POSTER PRESENTATIONS
ANimal Welfare: General Abstracts

1 Effect of Source of Dietary Fat on Dry Matter Intake and Feeding Behavior in Iranian Mahabadi Kids. M. H. Najafi 1, S. Zeinolla-dini 1, M. Ganjkhaniou 1, A. Najafi 1, H. Mohammadi 1
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Objectives: Fat is often fed to ruminant animals to increase the energy concentration of their diet; however, feeding fat often reduces dry matter intake (DMI), which limits its impact on metabolizable energy (ME) intake. To investigate the effects of different sources of dietary fat (saturated vs omega-6 vs omega-3 fatty acids) on intake and feeding behavior of goat kids (BW = 19.43 ± 1.2 kg; age 5 months), twenty-four male goat kids were assigned to three equal groups and received one of three dietary treatments as follows: control (C0), soybean oil (SO) or fish oil (FO).

Materials and Methods: Forage/ concentrate ratio in these diets was 30/70 and all three diets were isonitrogenous and isoenergetic, but contained different fat sources. Wet palm-oil (high in C16:0), soybean oil (high in C18:2 n-6) and fish oil (high in EPA 20:5 n-3 and DHA 22:6 n-3) were supplemented at 2% DM to control, soybean oil and fish oil diets, respectively. Fat sources were added and mixed completely with the concentrate before preparing total mixed ration (TMR) every day. Kids were housed in individual pens and were fed ad libitum and offered feed twice daily at approximately 0900 and 1700 for 12 weeks. Feed refusals were removed daily at 0800, and measurements of the feeding behavior of the kids were took place in the last part of period. Data were analyzed as a completely randomized design by using of the Statistical Analysis Software package (SAS Institute, 2002).

Results: Lipid sources did not affect feed intake (P>0.05), although there was a tendency for intake of the CO diet to be higher. Also, feeding behavior did not differ among treatments (P>0.05).

Table 1. Dry matter intake and chewing activities in growing kids fed three experimental diets.

<table>
<thead>
<tr>
<th>component</th>
<th>CO</th>
<th>SO</th>
<th>FO</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter intake (g)</td>
<td>1156.9 ± 44</td>
<td>1060.7 ± 43</td>
<td>1009.8 ± 58</td>
<td>ns</td>
</tr>
<tr>
<td>Chewing, min/day</td>
<td>623.5 ± 23</td>
<td>636.4 ± 42</td>
<td>599.6 ± 34</td>
<td>ns</td>
</tr>
<tr>
<td>Eating, min/day</td>
<td>223.5 ± 18</td>
<td>233.1 ± 24</td>
<td>200 ± 34</td>
<td>ns</td>
</tr>
<tr>
<td>Ruminating, min/day</td>
<td>400.1 ± 11</td>
<td>403.3 ± 37</td>
<td>399.8 ± 15</td>
<td>ns</td>
</tr>
<tr>
<td>CTU (min/g DM) A</td>
<td>0.54 ± 0.05</td>
<td>0.60 ± 0.03</td>
<td>0.59 ± 0.03</td>
<td>ns</td>
</tr>
<tr>
<td>CTU (min/g DM) B</td>
<td>0.19 ± 0.02</td>
<td>0.22 ± 0.01</td>
<td>0.19 ± 0.03</td>
<td>ns</td>
</tr>
<tr>
<td>RTU (min/g DM) C</td>
<td>0.34 ± 0.04</td>
<td>0.38 ± 0.02</td>
<td>0.39 ± 0.01</td>
<td>ns</td>
</tr>
</tbody>
</table>

A: CTU: chewing time per unit of feed, BETU: eating time per unit of feed, RTU: ruminating time per unit of feed.

Conclusion: In conclusion supplementation of soybean oil or fish oil at 2% DM did not affect dry matter intake and feeding behavior of kids.

Keywords: lipid supplementation, feeding behavior, Mahabadi kid

2 Effects of Intensification on Animal Behaviour and Welfare.


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Objectives: Uruguayan meat has been traditionally produced on pastures. However, intensive systems have recently become more widespread, with a wide range of pasture and concentrate utilization to fulfill different market requirements. The objective of this experiment was to evaluate the effect of intensification on animal behavior and welfare (AW).

Materials and Methods: 84 Hereford steers 1.5 years old and 391 kg of live weight (LW) were finished on 4 Treatments (T): T1: pasture composed by Medicago sativa, Trifolium repens and Festuca arundinacea (P), T2: P + concentrate (corn 0.6% of LW), T3: P + concentrate (corn 1.2% of LW) and T4: concentrate ad libitum. Steers from T4 were located in 3 open-air plots (8m²/animal). Behavior was evaluated 4 times (once a month) by direct observation using the instantaneous scan sampling technique within a 15-minute sample interval, from dawn to dusk by 4 trained observers rotating each 2 hours between T. The following states/events were recorded: lying or standing, walking, grazing, ruminating and drinking water. Animals from each T were divided in 3 pens. For behavioral observations, each subgroup was considered the experimental unit within each T. A logistic regression model was used to analyze daytime patterns of each behavior. Based on grazing ethology in range cattle, a polynomial 4th degree equation was fitted and differences between T were analyzed. Animals were slaughtered by humanitarian procedures in a commercial abattoir when they reached an average of 500 kg of LW in each treatment.

Results: Concentrate-fed animals had the highest average daily gain, which increased with the level of energy in the diet. Time spent ruminating was not different in pasture-based T. As ruminating time may change due to cell wall material consumed, these results suggested that the supplement did not substitute pasture ingestion. Ruminating time was lower in T4 than in T1, T2 and T3 (P<0.05). Ruminating time is a good indicator of AW and number of ruminating bouts affects overall production, because of buffering the rumen with saliva, which enhances the rumen environment. In this experiment, the reduction in time ruminating did not compromise the average performance in T4, but 1 animal was dead due to diet disorders. Animals from T1 spent more day time grazing when compared to T2 and T3 (6 hours in T1, 4.5 hours in T2 and 3.6 hours in T3). However, periodical grazing patterns were not altered due to supplementation in any of the pasture based T. One criterion of good AW is the expression of a time budget similar to that expressed by free ranging cows specific, so differences in grazing time were not considered relevant from the welfare perspective. On the other hand, the facts that animals could not express grazing behavior and spent less time ruminating, could have affected AW in T4.

Conclusion: Supplementation up to 1.2% of LW without deprivation of certain behaviors such as grazing should increase productivity without compromising AW. Overall production is higher in confined systems, but strict preventive measures should be applied to avoid diet problems and mortality. Future studies should evaluate aggressive behavior as indicators of discomfort, boredom, frustration and motivational systems underlying each behavior to reach firm conclusions about the influence of behavioral restriction on AW in confined systems.

Keywords: cattle behaviour, grazing, welfare
3 ASSESSMENT OF NON-PENETRATING CAPTIVE BOLT STUNNING FOLLOWED BY ELECTROLYTIC INDUCTION OF CARDIAC ARREST IN VEAL CALVES. M. Collins 1,*, B. M. Bartz 1, R. Livingood 1, H. Sobczynski 1, K. D. Vogel 1

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Objectives: The purpose of this study was to evaluate the impact of non-penetrating captive bolt stunning followed by electrolytic induction of cardiac arrest on veal quality and blood yield. This is the second part of a two-part study. The first part revealed that secondary electrolytic induction of cardiac arrest was unnecessary because all calves were rendered instantly insensible by the initial stun and did not return to consciousness. Ninety calves from the same farm were randomly assigned to one of two treatment groups in a balanced unpaired comparison design. The first treatment group (CONTROL) was stunned with a non-penetrating captive bolt gun (n = 45). The second group (n = 45) was stunned with a non-penetrating captive bolt gun followed by secondary electrolytic induction of cardiac arrest (HEAD/HEART). For meat quality evaluation, all samples were collected from the 12th rib region of the Longissimus thoracis. Carcasses were evaluated for petechial hemorrhaging (blood splash) and rib fractures at the cardiac region. Meat samples were evaluated for color, drip loss, ultimate pH, cook loss, and Warner-Bratzler shear force. The L* values (measure of meat color lightness) were darker (P<0.05) in the HEAD/HEART group (45.08 ± 0.72) than the CONTROL group (47.10 ± 0.72). There were no differences (P>0.05) observed in a* (redness) and b* (yellowness) values between treatments. No differences (P>0.05) were observed in drip loss, ultimate pH, cook loss, and Warner-Bratzler shear force. The blood yield from CONTROL (7,217.9 ± 143.5 g) was greater (P<0.05) than HEAD/HEART (6,656.4 ± 143.5 g). Overall, the data indicated no difference between CONTROL and HEAD/HEART with regard to animal welfare because the initial stun was effective in all calves. However, meat quality and blood yield were negatively impacted by the HEAD/HEART method. The data in this study suggest that secondary induction of cardiac arrest is not necessary with effective non-penetrating captive bolt stunning in veal calves.

Materials and Methods: 90 Holstein veal calves of farm of origin and all received on the same day. The mean HCW = 121.7 ± 12.6 kg All calves were initially stunned with a pneumatic captive bolt stunning (Model USSS-2a, Jarvis Corp., Middletown, CT). Applied Control Electronic Compact Stun system = secondary stun. Treatments were applied randomly. CONTROL: The non-penetrating captive bolt stun only, HEAD/HEART: The “head/heart” method, non-penetrating captive bolt stun followed by a 1s application of stunning wand to the ventral region of the ribcage directly caudal to the junction of the humerus and scapula while the stunned calf was in lateral recumbence.

Results:

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Control</th>
<th>Head/Heart</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean L*</td>
<td>90</td>
<td>47.10</td>
<td>45.08</td>
<td>.72</td>
<td>0.0497</td>
</tr>
<tr>
<td>Blood Yield (g)</td>
<td>90</td>
<td>7217.9</td>
<td>6656.4</td>
<td>143.5</td>
<td>0.0069</td>
</tr>
</tbody>
</table>

Conclusion: No differences were observed between CONTROL and HEAD/HEART with regard to animal welfare because the initial stun was effective in all calves. Meat quality and blood yield were negatively impacted by the HEAD/HEART method. Secondary induction of cardiac arrest is not necessary with effective non-penetrating captive bolt stunning in veal calves.


Keywords: animal welfare, stunning, veal

CONSUMERTOPICS: GENERAL ABSTRACTS

4 DEVELOPMENT, FUNCTIONALITY, AND CONSUMER ACCEPTANCE OF A NOVEL READY-TO-EAT LAMB LEG PRODUCT. B. Coty 1, L. Branham 2, R. Cope 1, M. Schwartz 1*, B. Wallace 1, K. Braden 1

1Agriculture, Angelo State University, San Angelo, TX, United States

Objectives: Lifestyles of American families are becoming more fast-paced thus increasing the need for convenience foods. American lamb is typically underutilized, and has comprised less than 1% of overall meat consumption for decades. Consumers of lamb typically are focused on buying higher-quality, higher-priced cuts, with the majority of lamb consumption concentrated within ethnically-driven markets. The meat industry is focused more on pork and beef as lamb has only recently become directed on meat production rather than textiles. The objective of this study was to determine an ideal formulation for maximal acceptability and functionality of a ready-to-eat (heat-serve) lamb leg product thus potentially broadening the consumer market for lamb.

Materials and Methods: Lamb legs (n = 160; NAMP 233E) underwent one of four marinations (Control, American, Caribbean, or Moroccan) using a standard brine. Base brine formulation consisted of water, salt, dextrose, sodium phosphate, and sodium erythorbate; lamb legs were pumped to 10 ± 0.5% of their green weight, and brine was maintained at 3.3 °C. Specific treatment seasoning blends were added during vacuum-tumbling for 30 minutes at -10 mm Hg and 12 RPM. The four treatments were then placed in separate containers in a cover picke for 16 hours at less than 3.3 °C. The final salinity of the injection brine was 66° with the final cover brine having a salinity of 33°. After marination, lamb legs were cooked and smoked to an internal temperature of 65.6 °C. Sliceability analysis occurred after lamb legs were chilled to an internal temperature of 3.3 °C. Lamb legs were then assigned one of two aging treatments (21d and 42d) and subsequently evaluated for trained sensory analysis, lipid oxidative stability (TBA), and consumer sensory analysis. Portions were reheat to an internal temperature of approximately 60 °C in a convection oven in preparation for all sensory panels.

Results: Sliceability and TBA were not affected by marination (P>0.05). Cook loss was affected by marination and aging (P<0.05). A merican treatment had the lowest cook loss with 11.77% while the Caribbean treatment had the most with 15.81%. An interaction between marination and aging was observed for initial and sustained juiciness, flavor intensity, and overall acceptability (P<0.05), but not initial or sustained tenderness, or warm-over flavor (P>0.05). Control was juiciest and most accepted while American had most intense flavor (21d). American was juiciest and had most intense flavor and acceptance (42d). Consumer analysis of flavor, overall acceptability, and willingness to purchase was affected by marination (P<0.05): American had the highest values for all attributes measured. The largest percentage of consumers (36.52%) ranked the American marination treatment as most liked. The Control was ranked second (28.43%) for most liked, followed by Moroccan (20.59%) then Caribbean (14.46%).

Conclusion: These results suggest that a spiral-sliced lamb leg with an American-style seasoning blend, regardless of aging, has the potential to be a successful convenience food product in today’s consumer market.

Keywords: Consumer perception, lamb, ready-to-eat
5 CONSUMERS ASSESSMENT OF PALATABILITY AND CARCASS EVALUATION, HAEMATOLOGICAL PARAMETERS AND SERUM METABOLITES OF BROILERS FED COWPEA TESTA AT GRADED LEVEL, AS BASED DIET. P. O. Fakolade 1*, O. J. Osunkeye 1, A. Ekacha 1, J. K. Ogunjolu 1
1Animal Science, Ogun State University, Osogbo, 2Animal Science, Ondo State University of Science and Technology, Okitipupa, Nigeria

Objectives: Livestock productions in developing countries are been threatened with acute scarcity of adequate nutrient in animal feed due to high cost of feed ingredient, most especially - ruminant animal e.g. poultry. The need to utilize locally available or cheaper alternative feedstuff as substitute to imported ingredients and acceptability of the end product cannot be over emphasized. Cowpea testa meal (CTM) has been reported to be one of the cheapest alternative feedstuff to soybean meal (SBM), however, CTM contains some haematological factors. Hence, this study was conducted to evaluate the effect of replacing SBM with CTM at 0%, 15%, 30% and 50% on haematological parameters and serum metabolites, carcass analysis and consumer assessment of broiler fed with CTM at graded levels.

Materials and Methods: Seven hundred and twenty (720) day old chick broilers (Arbor Acre) were allotted randomly into four dietary groups with three replicates for 56 days. The dietary groups are 0% (control, 18.75%CP and 3008 kcal/Kg, 15% (17.94%CP and 2904.69 kcal/Kg), 30% (16.93%CP and 2873.3 kcal/Kg) and 50% (15.58%CP and 2783.63 kcal/Kg). The birds were allowed free access to feed (Addlibitum). At the end of the experiment, breast muscles of 30 broilers from each treatment (10 from each replicate) were cooked for 20 minutes at 100°C in the laboratory to determine their palatability status. Each sample was served to 90 panelists (50 female and 40 male) under a red light using score card used in the meat science laboratory, with parameters like colour, flavor, tenderness, juiciness, texture and acceptability. For haematological and serum analysis, 30 samples of 5mls of blood from each treatment were drawn through the wing and jugular vein using hypodermic needle and syringe. Haematological parameter considered were Hb, PCV, TWBC, Heterophil, Monocyte, Eosinophil and Platelet, while that of serum analysis were total protein (TP), Albumin (ALB), Creatinine (CRT), Alanine transaminase (ALT) and Cholesterol (CHOLEST). All data collected were subjected to completely randomized block design of SAS 1999 software.

Results: Results showed that parameters for both haematological and serum analysis were not significantly different (P>0.05) except for the cholesterol (P<0.05). Panelist could not detect differences in cooked samples 0% and 15% level of CTM inclusion levels for colour, flavor, tenderness, juiciness, texture and overall acceptability; however their scores were ranked higher than 30% and 50% level of CTM inclusion.

Conclusion: Consumers acceptability shows that 0% and 15% level of CTM inclusion was highly appreciated, indicating that at 15% level inclusion of CTM with soybean meal, poultry production in developing countries could be at low cost of production and at consumers preference and CTM inclusion had no effects on the haematological and serum parameters except for Cholesterol.


Keywords: palatability status, carcass analysis, Haematology analysis, Serum metabolites and cowpea testa

6 CONSUMER PERCEPTION OF BEEF, PORK, LAMB, CHICKEN, AND FISH. K. Grimshaw 1*, R. K. Miller 1, M. A. Palma 2, C. R. Kerth 1
1Animal Science, 2Agricultural Economics, Texas A&M University, College Station, TX, United States

Objectives: One of the greatest challenges to developing successful marketing strategies in the food sector is gaining a better understanding of the diversity of consumer needs (Onwezen et al., 2012). It is important to understand consumer perceptions of beef, pork, lamb, chicken, and fish regarding average consumption levels, price, nutrition, animal handling, and animal welfare to help the industry educate and market to consumers, as well as understand perceived misconceptions. Moral and ethical beliefs, consisting of concerns for animal welfare, are reported as main reasons to avoid meat (Hoek et al., 2004). Consumers view high animal welfare standards at the production stage as an indicator that the resulting food is safe, healthy, and of high quality (Verbeke et al., 2010). To gain a better understanding of consumer perceptions, an online survey was emailed to consumers utilizing Qualtrics Q University Survey software (Qualtrics Labs, Inc., Provo, UT, United States).

Materials and Methods: Surveys (n = 1,602) were completed. Data was analyzed utilizing PROC MIXED procedure of SAS (v9.3, SAS Institute, Cary, NC). Results indicated two consumer groups: Meat Eaters and Non-Meat Eaters. Statistical analysis was also conducted using the Multinomial Logit (MNL) Model with STATA Statistics/Data Analysis (v12, StataCorp, College Station, TX). This model was designed to explain choice of Protein Consumers, Fish Only, and Vegetarian consumers. A 0.100 ≤ P>0.02 was used to determine significance. Three groups were identified: Protein Eaters, Fish Only, and Vegetable Protein Only.

Results: Consumer groups from both statistical analyses were evaluated for perceptions of beef, pork, lamb, chicken, and fish healthfulness, animal handling and animal welfare. The data indicated that females are less likely to consume animal protein (dy/dx = -0.044), while consumers with a history of family disease were more likely to consume animal protein (dy/dx = .033). At income level increased, likelihood of consuming protein decreased (dy/dx = .099, .094, .059) for income levels of $30,000-$59,000, $60,000-$99,000, and $100,000-$199,000, respectively. Thirty-six percent of consumers indicated animal welfare was somewhat important, while another 22% and 11% responded that it was very important and extremely important, respectively. When asked how often they purchased natural/organic, grass-fed, and free-range/cage-free products, 50%, 60%, and 63%, respectively, indicated they purchased these products less than once every 2-3 months.

Conclusion: Although consumers were emotionally invested in animal welfare, those emotions did not necessarily reflect purchasing habits.


Keywords: animal welfare, consumer perception, consumer survey, meat
7 RETAIL SHELF-LIFE, MICROBIAL SHELF-LIFE, SENSORY AND WARNER BRATZLER-SHEAR FORCE ANALYSIS OF SELECTED NILGAI (BOSELABUS TRAGOCAMELUS) MUSCLE. B. Wallace 1*, M. Schwartz 1, R. Cope 1, M. Boenig 1, L. Branham 1, K. Braden 1

1Agriculture, Angelo State University, San Angelo, TX, United States

Objectives: The objective of this study was to evaluate the properties of select Nilgai (Boselaphus tragocamelus) muscles for use as alternative protein sources. This will serve as baseline meat quality data supporting Nilgai as a valuable source of protein.

Materials and Methods: Tragocamelus dorsi (LD), supraspinatus (mock tender; MT), and semitendinosus (eye of round; ER) were fabricated from the left carcass side of Nilgai females one day post-mortem. The LD (n = 15) were fabricated from the 4th-13th rib, and placed in 4 °C refrigerated storage for 21 day ageing. The MT and ER were also fabricated, vacuum packaged, and placed in refrigerated storage for 21 days similar to LD. Following ageing, Nilgai LD was fabricated into 2.5 cm thick steaks and later evaluated for trained sensory attributes, Warner-Bratzler Shear Force (WBSF), and retail display utilizing American Meat Science Association protocols. Retail display attributes were evaluated on days 1, 3, and 5 of a 5 day display period through a PVC wrapped styrofoam tray. Microbial populations were determined by sampling a 25 cm2 area on designated microbial steaks paired with display day steaks on days 1, 3, and 5 in the simulated retail display environment. Following 21 day ageing MT and ER were analyzed for WBSF. All sensory and WBSF data were analyzed using PROC MEANS and retail and microbial data were analyzed with PROC GLM as implemented in SAS 9.3.1.

Results: Panelist rated LD samples to be moderately tender for initial tenderness (mean ± SD; 5.99 ± 0.33) and sustained tenderness (6.13 ± 0.42). Flavor intensity (6.05 ± 0.36) of Nilgai LD was rated as moderately very intense with littleto no off-flavor (3.99 ± 0.05). All trained retail evaluation attributes declined with extended display day (dd) as color, lean uniformity, lean discoloration, and browning all evidenced signs of deterioration (P < 0.001). Lean color declined substantially from dd 1 to dd 5 of the shelf-life period (6.64-4.63, respectively). Color uniformity decreased, lean discoloration increased and surface browning increased from dd 1 to dd 5. Objective color analysis L* values decreased through dd 1 to dd 5. Tristimulus a* values also decreased from dd 1 to dd 5. Microbial shelf-life evaluated with aerobic bacterial populations from the cut surface of Nilgai LD ranged from 5.54 to 6.49 log10 Colony Forming Units (CFU)/25 cm2, all means were different (P < 0.001). These populations are at least 1 full log under typical populations resulting in off odors and other spoilage characteristics of aerobically packaged raw meat. Tenderness evaluations of ER, MT and LD muscles all evidenced mean shear values well below 5 kg. The WBSF mean ± SD for LD was 2.57 ± 0.59, mean MT was 4.31 ± 0.83, and mean ER was 3.14 ± 0.43.

Conclusion: The trained sensory, tenderness and shelf-life evaluation of Nilgai product from three different representative muscles evidenced characteristics that of commonly consumed red-meat products. Moreover, shelf-life evaluation as determined by minimal microbial populations and retention of bright cherry red color through day 3 of retail display indicate a relative time available for display of at least 3-4 days in overwrapped refrigerated conditions after 21d of vacuum packaged prior storage.

Keywords: alternative protein, Antelope, Nilgai, quality

ENVIRONMENT, PRODUCTION SYSTEMS AND MEAT QUALITY: GENERAL ABSTRACTS

8 NUTRITIONAL COMPOSITION AND COLOR COMPARISON OF HERITAGE BRED CHICKENS (120 DAY GROWTH) VS. COMMERCIAL (50 DAY GROWTH) BROILERS. A. R. Christiansen 1*, E. A. Boyle 1, B. L. Goehring 1, A. J. Gaschler 1, J. J. Higgins 2

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Objectives: Efficiency in animal production has resulted in increased growth rate which could affect nutritional composition and quality parameters of commercial broiler meat. The objective of this study was to determine proximate analysis, yield, instrumental color, and fatty acid composition of breast and thigh meat and skin from free range heritage breed (Barred Rock) chickens raised for 120 days compared to commercial broilers raised for approximately 50 days prior to harvest.

Materials and Methods: Twenty whole bird carcasses for each treatment were obtained from retail vendors. Carcasses were weighed, and CIE tristimulus (L*, a*, and b*) color values were measured on breast and thigh skin and meat. Meat pH was measured, and then carcasses were deboned to determine raw weight yields on boneless breast and bone-in thigh muscles. Meat and skin were comminuted in a bench top food processor and stored at -80°C for less than one month until analyzed for moisture, protein, fat, and fatty acid composition following AOAC methods.

Results: Commercial broiler thigh meat had 2.41% more fat (P < 0.05) than heritage thigh meat; however, breast fat content was similar (P < 0.05) between types. Heritage chicken meat had higher (P < 0.05) protein than commercial broiler meat, and breast meat contained more protein (P < 0.05) than thigh parts regardless of breed type. Heritage chicken breast and thigh contained 35.60 and 35.21% polyunsaturated fatty acids (PUFA) as a percentage of total extractable fatty acids, respectively, while commercial broiler breast and thigh percent extractable fatty acids was 20.96 and 20.45% PUFA content, respectively. Commercial broilers had a greater PUFA amount (P < 0.05) than heritage chickens. Heritage breast and thigh meat had a lower (P < 0.05) eω/ω3 ratio at 9.11 and 10.45, respectively, than commercial broiler breast and thigh meat with 11.83 and 14.94%, respectively. It is preferable to have a lower eω/ω3 ratio in a healthy diet. Commercial breast and thigh meat had lighter, more yellow color (P < 0.05). In addition, whole carcass weight of commercial broilers was 71.3% heavier (P < 0.05) than heritage chickens. Commercial breast weight was 148.0% heavier (P < 0.05), and bone-in thigh was 52.2% heavier (P < 0.05) than heritage chickens. However, bone-in thigh yield was 2.1% higher (P < 0.05) in heritage chickens than from commercial broilers.

Conclusion: Heritage chickens display advantages in nutritional composition especially in protein content and omega fatty acid profile although the eω/ω3 ratio is still above the optimal ratio of 4. However, heritage chickens resulted in lower breast meat yields and overall carcass weights.

Keywords: alternative production system, heritage, meat quality and color, nutrition and fatty acid composition, poultry
9 BEEFCARCASS AND MEAT TRAITS OF STEERS FINISHED ON THREE FORAGE SYSTEMS. K. McMillin 1,2,3, G. Scaglia1, M. Persica III1, J. C. Gregoire 1, D. Torrico 4, W. Prinyawiwatkul 1
1School of Animal Sciences, 2Department of Food Science, LSU Ag Center, Baton Rouge, 3Iberia Research Station, LSU Ag Center, Jeanerette, United States

Objectives: Carcass characteristics and meat properties of beef from steers finished on three forage systems (S1, S2, and S3) different in percent of pasture area for each forage component were determined.

Materials and Methods: In 2011 and 2012, 54 spring weaned calves (257 ± 2.5 kg; 3/8 Gelbvieh, 3/8 Red Angus, and 1/4 Brahman) were allotted (1 steer/ha, 3 replicates/system) to S1 bermudagrass (45% of area) during summer, fall and spring and ryegrass (35% of area) and ryegrass no till drilled into a bermudagrass sod (20% of area) in winter, S2 bermudagrass (45% of area) in summer, dallisgrass/clovers mix (20% of area) during fall and spring, and ryegrass/clovers mix (35% of area) during winter, and S3 bermudagrass (20% of area) and sorghum-sudangrass hybrid/forage soybeans during summer (15% of area), dallisgrass/clovers mix (20% area) during fall and spring, and ryegrass/clovers mix (45% of area) during winter. After 324 d, 18 steers (6/system) were randomly chosen for humane harvest. Trained meat scientists evaluated carcasses at 24 h postmortem after 2°C overnight chilling. Ribs (IMPS 103) from right sides were removed to obtain 9–11 rib sections. Two 5.4-cm thick boneless steaks were vacuum packaged for 7 days at 3°C before cooking on a Farberware open hearth grill to 7°C internal temperature. Steaks were weighed before and after cooking to determine cooking yields. After cooling to room temperature, 1.27-cm cores from the Longissimus dorsi (Ld) for Warner-Bratzler shear force (Smith et al., 2007) and a 2.54 slice of Ld for slice shear force determination were removed. The 9–11 rib sections were physically dissected into lean, fat, and bone portions, with separate weighing of the Ld (Hankins and Howe, 1947). Boneless closely trimmed retail cuts (BCTR) were calculated from Hot carcass weight, Ld area, 12th rib fat thickness, and % KPH (Savell and Smith, 2009). Data were analyzed with SAS GLM and Tukey mean separation (α = 0.05).

Results: Previously reported average daily gains were different among different seasons and systems, but live slaughter weights (510.2 kg), hot carcass weights (266.9 kg), dressing percentages (52.3%), ribeye areas (64.4 cm²), and KPH (1.7%) did not differ (P > 0.05) with year or forage system. The carcass Ld lean color was darker (P < 0.05) for steers from S3 compared with S1 and S2. Carcass backfat thicknesses from S1 were less (P < 0.05) in 2011 and thicker (P < 0.05) in 2012 than the average backfat thickness of 5.5 mm for all steers, but there were no differences (P > 0.05) with year or forage systems for yield grade (2.4), calculated BCTR % (51.4%), Warner-Bratzler shear force (3.3 kg), or slice shear force (20.7 kg). Separable lean % (52.1%), Fat (23.2%), and bone % (24.5%) in 9–10–11 rib sections were not different (P > 0.05).

Conclusion: Lack of forage masses or nutritive values with systems during the grazing seasons did not result in major differences in carcass or meat characteristics of beef from forage finished steers.


Keywords: beef, carcass, forage, lean yield, tenderness

10 THE INFLUENCE OF MATERNAL ENERGY RESTRICTION DURING MID-GESTATION ON BEEF OFFSPRING GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS. A. R. Taylor 1,2, D. A. Mohrhauser 1, K. R. Underwood 1,2, R. H. Pritchard 1, A. E. Wertz-Lutz 1, A. D. Weaver 1
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Objectives: Fetal or developmental programming evaluates the effects of maternal alterations on the developing fetus. Specifically in beef, most fetal programming research has focused on under-nutrition of the dam, as cattle may experience a decrease in forage availability and quality due to gestation that could potentially impact the developing fetus. However, a limited amount of research effort has focused on maternal nutrient restriction during mid-gestation, a period when both myogenesis and adipogenesis are occurring. Impacts to these developmental processes could lead to alterations in fat and muscle tissue growth, animal performance, carcass composition and meat quality of beef offspring. Therefore, the objective of this study was to determine the effects of maternal nutrient restriction during mid-gestation on growth performance, carcass composition, and meat quality attributes of offspring.

Materials and Methods: One hundred fifty one beef cows were allotted to one of two treatments: 1) Control group (n = 76) fed to achieve and/or maintain body condition score (BCS) 5.0-5.5; or 2) Energy Restricted group (n = 75) fed to lose 1 BCS over the ensuing 90 day period of mid-gestation. Cows were weighed periodically during treatment, and ultrasound measurements were collected to determine subcutaneous fat thickness and ribeye area at the beginning and the end of the treatment phase. Body condition scores were also evaluated at the beginning and end of the treatment period. Following treatment cows were managed as a common group through weaning. At calving, calf birth weight, calving date, and calf gender were recorded. Following weaning, calves that met study protocol criteria (n = 133) were allotted into feedlot pens according to cow treatment, gender, and weight and dry matter intake, average daily gain, and feed efficiency were assessed. Calves were fed to achieve 1 cm of backfat thickness, and once this was achieved, they were harvested at a commercial abattoir. Carcass data were collected and full strip loins were removed to evaluate lean color and meat tenderness.

Results: Birth weight was decreased in energy restricted heifer calves compared to all other groups (P < 0.05). There were no differences (P > 0.05) between treatments during the receiving period on growth performance. However, body weights at days 28, 56, and 85 of the feeding phase were decreased (P < 0.05) in the energy restricted progesterone compared to the control group. There were no differences between treatments for subsequent weights, or growth performance characteristics (P > 0.05). There were also no differences in how, dressing percent, 12th rib fat thickness, ribeye area, percent kidney pelvic heart fat, Quality Grade, L*, a*, b* or Warner-Bratzler shear force (P > 0.05). However, energy restricted progeny had lower numerical yield grades (P < 0.05), and an increased ratio of marbling to subcutaneous fat (P < 0.05).

Conclusion: These results suggest energy restriction during mid-gestation may alter location of adipogenesis towards intramuscular fat and away from subcutaneous fat deposition without negatively impacting myogenesis in the resultant offspring.

Keywords: beef, fetal programming, maternal nutrition
mEASuREmENT And PREDICTION of mEATuAIrITY And ComPoSITION: GENERIC ABSTRACTS

11 CHANGES IN THE VOLATILE COMPOSITION OF FRESH PORK SAUSAGE WITH ROSEMARY (ROSMARINUS OFFICINALIS L.) AND GREEN TEA (CAMELLA SINENSIS L.) EXTRACTS DURING LONG-TERM FROZEN STORAGE FOLLOWED BY RETAIL DISPLAY. A. J. Pham 1, 2, J. B. Williams 1, S. M. Perez 1, M. W. Schilling 1
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Objectives: Comminuted meat products are often frozen or refrigerated for extended periods of time to accommodate consumer demand, production capacity, and commodity pricing. Volatile composition is seen as a measure of the shelf-life quality in muscle foods since certain compounds are reliable indicators of initial flavor deterioration. This research was designed to determine the changes in the volatile composition of fresh pork sausage links with the addition of rosemary (R) and green tea (G) extracts during long-term frozen storage followed by simulated retail display.

Materials and Methods: Ten batches of pre-rigor meat were formulated with synthetic antioxidants (control) and combinations of R (1500, 2000, 2500 ppm) and G (100, 200, 300 ppm). Fresh pork sausages were held frozen (-20 °C) followed by refrigerated (3 ± 1 °C) storage. Frozen pork sausages were analyzed after 0, 3 and 6 mos followed by simulated retail display (0, 7, 14, 21 d). The volatile compounds from these sausages were identified using solid phase microextraction (SPME), gas chromatography coupled with a mass selective detector (GC-MSD), and OSME-gas chromatography-olfactometry (GCO-OSME). A randomized block design with a factorial arrangement was utilized to determine if differences (P<0.05) existed among treatment combinations, time and treatment x time interactions for volatile compound concentrations of sausage links over 4 display times. When significant differences occurred among treatments, the LSMEANS function of SAS was utilized to separate treatment means. Only significant (P<0.05) variables were included in the final regression model.

Results: Fifty-five aroma-impact compounds were identified from the headspace of pork sausage links. Spice-derived volatiles such as terpenes (α-pinene, α-thujene) and terpenoids (isougeologue, 1,8-cineole) were the most abundant compounds in the headspace of the fresh product (0 d). Aldehydes (heptanal, 2-heptenal, (E,E)-2,4-decadienal and alcohols (1-octen-3-ol, 1-penten-3-ol) characteristic of lipid degradation and microbial metabolites (methanethiol, 3-methylbutanoic acid, acetoine) were associated with more intense odors as the product neared the end of shelf-life. Incorporation of R resulted in lower levels of hexanal (cut grass) and 1-octen-3-ol (mushroom) across all frozen storage periods. After 6 mos of frozen storage, higher levels of G showed lower concentrations for ethanol (alcoholic), 3-methylbutanoic acid (sweaty) and 2-acetyl-1-pyrroline (popcorn). The synergistic effects of both R and G improved with increasing levels of these natural plant extracts, showing higher concentrations for compounds α-pinene (ginger-nutmeg), 3-carene (citrusy) and cymene (minty) and lower concentrations for benzencetadialdehyde (rose-like), pinacol (alcoholic) and (E,E)-2,4-decadienal (oxidized spice) across all frozen storage periods.

Conclusion: Present findings demonstrate the effectiveness of natural plant extracts R and G on the shelf-life extension of fresh pork sausage during long-term frozen storage followed by simulated retail display as reflected by the changes in the volatile composition of the product over time. The synergistic effects of the natural plant extracts improved with increasing levels, showing the highest antioxidant efficiency at R2500/G300.

12 MEAT QUALITY AND SENSORY ATTRIBUTES OF BEEF FROM CATTLE THAT WERE FED NATIVE WARM SEASON GRASS DURING THE STOCKER PHASE AND FORAGE FINISHED. V. Kurve 1, 2, P. Joseph 1, 2, B. Williams 1, H. Boland 1, S. Riffell 1, M. W. Schilling 1
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Objectives: Native Warm Season grasses (NWSG) provide excellent wildlife habitat and are well adapted to the Southeastern United States. The effect on meat quality of feeding cattle NWSG in the stocker phase has been minimally researched. The objective of this research was to determine the meat quality of beef from cattle that were fed Native Warm Season grass in the stocker phase and forage-finished on tall fescue.

Materials and Methods: British cross-bred steers (n = 72) were randomly allotted to pasture plots with 3 different forage treatments that included CON (Bermudagrass), IND (Indiangrass monoculture), and MIX (Big Bluestem, Little Bluestem, and Indiangrass) and forage-finished on tall fescue. Loin wholesale cuts were obtained from 18 randomly selected cattle such that there were 3 replications of plots for each cattle from each treatment with 2 subsamples from each pasture plot. Loin steaks were removed from the Longissimus lumborum muscle, vacuum aged for 2 weeks and then subjected to simulated retail display for meat quality evaluation after 0, 3, and 6 days of storage. Additional beefsteaks were frozen, and consumer and descriptive sensory panels were conducted within 6 weeks of slaughter.

Results: Carcasses (n = 18) were 67% (n = 4) select for IND and 17% (n = 1) select for both CON and MIX treatments, respectively. A total of 33% (n = 2) for IND and 83% (n = 5) for CON and MIX carcasses received quality grades of Standard+ respectively. There was no difference (P>0.05) between treatments with respect to yield grade and proximate composition with yield grade averaging 2.2 for all treatments. Steaks from treatments did not differ (P>0.05) in sensory attributes, average sensory acceptability, color, tenderness, pH, or bacterial counts at each storage time. IND steaks had lower cooking loss (P<0.05) than steaks from the MIX and CON treatment. Steaks from the CON treatment had higher TBARS values (P<0.05) after 6 days of storage when compared to steaks from the MIX and IND treatments, which indicated a higher susceptibility to lipid oxidation. Cluster analysis was conducted to group consumers together based on their preference and liking of steak from the different forage treatments. Based on panelists’ acceptability scores, consumers were grouped into 4 clusters. The largest cluster (60%) of consumers liked all treatments between moderately and very much. In addition, 17% of consumers preferred steaks from the IND treatment over the CON treatment and 11% of consumers preferred steaks from the CON treatment over steaks from the MIX treatment.

Conclusion: Overall, there were no major differences between the treatments and finishing on forage resulted in loin steaks that the majority of consumers rated between like moderately and like very much. This indicates that forage fed beef can be produced when cattle are fed Mixed NWSG, Indiangrass, or Bermudagrass during the Stocker phase and then finished on fescue.

Keywords: beef, Native warm season grasses, forage, meat quality, sensory characteristics

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**Objectives:** This study analyzed the nutrient composition of ten retail beef loin and round cuts to update the nutrient data in the USDA National Nutrient Database for Standard Reference (SR).

**Materials and Methods:** Seventy-two beef carcasses were selected to meet the national consist of beef carcasses based on the 2005 National Beef Quality Audit. Beef short loins, strip loins, tenderloins, inside rounds, and eye of rounds (NAMP No. 173, 175, 190A, 169A, and 171C, respectively) were collected from selected carcasses. Subprimals were fabricated into the following retail cuts: porterhouse steaks, T-bone steaks, top loin steaks, tenderloin steaks and roasts, eye of round steaks and roasts, and top round steaks and roasts (NAMP No. 1173, 1174, 1180, 1190A, 190A, 1171, 171C, 1168, and 169), respectively. Retail cuts were trimmed to nationally representative retail fat trim levels of 0 cm or 0.32 cm. Immediately after fabrication, retail cuts were individually vacuum packaged and frozen until cooking and/or dissection. Nutrient analysis was performed for all cuts in their raw form. Loin steak and roast cuts designated for cooking were either grilled or roasted to reach a target final internal temperature of 71 °C. Individual samples were dissected into: separable lean, subcutaneous fat, and fat. Individual aliment samples were used to determine fat, moisture, protein, ash, and protein content due to yield grade (YG), gender, and cattle type. For quality grade (QG) analysis, separable lean and fat from each cut were composited to form samples that represented USDA Upper Choice, Low Choice, and Select quality grades. Nutrient analysis was conducted on composited samples to determine moisture, protein, ash, total fat, saturated fat, unsaturated fat, trans fat, cholesterol, and vitamin B2, B6, B12, and E. Analyses included lab and animal variation (or composite variation) to provide appropriate tests of mean differences among YG, gender, cattle type, and QG.

**Results:** Generally, there was no effect (P>0.05) of YG, gender, and cattle type (dairy versus beef) on the proximate composition of retail cuts. Total fat, trans fat, cholesterol, ash and B vitamin content did not differ (P>0.05) among QG for any retail cut. Overall, moisture, protein, fatty acid, and vitamin E content did not vary among QG. Based on QG and cooked verses raw, 11 out of the 13 cuts were lower in fat content and higher in moisture and/or protein content compared to the nutrient data for the same cuts in SR 25. In addition, all of the cuts in the current study had greater cholesterol content than the cuts in SR 25. All retail cuts met the USDA definition for “Lean”. As a result of this research, the following seven cuts will be added to the SR: raw top loin steak (0 cm trim), raw eye of round steak and roast, raw round steak and roast, raw tenderloin steak, and raw and cooked tenderloin roast.

**Conclusion:** Compared to existing data in the SR, the nutrient data generated from this study indicated that fat content decreased in retail cuts. However, due to increased leanness, cholesterol content has increased. These nutrient data will be utilized to generate nutrition labels at retail and to assist in the marketing of lean beef as a part of a healthy diet.

**Keywords:** beef, cholesterol, fatty acid, nutrition, vitamin

14 EFFECTS OF ROSEMARY (ROSMARINUS OFFICINALIS L.) AND GREEN TEA (CAMILLA SINENSIS L.) EXTRACTS ON OVERALL QUALITY AND SHELF-LIFE OF FRESH PORK SAUSAGE DURING LONG-TERM FROZEN STORAGE AND RETAIL DISPLAY. A. J. Pham 1, J. B. Williams 1, S. Kin 1, Y. L. Xiong 1, M. W. Schilling 1

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**Objectives:** Oxidative degradation of lipids and proteins occurs spontaneously in stored meats and plays a vital role in the loss of quality and acceptability of these products. Natural ingredients with similar functions as synthetic food additives such as rosemary (R) and green tea (G) extracts individually have been shown to extend the shelf-life of processed meats; however, their interactive effect has not been demonstrated in a commercial processing setting. Therefore, the quality attributes of fresh pork sausages formulated with combinations of rosemary (1500, 2000, 2500 ppm) and green tea (100, 200, 300 ppm) extracts were evaluated during long-term frozen storage (−20 °C) followed by simulated retail display (3 ± 1 °C).

**Materials and Methods:** A randomized block design with a factorial arrangement involving ten treatment combinations, three frozen storage periods (0, 3, 6 mos) and four retail display evaluation times (0, 7, 14, 21 d) was utilized. Differences (P<0.05) were determined among treatments, time and treatment x time interactions for thiobarbituric acid reactive substances (TBARS), color, psychrotrophic plate counts (PPC), physicochemical and sensory properties of the product. Only significant (P<0.05) variables were included in the final regression model.

**Results:** Both plant extracts displayed significant effects in delaying lipid oxidation across all frozen storage periods. TBARS were significantly reduced in treatments with higher amounts of R compared with the control after 6 mos of storage. Higher concentrations of R enhanced chroma and retarded discoloration throughout 14 d of retail display after 3 and 6 mos of storage. The synergistic effects of R and G on CIE L* (lightness), a* (redness) and b* were significant after 6 mos of storage where higher concentrations of both plant extracts resulted in increased redness and yellowness and decreased lightness. Combinations of at least R2000 and G had the most beneficial effect in inhibiting microbial growth with P values being lower (P<0.05) than the control throughout retail display. Also, G seemed to exert enhanced protection once the product had reached 6 mos of frozen storage and then retail-displayed. Addition of R and G resulted in higher (P<0.05) consumer acceptability scores compared with the control which displayed spoilage and detectable rancidity by day 7 following 6 mos of storage. All treatments had average consumer scores of 7 signifying “like moderately”. Consumers were clustered into segments where R1500/G100, R1500/G300, R2000/G100, R2000/G200, G2500/G200 and R2500/G300 were liked by >80% of the respondents across all storage periods. Pork and rosemary sausages were highest in sausages with increased concentrations of R following 0 and 3 mos of storage, whereas caramelized aroma followed a similar trend for those treatments with a higher G content. G had a significant effect on ginger, copper herbal, rancid, off-flavor and off-odor descriptors which were lower in sausages containing increased G concentrations. Both R and G were significant variables for rosemary flavor during initial frozen storage.
Conclusion: In conclusion, the addition of R and G can significantly enhance the shelf-life of fresh pork sausages throughout 6 mos of frozen storage and help maintain their keeping quality during retail display.

Keywords: fresh pork sausage, frozen storage, green tea extract, lipid oxidation, rosemary extract

15 WARNER-BRATZLER SHEAR FORCE ASSESSMENT OF SERIALLY-HARVESTED CALF-FED HOLSTEIN STEERS FED ZILPATEROL HYDROCHLORIDE

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Objectives: Longissimus dorsi steaks (2.54-cm-thick) were removed from NAMP 103 ribeye rolls of calf-fed Holstein steers (n = 60) of which one-half were fed the β-adrenergic agonist zilpaterol hydrochloride (ZH) and the remainder a control (CON) diet and subsequently evaluated for Warner-Bratzler shear force (WBSF) to evaluate objective tenderness in long-fed Holstein steers.

Materials and Methods: Cattle (n = 30 ZH, 8.33 mg/kg of dietary DM for 20 days with a 3-day withdrawal period; n = 30 CON) were harvested across six 28 days intervals beginning at 254 days on feed (mean final shrunken weight = 587.7 ± 71.5 kg). Steaks were randomly allocated to one of two aging (7 or 14 d postmortem) periods and frozen at -28 °C. Steaks were thawed at 1 °C for 24 h before being cooked in a forced-air convection oven set at 177 °C until internal endpoint of 70°C was reached. Steaks were weighed immediately prior to and 10 min after removal from the oven to calculate cook loss. Steaks were chilled for 24 h at 1 °C before 1.27 cm cores were randomly removed parallel to the muscle fiber orientation of each steak. Cores were immediately sheared using a V-shaped blade on a WBSF machine; peak shear force values were recorded for each core, which were averaged for each steak.

Results: Shear data was analyzed as a randomized complete block design using the GLM procedure in SAS, with days on feed, ZH supplementation, and aging duration as fixed effects in a 6 x 2 x 2 factorial treatment design. No three-way (P = 0.33) or two-way (P ≤ 0.29) interactions were observed for the effects of days on feed, ZH supplementation, or aging duration. An expected interaction amongst aging duration was observed with steaks aged 14 d exhibiting lower (3.54 vs. 4.58 kg; P<0.01) WBSF values compared to steaks aged 7 d. Moreover, steaks from cattle fed ZH exhibited greater (4.54 vs. 3.58 kg; P<0.01) WBSF values over steaks from CON cattle. In contrast to previous literature, no difference was observed amongst steaks from cattle differing in days on feed (254d = 3.43 kg, 282d = 3.99 kg, 310d = 4.32 kg, 338d = 4.24 kg, 366d = 3.94 kg, 394d = 4.43 kg; P = 0.18).

Conclusion: Supplementing calf-fed Holsteins ZH will increase WBSF values in steaks aged for 7 or 14 d compared to CON. Increased days on feed may not improve WBSF values of calf-fed Holstein steers. Furthermore, aging promoted reduced WBSF values regardless of ZH supplementation.

Keywords: aging, beef, days on feed, tenderness, zilpaterol hydrochloride

16 RELATIONSHIP OF CALF-FED HOLSTEIN SKULL MEASUREMENTS TO CARCASS PERFORMANCE CHARACTERISTICS

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Objectives: The objective of this exploratory observational study was to determine if a relationship exists between skull dimensions and measures of carcass yield of calf-fed Holstein steers.

Materials and Methods: Steers were either fed a ration containing the β-adrenergic agonist zilpaterol hydrochloride (ZH; n = 45) or fed a control ration (CON; n = 50). Steers (n = 95; final shrunken weight = 637.4 ± 115.9 kg) were humanely harvested by abattoirs located in the panhandle of Texas. After stunning and exsanguination, the head of each steer was measured for length from the top of the poll to end of the hairline superior to the nose pad (HL, mm) and for width lateral from the sagittal plane between the eyes (HW, mm). The left side of each carcass was graded according to USDA beef grading standards; the right side was transported to the West Texas A&M University meat laboratory for fabrication. Carcasses were fabricated into 27 sub-primals and trim; trim components were processed to a target composition of 85% lean. Upon completion of fabrication, overall mass of saleable lean, bone, and fat were weighed. Utilizing the REG procedure in SAS, HL, HW, the product of HL and HW, the ratio of HL to HW, and ZH supplementation (ZH; 0 = CON; 1 = ZH) were used to explain the variation in saleable lean, trimmable fat, and bone. Using the STEPWISE method of model selection, best fits equations were calculated.

Results: Head length ranged from 413 to 560 mm whereas HW ranged from 140 to 295 mm; the product of HL and HW (HL x HW) ranged from 65,800 to 165,200 mm² and the ratio of HL to HW (HL/W) ranged from 1.74 to 3.36. Total kg of saleable lean (LEAN) ranged from 151.5 to 308.3 kg, trimmable fat (PAT) ranged from 21.0 to 111.5 kg, and bone (BONE) ranged from 47.4 to 100.1 kg. Of the models calculated, the following were found to be significant (P≤0.0001) for explaining variation in weight of LEAN, FAT, and BONE. For prediction of LEAN, a three-variable (ZH, HW, and HL x HW) equation was calculated (Adj. R² = 0.66, RMSE = 22.47; LEAN = -328.94 + (23.60 x ZH) + (1.57 x HW) + (91.67 x HL x HW)). For prediction of FAT, a two variable (HW and HL x HW) equation was selected (Adj. R² = 0.63, RMSE = 14.48; FAT = -348.99 + (1.11 x HW) + (72.85 x HL x HW)). Furthermore, for prediction of BONE, a two-variable (HW and HL x HW) equation was calculated (Adj. R² = 0.51, RMSE = 7.43; BONE = -99.59 + (0.46 x HW) + (31.15 x HL x HW)). These results indicate that dimensional skull measurements and inclusion of ZH into a predictive model accounted for 66.63, and 51% of LEAN, FAT, and BONE weights.

Conclusion: Multiple fed beef sorting systems utilize biomechanical measures of the skeleton to group cattle into less variable harvest groups. Our data investigated the use of head width, the ratio of head length to head width, and zilpaterol supplementation, to account for significant variation in weight of carcass components. Our results support further research into the association between skull measurements and finished carcass composition.

Keywords: beef, Holstein, yield, zilpaterol hydrochloride

17 AN EXPLORATORY STUDY TO ESTIMATE THE FABRICATION YIELD OF EQUINE CARCASSES

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Objectives: The objective of this study was to establish an equation to estimate saleable red meat yield (RMY) of equine carcasses using available and quantifiable measurements of carcass cutability and quality.

Materials and Methods: Data was collected at Bouvy Exports, Fort Macleod, Alberta, Canada from equine carcasses that had been harvested
under supervision of the Canadian Food Inspection Agency (CFIA). Ninety carcasses were selected at random and followed through fabrication. Carcasses were evaluated using United States beef standards that included marbling (Practically Devoid to Moderately Abundant), lean maturity (A to C), and skeletal maturity (A 0 to E 9). Neck fat width was also measured (0 to 20 cm). During carcass evaluation, images were captured of the exposed section between the 5th and 6th thoracic vertebrae with a digital camera. Hot carcass weight (102 to 466 kg) was recorded and all bones (9.47 to 55.90 kg) and fat trim (1.17 to 19.72 kg) were collected, weighed and recorded individually. Carcass red meat yield was determined by subtracting total bone and fat collected during the fabrication process from each carcass side weight resulting in total saleable lean (65.77 to 79.44%), total bone (17.75 to 28.57%) and total fat (0.83 to 12.6%). Carcass muscling measurements were taken from the digital images using digital analysis software; measurements included Longissimus area (10.5 to 50 cm²), Rhomboideus area (9.6 to 53.1 cm²), and the distance perpendicular from the thoracic vertebra to the most lateral edge of the Longissimus (5.8 to 14.8 cm).

**Results:** Relationships between carcass traits and measures of red meat yield were initially calculated using the Pearson correlation coefficient. Variables that were significant (P<0.05) included hot carcass weight (r = 0.97), Longissimus depth (r = 0.46), Rhomboideus area (r = 0.44), Longissimus area (r = 0.36), internal fat (r = 0.34), and neck fat width (r = 0.24) for total kg of RMY; hot carcass weight (r = 0.23) and marbling (r = 0.09) for percentage RMY. Subsequently, multiple-linear regression models were developed using the stepwise selection method to predict weight and percentage RMY. The model (Adj. R² = 0.16, RMSE = 0.03) to predict percentage RMY = 0.69452 + (0.00026595*lean maturity) + (0.00072627*marbling). A second model was developed (Adj. R² = 0.95, RMSE = 0.42) to estimate total kilograms of RMY = -7.89525 + (0.74664*side width) + (0.52761*Longissimus depth) + (0.03102*lean maturity) – (0.11657*marbling). These equations accounted for 16% and 95% of the variation in percent RMY and total kilograms of RMY, respectively.

**Conclusion:** These data suggest that carcass traits including hot carcass weight, Longissimus depth and area, Rhomboideus area, internal fat weight, neck fat width and marbling score are associated with quantity and percentage of salable red meat yield of equine carcasses. Although equine grading systems do not currently exist, these data provide insight into predictors of carcass cutability.

**Keywords:** carcass, equine, yield

18 EVALUATION OF EYE LENS NITROGEN IN RELATION TO DENTITION, BONE OSSIFICATION, MYOGLOBIN, AND CHRONOLOGICAL AGE IN BEEF ANIMALS. K. Spivey 1**, L. Garcia 1, J. Starkey 1, S. Jackson 1, R. Rathsman 1, B. Johnson 1, C. Brooks 1, T. Lawrence 2, and M. Miller 1

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**Objectives:** The current study evaluated the relationship of age predictor variables dentition (DENT); skeletal maturity (OSS); dry lens weight (DWT); nitrogen content in mg (ENW); wet lens weight (WWT); percent nitrogen (NPER); and myoglobin (MYO) compared to chronological age in cattle.

**Materials and Methods:** Cattle (n = 184) of known age ranging from 5 to 110 mo of age were sampled. Approximately 15 minutes post-mortem, DENT was recorded and samples of the zygomaticus major and both eyes were taken. At approximately 24 hours post-mortem, all carcasses were evaluated for OSS by trained personnel.

**Results:** Age predictor variables were correlated to age in no demonstrating DENT, r = 0.84; OSS, r = 0.79; DWT, r = 0.76; ENW, r = 0.76; WWT, r = 0.61; NPER, r = 0.29; MYO, r = 0.15. Stepwise regression was used to develop an age prediction equation that utilized DENT and OSS: Age in mo = 11.86285 + 3.31019(ENT) + 0.03859(OSS). Stepwise logistic regression was used to develop an equation, utilizing DENT, to determine the probability of an animal being ≥ 30 mo of age. Probability of ≥ 30 mo = -5.2775 + 1.6229(DENT). Data also revealed that dental eruption (first pair of incisors to the second pair of incisors) rapidly occurs between 11 – 20 months and 21 – 30 months of age (0.26 and 3.71 permanent incisors, respectively).

**Conclusion:** Results indicated DENT and OSS were the best indicators of cattle age compared to WWT, DWT, ENW, NPER, and MYO.

**Keywords:** beef, Chronological age

19 A COMPARATIVE ANALYSIS OF UNITED STATES, CANADIAN AND JAPANESE YIELD GRADING SYSTEMS TO SALEABLE RED MEAT YIELD IN CALF-FED HOLSTEINS. N. D. May 1*, T. J. McEvers 1, J. A. Reed 1, L. J. Walter 1, J. P. Hutcheson 1, T. E. Lawrence 1

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**Objectives:** Countries use various methodologies, measurements, and predictive models in an attempt to estimate the percentage of saleable red meat yield (SRMY). When carcasses are marketed on a value-based system, a component of overall carcass value is often associated with estimates of saleable product. The objective of this study was to determine the linear relationship of predictive beef carcass meat yield models developed in the United States (USYG), Canada (OGY), and Japan (JGY) to actual SRMY of calf-fed Holstein steers.

**Materials and Methods:** Sixty steers were blocked by harvest date and assigned to one of two treatments: no Zilaprolol Hydrochloride (CON, n = 30), or supplemented Zilaprolol Hydrochloride (ZH, n = 30). Cattle were harvested at the West Texas A&M University Meat Lab (USDA est. 7124) after 254, 282, 310, 338, 366, or 394 days on feed. Kidney, pelvic and heart fat (KPH) was weighed along with hot carcass weight (Hcw) and left side weight (LSW) to calculate KPH percentage. Carcasses were then chilled for approximately 36-48 h before left carcass sides were ribbed and graded according to USYG and OGY standards between the 12th and 13th ribs, and JGY standards between the 6th and 7th ribs. Measurements for USYG included: Hcw (276.6 to 465.3 kg), KPH (1.38 to 5.54%), Longissimus dorsi area (48.38 to 101.94 cm²), and fat depth (0.20 to 2.24 cm). Similarly, measurements for OGY included fat class (1 to 9), Longissimus dorsi length (1 to 3), Longissimus dorsi width (1 to 3) and muscle score (1 to 4). Measurements for JGY included: Longissimus dorsi area (23.87 to 61.94 cm²), rib thickness (4.06 to 9.59 cm), subcutaneous fat thickness (0.20 to 1.73 cm), and left side weight (138.6 to 232.2 kg). After grading, right carcass sides were fabricated into 27 sub-primal pieces (fat in excess of 6 mm was removed) and trim. Trim components were visually assessed for an 85% lean content. Weights of all sub-primals, trim, fat and bone were recorded to determine SRMY. Predictive red meat yield models for USYG (49.75 ± 1.47%), OGY (64.11 ± 1.35%) and JGY (68.42 ± 0.97%) were compared to SRMY (62.14% ± 3.47%) via the Pearson correlation coefficient.

**Results:** Predictive equations of USYG and OGY displayed positive linear correlations (r = 0.48 and r = 0.40; P<0.01, respectively) to SRMY. In contrast, the JGY predictive equation resulted in a non-significant correlation (P = 0.38). When correlations were calculated between carcasses from cattle fed ZH or CON, the predictive model for USYG indicated a non-significant correlation (P = 0.13) amongst CON cattle and a modest positive relationship (r = 0.52, P<0.01) for ZH cattle. In contrast, OGY dis-
played a modest positive relationship ($r = 0.49, P = 0.05$) for CON cattle and a non-significant relationship ($P = 0.54$) for ZH cattle. The predictive model for J66 exhibited non-significant relationships for CON ($r = -0.03, P = 0.85$) and non-significant relationships for ZH ($P = 0.84$) cattle.

**Conclusion:** Thus, current global predictive models may need revision to accurately estimate the amount of saleable red meat yield in calf-fed Holstein carcasses.

**Keywords:** beef, Holstein, yield

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**20 COMPARISON BETWEEN A FUNCTIONALIZED GLASS SLIDE BIOSSENSOR WITH FLUORESCENTLY LABELED CALPASTATIN ANTIBODIES AND THE TRADITIONAL CALPASTATIN ACTIVITY ASSAY**

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**Objectives:** As one of the most important palatability characteristics influencing eating experience for consumers, the accurate measurement of tenderness can be used as a tool to market meat as “guaranteed” tender and the measurement of calpastatin activity can be used to predict it. The traditional laboratory assay method is the ‘gold standard’ but it is time consuming and laborious. Previous research to develop a biological sensor has been moderately successful but may have been detecting inactive fragments of calpastatin. As biosensor technologies evolve, they achieve greater sensitivity and more accurate results. The objective of this study was to compare two methods of measuring calpastatin activity, the traditional laboratory assay and the functionalized glass slide biosensor with fluorescently labeled calpastatin antibodies.

**Materials and Methods:** Calpastatin was extracted at 0h from Longissimus dorsi samples from between the 12th and 13th rib using a TRIS based buffer, dialyzed for 18h and further purified over an ion exchange column. For the forster resonance energy transfer (FRET) biosensor, glass slides were cleaned using 1M NaOH, 1M HCl, and a 1:1 H$_2$SO$_4$ : H$_2$O$_2$ solutions prior to silanization in 2% APTES. The slide was conjugated to AlexaFluor 546 labeled anti-calpastatin antibodies (domain II), exposed to calpastatin samples, and exposed to AlexaFluor 594 labeled anti-calpastatin antibodies (domain IV). Slides were then viewed under a fluorescence microscope. The activity of the samples was measured by the traditional assay method and the functionalized glass slide biosensor.

**Results:** Values for the traditional calpastatin activity assay ranged from 1.7 to 3.1 and had a mean of 2.5 of activity at 0h postmortem, but none of the biosensor tested samples showed FRET responses indicating that the fluorescently labeled anti-calpastatin antibodies were not within the forster radius.

**Conclusion:** Development of a biosensor specific for active calpastatin would provide a rapid method for predicting tenderness to segregate carcasses but more research is necessary in order to improve the method.

**Keywords:** beef, consumer preference, flavor, fatty acid, lipids, principal component analysis

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**21 PRINCIPAL COMPONENT ANALYSIS OF CONSUMER PALATABILITY SCORES FROM FOUR BEEF MUSCLES OF TWO USDA QUALITY GRADES IN RELATION TO FATTY ACID PROFILES**

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**Objectives:** Consumer preference is greatly influenced by muscle type and USDA quality grade, which also have great impact on fatty acid (FA) composition. The objective of this study was to determine the relationships between FA composition of neutral (NL) and polar lipid (PL) fractions and consumer preference of four muscles Longissimus lumborum (LL), Gluteus medius (GM), Semimembranosus (SM) muscles (aged 21 d, from two USDA quality grades (USDA Upper 2/3 Choice, Ch; modestly to moderate and Select, Se; slight to slight).

**Materials and Methods:** Muscles were fabricated into 2.5-cm thick, 5x5-cm pieces. Steaks were cooked on an electric clamshell grill for 5 min at 225 °C grill surface temperature. Consumers evaluated each treatment for tenderness, juiciness, flavor, and overall liking on a 10-cm verbally anchored line-scale. Lipids were extracted from raw steaks, fractionated into NL and PL, derivatized to FAME, and determined by gas chromatography. Principal component analysis (PCA) was performed on consumer palatability trait rankings. Principal component 1 and 2 explained 87% and 10% of the variances, respectively and were retained to determine treatment scores, which were subsequently correlated with other variables. The treatment PC scores and the variable correlation coefficients were plotted together (x coordinate = PC1 scores or correlation coefficients; y coordinate = PC2 scores and correlation coefficients) to evaluate variable relationships and treatment rankings.

**Results:** Overall liking, flavor, tenderness, and juiciness were all positively correlated ($r = 0.85 - 0.99, P<0.05$) to PC1. The percentage of MUFA was related closely with LD Ch+, GM Ch+, SV Ch+, GM Se, and SV Se treatments. Percentage of PUFAs was related with SM Ch+, SM Se, and LD Se. Percentage of SFA was found to be more evenly related with all treatments. Specific FA within the NL fraction were found to contribute to these relationships, with PUFAs Docosahexaenoic acid (C22:6n3), Linoleic acid (C18:2n6c), α-Linolenic acid (C18:3n6), and Eicosapentaenoic acid (EPA; C20:5n3) being related to SM Ch+, SM Se, and LD Se. Within the NL MUFA Myristoleic acid (C14:1), Palmitoleic acid (C16:1), Palmitoleic acid (C18:1n9c), and Garkgolic acid (C17:1) were related most closely with LD Ch, GM Ch, SV Ch, GM Se, and SV Se treatments. Among the PL FA, EPA (C20:5n3) and Oleic acid (C18:1n9) were found to be related with SM treatments.

**Conclusion:** This study shows that PUFAs of the NL and PL make significant contributions to flavor. Additionally, MUFA of the NL were found to be greatly related with treatments possessing greater flavor scores by consumers.

**Keywords:** beef, consumer preference, flavor, fatty acid, lipids, principal component analysis

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**22 SEPARABLE COMPONENTS OF RAW AND COOKED AUSTRALIAN LAMB CUTS**

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**Objectives:** USDA Food Safety Inspection Service now requires nutrient labeling on major cuts offered to consumers in retail. Currently, several Australian lamb cuts are marketed to U.S. consumers and, therefore, need current nutritional data for labeling. To develop nutritional data, the separable components of raw and cooked samples are needed. Therefore, the objective of this study was to determine the raw and cooked separable components of various lamb retail cuts originating from Australian meat processors and marketed to U.S. consumers.

**Materials and Methods:** Twelve subprimals for each cut were collected from Australian suppliers, shipped under refrigerated conditions to Texas Tech University and fabricated to represent the following retail cuts: Frenched lamb rack, cap off, rib chops (RC); Frenched lamb rack, cap off, denuded rib chops (RCD); Frenched lamb rack, cap off, roast (RR); Frenched lamb rack, cap off, denuded roast (RRD); Tenderloin (TEN);
Hind shank (HS); Semi boneless leg with chump/top sirloin on, aitch bone removed, shank on (SBL); and Buttermilk leg (BL). Retail cut were assigned to either raw or cooked groups. Cuts designated as raw were dissected into separable lean, separable fat (external and seam fat) and refuse. Those designated for cooking were either grilled or roasted as described by the USDA Nutrient Data Laboratory. Cuts were weighed before and after cooking to calculate cooking loss and chilled for 12-24 h prior to dissection into separable components.

**Results:** Data analysis revealed separable lean components of raw samples varied from 95.3% to 44.1%, with TEN exhibiting the greatest percentage (P<0.05) and HS exhibiting the least (P<0.05). External fat among raw lamb cuts showed RC, BL and HS had similar, but significantly greater, external fat percentages than RCB, SBL and TEN retail cuts with external fat values ranging from 1.6 to 10.3%. The percentage of refuse in raw samples was greatest (P<0.05) in HS (39.9%) retail cuts and lowest (P<0.05) in BL and TEN (5.0 and 1.1%, respectively) retail cuts. Cooking loss percentages were different among roasted cuts with the greatest (P<0.05) loss in SBL (32.1%) and least in TEN (17.4%). Cook loss values for roasted BL were similar to RC, but greater (P<0.05) in cooking loss than RRD roasted samples. The percentage of separable lean among roasted cuts was greatest for TEN and lowest for RR cuts (98.2% vs. 53.1%; P<0.05). A difference (P<0.05) was seen between percentage refuse of roasted retail cuts, with RR yielding the greatest percentage of refuse and TEN the least (34.5 vs. 0.1%). Edible percentage was significantly different among roasted cuts with TEN samples yielding the greatest percentage (98.8%; P<0.05); whereas SBL and RR were found to have the lowest edible percentage (68.2 and 63.6%, respectively). Finally, differences in edible portion were seen between grilled RC and RRD retail cuts, with RC cuts having a greater (P = 0.0171) percentage (68.0 vs. 61.5%) of edible portion.

**Conclusion:** These data indicate the separable components of the raw and cooked Australian lamb cuts evaluated in this project vary greatly, and this variation will likely influence the nutrient content and labeling of these cuts.

**Keywords:** Lamb, separable components, Australia, labeling

23 EXPLORING THE CORRELATIONS AMONG NUCLEOTIDES, NUCLEOSIDES, CREATINE, CREATININE, CARNOISNE AND SENSORY ATTRIBUTES OF BEEF STRIP STEAKS FROM THREE USDA QUALITY GRADES. T. Dinh 1, 2, J. F. Legako 1, 3, M. F. Miller 4, K. Adhikari 5, J. C. Brooks 6

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**Objectives:** Free-amino acids and reducing sugars contribute to beef flavor through thermal degradation and Maillard reactions. Similar mechanisms are suggested for nucleotides and other nitrogenous organic compounds, contributing to beef taste. The objective of this study was to determine the relationships among consumer preference, flavor descriptors, and non-amino acid, nitrogenous organic compounds (NOC).

**Materials and Methods:** Beef strip loins of three USDA quality grades (Prime – PR, Low Choice – LC, and Standard – ST) collected at two time points (PRCL1, PRCL2, LCCL1, LCCL2, STCL1, and STCL2; n = 4) were used to determine preference by consumer panel and beef flavor attributes by trained panelists. Nucleotides, nucleosides, creatine, creatinine, and carnosine were extracted in cold water, purified through a 3-kDa membrane, and quantified by reversed-phase high-pressure liquid chromatography with UV detection at 210 nm. In addition to effect of quality grade on NOC, principal component analysis (PCA) of consumer preference was also performed.

**Results:** Principal component 1 and 2 (PC1 and PC2), explaining 83% and 10% of total consumer preference variances, were retained to determine scores of six treatment combinations, which were subsequently correlated with consumer preference, flavor attributes, and concentrations of NOC (mmol/kg, dry matter basis). Raw ST steaks had greater NOC concentrations (P<0.05), except that creatinine and uridine were similar among ST and LC steaks (P>0.1). Cooking generally decreased concentrations of these compounds similarly across quality grades (P<0.05), with an exception of creatinine, by which the conversion of creatine to creatinine was confirmed. PR steaks scored much better on PC1 (0.63, -0.05) and (0.93, 0.33), compared with ST steaks (-1.00, 0.73) and (-0.94, -1.00) for both collections, respectively. Overall liking, flavor, flavor intensity, tenderness, and juiciness were positively correlated to PC1 (r = 0.84 to 0.99; P<0.04); so were flavor descriptor initial flavor, beef-like flavor, brown/roasted, and umami (r = 0.83 to 0.94; P<0.04). However, most NOC in both raw and cooked steaks, especially carnosine, creatine, and hypoxanthine, were negatively correlated to PC1 (r = -0.86 to -0.97; P<0.01) and were in close proximity to the descriptors green, liver, oxidized, metallic, cardboard, and bitterness.

**Conclusion:** The results suggest NOC have negative impacts on flavor and consumer preference ranking of beef strip steaks across three USDA quality grades.

**Keywords:** beef flavor, nucleotides, nucleosides, nitrogenous compounds, principal component analysis

24 A SIMPLE METHOD FOR SIMULTANEOUS DETERMINATION OF NUCLEOTIDES, NUCLEOSIDES, CARNOSINE, CREATINE, AND CREATININE IN WATER EXTRACT OF BEEF STRIP STEAKS. J. F. Legako 3, 4, T. T. N. Dinh 1, 2, O. Ca 5, T. Anderson 6, J. C. Brooks 7

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**Objectives:** Carnosine (CAR), creatine (CR), creatinine (CN), nucleotides (uridine 5’-monophosphate - UMP, guanosine 5’-monophosphate - GMP, inosine 5’-monophosphate - IMP, adenosine 5’-monophosphate - AMP), nucleosides and their degradation products (cytidine - CYD, uridine - URD, inosine - INO, guanine - GUA, hypoxanthine - HYP, xanthosine - XAN) have been reported to contribute to the flavor profile of beef. Determination of these compounds has been accomplished separately by ion-exchange, normal-phase, or ion-paired reversed-phase (RP) high-pressure liquid chromatography (HPLC). Separation of CAR and CR on a RP system may be achieved by a 100% aqueous buffer mobile phase. However, 100% aqueous buffer can cause hydrophobic phase to collapse, adversely affecting the resolution (R) and life-span of a column. The objective of this study was to evaluate a simple and reliable RP-HPLC method for simultaneous separation and determination of nucleotides, nucleosides, CAR, CR, and CN.

**Materials and Methods:** Raw and cooked beef strip steaks of USDA Prime, Low Choice, and Standard quality grades were used to create homogeneous beef matrices (raw and cooked), representing composition across quality grades. Water-soluble compounds were extracted with purine (PUR) as an internal standard, purified through a 3-kDa membrane, and injected directly in an HPLC system equipped with coupled RP-18 columns (150 mm x 4.6 mm and 250 mm x 4.6 mm, 5-μ particle size) and UV detection at 210 nm. The mobile phase was 150-mMNaH2PO4 at pH 6.0 and 45/45/10 (v/v/v) acetonitrile/methanol/water as the organic modifier. Repeatability (n = 4), reproducibility (n = 4, 4-d measurement), and recovery efficiency (n = 5, at low- and high-level spiking) were evaluated on both raw and cooked matrices.
Results: Resolution of 0.90 was found for CAR and CR. Nucleotides, nucleosides and their degradation products, CN, and PUR were well separated (R ≥ 1.05). Limit of detection was from 1 to 3 pmol/μL. Linearity compounds was determined in a wide range (R2 = 0.995 to 0.999, P<0.001), especially for CAR (3 to 1800 pmol/μL) and CR (10 to 5000 pmol/μL). Predominant compounds (more than 15 mg/100 g) such as CAR, CR, CN, IMP, HYP, and NO were determined with great result in both precision of the coefficients of variation, CV = 0.09 to 4.71%, similarly with less concentrated compounds (UMP, GMP, CYD, AMP, GU) or 1 to 2 mg/100 g, CV = 0.95 to 7.36%). However, reproducibility of UMP, GMP, CYD, AMP, and GU (CV = 8.33 to 12.32%) was lower than CAR, CR, CN, IMP, and HYP (CV = 1.55 to 3.14%; P<0.001). Recovery efficiency was 97.56 to 99.27% and 86.55 to 102.75% at high-level spiking for cooked and raw samples, respectively, whereas it was 96.57 to 116.53% at low-level spiking.

Conclusion: Results indicate that the evaluated method is rapid, simple, and reliable for analysis of nucleotides, nucleosides, CAR, CR, and CN in beef.

Keywords: beef, nucleotides, nucleosides, nitrogen compounds, taste

MEAT PROCESSING, INGREDIENT TECHNOLOGY AND PACKAGING: GENERAL ABSTRACTS

25 THE EFFECT OF MITOCHONDRIAL RESPIRATION ON COLOR POST MORTEM. E. Slinde1†*, M. Bjejanovic1, B. Egelandalsal 1
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Objectives: After death cells use energy until all ATP and other energy containing compounds are depleted. But electron transfer through the mitochondrial respiratory chain continues as long as there are substrates available. Substrates of the mitochondrial respiratory chain are NADH and FADH and these are generated in the Krebs cycle. NADH may also be formed through addition of lactate when pyruvate is formed. As long as there are respiratory substrates available the reduction capacity of the electron transfer chain removes all oxygen in MAP, then electron transfer reduces metmyoglobin (MMb) to myoglobin, and in the presence of CO, carboxymyoglobin is formed. Color change is seen when the amount of substrates for NADH or FADH are depleted, when the respiratory chain ceases to function or when enzymes in the Krebs cycle are destroyed. The aim of the present study was to add Krebs cycle compounds that stimulate formation of NADH and FADH that promote red color of stored meat mucins.

Materials and Methods: Minced beef (14% w/w fat; pH 5.8) was packaged in trays and stored in dark at 40°C: 8 days in a high-oxygen atmosphere (75%O2/25%CO2); 13 days in a low-oxygen atmosphere (60% CO2/40% N2). Succinate, pyruvate, glutamate and malate were added according to a mixture design within a factorial design (164 samples). The concentrations of substrates were 0.05 and 0.1 mol/kg mince. Samples were scanned, 400 – 1100 nm, with a Foss NIRSystems OptiProbe TM 6500 Analyzer (Foss NIRSystems Inc., Maryland, USA). Spectra were used to predict oxymyoglobin (OMb), MBb and deoxymyoglobin (DMb) according to a principle that has been reported by Khatli et al. [1]

Results: Low oxygen: The optimal mixture for high DMb ratio was an almost 1:1 mixture of succinate and glutamate/malate. The condition giving low DMb concentration was always a pyruvate-malate-glutamate mixture. The optimal mixture giving high DMb did not change much with incubation time. High oxygen: At start, a mixture of pure glutamate/malate with small amounts of pyruvate supported OMb formation. However, on day 8 a small amount of succinate seemed advantageous in order to keep OMb stable. In high oxygen, a combination of glutamate/malate with a small amount of succinate was optimal. Glutamate generated more reducing equivalents than malate. Malate alone does not support O2 consumption as oxaloacetate cannot be metabolized if acetyl-CoA is absent. However, glutamate can be oxidized, when acetyl-CoA is absent by glutamate dehydrogenase to give two reducing equivalents. Citrate stabilized OMb possibly due to its ability to chelate free iron.

Conclusion: In low oxygen, the additives succinate and glutamate rapidly increased DMb levels and maintained the level at 100% DMb for 13 days. In high oxygen glutamate/malate supported stabilization of DMb, now citrate addition was important to stabilize OMb for longer storage times. Optimal ratios of ingredients were time dependent in high oxygen packing. Correct additions of ingredients were superior to adding only water.


Keywords: color, glutamate, malate, respiration, succinate

26 INSTRUMENTAL AND SENSORY TEXTURE OF LOW-SODIUM RESTRUCTURED COOKED CAIMAN STEAKS. A. C. V. C. S. Canto 1*, B. R. C. Costa Lima 1, F. Suman1, C. A. Lazaro 1, M. L. G. Monteiro 1, A. C. Corte-Junior 1, M. Q. Freitas 1, A. G. Cruz 1, E. B. Santos 1, T. J. P. Silva 1
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Objectives: Restructuring is a processing strategy for value-addition of low-value meat trimmings, whereas sodium reduction can improve consumer confidence by providing heart-healthy meat products. Caiman (Caiman crocodilus yacare) carcass trimmings are low in fat, rich in polyunsaturated fatty acids, and offer potential for developing healthy meat products. Investigations are yet to be undertaken to examine the usefulness of microbial transglutaminase in combination with salt replacers to develop low-sodium restructured steaks from caiman trimmings. Therefore, our objective was to examine the instrumental and sensory texture attributes of restructured cooked caiman steaks containing microbial transglutaminase and salt replacers (potassium chloride and magnesium chloride).

Materials and Methods: Trimmed from five caiman carcasses were utilized in a trial, and the experiment was repeated four times (n = 4). The treatments included control (CON; 1.5% NaCl), MTG (1.5% NaCl + 1% microbial transglutaminase), and KMG (0.75% NaCl + 1% microbial transglutaminase + 0.375% KCl + 0.375% MgCl2). The ingredients were hand-mixed, and the meat mix was packaged into tube shape in polyvinyl chloride film. The meat tubes were stored at 4 °C for 18 h for cold binding. Two-cm thick steaks were sliced from the tubes, vacuum packaged, and frozen at -18 °C. Steaks were cooked to an internal temperature of 70 °C, and the textural attributes (instrumental and sensory) were evaluated. Tukey test was used for data analysis, and the treatment means were separated at 5% significance.

Results: KMG and MTG steaks demonstrated greater (P<0.05) cooking yield than CON. With respect to instrumental texture, KMG demonstrated lowest (P<0.05) values for hardness, springiness, and cohesiveness, whereas MTG had the greatest (P<0.05) resistance. On sensory analysis, KMG steaks exhibited greatest (P<0.05) tenderness, whereas MTG exhibited greatest (P<0.05) cohesiveness scores. The most succulent steaks (P<0.05) were KMG. While KMG and CON did not differ (P>0.05) in overall
acceptance, MTG demonstrated lowest (P<0.05) overall acceptance. Furthermore, consumer purchase intention was greater (P<0.05) for KMG steaks than others.

Conclusion: These findings suggest that potassium and magnesium chlorides can be utilized as salt-replacers in combination with microbial transglutaminase to develop low-sodium restructured caiman steaks with improved sensory attributes.

Keywords: Caiman meat, microbial transglutaminase, restructured meat, saltreplacers, Sodium reduction

27 CHANGES IN THE PHYSICOCHEMICAL, MICROBIAL AND SENSORY CHARACTERISTICS OF FRESH PORK SAUSAGE CONTAINING VARYING COMBINATIONS OF ROSEMARY (ROSMARINUS OFFICINALIS L.) AND GREEN TEA (CAMELLA SINENSIS L.) EXTRACTS DURING RETAIL DISPLAY.

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Objectives: Comminuted meat products, such as fresh pork sausage, are highly susceptible to oxidative changes and microbial spoilage which compromise the quality attributes and limit the shelf-life of these products. Interest in the application of natural plant extracts with antioxidant qualities in preventing these changes are largely due to consumer demand for clean labels. The objective of this study was to determine the effect of adding combinations of rosemary (RE) and green tea (GTE) extracts on the keeping quality, sensory characteristics and shelf-life of fresh pork sausage during simulated retail display (3 ± 1°C).

Materials and Methods: Fresh pork sausage was prepared from pre-rigor meat mixed with synthetic antioxidants and nine combinations of RE (1500, 2000, 2500 ppm) and GTE (100, 200, 300 ppm) and compared with the control (synthetic antioxidants only). Thiobarbituric acid reactive substances (TBARS), color (CIE L*, a*, b*, C, L*), pH, psychrotrophic plate counts (PPC), proximate composition, and sensory analyses were determined on every 7 d over a period of 21 d. A randomized block design with three replications was utilized to test the effects of adding RE and GTE on the sensory acceptability of fresh pork sausage. When significant differences occurred among treatments, the LSDMEANS function of SAS was utilized to separate treatment means.

Results: RE and GTE improved (P<0.05) oxidative stability as evidenced by lower TBARS compared with the control after 7 d of storage. All RE/GTE combinations resulted in higher CIE a* (redness) and C values throughout 14 d of storage, whereas hue angle was greater (P<0.05) in the control at 7 d of display, indicating slower red color deterioration with added natural extract treatment combinations. PPC were lower (P<0.05) in fresh pork sausages with at least RE2000 and GTE throughout retail display while lower (P<0.05) pH values and moisture content were detected in the control after 14 d of storage. Consumer acceptability scores were higher (P<0.05) in pork sausages with natural plant extracts compared with the control but all pork sausages had average consumer scores between 6 and 7, signifying like slightly to like moderately. Consumers were clustered into 6 segments where 4 treatment combinations (RE1500/GTE300, RE2000/GTE300, RE2000/GTE200, and RE2500/GTE300) were liked by 98% of the respondents. Principal components analysis (PCA) of the sensory data from 0 to 14 d of storage showed that pork sausages with combinations of at least RE2000 and GTE200 were described by positive drivers of liking such as spice complex, ginger, nutmeg, rosemary, pork complex, savory, salty, browned, caramelized flavors and aromas and lower scores for descriptors such as rancid, fruity, copper herbal, off-flavor and off-odor.

Conclusion: Combinations of at least RE2000 and GTE200 increased the shelf-life of fresh pork sausages to 15 d of storage compared with the control whose shelf-life was limited to less than 14 d (between 8-13 d) by psychrotrophic bacterial growth. This research shows that the addition of RE and GTE inhibited lipid-derivatived oxidation and rancidity, improved the keeping quality of fresh pork sausage under simulated retail display and enhanced the sensory properties without negatively impacting the product.

Keywords: fresh pork sausage, green tea extract, retail display, rosemary extract, shelf-life

28 THE EFFECT OF pH AND NITRITE CONCENTRATION ON THE ANTIMICROBIAL IMPACT OF CELERY JUICE CONCENTRATE COMPARED WITH CONVENTIONAL SODIUM NITRITE ON LISTERIA MONOCYTOGENES.

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Objectives: The objective of this study included evaluation of the effect of the pH of celery juice concentrate, normally pH 9-10, on the antimicrobial effect of nitrite on Listeria monocytogenes growth. In addition, equal concentrations of nitrite in celery juice concentrate and conventional nitrite were evaluated to determine the relative impact of these two sources on Listeria monocytogenes growth, independent of pH.

Materials and Methods: Trypticase soy broth and restructured hams were used in this study. Both were prepared with 100 mg/kg and 200 mg/kg nitrite concentration by addition of celery juice concentrate or conventional nitrite. Samples of each were also prepared with the same concentrations of nitrite after adjusting the celery juice concentrate from pH 9.2 to pH 6.0. A 5-strain cocktail of Listeria monocytogenes was prepared and both broth and ham samples inoculated at log 4 cells per ml or gm. Broth samples were analyzed for growth of Listeria monocytogenes during 12 days of storage at 4°C while hams were analyzed for growth during 35 days of storage at 4°C. The pH, residual nitrite and L*, a* and b* color values were measured during storage. Two replications were conducted. Data was analyzed using the statement proc glimmix with the Statistical Analysis System.

Results: Celery juice concentrate was significantly (P<0.05) less effective than conventional nitrite at 100 mg/kg nitrite in broth but in ham, both 100 and 200 mg/kg concentrations of nitrite from celery juice resulted in similar growth of Listeria monocytogenes (P>0.05) to that of 100 and 200 mg/kg of sodium nitrite. The pH of both the broth and the ham was significantly (P<0.05) increased by addition of celery juice concentrate. Adjusting the pH of the celery juice for the ham increased the impact on Listeria monocytogenes growth at 200 mg/kg of nitrite but not at 100 mg/kg. No differences in growth (P>0.05) were observed between the unadjusted 100 mg/kg celery juice concentrate and adjusted 100 mg/kg celery juice concentrate in either the broth or ham experiments. Residual nitrite concentrations were similar within the 100 and 200 mg/kg treatments in the ham study, except for the adjusted (pH=6.3) 200 mg/kg celery juice treatment which had significantly less (P<0.05) residual nitrite than the unadjusted (pH=6.6) 200 mg/kg celery juice and 200 mg/kg sodium nitrite treatments.

Conclusion: Celery juice concentrate has potential to increase meat product pH and may have implications for the antimicrobial impact of nitrite in some processed meat product applications, particularly at low (100 mg/kg) nitrite concentration.
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Keywords: celery juice concentrate, Listeria monocytogenes, nitrite, pH

29 USE OF STABILIZED RICE BRAN AS A MUSTARD REPLACER OR MEAT
REPLACER IN COMMINUTED MEAT PRODUCTS. G. Prabhu*, R. Husak

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Objectives: To evaluate the quality characteristics of regular fat beef hot
dogs utilizing stabilized rice bran to replace mustard or meat.

Materials and Methods: Beef hot dogs containing beef 80% and 50% were
formulated to target 30% fat. Three treatments were evaluated: Control
with 1.5% mustard flour, Treatment 2: 3% SRB replacing 1.5% mustard
flour and 1.5% beef 80% and 50% and Treatment 3: 3% SRB replacing beef
80% and 50% in equal proportions. Hotdogs were evaluated for cook yield
(cooked product weight/uncooked product weight x100). Exterior and
interior color was evaluated using a hand-held HunterLab color reflectance
test equipped with a D65 light source. Texture (peak force) was
measured using a Texture Analyzer equipped with a 1/4” diameter round
probe on the exterior and interior of warm hot dogs compressing the
hotdog to 30% of its height. Purge was measured on vacuum packaged
hot dogs every 4 weeks over 12 weeks of refrigerated storage. Freeze-
thaw purge was measured on frozen hot dogs after 120 days of frozen
storage. Purge was calculated as a percentage of the initial weight[(bag
& product weight)-(bag weight)-(product weight)/(bag & product
weight)-bag weight)]. Results, where applicable, were analyzed for signif-
ificant differences using ANOVA (P<0.05) with StatView 5.0.1 for Win-
dow manufactured by SAS Institute Inc, using a completely randomized
design on three replications.

Results: Results showed that SRB was able to increase cooked yields,
improve the texture and reduce purge loss in hot dogs. Cook yields were
significantly (P<0.05) higher for Treatments 2 and 3 compared to the
Control (P<0.05). The peak force (firmness) was significantly (P<0.05)
higher for Treatments 2 and 3 compared to the control. Interior color
of the hot dogs showed no significant (P>0.05) differences between treat-
ments for L, a and b values. Purge was significantly (P<0.05) lower for
both Treatments 2 and 3 after week 4, 8 and 12 of refrigerated storage
and freeze-thaw purge was also significantly (P<0.05) lower for both test
trials compared to the control.

Conclusion: Until recently, rice bran, a by-product of rice milling, was
considered unfit for prolonged storage and consumption. Due to new
stabilizing technology to inactivate the enzyme lipase, rice bran is no
longer viewed as waste material. Stabilized rice bran (SRB) is an all-nat-
ural, allergen-free/gluten free, functional ingredient which can replace
some or all of the traditional binders and ingredients like mustard (a
declared allergen in Europe and Canada) in meat products. SRB can also
be used to replace meat to provide cost savings while increasing cooked
yield and reducing purge and firming the texture of comminuted meat
products. In June 2008, SRB was approved by USDA as a binder in com-
mminuted meat and poultry products such as sausages, nugget-shaped
chicken patties, meatballs, meat loaf and meat patties where binders are
approved. This ingredient has widespread potential in the modification
of the current and development of next-generation meat products.

Keywords: rice bran, comminuted meat, mustard replacement

30 USE OF SODIUM CARBONATE AND NATIVE POTATO STARCH BLENDS
AS A PHOSPHATE REPLACER IN NATURAL ENHANCED PORK LOINS. G.
Prabhu*, R. Husak

1PHD TECHNOLOGIES LLC, Ames, IA, United States

Objectives: To evaluate sodium carbonate in combination with native
potato starch as a replacement for phosphate in enhanced pork loins.

Materials and Methods: Pork loins were injected to 18% of the green
weight with a salt and phosphate solution (control treatment), or salt,
sodium carbonate and various combinations of pre-gelled and cook up
potato starch (test treatments) as shown in the table below.

Brine pick up was measured pre (immediately) and post drain (2 min,
after injection). Purge was measured on raw vacuum packaged loins on
2, 6, 10 and 19 days of refrigerated storage. Purge was calculated as a
percentage of the initial weight [(bag & product weight)-(bag weight)-(product weight)/(bag & product weight)-(bag weight)]. Color was
measured on the surface of vacuum packaged pork loins on day 2 us-
ing a hand-held HunterLab color reflectance meter equipped with a D65
light source. Pork loins were evaluated for cook yield (cooked product
weight/uncooked product weight x100). Results, where applicable, were
analyzed for significant differences using ANOVA (P<0.05) with StatView
5.0.1 for Window manufactured by SAS Institute Inc, using a completely
randomized design on three replications.

Results: The brine pickup pre and post drain was significantly (P<0.05)
lower for Treatment 2 compared to other treatments. Purge after 19 days
on vacuum packaged refrigerated pork loins was significantly (P<0.05)
higher for Treatments 2 and 3 while lowest purge was seen in Treat-
ment 4 which was not significantly (P>0.05) different from the control
(P>0.05). HunterLab color showed no significant differences in treat-
ments. The cooked yields were significantly higher for Treatment 4 com-
pared to other treatments but was not significantly (P>0.05) different
from the control. The other treatments had lower cooked yield compared
to the control (P<0.05).

Total Finished product formulation

<table>
<thead>
<tr>
<th></th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork loin</td>
<td>84.750</td>
<td>84.750</td>
<td>84.750</td>
<td>84.750</td>
</tr>
<tr>
<td>Water</td>
<td>11.586</td>
<td>11.740</td>
<td>10.840</td>
<td>10.640</td>
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<td>Potassium lactate</td>
<td>2.810</td>
<td>2.810</td>
<td>2.810</td>
<td>2.810</td>
</tr>
<tr>
<td>Salt</td>
<td>0.449</td>
<td>0.449</td>
<td>0.449</td>
<td>0.449</td>
</tr>
<tr>
<td>Sodium tripolosphate</td>
<td>0.403</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Sodium carbonate</td>
<td>0.000</td>
<td>0.200</td>
<td>0.000</td>
<td>0.200</td>
</tr>
<tr>
<td>Cane sugar</td>
<td>0.000</td>
<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
<td>Penpuri 10 (native potato starch)</td>
<td>0.000</td>
<td>0.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>
| Penpuri UM (pre-
gelled potato starch) | 0.000 | 0.000  | 0.100  | 0.100  |
| Rosemary extract | 0.002 | 0.002  | 0.002  | 0.002  |
| **Total**      | **100.00** | **100.00** | **100.00** | **100.00** |

Conclusion: Due to increasing consumer interest for natural meat prod-

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ucts in the US has prompted the need for “clean label” ingredients. It is generally recognized that the addition of phosphate to enhanced pork increases meat pH, increases meat water-holding capacity that assists in reducing purge loss and cook loss. Although functional native starchy are able to replace the water binding capacity and texture provided by phosphate, starchy are not able to work at the molecular level on the actin-myosin complex. Their ability to bind water and improve texture can help achieve phosphate replacement. This study has shown that in natural products, sodium carbonate can be used to increase the meat pH and potato starch (blend of pre-gelled and cook up) can be used to provide the improved water holding capacity thereby resulting in improved cook yield and reduced purge in enhanced pork loins.

Keywords: phosphate replacement, sodium carbonate, potato starch, enhanced pork loin

31 EFFECTS OF TOMATO EXTRACTS AS AFFECTED BY DIFFERENT EXTRACTION SOLVENTS ON PHYSICOCHEMICAL PROPERTIES AND ANTIOXIDANT ACTIVITIES OF PORK PATTIES. H. Kim*, K. B. Chin

*Department of Animal Science and Functional Food Research Center, Chonnam National University, Gwangju, Korea

Objectives: In recent years, increasing attention has been paid to the role of natural antioxidants in human health. Tomato is the most important vegetable for both its large consumption and its richness in functional food components. This study was performed to evaluate the effects of tomato extracts on the physicochemical properties, and antioxidant and antimicrobial activities of pork patties.

Materials and Methods: Ripened fresh tomatoes were purchased from a local market. Prior to drying, fresh tomatoes were chopped, homogenized, and then, dried at 60 °C oven. Distilled water and 50% ethanol (1:20, w/v) were added to tomato powder and stirred to extract functional ingredients. After filtration and freeze-drying of water and 50% ethanol soluble fractions, two dried tomato extracts were obtained (water extracted tomato WET; ethanol extracted tomato, EET). The control (without tomato extract), reference (butylated hydroxytoluene, BHT 0.01%), T21 (WET 1.0%), TR2 (EET 0.5%), and TR3 (EET 1.0%) added patties were prepared and stored at 4 °C for 14 days. pH, Hunter color values (lightness, redness, yellowness), lipid oxidation (2-thiobarbituric acid reactive substances, TBARS, malondialdehyde (MDA) mg/kg), and microbial growth (total bacterial count, TPC; Enterobacteriaceae count, VRB, log cfu/g) of pork patties were measured during 14 days or storage. The entire experiments were replicated three times. Data were analyzed using SPSS 20.0 program. Two-way analysis of variance was used as factors for treatment (control, reference, TRT1, TRT2, TRT3) and storage time (0, 3, 7, 14 d). Significant differences among the means were analyzed by Duncan’s multiple range test (P<0.05).

Results: pH values of pork patties containing WET and EET 1.0% (5.53 and 5.55, respectively) were lower, while Hunter a* (10.2 and 10.1) values were higher than those of the control (5.62 for pH and 8.16 for Hunter a*) (P<0.05). Hunter b* values were higher than the control at day 0, however, there were no differences among all treatments from day 3 to 14 (P>0.05). Pork patties with WET (1.0%) and EET (0.5 and 1.0%) showed lower TBARS values (0.39, 0.39, and 0.16 MDA mg/kg, respectively) than the control (1.69 MDA mg/kg) at day 7 (P<0.05). Pork patties containing tomato extracts showed lower total bacterial counts (3.75, 3.75, and 3.75 for TR1, TR2, and TR3, respectively) as compared to the control (4.18 log cfu/g) (P<0.05). Addition of tomato extracts into pork patties lowered the number of Enterobacteriaceae (4.98, 5.14, and 4.68 log cfu/g for TR1, TR2, and TR3, respectively) than the control (6.78 log cfu/g) at day 14.

Conclusion: These results indicated that tomato water and 50% ethanol extracts could be used as an antioxidant and antimicrobial agent in meat products.

Keywords: antioxidant and antimicrobial activity, extraction solvent, pork patty, tomato extracts

32 CARBON DIOXIDE GENERATION BY TRONA MINERAL IN A MODEL SYSTEM AND ITS USE IN MODIFIED ATMOSPHERE PACKAGING. J. Lee*, K. Allan

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Objectives: Carbon dioxide (CO2) is often used in modified atmosphere packaging (MAP) due to its microbial inhibitory effect. Oxygen level in MAP affects quality of meat such as color, lipid oxidation and microbial growth. Trona is an evaporite mineral (Na2CO3 (H2CO3) (H2O)) and the primary source of sodium carbonate in the USA. In a preliminary study, trona generated CO2 in the presence of acid and moisture. A sufficient amount of moisture was required before CO2 generation initiated. The objective of this experiment was to examine the feasibility of trona as a CO2 producing product in modified atmosphere packaging of steaks.

Materials and Methods: The quality of PVC overwrapped short loins (4 oz; 3/4 inch thickness) packaged with an absorbent pad containing 4 g of trona/acid then placed in a non-gas permeable master package (7 x 7 in²) were compared with those stored in 80% N2/20% CO2 and 80% O2/20% CO2. Short loins were obtained from three different animals for replication. Hunter color, pH, total aerobic plate count (TAC), thiobarbituric acid reactive substances (TBARS) and myofibrillar fragmentation index (FFI) were measured at 0, 6, 12 and 18 days. The headspace CO2 in the bags with trona/acid mixture was monitored at 3, 6, 9, 12 and 18 days. Statistical significance was identified at the 95% confidence level, and post-hoc means comparisons were made based on p-values obtained using the Tukey-Kramer adjustment.

Results: The level of CO2 generated from the trona/acid mixture in the bags was 20% in 3 days and 30% by day 6. On day 12 it dropped to 25.8%, and then to 16% on day 18. There was no significant difference among the steaks packaged in different packaging systems in TBARS and FFI, for entire 18 days of experiment period. The pH in 80% N2/20% CO2 MAP increased steadily through day 18 while the pH of steaks packaged in 80% O2/20% CO2, or with trona increased through day 12 then decreased on day 18. There was no difference in pH among trona and high O2 packaging throughout the entire experiment period. Accelerated surface browning observed in 80% N2/20% CO2 packaging was most likely due to metmyoglobin formation by residual O2 higher than 0.05% despite its low TBARS value. Hunter a* (redness) values were lower (P<0.05) in 80% N2/20% CO2 (5.7 and 4.1 on storage days 6 and 12, respectively), compared to those seen in trona (12.2 and 10.4) or 80% O2/20% CO2 MAP (14.1 and 10.8). Color stability of the meat in trona treatment was similar to those in high O2, MAP, though small brown spots were observed after 6 days. Steaks had higher (P<0.05) TAC in 80% N2/20% CO2 (log10 2.8 and 2.7 CFU/cm²) than those in 80% O2/20% CO2 (log10 1.5 and 1.3) or trona (log10 2.2 and 1.8, respectively).

Conclusion: In conclusion, the mixture of trona and acid is a good source of CO2, and has potential for use as CO2 generating system in meat packaging. However, when the mixture is used in ambient air, discoloration is a possible problem.

Keywords: Carbon dioxide, meat quality and color, modified atmosphere packaging, red meat
33 REDUCTION OF SODIUM IN PROCESSED MEATS USING SOY SAUCE AND NATURAL FLAVOR ENHANCER. W. H. Shazer 1*, J. J. Sindelar 1, L. Jimenez-Matobo 2, S. Rankin 2, T. Sato 3
1Animal Science, 2Food Science, University of Wisconsin-Madison, Madison, WI, 3Kikkoman USA R&D Laboratory, Madison, WI, United States

Objectives: With reduction of sodium becoming an ever increasing target for food companies to build into their products, there is a need to understand how such changes impact sensory characteristics and functional qualities of food products that rely on sodium chloride (NaCl) functionality. The use of naturally brewed soy sauce (SS) and natural flavor enhancer (NFE), a product derived from soy sauce manufacture possessing a lower soy sauce flavor and color, has shown potential to enhance flavor profiles, including saltiness, of some meat products while maintaining product quality. Previous research has suggested SS and NFE can be successfully included in frankfurters for achieving a significant sodium reduction while maintaining salt taste and product quality. However, it is unclear if similar results can be expected for other types of processed meat products with unique, product-specific needs for NaCl inclusion.

Materials and Methods: Four different meat products produced in duplicate with SS and NFE additions were evaluated in this study and included bacon, beef jerky, summer sausage, and boneless ham. For each product, six treatments and a control were investigated. The control included only flake NaCl, and each experimental treatment had NaCl replaced at a 1:1 ratio using either SS or NFE as a NaCl source at three different levels, 25%, 50%, and 75%. Samples were evaluated using a trained sensory panel utilizing commercially available products and basic flavor scales for panel development. Lexicons were developed for each product by analyzing different products on the market for common flavor specifics for each product investigated. Qualitative color (L*a*b*), texture, salt, pH and proximate analysis (moisture, fat, and protein) tests were performed on all samples. Statistics were performed in JMP.

Results: Bacon salt and umami attribute perception increased (P<0.05) with addition of SS/NFE up to 50%. However, a decrease in L* and increases in a* and b* values (P<0.05) were exhibited when SS/NFE was added. Puncture analysis showed greater force (P<0.05) existed with increases in SS levels. Beef jerky containing SS/NFE improved (P<0.05) saltiness and umami responses. Decreases in objective L*a*b* values (P<0.05) were reported at SS 25% and 75% inclusion levels, while NFE treatments revealed lower (P<0.05) b* values for NFE 25% and 50% levels. Summer sausage sensory analysis revealed improvements (P<0.05) in saltiness and umami with increasing SS/NFE levels. Further, decreases in L* values (P<0.05) as SS/NFE levels increased were also observed. Summer sausage a* values displayed a decrease (P<0.05) with addition of SS at any level while chewiness also decreased with all levels of SS/NFE. Sensory analysis performed on boneless ham showed a minimal increase in saltiness with increasing amounts of SS/NFE. Additionally, color analysis indicated decreases (P<0.05) in L* and a* values, and chewiness with added SS/NFE. All products in this study revealed increases (P<0.05) in soy sauce flavor with addition of SS/NFE at any tested level, however detection would not always be expected to be perceivable by consumers.

Conclusion: The results of this study show that SS and NFE can be successfully used to enhance the saltiness in meat products with minimal impact in product quality. Therefore, both SS and NFE offer viable options for meat processors interested in reducing the sodium content in processed meat products.

Keywords: meat, Sensory evaluation, Sodium reduction

34 EFFECT OF SOY SAUCE INGREDIENTS ON LIPID OXIDATION IN TURKEY DELI LOAVES. S. Park 1, R. Wecker 1, N. Tatyaboworntham 1*, T. Sato 2, J. Sindelar 1, M. P. Richards 1
1Department of Animal Sciences, University of Wisconsin-Madison, Madison, WI, 2Kikkoman USA R&D Laboratory, Inc., Madison, WI, United States

Objectives: Lipid oxidation is a major cause of quality deterioration in various raw materials and processed meats. Turkey muscle is particularly sensitive to lipid oxidation compared to chicken, which has been partly attributed to lower concentrations of vitamin E that accumulate in muscles of turkeys compared to chickens. Preliminary sensory analysis suggested that uncured turkey deli loaf formulated with soy sauce had less off-flavor compared to control. Thus, our objective was to determine the effect of using soy sauce as an ingredient to inhibit lipid oxidation in uncured turkey deli loaf during refrigerated storage.

Materials and Methods: Naturally brewed soy sauce (SS) and Natural Flavor Enhancer (NFE), a product derived from soy sauce with less soy sauce flavor and color, were evaluated against a control formulation without soy products added. All 3 treatments included 1.67% NaCl of total formulation (w/w) with half of NaCl provided by either NFE (6.8% w/w of total formulation) or SS (6.1% w/w of total formulation). Deli loaves (formed product) were sliced (2-3 mm thick) and vacuum packaged after thermal processing. Lipid oxidation was measured based on hexanal analysis using solid phase micro-extraction (SPME). Sensory analysis (texture, saltiness, flavor, taste, and overall acceptability) was assessed in the sliced product by experienced panelists (n = 3 to 5) during 11 days of refrigerated storage at 1 °C on the 8-point hedonic test (1 = poor or low saltiness and 8 = good or highly salty). Panelists were familiarized with the onset of quality deterioration by examination of turkey deli loaves that were freshly prepared and also those that were oxidized through extended storage. Data were analyzed using one-way analysis of variance (ANOVA) with SPSS (version 20.0). Means were separated using the Duncan’s Multiple Range Test. Significance was determined using P-value less than 0.05.

Results: Storing ground turkey breast (9.35 mm plate diameter) for 7 days at 1 °C had no effect on hexanal values in the sliced product (two production runs evaluated, n = 2) compared to utilizing ground turkey breast that had not been stored (two production runs evaluated, n = 2). Therefore, there were a total of 4 separate production runs (n = 4). SS and NFE inhibited hexanal formation compared to the control after 1 and 7 days at 1 °C under vacuum packaged conditions (P<0.05). After 7 days of vacuum packaging, the sliced product was transferred to oxygen permeable bags for an additional 4 days of storage (represented as day 11). This simulates storage by a consumer after opening the package at home. SS and NFE suppressed hexanal formation at day 11 compared to control (P<0.05). Hexanal values in control at day 11 were 7.3 ± 0.4 µmol/kg compared to 4.7 ± 0.7 and 4.4 ± 0.5 µmol/kg in slices containing SS and NFE, respectively. Saltiness was elevated in SS (4.85) and NFE (5.25) groups at day 11 compared to control (3.38) (P<0.05). Flavor scores were higher in the SS and NFE at day 7 and day 11 (P<0.05). Taste scores were higher in SS (4.83) and NFE (5.17) at day 11 (P<0.05) compared against control (3.25). There were no differences in sensory scores or hexanal values when comparing SS with NFE at any time point.

Conclusion: These studies indicate that SS and NFE can stabilize lipids in uncured and sliced turkey deli meat during refrigerated storage.

Keywords: antioxidant, poultry, rancidity, soy sauce, warmed-over flavor
35 MECHANISM OF MEAT TENDERIZATION BY SOUS VIDE COOKING. D. Suraatmaja 1,*, T. Lanier 1
1Food, Bioprocessing and Nutrition Sciences, North Carolina State University, Raleigh, NC, United States

Objectives: Various claims have been made concerning the tenderizing effects of sous vide (SV) cooking on tougher meat cuts. Neither the chemical/physical mechanism(s) nor the exact conditions and effects of SV cooking on meat tenderness have been carefully studied however. This investigation sought to determine the required conditions under which tenderization of a lean, tougher meat cut might occur during SV parcooking, and the underlying chemical/physical explanation for the tenderizing effect.

Materials and Methods: Beef eye of round (Semtendinosus) muscle, aged by chilling 14 - 21 days post-mortem, was prepared by extended (24-48 hr) isothermal heating of steaks in evacuated bags held in a waterbath (SV) at 50-58 °C, then finished cooked by grilling to 65 °C internal. These were then cooked to the same mean only grilled to 65 °C with no prior SV treatment. +/- prior injection with a commercially used meat tenderizing enzyme solution (0.011% bromelain injected to 15% w/w).

Some tests and control samples were also pre-injected to 15% w/w with a salt (7%) phosphate (3.5%) solution to enhance moisture retention. Tenderness was evaluated by informal sensory and mechanical (slice shear force, SSF) measurements. Muscle myofibrillar protein integrity, evidenced by myosin heavy chain (MHC) retention (to detect autolytic protein degradation) was measured by sodium dodecyl polyacrylamide electrophoresis (SDS-PAGE). Collagen (connective tissue) degradation was monitored by assaying solubilization of collagen, before or after exposure to controlled proteolysis by pronase (the latter to detect heat-induced unfolding of collagen resulting in tenderization but not collagen solubilization). All differences reported (LSD) were significant at P<0.05.

Results: SSF revealed tenderization only at > 51.5 °C, despite holding (SV) at 50 °C for up to 48hr, meaning some combination of chemical/physical changes switched on only in the 50-51.5 °C range. SV at 56 °C/24 hr, finish cooked to 65 °C, produced SSF equivalent to bromelain-tenderized, fast cooked samples, but bromelain treated meat was highly inconsistent in texture while SV produced a more even (presumably more desirable) tenderization. This tenderization likely resulted from degradation of collagen, not myofibrillar proteins; the enzyme labile fraction, ELF, increased during SV at 56 °C/24hr, in accordance with decreasing SSF, while only slight degradation of myosin was evident by SDS-PAGE. The latter suggests minimal involvement of endogenous proteases in tenderization by SV at 56 °C/24hr. Without preinjection, SV cook yields were lowest, but after preinjection cook yields were not significantly different from the similarly treated control.

Conclusion: A controlled SV parcooking, coupled with preinjection to enhance moisture retention, yields a more evenly tender and succulent grilled steak compared to the use of tenderizing enzyme treatments as commonly practiced in multi-unit restaurant steakhouse chains. Enzyme tenderization often induces mushiness and dryness in steaks. This TenderVide™ parcooking process could allow many tougher cuts to be well accepted insteak restaurants.


Keywords: collagen degradation, enzyme labile fraction, Sous vide, tenderness, tough cut

36 NITRITE-EMBEDDED PACKAGING FILM EFFECTS ON BEEF COLOR AS INFLUENCED BY MEAT AGE AND MUSCLE TYPE. J. Claus 1,*, C. Du 1
1Animal Sciences, University of Wisconsin, Madison, WI, United States

Objectives: The objectives in the research were to evaluate the effect of different beef muscles (Longissimus lumborum, LL; Psoas major, PM, Semtendinosus, ST) and muscle aging (2, 9 d postmortem) on NEF-aged steaks displayed (fresh, 19 d, 2 °C; frozen, 39 d, -11 °C) on meat color.

Materials and Methods: Color was measured during the first 48 h of display (0, 12, 24, 36, 48 h) and then every 24 h (CIE L*“a*“b*“ L*“ lightness, a*“ redness, b*“ yellowness; and chroma C*; illuminant D65, 0 viewing angle; AMSA, 1991). NEF packaged companion fresh displayed steaks were opened (day 6) and overwrapped in oxygen permeable film (polyvinylchloride, PVC) and then displayed (0, 6, 24 h). Cooked color of fresh displayed (5 d) LL steaks was measured and compared with cooked non-NEF vacuum packaged steaks. Companion frozen NEF packaged steaks were stored in the dark for a color comparison. Residual NOx (nitrite, nitrate) was measured on 9 aged raw (control) muscles as well as the surface (3 mm thick) of NEF fresh displayed steaks (19 d; cooked LL fresh steaks; frozen LL steaks stored in dark, and under the light display (39 d). Fluorescent display lighting was used continuously to provide 1615 lux (unfrozen: 3000; frozen: 3500 K). Data (four replicates) were analyzed using Proc Mixed procedure of SAS to determine main effect and interaction effects. When significance (P<0.05) was found in the model, means were separated by pairwise comparisons using the PDFF option of SAS.

Results: Fresh NEF increased (P<0.05) in redness during the first 48 h (CIE a*, 15.1%; chroma C*, 14.4%). Upon opening fresh NEF and PVC overwrapping, steak redness declined (P<0.05) by 37.7% (2 d) and 41.8% (9 d). Steaks from less aged muscles were (P<0.05) more red, had greater color saturation and less Mb. PM had highest (P<0.05) chroma C*. NEF packaged cooked LL surface was redder (P<0.05; CIE a*, 12.1) compared to non-NEF (9.5). Exposure to light during frozen display decreased (P<0.05) CIE a*, chroma C*, and redness estimator (%reflectance at 610 nm/reflectance at 525 nm) by 21.2%, 21.3%, and 11.8% respectively compared to dark storage. However, intact NEF packages maintained acceptable red color throughout display (fresh, frozen) based on an average chroma C* above 16. Absolute residual nitrite and nitrate levels (above non-NEF) associated with fresh NEF (1.8 ppm nitrite; 15.4 ppm nitrate) and nitrate in NEF cooked LL (7.4 ppm) were found (P<0.05) in the outer layer.

Conclusion: Consideration should be given to providing sufficient time for nitric oxide myoglobin development when using NEF which may be influenced by meat age and muscle differences. NEF packaging has potential to extend fresh beef color display life. NEF appears to offer the opportunity to display bright red beef in frozen display by limiting the typical effects of photooxidation.


Keywords: beef color, display, fresh and frozen, meat age, Nitrite-embedded film
37 EFFECTS OF VACUUM TUMBLING TIME AND SAL T CONCENTR ATION ON THE PROCESSING AND QUALITY CHARACTERISTICS OF REDUCED SODIUM NATURAL DELI-STYLE TURKEY BREAST. D. Schroeder 1*, D. E. Burson 1, G. A. Sullivan 1
1Animal Science, University of Nebraska, Lincoln, NE, United States

Objectives: Consumer demand for low sodium products formulated with minimal ingredients stimulated this research. The objective was to produce reduced sodium natural deli-style turkey breast by evaluating the effect of vacuum tumbling time and salt concentration on processing and quality characteristics.

Materials and Methods: Natural deli-style turkey was formulated with varying salt concentrations (1.0%, 1.5%, 2.0%), 1.0% sugar, and water to equal 25% added ingredients. A standard control formulation was produced to include 1.0% sugar, 2.0% salt, 1.0% sugar, 0.35% phosphate, and 22.65% water. The meat block consisted of 85% kidney plated turkey breast and 15% 3/16” ground turkey breast. Batches of 11.34 kg were vacuum tumbled for 3 or 3 hours at refrigeration temperatures. Batches were vacuum tumbled in casings and cooked to an internal temperature of 160 °F. Cooked turkey breast was sliced for a Bizerba slice into 13mm slices for texture profile analysis (TPA), and 2mm slices for sliceability and fold tests. Sliceability was defined as the percent of intact slices from 3 sets of 25 slices. Fifteen slices were used to conduct a fold test, which is a measure of binding strength. Texture profile analysis was performed to quantify the characteristics of hardness, chewiness, cohesiveness, resilience, and gumminess. Data were analyzed using the PROC GLIMMIX procedure in SAS.

Results: Mean treatment values for hardness (P = 0.36) and sliceability (P = 0.06) were similar for all treatments. However, the slices from the control treatment with phosphate had greater (P<0.05) mean values for springiness, resilience, and chewiness compared to the natural treatments for all salt concentrations and mixing time combinations. In addition, the slices from the natural treatments with 1.0% salt had lower (P<0.05) mean values for springiness, resilience, and fold test than the slices from 2.0% salt treatments and the slices from the phosphate added control. Additional analysis on the effect of salt level and mixing time was conducted for the natural treatments in a factorial design. With this analysis, the effect of tumbling time was not significant (P>0.05) in the model for all measures and the effect of salt was significant (P<0.05) for springiness, resilience, chewiness, sliceability, fold test, and cooking yield. For these measures, the slices from treatments with 1.0% salt were lower (P<0.05) than the slices from treatments with 2.0% salt. In addition, gumminess, sliceability, and fold test for 1.0% salt slices were also lower (P<0.05) than slices from treatments with 1.5% salt.

Conclusion: Production of reduced sodium natural deli-style turkey breast without phosphate is lower in texture and processing properties than deli-style turkey breast produced with phosphate. In addition, reducing salt concentration to 1.0% produces natural deli-style turkey breast with less acceptable texture and processing characteristics compared to 1.5% or 2.0% added salt.

Keywords: natural deli-style turkey, sliceability, Sodium reduction, texture profile analysis, vacuum tumbling time

38 MECHANICAL TENDERIZATION CAN ALTER FRESH MUSCLE CHARACTERISTICS OF STEAKS FROM THE BEEF ROUND. R. P. Wyatt 1*, C. R. Ahrens 1, J. T. Sawyer 1, B. D. Lambert 2, T. W. Schwertner 1, C. T. Thomas 1, M. H. Light 1, K. H. Keahey 1, A. J. Fink 1, K. G. McCall 1, T. P. Jones 1
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Objectives: Evaluating the impact of mechanical tenderization on fresh characteristics of beef may increase the acceptability of underutilized muscles from the round and chuck. In the retail setting, tenderized round or cube steaks are blade tenderized by passing through a mechanical tenderizer one or more times. This study focused on the number of passes through a mechanical tenderizer and the subsequent changes to fresh characteristics of beef round steaks.

Materials and Methods: Fresh Biceps femoris and Semimembranosus subprimal steaks were purchased from a major beef packing facility, aged for 14 d and randomly assigned to a tenderization methodology (single; double; triple; double – folded; triple – folded). Subprimal steaks (Biceps femoris N = 15, Semimembranosus N = 16) were fabricated into 1.27 cm-thick steaks and passed through a mechanical tenderizer. Each steak was placed onto a styrofoam tray with an absorbent pad, over-wrapped with a poly-vinyl chloride film (PVC), and placed into a three-tiered retail display case set at 2 °C for 7 d. Throughout the 7d simulated retail display period steaks were assessed for sensory and instrumental color, pH, purge loss and thiobarbituric acid reactive substance assay (TBARS). Steaks allocated to instrumental tenderness and cooking yield were placed into a vacuum package and frozen at -20 °C until analysis could be completed.

Results: Sensory panelist ratings for total color decreased (P<0.05) for steaks passed through the tenderizer three times regardless of muscle. Whereas, discoloration percentages were greater (P<0.05) for steaks only passed through the tenderizer one or two times for both muscles. Instrumental color values (L*, a*, and b*) decreased (P<0.05) from d 0 to d 7 for both Biceps femoris and Semimembranosus steaks. Instrumental color readings (a* and b*) decreased significantly (P<0.05) as retail display time increased for both muscles, however, Biceps femoris steaks had less redness (a*; P<0.05) after passing one or two times through the tenderizer. There were no differences (P>0.05) across tenderizing treatments for purge loss and lipid oxidation increased throughout the display period (P<0.05) regardless of muscle. Adding a folding procedure during tenderization aided in inhibiting lipid oxidation (P<0.05) as noted in steaks from both muscles. Instrumental tenderness values were greater (P<0.05) for steaks folded and passed two or more times from the biceps femoris. However, there were no differences (P>0.05) in tenderness for Semimembranosus steaks. Cook yield was greater (P<0.05) for steaks that were folded and passed two or more times through the tenderizer for both the Biceps femoris and Semimembranosus.

Conclusion: Nonetheless, the results generated from this study suggest that folding and multiple passes through a mechanical tenderizer can improve some fresh muscle characteristics, but do not offer overwhelming improvements in mechanical tenderness of steaks from the Biceps femoris or Semimembranosus.

Keywords: instrumental color, sensory color, beef, mechanical tenderization, shear force
39 A COMPARISON OF BACON SENSORY CHARACTERISTICS OF IMMUNOLOGICALLY CASTRATED BARROWS WITH OTHER SEX CLASSES. J. M. Kyle 1*, K. L. Little1, B. M. Bohrer1, A. L. Schroeder1, C. A. Fedler3, K. J. Prusa 3, D. D. Boler 1
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Objectives: The objective was to compare bacon sensory attributes of immunologically castrated barrows (IC) with other sex classes when evaluated by a trained sensory panel. Two separate experiments obtained bacon samples for sensory evaluation. Experiment 1 compared IC barrows, IC barrows fed ractopamine hydrochloride (IC + RAC), physically castrated (PC) barrows, intact males (IM), and gilts (G). Trimmed and squared bellies from pigs (n = 188) slaughtered at 130 kg were used in the experiment. Data were analyzed as a SAS GLM model. The fixed effect in the model was sex class. Experiment 2 compared IC and PC barrows fed 0%, 30%, or a 30% DDGS/withdraw distillers grains program when slaughtered at 5 or 7 weeks post 2nd dose (25 and 27 wks of age). Data were analyzed as a 2 x 3 factorial arrangement in a randomized complete block design. Bellies from pigs (n = 193) were untrimmed, natural fall bellies.

Materials and Methods: Bellies from both experiments were cured, smoked, pressed and sliced using the same commercial protocol. Bellies were divided into five equal zones representing approximately 20% of the length of the belly. One slice was collected from the middle of each of the 5 zones for sensory evaluations. Slices were identified, vacuum packaged, frozen, and sent to Iowa State University for sensory evaluation using a 15 cm unstructured line scale.

Results: In experiment 1, IM (boar aroma = 6.24) had the greatest (P<0.05) boar aroma (BA), while all other treatment groups were similar (P>0.05), [BA for IC barrows (0.10), IC + RAC (0.30), PC barrows (0.28), and G (0.16), respectively.] IM (cured bacon aroma = 3.65) had the least (P<0.05) desirable cured bacon aroma and the other sex classes were not different (P>0.05). IM (cured bacon flavor = 3.85) had the least (P<0.05) desirable cured bacon flavor, while there were no differences among the other sex classes (P>0.05). IM (boar flavor r = 2.55) had the greatest (P<0.05) boar flavor. All other sex groups were not different (P>0.05) and had minimal boar flavor values. There were no differences (P>0.05) among any sex classes for off-flavor. In experiment 2, pigs slaughtered at 5 weeks post 2nd dose were not different (P>0.05) between IC and PC barrows fed different levels of DDGS for raw weight, cooked weight, cook loss, aroma score, bacon off-flavor, bacon flavor, and saltiness parameters. However, a sex x diet interaction was observed in bacon off-flavor scores (BOFS). PC barrows fed DDGS withdraw (BOFS = 0.08) were the lowest (P<0.05), IC barrows fed 0% DDGS (BOFS = 0.17), PC barrows fed 30% DDGS (BOFS = 0.17), and PC barrows fed 0% DDGS (BOFS = 0.30) were intermediate. IC barrows fed 30% (BOFS = 0.37) and DDGS withdraw (BOFS = 0.37) were the greatest, but not different (P>0.05) from the intermediates. Pigs slaughtered at 7 weeks post 2nd dose were not different (P>0.05) for raw weight, cooked weight, aroma score, bacon off-flavor, bacon flavor, and saltiness parameters.

Conclusion: Overall, panelists were successfully able to detect boar odor. Immunological castration is as effective at eliminating boar odor as physical castration even when feeding differing DDGS levels or when harvested at 5 or 7 weeks post 2nd dose.

Keywords: bacon, immunocastration, sensory evaluation

40 EFFECT OF POSTMORTEM AGING TIME ON TUMBLING MARINATION PERFORMANCE OF BROILER BREAST FILLETS. H. Zhuang 1*, B. C. Bowker 1, D. Samuel 1
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Objectives: Previous data demonstrated that water-holding capacity (WHC), as measured by the salt-induced water uptake method, increases with aging up to 24 h postmortem in early-deboned chicken breast fillets (pectoralis major). Therefore, it was hypothesized that 24 h postmortem aging may enhance marination performance in chicken breast meat. The objective of this study was to determine the influence of postmortem time of marination on the pickup and retention of NaCl-based marinade in boneless skinless broiler breast fillets.

Materials and Methods: Broiler breast fillets (n = 24), which were removed from carcasses (42-day-old broilers) 2 h postmortem, were collected from a commercial deboning line. The right and left fillets from each butterfly were separated and one was marinated at 6 h postmortem and the other at 24 h postmortem. Fillets were vacuum-tumbled (20 KPa at 15 rpm for 20 min) in a 20% solution (w/w) with a targeted final concentration of 0.75% salt and 0.45% sodium tripolyphosphate and 15% marinade pickup. Marination performance parameters measured included marinade pickup at 5 and 20 min, marination retention (24 h after marination), marination weight gain, and cook loss. Data were analyzed in SAS using PROC UNIVARIATE for WHC and PROC MIXED with a model that included postmortem aging time as a fixed effect and replication and butterfly as random effects for marination performance.

Results: At 24 h postmortem samples exhibited greater (P<0.05) salt-induced water uptake than at 6 h postmortem (80.0% vs. 57.6%). Overall marinade pickup was 8.8% after 5 min of marination and 14% after 20 min of marination. Fillets marinated at 6 and 24 h postmortem exhibited similar marinade pickup (P>0.60). Marination retention was greater than 98% after 24 h of storage, overall marination weight gain was 11.6%, and cook loss was 12.7% across all samples. The postmortem time at which samples were marinated had no effect on marination retention or cook loss (P>0.70).

Conclusion: Data show that with a targeted 15% marinade pickup, aging fillets to 24 h postmortem prior to marination does not enhance marination performance compared with marinating chicken fillets at 6 h postmortem.

Keywords: breast muscle, broiler, marination, postmortem time, vacuum-tumble

41 THE EFFECT OF A LOW SODIUM CURING SOLUTION ON FURTHER PROCESSED HAMS FROM PUREBRED BERKSHIRE PIGS FED A STEP-UP RACTOPAMINE FEEDING PROGRAM. B. M. Bohrer 1*, J. M. Kyle 1, K. L. Little 1, H. N. Zerby 1, D. D. Boler 1
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Objectives: Objectives of the study were to test the effect of a lower sodium curing solution on processing characteristics of hams from purebred Berkshire pigs fed a step-up ractopamine (RAC) feeding program or a negative control diet.

Materials and Methods: Three-piece (inside+outside+knuckle) sectioned furred hams were cured with a standard cured solution (1.98% NaCl; REG) or a low sodium with potassium chloride substitute (0.67% NaCl and 1.29% KCl; LOW) cure solution. Lowering sodium in curing solution may create processing challenges associated with water holding capacity and protein binding. Berkshire pork contains a higher propor-
tion of type 1 muscle fibers, thus greater water holding capacity and an elevated ultimate pH when compared with other breeds. Sixty pairs (n = 120) of hams were randomly selected from 2 blocks of purebred Berkshire pigs (n = 200) fed either 7.4 mg of RAC/kg of diet for 14 days followed by 10.0 mg of RAC/kg of diet for the last 14 days prior to slaughter or a negative control diet. Pigs were weighed and ultrasonic measurements were taken for 10th rib fat thickness and loin muscle area weekly. Objective cured ham color was measured by slicing the cured hams 3/4" from the factory clipped end of the netting using a minolta colorimeter (L*, a*, b*). Growth and ultrasonic data were analyzed as repeated measures over time with fixed effects of diet, day, and their interaction. Live and carcass data were analyzed as randomized complete block design. Cured ham data was analyzed as a 2 x 2 factorial in a split-plot design.

Results: Pigs fed RAC had greater (P<0.01) loin muscle area when compared to control fed pigs. There was no overall difference (P = 0.83) in fat thickness during the finishing period. Overall, RAC fed pigs tended (P = 0.09) to have greater (P<0.05) percent lean at d 14, 21, and 28 of the finishing period. At the end of the finishing period, RAC fed pigs were 3.29 kg heavier (3.2% improvement; P<0.01) than control pigs. Furthermore, RAC fed pigs had a 0.10 kg/d greater ADG (11.9% improvement; P<0.01), and a 0.03 greater feed efficiency (10.3% improvement; P = 0.02) over the 28 day finishing period. No differences (P>0.11) were detected between RAC and control fed pigs for loin ultimate pH, marbling, firmness, subjective or objective color, drip loss, cook loss, shear force, or proximate composition. No differences (P>0.07) were detected in ham weights throughout processing, pump uptake (P>0.41), or cook yield [(cooked weight / green weight) x 100; P>0.27] for the effect of diet, cure solution, or the interaction between diet and cure solution. However, LOW hams had greater (P<0.05) lightness (L*) and yellowness (b*) and lesser (P<0.05) redness (a*) values than REG hams. Break strength (an indication of protein interaction) of LOW hams (5.97 kg) required less (P = 0.05) force to break than REG hams (6.99 kg). Additionally, LOW hams (24.58%) had a lower (P<0.01) protein fat-free (PFF) value than REG hams (25.98%).

Conclusion: Overall, using a potassium chloride substitute (LOW) in comparison to a standard solution (REG) had impacts on objective visual color and protein bind of hams, but may be a justifiable way to lower sodium content of processed meat products without detrimentally affecting processing yields.

Keywords: low-sodium ham, meat processing, Ractopamine

42 EFFECT OF PREHEATING ON THE GEL CHARACTERISTICS OF PORK MYOFIBRILLAR PROTEIN GELS WITH RED BEAN PROTEIN AND 7S GLOBULIN

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Objectives: Red bean protein (RBP) has been reported to be divided by 7S or 115 globulin, like other legumin proteins. Since RBP mainly consists of major 7S globulin, this study was to determine the gel properties of myofibrillar protein (MP) with the addition of 7S globulin as compared to the RBP. In addition, gel characteristics of pre-heated RBP and 7S globulin were investigated if they have interactions among MP gels.

Materials and Methods: MP mixtures with raw RBP and 7S globulin, or preheated RBP and 7S globulin at 95 °C temperature were evaluated by viscosity, sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) and differentialscanning calorimetry (DSC). And the cooked MP gels were also measured by cooking yields (Cy), gel strength (GS) and Scanning electron microscopy (SEM).

Results: SDS-PAGE profile of RBP showed that 7S globulin of acidic sub-units were identified at the molecular weight of 38-45 kDa. DSC results indicated that RBP and 7S globulins were shown at 93 °C and 95 °C as unfolding peak, respectively. Cy of MP gel with RBP and 7S globulin increased with the addition of RBP alone as compared to the control. The addition of RBP or 7S globulin decreased the GS, however, the addition of pre-heated protein (RBP or 7S) improved the GS. The addition of pre-heated RBP or 7S globulin of RBP improved the viscosity of the gel mixture. The addition of RBP increased more thermal stability of first and second peak than the control (MP alone), regardless of pre-heating. SDS-PAGE profile indicated that the addition of pre-heated RBP or 7S decreased myosin heavy chain band more than control. SEM showed that RBP could increase void of MP gel, while pre-heated RBP or 7S gels confirmed more compact structure than the control.

Conclusion: These results suggested that pre-heated RBP and 7S protein improved the gel properties of pork MP mixture.

Keywords: myofibrillar protein, red bean protein, 7S globulin, gel properties

43 EFFECT OF NATURAL ANTIOXIDANT CONCENTRATION ON LIPID OXIDATION OF READY TO EAT GROUND BEEF LINKS FROM CATTLE FED DISTILLERS GRAINS IN DIFFERENT PHASES OF PRODUCTION

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Objectives: Lipid oxidation in ground beef products may increase when distiller’s grains are fed to cattle. Furthermore, there is an increase in the usage of antioxidants from natural sources, due the large interest to clean up labeling in meat products. The objective of this study was to evaluate the effectiveness of natural rosemary and green tea extract in beef from cattle fed distiller’s grains.

Materials and Methods: Cattle were randomly assigned to a 2X2 factorial that included 2.27 or 0.91 kg of wet distiller’s grain during the winter/spring back-grounding phase and either sweet bran or modified wet distiller’s grains during the finishing phase (40% DM). All cattle were supplemented with modified wet distiller’s grain at a rate of 0.6% of BW during the summer stocker phase. A total of 16 cows from four carcasses from each dietary treatment group were collected. Each cow was independently ground and divided into three 2.27 kg batches. All treatments contained 0.75% salt, 0.25% phosphorus and either 0, 0.13% or 0.20% rosemary plus green tea extract (FORTIUM RGT12 Plus Dry Natural Plant Extract; Kemin, Des Moines, IA). Beef and non-meat ingredients were mixed for 1 min and the mixture was stuffed into skinless links using a piston stuffer. After cooking, links were placed in individual foil trays for each cow and cooked to an internal temperature of 71 °C. Links were placed in zip-top bags and placed in dark refrigerated storage. Lipid oxidation was evaluated on days 0, 3, 6, 9, 12, 15 and 18 using the thiobarbituric acid reactive substances (TBARS) analysis. Data were analyzed as a 2X2 factorial with repeated measures (day) using the PROC GLIMMIX procedure of SAS.

Results: An antioxidant concentration × day interaction (P<0.05) was observed, whereas no significant dietary treatment interactions or main effects were observed. The lack of dietary effects (P>0.16) is likely due to the addition of antioxidants. On days 9, 12, 15 and 18, links with no added antioxidants were more oxidized (P<0.05) than all treatments with either concentration of antioxidant on any day. There was no (P>0.05) differences between any day when using 0.13 or 0.20% concentrations of antioxidants.
Conclusion: Results indicate that when no antioxidants are added, samples stored at or beyond 9 days were more oxidized than those samples with added antioxidant. Additionally, no differences in lipid oxidation were observed among 0.13 and 0.20% antioxidant concentrations among refrigerated storage days. The possible compromising effects of distillers grains on beef quality were nullified by the addition of antioxidants.

Keywords: antioxidant, distiller’s grains, ready-to-eat beef, rosemary and green tea extract, TBARS

44 EFFECT OF NATURAL ANTIOXIDANT ADDITIVES IN GROUND BEEF FROM GRASS FINISHED STEERS. K. McCalland 1, R. Cox 1
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Objectives: The objective of this study was to evaluate four natural antioxidant additives and their effect on shelf life and color stability in ground beef from grass finished steers.

Materials and Methods: Twenty-four Angus steers were grazed on ryegrass pasture at the North Central Research and Outreach Center (NCROC) in Grand Rapids, MN. Cattle were allowed to graze until sufficient forage was available to support gain at which time cattle were transported to the University of Minnesota Meats Laboratory in Saint Paul, MN. At 48 hours postmortem carcass data was collected and inside rounds (IMPS #168) and shoulder clods (IMPS #114) removed from the right side of each carcass. Shoulder clods and inside rounds were ground in (4 animals/group; 6 groups total; 6 replications) twice through a 0.375-cm grinder plate. Each group was divided into five 35 kg batches (30 batches total) and assigned randomly to one of five antioxidant treatments: control (CON); ground wild rice (WR); rosemary extract (Rose); cherry seed powder (Cherry); rosemary and pomegranate extract (XtraBlend). Each antioxidant solution was added at 1% into 105 kg of water then mixed into its respective batch for 1 minute. The same amount of water was also added to the control treatment and mixed. Two trays of fresh, ground beef (0.5 kg) from each batch were packaged with PVC overwrap and stored at 4 °C under cool white fluorescent lighting for seven days. Objective color values (L*, a*, and b*) were taken with a HunterLab Miniscan EZ with a 2.5 cm aperture and D65 illuminant, at three locations on each ground beef package. Remaining ground beef from each batch was immediately formed into 0.09 kg patties for sensory analysis. Patties were cooked to an internal temperature of 71 °C, cut into eight sections and each untrained consumer panelist received one piece from each treatment with two replications per treatment. Panelists were asked to evaluate ground beef for overall liking, flavor liking, texture liking, toughness, juiciness, and off flavor. Liking attributes were rated on a 120 point scale and all other attributes were rated on a 20 point scale with 0 = none and 20 = extremely. Data were analyzed as a randomized block design and were subjected to the MIXED procedure of SAS. Group was considered the experimental unit and an alpha level of 5% was used to determine statistical significance.

Results: L* and b* did not differ between treatment (P = 0.49 and 0.66, respectively), however the inclusion of cherry did increase a* values compared to all other treatments (P = 0.01). For sensory evaluation, texture liking was decreased with the XtraBlend treatment compared to the WR and cherry treatments (P = 0.006), with all other treatments having similar results. Toughness was decreased with the inclusion of WR (P = 0.03) as compared to XtraBlend and juiciness increased with the addition of cherry (P = 0.003). Overall liking, flavor liking, and off flavor was unaffected by treatment (P = 0.09, 0.07, and 0.06, respectively).

Conclusion: In conclusion, the addition of natural antioxidant compounds to products susceptible to lipid oxidation can improve and prolong shelf life stability. Results of this study have shown the inclusion of cherry seed powder lead to an increase in a* value, increased shelf stability, and an increase in juiciness in for ground, pattied beef.

mEATQuAlTy: GENERAL ABSTRACTS

45 DEVELOPMENT OF A STIR BAR SORPTIVE EXTRACTION AND THERMAL DESORPTION – GAS CHROMATOGRAPHY-MASS SPECTROMETRY METHOD FOR DETERMINATION OF FLAVOR COMPOUNDS IN GRILLED BEEF. E. D. RUAN 1, M. Juárez 1, J. L. Aalhus 1
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Objectives: The objective of the present study was to develop a simple, rapid, and solvent-less sampling method for identification and further quantitative analysis of target flavor compounds in cooked beef samples by using stir bar sorptive extraction (SBSE) with thermal desorption-gas chromatography-mass spectrometry (TD-GC-MS).

Materials and Methods: Standards for volatile/flavor compounds were purchased from Sigma-Aldrich and extracted samples were analyzed by gas chromatography coupled with a mass-selective detector (Agilent). Lean beef was grilled at 200 °C for 6 min. Dipping was collected in cooking and grilled beef was ground after cooling down on ice. Around 3 g ground beef and 3 ml dipping samples were put into 15 ml sample vials with 8 ml extraction solution (75% saturated NaCl with 25% MeOH, v/v). Two stir bars were used for SBSE (Gerstel) for 45 min, 1000 rpm, at room temperature and two stir bars were placed in thermal desorption tube for analysis by using TD-GC-MS.

Results: To achieve optimum extraction and analysis performance for flavor compounds in beef by SBSE and TD-GC-MS the thermal desorption temperature for background (cyclopentane from Twister bar) and for flavor compounds was optimized. PDMS material intensity in the background was reduced with no negative effects on potential target compounds. The SBSE conditions for potential flavor compounds, including salt addition, extraction temperature and extraction time, were examined, based on four flavor compounds: hexanal, methional, 2-ethylpyrazine and nonanal (n = 3, RSDs < 8%). The optimized method showed good linearity over the concentration range from 0.5 ng/mL to 200 ng/mL for all analytes and correlation coefficients were higher than 0.998 (n = 4, RSDs < 5%). The limits of detection (LOD) range was 0.17 – 0.26 ng/mL and the limits of quantification (LOQ) range was 0.56 – 0.88 ng/mL for all four analytes.

Conclusion: The method was successfully applied to low-level concentration of flavor in grilled beef and grilled beef dipping samples. In total, 57 compounds were identified, including 30 flavor compounds. At the same time, semi-quantification of the four selected flavor compounds in ground grilled beef and grilled beef dipping samples was successful.

Keywords: flavor compounds, GC-MS, grilled beef stir borsosptive extraction (SBSE), thermal desorption

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Objectives: Ractopamine is a feed additive utilized to increase leaness in pigs. More than three-fourths of fresh pork is further processed to variety of products. While the influence of ractopamine on fresh pork has been extensively examined, limited information is available on the effect of this feed additive on further processed and ready-to-eat pork products. Therefore, our objective was to evaluate sensory and instrumental characteristics of frankfurters manufactured from ractopamine fed gilts and barrows.

Materials and Methods: Ten gilts (GL) and ten barrows (BR) were used in this study. During the finishing period, five animals (n = 5) from each sex were fed with 7.5 ppm ractopamine (RAC) or without ractopamine (CON) for 21 days prior to harvest. The pigs were divided based on diet and sex, and were raised in four separate pens containing five animals each. Animals were humanely harvested, and carcasses were fabricated after 24 h chilling. Green hams were deboned, and the lean meat and fat from the same treatment and replicate were processed into emulsion containing 53% lean meat, 25% fat, and 18% added water. The emulsion was stuffed in cellulose casings, and the frankfurters were cooked to an internal temperature of 75 °C in an oven. Cooking yield and proximate composition were determined. Mouthfeel, flavor, and odor were evaluated by sensory panelists. In addition, instrumental analysis was accomplished for texture (cohesiveness, springiness, hardness, and resistance) and color (L*, a*, and b*) attributes. The data were analyzed using principal component analysis.

Results: Principal component analysis explained 83.46% of the total variance in data. Principal component 1 represented 58.11% of the explained variance and separated the treatments in two groups: GL-CON and BR-RAC; GL-RAC and BR-CON. The representative parameters for this separation were texture (springiness, cohesiveness, and resilience), color (L*, a*, and b*), cooking yield, proximate composition (lipid, protein, and moisture), and overall acceptance. GL-CON and BR-RAC exhibited greater (P<0.05) cohesiveness, resilience, L*, and cooking yield than the other two treatments. On the other hand, GL-RAC and BR-CON frankfurters had greater (P<0.05) protein and moisture contents, springiness, a*, and b* than other treatments, resulting in an improved overall acceptance. Principal component 2 represented 25.35% of explained variance and separated the treatments into two new groups based on sex. Mouthfeel was greater (P<0.05) for BR than for the GL group. Combining principal components 1 and 2 revealed four different groups; gilts were apart from barrows, whereas CON was different from RAC. The planar arrangement of data suggested that dietary ractopamine influenced the quality attributes of pork frankfurters and that gilt and barrows respond differently to dietary ractopamine.

Conclusion: Our results indicated that the influence of ractopamine on quality attributes of pork frankfurters is sex-specific. Swine industry may adopt sex-specific dietary strategies to optimize the quality of further processed pork products.

Keywords: color, pork frankfurters, Ractopamine, sensory evaluation, texture

47 IMMUNOCASTRATION AND SURGICAL CASTRATION IMPROVES COLOR ATTRIBUTES OF BEEF FROM NELLORE MALES. G. Z. Miguel 1, 2, 3, 4*, R. O. Roca 1, S. P. Suman 1, M. H. Faria 5, C. T. Santos 1, F. D. Resende 1, G. R. Siqueira 1, L. S. Su 1
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Objectives: Immunocastration is a non-invasive management strategy that ensures welfare of meat animals. The metabolic consequences of immunocastration are similar to those of surgical castration. Nellore is a major beef breed in Brazil, where immunocastration is approved in beef production. The effects of immunocastration on quality of beef from Nellore male animals are yet to be examined. Therefore, the objective of the present study was to determine the effects of immunocastration on quality attributes of Longissimus lumborum steaks from Nellore cattle.

Materials and Methods: Twenty-nine Nellore males were raised on pasture for 22 months. The animals were then fed at the feedlot for 90 days in individual pens. Nine animals were surgically castrated (SRC) 28 days before transferring to feedlot. Ten animals were immunocastrated (IMC) by vaccinating twice with anti-GnRH vaccine (Bovriva, Pfizer Animal Health) at 28 days and one day before the transfer to feedlot. Ten animals were kept intact (NOC). At the feedlot, the animals were fed a high-grain diet containing 85% concentrate. The animals were harvested, and the carcasses were chilled for 24 h at 2 °C. The carcasses were fabricated, and one 2.5-cm steer was cut from the Longissimus lumborum muscle at the 12th rib of the left side of the carcasses. The steaks were individually vacuum packed immediately and frozen until further analysis. Frozen steaks were thawed overnight, and instrumental color (L*, a*, and b* values) was evaluated on the surface. Thawed steaks were cooked to an internal temperature of 71 °C, and cooking yield and shear force were determined. The experiment was a completely randomized design, and data were analyzed using the MIXED procedure. Fixed effect was sexual condition, and the means were compared by Student’s t-test at 5% level of significance.

Results: While shear force and cooking loss were similar (P>0.05) among the treatments, instrumental color demonstrated differences (P<0.05). SRC and IMC steaks were similar (P>0.05) in all color parameters, but were different (P<0.05) from NOC steaks. Steaks from NOC animals were darker (P<0.05; lower L* value) than the steaks from the castrated animals. In addition, redness (a* value) and yellowness (b* value) were greater for SRC and IMC steaks than the NOC ones. Redness is an important trait influencing consumer purchase intention of fresh beef. Our results indicate that castration (surgical as well as immunological) of Nellore male animals improved surface redness and decreased darkness of Longissimus lumborum steaks. Beef from castrated Nellore males demonstrated better color attributes than beef from non-castrated animals.

Conclusion: The greater redness of steaks from castrated animals than those from intact males suggests that consumers may be inclined to purchase beef from immunocastrated and surgically castrated Nellore males.

Keywords: beef quality, immunocastration, meat color, nellore cattle
48 THE EFFECT OF CITRUS FIBER ON QUALITY OF GROUND BEEF MEATBALLS. A. Gedikoglu 1*, A. D. Clarke 1
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Objectives: Use of functional ingredients has been adopted to increase protein content, and replace or reduce fat content of the meat products. Recently, there is a growing interest in increasing fiber content of food products, including meat products. Fiber not only provides different functions through reducing fat content and gelling properties but also provides nutritional health benefits. Citrus fiber obtained from citrus peel and albedo is a byproduct of the fruit juice industry. The effect of citrus fiber on quality of meat products is not well investigated. Therefore, the objective of this study was to determine the effect of different citrus fiber (CF) levels (0%, 1%, 5% and 10%) on quality attributes of ground beef meatballs at day 0, 3, 6 and 9.

Materials and Methods: Citrus fiber used in this study was a dry powder. Different levels of citrus fiber were weighed and mixed with 85% lean ground beef using a stand mixer. Then, all the treatments were made into meatballs, packaged, labeled and kept in the refrigerated temperature for further use. Quality attributes tested were pH of both raw and cooked samples, water holding capacity (WHC) of raw samples, cooking yield (CY%), texture profile analysis, and color L (Lightness), a (redness), b (yellowness) values for raw samples, and moisture, protein and fat content. Experiment was conducted in triplicates.

Results: Results of this study showed that treatment and day had significant (P<0.01) effect on both raw and cooked samples. The pH of both raw and cooked samples increased over time. On the other hand, both treatment and day had no significant (P>0.05) effect on water holding capacity of raw ground beef samples. Samples with highest level of citrus fiber (10%) had the highest water holding capacity and treatment levels had significant (P<0.01) effect on cooking yield with increasing the concentration of citrus fiber increased the cooking yield. Mean cooking yield at day 0 were 65.56% for Control, 72.44% for CF1%, 80.11% for CF5% and 85.07% for CF10%. All of the texture parameters were significantly (P<0.01) affected by the treatments. Day had a significant effect on hardness (P<0.01) and cohesiveness (P<0.05) values. Hardness and cohesiveness of all samples decreased over time. Increasing the fiber concentration had negative correlation with hardness, springiness, cohesiveness, gumminess, chewiness and resilience of the ground beef samples. Color L, a, b values were also significantly (P<0.05) affected by the addition of the citrus fiber. L and a values were highest for control group and b value was highest for CF 10%. Protein and fat concentrations were not significantly (P>0.05) different for treatments. On the other hand, a treatment difference was found for moisture content of the samples (P<0.05). Samples with 10% CF had the lowest moisture content and was significantly (P<0.01) different than control samples.

Conclusion: Results of this study showed that citrus fiber can be added to ground beef meatballs in lower levels (1% and 5%) to increase cooking yield and water holding capacity thereby providing fiber content with no detrimental effect on texture and color.

Keywords: citrus fiber, color, cooking yield, ground beef meatballs, texture

49 EFFECT OF FEEDING DE-OILED WET DISTILLER’S GRAINS PLUS SOLUBLES ON BEEF OXIDATION. K. Domenech 1*, C. R. Calkins 1, M. Chao 1, M. Semler 1, K. Varnold 1, G. Erickson 1
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Objectives: This research was conducted to determine if feeding de-oiled wet distiller’s grains plus solubles (WDGS) caused negative effects on retail display (RD) life and oxidation after aging compared to a corn or full-fat WDGS diet.

Materials and Methods: A total of 336 steers were fed one of seven dietary treatments: an all corn control, 35%, 50%, or 65% inclusion of WDGS, either full-fat or de-oiled. After harvest, 15 low Choice carcasses were selected within each treatment (N = 105) and strip loins were obtained. Samples were aged 7 and 21 days and placed in RD conditions for 7 days.

Results: Treatment had no effect on discoloration in samples aged for 7 days (P>0.05). After 21 days of aging, discoloration was significant at 5 days of RD (P<0.001) and all samples surpassed 50% discoloration by day 7 of RD. At day 5 RD, meat from the corn control had the most discoloration (20.03%) and was as equally colored as 50% de-oiled WDGS and 65% full-fat WDGS (15.42% and 14.98%, respectively). At day 6 RD, 65% full-fat WDGS had the most discoloration (50.30%) followed by 65% and 50% de-oiled WDGS (40.20% and 39.50%, respectively). By day 7 RD, 65% full-fat and 65% de-oiled WDGS showed the most discoloration (76.72% and 69.88%, respectively) while 35% de-oiled WDGS presented the least discoloration (52.98%). Treatment had a significant effect on oxidation (P<0.0001), as measured by the amount of thiobarbituric acid reactive substances. The corn control was found to have the highest amount of oxidation (1.98 mg/kg), and was not statistically different from 35% full-fat WDGS (1.78 mg/kg) and 65% full-fat WDGS (1.78 mg/kg). The oxidation measures suggest that de-oiled WDGS and 50% full-fat WDGS had less oxidation, yet these data were not in full agreement with the discoloration data. There was an increase in tenderness at 21 day aging (P<0.0001) and, as RD progressed (P<0.0001), dietary treatment had no effect on WBSF (P = 0.5729).

Conclusion: At 7 days of aging, dietary treatment had no effect on RD discoloration and all samples had an increase in oxidation regardless of the treatment. However, at 21 days of aging, feeding de-oiled WDGS had less oxidation compared to the corn control and several of the full-fat WDGS treatments. These findings suggest that dietary treatment at short aging periods do not have a large impact on shelf life stability and oxidation, but with prolonged aging periods and RD, feeding de-oiled WDGS can reduce oxidation.

Keywords: beef, De-oiled WDGS, oxidation, retail display

50 BACKGROUND GRAZING, SUPPLEMENTATION, FINISHING DIET AND AGING AFFECT FLAVOR IN LONGISSIMUS DORSI STEAKS. K. Varnold 1*, C. Calkins 1, R. Miller 1, G. Erickson 1
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Objectives: The objective of this study was to determine diet and aging combinations that generate desirable beef flavor.

Materials and Methods: Crossbred steers (n = 64) were grazed on warm or cool-season grasses, without or with energy supplementation from wet distillers grains with solubles (WDGS), and were finished on corn or 35% WDGS. Six carcasses from each treatment (n = 48) that graded USDA Choice or Select were identified and Longissimus dorsi muscles from each side of each carcass were collected and aged undervacuum for 7 and 28 d. Steaks displayed at retail conditions for 7 d were used for
consumer taste panels in Kansas and Texas. Panelists (n = 120 per city) rated cooked steaks for overall acceptability, overall flavor acceptability, and beefy flavor and intensity (1 = extremely dislike or extremely bland and 9 = extremely like or extremely intense). The beef lexicon panel at Texas A&M University, College Station, TX was used to analyze the hedonic scores for beef flavor. The supplemented steaks rated higher than the control group on all attributes except for “overall flavor.” The beef lexicon scores for overall flavor were significantly higher for the supplemented group (P = 0.01). Grass type caused the most biochemical changes in meat. Grazing cool-season grasses also shifted the FA profile, but provision of an energy supplement during grazing seemed to minimize the changes.

Keywords: biochemically constituents, diet, fatty acids, forages, supplementation

52 NUTRIENT DIFFERENCES OF BEEF FROM HEIFERS WITH DIFFERENT GENOTYPES FOR MYOSTATIN. M. Semler 1*, C. Calkins 2, G. Erickson 3
1Animal Science, University of Nebraska, Lincoln, NE, United States
2Objectives: The objectives of this study were to determine nutrient and composition differences in heifers from different genotypes (Angus, Angus x Piedmontese, and Piedmontese).
Materials and Methods: Heifers were genotyped for zero (OC), one (1C), and two (2C) copies of the inactive myostatin allele leading to an increase in muscle fiber number (hyperplasia) and yielding a leaner carcass for the 2C animals (n = 19, 20, and 20). At 3 d post mortem the Longissimus dorsi (LD) and Semimembranosus (ST) muscles were collected from each carcass (n = 59/muscle). Steaks to be used for nutrient analysis (proximate, lipid, and mineral) were cut 1.3 cm thick, trimmed to 3 mm of fat, and frozen at -20 °C for future analyses. Warner-Batzler shear force (WBS) analysis for tenderness was conducted on steaks that were aged for 14 d and never frozen. Six cores were taken from each steak parallel to the muscle fiber.
Results: There were no differences in WBS values among genotypes for either the LD or the ST. The following trends seen in the LD were consistent with the ST. Fat content (P<0.01) and total calories (P<0.01) were lower while moisture (P<0.01) and protein (P<0.01) were higher for 2C samples compared to OC. When lipids were analyzed, 2C samples had a higher level of cholesterol (P<0.01), a lower percentage of monounsaturated fatty acids (P<0.01), and a higher percentage of polyunsaturated fatty acids (P<0.01) than 0C and 1C samples. For trans fatty acids, 2C samples had a higher percentage (P<0.01) when compared to OC. The percentages of saturated fatty acids were not significantly different. Mineral analysis showed increased potassium levels (P<0.01) and increased calcium (P<0.01) for 2C samples compared to OC and 1C samples.
Conclusion: In summary, meat from 2C cattle had lower fat and calorie content and more polyunsaturated fatty acids than OC cattle. No differences were observed for WBS values for either the LD or the ST.
Keywords: beef, myostatin, nutrient analysis, Piedmontese

53 TENDERNESS AND PALATABILITY OF NILGAI ANTELOPE MEAT. T. J. Machado 1, C. L. Jordan 1, C. M. Albert 2
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2Objectives: Nilgai antelope (Boselaphus tragocamelus Pallas) are a common exotic ungulate in south Texas. The objectives of the study were…
to determine 1) the impact of degree of doneness on tenderness and moisture content of nilgai steaks, and 2) determine if beef or pork fat influenced nilgai flavor in ground nilgai patties. **Materials and Methods:** For the degree of doneness segment, nilgai and beef Longissimus steaks were subjected to three degree of doneness treatments (63, 71 and 74 °C). The fabrication of nilgai steaks occurred by removing the *Longissimus dorsi* from nine female nilgai carcasses. The selection of the *Longissimus* from the left or right side was randomized. Six steaks from each *Longissimus* were cut 2.54 cm thick and two steaks from each individual were assigned to the three sides (n = 18 steaks per treatment). Steaks were vacuum packaged and aged 7 d then frozen (-20°C). Three USDA Choice beef strip loins from electrically stimulated carcasses and wet aged 21 d were frozen (-20°C), and then cut into 2.54 cm thick steaks. Beef steaks were randomly assigned to the three treatments (n = 9 per treatment). The measurements for shear force from the two nilgai steaks per *Longissimus* per degree of doneness were averaged to obtain a single shear force value. Cooking loss was determined from a cooked weight five minutes after cooking and cooler loss was determined from the cooked weight and weight 24 h after cooking. Percent moisture was conducted on the remnants of the shear force steaks, seared cores and steaks pieces, using a method from the Association of Analytical Communities (AOAC). For the nilgai flavor segment, ground nilgai was assigned to the following three treatments: 1) 100% nilgai no fat inclusion, 2) 85% nilgai, 15% beef fat, and 3) 85% nilgai, 15% pork fat. The ground nilgai samples were formed into 114 g patties and evaluated by a trained sensory panel for nilgai flavor intensity, juiciness, texture and off-flavor. The scale used for nilgai flavor intensity, juiciness, and texture was an eight point scale (1 = extremely bland, dry, and crumbly; 8 = extremely intense, juicy, and rubbery) and off-flavor was on a four point scale (1 = extreme off-flavor; 4 = no off-flavor). **Results:** Beef steaks were tougher (P<0.05) (2.48 kg vs. 1.98 kg), with less (P<0.05) cooking loss (15.94% vs. 19.88%), less (P<0.05) cooler loss (1.78% vs. 3.90%), and had a greater (P<0.05) percent moisture (55.82% vs. 45.29%) than nilgai steaks. For both beef and nilgai steaks, the increase in degree of doneness resulted in an increase (P<0.05) in toughness. The steaks cooked to 63 °C had the least (P<0.05) cooking loss. There was no (P>0.05) interaction for species and degree of doneness for shear force, cooking loss, cooler loss or percent moisture. The ground nilgai with no fat inclusion had the highest (P<0.05) nilgai flavor intensity, the lowest (P<0.05) juiciness scores, and the most (P<0.05) crumbly. There was no difference (P>0.05) between beef or pork fat inclusion on nilgai flavor intensity, juiciness, texture or off-flavor. **Conclusion:** Based on the results of the study, nilgai was more tender than beef and increasing the cooking temperature of nilgai steaks resulted in tougher, drier steaks. Use of beef and pork fat in ground nilgai products resulted in similar sensory characteristics providing flexibility for processors. **Keywords:** Nilgai, palatability, tenderness

54 **PRINCIPAL COMPONENT ANALYSIS OF CONSUMER PALATABILITY SCORES OF BEEF STRIP STEAKS IN RELATION TO TRAINED PANEL DESCRIPTORS, VOLATILE FLAVOR COMPOUNDS, FREE AMINO ACIDS, AND REDUCING SUGARS:** P. R. Broadway, J. F. Legako, T. Dinh, M. F. Miller, K. Adhikari, J. C. Brooks

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**Objectives:** Flavor is an important component of beef palatability that influences consumer acceptability and purchasing. The objective of this study was to identify the relationships between consumer preference, flavor descriptors, volatile flavor compounds, and flavor precursors to better understand the drivers of beef flavor. **Materials and Methods:** Strip loins representing three USDA quality grades from two collections (Prime, Low Choice, and Standard; PRCL1, PRCL2, LCCL1, LCCL2, STCL1, and STCL2) were used to determine preference by consumer panel and flavor attributes by trained panelists. Volatiles were extracted from the head space of cooked steaks using solid-phase microextraction and subsequently analyzed by gas chromatography/mass spectrometry. Reducing sugars, sugar phosphate derivatives, and free-amino acids were extracted from raw and cooked steaks and quantified by high-pressure liquid chromatography with a fluorescence detector. Principle component analysis (PCA) was performed on consumer palatability trait data. **Results:** Principal component 1 and 2 explained 83% and 10% of the variances, respectively, and were retained to determine coefficients of correlation with other variables. The correlation coefficients of the variables were plotted with treatment scores (x coordinate = PC1 correlation coefficients or scores; y coordinate = PC2 correlation coefficients or scores) to evaluate variable relationships and treatment rankings. Treatments PR-CL1 and PR-CL2 scored (0.63, -0.05) and (0.93, 0.33), respectively; whereas ST-CL1 and ST-CL2 treatments scored (-1.00, 0.73) and (-0.94, -1.00), respectively. Overall liking, flavor, flavor intensity, tenderness, and juiciness were all positively correlated (r = 0.84 - 0.99; P<0.04) to PC1. Flavor descriptors initial flavor, beef-like flavor, brown/roasted, and umami were positively correlated to PC1 (r = 0.83 - 0.94; P<0.04) and closely related to consumer preferences. Volatile compounds previously shown to contribute to off-flavor were in close proximity with the descriptors green, livery, oxidized, metallic, cardboard, and bitterness. Strecker aldehyde producing free-amino acids (serine, threonine, alanine, valine, methionine, isoleucine, leucine, phenylalanine, lysine) in raw steaks were related with short chain volatile aldehydes (3-methyl butanal, 2-methyl butanal, isobutanal), whereas free-amino acids from cooked steaks were found to be more related to taste descriptors. In raw steaks, cysteine and cystine were in close proximity with ribose, glucose, and glucose-6-phosphate and sulfur-containing volatile compounds (dimethyl sulfide and dimethyl disulfide), as well as Maillard reaction compound 2,5-dimethyl pyrazine. **Conclusion:** The variances of consumer preference scores were primarily explained by PC1 and can be used to explain the relationships of volatile compounds, trained attributes, and flavor precursors among three USDA quality grades. **Keywords:** amino acids, flavor, principal component, sugars, volatiles

55 **EFFECT OF DEGREE OF DARK CUTTING ON TENDERNESS AND FLAVOR ATTRIBUTES OF BEEF:** A. L. Grayson, S. D. Shackelford, R. O. McKeith, D. A. King, R. K. Miller, T. L. Wheeler

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**Objectives:** The objective of this experiment was to determine the effects of degree of dark cutting (DC) on tenderness and flavor descriptive attributes of beef. **Materials and Methods:** During routine grading procedures at a large-scale U.S. beef harvesting facility (36 h chill), DC carcasses (n = 160) and matching normal cohorts (NC; n = 160) were selected for the study. *Longissimus lumborum* (LL) pH was determined online and DC carcasses were classified as severe DC (SEDC; mean pH = 6.9, n = 40),
moderate DC (MODC; mean pH = 6.6, n = 40), mild DC (MIDC; mean pH = 6.4, n = 40) or shady DC (SHDC; mean pH = 6.1, n = 40). Mean pH for NC was 5.7. Not all of the DC carcasses were ungraded (No Roll) carcasses. In fact, for SHDC less than half of the carcasses were No Roll. The number of carcasses in each of the DC classes for Certified Angus Beef, U.S. Choice, U.S. Select, and No Roll was 0, 1, 3, and 36 for SEDC; 0, 2, 3, and 35 for MODC; 0, 6, 8, and 26 for MIDC; 0, 6, 16, and 18 for SHDC; and 8, 83, 67, and 2 for NC. Vacuum-packaged strip loins (LL) were obtained from the left side of each carcass and aged (2 °C) to 14 d postmortem. One steak (2.54 cm) was collected for fresh 14 d slice shear force (SSF). A 6 cm section was frozen (2, 2.54 cm steaks per section) and used for trained descriptive analysis of tenderness, juiciness (8 = extremely tender/juicy, 1 = extremely tough/dry) and flavor (0-15 point scale from low to high intensity). Data were analyzed using PROC GLIMMIX in SAS.

Results: Slice shear force was higher (P<0.05) for SHDC (251 N) and MIDC (225 N) than MODC (190 N), NC (174 N), and SEDC (165 N). Sarcomere length was shorter (P<0.001) for all DC classes (1.66, 1.67, 1.71, and 1.73 μm for SEDC, MODC, MIDC, and SHDC, respectively) than NC (1.86 μm). Additionally, sarcomere length was shorter for SEDC and MODC than SHDC (P<0.01). Western blotting of desmin to assess the extent of postmortem proteolysis at 14 d postmortem indicated that samples from NC had approximately 10% more proteolysis than all DC classes (P<0.05). Trained sensory panel ratings for tenderness differed (P<0.05) among each class and indicated that SEDC (6.5) was most tender, MODC (6.1), MIDC (5.2), and NC (4.9) were intermediate, and SHDC was least tender (4.7). Panelist scores for tenderness did not agree with SSF and could be attributed to sensory panel samples being frozen (and subsequently thawed) prior to evaluation. Juiciness ratings differed (P<0.05) among each DC class (5.9, 5.7, 5.4, and 5.2 for SEDC, MODC, MIDC, and SHDC, respectively). Despite differing in pH, juiciness was similar for SHDC and NC. Fat flavor scores increased from NC progressively through the DC classes as pH increased (1.4, 1.6, 1.9, 2.0, 2.2 for NC, SHDC, MODC, MIDC, and SEDC, with NC and SHDC differing from MODC and SEDC (P<0.001). Musty flavor scores were higher (P<0.001) for SEDC and MODC than other groups. In accordance with the pH differences, all DC classes had lower sour flavor scores than NC (P<0.001).

Conclusion: This study shows DC and NC carcasses differed in LL tenderness, juiciness, and flavor attributes and the direction and/or magnitude of those differences varies greatly depending on the severity of DC. Steaks from DC with intermediate pH (SHDC) are most likely to be tough, yet many SHDC carcasses are included in routine U.S. Select and U.S. Choice product lines.

Keywords: beef, dark cutter, flavor, tenderness

56 EVALUATING QUALITY CHARACTERISTICS OF GROUND ROUND FORMULATED WITH THREE FAT SOURCES. Z. Callahan 1*, M. Brown 1, C. Ballard 1, J. Nasrallah 1, C. Lorenzen 1, B. Wiegard 1
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Objectives: This research was performed to determine if changing the source of fat for inclusion in ground beef from the round will cause a change in the number of days that the ground beef has a visible shelf-life as influenced by oxidation. The objectives were to evaluate the color stability and degree of fat oxidation in storage of ground beef patties and to determine the influence of fatty acid profile on the extent of ground beef lipid oxidation and shelf-life of ground beef patties over 7 d of refrigerated retail storage.

Materials and Methods: Beef carcasses (n = 30) were chilled for two days and then fabricated. Top round muscles (IMPS # 168) were removed and closely trimmed. Within each carcass, three sources of fat (visceral = V, subcutaneous = S, or seam = I) were sourced to blend with the top round to achieve either 75% or 93% lean ground beef. Trim and fat blocks were individually ground through a coarse 10 mm plate. Final meat blocks (862 g lean and 45 g of fat) for 93% lean product and (680 g of meat and 227 g of fat) for 75% lean product were blended and finely ground through a 4.5 mm plate. The 907 g of product from each treatment within animal then was used to create four, 115g patties to be used for the shelf-life study. Patties were placed on Styrofoam trays and overlapped with oxygen permeable, polyvinyl chloride and placed in refrigerated retail storage (4 °C) where an instrumental measurement of color (L*, a*, b*) and thiobarbituric acid reactive substances (TBA) were collected on d 1, 3, 5, and 7 of the study. The additional 447 g of sample was placed in a whirl-pack bag, stored at 4 °C, and used for fat and moisture % determination, myoglobin concentration, fatty acid analysis, and calculated iodine value (IV).

Results: Data analysis indicated different (P = 0.0004) saturated fat (SFA) percentages (V > I > S) with means of 57.9%, 53.5%, and 52.1%, respectively. Calculated IV differed (P = 0.003) where V < I = S with means of 33.9, 37.1, and 38.3, respectively. Changes in fat profile likely explain differences (P = 0.007) in TBA values where V = S > I with means of 0.110 mg/kg, 0.118 mg/kg, and 0.120 mg/kg, respectively. However, fat percentage of ground beef did not change (P = 0.83) TBA values (75% = 0.116 mg/kg and 93% = 0.116 mg/kg). Minolta a* value differed (P = 0.004) where S>V with I not differing from S or V (S = 14.78, I = 14.52, and V = 14.46). However, these differences in Minolta a* reflectance were likely not discernible by visual appraisal of ground beef patties.

Conclusion: Fat source is a significant contributor to quality indicators in ground beef patties and should be considered when formulating products intended for fresh, refrigerated retail sale.

Keywords: fat percentage, ground round, iodine value, Lipid oxidation

57 EFFECT OF SUBPRIMAL TYPE, QUALITY GRADE, AND AGING ON DISPLAY COLOR STABILITY OF GROUND BEEF PATTIES. C. M. Highfill Garner 1*, J. A. Unruh 1, M. C. Hunt 1, E. A. E. Boyle 1, T. A. Houser 1
1Animal Science, Kansas State University, Manhattan, KS, United States

Objectives: A factorial arrangement of treatments was used to evaluate the effects of two subprimal types (chuck roll and knuckle), two quality grades (Premium Choice and Select), and three vacuum storage aging times before processing (7, 21, and 42 d) on ground beef patty display color stability.

Materials and Methods: At the end of each aging time (7, 21, and 42 d), four knuckles or two chuck rolls representing their respective quality grade categories were combined and ground to form a sample batch. Six replicates were made for each of the 12 treatment combinations. Patties (113 g) were formed using a patty machine, packaged in PVC-overwrapped trays, and displayed in a coffin-type retail case (two defrost cycles) under continuous fluorescent lighting at 2 °C. Trained color panelists evaluated ground beef patties using an 8-point scale for visual color (1 = Extremely bright cherry-red to 8 = Extremely dark red) and discoloration (1 = Very bright red to 8 = Tan to brown). One ground beef patty package from each sample was analyzed for CIE (Illuminant A) L* (brightness), a* (redness), and b* (yellowness) using a HunterLab MinScan™ EZ (Model 4500) with an aperture of 31.8 mm and a 10° observer. Visual and instrumental color were evaluated after 0, 24, 48, and 72 h with display time used as a repeated measure.

Results: In a subprimal type x quality grade interaction (P<0.05), ground beef patties from chuck rolls had (P<0.05) higher percentages of fat than those from knuckles and patties from Premium Choice subprimal were fatter (P<0.05) than those from Select subprimals. Ground beef patties from chuck rolls had (P<0.05) brighter red visual color scores, less dis-
coloration, and higher L*, a*, b*, and chroma values than those from knuckles. In addition, Premium Choice patties had (P<0.05) brighter red visual color scores, less discoloration, and higher L*, a*, b*, and chroma values than Select patties. With increased display time, Patties became (P<0.05) darker red and more discolored and had (P<0.05) decreased L*, a*, b*, and chroma values and increased hue angle values. A subprimal type × aging time × display time interaction (P<0.05) occurred because chuck roll subprimals aged for 42 d were (P<0.05) darker and more discolored at 48 and 72 h of display than chuck rolls aged 7 and 21 d. Furthermore, if a visual and discoloration score of 5 was considered the threshold of consumer acceptability, ground beef patties from knuckle subprimals were the first to reach this threshold at approximately 24 h, chuck roll subprimals aged 42 d reached this threshold at approximately 48 h, and chuck roll subprimals aged 7 and 14 d reached the threshold at approximately 72 h.

**Conclusion:** Therefore, Premium Choice chuck rolls aged for fewer days than 21 d could be utilized to maximize display color life.

**Keywords:** aging, display color, ground beef, quality grade, subprimal type

58 EFFECT OF SUBPRIMAL TYPE, QUALITY GRADE, AND AGING ON SENSORY PROPERTIES OF GROUND BEEF PATTIES. C. M. Highfill Garner*,†, J. A. Unruh 1, H. C. Hunt 1, E. A. E. Boyle 1, T. A. Houser 1

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**Objectives:** A factorial arrangement of treatments was used to evaluate the effects of two subprimal types (chuck roll and knuckle), two quality grades (Premium Choice and Select), and three vacuum storage aging times before processing (7, 21, and 42 d) on ground beef sensory attributes.

**Materials and Methods:** At the end of each aging time, four knuckles or two chuck rolls representing their respective quality grade categories were combined and ground to form a sample batch. Six replicates were made for each of the 12 treatment combinations. After a final grind, fatty acid analyses were conducted on raw uncooked ground beef samples. Patties (113 g) were formed using a patty machine, placed on trays, and crust frozen at -40 °C before vacuum packaging and storage at -20 °C until analysis. For sensory panels and instrumental tenderness (slice shear force, textural profile analysis [TPA], and Lee-Kramer shear), patties were thawed at 2 °C for 24 h and cooked on a griddle to an internal end point temp of 71 °C. For sensory panel traits of firmness, cohesiveness, juiciness, beef flavor intensity, mouth coat, off-flavor, and desirability, the chuck roll and knuckle subprimals were analyzed separately resulting in a 2 × 3 factorial arrangement of treatments with panel added to the model as a blocking factor.

**Results:** Knuckle subprimals had (P<0.05) lower percentages of total fatty acids (TFA) and saturated fatty acids (SFA) resulting in a greater (P<0.05) monounsaturated fatty acid (MUFA) to SFA ratio than those from chuck roll subprimals. Premium Choice subprimals had (P<0.05) greater percentages of TFA and MUFA and lower percentages of SFA resulting in a greater (P<0.05) MUFA:SFA ratio than those from Select subprimals. For the chuck roll, ground beef patties from Select subprimals were (P<0.05) firmer and had (P<0.05) less mouth coating than those from Premium Choice subprimals. However, for the knuckle, ground beef patties from Premium Choice and Select subprimals had similar (P>0.05) scores for all sensory traits. Ground beef patties from chuck roll subprimals had (P<0.05) lower slice shear force, Lee-Kramer shear force, and TPA hardness values but greater (P<0.05) TPA springiness than those from knuckle subprimals. Patties from Premium Choice subprimals had (P<0.05) lower slice shear force, Lee-Kramer shear force and TPA hardness values than those from Select subprimals. As aging time increased, ground beef patty slice shear force, Lee-Kramer shear force values and springiness decreased (P<0.05). Even though the percentages of total fat and fatty acid composition varied among the patties, patties from chuck roll and Premium Choice subprimals and subprimals aged for longer periods of time had more instrumental tenderness (lower shear force values) than those from knuckle and Select subprimals and subprimals aged for fewer days, respectively. However, sensory panelists detected few differences in sensory traits for subprimal types from either the chuck roll or knuckle.

**Conclusion:** Thus, ground beef from all treatment combinations of subprimal type, quality grade and aging time would be acceptable in palatability.

**Keywords:** aging, ground beef, quality grade, sensory, subprimal type

59 EXPLORING THE RELATIONSHIPS BETWEEN CONSUMER PALATABILITY RANKING AND FATTY ACID COMPOSITION OF BEEF STRIP STEAKS WITH VARIOUS INTRAMUSCULAR FAT CONTENTS. L. D. Woolley †*, J. C. Brooks ‡, C. H. Corbin 1, A. J. Garmyn 1, J. F. Legako 1, T. T. Dinh 1, M. F. Miller 1

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**Objectives:** Flavor is an important component of beef palatability that influences consumer acceptability. Beef flavor is greatly affected by the oxidation of lipids, which depends on the degree of saturation of fatty acids (FA). Intramuscular lipids are composed of the neutral lipid (NL) fraction primarily consisting of triglycerides and the more unsaturated polar lipid (PL) fraction containing phospholipids. The objective of this study was to identify the relationships between consumer preference and the FA composition.

**Materials and Methods:** Strip loins (n = 4; WBSF value ≤ 3.4 kg) of 10 categories USDA Prime (PR), High Choice (HC; upper 1/3 choice), Low Choice (LC; lower 1/3 Choice), Select (SE), Standard (ST), USDA High Choice and Select from Holstein cattle (HOLTC and HOLSEL, respectively), Australian Wagyu (AUWA), American Wagyu (AMWA), and Grass-finished (GR) were selected (all aged 28 d, except 48 d for GR). Strip loins were fabricated into 2.5-cm thick steaks and further processed into 5×5 cm pieces. Each steak was cooked on an electric clamshell grill for 5 min at a grill surface temperature of 225 °C. Consumers were served one sample from each treatment. Each sample was evaluated for tenderness, juiciness, flavor and overall liking on a 1-10 cm, verbally anchored line-scale. Lipids were extracted from raw steaks, fractionated into NL and PL, derivatized to FAME and determined by gas chromatography. Principle component analysis (PCA) on consumer palatability rankings was performed, which resulted in two PCs- PC1 and PC2 explaining 98% and 2% of variances, respectively. The PC1 and PC2 were used to determine treatment scores, which were subsequently correlated with lipid variables. The treatment PC scores and variable correlation coefficients were plotted together (x coordinate = PC1 scores or correlation coefficients; y coordinate = PC2 scores or correlation coefficients) to evaluate relationships among variables and treatment rankings.

**Results:** Tenderness, juiciness, flavor and overall palatability were all positively correlated to PC1 (r = 0.98 to 0.99; P<0.001) and plotted near PR, AMWA and AUWA. Treatment PC, AMWA and AUWA were highly scored by PC1, compared to lower PC1 scores of ST, SE, HOLSEL and GR. However, AUWA and GR (0.58 and 1.00, respectively) had similar PC2 scores. Percentage of MUFA was more greatly related to PR, AMWA and AUWA. Percentage of MUFA was more closely related to SE, HOLSEL, ST and GR treatments. Fatty acids from NL were related to PR, AMWA and AUWA,
except arachadonic acid (C20:4n6). The MUFA and SFA from PL were located closely to PR, AMWA and AUWA.

**Conclusion:** The variances of consumer preference were primarily explained by one PC and can be used to explain the relationships of lipid fraction among ten treatments. These results indicate that FA composition of NL and PL were highly correlated to consumer preference, including beef flavor.

**Keywords:** beef quality, flavor, lipid, principal component analysis, strip loin steaks

60 CASPASE-3 DOES NOT ENHANCE IN VITRO BOVINE MYOFIBRIL DEGRADATION BY μ-CALPAIN. D. Mohrhauser 1*, S. Kern 1, K. Underwood 1, A. Weaver 1
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**Objectives:** Tenderness is a key component of palatability which influences consumers’ perception of meat quality. There are a variety of factors that contribute to the tenderness of beef carcasses including post-mortem proteolysis. A more complete understanding of this biological mechanism regulating tenderness is needed to ensure consistently tender beef. Numerous reports indicate μ-calpain is primarily responsible for the degradation of proteins postmortem. Meanwhile, it has been shown that caspase-3 can cleave calpastatin, the inhibitor of μ-calpain. Therefore, the objective of this study was to determine if in vitro degradation of calpastatin by caspase-3 can enhance the postmortem breakdown of myofibrillar proteins by μ-calpain.

**Materials and Methods:** Bovine Semitendinosus muscles were excised from two carcasses 20 min postmortem. Muscle strips were dissected from the Semitendinosus, restrained to maintain length, and placed in a neutral buffer containing protease inhibitors. Upon rigor completion, myofibrils were isolated from each strip and sarcromere length was determined. Samples with similar sarcromere lengths were then incubated at 22 °C with either μ-calpain, μ-calpain + calpastatin, μ-calpain + caspase-3 + calpastatin, or caspase-3 + calpastatin. After 0.25, 1, 24, 48, or 72 h at a pH of 6.8, proteolysis of troponin T (TnT) and calpastatin was evaluated using SDS-PAGE and western blotting techniques.

**Results:** Analysis of western blots confirmed significant degradation of calpastatin by caspase-3. Additionally, western blots revealed intact calpastatin disappeared rapidly as a result of digestion by μ-calpain. While caspase-3 did not significantly degrade TnT, all μ-calpain digestion treatments resulted in substantial TnT breakdown. Degradation of TnT did not differ between the μ-calpain + calpastatin and μ-calpain + caspase-3 + calpastatin digests.

**Conclusion:** Results of this study indicate caspase-3 cleavage of calpastatin does not enhance in vitro degradation of troponin T by μ-calpain.

**Keywords:** Calpastatin, Caspase, proteolysis, tenderness, μ-Calpain

61 INFLUENCE OF AN ANTIOXIDANT ON THE SHELF-LIFE AND QUALITY OF GROUND BEEF STORED IN A HIGH-OXYGEN MASTER PACKAGE PRIOR TO DISPLAY. J. Martin 1*, C. Moon 1, T. R. Brown 1, P. R. Broadway 1, T. Dinh 1, J. C. Brooks 1
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**Objectives:** Master packaging allows for the utilization of case-ready packaging while balancing the consumers’ preference for overwrapped fresh meat. Limited information regarding the use of high-oxygen (HI-OX) master packaging is available; furthermore, the efficacy of an antioxidant in this system is unknown. Therefore, we aimed to evaluate the effects of HI-OX master packaging on the shelf-life, color stability, and quality traits of overwrapped ground beef treated with a natural antioxidant blend.

**Materials and Methods:** Finely ground beef chubs (80:20; lean:fat) were obtained from a commercial processing facility. At 7 d post-processing, chubs were removed from storage, finely ground, and portioned onto black expanded polystyrene trays. After portioning, one-half of the trays were randomly assigned to an antioxidant application (AOX) and one-half were left untreated (CON). AOX trays were topically sprayed with a 10% solution of a natural antioxidant blend applied at a level not to exceed 0.49% of the total package weight. All trays were overwrapped using a micro-perforated polyvinyl chloride film before placement into high-barrier master bags. Residual atmosphere was evacuated from the bag prior to flushing with a premixed 80% O₂, 20% CO₂ atmosphere and sealing. Master packs were stored at 0 ± 2 °C for 5, 8, 10, 12, or 15 d post-packaging prior to lighted retail display for 5 d. Myoglobin forms (as calculated by spectrophotometric reflectance data), pH, metmyoglobin reducing activity, thiobarbituric acid reactive substances (TBARS), and microbiological activity were assessed after 0, 3, and 5 d of display while instrument color (L*, a*, b*, and saturation) were measured daily. Objective color and palatability characteristics were evaluated by trained sensory panelists daily (color) or after 0, 3, and 5 d of display (palatability).

**Results:** As expected, all subjective and objective color measurements indicated that ground beef color stability decreased (P<0.05) as storage and display length increased. Antioxidant application generally resulted in a delayed loss of redness when compared to CON lean. After 5 d of display, no differences (P>0.05) in objective lean color measurements were observed between AOX and CON. While all values indicated discoloration with display, AOX packages maintained superior redness (increased a*, saturation index, and oxymyoglobin values; P<0.05) when compared to CON packages at 8, 10, 12, and 15 d of display. Likewise, trained panelist color scores indicate a treatment effect was first apparent in packages displayed for 1 d after 8 d of dark storage. Trained palatability evaluations indicated less desirable beef flavor (P<0.05) and increased off-flavors (P<0.05) as storage and display lengthened. Antioxidant treatment had minimal influence on the deterioration of beef palatability (flavor, P = 0.52; off-flavor, P = 0.73). Aerobic plate counts and TBARS increased (P<0.05) with storage and display, but were generally reduced (P<0.05) in AOX versus CON ground beef.

**Conclusion:** Overall, these data suggest that while storage and display propagate the deterioration of ground beef, color stability in a HI-OX packaging system can be enhanced with the use of a natural antioxidant blend.

**Keywords:** beef, color stability, modified atmosphere package, natural antioxidant

62 CONSUMER ASSESSMENT AND FATTY ACID ANALYSIS OF BEEF STRIP STEAKS OF SIMILAR TENDERNESS WITH VARYING MARBLING LEVELS. C. Corbin 1*, M. Miller 1, T. O’Quinn 1, T. Dinh 1, J. Legako 1, A. Garmyn 1, M. Hunt 1, C. Brooks 1
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**Objectives:** A consumer study was conducted to measure the effects of varying marbling levels on consumer assessment of strip loin steaks. Strip loins were aged to produce WBSF values less than 3.4 kg to minimize the effect of tenderness on consumer evaluation of flavor. Total
SFA, MUFA and PUFA was quantified to determine the effect on flavor liking.

**Materials and Methods:** Strip loins (n = 60) were selected by trained personnel to equally represent USDA Prime (PR), High Choice (HC; upper 1/3 choice), Low Choice (LC; lower 1/3 Choice), Select (SE) and Standard (ST). In addition, strip loins (n = 24) were sourced from a foodservice distributor to represent USDA Top Choice and Select grades from Holstein (HOLT) and HolSEL, respectively. In addition, 4 Australian Wagyu (AUW) and 7 American Wagyu (AMW) strips were obtained from Australian and American Wagyu distributors. Moreover, 10 strip loins were sourced from a retail to represent Grass-finished beef (GR). All strip loins were aged 28 d, except 48 d for GR. Proximate analysis was conducted on all strip loins to determine percentage fat, protein, moisture, and collagen; fat percentages that represented the preferred USDA grade were selected for use in consumer evaluations. Strip loins were fabricated into 2.5-cm thick steaks and further processed into 5 x 5 cm pieces. Each steak was cooked on an electric clamshell grill for 5 min at a grill surface temperature of 225 °C. Consumers (n = 120) were served one sample from each treatment. Each sample was evaluated for tenderness, juiciness, flavor, and overall liking on a 10-cm, verbally anchored line-scale. Each palatability trait was also rated as either acceptable or unacceptable. Overall quality of each sample was rated as unsatisfactory, good everyday quality, better than everyday quality, or premium quality. Lipids were extracted from raw steaks, derivatized to FAME and analyzed by gas chromatography (mg/g).

**Results:** Each palatability trait increased in rating, was considered acceptable, and percentage of samples perceived premium quality increased as fat content increased (P<0.05). However, AUW and GR did not follow this trend. Also, no differences were observed among AMW and PR for all palatability factors (P>0.05). GR had a similar fat percentage to both, SEL and HOLSEL, but was rated the lowest of all treatments in flavor liking (P<0.05). With WSBF being standardized, juiciness was greatly correlated to tenderness ratings by consumers (r = 0.93, P<0.01) compared to flavor liking (r = 0.88, P<0.01). Consumer overall liking was highly correlated (P<0.01) with tenderness (r = 0.92), juiciness (r = 0.93) and flavor liking (r = 0.96). Grass-finished, ST, SEL, and HOLSEL had the lowest concentration of total SFA and total MUFA (P<0.05). Total SFA (r = 0.75, P<0.01) and total MUFA (r = 0.77, P<0.01) was positively correlated to flavor rating by consumer. This was most likely due to a residual effect of increasing fat levels from the different treatments.

**Conclusion:** In this study 5.5% fat was shown to be a critical threshold for consumer acceptability, with percent consumer acceptability decreasing significantly (P<0.05) with lower fat levels. Results from this study showed that increased fat levels positively affected tenderness, juiciness, flavor and overall liking consumer ratings.

**Keywords:** beef, consumer, fat, flavor, marbling, strip loin steaks

**63 NUTRIENT COMPARISON FOR ENHANCED AND NON-ENHANCED DARK MEAT CHICKEN.** J. R. Williams 1, J. M. Roseland 1, J. C. Howe 1, K. Y. Patterson 1, L. D. Thompson 1, A. M. Luna 2

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**Objectives:** According to a recent CDC report, most of the U.S. population consumes sodium in excess of daily guidelines. The mean daily sodium consumption was 3,266 mg (excluding salt added at the table), while the national guidelines are 2,300 mg sodium overall and 1,500 mg for specific populations. Forty-four percent of sodium consumed came from 10 food categories. For the majority of these categories, >70% of the sodium consumed came from foods including poultry available at the retail stores. In today’s market, 40% of poultry products are enhanced including dark meat chicken (drumsticks and thighs). Solutions for enhancement include water, salts, and other flavorings to preserve taste and tenderness. The two objectives of this study are to evaluate the effect of enhancement on the mineral content of enhanced and non-enhanced raw drumsticks and thighs available in the retail market, and to update the raw nutrient profiles of non-enhanced and enhanced dark meat chicken data in the USDA National Nutrient Database for Standard Reference SR.

**Materials and Methods:** Six non-enhanced and four enhanced raw drumsticks, as well as six non-enhanced and five enhanced chicken thighs, were purchased from 12 retail outlets using a nationwide sampling plan developed for USDA’s National Food and Nutrient Analysis Program. Skin, bone and connective tissue were removed from each drumstick and thigh. Dark meat from each cut type was homogenized separately prior to nutrient analyses. Skin was homogenized and analyzed for nutrient analyses. Nutrient values for proximates composition and minerals were determined by commercial laboratories using validated AOAC methodologies. Quality assurance was monitored using commercial reference materials, in-house control materials, and random duplicate samples.

**Results:** Nutrient values for non-enhanced and enhanced chicken drumsticks and thighs were compared using the Wilcoxon Rank Sum Test and Factorial ANOVA (P<0.05).

**Results:** In enhanced raw chicken drumsticks and thighs, moisture (77 mg), iron (0.65 mg), phosphorus (160 mg), potassium (215 mg) and magnesium (18 mg) were significantly greater (P<0.05) when compared to non-enhanced products. Sodium values for example, were significantly greater (P = 0.0016) for enhanced dark meat chicken (155 mg) when compared to the non-enhanced cuts (106 mg).

**Conclusion:** Based on these results, we found that sodium levels increased (20 to 25%) in enhanced dark meat chicken when compared to non-enhanced chicken. These results also indicate that consumption of enhanced products can impact an individual’s daily total sodium intake. These nutrient data are available to dietitians and other health professionals who advise individuals with sodium related health issues and to researchers and government agencies involved in the National Sodium Reduction Initiative (NSRI).

**Keywords:** enhanced, nutrient, poultry

**64 EFFECTS OF DIVERGENT SELECTION FOR RESIDUAL FEED INTAKE AND DIETS VARYING IN ENERGY AND FIBER CONTENT ON PORK LOIN PROTEIN DEGRADATION AND SENSORY QUALITY.** E. K. Arkfeld 1,2, E. R. Benedict 1, R. C. Johnson 2, J. M. Young 3, J. F. Patience 1, J. C. M. Dekkers 1, N. K. Gabler 1, S. M. Lonergan 1, E. Huff-Lonergan 1

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**Objectives:** The project objectives were to determine the effects of divergent selection for residual feed intake (RFI) and for feeding pigs a high energy, low fiber (HELF) or a low energy, high fiber (LEHF) diet on pork loin protein degradation and sensory properties. RFI is the difference between observed feed intake and expected feed intake given an animal’s growth and backfat. The Low RFI (LRFI) line was selected to consume less feed than expected given observed growth performance and backfat and is generally more efficient than the divergently selected High RFI (HRFI) line.

**Materials and Methods:** Pigs (n = 72 LRFI [37 barrows, 35 gilts], n = 79 HRFI [43 barrows, 36 gilts]) from the 8th generation of the ISU RFI selection project were randomly assigned to 12 mixed sex and line pens. Six pens were placed on the HELF diet (3.32 Mcal ME/kg; 9.4% NDF) and
6 on the LEHF diet (2.87 Mcal ME/kg; 25.9% NDF). Pigs were slaughtered (97.5-139.7 kg BW) at 3 groups at a commercial facility. Sensory loin chops were aged for 6 days then frozen. Samples thawed for 48 h at 4°C and were cooked to an internal temperature of 70°C. Trained panelists (n = 8) evaluated samples for juiciness, tenderness, chewiness, pork flavor, and off-flavor. Star probe measures for tenderness were made on loin chops. Desmin degradation was determined on loin chops on days 1, 2, 5, and 7 postmortem (pm). Data were analyzed using the MIXED procedure of SAS with the fixed effects of line, diet, sex, and significant interactions, and the random effects of slaughter group, pen, sire, and litter. End live weight was fitted as a covariate.

Results: No line or diet differences (P>0.05) were found for cook loss, star probe, or any of the sensory traits. At day 2 pm, losses from pigs fed the LEHF diet tended (P=0.06) to have greater desmin degradation than pigs fed the LEHF diet (0.84 vs. 0.64). Line impacted (P<0.05) desmin degradation on day 5 pm, with losses from HRFI pigs having greater degradation than LRFI pigs (1.47 vs. 1.18). On day 7 pm, within the HRFI line, losses from gilt exhibited greater degradation than losses form barrows.

Conclusion: In conclusion, line and diet affected desmin degradation but not sensory quality of pork loin chops aged 6 days. Supported by USDA-AFRI Grant no. 2011-68004-30336.

Keywords: Desmin, pork quality, residual feed intake, sensory


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Objectives: The use of clean-label antimicrobials is increasing in popularity, and the objective of this study was to investigate the effects of commercial “natural” (vaccine-based) antimicrobials on physico-chemical characteristics of deli-style ham.

Materials and Methods: Three replications of seven ham treatments (1 control and 6 antimicrobial treatments) were manufactured using a base formulation of 1.6% sodium chloride, 0.4% sodium phosphate, 0.7% sweeteners, 421 ppm of sodium erythorbate, 183 ppm of sodium nitrilotriazide, and 19.5% added water. All ham treatments were injected to 122.5% of green weight. The control brine contained 0.0% antimicrobial, four brines contained Verad N5 (0.5, 1.0, 1.5, or 2.0%), and two brines contained Verad Powder N6 (0.5 or 0.7%) to achieve addition based on green weight (both antimicrobials from Purac America, Lincolnshire, IL). Added antimicrobials replaced water in the brine formulation. Brine pH ranged from 5.87 (2.0% N5) to 5.10 (control), and brine water activity ranged from 0.933 (2.0% N5) to 0.946 (control). Boneless (three-piece) hams were injected with brine, ground with a kidney plate, vacuum tumbled for 2 h, stuffed into pre-smoked nettings, and cooked to an internal temperature of 71°C. The cooked hams were sliced into 13 mm slices, vacuum packaged, and were stored at 4°C in opaque containers containing undergoing physico-chemical testing. Water activity was measured once (day 0 of post-processing). Color (L*, a*, and b*) was measured on 0, 14, 28, 42, 56, 70, 84, 96, and 112 days post-processing. Texture profile analysis and pH were measured on 0, 28, 56, 84, and 112 days post-processing. The texture profile analysis properties were calculated for hardness, cohesiveness, gumminess, springiness, and chewiness. Data were analyzed using the PROC GLIMMIX procedure of SAS.

Results: No significant treatment by storage time interactions were found for any physico-chemical measures (P>0.05). Ham LSMEANS water activity ranged from 0.982 to 0.985, and there were no significant differences among treatments (P>0.05). Ham LSMEANS pH ranged from 6.34 to 6.48, and the pH did not vary significantly (P>0.05) among treatments or over time. Color values (L*, a*, b*) did not differ (P>0.05) among treatments or over time. Hardness, gumminess, and chewiness increased (P = 0.02, 0.003, and 0.03, respectively) over time, and cohesiveness varied (P = 0.03) among treatments.

Conclusion: The control ham was more cohesive than all other treatments. While antimicrobial type and quantity affected cohesiveness and storage time affected hardness, gumminess, and chewiness, neither variable affected ham pH or color.

Keywords: antimicrobial, color, ham, pH, texture profile

66 RELATIONSHIP BETWEEN RESIDUAL FEED INTAKE, PROTEIN OXIDATION, AND PROTEIN DEGRADATION IN PIGS. R. M. Punt*, A. M. Blakely†, J. K. Grubbs†, S. M. Cruzen†, E. Huff-Lonergan†, S. M. Lonergan†

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Objectives: Much emphasis has been placed on increasing pork production efficiency. Through genetic selection for residual feed intake (RFI), it is possible to study the effects of increased feed efficiency on pork quality. The objective of this project was to determine the extent to which genetic selection for RFI impacts protein modification by 4-hydroxyxenonenal (4-HNE) and troponin-T (TT) degradation.

Materials and Methods: Gilts (n = 9 high RFI line, n = 9 low RFI line, BW = 95.3 kg) from the eighth generation of the Iowa State RFI Selection Project were used. Chops from the Longissimus dorsi muscle were held at 4°C and sampled at days 0, 1, 3, and 7 postmortem. Day 0 samples were collected at 1 hour postmortem. Protein oxidation and degradation was determined through Western blotting for protein modification by 4-HNE and TT degradation, respectively. To determine protein modification by 4-HNE, the total density of eight prominent and consistent bands were analyzed. For TT degradation the 30-kDa degradation product was analyzed.

Results: Protein modification by 4-HNE was not different between lines at any time point postmortem. TT degradation was not different between high and low RFI lines at days 0, 1, and 7 postmortem. However, at day 3 postmortem, muscle from the less efficient, high RFI line had more TT degradation than that from the more efficient, low RFI line (P<0.05). In the low RFI line, formation of the 30-kDa degradation product increased as days postmortem increased. A similar trend in the high RFI line was observed through day 3 postmortem, followed by a reduction in the 30-kDa degradation product at day 7 postmortem. A reduction in the presence of the 30-kDa TT degradation product between days 3 and 7 may indicate continued proteolysis of TT in muscle from the high RFI line.

Conclusion: These data indicate muscle from more efficient pigs selected for low RFI may undergo proteolysis at a slower rate than muscle from less efficient, high RFI pigs. A slower rate of proteolysis in the more efficient low RFI line indicates that selection for efficiency has the potential to impair the rate of tenderization but not overall tenderness. The extent of 4-HNE modification of the 8 prominent bands evaluated is not related to differences in protein degradation in muscle from low or high RFI pigs.

Keywords: 4-hydroxyxenonenal, pork, Residual feed intake, troponin-T
67 THE IMPACT OF BEEF CHUCK MUSCLE ISOLATION ON COLOR OF GROUND CHUCK. N. Jackson 1, C. Ohman 1*, R. Lee 1, K. Shircilf 1, T. Wilmoth 1, Z. Robertson 1, Z. Callahan 1, M. Singer 1, B. Wiegand 1, C. Lorenzen 1

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Objectives: Due to the success of the Beef Muscle Profiling Project, the need for research in the quality attributes for ground beef containing varying muscles has become apparent. This experiment evaluated whether isolating certain muscles from the chuck for retail sale and excluding them from ground beef will cause a change in the number of days that the ground beef has a viable appearance to consumers.

Materials and Methods: Twenty-four beef steers were slaughtered at the University of Missouri-Columbia. Right chucks were assigned to a traditional method (TRA) and left chucks to an innovative method (INN). TRA excluded half of the cod (IMPS 114I) and half of the chuck roll (IMPS 116IA) and INN excluded half of the cod heart (IMPS 114E), half of the chuck eye roll (IMPS 116D), infraspinatus (IMPS 114D), supraspinatus (IMPS 116B), teres major (IMPS 114F) and serratus ventralis (IMPS 116G). Resulting ground beef patties were placed on Styrofoam trays, overwrapped with polyvinyl chloride and displayed under fluorescent lights for 7 days to determine oxidative color stability. Raw patties were analyzed on days 1, 3, 5 and 7 after manufacture for myoglobin concentration, objective color by Minolta Chromameter, and by eight, trained sensory panelists for percent discoloration and color. The sensory panelists assigned values to the patties under a Macbeth fluorescent lighting simulator, using the following scale: 0 = no discoloration, 1 = 1-12.5% discoloration, brownish-green and 8 = 87.5-100% discoloration, very light cherry red. Fat content was measured using the CEM SMART Trac system. Statistical analysis was performed using the MIXED procedure of SAS.

Results: No differences in fat percentage were found between TRA and INN, and fat content was used as a covariate in all other analysis. Myoglobin concentration was not different (P>0.05) between treatments, but did increase with days of storage (P<0.05). Color by panelists was also not different between INN and TRA patties on any days (P=0.092). No differences were observed in patty consistency between treatments on any days (P=0.102), but patty discoloration did increase with days of storage (P<0.05). Minolta color readings showed no differences (P>0.05) between TRA and INN for L*, a* or b*. Color change from day 0 to all other days of storage for a* and b* was greater (P<0.05) for TRA than for INN, indicating more substantial fading in TRA patties. Magnitude of color change for a* increased as storage day increased (P<0.05).

Conclusion: This study demonstrated that removing certain muscles from ground beef could have an effect on visual appearance of the resulting patties.

Keywords: color, ground beef, myoglobin, shelflife

68 CHANGES IN TOTAL AND HEAT SOLUBLE COLLAGEN LOCATED IN THE LONGISSIMUS LUMBARUM, GLUTUS MEDIANUS, AND PSEOS MAJOR IN IMPLANTED CATTLE FED ZILPATEROL HYDROCHLORIDE. S. M. Knobel 1*, H. L. Bruce 1, J. C. Brooks 1, B. J. Johnson 1, J. D. Starkey 1, J. L. Beckett 2, R. J. Rathmann 1, J. M. Hodgson 3, J. P. Hutcheson 4, M. N. Streeter 2, C. Thomas 4, M. F. Miller 1

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Objectives: Previous research has demonstrated beta agonists such as zilpaterol hydrochloride (ZH) along with some implant regimens can affect meat tenderness as measured by Warner-Batzler Shear Force (WBSF). Collagen is traditionally acknowledged as a factor impacting meat tenderness. Thus, the objective of this study was to evaluate the effects of ZH (0 or 8.3 mg/kg of DM) and implant status (no implant [NI]; Revalor-S [RS]; or Revalor-XS [XS]) on concentration of collagen in the Longissimus lumbarum (LL), Gluteus medius (GM), and Psoas major (PM).

Materials and Methods: Cattle (n = 168) were assigned to 1 of 6 treatments (no ZH [NZ] & NI, NZ RS, NZ XS, ZH NI, ZH RS, and ZH XS). Full loins were collected from the carcass (n = 16/treatment) and fabricated into strip loin, top but, and tenderloin subprimal. On 7 steaks were fabricated from each subprimal and aged (7, 14, 21, 28, 35 d) for WBSF determination. An additional 7 aged steaks was preserved for collagen analysis. Samples representing the top 3 (HIGH) or bottom 3 (LOW) WBSF values for each muscle type, treatment, and postmortem aging category were selected for collagen analysis. Only samples which were consistently HIGH and LOW over the postmortem aging period were analyzed (LL n = 70; GM n = 62; PM n = 64). Powdered samples were heated in water to separate heat soluble (HS) and insoluble fractions of collagen followed by 16 h of acid hydrolysis. Hydroxyproline levels were analyzed using a spectrophotometer. Total collagen content was estimated as the sum of heat soluble and insoluble collagen.

Results: No differences (P>0.05) were observed in amount of heat soluble or total collagen for the LL except HIGH steaks from ZH fed cattle contained a higher (P = 0.03) percent of heat soluble collagen than cattle not fed ZH (23.7% and 19.2%, respectively). Analysis of the GM indicated NZ samples contained a greater amount (P = 0.05) of total collagen than ZH samples (2.98, 2.71 mg/g respectively). Interactions among treatments were observed for both total collagen (P = 0.03) and amount of HS collagen (P = 0.04). When analyzing HIGH and LOW GM samples, LOW NZ samples contained more total collagen than LOW ZH samples (P = 0.02) and HIGH RS samples exhibited a greater amount of total collagen than HIGH NI samples. Interactions were observed between ZH and implant regimen for total collagen (P = 0.0023) and HS collagen (P = 0.0025) of HIGH GM samples. No differences (P>0.05) were found in percent of HS collagen of the GM or PM. However, NZPZ samples also had greater (P = 0.0004) concentrations of total collagen than ZH samples. Interactions between ZH and implant status occurred in total collagen of all (P = 0.04) and HIGH (P = 0.04) PM samples. Analysis of LOW PM samples indicated that all NZ samples also contained a greater (P = 0.0015) amount of collagen than ZH samples.

Conclusion: Overall, results revealed a variety of effects on concentration of collagen which could be dependent on muscle type. In the LL, an increased percentage of HS collagen in HIGH ZH samples may be related to the positive response of ZH steaks to extended aging. A lower amount of total collagen in GM and PM ZH samples supports the dilution effect theory in which ZH increases overall skeletal muscle mass and therefore lowers the concentration of collagen per gram of muscle.

Keywords: collagen, implant, zilpaterol hydrochloride

69 EFFECTS OF FEEDING FIELD PEAS TO BISON ON ANIMAL PERFORMANCE AND MEAT QUALITY CHARACTERISTICS. K. R. Welnitz 1*, A. N. Lepper-Blühe 1, V. L. Anderson 1, B. Isle 1, E. P. Berg 1

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Objectives: Two trials were conducted to determine the effects of feeding fieldpeas on bison performance and meat quality traits.
Materials and Methods: In the first trial, 40 head of bison were fed for approximately 3 months prior to harvest. 20 bison were fed peas (PEA; 15% inclusion) and 20 were fed no peas (NP) in a normal finishing ration offered in self-feeders. In the second trial, 15 head of bison were fed PEA at 15% inclusion in a completely pelleted self-fed ration for 56 d vs. NP. Carcass characteristics and meat quality measurements were obtained from 30 bison. All animals were shipped to Double J Packing Plant in Pierce, CO and harvested.

Results: No differences were observed for rate or cost of gain between the bison fed PEA vs. NP. The NP group was slaughtered on arrival while the PEA group was housed overnight and slaughtered the following morning. Slaughter of NP on one day and PEA treatment the next confounds the data; preventing the ability to distinguish intramuscular pH and palatability differences were due to pea consumption or overnight lardage. Bison housed overnight (PEA) had tougher ribeye steaks (as shown by mechanical tenderness and trained sensory panel) and lower intramuscular pH (P<0.01). No differences were seen across treatment for 8 d shelf life color stability. These data do justify further research to decipher the cause for the differences, particularly in meat tenderness. In trial 2, blood lactate levels along with ribeye and fat thickness were measured. Additionally, a 5 cm section of chuck-eye roll (Longissimus thoracis and Spinalis dorsi) was collected adjacent the 3º4º thoracic vertebra and to be used later for slice shear force (SSF) tenderness measurements. Bison consuming NP had numerically increased average daily gains compared to those that received PEA. Steaks from PEA bison were numerically tougher than NP, but did not differ statistically (P = 0.52). No differences were seen across treatment for blood lactate concentration at exsanguination, carcass ribeye area, fat depth or 10 d shelf life color stability.

Conclusion: Conclusions cannot be drawn from Trial 1 due to the confounding nature of slaughter day and treatment, yet a significant effect was noted on tenderness. Further research is necessary to determine if this effect is a result of prolonged lardage of bison (essentially a wild animal) or pea inclusion in the diet. There was no influence of pea feeding on any carcass, meat quality, or palatability attribute in Experiment 2 suggesting that the differences in palatability observed from Experiment 1 may more likely be due to overnight lardage.

Keywords: bison, field peas, meat quality, shelf life

71 EFFECTS OF FEEDING RACTOPAMINE TO IMMUNOCLOGICALLY CASTRATED PIGS ON HAM AND BELLY PROCESSING CHARACTERISTICS. B. K. Lowe 1, 2, G. D. Gerlamm 2, S. N. Carr 3, P. J. Rincker 3, A. L. Schroeder 1, D. B. Petry 1, G. L. Allee 1, F. K. McKeith 1, A. C. Dilger 1
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Objectives: Evaluate the effects of feeding ractopamine to immunologically castrated pigs on ham and belly processing characteristics.

Materials and Methods: Bellites and two-piece hams (inside and outside) from physically castrated (PC) and immunologically castrated (IC) pigs fed diets with or without ractopamine (RAC; 5 mg/kg) were used. Male pigs were randomly assigned to sex groups at birth. Pigs in the PC group were physically castrated at 5 d of age. Pigs in the IC group were administered Impruvest at 11 and 18 wk of age (665 of study). Diet treatments (control or RAC) were initiated on day 87 of study, and final treatment arrangement was a 2 x 2 factorial of sex and diet. Pigs were slaughtered in three market groups (MG) at 99, 106, and 120 of study based on ending live weight (136 kg). Three pigs closest to the mean weight for each MG (N = 285) were identified for fresh ham and belly evaluations. One carcass from each pen per MG (N = 96) was selected to evaluate further processing characteristics. Data were analyzed using PROC MIXED in SAS with fixed effects of sex, diet, MG, and their interactions; carcass served as the experimental unit.

Results: For sex and diet interactive effects, feeding RAC increased (P<0.02) ham pump uptake (2.3% units), ham cooked yield (3.8% units), cured ham moisture (0.97% units), and belly pump uptake (1.2% units) from PC carcasses but did not affect (P>0.42) products from IC carcasses. Additionally, feeding RAC decreased (P<0.01) bacon fat content (4.7% units) and total SFA (1.0% units) in PC carcasses but did not affect (P>0.20) IC carcasses. Overall, feeding RAC increased (P<0.03) cured ham moisture (0.65% units), belly pump uptake (0.63% units), total MUFA (0.92% units), and iodine values (0.98 units) but did not affect (P>0.10) other ham quality or processing characteristics, or bacon slicing yields. While hams from PC and IC carcasses were similar (P>0.37) in terms of fresh ham quality and processing characteristics, cured hams from PC carcasses had 0.75% units more (P<0.01) fat than those from IC.
carcasses. Bellies from PC carcasses were 0.3 cm thicker (P<0.01), had 1.3% units less (P<0.01) total MUFA, and 0.84% units less (P<0.01) total PUFA than those from IC carcasses. Flop distance was also 0.3 cm greater (P<0.01) in PC carcasses. Additionally, IC bellies had 1.1% units greater (P<0.01) pump uptake, 3.1% units more (P<0.01) moisture, and 4.2% units less (P<0.01) fat than those PC bellies. There were no differences (P=0.08) between PC and IC bellies when evaluating cooked yield, slicing yield, or iodine values (avg. = 61.6 g/100 g). Market group (MG) 1 and 2 hams had a 0.2 unit increase in pH value (P<0.01) and greater pump uptake (P<0.01) than MG 3 hams. Market groups 1 and 3 bellies were thicker (P<0.01) than MG 2 bellies; however, belly flop distances increased (P<0.01) in each successive market group. While MG 1 bellies had greater (P<0.01) pump uptake than MG 3 bellies, MG 3 bellies had greater (P<0.01) cook yields than all other market groups. Market groups did not differ (P>0.05) in bacon slicing yields, composition, fatty acid composition, or iodine values.

Conclusion: Overall, immunological castration and feeding RAC both resulted in leaner hams and bacon without affecting bacon slicing yields. While both technologies affected processing characteristics, the impact of the technologies together was no greater than either technology alone.

Keywords: bacon, ham, Improvest, Paylean

72 TENDERNESS AND PALATABILITY TRAITS OF BEEF FROM LIMOUSIN JERSEY BRED STEERS AND CERTIFIED ANGUS BEEF. J. Bumsted 1,*, L. M. Hoffman 1, R. S. Metzger 1, A. D. Blair 1, S. M. Scramlin 1, K. R. Underwood 1

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Objectives: Variation in meat tenderness has significant impacts on consumer satisfaction with beef; however, classic breeding selection techniques have not been effective in eliminating the portion of animals yielding undesirable palatability traits. The Limousin x Jersey cross capitalizes on positive attributes in both breeds with Jersey cattle offering exceptional palatability and the Limousin breed contributing outstanding cutability attributes. The objective of this study was to determine the overall acceptance and palatability of Limousin x Jersey crosses compared to Certified Angus Beef (CAB).

Materials and Methods: Limousin x Jersey cross steers (n = 56) were randomly selected and slaughtered at a commercial packing plant. Objective color analysis including L*, a*, and b* measurements were recorded on the exposed external carcas fat over the rib and loin sections. Limousin x Jersey carcasses (n = 31) were selected that possessed adequate marbling to grade USDA Select and Choice. Strip loins were removed from the subsample of Limousin x Jersey carcasses and randomly selected CAB carcasses (n = 25) were marbled and transported to the SDSU Meat Laboratory. Strip loin steaks were analyzed for WBSF and sensory evaluation.

Results: Limousin x Jersey steaks showed increased WBSF values (P<0.01) compared to CAB steaks signifying a less tender steak than CAB. However, according to trained sensory panelists, Limousin x Jersey steaks were not different (P>0.05) in tenderness, juiciness, beef flavor, and off flavor when compared to CAB steaks. Fat color over the rib showed L* and b* measurements were decreased (P<0.05) in carcass fat color of Limousin x Jersey steers verses CAB carcasses indicating a darker, more blue fat color. Additionally, Limousin x Jersey steers showed an increased a* color value (P<0.01) for fat over the rib. Fat over the loin showed L* and b* were increased (P<0.05) for CAB carcasses. Meanwhile a* values off fat over the loin region did not differ (P>0.05).

Conclusion: Limousin x Jersey steaks and CAB steaks were categorized as tender products, with CAB having a benefit of being more tender according to WBSF assessment. However, from a consumer stand point, Limousin x Jersey steaks are comparable to CAB steaks.

Keywords: Limousin x Jersey, palatability, tenderness

73 EFFECTS OF POST-MORTEM AGING TIME AND TYPE OF AGING ON PALATABILITY OF LOW MARBLED BEEF LOINS. A. N. Lepper-Blillie 1,*, E. P. Berg 2, D. S. Buchanan 2, P. T. Berg 1

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Objectives: The objective of this study was to evaluate the effect of post-mortem aging time and type (dry vs. wet) of aging on sensory panel flavor characteristics, tenderness, Warner-Brazzler shear force (WBSF) and slice shear force (SSF) of beef loins with marbling between Slight 60 and Small 80.

Materials and Methods: Ninety-six short loins (NAM 174 PS02) and 96 strip loins (NAM 180) were obtained from two processing facilities and randomly assigned to one of four treatment groups: dry bone-in (DBI), dry boneless (DBL), wet bone-in (WBI), and wet boneless (WBL). Loins were evaluated at seven day intervals beginning at 14 d post-mortem and continuing through day 49. At the end of each specified aging period steaks (2.5 cm thick) were cut from cranial end of each loin, vacuum packaged, and frozen for further evaluation. The effect of aging was assessed by WBSF, SSF, and a trained 8-member sensory panel. Panelists evaluated samples for tenderness and juiciness on an 8-point scale (1 = extremely tough and dry; 8 = extremely tender and juicy) and overall aged flavor, beefy, bloody/serumy, brown-roasted, and sour flavor characteristics on a 9-point scale (0 = no presence of flavor; 8 = extremely flavorful). Data were analyzed using generalized least squares (PROC MIXED, SAS). The model included aging time, aging type, loin type, and quality grade as fixed main effects with the random main effect of kill data.

Results: Aging time and type did not influence SSF, juiciness, beefy flavor, and brown-roasted flavor. Length of aging affected WBSF with the product becoming more tender as the days increased (P = 0.003) up to 35 d, with days 35, 42, and 49 being similar. Bone-in steaks evaluated by WBSF also tended to be tougher than boneless (P = 0.06). Panelists found an improvement in tenderness when steaks reached 28 d of aging (P = 0.0004). Dry bone-in steaks were tougher than DBL (P = 0.05), but not different from WBL and WBI. Overall aged flavor increased as the days of aging increased (P = 0.02). Days 42 and 49 had the highest aged flavor compared to days 14 and 21. Aged flavor was also found to be highest for DBL (P = 0.006). Wet-aged steaks exhibited more bloody/serumy notes compared to dry-aged (P = 0.05). Quality grade (Low Choice and Select) did not influence WBSF and SSF tenderness analysis.

Conclusion: These data suggest that aging steaks up to 35 d improves tenderness of low-marbled loins. Dry-aging strip loins for up to 49 d will increase the favorable aged flavor of the loins. Dry-aging did not have an advantage over wet-aging to improve beefy flavor. Wet-aging of these low-marbled loins produces a tender product, but does not increase flavors that are commonly lacking in low-marbled beef.

Keywords: beef, dry-aging, flavor, tenderness, wet-aging

74 WATER-HOLDING CAPACITY OF BROILER BREAST MUSCLE DURING THE FIRST 24 H POSTMORTEM. B. Bowker 1,*, H. Zhuang 2

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Objectives: Water-holding capacity of poultry muscle influences both
the sensory appeal for consumers and the product yield for processors. The influence of postmortem aging on the water-holding capacity of poultry is not fully understood. The objective of this study was to determine the evolution of water-holding capacity and physicochemical traits in broiler breast fillets during the first 24 h postmortem.

**Materials and Methods:** Carcasses (n = 6) from 42-day-old broilers were removed from a processing line immediately following evisceration and the right and left breast fillets (*pectoralis major*) were deboned and chilled in an ice slush for 45 min and then stored at 4 °C until 24 h postmortem. Both the right and left fillets from each carcass were subdivided into three portions which were randomly designated for sampling at 0.75, 2, 4, 8, 12, or 24 h postmortem for determination of water-holding capacity (salt-induced water uptake and cook yield methods) and biochemical measurements. Data were analyzed in SAS using PROC MIXED with a model that included postmortem time as a fixed effect and carcass as a random effect.

**Results:** Both salt-induced water uptake (P < 0.0001) and cook yield (P < 0.0001) changed throughout the first 24 h postmortem in samples in a non-linear manner. Salt-induced water uptake increased from 0.75 to 4 h postmortem (38.0% to 54.1%), decreased from 4 to 8 h postmortem (54.1% to 31.4%), and then increased from 8 to 24 h postmortem (31.4% to 47.4%). Cook yield decreased from 0.75 to 4 h, increased from 4 to 12 h, and then decreased from 12 to 24 h postmortem. Muscle pH decreased (P < 0.0001) from 6.51 at 0.75 h postmortem to 6.03 at 8 h postmortem. Muscle pH did not change from 8 to 24 h postmortem. Protein solubility was utilized as an indicator of muscle protein denaturation over the first 24 h postmortem. Both myofibrillar (P < 0.01) and sarcoplasmic (P < 0.001) protein solubility were influenced by postmortem time of sampling. Myofibrillar protein solubility values were not different between 0.75 and 2 h samples, but were lower by 4 h postmortem. Myofibrillar protein solubility did not change from 4 to 24 h postmortem. Sarcoplasmic protein solubility values were similar from 0.75 to 2 h postmortem but then increased through 24 h postmortem.

**Conclusion:** Overall data show that water-holding capacity in broiler breast fillets fluctuates over the first 24 h postmortem. Data suggest that while alterations to muscle proteins and ultrastructure influence water-holding capacity, myosin denaturation does not explain changes in the water-holding capacity of broiler breast fillets.

**Keywords:** breast muscle, postmortem time, protein solubility, water-holding capacity

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**75 CONSUMER ASSESSMENT OF FLAVOR OF STEAK OF VARYING FAT LEVELS FROM FOUR BEEF MUSCLES.** M. Hunt 1*, A. Corbin 1, A. Garmyn 1, J. Legako 1, T. O’Quinn 1, R. Rathmann 1, C. Brooks 1, M. Miller 1

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**Objectives:** A consumer study was conducted in Lubbock, Texas, to measure the effects of fat level on the palatability traits of flavor, tenderness, juiciness, and overall liking of four beef muscles. The study was arranged as a 2 × 4 factorial representing 2 quality grade categories (Upper 2/3 (Top) Choice and Select) and 4 muscles (*Longissimus lumborum* (LL), *Gluteus medius* (GM), *Serratus ventralis* (SV), and *Semimembranosus* (SM)).

**Materials and Methods:** Sides (n = 40; 20 per quality grade category) of beef were selected from a commercial processing facility by trained Texas Tech personnel to obtain the four subprimalms. Proximate analysis was conducted on each subprimal to determine percentage fat, moisture, protein, and collagen. The muscles were then fabricated into 2.5-cm steaks, and further processed into 5 × 5 cm pieces. Consumers rated each of 8 steak samples for tenderness, juiciness, flavor liking, and overall liking and rated each trait as either acceptable or unacceptable.

**Results:** According to proximate analysis, SV had greater (P < 0.01) fat percentage (9.7%) than any other muscle, and SM had the lowest (2.5%); LM (4.9%) and GM (5.1%) were intermediate. Regardless of muscle, Top Choice had greater (P < 0.01) fat percentage (7.1%) than Select (4.0%). An interaction between muscle and quality grade was observed (P < 0.05) for juiciness, flavor liking, and overall liking. For juiciness, Top Choice SV had greater (P = 0.02) consumer scores than any other muscle × quality grade combination, followed by Select SV. *Semimembranosus* had the lowest juiciness scores, regardless of quality grade, which did not differ (P > 0.05). Flavor liking and overall liking had similar trends for consumer scores as Top Choice LL, GM, and SV had greater (P < 0.02) consumer scores than the remaining muscle × quality grade combinations. For all muscles except SM, consumer scores for flavor liking and overall liking were greater for Top Choice compared to Select. Similarly, tenderness scores were greater (P < 0.01) for Top Choice compared to Select, regardless of muscle. Consumers rated LL as more tender (P < 0.01) than SV and GM, but similar to GM (P > 0.05). Consumers scored the tenderness of SM far lower (P < 0.01) than any other muscle. A decrease (P < 0.05) in consumer acceptability of each palatability trait was observed as fat level decreased from Top Choice to Select. The *Semimembranosus* showed the lowest acceptability scores for all the palatability traits. Overall and flavor acceptability were similar (P > 0.05) between LL, GM, and SV regardless of fat level. Consumer overall liking was correlated (P < 0.01) with consumer tenderness (r = 0.86) and juiciness ratings (r = 0.71), but most highly correlated with flavor liking (r = 0.93).

**Conclusion:** When tenderness was acceptable, flavor and juiciness played a major role in determining overall acceptability. Even when consumers scored tenderness low, as with the SM, superior flavor and juiciness could compensate and improve the overall liking and acceptability of beef. Overall liking of SV and GM from high quality carcasses was superior to LL from lower quality carcasses and comparable to LL from high quality carcasses. Therefore, results from this study showed additional value could be captured by marketing those more underutilized cuts from high quality carcasses.

**Keywords:** beef, consumer perception, flavor, marbling

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**76 REDOX STABILITY OF MYOGLOBIN INFLUENCED BY INORGANIC REDOX IRON FORMS AND METABOLIC SUBSTRATES IN A BEEF HOMOGENATESYSTEM.** A. Puchito 1*, A. Mohan 1, S. Park 1, V. Sharma 1

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**Objectives:** Beef color is a major intrinsic quality cue determining purchase by consumers with discrimination against beef that is not red. The red color is generally associated with freshness. Iron, in both the non heme and heme forms have been implicated to cause lipid peroxidation, the products of which promote myoglobin formation which degrades the redness and thus visual quality of beef. The effect of heme iron as an oxidant has been documented. Metabolic substrates which are intermediaries of biochemical pathways such as malate, succinate, lactate and others have been shown to promote myoglobin reduction activity which stabilizes color. However, the effect of inorganic iron forms on color stability of fresh beef remains elusive. Thus, the objective of this study was to examine the effect of inorganic redox iron forms on the color stability of beef homogenate with or without the presence of metabolic substrates.

**Materials and Methods:** Beef M. *Longissimus dorsi* muscle was obtained from a local meat processor and frozen at -40 °C until further use. A model system was developed using Beef M. *Longissimus dorsi* muscle homog-
enate to mimic practical applications. The homogenate was prepared using 1:4 beef muscle and 0.04M 3-(N-Morpholino) propane sulfonic acid (MOPS) buffer of pH 5.6. Ferrous chloride and Ferric chloride were used as sources of the inorganic iron. Potassium lactate and Sodium succinate were added at 2% levels dissolved in the buffer. The pH of all the homogenate systems was measured before treatments. The three systems studied were meat homogenate with buffer without any metabolizable substrate, homogenate with buffer containing 2% succinate and homogenate with buffer containing 2% lactate. The homogenate was mixed with varying concentrations of ferric and ferrous ions at 0.2, 0.4, 0.6, 0.8, and 1 ppm and incubated at 37 °C for 30 minutes. To determine the retail display color properties, color was measured for Hunter Lab color space values L*, a*, and b* and reflectance in the visible range (400-700 nm) before and after incubation. The percentages of the three myoglobin redox forms: oxy-, deoxy- and met-myoglobin were estimated using the absorption and scattering coefficient (K/S) values from the reflectance at wavelengths specific to the three myoglobin redox forms.

**Results:** Metmyoglobin formation was significantly affected by Fe⁺⁺ concentration and time of incubation (P<0.05 for each) in the no substrate and in the lactate systems and significantly affected (P<0.05) by Fe⁺ and Fe⁺⁺ and time in the succinate system. In all the 3 systems, Oxymyoglobin concentration reduced with increasing Fe⁺⁺ concentration and time (P<0.05 for each). The a* value associated with redness was affected by Fe⁺⁺ (P<0.05) and time (P<0.05) in the no substrate system and in the lactate containing system. a* was affected by Fe⁺⁺, Fe⁺⁺ and time (P<0.05 for each) in the succinate system.

**Conclusion:** The non-heme iron redox forms will influence the redox stability of myoglobin. The value addition of metabolizable substrates in beef homogenate will affect the redox reaction of inorganic iron forms and stabilize myoglobin redox stability. These results present scope for elucidating the mechanisms by which inorganic redox iron forms affect color stability of different raw meat products and their consumer acceptability at large.

**Keywords:** meat color, Myoglobin, iron, lactate, succinate

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77 EFFECTS OF BICARBONATES ON COLOR STABILITY AND FUNCTIONAL PROPERTIES OF GROUND BEEF. S. Park 1, A. Mohan 1, A. Purohit 1, V. Sharma 1, T. Jaico 1
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**Objectives:** Color is the single most important factor of meat products that influences consumer buying decision and affects their perception of the freshness of the product. Sodium bicarbonate (SB) is known for improving the functional properties of the meat product. However, little is known how SB influences myoglobin redox status and meat color stability, and functional properties of the ground beef during storage and display. Therefore, the objective of this study was to determine the impact of the bicarbonate salt forms (sodium, potassium, and ammonium) on ground beef functional properties, myoglobin redox forms, and overall color stability during simulated retail display.

**Materials and Methods:** Ground beef (80% lean, 20% fat) was obtained from a local supplier (US Food, Inc., Augusta, GA), and was stored at 40 °C until further use. The ground beef was mixed with one of the following eight treatments (g/100 g water) combinations: A) Control (no bicarbonate; no salt); B) 0.5% Salt; C) 0.5% NaHCO₃; D) 1% NaHCO₃; E) 0.5% KHCO₃; F) 1% KHCO₃; G) 0.5% (NH₄)₂CO₃; H) 1% (NH₄)₂CO₃. After the treatment, ground beef was formed into patties and packaged on styrofoam trays with soak-pads and PVC wrapped. The trays were stored and displayed at 2-4 °C in a retail display case. The color measurements were recorded on days 1, 2, 3, 4, 6, and 7 using a HunterLab Miniscan EZ with illuminant D65, and 10° standard Observer. At each time of color determination, reflectance spectral values (400-700 nm) and CIE L*, a*, b* were measured at 3 random locations on each patty. The expressible moisture, internal cooked color, and cook yield were also determined on ground beef cooked in an aluminum tray to an internal temperature of 71 °C (160 °F) in a Blodgett oven.

**Results:** Mean pH for ground beef treated with bicarbonate (treatments C to H) ranged from 7.14 to 7.91, compared to 5.61 for the control (A). CIE a* value, an indicator of meat “redness”, showed that control and salt treated ground beef were redder (P<0.05) compared to all other samples (treatments C to H) up to 3 days of retail display and storage. However, on day 6 and 7, sodium bicarbonate treated ground beef was redder (P<0.05) compared to all other treatments. Hue angle and saturation index showed the similar trend. With regard to cooked meat color, 0.5% Potassium and ammonium bicarbonate treated ground beef cooked interiors showed the lightest (highest L*) (P<0.05). All three forms of bicarbonates treated ground beef showed significantly higher (P<0.05) Cooked yield and Expressible moisture (%) than the control. Treatment H i.e. 1% ammonium bicarbonate showed the most effective and was significantly different (P<0.05) from all other treatments.

**Conclusion:** Results from this study demonstrate that application of bicarbonate as non-meat ingredient in ground beef will influence the color life, increase the cook yield, and moisture content. Since sodium and ammonium bicarbonate each influenced meat color, expressible moisture, and cook yield, further experiments need to be performed in order to optimize the levels of these treatments.

**Keywords:** meat color, bicarbonate, cook yield, cooked color

78 INFLUENCE OF MITOCHONDRIAL EFFICIENCY ON BEEF LEAN COLOR STABILITY. R. O. McKee 2*, D. A. King 2, A. L. Grayson 1, S. D. Shackelford 2, J. W. Swell 2, T. L. Wheeler 2
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**Objectives:** Loss of electrons in the electron transport chain has been implicated as a source of variation in feed efficiency of meat producing animals. The present study was conducted to evaluate the effects of electron loss during electron transport on beef lean color stability.

**Materials and Methods:** Beef carcasses (n = 91) were selected from a commercial beef processor and Longissimus lumborum pH and marble score were determined as the carcasses were presented for grading. Beef, loin, strip loin subprimal were aged until 13 d postmortem, when Longissimus lumborum steaks were cut for simulated retail display. Instrumental color attributes [lightness (L*), redness (a*), yellowness (b*), hue angle] were determined on d 0, 1, 4, 7, and 11 of simulated retail display. Overall color change from d 0 (ΔE) was calculated for d 1, 4, 7, and 11 of simulated retail display. Additional steaks were used for determination of electron loss from the electron transport chain, oxygen consumption, myoglobin reducing activity, glycolytic potential, and myoglobin concentration determination. Electron loss was determined as the percentage increase in fluorescence units resulting from incubating (37 °C for 20 minutes) isolated mitochondria in the presence of 2'-7' dichlorofluorescin diacetate with succinate as a substrate for electron transport.

**Results:** Longissimus lumborum steak lightness on d 0 of display was positively correlated (P<0.05) to electron loss (r = 0.28), marbling score (r = 0.40), and glycolytic potential (r = 0.25). Myoglobin concentration (r = 0.41), metmyoglobin reducing activity (r = 0.51), oxygen consumption (r = 0.41), and muscle pH (r = 0.29), were negatively correlated
(P<0.05) to d 0 L* values. Redness (a*) on d 0 of display was negatively correlated (P<0.05) to metmyoglobin reducing activity (r = -0.21), oxygen consumption (r = -0.28), and muscle pH (r = -0.35). Overall color change during 11 d of simulated retail display was associated (P<0.05) with increased electron loss (r = 0.35) and decreased metmyoglobin reducing activity (r = -0.21), oxygen consumption (r = -0.22), and muscle pH (r = -0.32). Increased electron loss was associated (P<0.05) with decreased metmyoglobin reducing activity (r = -0.23) and muscle pH (r = -0.39). Increased electron loss was also associated (P<0.05) with increased glycolytic potential (r = 0.24) and marbling score (r = 0.26).

**Conclusion:** These data suggest that greater electron loss is associated with decreased metmyoglobin reducing activity and, consequently, reduced beef lean color stability. Electrons lost during electron transport from reactive oxygen species which then must be reduced by the cell. Lower reducing ability associated with increased electron loss may be due to the NADH pool being depleted while reducing the reactive oxygen species. Another mechanism may be the oxidative damage of enzymes associated with metmyoglobin reduction by reactive oxygen species. Moreover, increased electron loss was associated with greater glycerone stores (evidenced by glycolytic potential) and reduced muscle pH, which contributed to increased lightness at the beginning of simulated retail display. Thus, it appears that reduced mitochondrial efficiency influences beef lean color and color stability. Increased feed efficiency through mitochondrial efficiency may result in fewer losses associated with discoloration of beef products at retail.

**Keywords:** beef, color, color stability, electron transport, Mitochondria

**79 EFFECTS OF INJECTION ENHANCEMENT WITH SODIUM TRIPOLYPHOSPHATE, CARRAGEEAN, AND SEA SALT ON BEEF RETAIL DISPLAY PROPERTIES AND COLOR STABILITY.** V. Sharma 1, N. Lee 1*, G. Nagaraj 1, R. Singh 1, A. Mohan 1

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**Objectives:** The application of ‘injection enhancement’ has been shown to improve beef tenderness and juiciness. The current industry practices of subjecting different quality grade beefs to the same enhancement strategies may not adequately represent differences in quality attributes and other additional problem associated with enhanced beef. The objective of this study was to assess the effects of injection enhancement on display color properties and sensory traits of beef strip loins of different quality grades.

**Materials and Methods:** Subprimals from USDA Choice and Select (USPS # 180 from A-maturity beef carcass) were randomly selected (n = 12) and assigned to one of the following injection enhancement treatments: A) Control (non-enhanced); B) 0.3% Sodium Tripolyphosphate (STPP) + 0.25% Carrageenan (CG) + 1% Sea Salt (SS); Treatment C) 0.3% STPP + 0.5% CG + 1% SS; and Treatment D) 0.3% STPP + 2.5% Potassium Lactate (PL) + 1% SS. The subprimals were enhanced at 110% of their green weight and the steaks were fabricated (2.54 cm thick) and packaged on styrofoam trays with soaker pads and PVC wrapped. The trays were stored and displayed under fluorescent lighting at 24°C for 7 days for 0, 1, 2, 3, 4, 5, 6 and 7 days of retail display and storage. Instrumental color characteristics during retail storage and display were recorded using HunterLab MiniScan EZ. The experimental design was a split-plot design, with loin served as experimental unit. The steaks served as the sub-plot and the data was analyzed using the Mixed Procedure (PROC MIXED) of SAS (SAS Institute, Inc., Cary, NC).

**Results:** The cooked color properties for the choice steaks had higher (P<0.05)L*, a*, and b* values than the select steaks. The a* values for the choice steaks injected with treatment D exhibited increased redness than any other treatments and was significantly different (P<0.05) from the select steaks. For select steer L* -values for all the treatments were significantly different (P<0.05) from the control (P<0.05). Visual score and the discoloration score also suggest that treatments C and D outperformed other treatments and were significantly different (P<0.05) for both choice and select grade steaks. Choice quality grade steaks enhanced with treatment D had lower (P<0.05) discoloration score than the select and outperformed select steaks in low discoloration during display days of 4, 5, 6, and 7.

**Conclusion:** Results from these experiments suggest that injection-enhancement of meat with STPP, CG, SS, and PL in combination can effectively extend the color shelf-life of post-rigor beef by providing more reducing conditions for myoglobin, thus increasing myoglobin redox form stability. The results obtained from this research provides new strategies for the beef industry to provide and promote good tasting beef that results in a pleasurable eating experience with consistent quality that will, in turn, ensure repeat purchases and consumption of beef.

**Keywords:** Injection enhancement, meat color, meat color stability

**80 INJECTION ENHANCEMENT OF BEEF STRIP LOINS WITH SOLUTIONS CONTAINING SODIUM TRIPOLYPHOSPHATE, CARRAGEEAN, SEA SALT AND POTASSIUM LACTATE IN COMBINATION TO IMPROVE SENSORY TRAITS AND COLOR STABILITY OF BEEFSTRIP LOINS.** N. Lee 1*, V. Sharma 1, A. Mohan 1, R. Singh 1

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**Objectives:** The objective of this study was to examine the effects of injection enhancement of Sodium Tripolyphosphate (STPP), Carrageenan (CG), Sea Salt (SS) and Potassium Lactate (PL) in beef strip loins of USDA Choice and Select carcasses on Warner-Batzler shear force, Cook Yield and color characteristics, cooked by two different methods.

**Materials and Methods:** Beef strip loins (n = 12) obtained from the USDA Choice and Select, A-maturity carcasses were randomly assigned to injection enhancement with one of the following treatments i.e. A) Control (non-enhanced); B) 0.3% STPP + 0.25% CG + 1% SS; C) 0.3% STPP + 0.5% CG + 1% SS; and D) 0.3% STPP + 2.5% PL + 1% SS. The subprimals were enhanced to 110% of the green weight. The subprimals were fabricated into 2.54 cm thick steaks, vacuum-packaged, and stored at 2°C for 14 days. After the 14-d storage, the steaks were cooked in a water bath and Blodgett oven to an internal temperature of 60°C and allowed to cool for 30 min before measurements. Instrumental color properties were recorded using HunterLab MiniScan EZ. The steaks from each treatment were then divided into two halves and six cores per steak, taken parallel to muscle fiber orientation using a #12 brass core borer. Shear-force was determined using a Texture Analyzer with a 25-kg load cell using a shearing blade. Expressible moisture, moisture content, and cook yield were calculated for each grade steak cooked by water bath and oven. The experimental design was a split-plot design, with loin served as experimental unit. The steaks served as the sub-plot and the data was analyzed using the Mixed Procedure (PROC MIXED) of SAS (SAS Institute, Inc., Cary, NC).

**Results:** The cooked color for L* and a* -values from treatment D was significantly different (P<0.05) than control and all the other treatments. The L* -values for treatment D for the choice steaks were different (P<0.05) from the select. The a* -values were significantly higher (P<0.05) for the select steaks for treatment D as compared to choice. The non-enhanced choice steaks cooked in water bath was not different from the enhanced steaks. However, the quality grade select steaks,
treatment C had the highest $a^*$ value and was significantly different ($P<0.05$) from all other treatments. The non-enhanced control steaks for quality grade select cooked by water bath had higher shear force values than injected steaks. Treatment B & C for quality grade choice had the lowest shear force values and were significantly different ($P<0.05$) from all other treatments. For the oven-cooked steaks quality grade select had the lowest shear force values for Treatment C and D and was significantly different ($P<0.05$) from all other treatments.

Conclusion: Results from these experiments suggest that injection-enhancement of meat with STPP, CG, SS, and PL in combination can effectively extend the color life of cooked meat. The enhancement of beefstrip loins with STPP, CG, SS, and PL in combination can effectively decrease the WBS values and can be used by the US beef processors in meeting consumer demands for high quality and a more convenient product. More research is needed to determine the optimum levels of these treatments.

Keywords: cook yield, moisture content, cooked color, injection enhancement

81 THE EVALUATION OF VARIOUS AGES OF BEEF CARCASSES AND ITS IMPACT ON WARNER-BRATZLER SHEAR FORCE. B. Corliss $^{1,2}$, L. G. Garcia $^1$, M. F. Miller $^1$
$^{1}$Animal and Food Science, Texas Tech University, Lubbock, TX, United States

Objectives: Even though beef cattle of advanced maturity are often discounted due to natural increase in toughness, darker colored appearance, and in some cases intense flavor profile; the use of under valued beef cuts is worth investigating in a time of high beef prices.

Materials and Methods: Beef carcasses (n = 25) were evaluated and identified using USDA Grading Standards: A (n = 5); B (n = 5); C (n = 5); D (n = 5); and E (n = 5). Following fabrication, individual steaks were randomly assigned to one of the five aging treatments: 0, 7, 14, 21, and 28 days resulting in twenty-five steaks per age group. Analysis conducted includes Warner-Bratzler Shear Force (WBSF)(kg).

Data were analyzed using the General Linear Model procedure of SAS (SAS Institute; Cary, NC). The main effect was aging treatment and the random effect was the maturity group. Treatments means were generated using the LSMEANS option and separated when significant ($P<0.05$) using the p-diff option. Descriptive statistics were calculated using the PROC MEANS procedure of SAS.

Results: All treatments exhibited similar WBSF values regardless of aging treatment. Warner Shear Force Scores were as follows: A (4.76 kg), B (4.71 kg); C (4.78 kg); and D (4.69 kg) regardless of aging treatment. However, shear force values significantly differed for the E maturity group (6.49 kg).

Conclusion: The current data indicates aging can have a positive effect on WBSF values for the majority of beef steaks originating from beef carcasses within maturity age groups A – D. However, regardless of aging treatment, WBSF values did not decrease for beefstrip steaks in the E maturity group; therefore, would not be recommended to utilize as steaks, but rather as a roast product.

Keywords: age, beef, maturity, tenderness

82 CONSEQUENCES OF EXTENDED AGING ON RETAIL SHELF-LIFE OF FOUR BEEFMUSCLES. M. J. Colle $^1$, R. A. Gray $^1$, R. N. Day $^1$, W. I. Loucks $^1$, H. A. Sutton $^1$, J. A. Nasados $^1$, A. S. Cochran $^1$, R. P. Richard $^1$, M. E. Doumit $^1$
$^1$University of Idaho, Moscow, ID, United States

Objectives: Our objective was to determine the consequences of aging for 2, 14, 21, 42, and 63 days post-fabrication on fluid loss, retail color stability, and lipid oxidation of top loin, top round, top sirloin, and bottom round steaks.

Materials and Methods: At 48 h post mortem (day 0), beefstrip loin (IMPS 180), top (inside) round (IMPS 168), top sirloin butt (IMPS 184), and outside round (IMPS 171B) from the left side of USDA Select carcasses (n = 12) were purchased from AB Foods (Toppenish, WA) and transported to the University of Idaho Meat Science Laboratory. The Longissimus dorsi (LD), Semimembranosus (SM), Glatues medius (GM), and Biceps femoris (BF) were removed from their respective wholesale cuts for aging and subsequent analysis. The muscles were cut into five sections at least 5.1 cm-thick on day 2. Each section was randomly assigned to one of the five aging periods (2, 14, 21, 42, and 63 days post-fabrication).

Sections were vacuum shrink packaged and subsequently aged at 0 °C. Each section was weighed prior to vacuum packaging and after aging to determine percent purge during storage. At the end of each aging period, 2.54 cm-thick steaks were cut from designated sections for retail shelf-life. Steaks were weighed, placed in white styrofoam trays with the freshly cut surface exposed, and wrapped with an oxygen permeable PVC film. Steaks were displayed in a glass-fronted retail display case at 2 °C for 4 days. Thiobarbituric acid reactive substances (TBARS) were analyzed on days 0, 1, and 4 of retail display. Steaks were allowed to bloom for at least 60 min and then two objective color measurements per steak were taken using a Hunter MiniScan EZ. This represented day 0 of retail display, and subsequent color measurements were taken on days 1, 2, 3, and 4. The instrument was set to Illuminant A and Commission Internationale de l’Eclairage (CIE) L*, a*, b* and values and spectral reflectance between 400 and 700 nm were recorded. Following the day 4 color measurement, steaks were weighed to determine fluid loss during retail display. Thiobarbituric acid reactive substances (TBARS) were quantified in samples obtained from steaks on days 0, 1, and 4 of retail display. Data were analyzed using the Mixed Procedure of the SAS Institute, Inc., Cary, NC and significance was determined at $P<0.05$.

Results: Percent purge increased over storage time for the BF ($P<0.001$), GM ($P<0.02$), and SM ($P<0.001$), and tended to increase for the LD ($P = 0.066$). In contrast, percent retail fluid loss decreased ($P<0.001$) with aging time for all four muscles. An aging period by day of retail display interaction was observed for TBARS (ppm) values in the BF ($P<0.001$), GM ($P<0.001$), LD ($P = 0.001$), and SM ($P = 0.025$), and this indicates that lipid oxidation increased to a greater extent with increasing aging period and retail display time. Furthermore, an aging period by day of retail display interaction ($P<0.001$) was observed for $L^*$, $a^*$, and $b^*$ for each of the four muscles. Interestingly, $L^*$, $a^*$, and $b^*$ values varied inconsistently during the first two aging periods within a muscle, while during the final three aging periods $L^*$, $a^*$, and $b^*$ values decreased with retail display time.

Conclusion: In conclusion, longer aging periods lead to increased lipid oxidation and decreased color stability in all four beef muscles examined.

Keywords: aging, beef, color, lipid oxidation
83 COOKED COLOR OF PRECOOKED GROUND BEEF PATTIES FORMULATED WITH MATURE BULL TRIM. J. J. Hollenbeck 1, J. K. Apple 1, J. W. S. Yaney 1, K. N. Kerns 1, A. N. Young 1
1Animal Science, University of Arkansas, Fayetteville, AR, United States

Objectives: Mature bull necks and A-maturity peeled knuckles were used to test the effect of high pH trim on the cooked color of precooked ground beef patties.

Materials and Methods: Lean (85%) ground beef was formulated with the lean portion consisting of 0, 25, 50, 75, or 100% bull trim, with the remaining lean from USDA Select peeled knuckles and 50:50 lean trimmings as the “fat” portion. Five 13.6-kg batches of each ground beef blend were ground and mixed with 0.5% sweet rosemary extract and 4% water. Then, 151-g patties were formed, allowed to bloom 30 min before instrumental color (L*, a*, and b*) values were collected, refrigerated overnight, and subsequently cooked to an internal temperature of 71 °C in an air-impingement oven. Internal temperature was monitored with a hand-held thermometer, patties were submerged in an ice bath to stop the cooking process, and internal and external instrumental cooked color was measured on 12 random patties/batch. Precooked patties were loosely packaged and frozen at −20 °C until reheating to an internal temperature of 71 °C in either a microwave oven or gas-fired grill. Reheated patties were submerged in an ice water bath to stop the cooking process before internal and external cooked color was measured on 12 random patties/batch for each cooking method.

Results: Patty pH increased linearly (P<0.001) as the percentage of bull trim increased from 0 (5.64) to 100% (6.13). Raw patties became lighter (greater L* values) as the proportion of bull trim increased (linear, P = 0.005); however, a*, b*, chroma (C*), and hue angle (HA) were not (P>0.0120) affected by the percentage of bull trim in the ground beef patty. The L*, b*, C*, and HA decreased linearly (P<0.001) with increasing percentages of bull trim. Yet, internal color of the initial cooked patties became darker (lower L* values) and more yellow (greater b* values) with increasing percentages of bull trim (linear, P<0.002), although proportions of bull trim did not (P>0.278) affect the internal redness (a* values and HA) of initial cooked patties. External cooked color (L*, a*, b*, C*, and HA) was greater (P<0.001) in patties reheated in the microwave than those reheated on the chargrill. Internal cooked color was lighter (P<0.001) in patties reheated on the chargrill than in the microwave; otherwise, reheating method did not (P>0.406) affect the internal color of reheated patties. Conversely, internal color of reheated patties remained redder (greater a* values and lower HA) as the percentage of bull trim increased from 0 to 100% of the lean portion (linear, P<0.001). Also, b* and C* values increased linearly (P<0.001) with increasing proportions of bull trim.

Conclusion: Although high levels of bull trim have minimal effects on raw ground beef color, results of this study indicated that ground beef patties with the highest proportions of bull trim appeared undercooked even after cooking twice to 71 °C. This could lead to consumer discrimination of precooked ground beef patties, especially those formulated with greater than 50% high pH, mature bull trim beef.

Keywords: bull trim, cooked color, ground beef, precooked, reheated

84 NORTH AMERICAN BEEF TENDERNESS SURVEY 2011–2012: BENCHMARKING TENDERNESS AND SAMPLE SHIPPING PROCEDURES. S. Howard 1, J. Scanga 1, D. Wener 1, D. L. VanOverbeke 1, J. Tatum 1, K. Belk 1
1Animal Science, Colorado State University, Fort Collins, CO, 2Elanco Animal Health, Greenfield, IN, 3Oklahoma State University, Stillwater, OK, United States

Objectives: Fifty-four stores in thirty U.S. cities were sampled from June 2011 through May 2012 to benchmark tenderness of beef steaks at retail as assessed by Warner−Batzler shear force (WBSF).

Materials and Methods: Top loin (N = 1042) and sirloin (N = 935) steaks were purchased and shipped via overnight delivery to Colorado State University, Fort Collins, CO. From June 2011 through November 2011 (Period 1) samples were shipped fresh.

Results: Mean WBSF values during Period 1 were 2.9 and 3.9 kg for top loin and sirloin steaks, respectively. Frequencies of steaks classified as tough (WBSF ≥ 4.4 kg) were 8.6% and 17.7% for top loin and sirloin steaks, respectively. When shipped fresh a disproportionately high number (16.9%) of top loin steaks produced WBSF ≥ 2.0 kg, representing significant deviation from WBSF values in previous works. Two trials were conducted to assess the influence of freezing, retail display and shipping on WBSF and slice shear force (SSF) of beef top loin steaks. All treatments were compared to a non-frozen control using PROC MIXED in SAS (SAS Institute, Cary, NC). Freezing, retail display and shipping reduced WBSF by 0.4, 0.3 and 0.0 kg and by 0.4, 0.3 and 0.1 in trial 1 and 2, respectively. Slice shear force was lower (P<0.05) in steaks exposed to shipping conditions during trial 1; however this difference was not observed in trial 2. Shipping decreased the frequency of steaks categorized as tough via SSF determination from 5.7% to 0.0% and from 19.4% to 11.4% for trial 1 and 2, respectively. During trial 1, shipping increased incidence of tough samples from 0.0% to 3.8% as determined by WBSF, however this trend was reversed in trial 2 where shipping reduced incidence of tough samples from 13.0% to 5.6%. Coefficients of variation for treatment effects suggested variance remained unchanged (± 2.0%) with respect to shear force values, however mean values were reduced as a result of shipping conditions. These findings dictated a change in sampling protocol from December 2011 through May 2012, during which samples were shipped frozen. Mean WBSF values were 3.4 and 4.0 kg for top loin and sirloin samples, respectively. Frequencies of steaks classified as tough were 18.0% and 23.5% for top loin and sirloin steaks, respectively.

Table 1. Summary of sample population means for Warner-Batzler shear force (WBSF) of top loin and sirloin steaks from major tenderness surveys conducted in the United States.

<table>
<thead>
<tr>
<th></th>
<th>Top Loin Steak</th>
<th>Sirloin Steak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (kg)</td>
<td>≥ 3.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Morgan et al., 1991</td>
<td>3.3</td>
<td>4.0 – 21.0&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>George et al., 1999</td>
<td>1.9 – 3.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.3%</td>
</tr>
<tr>
<td>Brooks et al., 2000</td>
<td>2.8</td>
<td>6.6%</td>
</tr>
<tr>
<td>Voges et al., 2007</td>
<td>2.1</td>
<td>0.0%</td>
</tr>
<tr>
<td>Savell, 2012</td>
<td>2.4</td>
<td>4.3%</td>
</tr>
<tr>
<td>NABTS – Fresh</td>
<td>2.9</td>
<td>15.0%</td>
</tr>
<tr>
<td>NABTS – Frozen</td>
<td>3.4</td>
<td>24.6%</td>
</tr>
</tbody>
</table>

<sup>a</sup> WBSF ≥ 3.9 indicates steaks predicted to be intermediate in tenderness (Platter et al., 2005).
<sup>b</sup> Range represents inclusion of all quality grades analyzed.

Conclusion: These findings suggest freezing samples prior to shipment may be essential to more accurately and precisely reflecting tenderness at the retail level. These data should be considered during design of future beef tenderness surveys.

Disclosure of Interest: J. Scanga Grant / Research Support from: Funded Project

Keywords: beef quality, shear force, shipping, tenderness
85 PRINCIPAL COMPONENT ANALYSIS OF CONSUMER PALATABILITY SCORES OF BEEF STRIP STEAKS IN RELATION TO TRAINED PANEL DESCRIPTORS, VOLATILE FLAVOR COMPOUNDS, AND FATTY ACID COMPOSITION. T. R. Brown 1, J. F. Legako 1, S. Dinh 1, M. R. Broadway 1, M. F. Miller 1, K. Adhikari 1, and J. C. Brooks 1
1Department of Animal and Food Sciences, Texas Tech University, Lubbock, TX, Texas Tech University, Lubbock, TX 2Department of Human Nutrition, Kansas State University, Manhattan, KS, United States

Objectives: Flavor is a major component of beef palatability that influences consumer acceptability. Beef flavor is greatly affected by the oxidation of lipids, which depends on the degree of saturation of fatty acids (FA). Intramuscular lipids are composed of the neutral lipid (NL) fraction, primarily consisting of triglycerides and the more unsaturated polar lipid (PL) fraction, containing phospholipids. The objective of this study was to identify the relationships between consumer preference, flavor descriptors, volatile flavor compounds, and flavor precursors to better understand the drivers of beef flavor.

Materials and Methods: Strip loins (n = 4) representing three USDA quality grades (Prime; PR, Low Choice; LC, and Standard; ST) from two collection periods (PRCL1, PRCL2, LCCL1, LCCL2, STCL1, STCL2) were used to determine preference by consumer panel (n = 108) and flavor attributes by trained panelists (n = 6). Volatiles (n = 4) were extracted from the head space of cooked steaks using solid-phase microextraction and analysis by gas chromatography/mass spectrometry. The NL and PL fractions (n = 4) were extracted from raw and cooked steaks and quantified by gas chromatography. Principal component analysis (PCA) was performed on consumer palatability traits. Correlation coefficients of the variables were plotted with treatment scores (x coordinate = PC1 correlation coefficients or scores; y coordinate = PC2 correlation coefficients or scores) to evaluate variable relationships and treatment rankings.

Results: Principal component 1 and 2 explained 83% and 10% of the variances, respectively, and were retained to determine coefficients of correlation with other variables. Treatments PR in both collection periods scored greater than ST treatments (0.63 and 0.93 for PRCL1 and PRCL2 compared to −1.00 and −0.94 for STCL1 and STCL2). Overall liking, flavor, flavor intensity, tenderness, and juiciness were positively correlated (r = 0.84; P < 0.04) to PC1. Initial flavor, beef-like flavor, brown/roasted, and umami descriptors were positively correlated to PC1 (r = 0.83 to 0.94; P < 0.04) and closely related to consumer preferences. Short-chain aldehydes previously indicated to contribute to oxidized-off-flavor were in close proximity to oxidized, livery and metallic descriptors. All FA categories (SFA, MUFA, and PUFA) from the NL fraction of raw steaks were greatly correlated with PC1 (r = 0.93; P < 0.07). However, most FA from the PL fraction of raw steaks, except for eicosatrienoic acid (20:3n6), had a neutral effect on consumer preferences, including flavor (PC1 correlation coefficient = −0.1 to 0.46). Total cooked FA’s were negatively related to PC1 (−0.70 to −0.78, 0.62, for SFA, MUFA, PUFA, respectively) and similar to STCL1 treatment. The effect of total cooked FA’s were driven by the cooked PL fraction, with a similar correlation pattern to PC1 (−0.73 to −0.56). However, FA’s from the cooked NL fraction were positively correlated to PC1 (0.54 to 0.99), excluding arachidonic (20:4n6).

Conclusion: The variances of the consumer preference can be used to explain the relationships between the FA composition and the consumer preference ranking. The results indicate that the correlations between FA composition and consumer preference, flavor descriptors, and volatile compounds are driven by the FA’s in the PL fraction.

Keywords: beef quality, flavor, lipid, principal component analysis, volatiles

86 CONSUMER PERCEPTION OF STEWED AND ROASTED GRASS-FED BEEF MUSCLES FROM THE CHUCK AND ROUND IN RELATION TO VOLATILE FLAVOR COMPOUNDS. J. F. Legako 1*, M. F. Miller 1, T. G. O’Quinn 1, K. S. Spivey 1, M. F. Miller 1, J. C. Brooks 1
1Animal and Food Science, Texas Tech University, Lubbock, TX, United States

Objectives: Grass-fed beef has variable effects on palatability. The objective of this study was to examine the effect of two different cooking methods, (roasting, R; stewing, S), on consumer palatability traits (tenderness, juiciness, flavor, and overall liking) of grass-fed beef among 5 muscles (Triceps brachii, TB; Serratus Ventralis, SV; Semimembranosus, SM; Semitendinosus, ST), and explore the relationships of measured traits with volatile flavor compounds.

Materials and Methods: Roasts aged 7 d were cooked to medium degree of doneness (65°C) and served to consumers (n = 330). Portions of the same muscles were further utilized for stewing. Muscles were portioned into 22 equal pieces (21 x 21 x 21 mm) before being pan browned with olive oil, and stewed for 2 hours in a broth made from carrots, onions, potatoes, and salt. Consumers (n = 370) evaluated the stewed pieces for the same palatability traits as R. Each sample was evaluated on a 10 cm, verbally anchored line-scale for tenderness, juiciness, flavor, and overall liking. Volatile flavor compounds were determined for R and S by head space solid phase microextraction followed by gas chromatography mass spectrometry. Univariate analysis was conducted to determine effects of muscle and cook type on palatability traits at a 0.05 significance level. Principal component analysis (PCA) was performed using consumer palatability rankings. The PC1 and PC2 were then used to determine treatment scores, and were correlated with volatile flavor compounds. Treatment scores, palatability traits, and volatile compounds were correlated with PC1 (x-axis), PC2 (y-axis), and plotted together to determine relationships.

Results: Muscle type was found to be different for tenderness (P < 0.05). Triceps brachii was most tender followed by the SV being similar to SM, and the SM being similar to the ST with the BF ranked lowest (P < 0.05). Interactions were determined between muscle and cook type for juiciness, flavor, and overall liking (P < 0.05). Principal Components 1 and 2 explained 89.1% and 6.5% of variances, respectively. Tenderness, juiciness, flavor, and overall palatability were all positively correlated to PC1 (r = 0.90 to 0.98; P < 0.05). Stewed and R muscles of the chuck, TB and SV, along with SM-R were found to be most closely related with palatability scores. By comparison the R and S of BF, ST, and SM-S were less closely related with palatability scores. Sulfur containing volatile flavor compounds (methanethiol, dimethyl-disulfide, dimethyl-sulfide, and carbon-disulfide) and carboxylic acids (butanoic, octanoic, deca-noic) were related to TB, SV, and SM-R. Volatile aldehydes (pentanal, hexanal, heptanal, octanal, nonanal, decanal), alcohols (1-heptanol, 1-hexanol), and ketones (2-propanone, 2-butanoone) were related to BF, ST, and SM-S.

Conclusion: Stews and R of chuck muscles (TB, SV) were found to be preferred by consumers along with SM-R. Volatile flavor compounds were found to be related to both preferred treatments (TB, SV, and SM-R) and lower scoring treatments (BF, ST, and SM-S). Palatability traits may be enhanced through selection of muscle and cookery method among grass-fed beef.

Keywords: beef, consumer, flavor, grass-fed, volatile compounds
87 OXIDATION OF COOKED GROUND BEEF LINKS FROM CATTLE FED DISTILLERS GRAINS IN DIFFERENT PHASES OF PRODUCTION. B. D. Cleveland 1*, J.O. Buntyn 1, L. A. Redfield 1, J. C. MacDonald 1, G. E. Erickson 1, T. F. Jones 1, T. B. Schmidt 1, G. A. Sullivan 1
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Objectives: Cattle fed distiller’s grain have an increase in polyunsaturated fatty acids, which may decrease oxidative stability. The objective of this trial was to evaluate the impact of feeding modified wet distiller’s grain during different production phases on lipid oxidation in ready-to-eat beef.

Materials and Methods: Heifers were randomly assigned to a 2 x 2 factorial that included 2.27 or 0.91 kg/hd/d supplementation of wet distiller’s grain during the winter/spring back-grading phase and either 40% DM sweet bran or modified wet distiller’s grains during the finishing phase. During the summer stocker phase months, all cattle were supplemented with modified wet distiller’s grains at a rate of 0.6% of BW. A total of 16 cows from four USDA Choice carcases within each dietary treatment group were collected. Each cow was independently ground and divided into three, 2.27 kg batches. Beef and non-meat ingredients were mixed for 1 min and the mixture was stuffed into stainless steel links using a plastic stuffer. Links were placed in individual foil trays for each cow and cooked to an internal temperature of 71 °C. The links were placed in zip-top bags and placed in refrigerated storage. Lipid oxidation was evaluated on days 0, 3, 6, 9, 12, 15, and 18 using the thiobarbituric acid reactive substances (TBARS) analysis. Data were analyzed as a 2 x 2 factorial with repeated measures (day) using the PROC GLMMIX procedure of SAS.

Results: Significant winter back-grading diet x day (P = 0.008) and finishing diet x day (P = 0.02) interactions were identified. During winter back-grading regardless of finishing diet, there was no difference (P = 0.05) in lipid oxidation between early fed 0.91 kg and 2.27 kg of modified wet distiller’s grains on days 0, 3, 6, 9, 12, 15, and 18. However, cattle fed 2.27 kg of modified wet distiller’s grains during back-grading had greater lipid oxidation than cattle fed 0.91 kg of distiller’s grains on days 9, 12, 15, and 18 (P = 0.02, 0.02, 0.09, and 0.01, respectively). In finishing (regardless of back-grading), there was a linear increase in lipid oxidation for days 0, 3, 6, 9, 12 for cattle fed modified wet distiller’s grains. There was no increase in lipid oxidation for cattle fed sweet bran during finishing for days 0, 3, 6, 9, and 12. On days 12, 15, and 18, the oxidation of cattle fed distiller’s grains and cattle fed sweet bran were similar (P = 0.55, 0.62, and 0.09, respectively).

Conclusions: Therefore, ready-to-eat beef links from cattle fed 2.27 kg/hd/day of modified wet distiller’s grains during back-grading had greater TBARS concentration with extended storage than those from cattle fed 0.91 kg/hd/day.

Keywords: distiller's grains, lipid oxidation, ready-to-eat beef, TBARS

88 EFFECT OF FEEDING DIFFERENT CONCENTRATIONS AND BY-PRODUCTS THROUGHOUT A BEEF GROWING SYSTEM ON GROUND BEEF COLOR AND LIPID OXIDATION. J. O. Buntyn 1*, B. D. Cleveland 1, J. C. MacDonald 1, G. E. Erickson 1, T. F. Jones 1, T. B. Schmidt 1, G. A. Sullivan 1
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Objectives: The objective of this trial was to evaluate the effect of feeding different concentrations of wet distiller’s grains during winter back-grading and either modified wet distiller’s grains (MDGS) or sweet bran (SB) during the finishing phase on ground beef color and lipid oxidation.

Materials and Methods: Sixty-four heifers were randomly assigned to a 2 x 2 factorial design that included supplementation of 2.27 kg or 0.91 kg/hd/d during the winter/spring back-grading phase (WBGP) and feeding a finishing diet (FIN) with either 40% MDGS or 40% SB (DM basis) during summer stocker all treatment groups were supplemented with MDGS at a rate of 0.6% of BW/hd/d. At the conclusion of the finishing phase, cattle were harvested as a commercial abattoir. Forty-eight h post-harvest, four clods were collected from USDA Choice carcases representing each dietary treatment group; vacuum packaged, and aged for 14 d. On d 14, each clod was independently ground and twelve 113 g patties (hand hamburger press), overwrapped with permeable oxygen PVC wrap, and placed undersimulated retail display for 7 d. During retail display, thiobarbituric acid reactive substances (TBARS); d 0, 0.5, 1, 2, 4, and 6 concentrations, percent discoloration (%Disc; 5 person panel; d 0, 1, 2, 3, 6, 9, and 7 and objective color (L* a* b*) d 0, 0.5, 1, 2, 3, 4, 5, and 6) were evaluated. Data were analyzed as a 2 x 2 factorial with repeated measures (day) utilizing the PROC GLMMIX procedure of SAS.

Results: There was a linear increase (P < 0.001) over time for TBARS concentration, however, the main effects of WBGP or FIN did not impact (P = 0.53) TBARS concentration. There was a FIN x day interaction (P = 0.001) for %Disc patties from heifers fed MDGS on days 3, 5, and 6 were observed to have a greater (P = 0.02) %Disc when compared to patties from heifers fed SB (all other days were similar; P = 0.19). For objective color, a* and L* values linearly decreased (P < 0.001) over time regardless of treatment. The main effects of WBGP and FIN did not have an impact (P = 0.65) on %Disc. Both FIN and day had an impact (P = 0.03) on L* values. Patties from heifers fed MDGS had greater (P = 0.03) L* values compared to heifers fed SB during the finishing phase and L* increased (P = 0.001) linearly as days of simulated retail display increased.

Conclusions: The results of this trial suggest that while there was no difference in TBARS oxidation regardless of dietary treatment, ground beef from heifers finished with MDGS discolored at a greater rate compared to ground beef from heifers finished with SB.

Keywords: color, distiller’s grains, ground beef, lipid oxidation, sweet bran

mEATSAFETy: GENERAl ABSTRACTS

89 HIGH HYDROSTATIC PRESSURE MINIMIZES FORMATION OF BIOGENIC AMINES IN REFRIGERATED CAIMAN MEAT. A. C. V. C. S. Canto 1*, B. R. C. Costa Lima 1, S. P. Suman 1, C. A. Lazarro 1, A. S. Santana 1, C. A. Conte-Junior 1, R. M. Franco 1, T. J. P. Silva 1
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Objectives: Caiman (Caiman Crocodilus yacare) meat is low in fat and is a source of high quality protein. The increasing popularity of caiman meat in Brazil promoted applications of novel preservative strategies to control spoilage and improve safety. High hydrostatic pressure (HHP) is an emerging non-thermal processing method for extending shelf-life of meat and meat products. HHP reduces microbial count, which can decrease the formation of biogenic amines in muscle foods. Biogenic amines exert toxic effects on humans and are considered as indicators of food quality. Nonetheless, limited information is available on the effects of HHP on formation of biogenic amines in fresh meats. Therefore, the objective of the present study was to examine the influence of HHP on generation of biogenic amines in refrigerated caiman meat.

Materials and Methods: Captive-raised caiman (30-month old) were humanely harvested, and the carcases were fabricated. Tail cuts were deboned, vacuum-packaged, and subjected to HHP treatments (200 and 400 MPa) for 10 minutes at 20 °C. Control samples were vacuum-packaged, but not subjected to HHP. The samples were removed from the vacuum packaging and were then aerobically packaged using polyvinyl chloride film. Aerobically packaged caiman meat was stored at 4 °C for seven days and were analyzed for biogenic amines on days 0, 2, 4, and 7. Benzoyl-derivatized biogenic amines (putrescine, cadaverine, and histamine) were identified employing high performance
liquid chromatography equipped with UV detector and based on the retention time of external standards. The identified biogenic amines were quantified. The detection limit was 0.03 – 1.25 µg/kg, whereas the quantification limit was 0.15 – 5 µg/kg. The experiment was repeated six times (n = 6). Data were analyzed using Tukey test, and the means were separated at 5% significance level.

Results: Biogenic amine contents increased (P<0.05) only in controls over the storage. On day 0, samples subjected to 200 and 400 MPa demonstrated lower values (P<0.05) for putrescine and cadaverine than the controls. While HHP-treated samples had lower (P<0.05) cadaverine content than the controls throughout the storage, a difference (P<0.05) in putrescine level between HHP treatments and controls was observed only on day 7. Histamine levels were lower (P<0.05) in 400 MPa samples than the other two treatments on days 4 and 7.

Conclusion: Our results suggest that 400 MPa HHP decreases formation of putrescine, cadaverine, and histamine in refrigerated caiarn meat. Meat industry can utilize HHP treatment as a valuable means to improve meat safety.

Keywords: Biogenic amines, Caiman meat, high hydrostatic pressure

90 CONTROLLING LISTERIA MONOCYTOGENES AND LEUCONOSTOC MESENTEROIDES IN AN UNCURED DELI-STYLE TURKEY BREAST USING A CLEAN LABEL ANTIMICROBIAL

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Objectives: Antimicrobials are an important ingredient for food safety and shelf life. Recent interest in natural and organic meat/poultry processing have resulted in the need to identify and validate clean label antimicrobials in products with different compositional factors. This study investigated the effect of varying levels of moisture, pH, and a cultured sugar-vinegar blend antimicrobial (CSV) to inhibit Listeria monocytogenes (LMON) and Leuconostoc mesenteroides (LMES) in uncured turkey in two separate research phases.

Materials and Methods: Phase I uncured deli-style turkey breast treatments (TRTs; n=20) were generated using a central composite design with variables of moisture (53.7-86.3%), pH (5.6-6.6), and CSV (1.71-5.79%) with five levels for each variable and a center point treatment replicated 6 times. Sliced, cooked products were surface inoculated with 3-log CFU/g of a 5-strain mix of LMON or LMES, vacuum packaged (<100 g/package), and stored at 4°C for up to 16 weeks. Triplicate samples were assayed at 0, 1, 2, 4, 6, 8, 12, 14, and 16 weeks by enumerating on Modified Oxford (LMON) or All Purpose Tween (LMES) agar. Predictive models based on main effects and the interaction between moisture, pH, and CSV were developed to identify formulations that inhibit growth of LMON and LMES. Phase II uncured deli-style turkey breast TRTs (n=16) were generated to test the predictive models against LMON. Moisture remained constant (74.0%) across Phase II TRTs, while pH ranged from 5.8-6.4, and CSV ranged from 2.14 to 2.75%. For both phases, finished products were analyzed for moisture, pH, NaCl, and aw, and positive growth controls containing no antimicrobial were also included.

Results: In Phase I, TRTs had greater inhibitory effects for LMON than LMES (P<0.05). Predictive models (P<0.05) for lag and growth rate were developed for both species. The predictive model for LMES growth rate had the best fit (R² = 0.9093) whereas the models for LMES, LMON growth rate, and LMON lag had a poorer fit (R² = 0.00, 0.00, and 0.2581 respectively). Significant interactions for the LMES growth rate model were pH×pH and moisture×CSV (P<0.05), while significant interactions for the LMES lag model were pH×moisture, pH×CSV, and moisture×CSV (P = 0.051). Significant interactions for the model for LMON for growth rate were pH×CSV and moisture×CSV (P<0.05), where the significant interaction for the LMON lag model was pH×moisture (P<0.05). Based on the Phase II data, the models for LMON yielded a bias factor of 1.20 & 1.18, and accuracy factor of 1.90 & 1.88 for growth rate and lag respectively, whereas models for LMES had a bias factor of 0.89 & 2.38, and accuracy factor of 1.68 & 4.39 for growth rate and lag respectively.

Conclusion: The CSV was effective for inhibiting the growth of LMON, while having little effect on LMES, demonstrating its potential to improve food safety in uncured meat systems, while suggesting it may not offer a shelf life extension benefit. While models generated from this study show trends of lag and growth rate for the species tested, additional validation of formulations used in industry would likely be needed.

Keywords: clean label antimicrobials, Leuconostoc mesenteroides, Listeria monocytogenes

91 CULTURED CORN SUGAR AND VINEGAR AS A CLEAN LABEL ANTIMICROBIAL SOLUTION IN READY-TO-EAT MEATS

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Objectives: According to market research, a top trend is consumers demand for purity and simplicity; the rise of clean labels. This refers to products exhibiting ingredient statements featuring simple language, that is easy for consumers to understand, such as sugar and vinegar. Processors want to meet consumer demand for clean label products, but cannot sacrifice shelf life or food safety. The objective of this study was to evaluate the anti-microbial efficacy of a product containing cultured corn sugar and vinegar in commercial RTE meat formulations such as cured honey ham and cured honey turkey. The efficacy was evaluated independently for Listeria monocytogenes growth potential, shelf life and sensory profile of the products incubated at 4°C for 90 days.

Materials and Methods: Following is the treatment structure (see table) that was used for inoculation with a 5-strain Listeria monocytogenes cocktail and vacuum packed.

The treatments were sampled and enumerated for Listeria monocytogenes (in triplicate) on 0, 15, 30, 45, 60, 75 & 90 days of incubation using modified Oxford media. In parallel, non-inoculated samples were enumerated on TSA YE and MRSA agar to determine the growth of spoilage bacteria and lactic acid bacteria. Proximate and physico-chemical analyses were performed for all the treatments. Sensory evaluations of the different formulations were done by a consumer preference test.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cured Honey Ham</th>
<th>Cured Honey Turkey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>pH</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>6.49</td>
</tr>
<tr>
<td>A</td>
<td>2.0%</td>
<td>6.44</td>
</tr>
<tr>
<td>B</td>
<td>3.0%</td>
<td>6.41</td>
</tr>
<tr>
<td></td>
<td>3.8%</td>
<td>6.39</td>
</tr>
</tbody>
</table>

*Treatment A: Sodium lactate (52%) & Sodium diacolate (8%); Treatment B: Cultured Corn Sugar & Vinegar*

*25% sodium reduced

For cured honey ham, the use of 2.0% antimicrobial A (sodium lactate & sodium diacolate), 3.0% & 3.8% antimicrobial B (cultured corn sugar and vinegar) showed significant (P<0.05) control in outgrowth of Listeria monocytogenes compared to the control treatment. The log outgrowth for Listeria monocytogenes was reached in 45 days for the control and at more than 90 days for antimicrobial A and antimicrobial B treatments. There was no difference in the shelf life counts and consumer preference testing for antimicrobial A and antimicrobial B treatments.
For cured honey turkey, the use of 2.4% antimicrobial A, 3.4% antimicrobial B showed significant (P<0.05) control in outgrowth of Listeria monocytogenes compared to the control treatment. The 2 log outgrowth for Listeria monocytogenes was reached in 35 days for the control and in 90 days for antimicrobial A treatment, respectively. For antimicrobial B treatment, complete inhibition of Listeria monocytogenes was observed during 90 days of incubation. There was no difference in the shelf life of antimicrobial B treatments.

Conclusion: Results from this study demonstrate the antimicrobial efficacy of cultured corn sugar and vinegar in both meat applications to control Listeria monocytogenes without negative taste impact or loss in shelf life. This study provides the meat industry with a clean label antimicrobial intervention without sacrificing shelf life and food safety.

Keywords: antimicrobial, clean label, cultured corn sugar, Listeria monocytogenes, vinegar

92 SURVIVAL AND GROWTH OF LISTERIA MONOCYTOGENES ON DELI

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Objectives: The objective of this work was to investigate the survival and growth of Listeria monocytogenes (LM) on deli roast beef during refrigeration storage. LMs are a food-borne pathogen with serious consequences to human health as it has been identified as the causative agent in multiple outbreaks of foodborne disease. Listeriosis affects an estimated 2500 people annually in the United States. Symptoms may include minor flu-like symptoms to meningitis and spontaneous abortion. Although LM is of great concern due to its potentially serious clinical outcomes, limited information is available regarding the behavior of the pathogen under home storage conditions. Compositional differences between RTE products affect LM growth and survival as well as retail display times, cross-contamination with other meat processing equipment, and transit to home. Inoculum concentrations were chosen to investigate LM survival from minor and major contamination. The identification and analysis of LM growth will be useful in generating more effective strategies to prevent food outbreaks.

Materials and Methods: Growth of Listeria monocytogenes was evaluated in 4 retail brands of roast beef. These products were selected to represent variable ingredient compositions and processing facilities. Individual 25 g slices were placed in a Whirl pack bag and inoculated with serotype 10403S at a concentration of 5.42 log CFU/g or 1.42 log CFU/g. Roast beef samples were placed in 4°C storage and enumerated at days 0, 1, 3, 6, 8, 12, and 16. An additional set of uninoculated roast beef samples (control samples) were stored at both 4°C and 25°C and evaluated at days 0, 2, 6, 10, 16 and days 0, 2, 4, 6 and 8, respectively. All experiments were conducted in duplicate. For LM enumeration, samples were diluted with 100 mL of 1% peptone water and homogenized in the AES smasher for 120 seconds. Dilutions were then made and plated onto Oxford agar and colonies were enumerated after 48 hours at 37°C. DNA was isolated from the samples using the chloroform/phenol extraction method. PCR was performed using primers 341FGC and 534R (V3 region) as described by Muyzer et al. DGGE analysis of the 16S rDNA was performed using a BioRad DC apparatus. The gels were run at 50V for 10 min followed by 150V for 7 hours. Sample means were analyzed for significant differences at P<0.05 using the GLM procedure in SAS.

Results: The growth of Listeria monocytogenes for each brand (A-D) over a period of 16 days is shown in Table 1. No differences were seen in growth at initial concentrations of 5.42 log CFU/g or 1.42 log CFU/g over a 16 day period (P<0.05). No LM was detected on uninoculated samples.

TABLE 1: Survived Listeria counts (log CFU/g) on four brands of RTE roast beef during storage at 4°C.

<table>
<thead>
<tr>
<th>Brand</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>6</th>
<th>8</th>
<th>12</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.60</td>
<td>1.00</td>
<td>1.38</td>
<td>1.49</td>
<td>1.64</td>
<td>1.58</td>
<td>1.00</td>
</tr>
<tr>
<td>B</td>
<td>5.33</td>
<td>5.46</td>
<td>5.66</td>
<td>5.63</td>
<td>5.55</td>
<td>5.34</td>
<td>5.37</td>
</tr>
<tr>
<td>C</td>
<td>1.60</td>
<td>1.30</td>
<td>1.56</td>
<td>1.64</td>
<td>1.73</td>
<td>1.66</td>
<td>1.45</td>
</tr>
<tr>
<td>D</td>
<td>5.73</td>
<td>5.72</td>
<td>5.61</td>
<td>5.74</td>
<td>5.63</td>
<td>5.54</td>
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<td>1.00</td>
<td>1.61</td>
<td>1.61</td>
<td>1.49</td>
<td>1.53</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td>5.65</td>
<td>5.78</td>
<td>5.83</td>
<td>5.66</td>
<td>5.67</td>
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<td>1.20</td>
</tr>
<tr>
<td></td>
<td>5.17</td>
<td>5.58</td>
<td>5.69</td>
<td>5.69</td>
<td>5.51</td>
<td>5.54</td>
<td>5.61</td>
</tr>
</tbody>
</table>

Initial inoculum concentration of 1.42 log CFU/g

Conclusion: No LM growth was observed during the storage period. Although different retail brands may use variable ingredients and Listeria inhibitors, the survival of LM in retail RTE roast beef did not vary by brand and survived for 16 days during 4°C storage.

Keywords: Listeria monocytogenes

93 PROCESSORS' PERCEPTIONS OF MOLD ON MEAT AND IN PROCESSING PLANT ENVIRONMENTS IN KANSAS. A. R. Christiansen ¹*, E. A. Boyle ¹, K. J. Getty ³, D. W. Evans ², A. W. Stedry ³
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Objectives: There is potential for mold to grow on product and on non-food contact surfaces in meat processing environments. The study objective was to assess meat and poultry processors’ perception of mold, mold incidence levels, and control methods used by Kansas facilities.

Materials and Methods: A 54-question survey instrument was developed. A packet containing a survey cover letter, informed consent form, and a paper copy, and online link of the survey was sent to 144 Kansas meat and poultry processing facilities with a 31.9% response rate.

Results: Of these 20, 19, 12, and 10 were federal, state, custom exempt, or retail exempt facilities, respectively, and from these, 11 facilities had a combination of inspection status. Facilities included slaughter (69.6%), further processing (82.6%), fabrication (43.5%), and/or retail exempt (54.3%) that processed beef (91.3%), pigs (87.0%), sheep (56.5%), poultry (34.8%), and other species (93.4%). Just over 37.0% of respondents perceived mold on meat to be a potential allergen for consumers and 30.4% agreed that it represented an insanitary condition while only 15.21% of respondents believed customers should be informed if mold was trimmed from a carcass. Reported incidence of mold in facilities was most frequent in summer (41.3%), and 82.6% of respondents agreed or strongly agreed that mold contaminated non-food contact surfaces should be cleaned and sanitized prior to processing. Respondents believed that a moist plant environment (82.6%) and increased cooler humidity (87.0%) contributed to mold growth in facilities. If mold was found anywhere in a carcass cooler, 10.9% of respondents believed...
this was not an issue, while 89.1% felt it was a sanitation issue. To sanitize non-food contact surfaces if visible mold was observed, 78.3% of respondents would at least use chlorine bleach or a similar compound, followed by 34.8% using hot water or quaternary ammonium compound alone or in combination with other sanitizers. If mold was found on a carcass, 84.8% of respondents believed proper removal should be by trimming. Of these, 16 responded that trimming should wait until the fabrication step to remove mold. Alternatively, 4.3% of respondents believed using a spray containing acid, base, or water, or using a spray in conjunction with trimming was the best way to treat mold on a carcass or on subprimal parts. No respondents believed a whole carcass should be discarded if mold contamination was visible, but 30.4% of respondents were willing to discard packaged or unpackaged raw products if mold was visible. Additionally, 23.9% of respondents would discard further-processed products, and of these respondents, 83.3% would consider changing their processing or packaging methods to prevent reoccurrence. Just over 60.0% of respondents dry age primal and/or smaller products and the majority dry age these products for 11–20 days. There were 8 out of 20 respondents who reported observing mold on cuts while dry aging in a cooler. Respondents did not provide follow-up comments on how mold on dry aged meat was handled in their facility.

**Conclusion:** Survey results indicate that processors are concerned about mold in plant environments and on meat product surfaces and would use sanitation and trimming interventions for mold control.

**Keywords:** meat processing, meat safety, mold Perceptions

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**94 REDUCTION OF PATHOGENIC BACTERIA IN GROUND BEEF USING A LACTOBACILLUS-BASED BIOLOGICAL INTERVENTION.** V. K. Sunkara --*, J. C. Brooks --*, W. E. Chaney --*, J. N. Martin --, M. M. Brashears

--*Animal and Food Sciences, Texas Tech University, Lubbock, United States

**Objectives:** Two pathogenic bacteria that can be found in ground beef are *Escherichia coli* 0157:H7 and *Salmonella*. Recently, six additional non-0157 Shiga toxin producing *Escherichia coli* (STEC) serogroups were declared adulterants in raw ground beef by USDA-FSIS. The objective of this experiment was to evaluate the efficacy of a commercially available multi-species lactobacillus-based biological intervention strains - NPS1, NPS2, NPS7, and NPS3) on the reduction of *E. coli* 0157:H7, *Salmonella* and non-0157 STEC populations in ground beef during retail display using split-split plot experimental design.

**Materials and Methods:** Ground beef was inoculated with cocktail mixtures (10^6 CFU/ml) of either *E. coli* 0157:H7, *Salmonella* or non-0157 STEC and mixed to assure uniform pathogen distribution. Experiment was replicated 3 times for each bacteria. The meat block was then divided into two equal portions (Control; CON and Lactobacillus treated; LAC). The LAC treatment was prepared by adding potable water to each of the aforementioned strains and mixed to prepare the cocktail of desired concentrations (NPS1 and NPS2 at 10^6 CFU/ml and NPS3 and NPS7 at 10^7 CFU/ml). After dilution, 50 ml of the LAC cocktail was added to the ground beef after inoculation and thoroughly mixed prior to grinding. Similarly, CON ground beef (no potable water) was finely ground without the application of a LAC. Finely ground meat from both treatments was portioned on black expanded polystyrene trays prior to overwrapping with polyvinyl chloride film. Packages were displayed in a retail display case (0–4 °C) and sampled on days 1, 3, and 5 of display. At each sampling interval, ground beef samples were stomached in buffered peptone water (BFW), prior to serial dilution and plating in duplicates on MacConkey, Xylose Lysine Desoxycholate (XLD) and deMan Rogosa Sharpe (MRS) agars for all *E. coli*, *Salmonella* and *Lactobacillus* samples, respectively.

**Results:** Microbial counts did not indicate any immediate (d 1 of display) reduction due to LAC treatment. The total *E. coli* 0157:H7 in CON ground beef increased (P<0.05) from d 1 to d 5 of display, while no significant increase (P>0.05) was observed in the number of 0157:H7 from d 1 to d 5 in LAC ground beef. Furthermore, LAC treated ground beef had significantly less (P<0.05) *E. coli* 0157:H7 on days 3 and 5 of retail display than CON. This suggests that LAC was inhibitive toward *E. coli* 0157:H7 proliferation in the treated samples with populations being 0.35 log cycles and 1.02 log cycles lower than the CON on days 3 and 5 respectively. A similar trend was observed in ground beef inoculated with *Salmonella*. Ground beef treated with LAC was effective in controlling the growth of *Salmonella* during retail display with populations being 0.90 log cycles and 1.44 log cycles lower than the CON on days 3 and 5 respectively. In regards to STECs, LAC samples had reduced (P<0.05) pathogen populations on d 5 when compared to CON ground beef. STEC populations were 1.5 log cycles lower in LAC treated ground beef when compared to CON samples on d 5 in the retail display.

**Conclusion:** These results imply that the addition of the commercially available lactobacillus cocktail may provide an efficacious intervention to inhibit the proliferation of *E. coli* 0157:H7, *Salmonella* and non-0157 STECs in overwrapped ground beef subjected to retail display.

**Keywords:** ground beef, intervention, *Lactobacillus*, *Salmonella*, Shiga toxin producing *Escherichia coli*

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**95 ESTABLISHMENT OF NON-0157 SHIGA TOXIN-PRODUCING ESCHERICHIA COLI (STEC) BASELINE OF RETAIL GROUND BEEF IN THE UNITED STATES.** Y. T. Liao --*, G. H. Lonergan --, J. C. Brooks --, A. Echeverry --, M. F. Miller --, M. M. Brashears

--*Animal and Food Sciences, Texas Tech University, Lubbock, TX, United States

**Objectives:** Non-0157 Shiga Toxin-Producing *E. coli* (STEC) have been associated with numerous foodborne outbreaks and capable of causing disease as severe as *E. coli* 0157:H7. Certain non-0157 STEC strains including serotypes of O26, O45, O103, O111, O121, and O145 have been responsible for more than 70% of non-0157 STEC-associated illness in the United States (Scallan et al., 2011). In 2011, U.S. Department of Agriculture Food Safety and Inspection Service (FSIS) declared these six non-0157 STECs as adulterants in ground beef and non-intact beef products (FSIS, 2011). It is not safe to fully assume that the interventions that reduce *E. coli* 0157:H7 will adequately reduce non-0157 STECs on ground beef. With this in mind, the objective of this study was to determine the point prevalence of the six non-0157 STECs in retail ground beef samples in the United States.

**Materials and Methods:** The retail ground beef (n = 1,129) were purchased from October 2011 to May 2012 in 24 US states (NE, IA, TX, KS, WY, CO, WI, CA, OK, MS, OH, MI, IN, IL, MO, FL, AZ, NM, AL, SC, GA, NC, TN, and AR) containing more than half of the total population of the United States. Ground beef with different lean/fat ratios, cuts (chuck, round or sirloin), and packaging types were selected for microbial analysis. Twenty-five grams of each beef sample was taken and enriched with 225 ml of tryptic soy broth (TSB) added with antibiotics in a stomacher bag. After homogenizing, beef samples were incubated at 41 °C for 18 ± 2 hr. After incubation, enriched samples were subjected to BAX® System to detect the presence of the non-0157 STECs, and confirmed by IMS and latex-agglutination test. Frequency of positive samples was determined for all samples, by purchase state, by lean/fat ratio, and by product type (chuck, round, or sirloin).

**Results:** There were 14 presumptive isolates of non-0157 STEC obtained
from 0.8% (n = 9) of the total ground beef samples as shown in Table 1. Ground beef samples of 85/15 ratio (lean/fat) without specific cuts were more likely to be associated with non-0157 STEC contamination. The presumptive isolates of serotype included 026 (n = 4), 0103 (n = 4), 0145 (n = 3), 045 (n = 2), and 0121 (n = 1); however, serotype 0111 was not found in this study.

Table 1. Retail ground beef samples with presumptive STEC isolates.

<table>
<thead>
<tr>
<th>State</th>
<th>Lean/fat</th>
<th>Type of cut*</th>
<th>Serotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>85/15</td>
<td>Regular</td>
<td>0103</td>
</tr>
<tr>
<td>Illinois</td>
<td>93/7</td>
<td>Regular</td>
<td>0103</td>
</tr>
<tr>
<td>Colorado</td>
<td>85/15</td>
<td>Round</td>
<td>026, 0145</td>
</tr>
<tr>
<td>California</td>
<td>85/15</td>
<td>Regular</td>
<td>026</td>
</tr>
<tr>
<td>California</td>
<td>85/15</td>
<td>Regular</td>
<td>026</td>
</tr>
<tr>
<td>Texas</td>
<td>85/15</td>
<td>Regular</td>
<td>045, 0103, 0145</td>
</tr>
<tr>
<td>Texas</td>
<td>90/10</td>
<td>Sirloin</td>
<td>0121, 045, 0103</td>
</tr>
<tr>
<td>Texas</td>
<td>96/4</td>
<td>Regular</td>
<td>0145</td>
</tr>
<tr>
<td>Texas</td>
<td>96/4</td>
<td>Regular</td>
<td>026</td>
</tr>
</tbody>
</table>

*Regular indicates no specific cuts on the ground beef sample.

Conclusion: The results of this study indicate that the individual tested STEC serotypes were not present in more than 0.35% of the ground beef samples; while providing us with information that can not only be used to validate the current interventions for non-0157 STECs, but also be helpful in targeting commonly contaminated subprimal Roast beef risk assessments.


Keywords: Non-0157 STEC, retail ground beef

96 VALIDATION OF D- AND Z- VALUES FOR LISTERIA MONOCYTOGENES, SALMONELLA AND SHIGA-TOXIN PRODUCING ESCHERICHIA COLI IN READY-TO-EAT MEAT AND POULTRY PRODUCTS. A. M. King 1*, R. P. McMinn 2, J. J. Sindelar 3, K. A. Glass 1, A. L. Mikowski 1, R. D. Hanson 1

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Objectives: USDA, FSIS Appendix A is widely used as validation support for thermal processes of processed meats, but its time-temperature tables were developed only for Salmonella in roast, cooked, and corned beef. Pathogen- and product-specific time-temperature tables are needed to improve validation of thermal processes. The objective of this study was to validate temperature-death times of Listeria monocytogenes, Salmonella, and shiga-toxin producing Escherichia coli (STEC) in ready-to-eat turkey breast, roast beef, and ham.

Materials and Methods: D- and Z- values for each pathogen were determined in a previous phase of this study for ground turkey breast (containing 1.5% salt, 1.5% dextrose, 20% water), ground roast beef (containing 1.0% salt, 0.35% sodium phosphates, 0.75% sugar, 20% water), and ground ham (containing 2.5% salt, 1.65% sugar, 0.35% sodium phosphates, 547 ppm Na erythorbate, 200 ppm Na nitrite, 20% water).

In this phase, turkey breast, roast beef, and ham were manufactured according to the same formulations as the previous D- and Z- value generation phase, inoculated with 8 log CFU/g of the designated pathogen cocktail, and stuffed into 4" diameter casings. Treatments were cooked to one of three target temperatures (130, 145, 160 °F) using a either a step-up 100% humidity (turkey breast or roast beef in impermeable casings) or wet bulb/dry bulb (ham in fibrous casings) thermal process. Triplicate samples were removed from the core, midpoint, and surface of each chub for enumeration of surviving pathogens at 3 pre-determined time-points during each thermal process (130 °F - sampled at 130, 130 +1h, and 130 °F +2h; 145 °F - sampled at 130, 145, and 145 °F +5min; 160 °F - sampled at 130, 145, and 160 °F). Additional samples were processed after chilling to ≤40 °F to account for integrated lethality during cooling. Turkey breast was inoculated with Salmonella and cooked to a final temperature of 160 °F. Roast beef was inoculated with Salmonella or STEC and cooked to a final temperature of 130, 145, or 160 °F. Ham was inoculated with Listeria monocytogenes and cooked to a final temperature of 145 or 160 °F. Surviving Listeria monocytogenes, Salmonella or STEC were enumerated using Modified Oxford, XLD or Sorbitol MacConkey agar, respectively, with thin layer overlay of nonselective media to enhance recovery of injured cells. Each treatment combination was replicated twice.

Results: Cooking to 160 °F was sufficient to kill >6 log of the 3 pathogens in all the products tested. STEC and Salmonella were similarly inactivated in roast beef when cooked to 145 °F, but the additional lethality contributed during cooling was necessary to inactivate >6 log Listeria monocytogenes in ham cooked to a final temperature of 145 °F. Less than 4 log of Salmonella or STEC were inactivated in the core samples of beef heated to 130 °F and held for 2 hours.

Conclusion: Results from this study confirm that cooking temperatures and times identified in Appendix A are sufficient to kill pathogens when temperatures meet or exceed 145 °F. Additional investigation is needed to identify hold times or other modifications necessary to achieve > 6 log reductions of Salmonella and STEC when utilizing 130 °F as the final Cool storage temperature for roast beef.

Keywords: Meat safety, thermal processing, validation

97 EFFICACY OF CHEDDAR AND EDAM WHEY IN REDUCING OXIDATIVE DEGRADATION OF CUBED BEAK FEEK. Z. Z. Haque 1, D. Mukherjee 1, B. Williams 1*, H.B. Abessino 1, S. Chang 1

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Objectives: Retail-cut cubed steak is most susceptible to oxidative degradation due its increased surface area caused by the metallic cubing machine. Antioxidants can reduce degradation which would be economically beneficial if the protection extended the refrigerated storage from 3 to 5 days. Adding 1 to 2 additional days of display shelf-life is a significant increase for the retailer. It is even more desirable if the antioxidant is of natural origin with GRAS status in the face of increased consumer concerns of the potentially negative effects of long term consumption of synthetic preservatives. Sweet whey has been shown to possess good antioxidative activity and when used in edible coatings applied to various foods. The manufacture of both Edam (E) and Cheddar (C) cheese produce sweet whey (W) but they are processed differently in terms of starter culture and applied heat. Manufacturing process of Cheddar subject the curd to temperatures (~61 °C) favorable for abundant microbial growth for a longer period of time than Edam. This causes greater starter-culture bacteria related enzymatic breakdown of milk proteins producing higher peptide content that results in the characteristic fla-
tor of Cheddar. It is hypothesized that a difference may also exist in the antioxidative efficiency of the two wheys due to the conceivably formation of Maillard reaction products during Cheddaring process. This study investigates the antioxidative activity of powdered EW and CW manufactured under controlled conditions at the MSU pilot plant.

**Materials and Methods:** Edible coatings containing different amounts (0.25, 0.5, 1 and 2%, w/v) of EW and CW were prepared by dissolving the respective whey powders in McIlvaine’s siso-ionic buffer (pH 7.0), and applied to freshly prepared cubed beef steaks samples of equal weight and uniform geometry. Samples were treated by immersing them for two minutes in the whey solutions while controls were immersed only in the buffer. These were placed in Styrofoam trays wrapped with polythene film and stored up to 7 days at 4°C. The samples stored for 0, 1, 3, 5 and 7 days were minced, extracted with McIlvaine’s buffer and the average carbonyl content (ACs) (the most abundant product of protein oxidation) was measured. The experiments were replicated three times. Data were analyzed using student’s t-tests to determine whether the ACs of the various samples were significantly different compared to control.

**Results:** It was evident that EW and CW had high antioxidative efficacy. The ACs of the samples treated with only 0.5 and 1% (w/v) CW were lower (P = 0.03) compared to controls after 3 and 5 days of storage, and even on extended storage for 7 days. Coatings containing EW were similarly effective at the same concentration range and storage period compared to controls. However, EW was not as effective as CW in the critical storage period of 3-5 days. The study showed a marked increase in antioxidative efficacy of edible film coating containing CW compared to those containing EW at a low concentration of only 0.5-1% (w/v) when applied to cubed beef steak.

**Conclusion:** Data illustrate CW’s potential use as a natural and comparatively inexpensive component in edible films to protect cubed steak from the adverse effects of oxidative degradation.

**Keywords:** antioxidant, beef steak, protein oxidation, sweet whey

98 REDUCTION OF SALMONELLA IN CATTLE SUBILIAC LYMPH NODES IN A RESEARCH FEEDLOT SETTING USING A LACTOBACILLUS ACIDOPHILUS (NP51) BASED PRE-HARVEST INTERVENTION. J. L. Vpham 1, 2, G. H. Long 3, L. M. Guille 1, L. M. Brashear 1

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**Objectives:** Despite the beef industry efforts, Salmonella still poses a significant threat to public health, as it is protected within the lymph node and cannot be eliminated with current post-harvest interventions. Recent studies indicate that lymph nodes from beef carcasses that are incorporated into ground products may potentially contribute to Salmonella contamination of ground beef. Direct-fed microbial pre-harvest interventions containing Lactobacillus acidophilus NP51 have been shown to reduce both Salmonella and Shiga-toxi geneic Escherichia coli in rumi nant systems. The objective in this study was to determine if the addition of a high dose (109/head/day) of NP51 to feedlot cattle diets will also reduce Salmonella in lymph nodes of cattle at slaughter.

**Materials and Methods:** A total of 112 steers were blocked by weight in a research feedlot with 14 pens/treatment and 4 steers/pen. The cattle were randomized to one of the following treatments: 1) control group without NP51 supplementation, 2) treatment group with 109/head/day NP51 supplementation. Immediately after slaughter lymph nodes were acquired from the steers (n = 107). Samples were placed on ice and transported back to the laboratory for qualitative and quantitative Salmonella analysis.

Samples were homogenized in 80 ml of trypticase soy broth (TSB) and incubated at room temperature for 2 hours and then at 42°C for 12 hours. Immunomagnetic separation (IMS) was conducted using anti-Salmonella Dynabeads and transduced to 3 ml of Rappaport Vassiliadis (RV) broth and incubated at 42°C for 18 - 20 hours. Enrichments (RV) were streaked onto Brilliant Green Sulfite (BGS) and Xylose Desoxycholate (XLD) agar plates. Characteristic colonies of Salmonella were considered presumptive positives. Further identification was gained using commercial agglutination kits. Enumeration was completed using Enterobacteriaceae (EB) petrifilm. Petrifilm growth was transferred to XLD agar and incubated for 16 hours at 37°C. Plates displaying characteristic Salmonella growth were counted and compared with pet rifilm counts. Concentrations of Salmonella are reported on a CFU/g and CFU/gram basis.

**Results:** Salmonella prevalence in bovine subiliac lymph nodes from control cattle was found to be 34.00%. A significant (P<0.05) reduction in Salmonella prevalence of 88.00% was observed between control cattle and cattle fed NP51. Concentration shifts of Salmonella in lymph nodes were also observed. Concentration in treatment cattle were more likely to be low (at 1 log cfu/gram or below) and the level of detection while higher (4 log cfu/gram) concentrations were more likely to be found in control samples.

**Conclusion:** Results from this study indicate that supplementation with 109/head/day NP51, as a pre-harvest intervention will successfully reduce both the prevalence of Salmonella in bovine lymph nodes as well as Salmonella concentration in lymph nodes. Products such as NP51 can reduce the pathogen loads entering harvest facilities, therefore, reducing contamination entering ground beef products. Ultimately contributing to outbreak prevention, reduction of recall costs for the industry and government, and increased protection of public health.

**Keywords:** Salmonella, lymph nodes

99 SURVIVAL COMPARISON OF SHIGA TOXIN PRODUCING ESCHERICHIA COLI (STEC) 026 AND FARM ISOLATED 026 IN GROUND BEEF. C. Palmer 1, 2, C. Bratcher 1, M. Singh 3, J. Wang 1

1Department of Animal Sciences, 2Department of Poultry Science, Auburn University, Auburn, AL, United States

**Objectives:** Six non-O157 STEC serogroups were added to the zero-tolerance adulterant list in June 2012, one of which was Escherichia coli 026. In August 2010, Cargill meats solutions corp. recalled approximately 8,500 pounds of ground beef products due to Escherichia coli contamination. In a recent study conducted in the author’s lab, 026 was found to be the dominant serogroup isolated from calves during the pre-harvest stage. The objective of this study is to evaluate and compare the survival of bacterial- and farm-isolated 026 strains in ground beef during refrigeration storage.

**Materials and Methods:** Three farm isolated strains and one clinical isolate were used in this study. Before the beef inoculation study, a multiplex PCR assay targeting stx1, stx2, and eaeA genes was used to determine the presence of three major STEC genes. After the initial screening, an antimicrobial resistance test and a pulse field gel electrophoresis (PFGE) fingerprinting were done for all isolates. The selected strains were transformed with a GFP plasmid and used for the inoculation study. Ground beef was purchased from a local store and proved to be 026 and O157 free via PCR; those pathogen free beef samples were then inoculated with overnight 026 cultures to reach the final concentration of approximately 8 Log CFU/g, 6 Log CFU/g, and 2 Log CFU/g. Samples were then stored at 4°C for 10 days. To enumerate surviving 026 cells, 125 mL of 0.1% peptone water was added to 25g of ground beef, the bag was stomached, and a 100µL sample was spread on LB agar plates supplemented with 0.1 mg/ml ampicillin and 50mg/ml arabinose. Colo-
nies were counted the next day after 24 hrs incubation at 37 °C.

**Results:** Multiplex PCR showed that the three farm isolates all contained the eaeA gene while the clinical strain had both the eaeA and the stx1 genes. The antimicrobial test showed no great difference in resistance among all strains. In the PFGE test, none of the strains tested exhibited a >94% similarity, so none of them could be considered the same in PFGE type. The ground beef survival test comparing the clinical and farm strains was done in duplicate. The O26 strains survived in ground beef for 10 days with no significant difference in counts (P>0.05). In addition, no significant difference was found between clinical and farm strains regardless of inoculation level (Mauchly’s Test of Sphericity, P = 0.965).

**Conclusion:** PFGE results show that the farm strains were more similar to each other than they were to the clinical strains. Survival rate of the clinical strain compared to the farm strains in the ground beef was found to be the same. The clinical and farm strains exhibit different genes related to pathogenicity, but this does not appear to affect its survival in the antimicrobial and ground beef studies. This research and similar studies will help further research in identifying the impact of bacteria within the same serogroup having different pathogenic-related genes. Further tests looking at inactivation of clinical and farm strains held at certain temperatures for an extended period of time should be conducted to see if there are any differences.

**Keywords:** ground beef, O26, Shiga toxin producing *Escherichia coli*, survival

**100 ASSESSMENT OF PHYSICAL AND CHEMICAL MULTI-HURDLE DECONTAMINATION APPROACH USING ORGANIC ACIDS TO ENHANCE MICROBIAL PROPERTIES OF BEEF TRIMMINGS:** J. A. Marcos **1**, F. W. Pohlmans **1**, P. N. Dias-Morse **1**, C. L. Coffman **1**

**1**Animal Science, University of Arkansas, Fayetteville, AR, United States

**Objectives:** Despite substantial control measures implicated in the production line, prevalence of pathogenic bacteria in beef products continues to challenge the safety. The use of organic acid solutions such as acetic, citric and lactic acids have been widely used in meat decontamination at 1 – 3% concentration and it is reported that combination of two organic acids may establish a stronger lethality effect on bacteria due to the release of more proton ions by acids compared to a single acid alone. Further, the effectiveness of organic acid in meat decontamination expected to be enhanced when the temperature of acid solution is elevated to 55 °C. Hence, our objectives were to evaluate the antimicrobial properties of malic, octanoic acids and paracetic acid (an equilibrium mixture of acetic acid and hydrogen peroxide) through simultaneous physical and chemical multi-hurdle approaches and assess the treatment effects on instrumental color and weight gain of intact beef trimmings.

**Materials and Methods:** The intact beef trimmings (7.6 X 7.6 cm) inoculated with a cocktail mixture containing *E. coli* O157:H7, O26, O103, O111, O121, O45, O145 and *Salmonella* Typhimurium DT 104, Newport MDR-AmpC (105 CFU/g) were immersed (n = 4/treatment) in treatment solution (100 ml) for 10 s and then allowed to drip for 30 min following the treatment application and prior to the secondary treatment application. The treatments included single acids (6% malic acid (M6) and 6% octanoic acid (O6)); acid mixtures (1:1 mixture of malic and octanoic acid at 2% (M02) and 6% (M06) concentrations; acid mixtures (M025S and M065S) or 0.02% paracetic acid (PA55) heated up to 55 °C; acid mixtures or 0.02% paracetic acid at 23 °C followed by sterile water at 23 °C (M02W, M06W, PAW) or sterile water heated to 55 °C (M2HW, M06HW, PAHW); 0.02% paracetic acid followed by 5% lauric arginine (PALA), 0.02% octanoic acid (PAO) or 10% trisodium phosphate (PAT). Each treatment was repeated 3 times. Next 25 g sample from each treated and untreated (IN) beef trimmings were aseptically removed and stomached with 225 ml water for microbiological enumeration. The CIE L’, a* and b* measurements (n = 3/sample) were obtained using Hunter Lab mini scan I-luminant A/10° observer and the weight gain was calculated as (treated weight-initial weight)/initial weight*100. Data was analyzed using: LS MEANS DFF option of SAS.

**Results:** The treatments O6, M02W, M065S, M06W, M06HW, PALA and PAO surpassed other applications with >1 log (P<0.05) in *E. coli* and *Salmonella* population reductions compared to the untreated control. All treatments showed no difference (P>0.05) to the control in lightness. The PALA, PAW and PAHW- treated beef trimmings had greater (P<0.05) redness (a*) while other treatments showed no difference (P>0.05) in redness compared to the control sample. All the treatments showed similar (P>0.05) weight gain, however, M06W-treated samples had a higher weight gain (P<0.05) in relation to PALA and PA55 treatments.

**Conclusion:** The results suggest that 1:1 combinations of malic and octanoic acid at 6% concentration, in combination with elevated temperature or paracetic acid followed by lauric arginine, sterile water or sterile water heated to 55 °C may provide successful beef decontamination interventions with no changes or enhancements in meat color.

**Keywords:** beef trimmings, decontamination, meat safety, microbial, organic acids


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**Objectives:** One of the primary objectives in the meat industry is meeting consumer demands through the manufacturing of safe and wholesome products. Food safety is a major focus of the entire meat industry, and it is necessary that the meat industry continues its focus on developing new technologies for reducing food borne illnesses and while striving for consumer satisfaction. Often the center of attention for enhancing the food safety of our meat supply begins in slaughter facilities. Therefore, the objectives of this study were to evaluate carcass washing technologies organic (lactic acid) and inorganic (buffered sulfamic acid-AFTEC 3000) on reducing microbial loads within a commercial beef slaughter facility.

**Materials and Methods:** Forty (n = 20/treatment) carcasses were sampled at three intervals (PRE, POST, and 8 HR) during a production shift. Carcasses were sampled prior to entering the wash cabinet (POST) and then again following a 180 sec drip period (PRE) after entering the chilling coolers. Prior to carcass fabrication, carcasses were again swabbed (8 HR) to assess the post wash effectiveness. Carcasses pass through a two-phase wash cabinet, with the first being hot water, and the second an intervention wash. Carcass wash ingredients are mixed and delivered through an automatic dosing system. Solution concentration for this study was 2% for AFTEC and 4.5% for lactic. During carcass swabbing, 4000 cm² from each side of the beef carcass was swabbed with a premoistened sponge containing 5ml of butteflies buffer. Sponges were placed into a sterile puch-pak bag and individually identified. Following collection, samples were transported on ice to the Tarleton State University Meat Laboratory for plating. Samples were plated onto aerobic, coliform, and *generic E. coli* petrifilm plates and incubated at 37 °C for 24 to 48 h per plating specifications.

**Results:** Results generated during this study indicate there were no
differences (P<0.05) across sampling periods (PRE, POST and 8 HR) for coliforms and E. coli organisms regardless of carcass wash technology. Coliform results indicate that both AFTEC and Lactic generated a reduction in surface organism equaling 1.3 logs as detected from surface swabs. Additionally, aerobic organisms resulted in a 1.30 (P<0.05) log reduction on carcasses receiving AFTEC compared to only a 0.6 log reduction for lactic. Carcass swabs collected at 8 (HR) indicate that carcasses treated with AFTEC-3000 had a greater (P<0.05) sustaining reduction in surface organisms than those receiving lactic. The results collected at (8HR) suggest that AFTEC could have a more sustained effect as a result of pH on elimination of surface organisms.

Conclusion: Results from this study suggest AFTEC 3000 as a carcass washing intervention for beef carcasses is as effective as lactic acid in reducing surface organisms. Furthermore, these suggest newer technologies can lead to enhancing the safety of beef production and provide interventions that are potentially cost-effective to production facilities.

Keywords: inorganic acid, organic acid, beef, carcass wash

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Objectives: Introduction: Lactobacillus acidophilus strain NP51 is a commercially available direct-fed microbial. This direct-fed microbial is recommended by the FSIS to be a pre-harvest management control and intervention option for the reduction of Escherichia coli O157:H7. The addition of NP51 in cattle diets at a dose of 10^8/head/day (high dose) has been proven to reduce E. coli O157:H7 and Salmonella in cattle feces. Additionally, an improvement in performance of cattle has been identified making it highly accepted in the cattle feeding industry. Currently, there has been no research conducted on the effects of NP51 and the reduction of the “Big Six” non-O157 G0 groups in cattle. The purpose of this study was to evaluate the pre-harvest direct-fed microbial intervention, Lactobacillus acidophilus NP51 at a rate of 10^8/head/day (hNP51) on the reduction of E. coli O157:H7 and non-O157 G0 groups in cattle feces.

Materials and Methods: Approximately 1,800 cattle were blocked by weight and randomized into treatments in a commercial feedlot that included 12 control pens and 12 treatment pens. Each pen included 75 head per pen. The treatments included control cattle (not fed NP51) and treatment cattle (supplemented with 109/head/day NP51). Twenty-five fecal pads were taken from each pen (n = 600) and transported to the laboratory for microbial analysis. All samples were analyzed for E. coli O157 and the genes that encode for the “Big 6” non-O157 serogroup antigens. Quantitative estimates were derived from fecal samples that were positive for E. coli O157. Ten grams from each fecal sample were incubated in 90 mL of GN broth for 6 hours at 37°C. A PCR analysis was conducted with each sample for the presence of genes encoding for the Non-O157 STEC serogroups. To detect the presence of E. coli O157, MS analysis was conducted for each sample and plated onto selective, chromogenic agar plates. The chromogenic plates were incubated at 35°C for 22-28 hours. Typical E. coli O157 colonies were agglutinated for the O antigen. Presumptive positive isolates were frozen in TSB with added glycerol for further analysis. Positive fecal samples were subjected to enumeration using direct plating and MPN methods. This study had a binomial response variable and a generalized linear mixed model was used using SAS (all P values are included).

Results: A 45% reduction of E. coli O157 in fecal samples was observed when comparing control groups to treatment groups (P=0.015). Overall E. coli O157 enumeration resulted in a significant reduction of 0.9 log when comparing control and treatment groups (P=0.026). Non-O157 STEC results indicated a reduction in 0 groups O26, O45, O103 and O121 with a reduction of 53% (P=0.02), 41% (P=0.02), 35% (P=0.03) and 47% (P=0.02) respectively. The genes encoding for O111 and O145 serotypes were not detected in quantities sufficient for statistical analysis.

Conclusion: In conclusion, NP51 statistically reduced the detection and enumeration of E. coli O157 and the detection of the genes encoding for serotypes O26, O45, O103 and O121 in cattle feces. This pre-harvest food safety intervention shows to be a successful tool in reduction of pathogens within cattle.

Keywords: E. coli, Lactobacillus acidophilus, NP51, pre-harvest

103 SALMONELLA PRESENCE IN LYMPH NODES AND TONSILS OF SWINE HARVESTED IN CANCUN AND MERIDA, MEXICO. H. Ruiz 1*, M. F. Miller 1, L. D. Thompson 1, L. G. Garcia 1, C. Brooks 1, G. H. Loneragan 1, A. Echeverry 1, M. M. Brashears 2, G. O. Cervera 2
1Animal and Food Science, Texas Tech University, Lubbock, TX, United States, 2Facultad de Medicina Veterinaria y Zootecnia, Universidad Autonoma de Yucatan, Merida, Mexico

Objectives: To 1) determine the prevalence of Salmonella in lymph nodes (LN) and tonsils from swine presented for harvest in Merida and Cancun, Mexico; and 2) examine the prevalence variation between lymph node types and tonsils.

Materials and Methods: Mandibular, mesenteric, subiliac LN’s and tonsils were collected from two municipalities slaughter operations in the Yucatan Peninsula of Mexico in 2 separate visits (n = 230, n = 49 LN and Tonsil respectively). Samples were trimmed of as much exterior fat as possible and surface sterilized by dipping each sample in to boiling water for 3-5 seconds. Samples were pulverized and enriched in tryptic soy broth (TSB), subjected to immunomagnetic separation (IMS) and streaked on xylose lysine deoxycholate (XLD) agar and brilliant green sulf (BGS). Isolates with typical morphology that yielded a positive result on a latex agglutination assay were classified as Salmonella.

Results: Prevalence in LN from Merida was 16.67%, 46.67%, 10.00% for mandibular, mesenteric, and subiliac LN, respectively and 25.00% for tonsils. Prevalence in LN from Cancun was 8.00%, 12.00% for mandibular, and subiliac LN, respectively and 28.00% for tonsils. Overall prevalence in LN from both cities was 14.78%, 46.67%, 9.56% for mandibular, mesenteric, and subiliac LN, respectively and 26.53% for tonsils

Conclusion: While previous reports indicated that pork lymph nodes collected in the northern states of the US do not regularly contain Salmonella, our findings suggest that Salmonella is commonly found in pork lymph nodes. Mesenteric LN had the highest overall prevalence but the pathogen was also recovered in the other four locations. We recovered Salmonella from 9.56% of subiliac LN which is distinctly different from research conducted in Iowa in which only 1 of approximately 1,700 subiliac LN were positive. In the study described herein, we observed substantial variation among LN types in terms of the likelihood of recovery of Salmonella. The two LN types that are of the most public-health importance, based on the data collected in Merida and Cancun are the subiliac and the mandibular LN. The subiliac lymph node can be readily incorporated into ground pork. The mandibular LN can be incorporated into Mexican-style breakfast chorizo in the US. Further investigation should be conducted to better understand Salmonella dissemination among various lymph nodes and to identify opportunities for meaningful control.
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Keywords: lymph node, pork, Salmonella

104 PREDOMINANCE AND SEROGROUP TYPE OF SALMONELLA spp. IN FEEDLOT LAMB FECAL AND HIDE SAMPLES BEFORE AND AFTER HARVEST. W. Bruha 1 *, K. Braden 1, B. Wallace 2, M. Schwartz 2, L. Branham 3
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Objectives: With identification of Salmonella as the number one bacterial foodborne pathogen within the United States, it is important to have a realistic estimate of the pathogen in all production livestock species. A trial surveying 200 feedlot sheep was conducted in order to determine the incidence of Salmonella spp. in fecal and hide samples before transportation, as well as the incidence of hide samples after transportation to a commercial processing plant in north Texas.

Materials and Methods: Two cohorts were sampled three weeks apart with each cohort consisting of 100 animals. Approximately 20g of fecal matter was collected via rectal palpation and 300 cm2 was swabbed on the right side of each animal’s abdomen at the feedlot. Animals were then immediately transported in a double decked livestock trailer approximately 418 km to the processing plant, where the animals were swabbed on the left side of their abdomen. Fecal samples were selectively enriched in Rappaport-Vassiliadis broth and Tetrathionate broth before selective plating on Xylose-Lysine-Tergitol 4 (XLT4). Hide samples were processed in the same manner with an added initial pre-enrichment in Buffered Peptone Water (BPW) to aid in Salmonella repair. Presumptive positive samples were confirmed using a commercial latex agglutination kit, which was also used to classify one isolate from each sample into serogroup type. Isolates will be analyzed for antibiotic susceptibility using a commercial micro broth dilution plate.

Results: Five percent of fecal samples from cohort one tested positive, while no Salmonella spp. was isolated from fecal samples of cohort 2 (P = 0.02). When comparing feedlot hide samples taken from the two cohorts, 10% of hide samples from cohort one tested positive, while five percent of cohort two tested positive for the bacteria (P = 0.18). A significant difference in prevalence between the two cohorts was found in hide samples taken at the plant (P = 0.75). Sixty-nine percent of cohort one hides taken at the plant and 71% from cohort two were positive. In both cohorts, there was a significant increase in prevalence of Salmonella spp. on hides pre-to post-transport (P<0.001). Of the 160 total isolates tested for serogroup, 64(40%) were classified as serogroup B and 77(48.13%) were from serogroup C. An additional 16 isolates (10%) fell into serogroups E or G, and one isolate was identified as containing the Vi Antigen. Interestingly, the isolates from cohort one were predominantly serogroup C (88.10%); while within cohort two, serogroup B was predominant (76.32%).

Conclusion: These results help establish baseline prevalence data of Salmonella in feedlot hair sheep and expose the impact transportation can have on the presence of this bacteria on small ruminant hides. Evaluating antibiotic susceptibility levels in Salmonella isolates obtained from these relatively isolated feedlot sheep populations will help to further shed light on the dynamic factors which potentially contribute to anti-biotic resistance.

Keywords: lamb, Salmonella, serogroup, transportation

105 EVALUATION OF PROCESS CONTROL TO PREVENT CONTAMINATION OF BEEF WITH NON-0157 SHIGA TOXIN-PRODUCING ESCHERICHIA COLI (STEC) IN U.S. EXPORT ABATTOIRS IN HONDURAS AND NICARAGUA. B. D. Chaves 1, M. Maradiaga 1, M. A. Calle 1, L. Thompson 1, S. P. Jackson 1, T. Jackson 1, M. E. Miller 1, L. G. Garcia 1, A. Echeverry 1, *, H. Ruiz 1, M. M. Brashears 1
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Objectives: The objectives of this project were to determine 1) the prevalence of non-0157 STEC on beef hides and carcases in export abattoirs in Honduras (Plant A) and Nicaragua (Plant B) and 2) if current practices and interventions controlled final carcass contamination.

Materials and Methods: Samples were collected on the foreshanks from the hides, at pre-erevisceration, and after application of an antimicrobial treatment (2-2.5% lactic acid spray). A PCR protocol was used to assess the presence of S. enterica and STEC serogroups O26, O45, O103, O111, O121, O145, and O157. In Plant A, 30 swabs were collected at each point for a total of 90 samples corresponding to 30 animals. Similarly, 50 swabs were collected at each point in Plant B for a total of 150, corresponding to 50 animals. An FSIS-approved PCR protocol was used to assess the presence of STEC serogroups O26, O45, O103, O111, O121, O145 using the Dupont Qualicon BAX® system.

Results: In Plant A, 23.3% (7/30) of hides contained at least one STEC serogroup, whereas in Plant B, 90.0% (45/50) tested positive. Pre-erevisceration samples had a prevalence of 6.7% (2/30) for Plant A and of 0% for Plant B. No STEC were detected after antimicrobial intervention. Serogroups O26, O45, and O121 were the most prevalent in plant A with frequencies of 27/75 (36.0%), 24/75 (32.0%), and 18/75 (24.0%), respectively. In Plant B, 206 and O121 were predominant with 47.5% (38/80) and 46.3% (37/80), respectively.

Conclusion: The results of this study indicate that STEC were present on the hides but current hygienic practices and interventions effectively controlled them and reduced final carcass contamination. This information will serve to these companies as evidence of adequate process control.

Keywords: abattoir, Honduras, Nicaragua, Non-0157 STEC, process control

106 INHIBITION OF FOODBORNE PATHOGENS IN “NO NITRATE- OR NITRITE-ADDED” BACON BRINE AND BACON. A. G. McKeith 1 *, E. W. Mills 1, C. N. Cutter 1, K. B. Kephart 2
1Agriculture, Western Kentucky University, Bowling Green, KY, 2Animal Sciences, Food Science, Pennsylvania State University, University Park, PA, United States

Objectives: Processed meats manufactured using natural curing ingredients may exhibit color, flavor and shelf-life attributes similar to traditional products. However, few reports describe the effects of natural curing ingredients on survival and growth of foodborne pathogens in meat products. Therefore, the objective of this study was to evaluate the inactivation of vegetative Clostridium perfringens (CP), Listeria mono- togenes (LM), Escherichia coli 0157:H7 (EC) and Salmonella Typhimurium (ST) inoculated in bacon brine formulations using natural nitrate (vegetable juice powder, Symrise, Teterboro, NJ) with starter culture (CS-299 Bactoferm, Chr Hansen, Inc., Milwaukee, WI), natural nitrite with a natural cure accelerator (celery baste and cherry baste aid, Newy Weds, Chicago, IL), and traditional cure (sodium nitrate and sodium erythorbate).

Keywords: antibacterial, nitrate, nitrite, meat processing
Materials and Methods: All cure ingredients were utilized at the concentrations recommended by the manufacturers and sodium nitrite and sodium erythorbate were used at concentrations approved by the United States Department of Agriculture. In all instances, salt and sugar were added to 20% and 5% of brine formulation, respectively. Three replications with two quarter bellies per replication per treatment were utilized to evaluate the inhibition of foodborne pathogens of “no nitrate- or nitrite-added” bacon. Bellies were inoculated with a cocktail of the four foodborne pathogens (initial inoculation = 8 log10 CFU/mL for each pathogen), injected with respective brine treatments (10% target pump), and cooked to an internal temperature of 53°C. Following approximately 24 hours of chilling, bellies were sliced and vacuum-packaged. Individual, refrigerated sliced bacon samples were taken at 0, 1, 3, 7, 14, and 21 days after inoculation and evaluated for remaining bacterial populations on selective agar for each pathogen evaluated. Enumeration of pathogens were done using direct plating and/or enrichment procedures for each pathogen.

Results: The pH of each brine was different (P<0.05) from each other with the natural nitrate brine having the lowest pH (4.01) and the natural nitrite having the highest pH (7.48). Thienoace had a pH of 4.81 and the traditional cure had a pH of 5.58. However, once the brine was inoculated into the belly they quickly buffered to near neutral (pH = 6.8). There were no differences (P>0.05) among the treatments for aerobic bacteria, coliforms, and generic E. coli. Inoculated bellies treated with natural nitrate, natural nitrite, traditional cure, and no cure exhibited growth (7 log10 CFU/g) of LM, EC, and ST (P>0.05). Traditional cure was more effective at inhibiting CP than all other treatments, regardless of day of storage (P<0.05).

Conclusion: Traditional cure was the only treatment that resulted in no growth of CP. The information from this study can be utilized by the USDA or processed meat manufacturers when making their decision about the usage of “natural curing” ingredients in cured meat products.

Keywords: bacon, foodborne pathogens, nitrite

107 SALMONELLA PREVALENCE IN BEEF LYMPH NODES AND FECES FROM CATTLE HARVESTED AT FIVE MEXICAN ABATTOIRS. H. Ruiz 1*, M. F. Miller 1, S. Gagg 1, G. H. Lonergan 1, L. G. Garcia 1, M. M. Brashears 1
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Objectives: The objectives of this study was to determine prevalence by city and the overall prevalence of Salmonella isolated from LN's and feces collected from cattle at harvest in five Mexican harvest facilities in Veracruz, Veracruz, Cancun, and Playa del Carmen, Mexico.

Materials and Methods: From each carcass, one lymph node from the following; mandibular (MAN), mediastinal (MENS, mesenteric (MES) and subiliac (SUB) was collected (n = 1056) and feces (FE) was also collected from the same carcasses (n = 267). LN samples were enriched using tryptic soy broth (TSB), subjected to immunomagnetic separation (IMS) and streaked on Xylose Lysine Deoxycholate (XLD) agar and Brilliant Green Sulfa (BGA) and final confirmation for Salmonella with latex agglutination. Feces samples were enriched using a primary enrichment of Buffered Peptone Water (BPW), and secondary enrichments of Rappaport-Vassiliadis Broth (RV), Tetrathionate Broth (TT) and were streaked using selective media Xylose Lysine Tergitol-4 (XLT-4) typical colonies where selected and agglutinated.

Results: For the city of Veracruz, prevalence was as follows: 49.15%, 4.23%, 63.55%, 67.79%, and 77.11% for MAN, MENS LN, MES LN, SUB LN and FE, respectively. Merida prevalence was as follows: 23.00%, 19.67%, 40.87%, 8.51, and 55.44% for MAN LN, MENS LN, MES LN, SUB LN and FE, respectively. Cuatla prevalence was as follows: 30.00%, 20.00%, 10.00%, 0.00%, and 40.00% for MAN LN, MENS LN, MES LN, SUB LN and FE, respectively. Cancun presence was as follows: 18.75%, 0.00%, 37.65%, 12.50%, and 81.25% for MAN LN, MENS LN, MES LN, SUB LN and FE, respectively. Playa Del Carmen prevalence was as follows: 50.00%, 12.50%, 62.50%, 12.50%, and 50.00% for MAN LN, MENS LN, MES LN, SUB LN and FE, respectively. Lastly, overall prevalence was 35.47%, 9.38% 49.48%, 36.99% and 66.40% for MAN LN, MENS LN, MES LN, SUB LN and FE, respectively.

Conclusion: Results suggest that Salmonella is commonly harbored in cattle lymph nodes throughout the body with certain lymph nodes having higher prevalence of Salmonella. Also, results suggest that anatomic location may play a role in variation of prevalence with Mesenteric lymph nodes having the highest overall prevalence; Mediastinal lymph nodes had the lowest prevalence. These findings should be further investigated to better understand potential infection pathways, mode of action, opportunities for Salmonella control in ground beef products and eventually a resolution to Salmonella infection in beef lymph nodes.

Keywords: beef, feces, lymph node, Salmonella

mEAT SCIENCE Education And Extension TOOLS: GENERAL ABSTRACTS

108 PRODUCER AND PROCESSOR KNOWLEDGE ENHANCEMENT OF FOOD DEFENSE AND TRACEABILITY AS A RESULT OF TRAINING. J. B. Williams 1*, A. F. Hood 2, E. L. Griswold 2
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Objectives: Agriculture and food are global industries, and any attack on these would be felt worldwide. There are numerous points of vulnerability within the food chain for intentional and unintentional contamination which jeopardize the overall safety and biosecurity of our food supply. Intentional, as well as unintentional threats and attacks can occur in various ways: biological, physical, radiological, chemical, or nuclear. USDA has enhanced efforts recently to encourage all meat, poultry and egg processing operations to have Food Defense Plans in place by 2015. With a target of 90% voluntary compliance by 2015, the small and very small plants are currently well behind the stated target which could lead to mandatory compliance. With passage of the Food Safety Modernization Act of 2011 and the recent publication of guidelines for compliance requirements for produce and other human food from FDA, food defense and hazard assessments will be mandatory for producers and processors of foods under FDA regulation. The objective of this research and subsequent training sessions was to promote awareness and educate all types of food producers and food manufacturers on the principles of food defense, biosecurity and traceability of agricultural commodities and ingredients used in human food production. For those operations with existing plans, the intent was to further advance training and knowledge to their sector of the industry.

Materials and Methods: Food defense and traceability plans evaluate all areas of a business and infrastructure including: personnel, incoming ingredients/pesticides/feed, supplies, supply transportation, processing, finished product transportation, and product tracking. Training was conducted through seminars, workshops, supplementary materials, and checklists. Pre-tests and post-tests were administered to determine knowledge base and improvement.

Results: Preliminary investigations indicated that most small and very small operations were unprepared for such incidents and threats. Eight training sessions were conducted at various locations with a total of 117 participants made up of meat and poultry processors (44) and various other food com-
modifying producers (73). Fifty-four percent of participants indicated having existing food defense plans prior to the workshops while 84% indicated intent to implement and/or make changes to their plan. Seventy-five percent had an increased knowledge of food defense, biosecurity, and traceability after workshop completion. Individual scores improved up to 42%.

**Conclusion:** Many of the areas and points of an operation may often be overlooked or taken for granted under normal day to day activities by employees which can jeopardize the overall food safety and security. Through effective food defense training and education, farmers and food manufacturers including distributors and suppliers will be able to better assess all vulnerable points to develop a defense plan that is best suited for their operation. Whether problems arise from intentional or unintentional means, farmers and food manufacturers need to be prepared to respond quickly and efficiently to problems that arise. Through these workshops 117 members of the food industry chain now have a better understanding of food defense and are better prepared to continue and increase the overall safety of our food supply.

**Keywords:** food defense, food producers, meat/poultry processors, traceability

**muSCLe ANd IIPlD BIOLOGy ANd BIOChEmIstry: GENERAL ABSTRACTS**

**109 DIFFERENTIAL ABUNDANCE OF SARCOPLASMIC PROTEOME IN BEEF INSIDE AND OUTSIDE SEMIMEMBRANOSUS MUSCLE.** S. P. Suman 1,*, M. N. Nair 1, M. K. Chattii 1, 2, S. Li 1, P. Joseph 1, 2, C. M. Beach 1, G. Rentfrow 1

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**Objectives:** Beef Semimembranosus muscle has distinct color-stable outside (OSM) and color-labile inside (ISM) regions. The differential color stability between OSM and ISM has been partly attributed to the variations in temperature and pH decline during carcass chilling. Nonetheless, the underlying molecular mechanisms are not completely understood. Differential abundance of sarcoplasmic proteome influences color stability of beef muscles. However, the proteome basis for intramuscular variations in the color stability of beef Semimembranosus is yet to be investigated. Therefore, our objective was to characterize the sarcoplasmic proteome of beef OSM and ISM.

**Materials and Methods:** Eight (n = 8) beef inside rounds (48 h post-mortem; IMPS # 168) were procured from a commercial packing plant. The Semimembranosus muscles were separated and fabricated into ISM and OSM. Samples for proteome analyses were collected and frozen at 0°C. Sarcoplasmic proteome was extracted from each sample and subjected to two-dimensional gel electrophoresis in duplicate. Gels were stained, and the images were analyzed. Protein spots exhibiting differential abundance (P<0.05) were subjected to tryptic digestion and were identified using tandem mass spectrometry.

**Results:** Beta-enolase, fructose-bisphosphate aldolase A, phosphoglycerate mutase, and phosphatidylethanolamine-binding protein 1 were over-abundant in ISM, whereas triose phosphate isomerase and creatine kinase M-type were over-abundant in OSM. Beta-enolase, fructose-bisphosphate aldolase A, and phosphoglycerate mutase are enzymes critically involved in glycolysis.

**Conclusion:** The over-abundance of three glycolytic enzymes in color-labile ISM suggests the possibility that a rapid post-mortem pH decline associated with high glycolytic activity could accelerate myoglobin oxidation, compromise the metmyoglobin reduction system, and thus potentially contribute to discoloration.

**Keywords:** beef color, color stability, proteome, Semimembranosus

**110 SARCOPLASMIC PROTEOME PROFILE OF LONGISSIMUS LUMBORUM FROM RACTOPAMINE FED PIGS.** B. R. C. Costa Lima 1,*, S. P. Suman 2, T. J. P. Silva 1, E. T. F. Silveira 1, S. Li 2, C. M. Beach 1, B. M. Bohrer 4, D. D. Boler 4

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**Objectives:** Ractopamine is a repartitioning agent with beta-adrenergic agonist properties and is used in the finishing diet to promote leanness in pigs. The effect of ractopamine on pork quality is associated with a decrease in the breakdown of myofibrillar proteome. A variety of enzymes involved in cellular metabolism are present in sarcoplasmic proteome. However, the influence of ractopamine on sarcoplasmic proteome is yet to be investigated. Therefore, our objective was to examine the effects of dietary ractopamine on sarcoplasmic proteome of pork.

**Materials and Methods:** Barrows (n = 9) were fed a finishing diet containing 7.4 ppm ractopamine for 14 days and then increased to 10.0 ppm ractopamine for an additional 14 days (RAC) or without ractopamine for 28 days (CDN). The animals were harvested, and the carcasses were fabricated after chilling at 2°C for 24 h. Loins (Longissimus lumborum muscle) from the right sides of the carcasses were collected and frozen until further analysis. Sarcoplasmic proteome was extracted and analyzed using two-dimensional electrophoresis. The gels were stained, and the images were analyzed to determine differences (P<0.05) in the abundance of protein spots. The proteins spots exhibiting 1.5-fold or more intensity differences (P<0.05) between the treatments were subjected to tryptic digestion and tandem mass spectrometry.

**Results:** Stress-induced-phosphoprotein 1, carbonic anhydrase 3, L-lactate dehydrogenase A chain, and fructose-bisphosphate aldolase A were over-abundant in RAC, whereas glyceraldehyde-3-phosphate dehydrogenase and phosphoglucomutase-1 were over-abundant in CDN. Stress-induced-phosphoprotein 1 coordinates the functions of heat shock proteins, the latter of which protects proteins from oxidation and aggregation. Dietary ractopamine promotes protein accretion in tissues, and this could have partially contributed to the increase in the expression of stress-induced-phosphoprotein 1 in RAC. Carbonic anhydrase catalyzes the reversible hydration of carbon dioxide, and the over-abundance of this enzyme in RAC indicated the enhanced ability of muscles to metabolize the end products of glycolysis. The low abundance of glyceraldehyde-3-phosphate dehydrogenase enzyme in RAC suggested a decrease in NAD consumption. The accumulated NAD can be used by lactate dehydrogenase (over-abundant in RAC) to convert lactate to pyruvate, which increases mitochondrial oxygen consumption.

**Conclusion:** The results suggested that dietary ractopamine influences the abundance of enzymes involved in glycolytic metabolism in pork Longissimus lumborum. The differential abundance of glycolytic enzymes between ractopamine fed and control pigs may potentially influence the conversion of muscle to meat.

**Keywords:** Longissimus lumborum, pork quality, Ractopamine, Sarcoplasmic proteome
111 EFFECTS OF AGING TEMPERATURE AND TIME ON BEEF LONGISSIMUS COLOR INTENSITY AND STABILITY. R. Ramathanand 1*, R. A. Mancini 2, C. Van Buiten 2
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Objectives: Meat color, in particular intensity and stability, is significantly influenced by mitochondrial activity via two mechanisms: oxygen consumption and metmyoglobin reducing activity. Oxygen consumption limits red color intensity by decreasing myoglobin oxygenation when mitochondrial respiration outcompetes myoglobin for oxygen. As a result, extended aging can improve bloom because mitochondrial oxygen consumption tends to decrease with postmortem aging. Although aging can increase initial myoglobin oxygenation, it can be detrimental to color stability because the activity of mitochondrial reducing enzymes are depleted postmortem, resulting in less NADH regeneration and less subsequent metmyoglobin reducing activity. Previous research has assessed the effects of extended aging on tenderness. However, limited published research is available documenting the role of aging time beyond 21 days on color intensity and stability. Therefore, the objective of this research was to assess the effects of aging time and temperature on beef color intensity and stability.

Materials and Methods: Longissimus lumborum (n = 15) were divided into 6 roasts, each 5 cm thick, and vacuum packaged. Three of the 6 roasts within each loin were aged at either 0 °C or 5 °C. Of the 3 roasts within each temperature, 1 roast was aged in vacuum packaging for either 15, 30, or 45 days. Two aging temperatures x 3 aging times resulted in the following 6 treatments: (1) 15 days aging at 0 °C, (2) 15 days aging at 5 °C, (3) 30 days aging at 0 °C, (4) 30 days aging at 5 °C, (5) 45 days aging at 0 °C, and (6) 45 days aging at 5 °C. After aging, each 5 cm roast was fabricated into 2 steaks and over-wrapped in PVC. Each steak was used to determine both initial color intensity and color stability. Initial color intensity was measured using the change in oxymyoglobin and a* during bloom (1 hour at 1 °C). Color stability was measured using a* and surface metmyoglobin (7 days at 4 °C). Metmyoglobin reducing activity and lipid oxidation also were measured. Increased metmyoglobin reducing activity and decreased lipid oxidation are associated with improved color stability. To evaluate the effects of aging temperature and time on color intensity, metmyoglobin reducing activity, and lipid oxidation, a split plot was used. Aging effects on color stability were measured using a randomized complete block with repeated measures.

Results: As aging time increased, initial color intensity decreased. However, the color stability of steaks decreased as aging time increased (P<0.05). More specifically, a* values decreased and surface metmyoglobin increased as aging time increased. Color intensity was greater following aging at 5 °C compared with 0 °C whereas aging at 5 °C decreased color stability compared with 0 °C (P<0.05). This was supported by temperature effects on metmyoglobin reducing activity (increased aging temperature decreased metmyoglobin reduction). Lipid oxidation increased as aging time increased.

Conclusion: Increased storage time and temperature can benefit initial bloomed color intensity (red color development) following aging. However, this benefit is negated by a significant decrease in color stability. As a result, increasing storage temperature and time will limit color stability following aging.

Keywords: aging, Mitochondria, myoglobin

112 ANALYSIS OF CALPASATIN POOLS SEPARATED USING ION EXCHANGE CHROMATOGRAPHY. S. M. Cruzan 1*, S. M. Lonergan 1, E. Huff-Lonergan 1
1Animal Science, Iowa State University, Ames, IA, United States

Objectives: The objective of this project was to determine differences in two calpastatin eluate pools obtained using ion exchange liquid chromatography. These pools had been identified consistently in two previous studies involving muscle from either swine or cattle.

Materials and Methods: A bull Triceps brachii sample was obtained within 90 min postmortem, and sarcoplasmic proteins were separated using a Q-Sepharose Fast Flow column. Proteins were eluted using a KCl gradient from 60 to 200 mM. Fractions containing calpastatin activity were eluted in two separate peaks (50-90 mM KCl for Calpastatin I and 120-190 mM KCl for Calpastatin II), as determined by assaying fractions for inhibitory activity against porcine lung m-calpain, using casein as a substrate. Fractions from each peak containing calpastatin activity were pooled, then concentrated and desalted using centrifugal concentrators. Samples were then analyzed with 2-dimensional SDS-PAGE, using pH 4-7, 7 cm strips in the first dimension and 12.5% acrylamide gels in the second dimension. Gels were analyzed using immunoblotting; in addition, phosphoprotein staining and total protein staining techniques were applied in order to determine differences in post-translational phosphorylation and total protein.

Results: Immunoblotting identified two major areas of interest in both activity peaks, located at approximately 150 and 50 kDa. Additionally, in Calpastatin II, a third area of interest was identified intermediate to the primary spots, at approximately 80 kDa. A low molecular weight spot (approximately 37 kDa) was also identified by the immunoblot of the Calpastatin I sample. Two spots in a chain located at 50 kDa had a 4 to 5 fold greater phosphorylation to total protein ratio in the Calpastatin II sample versus Calpastatin I (0.37 and 0.44 in Calpastatin I, and 1.86 and 1.83 in Calpastatin II). A similar analysis of the 150 kDa spot also revealed a 4 fold greater phosphorylation to total protein ratio in the Calpastatin II sample (0.22 vs 0.89).

Conclusion: The current results support the conclusion that phosphorylation may explain the differences in the elution profile of calpastatin.

Keywords: Calpastatin, ion exchange chromatography, phosphoprotein stain

113 EFFECT OF MATERNAL METABOLIZABLE PROTEIN SUPPLEMENTATION IN ISOCALORIC DIETS DURING LATE PREGNANCY ON MUSCLE FIBER TYPE AND ENZYME EXPRESSION IN OVINE FETAL SKELETAL MUSCLE. C. Schwartz 1*, K. A. Vonnahme 1, C. S. Schauer 2, S. M. Lonergan 3, K. J. Grubbs 1, W. L. Keller 1, K. R. Maddock-Carlin 1
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Objectives: The purpose of the study was to investigate the impact of contrasted protein levels in isocaloric diets of pregnant dams during late gestation on the muscle fiber type and enzyme expression of ovine fetal skeletal muscle.

Materials and Methods: Multiparous singleton pregnant ewes (n = 18) were randomized to receive 1 of 3 diets that were isocaloric and formulated to supply 60% (MP60), 100% (MP100), or 140% (MP140) of MP requirements during late gestation (d 100 to 130). Pregnant ewes and fetuses were necropsied on d 130 ± 1 of gestation and samples from the LM, Semimembranosus (SM), and Psoas major (PM) were immediately
collected. Two-dimensional difference in-gel electrophoresis was used to compare the sarcoplasmic and myofibrillar protein fractions of fetal LM and data was analyzed using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry techniques.

**Results:** Seven spots in the sarcoplasmic fraction corresponding to 5 proteins, and zero spots in the myofibrillar fraction differed in relative abundance (P<0.10) among MP treatments. Uproellation of aldolase A in the LM of fetuses from MP140 and MP60 ewes vs. MP100 ewes was further validated (P = 0.05) by western blot analysis. The main changes evidenced in the proteome of fetal LM were involved in AA metabolism and protein turnover. Creatine kinase was less (P=0.02) abundant in fetal LM from MP140 ewes compared with MP100 ewes. Phosphoglucomutase 1 was more abundant (P=0.02) in fetal LM of MP100 ewes compared with MP60 ewes. Western blotting was used to determine myosin heavy chain (MHC) type I and II expression, as well as aldolase A and glycoldehyde-3-phosphate enzymatic expression within LM, SM, and PM muscles. Optical densities of immunoreactive bands were quantified and Western blots were standardized to a control. Fetal LM and SM had increased expression (P<0.01) of MHC type II in offspring of dams receiving the MP60, when compared with other treatments. The PM from offspring of dams fed the MP140 treatment had increased expression (P = 0.01) of MHC type I when compared to that of offspring from dams fed MP60 or MP100 treatments. There was a tendency (P=0.08) of glycolytic and oxidative enzyme to have increased expression in the offspring LM from dams fed the MP60 and MP140 treatments, compared with fetal LM from dams receiving the MP100 treatment during late pregnancy.

**Conclusion:** Maternal supplemental protein through isocaloric diets in late pregnancy influenced fetal skeletal muscle fiber type, as well as glycolytic and oxidative enzyme expression during development. Results indicate more research is needed to fully understand the relationship of these alterations during fetal muscle development to the long-term effects on offspring.

**Keywords:** Metabolizable protein, Muscle fiber, Proteomics, Sheep, Western blotting

**114 POSTTRANSLATIONAL MODIFICATION DIFFERENCES IN THE MITOCHONDRIA PROTEIN PROFILE OF PIGS SELECTED FOR LOW AND HIGH RESIDUAL FEED INTAKE.J. K. Gubbs*, N. K. Gabler1, E. Huff-Lonergan1, S. M. Lonergan1
1Department of Animal Science, Iowa State University, Ames, IA, United States

**Objectives:** The objectives of this project were two fold; 1) to establish differences in the protein profile of isolated liver mitochondria from pigs divergently selected for low and high residual feed intake and 2) to determine the extent of phosphorylations of these proteins.

**Materials and Methods:** Gilts (n = 9 per RFI line, BW = 95.3 kg) from the eighth generation of the Iowa State RFI Selection Project were used. Mitochondria from the liver were isolated immediately postmortem using differential centrifugation. The protein profile of liver mitochondria was then established using 2D-Difference in Gel Electrophoresis (2D-DIGE). Separation by isoelectric point and molecular weight was carried out on an 11 cm, pH 4-7 range immobilized pH gradient strip followed by SDS-PAGE (12.5% acrylamide). Image analysis was conducted and protein spots that were determined to be different were identified using time of flight mass spectrometry. Additional gels were stained with ProQ Diamond phosphoprotein stain for identification of phosphorylated proteins, followed by staining with SyPRO Ruby total protein stain. This allowed for the identification of phosphorylated proteins.

**Results:** In the liver, a total of 6 proteins were identified across 11 different spots. Notably, heat shock protein 60 (HSP60), heat shock protein 70 (HSP70), and ATP synthase subunit beta (ATP) were identified in multiple spots; all were increased in the more efficient low RFI pigs (P<0.10). Increased abundance of these HSP60 and HSP70 isoforms in mitochondria from low RFI pigs indicates an increase in their ability to handle physiological stress. An increased ability to handle stress can be coupled with an increase in the potential for ATP production, which is suggested to be possible through the observed increase of ATP. ATP is responsible for the conversion of ADP to ATP, thus it may play a role in the more efficient conversion of dietary energy to growth observed in the low RFI line. Spots of similar molecular weight with differing isoelectric points may indicate a posttranslational modification. Modifications, such as phosphorylations, are known to play an important role in the activity of many metabolic processes, like electron transport and ATP production. The modification of the proteins of interest were confirmed as phosphorylations through phosphoprotein staining. All the spots identified as being HSP60, HSP70, and ATPB were phosphorylated.

**Conclusions:** These data provide insight into the impact of the protein profile and posttranslational modification of proteins on the underlying biology of efficiency of livestock growth.

**Keywords:** 2D-DIGE, posttranslational modification, residual feed intake

**115 BILIARY CHOLESTEROL, VITAMIN E, AND VITAMIN E METABOLITES IN TURKEYS AND CHICKENS: PROBING THE MECHANISM OF POOR ACQUISITION OF DIETARY VITAMIN E INTO TURKEY MUSCLE.D. Perez*, M. P. Richards1, R. S. Parker2, M. Sifri1
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**Objectives:** Vitamin E (vit E) is a chain breaking antioxidant that is commonly supplemented into commercial poultry feeds. Vit E consists of 8 isomers which include a, b, g, d tocopherol as well as a, b, g, d tocotrienol. Vit E is absorbed in the intestine and transported to the liver where it can be sent into circulation via VLDL, metabolized, or expelled, intact, into bile for excretion. Chickens are superior to turkeys in their ability to accumulate dietary vit E into muscle tissues when compared to turkeys. The liver is a major site of vit E and cholesterol metabolism and transport. Differences in the fate of vit E in the liver could play an important role in why chickens are able to accumulate more vit E in muscle tissues than turkeys. Analysis of bile can be used to probe the mechanism by which turkeys poorly accumulate vit E in muscle. First, elevated cholesterol in turkey bile (relative to chicken) can decrease absorption of dietary vit E when bile dumps into the intestinal lumen during feeding. Second, the liver may export vit E isomers (a and g-tocopherol) to the bile which will decrease the amount of vit E that is delivered to the circulation and routed for deposition in muscle. Third, elevated concentrations of tocopherol metabolites in bile are indicative of vit E metabolism in the liver which will decrease the amount of dietary vit E that accumulates in the muscle. Thus, biliary cholesterol, vit E, and vit E metabolites in 5 week old turkeys and chickens were assessed as part of a controlled study in which the birds were grown out at a single facility providing equivalent environmental conditions.

**Materials and Methods:** Three diets were examined, synthetic a-tocopherol acetate at two levels (10 and 50 IU/kg) and a natural form of a-tocopherol acetate (50 IU/kg). Bile samples were obtained from the gall bladders of stunned and euthanized turkeys (n = 3 for each dietary treatment, 9 total) and chickens (n = 3 for each dietary treatment, 9 total) using a needle and syringe. Biliary vit E, cholesterol and vit E metabolites were assessed using GC-MS.
**Results:** Cholesterol was elevated 1.9-fold in turkey bile compared to chicken (32.3 and 17.4 μM) when examining the SynE diet at 50 IU/kg (P<0.05). Alpha tocopherol was elevated 2.0-fold in chicken bile compared to turkey (116.6 and 59.5 μM) when examining the SynE diet at 10 IU/kg (P<0.05). Gamma tocopherol was elevated 2.5-fold in chicken bile compared to turkey (6.4 and 2.9 μM) when examining the SynE diet at 10 IU/kg (P<0.05). Alpha tocopherol metabolites were elevated 8.3-fold in turkey bile compared to chicken (165.9 and 19.9 μM) when examining the Nat E diet and a 2.6-fold increase was observed when examining the SynE diet at 50 IU/kg (P<0.05). Gamma tocopherol metabolites were elevated 5.5-fold in turkey bile compared to chicken (97.4 and 17.6 μM) when examining the Nat E diet and a 2.4-fold increase was observed when examining the SynE diet at 50 IU/kg (P<0.05).

**Conclusion:** The apparent increased metabolism of both α and γ-tocopherol in turkeys may in part explain the deficiencies that turkeys have at transferring vitamin E from the feed into muscle tissue. The elevated cholesterol in turkey bile may also be of importance.

**Keywords:** metabolism, vitamin E

**116 EFFECTS OF SUPPLEMENTAL LYSINE AND METHIONINE IN COMBINATION WITH ZILPATEROL HYDROCHLORIDE ON BETA-ADRENERGIC RECEPTORS IN FINISHING FEEDLOT CATTLE.** J. E. Hergenreder 1*, A. D. Hosford 1,1, W. Rounds 1, B. J. Johnson 1
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**Objectives:** Beta-adrenergic receptors (β-AR) are a member of the G-coupled protein receptor family and are responsible for binding endogenous catecholamines and synthetically produced β-adrenergic agonists (β-AA). Synthetically produced β-AA are established growth promoters that increase muscle accretion, decrease lipidogenesis, and improve feed efficiency when fed to finishing cattle. Feeding β-ARs, like zilpaterol hydrochloride (ZH), have been shown to increase muscle accretion by causing hypertrophy of the muscle fiber. However, studies have shown after extended exposure to β-ARs, cells become desensitized to β-ARs due to internalization of β-ARs. Little is known about the limiting amino acid requirements during this phase of rapid muscle growth, and what their effects may be on β-ARs. Therefore, our objective was to evaluate the effects of feeding encapsulated amino acids in combination with ZH on β-AR density in continental crossbred steers.

**Materials and Methods:** Steers (n = 180; initial BW = 366 kg) were blocked by weight and randomly assigned to pens (n = 45 pens; 9 pens/treatment) and to 1 of 5 treatments including: 1) no amino acids and no zilpaterol HCl (Cont-); 2) no amino acids and zilpaterol HCl (Cont+); 3) encapsulated lysine supplement (Lys; LysiPEARLTM) and zilpaterol HCl (Lys+Cont+); 4) encapsulated methionine (Met; MetiPEARLTM) and zilpaterol HCl (Met+Cont+); 5) encapsulated lysine and methionine (Lys+Met) and zilpaterol HCl. Zilpaterol HCl (8.3 mg/kg DM) was fed for the last 20 d of the finishing period with a 3 d withdrawal. Lysine and Met were top dressed daily for 134 d to provide 12 or 4 gohd−1d−1, respectively to the small intestine. At the end of the trial, steers were harvested at a commercial abattoir, and one steer per pen was selected for Longissimus muscle histology analysis. Longissimus muscle samples were cryosectioned (10 μm) and immunofluorescence stained. Nuclei density per mm², and β-1 adrenergic receptor (β-1AR), and β-2 adrenergic receptor (β-2AR) densities per mm² were determined via Nikon imaging software analysis.

**Results:** Negative control steers tended to have greater nuclei density compared to Lys+Met steers (P = 0.11; 669.02 vs. 599.54 nuclei per mm², respectively). There was no difference in β-1AR or β-2AR densities between all treatments (P>0.31).

**Conclusion:** These data indicate that nuclei, β-1AR, and β-2AR densities are not affected by feeding encapsulated amino acids in combination with zilpaterol HCl during the finishing period.

**Keywords:** beta-1 adrenergic receptor, beta-2 adrenergic receptor, zilpaterol hydrochloride

**117 EFFECTS OF SUPPLEMENTAL LYSINE AND METHIONINE IN COMBINATION WITH ZILPATEROL HYDROCHLORIDE ON MUSCLE FIBER TYPE AND SIZE IN FINISHING FEEDLOT CATTLE.** A. D. Hosford 1*, J. E. Hergenreder 1, W. Rounds 1, B. J. Johnson 1
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**Objectives:** Feeding β-adrenergic agonists, like zilpaterol hydrochloride (ZH), have been shown to increase muscle accretion by causing hypertrophy of the muscle fiber. Additionally, a shift from smaller oxidative muscle fibers to larger glycolytic fibers has been reported with ZH feeding. Little is known about the limiting amino acid requirements during this phase of rapid muscle growth. Our objective was to evaluate the effects of feeding encapsulated amino acids in combination with ZH on muscle fiber type and muscle fibersize in continental crossbred steers.

**Materials and Methods:** Steers (n = 180; initial BW = 366 kg) were blocked by weight and randomly assigned to pens (n = 45 pens; 9 pens/treatment) and to 1 of 5 treatments including: 1) no amino acids and no zilpaterol HCl (Cont-); 2) no amino acids and zilpaterol HCl (Cont+); 3) encapsulated lysine supplement (Lys; LysiPEARLTM) and zilpaterol HCl; 4) encapsulated methionine (Met; MetiPEARLTM) and zilpaterol HCl; 5) encapsulated lysine and methionine (Lys+Met) and zilpaterol HCl. Zilpaterol HCl (8.3 mg/kg DM) was fed for the last 20 d of the finishing period with a 3 d withdrawal. Lysine and Met were top dressed daily for 134 d to provide 12 or 4 gohd−1d−1, respectively to the small intestine. At the end of the trial, steers were harvested at a commercial abattoir, and one steer per pen was selected for Longissimus muscle histology analysis. Longissimus muscle samples were cryosectioned (10 μm) and immunofluorescence stained. Myosin heavy chain (MHC) type I, IIa, IX were identified and area was measured.

**Results:** Myosin heavy chain (MHC) type I muscle fiber area was increased for Lys+Met treated cattle when compared to Lys and Met (P = 0.03). There was no difference in MHC II fiber abundance for any treatment. Myosin heavy chain IX muscle fiber size was increased for Lys+Met when compared to Cont- (P = 0.05). The MHCIIA fiber area tended to be increased for Lys+Met treatment as compared to Met and Cont- (P = 0.10). The proportion of MHC IIA fibers were increased with Cont+ as compared to Cont- and Met (P = 0.05 and 0.03, respectively).

**Conclusion:** These data indicate that muscle hypertrophy is occurring with ZH administration, and that this hypertrophic effect is increased with the addition encapsulated lysine and methionine.

**Keywords:** fiber area, lysine, methionine, zilpaterol hydrochloride

**118 INVESTIGATING THE USEFULNESS OF CYCLIC VOLTMETRY TO DETERMINE MYOglobin REDUCTION POTENTIAL AND OXYGENATION.** R. Ramanathan 2*, R. Nerimetla 2, S. Krishnan 2, D. L. VanOverbeke 1, G. G. Mafi 1
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**Objectives:** Myoglobin is the protein primarily responsible for meat color and can exist in three different forms; namely deoxy-, oxy-, or metmyoglobin. Although various pre- and post-harvest factors can in-
crease myoglobin oxidation, meat has an inherent capacity to delay met-myoglobin accumulation by a process called met-myoglobin reduction. To date, research has been focused on the role of enzymes, mitochondria, and NADH levels in met-myoglobin reducing capacity. However, it is possible that reduction potential of myoglobin also can influence met-myoglobin reduction. The term reduction potential refers to the ability of iron in myoglobin to accept an electron (or to undergo reduction). Nevertheless, no reports have as yet characterized the role of myoglobin reduction potential in beef color. The objectives of the current study were to investigate the usefulness of cyclic voltammetry (1) to determine beef myoglobin reduction potential and (2) to evaluate myoglobin oxygenation at pH 5.6 or 7.4.

**Materials and Methods:** Myoglobin was isolated from bovine cardiac muscle by gel filtration technique. Briefly, myoglobin solution (0.15 mM) was passed through chromatography columns pre-calibrated with either pH 5.6 or 7.4 buffer to alter myoglobin pH. Approximately 10 μL of metmyoglobin was placed on a high purity graphite electrode and adsorbed for 10 minutes. A CH electrochemical analyzer was used to perform voltammetry. The myoglobin reduction potential responses were recorded in millivolt (mV) units. For the second objective, a controlled amount of oxygen was added to bind with deoxymyoglobin at pH 5.6 or 7.4 using an oxygen mass flow controller. The experimental design was completely randomized and the data were analyzed using Proc Mixed of SAS (n = 3 replications). Least-squares means were separated with a protected pairwise t-test and were considered significant at P<0.05.

**Results:** There was a significant effect of pH on myoglobin reduction potential. At pH 5.6, myoglobin reduction potential was −290 mV compared with −330 mV at pH 7.4 (P<0.05). The reduction potential value provides information about the ability of heme within myoglobin to accept electron. A lower number indicates that the myoglobin has greater capacity for reduction. For the second objective, 0 – 1600 μM of oxygen was allowed to bind with myoglobin at pH 5.6 or 7.4. The oxygen binding to myoglobin produced electric current and this response was recorded in micro amperes. The greater the oxygen binding, the larger is the resulting current. This relationship was used to determine the myoglobin oxygen affinity.

**Conclusion:** The results from the current study suggest that cyclic voltammetry is a useful tool to determine myoglobin reduction potentials and to quantify myoglobin oxygenation capacity. The application of electrochemical methods will help to probe the myoglobin reduction potential changes in the environment of heme cofactor. Thus, characterizing the interrelationship between myoglobin reduction potential (related to color stability) and myoglobin oxygenation (related to bloom) will increase the body of knowledge related to beef color.

**Keywords:** meat color, met-myoglobin reduction, myoglobin

119 EFFECTS OF OXYGEN ON BEEF MYOGLOBIN REDUCTION POTENTIAL IN VITRO. R. Nerimetta 1, S. Krishnan 1, G. G. Mafi 2, D. L. VanOverbeke 2, R. Ramanathan 1,2

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**Objectives:** Metmyoglobin reducing capacity is an important intrinsic property that can influence color stability of beef. This involves addition of an electron to metmyoglobin via enzymatic or non-enzymatic pathways. Although various biochemical processes can increase metmyoglobin reducing activity, it is possible that the myoglobin reduction potential also can influence metmyoglobin reduction. The term reduction potential of purified myoglobin refers to the ability of iron within the myoglobin to accept an electron (or to undergo reduction) in the absence of either mitochondria, enzymes, or NADH. It is known that the presence of oxygen will decrease metmyoglobin reduction in beef; however, no reports are available characterizing the effects of oxygen on purified myoglobin reduction potential. We hypothesize that the presence of oxygen will decrease purified myoglobin reduction capacity. Therefore, the objective of the current study was to determine the effects of oxygen on myoglobin reduction potential using cyclic voltammetry at pH 5.6 in vitro.

**Materials and Methods:** In the current study, bovine hearts were used to isolate myoglobin because the myoglobin concentration in cardiac muscle is greater than in skeletal muscle. pH of the isolated myoglobin solutions were altered to pH 5.6 by passing through a PD-10 column pre-calibrated with citrate buffer (50 mM), pH 5.6. A 3-electrode cell system consisting of a myoglobin coated (0.15 mM) high purity graphite as the working electrode, a silver reference electrode, and a platinum wire counter electrode was employed to study the reduction potential of myoglobin. The electrodes were immersed in nitrogen purged citrate buffer in a sealed electrochemical cell. A potential in the range of 0 to −0.5 volt (V) was applied to the myoglobin coated electrode. Oxygen at different levels was delivered to the electrochemical cell using oxygen mass flow controllers. Initial reading (0% oxygen) was used to determine anaerobic myoglobin reduction potential. Different concentrations of oxygen were allowed to bind with myoglobin. The binding of oxygen to myoglobin produced reduction potentials and the responses were recorded in volt units. The experimental design was completely randomized and the data were analyzed using Proc Mixed of SAS (n = 3 replications). Least-squares means were separated with a protected pairwise t-test and were considered significant at P<0.05.

**Results:** There was a significant effect of oxygen on reduction potential of myoglobin. The cyclic voltammetry has the ability to donate electrons in a controlled microenvironment to monitor the reduction potential. Myoglobin reduction potential in oxygen was −0.28 V ± 0.003 compared with −0.33 V ± 0.003 in nitrogen at pH 5.6 (P<0.05). A lower value indicates a greater tendency of the heme to acquire electron or get reduced.

**Conclusion:** The result from the current study suggests that in addition to the biochemical pathways, presence of oxygen also can influence purified myoglobin reduction potential. Hence, understanding the factors affecting the myoglobin reduction potential will help to formulate modified atmospheric packaging strategies to minimize the losses resulting from discoloration.

**Keywords:** beef color, met-myoglobin reduction, myoglobin