (a* 12.6; b* 9.2) but the differences were not as great the effect of reducing agents. Total meat pigment ($P > 0.06$) and L* ($P > 0.32$) were not affected by nitrite source or reducing agents. Holding time was not included in any significant interactions ($P > .349$). The only significant main effect of holding time was for a* ($P = 0.011$) where sausages held for 120 min was more red than those held for 5, 15, and 30 min.

Conclusion: The addition of reducing agents (SE or CP) had the largest impact on cured meat color development and reduced the residual nitrite in a cured meat model system. Treatments with SN had slightly greater cured color development than CPJ treatments. Holding times prior to cooking had limited impact on cured meat color development.

Keywords: Alternative curing, Cured color development, Holding times, Reducing agents, Sodium nitrite

Undergraduate Research Competition

161: EFFECT OF PROBIOTIC FEEDING ON OXIDATIVE STABILITY AND MEAT QUALITY ATTRIBUTES OF BREAST MUSCLE FROM CHICKENS EXPOSED TO CHRONIC HEAT STRESS

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Objectives: Heat stress (HS) has long been known to reduce the productivity of broiler chicken, decreasing breast muscle size and protein content, as well as damage to various tissues including skeletal muscle. Recently, feeding a dietary probiotic supplement to broilers has been suggested to alleviate these negative impacts by improving their gut health and nutrient absorption. However, little research has been performed to determine the effect of probiotic feeding on meat quality of broilers exposed HS, especially concerning oxidative stability and meat quality attributes. Furthermore, heat shock proteins (HSPs), which are chaperon proteins produced in response to heat stress, could be potentially related to oxidation stability in skeletal muscle by interfering with apoptosis mechanism. Therefore, the objective of this study was to determine the impact of probiotic feeding on oxidative stability, HSP expression, and meat quality characteristics of breast muscle from heat-stressed chickens.

Materials and Methods: Two hundred forty male Ross 708 broilers were assigned to 48 pens in temperature-controlled rooms. Using a 2 x 2 factorial design, HS broilers were kept at either 32°C or the thermoneutral room at 21°C. Control broilers were fed a regular diet, while probiotics fed received Sporulin (250 ppm; containing three strains of *B. subtilis*). Forty-eight chickens (12 birds/treatment) were harvested at day 46. At 1 day postmortem, paired breast muscles (*M. pectoralis*) were collected for the meat quality analyses such as, drip loss, cook loss, Warner-Bratzler shear force, and display color. 2-thiobarbituric acid reactive substances (TBARS), phospholipid, and 2,2-diphenylpicrylhydrazyl (DPPH) were measured. Western blots for HSP70 and HSP27 were performed. Data were analyzed using the PROC MIXED procedure of SAS, and means were separated using least significant differences ($P < 0.05$).

Results: Probiotic feeding significantly decreased TBARS and phospholipid contents in HS chicken breast ($P < 0.05$). HS increased the DPPH radical scavenging activity in chicken breast ($P < 0.0001$). However, probiotic feeding had no impacts on the DPPH radical scavenging activity in HS chicken breast ($P > 0.05$). HS increased HSP70 in chicken breast ($P=0.08$), whereas probiotic feeding had no significant impact on HSP70. Based on the qualitative Western blot analysis of HSP27, HS increased HSP27 in the breast muscle compared to its counterpart. Neither HS nor probiotics had impacts on water-holding capacity, shear force, and color stability ($P > 0.05$).

Conclusion: The results of this study indicate that probiotic feeding could alleviate oxidative deterioration of breast muscle from broilers undergoing HS, possibly through the decrease in phospholipid and increase in antioxidant capacity of the muscle. Further studies elucidating the underlying mechanisms behind antioxidant property associated with probiotics supplementation and possible involvement of HSP activity would be highly warranted.

Keywords: broilers, heat stress, probiotics

Undergraduate Research Competition

162: PROTEIN SOLUBILITY DURING THE AGING PERIOD IN BOS TAURUS AND BOS INDICUS BEEF

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Objectives: During the postmortem period, muscle cells are unable to maintain reducing conditions and this leads to oxidation of proteins that could affect function, solubility, and susceptibility to degradation. Compared to *Bos taurus* steers, *Bos indicus* influenced cattle exhibit differences in beef tenderness as well as muscle metabolic characteristics. Therefore, the objective of this study was to determine sarcoplasmic and myofibrillar protein solubility in beef during the aging period.

Materials and Methods: *Bos taurus* (Angus), *Bos indicus* (Brahman) and Brangus steers were harvested according to standard industry procedures (n=2 per breed group for 3 harvest days). Longissimus lumborum was collected at 24h and 14d. Sarcoplasmic protein solubility was determined by homogenizing triplicate 0.1 g muscle samples with 0.025 M potassium phosphate (pH 7.2) buffer. The homogenate was incubated overnight at 4 °C and then centrifuged at 1500 x g for 30 min. The supernatant was collected and protein concentrations were measured using the BCA protein assay. Total protein solubility was determined by homogenizing triplicate 0.1 g muscles samples with buffer containing 8M urea, 2M thiourea, and 3% SDS. The homogenate was incubated at 4 °C for 30 min and then centrifuged at 1500 x g for 30 min. The supernatant was collected and protein concentrations were measured using the Pierce 660 nm protein assay. Myofibrillar protein was calculated from the difference between total and sarcoplasmic protein solubility. Values are expressed as mg protein/g tissue. Data were analyzed using SAS JMP and the model included fixed effects of breed, time, breed × time, and harvest day.

Results: Sarcoplasmic protein solubility decreased from 24 h to 14 d (time, $P < 0.05$). Curiously, the decrease in sarcoplasmic protein solubility over time tended to be dependent on breed (breed × time, $P < 0.1$); sarcoplasmic protein solubility decreased less in Brahman compared to Angus and Brangus. Breed did not influence myofibrillar protein solubility.

Conclusion: Breed-related changes in sarcoplasmic protein solubility suggest the cellular environment during the aging period may differ in longissimus muscle of *Bos indicus* compared to *Bos taurus* steers. Further work is needed to determine if protein oxidation or other cellular factors contribute to these protein solubility changes during aging.

Keywords: *Bos indicus*, *Bos taurus*, Protein Solubility