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Funded by the Beef Checkoff.
Objectives: The objective of this research was to utilize thermal imaging technology to estimate body temperature, so that an early stage of BRD can be detected.

Materials and Methods: Ninety-two steers were restrained in a squeeze chute that is housed in an indoor handling facility on 6 separate occasions. At least one image was taken of each side of the head using a thermal infrared camera (FLIR E8 WiFi, FLIR, Wilsonville, OR). The distance at which the images were taken was approximately 1 m from the steer. The rectal temperature was used as the control method to compare thermal imaging data. After thermal image acquisition, images were analyzed using the FLIR ResearchIR Max software (v. 4.40.8.28, FLIR, Wilsonville, OR), with the regions of interest being the eye and nasal cavity.

Results: The analysis focused on minimum (MIN), maximum (MAX), mean, standard deviation (SD), and range of temperatures in the regions of interest. The REG procedure in SAS (v. 9.4, SAS Institute, Inc., Cary, NC) was used to perform stepwise regression to predict rectal temperature from the outdoor temperature (OTEMP) and all imaging features. When OTEMP was greater than -17.8 °C, the regression model contained OTEMP, left nasal MAX, left nasal SD, and left eye MAX temperature and right eye temperature range, with an R² of 0.24. When OTEMP was above freezing (0 °C), the regression model contained left nasal temperature range, right eye temperature range, and average nasal mean temperature, with an R² increase to 0.50. When using all data, the regression model fit left nasal MAX, right nasal MIN, average nasal mean, and left eye MAX temperatures and right eye temperature range, with an R² of 0.08. These results show that thermal imaging technology has higher prediction accuracy in warmer temperature ranges than extreme cold conditions.

Conclusion: More validation research on this thermal imaging technology needs to be conducted at warmer temperatures since all the current data was collected on cold winter days and a large portion of U.S. cattle are reared in more temperate and warmer areas than North Dakota such as Nebraska, Kansas, Texas, Oklahoma, and Florida. Overall, these results show promise for using thermal imaging technology to help detect BRD in an earlier stage by detecting fever before other clinical signs of BRD are present.

Keywords: Animal, Meat Quality, Thermal, Welfare
2- EVALUATION OF BEEF CATTLE TEMPERAMENT ATTRIBUTES USING INFRARED THERMOGRAPHY TECHNOLOGY

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Objectives: The objective of this study was to evaluate beef cattle temperament scores using infrared thermography technology.

Materials and Methods: Angus and Angus x Hereford calves (total n=650) were brought through a handling chute system over two weaning sessions (October 2016 & 2017). Beef cattle temperament was subjectively quantified by 1) temperament score (TS), the disposition of the animal observed by an individual evaluator on a scale of 1 (calm) to 5 (excitable); 2) docility score (DS), the level of observed calmness of the animal displayed (1=calm to 6=excitable); and 3) qualitative behavior assessment (QBA), scored on twelve different attributes, (i.e. active, relaxed, etc.). There were two traits measured on a four-platform standing scale: 1) the standard deviation of total weight over time (SSD); and 2) the SSD’s coefficient of variation (CVSSD). Thermal images of the animal’s head were acquired by industrial fixed focus infrared camera (TiS40, Fluke Corporation, Everett, WA). The maximum, minimum, average, and standard deviation of temperature of the eye region were extracted from the thermal images. Stepwise and linear regression analyses to estimate subjective temperament traits from thermal imaging data and scale data were conducted using the reg procedure in SAS (v. 9.4, SAS Institute, Inc., Cary, NC). Correlations were estimated using the corr procedure in SAS.

Results: The results showed low correlations between thermal imaging and subjective temperament traits. The correlations that were significant were around an absolute value of 0.1. However, all four thermal imaging traits were significantly correlated when the animal exhibited distress observed by QBA. When fitting only thermal imaging data into the regression analyses, R2 values were all under 0.03. When including SSD and CVSSD, there were a few traits with an R² > 0.1 and none having an R² > 0.15. The QBA traits that had an R² between 0.1 and 0.15 were active, fearful, calm, apathetic, happy, and distressed for both linear and stepwise regressions.

Image:
**Conclusion:** Additional validation research on this thermal imaging technology needs to be conducted with temperamental cattle as this current data was collected using observed calmer cattle, to give a more realistic application to beef cattle production. Overall this result shows potential to achieve beef cattle temperament evaluation with thermal imaging.

**Keywords:** Cattle temperament, Infrared thermography
**Consumer Topics**

3- CONSUMER PERCEPTION TOWARDS THE ENHANCED COLOR OF ATYPICAL DARK-CUTTING BEEF BY NITRITE-EMBEDDED PACKAGING

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**Objectives:** Meat color is often seen by consumers as an indicator of freshness and wholesomeness. Nitrite-embedded (NE) packaging forms nitric oxide myoglobin, which imparts a bright red color similar to oxymyoglobin. However, limited research has determined the effects of NE packaging to improve the appearance of atypically dark cutting beef. Consumers’ perception of NE packaging ultimately determines its success in the market. Educating consumers through infographics can transfer knowledge more effectively than text alone, potentially being a useful method to introduce and simplify the complexity of NE packaging’s role in improving the surface color of beef steaks. The objectives of this study were to evaluate FreshCase® nitrite-embedded packaging’s effect on atypical dark-cutting beef steaks and to evaluate student consumer perception of nitrite-embedded packaging improving the surface color of beef before and after exposure to infographics containing equal content.

**Materials and Methods:** Atypical dark-cutting (n = 13, pH 5.70 ± 0.09) and normal-pH (n = 13, pH = 5.57 ± 0.1) USDA Low Choice beef strip loins were selected 3 d postharvest. Atypical dark-cutting loins were cut into 2.54 cm thick steaks and randomly packaged in polyvinyl chloride film (PVC) or NE film. Normal-pH control loins were cut 2.54 cm and randomly packaged in PVC overwrap. Packages were placed in a coffin-style retail case under fluorescent lighting for 6 d. Instrumental color was observed every 24 h using a HunterLab MiniScan XE spectrophotometer. The color was determined as a* values and chroma. In the second objective, surveys using a ten-point Likert sliding scale (0 = not familiar at all, 10 = extremely familiar) were randomly allocated and emailed via Qualtrics to students enrolled in the Introduction to Animal Science course at Oklahoma State University. These surveys used a pre-questionnaire to evaluate students’ pre-perception of their knowledge of beef color and NE packaging. After the pre-perception questionnaire students were provided one of the following: a static infographic presented as a still image with annotated graphics, a 46 s video infographic with audio and animated graphics, or both infographic formats. A post-questionnaire followed exposure to students’ respective infographic to evaluate changes in the perception of knowledge.

**Results:** Atypical dark-cutting steaks treated in NE packaging had higher (P < 0.05, more red intensity) chroma and a* values compared to atypical dark-cutting steaks in PVC on d 4, 5, and 6. There was a significant difference (P < 0.05) in the students’ (n=288) pre- and post-questionnaire self-assessment of their familiarity with NE packaging. Prior to randomly viewing infographics, students were less familiar (=3.18) with NE packaging than after viewing infographics (=6.46). However, there was no significant difference in perceptions (P=0.22) between viewing the different infographic formats.

**Conclusion:** The results suggest that NE packaging with consumer education can improve their perceptions and knowledge and enhance the appearance of atypical dark-cutting beef.

**Keywords:** Atypical Dark-Cutter, Beef Color, Consumer Perception, Nitrite Packaging
Objectives: The objective was to determine the effects of cooking method and degree of doneness on consumer eating experience of pork chops when consumers were allowed to observe differences in cooked color. The hypothesis was that when consumers were able to visualize cooked color, they would rate pork cooked to 63°C less acceptable than chops cooked to 71°C due to historical perceptions of pork degree of doneness. Additionally, consumers would find sous-vide chops less acceptable due to the lack of browning.

Materials and Methods: Sensory procedures for all consumer evaluations were reviewed and approved by the University of Illinois Office for the Protection of Research Subjects. Loins were purchased from a commercial abattoir at 1 d postmortem, vacuum packaged, aged until 10 d postmortem, then frozen. Frozen pork loins were cut into 3.2 cm thick chops. Loin origin was maintained for each chop such that consumers were served 4 chops that originated from the same loin. Frozen chops were vacuum packaged and allowed to thaw at approximately 4°C. Pork chops were cooked to either 63°C or 71°C using either an open-hearth grill or an immersion cooker sous-vide device. After cooking, chops were removed from the heating source and cut to expose the internal cooked surface. Cooked color was measured with a Minolta chroma meter. Chops were cut into 1 cm × 1 cm × 3.2 cm sections and served to 132 consumers. Consumers were seated in a breadbox style sensory booth room under fluorescent light to allow for cooked color appraisal. Each consumer was provided 4 samples (grill/63, grill/71, sous-vide/63, sous-vide/71). Consumers used a 9-point Likert-type score system to determine tenderness, juiciness, flavor, and overall acceptability. Data were organized as a percentage of responses to determine the effects of cooking method, degree of doneness, and their interaction.

Results: Chops cooked to 63°C (4.10, 9.08) were more red and less yellow \((P = 0.01)\) than chops cooked to 71°C (3.82, 9.39). There was an interaction of cooking method and degree of doneness for both tenderness and acceptability. Consumers rated a greater percentage \((P < 0.001)\) of chops cooked sous-vide at 63°C as tender (82.82%) and acceptable (60.34%) compared with all other cooking method and degree of doneness combinations. There were no differences \((P = 0.06)\) in the percentage of chops rated tender when cooked to 71°C between those sous-vide (33.07%) and grilled (22.42%). Additionally, there were no differences \((P = 0.06)\) in the percentage of chops rated acceptable when cooked to 71°C between those sous-vide (26.35%) and grilled (28.63%). For juiciness, consumers rated a greater \((P < 0.01)\) percentage of chops cooked to 63°C as juicy (44.37%) than those cooked to 71°C (14.78%) but ratings as juicy did not differ between cooking methods. For flavor, consumers rated a greater \((P < 0.01)\) percentage of chops cooked to 63°C as flavorful (34.61%) than those cooked to 71°C (24.31%). Contrary to the expectation, ratings as flavorful did not differ between cooking methods \((P = 0.88)\).

Conclusion: Even when consumers can identify cooked color, they preferred chops cooked to 63°C. However, the lack of browning on chops cooked using sous-vide did not compromise eating quality of chops.

Keywords: Consumer preference, Cooked color, Grill, Pork, Sous-vide
INFOGRAPHICS INFLUENCE ATTITUDES AND RISK PERCEPTIONS FOR FOOD TECHNOLOGIES

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Objectives: Food technologies have facilitated a healthier, more efficient, and sustainable food supply. They nevertheless often face resistance from consumers. Compared to organic and traditional farming techniques, food produced with technologies tends to be associated with higher perceptions of risk, lower attitudes, and fewer perceived benefits. Countering resistance toward technologies poses a serious challenge because persuasive appeals have the potential to amplify preexisting attitudes instead of changing them. We tested six infographics for their ability to improve attitudes and risk perception toward six food technologies: hormones, antibiotics, GM crops, vaccines, sustainability technology, and animal welfare technology. Our objective was to determine whether these infographics would successfully shift perceived risk and attitudes toward these technologies.

Materials and Methods: Participants (n = 810) from English speaking countries (in North America, Europe, and Australia) were recruited from Amazon’s MTurk service. They answered a survey assessing their levels of risk perception and attitudes regarding each of the six food technologies, followed by a general food technology neophobia (FTN) survey. An experimental condition (n = 416) saw an infographic before answering questions about each technology and a control condition (n = 394) did not. Linear mixed effects models implemented in R were used to test risk and attitude differences amongst technologies and whether the infographics affected risk perception and attitudes.

Results: Linear mixed effects models revealed that there was a significant interaction between technology and condition for both risk: F(5,4040) = 5.068, p < .001, and attitudes: F(5,4040) = 26.34, p < .001. Overall, there was a tendency for risk perception to decrease (g = -.36, z = 6.89, p < .001) and attitudes to increase (g = .48, z = 9.38, p < .001), in the condition that saw the infographics. However, there were larger decreases in risk perception and increases in attitudes for hormones (risk: z = 5.05, p < .001; attitudes: z = 8.30, p < .001), GMOs (risk: z = 6.89, p < .001; attitudes: 13.21, p < .001), vaccines (risk: z = 6.45, p < .001; attitudes: z = 6.11, p < .001), and antibiotics (risk: 5.06, p < .001; attitudes: z = 7.83, p < .001), but smaller changes for sustainability (risk: z = 2.77, p = .03; attitudes: z = 2.89, p = .02) and animal welfare (risk: z = 4.91, p < .001; attitudes: z = 3.51, p = .003). Including FTN in the models did not affect the overall pattern of results, suggesting that the changes in risk perception and attitudes were not due to simply a general change in FTN.

Conclusion: Our results found that infographics provide a potential avenue for improving attitudes and risk perception for food technologies. Across six different infographics, we found attitudes and risk perception improved for hormones, antibiotics, vaccines, GMOs, sustainability technologies, and animal welfare technologies. These results are important because such persuasive appeals can often backfire, yet here we observed general improvement. In future studies it will be critical to examine how such attitude and risk perception changes relate to consumer behavior (e.g., willingness-to-pay), and which specific strategies in the infographics led to the improved attitudes.

Keywords: attitudes, consumer perceptions, food technologies, hormones, risk
6- PERCEIVED NORMS INFLUENCE PERCEPTIONS OF RISK AND ATTITUDES FOR FOOD TECHNOLOGIES

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Objectives: Understanding the factors that influence consumer attitudes and risk perception is critical for effective marketing of new food technologies. Many variables impact attitudes and risk perception. However, food technology research has largely focused on demographic variables, and often only single technologies (e.g., GMOs). Our goal was to determine how psychological variables differentially influence attitudes and risk perception for a range of food technologies: antibiotics, hormones, vaccines, GMOs, sustainability, and animal welfare technologies. We examined how attitudes and risk perception for these technologies related to four social psychological variables from the Theory of Planned Behavior (TPB): perceived norms, past behavior, familiarity, and perceived control. In addition, we measured general Food Technology Neophobia (FTN), Trust in Science (TIS), chemical reasoning (CR).

Materials and Methods: Participants (n = 394) provided demographics followed by TPB, attitude, and risk perception surveys for each of the six technologies. Then they completed FTN, TIS, and a CR survey measuring dose-response beliefs (DR), beliefs in unknown risks (UR), the role of risk in society (RS), and naturalness/knowledge of chemicals (NKC). Multiple regression analyses were used to test for associations amongst the survey measures.

Table 1. Standardized betas (>0.10 in bold) from selected coefficients of regression models predicting risk perceptions and attitudes (rows) for each technology (columns)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Antibiotics</th>
<th>GM Food</th>
<th>Hormones</th>
<th>Vaccines</th>
<th>Animal Welfare</th>
<th>Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk perceptions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DR</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.11</td>
<td>0.13</td>
<td>-0.07</td>
</tr>
<tr>
<td>UR</td>
<td>0.09</td>
<td>0.11</td>
<td>0.23</td>
<td>0.08</td>
<td>0.06</td>
<td>0.17</td>
</tr>
<tr>
<td>NKC</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.01</td>
<td>-0.12</td>
<td>-0.05</td>
</tr>
<tr>
<td>Perceived norms</td>
<td>-0.55</td>
<td>-0.40</td>
<td>-0.40</td>
<td>-0.51</td>
<td>-0.38</td>
<td>-0.50</td>
</tr>
<tr>
<td>Past behavior</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td>0.14</td>
<td>0.18</td>
<td>0.11</td>
</tr>
<tr>
<td>Familiarity</td>
<td>0.09</td>
<td>0.04</td>
<td>0.10</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

| Attitudes         |             |         |          |          |                |                |
| UR                | -0.16       | -0.17   | -0.24    | -0.18    | -0.01          | -0.1           |
| NKC               | -0.01       | 0.03    | 0        | 0.07     | 0.09           | 0.13           |
| Perceived norms   | 0.71        | 0.51    | 0.56     | 0.62     | 0.45           | 0.64           |
| Control           | -0.05       | 0.02    | -0.04    | -0.06    | -0.12          | 0.02           |

Results: The multiple regression models were all significant (p < .05). Variance accounted for (R^2) ranged from 0.49 to 0.69 (See Table 1 for summary). Perceived norms were the strongest predictor of attitudes and risk with higher values being associated with stronger attitudes (standardized betas ranging from 0.51 to 0.71) and lower risk perception (-0.54 to -0.40). There were a number of technology-specific associations, including familiarity increasing perceptions of risk for hormones, and NKC being primarily associated with animal welfare and sustainability technologies.

Conclusion: The present findings show a critical role for perceived norms – a person’s perception that people they like also approve of or use a technology – across all technologies. This suggests that social factors like norms play a major role in consumer acceptance of food technologies. Other predictors varied in strength across technologies suggesting marketing may benefit from strategies tailored to specific technologies.

(Supported by a grant from Merck Animal Health to TD and MFM)

Keywords: attitudes, consumer perceptions, food technologies, hormones, risk
INVESTIGATION OF BEEF BRISKET PALATABILITY FROM THREE USDA QUALITY GRADES

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Objectives: Barbecuing and smoked meat continues to grow in popularity for food service and consumers at home. However, little research has examined the eating quality differences of point (pectoralis superficialis) and flat (pectoralis profundus) muscles across USDA quality grade. The objective of this study was to investigate differences in smoked beef brisket palatability from three USDA quality grades.

Materials and Methods: Beef briskets from the USDA Prime, Average Choice, and Select quality grades (n = 54; 18 per treatment) were collected at a commercial abattoir in Omaha, NE. Briskets were trimmed to 6 mm of external fat, seasoned with a blend of 1:1 coarse kosher salt/coarse black pepper by hand (0.05% of the brisket raw weight), and were held at 2-4º for 12 h prior to cooking. Briskets were cooked in an electric pellet smoker utilizing Gold Blend Hardwood Pellets (red oak, hickory, and maple wood) for ~4 hours to an internal temperature of 63˚C; wrapped in aluminum foil, placed back in the smoker for ~4 hours, and cooked to 93˚C, then held in an insulated cooler until slicing. Approximately 90 min prior to serving, briskets were separated in point and flat portions, and then sliced (6 mm x 50 mm x cooked depth) perpendicular to the muscle fiber for consumer evaluation and held in warmers at (~50˚C) until serving. Each consumer (n = 360) received six test samples representing all quality grade x muscle combinations to evaluate tenderness, juiciness, flavor liking, overall liking, as well as the acceptability of these traits. Additionally, willingness to pay (WTP) was collected on an individual sample basis.

Results: An interaction between quality grade and muscle was observed (P ≤ 0.03) for all palatability traits, proportion of acceptable samples, and WTP. Consumers could not distinguish between quality grades of the point portions for tenderness, juiciness, flavor and overall liking (P > 0.05). Point samples, regardless of quality grade were scored greater than Prime flat samples, which were intermediate (P < 0.05). Consumers similarly (P > 0.05) scored Choice and Select flat samples lower for all palatability traits compared to all other treatment combinations. In alignment with palatability traits, consumers were willing to pay the most for point portions, regardless of quality grade (P < 0.05). Consumers WTP of the Prime flat portion was intermediate, and consumers were willing to pay the least for Choice and Select flat portions (P < 0.05). Consumer acceptability followed similar trends as palatability scores. However, a greater proportion of consumers classified Choice and Select point samples as acceptable than that of Prime point samples in all categories of acceptability (P < 0.05). Consumers struggled to distinguish differences in acceptability for Choice and Select flat portions (P > 0.05) in all factors except juiciness acceptability.

Conclusion: Quality grade had no effect on the eating quality of the point portions of smoked briskets, and point portions received superior palatability scores to flat portions. Briskets from the Prime flat portions had greater eating quality than Choice and Select briskets from the flat portion, and consumers were willing to pay more for what they perceived as superior eating quality. This data suggests that unless consumers prefer the flat portion of the brisket there is no benefit to paying the premium for a prime brisket from a palatability standpoint.

Keywords: Brisket, Palatability, Quality Grade, Smoke
Objectives: The objective of this study was to evaluate factors affecting Asian consumers’ purchasing decisions and eating preferences of six different beef shank cuts.

Materials and Methods: Six shank cuts, three from forequarter [biceps brachii (shank A); a combination of deep digital flexor and flexor digitorum superficialis (shank B); extensor carpi radialis (shank C)], and three from hindquarter [flexor digitorum superficialis (shank D); deep digital flexor (shank E), a combination of long digital extensor, medial digital extensor and peroneus tertius (shank F)] were collected from 12 USDA low choice beef carcasses (n=72). Shanks from the left side of the carcasses were used for consumer panels and stewed in water for 90 minutes at 98°C. Asian consumers (n=91) from Manhattan, KS evaluated samples for connective tissue texture, amount of connective tissue, juiciness, flavor, overall texture (a combination of myofibrillar tenderness and connective tissue texture) and sensory overall liking. Consumers (n=84) also visually evaluated the size, surface color and visual overall liking of shank samples from the right side of the carcasses. Finally, consumers rated each sample as either acceptable or unacceptable. All ratings were done on either a Just About Right (JAR) or a continuous line scale.

Results: Shanks A, C, D and F received similar scores close to JAR (P>0.05) for connective tissue texture. Connective tissue texture of shank E was harder than shanks A and D, and shank B was the hardest of all (P<0.01). For connective tissue amount, shanks A, D, and E received ratings close to JAR (P>0.05). Consumers rated shank B with too much and shank C and F with too little (P<0.01) connective tissue. Shanks A, D, and F received similar ratings close to JAR for juiciness (P>0.05), while shanks C and E were rated less juicy, and shank B was the least juicy among all (P<0.01). For overall texture, shanks A, D, and F received similar ratings close to JAR (P>0.05), and shanks C and E were tougher than those rated JAR (P<0.01). Again, shank B was the toughest among all for overall texture (P<0.01). Shanks A, D, and F received the highest sensory overall liking scores, followed by shanks C and E, and shank B received the lowest overall liking score among all the shank cuts (P<0.01). All shank cuts received high sensory acceptability scores (>85%) except for shank B (62%; P<0.01). Shanks A and C both received scores that were close to JAR for shank size. Consumers indicated that shanks B, E, and F were too big in size, while shank D was too small (P<0.01). However, shanks B, C, E, and F had the greatest and similar raw weight (P>0.05), followed by shank A, while shank D was the lightest of all (P<0.01). For visual overall liking, shanks A and C received the highest scores, followed by shanks B, E, and F, and shank D received the lowest score (P<0.05). Shanks A and C were most visually acceptable (>95%), while shanks B, D, E, and F were less acceptable than shanks A and C (>70%; P<0.01). Finally, consumers indicated that there was no difference in flavor and surface color among different shank cuts (P>0.05).

Conclusion: Connective tissue texture and amount directly affected Asian consumers’ eating preference for different beef shank cuts, while shank size was the main factor affecting their purchasing decision.

Keywords: beef shank, connective tissue, consumer, taste panel, visual evaluation
Objectives: The objective of this study was to evaluate the impact of quality grade on beef eating quality of top sirloin steaks when cooked to multiple degrees of doneness (DOD).

Materials and Methods: Beef top sirloin butts (IMPS #184; \(N = 60\); 15 / quality grade) were collected to equally represent 4 quality grades [Prime, Top Choice (Modest and Moderate marbling), Low Choice, and Select]. Top butts were cut into six consecutive steaks, and then divided laterally to get a total of twelve steaks per top butt. Steaks were assigned to one of three DOD: rare (60°C), medium (71°C), and well-done (77°C). Steaks within each DOD were assigned to consumer sensory analysis, trained sensory analysis, fat and moisture analysis, and Warner-Bratzler shear force (WBSF). Consumers (\(N=236\)) were fed samples under red lighting and evaluated steaks for juiciness, tenderness, flavor, and overall liking on continuous line scales. Trained sensory panelists evaluated samples for initial and sustained juiciness, myofibrillar and overall tenderness, connective tissue amount, beef flavor intensity, and off flavor intensity on similar continuous line scales. Data were analyzed as a split-plot, with a whole plot factor of quality grade, and sub-plot factor of DOD.

Results: There were no interactions (\(P > 0.05\)) for all consumer ratings of palatability traits. For quality grade, no differences (\(P > 0.05\)) were observed for consumer ratings of tenderness, flavor, and overall liking; however, there was a significant effect (\(P < 0.01\)) on juiciness. Prime top sirloin steaks had higher (\(P < 0.05\)) juiciness ratings than all other quality grades, except for Top Choice. Additionally, as DOD increased, consumer ratings and the percentage of steaks rated acceptable for all palatability traits decreased (\(P < 0.05\); rare > medium > well-done). There was a quality grade \(\times\) DOD interaction (\(P < 0.05\)) for trained sensory ratings of myofibrillar tenderness, initial juiciness, and sustained juiciness. When steaks were cooked to medium, Prime and Top Choice steaks had higher (\(P < 0.05\)) panelist ratings for initial and sustained juiciness than Low Choice and Select steaks. Similar to trained panelist ratings of juiciness, Prime and Top Choice steaks had higher (\(P < 0.05\)) ratings of myofibrillar tenderness than Select steaks. Prime and Top Choice steaks had similar (\(P > 0.05\)) and higher (\(P < 0.05\)) ratings for myofibrillar tenderness when compared to Low Choice steaks. Within DOD, each successive increase in DOD resulted in a concurrent decrease (\(P < 0.05\); rare > medium > well) in trained panelist ratings of myofibrillar tenderness, initial juiciness, and sustained juiciness. There was no quality grade by DOD interactions (\(P > 0.05\)) for Warner-Bratzler shear force. Prime steaks were more (\(P < 0.05\)) tender than Low Choice and Select steaks but were similar (\(P > 0.05\)) to Top Choice. Moreover, as DOD increased, WBSF concurrently increased (\(P < 0.05\); well-done > medium > rare), with well-done steaks having WBSF values 0.8 kg tougher than rare steaks.

Conclusion: These results indicate that regardless of DOD, quality grade had minimal impact on the palatability of beef top sirloin steaks. Therefore, unless cooked to a medium DOD, it is unnecessary for consumers, retailers, and foodservice to pay premium prices for higher quality top sirloin steaks, as the same eating experience will be provided.

Keywords: beef, consumer, degree of doneness, marbling, palatability
Objectives: The objective of this study was to evaluate the effect of increased pork hot carcass weights on consumer visual acceptability and purchase intent ratings of top loin chops cut to various thicknesses in a price labeled versus unlabeled retail display scenario.

Materials and Methods: Pigs in this study were intentionally raised to reach heavier hot carcass weights when compared to industry standards. Pork loins ($N = 200$) were collected from 4 different hot carcass weight groups: a light weight (LT; less than 111.8 kg), medium-light weight (MLT; 111.8 to 119. kg), medium-heavy weight (MHVY; 119.1 to 124.4), and a heavy weight (HVY; 124.4 and greater). Loins were fabricated into 4 pairs of chops of specified thicknesses (1.27, 1.91, 2.54, and 3.18 cm) at day 7, 8, or 9 postmortem. For each chop loineye area, length and width were measured. One chop from each specified thickness was then randomly assigned to be packaged with a label containing package price and weight information. The other paired chop was packaged without a label. Consumers ($N = 393$; 8 per panel) from the Manhattan Kansas area assessed chops from each weight group × thickness combination in both labeled and unlabeled scenarios. Chops were assessed on a 0 to 100 continuous line scale for desirability and purchase intent. Consumers were also able to indicate “yes” or “no” if the chop was either desirable and if they would purchase the chop.

Results: As hot carcass weight increased, there was an increase in loineye area and chop length, with chops from HVY carcasses having greater ($P < 0.05$) loineye areas and lengths compared to all other weight treatments. For both appearance and purchase intent ratings, chops from HVY carcasses were given higher ($P < 0.05$) ratings compared to LT chops. Additionally, consumers gave greater ($P < 0.05$) appearance ratings to thicker cut chops. There was a hot carcass weight × chop thickness interaction ($P < 0.05$) for the percentage of consumers that indicated the chop was desirable overall. Regardless of hot carcass weight treatment, chops with a thickness of 1.27 cm had the lowest ($P < 0.05$) percentage of consumers indicate they were desirable overall. Within the LT and MLT weight treatments, chops with a thickness of 1.91 and 2.54 cm were similar ($P > 0.05$) with the greatest ($P < 0.05$) percentage of consumers who indicated they were desirable. Within the HVY weight treatment, chops with a thickness of 2.54 cm had the greatest ($P < 0.05$) percentage of consumers who indicated they were desirable. A greater ($P < 0.05$) percentage of consumers indicated “yes” they would purchase chops cut to a thickness of 2.54 cm compared to all other thicknesses. Additionally, there was a greater ($P < 0.05$) percentage of consumers who indicated they would purchase chops that were unlabeled compared to chops labeled with weight and pricing information.

Conclusion: These results indicate that carcass weight and chop thickness can affect consumer preference and purchasing decisions. Thus, both should be considered by retailers when marketing fresh pork top loin chops.

Keywords: consumer preference, heavy pigs, hot carcass weight, pork, quality
11- THE EFFECT OF INCREASED PORK HOT CARCASS WEIGHTS ON LOIN QUALITY AND PALATABILITY


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Objectives: The objective of this study was to evaluate the effects of pork hot carcass weight on loin quality and palatability of top loin chops.

Materials and Methods: The pigs in this study were raised to exceed standard market weights. Pork loins (N = 200) were collected from 4 different hot carcass weight groups: light (LT; less than 111.8 kg), medium-light (MLT; 111.8 - 119.1 kg), medium-heavy (MHVY; 119.1 - 124.4), and a heavy (HVY; 124.4 and greater). Prior to fabrication, purge loss percentage, instrumental color, subjective color and marbling, and pH were taken for each loin. Following fabrication, chops were assigned to fat and moisture analysis, Warner-Bratzler shear force (WBSF), consumer sensory analysis, or trained sensory analysis. For WBSF, consumer, and trained panels, chops were thawed for 24 h prior to analysis. Chops were cooked on clam-shell style grills and removed from the heat with the internal temperature rising to a peak internal temperature of 71°C. Consumers (N=197) evaluated each sample for tenderness, juiciness, flavor like, and overall liking on 0 to 100 continuous line scales. Consumers were also able to indicate "yes" or "no" if the chop was acceptable for all palatability traits and overall. Trained panelists evaluated each sample for initial juiciness, sustained juiciness, myofibrillar tenderness, connective tissue amount, overall tenderness, pork flavor, and off flavor on similar 0 to 100 continuous line scales.

Results: Loins from all weight groups differed (P<0.05) in weight (LT<MLT<MHVY<HVY). No carcass weight effects (P>0.05) were found for loin instrumental color, subjective color, subjective marbling, purge loss percentage, pH, WBSF, moisture percentage, fat percentage, and drip loss. Carcass weight did not affect (P>0.05) juiciness or flavor like ratings but did affect (P<0.05) tenderness ratings and overall liking ratings. Chops from the HVY group were rated as more tender (P<0.05) compared to chops from the LT weight group. Additionally, chops from the HVY weight group had greater (P<0.05) consumer overall liking rating compared to chops from both the LT and MLT weight treatments. Hot carcass weight treatment did not contribute (P>0.05) to the percentage of chops rated acceptable for flavor and overall liking. Chops from the HVY weight carcasses had the greatest (P<0.05) percentage of chops rated acceptable for juiciness. Chops from LT carcasses had the lowest percentage of chops rated acceptable for tenderness. Trained sensory results also reflected tenderness and juiciness differences among carcass weight treatments. For both initial and sustained juiciness, chops from MHVY carcasses were rated as juicier (P<0.05) compared to chops from both MLT and LT carcasses. Additionally, chops from the LT hot carcass weight treatment had the lowest (P<0.05) myofibrillar tenderness ratings. Chops from MHVY and HVY carcasses were similar (P>0.05) with greater (P<0.05) overall tenderness ratings compared to chops from LT carcasses.

Conclusion: These results indicate that as hot carcass weight increased, there were no negative effects on loin quality, and top loin chops from heavier weight carcasses had improved tenderness and juiciness compared to chops from lighter carcasses. This provides evidence that as the hot carcass weights of pigs in the United States continue to increase there will be no negative effects on quality and palatability.

Keywords: consumer, heavy pigs, hot carcass weight, palatability, pork quality
EVALUATION OF CONSUMER PREFERENCES AND VOLATILE COMPOUNDS OF BEEF STRIP LOIN STEAKS DIFFERING BY QUALITY GRADE, POSTMORTEM AGING, AND DEGREE OF DONENESS

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Objectives: The purpose of this study was to determine consumer preferences and volatile aroma compounds for differences in flavor concerning quality grade, day of age, and degree of doneness on beef strip loins.

Materials and Methods: USDA Select (n = 18) and USDA upper 2/3 Choice (n = 18), boneless beef strip loins (IMPS 180), were selected from a commercial processing plant. Loins were cut in half and wet aged for either 10 or 20 d at 2°C. After aging, loins were cut into 2.54 cm steaks, individually vacuum-packaged and stored in a freezer at -40°C. Steaks were thawed at 4°C for 12 to 24 h prior to cooking. Steaks were cooked on a flat top griddle set to 204.4°C (±11.1°C). The steaks were cooked to one of three degrees of doneness: 63°C (63; medium rare), 71°C (71; medium) or 80°C (80; medium well) and flipped once at the halfway cook temperature. Steaks were held at 60°C no longer than 20 minutes. Consumer testing was conducted over five sessions with 93 consumers. Each consumer evaluated the samples on five different attributes: overall liking, overall flavor, appearance juiciness, and tenderness. The consumers rated each sample based on a 9-point hedonic scale. Consumer data were run using a full factorial design using grade, age, and degree of doneness as main effects. The order in which samples were served was included as a random effect and data were blocked by session. Portions of cooked samples were collected for GC analysis by being placed into a 20mL glass jar and collected with a solid-phase micro-extraction fiber for 60 min. The SPME was then placed into a GC/MS to separate and identify each volatile chemical compound. Three-way interactions amongst volatile compounds were determined to be not significant (P > 0.05); therefore, they were removed from the model. Additionally, volatiles that were not present in cells of two-way interactions were not included. Multivariate relationships between consumer preference and GC/MS data were explored using PCA.

Results: USDA Choice had a higher (P < 0.001) liking score than USDA Select grade beef loins for each of the five attributes tested. The 20-d aged steaks had higher (P < 0.03) scores for overall liking, overall flavor, juiciness, and tenderness. The degree of doneness affected overall liking and juiciness liking (P < 0.001) with 63°C having the greatest score followed by 71°C and then 80°C. For overall flavor, 63°C and 71°C were greater (P = 0.013) than for 80°C. For appearance, the degree of doneness of 63°C was preferred to steaks cooked at 71°C and 80°C (P = 0.002). Of the total volatiles (n = 52) present in the samples, 20 d age had greater (P < 0.04) iso butyraldehyde (pungent), 2-methyl-butanal (chocolate), and 3-methyl-butanal (fatty almond). Whereas, 3-hydroxy-2-butane (buttery) was greater (P < 0.002) in 10 d age. Octanal (fatty) and nonanal (fatty) were greater (P < 0.04) in USDA Select than USDA Choice. 2-methyl pyrazine (chocolate, meaty, roasted) was greater (P < 0.04) in 20 daged steaks cooked to 71°C and 80°C compared to other treatment combinations.

Conclusion: Consumer preferences were distinctly different based on quality grade, age, and degree of doneness. USDA Choice was generally the most preferred along with 63°C and 20 d age steaks. Positive (by their descriptors) volatile aroma compounds can be improved with aging and a degree of doneness of at least 71°C.

Keywords: Beef, Consumer Preference, Gas Chromatography - Mass Spectrometry, Metabolomics, Volatiles
**Objectives:** Understanding functional connectivity after consuming meat can be essential to fully understanding consumer's preferences and the connection to certain flavor compounds. The objective of this study was to determine differences in the functional brain connectivity of consumers after consuming grass-fed beef, grain-fed beef and chicken while determining the different chemical and volatile components that differentiate the treatments.

**Materials and Methods:** Grass-fed strip steaks, Grain-fed strip steaks and chicken breasts were collected, aged 21 days and cut into 1"x1" consumer steaks. Each steak was vacuum sealed with a random identification number and frozen at -20°C. 23 volunteered consumers evaluated each treatment randomly followed by a Blood Oxygen Level-Dependent (BOLD) fMRI scan. Each consumer received a resting state scan and three scans following each sample. The beef was cooked to a medium degree of doneness (71°C) and the chicken was cooked to a well-done degree of doneness (75°C), followed by a one-minute resting period. The consumers were asked to complete a sensory ballot for each sample to quantify tenderness, juiciness, flavor, overall liking and quality. Each attribute was evaluated on a 100mm line scale. The sensory ballot, volatile and fatty acid data were analyzed by ANOVA and multiple means comparison using SAS while the fMRI data were analyzed using FSL's FEAT software.

**Results:** The results indicated all treatments were equal for tenderness and flavor, but the chicken was the least juicy (P<0.05) and the grain-fed steak was ranked higher for overall liking (P<0.05) in comparison to chicken. Furthermore, based on an independent component analysis, there was a significant difference in the functional connectivity (P<0.05) from the resting state scan to all three treatments within the insular, medial prefrontal cortex, and amygdala regions. Additionally, there were significant differences in connectivity (P<0.05) between the insula and orbitofrontal cortex in grass-fed compared to grain-fed beef. These areas are involved in processing sensory characteristics related to smell and taste and tend to track differences in preferences and stimulus value. Also, the samples were evaluated for volatile compounds with GCMS and fatty acids using the FAMES method. Chicken and grass-fed beef was found to have a higher concentration (P<0.05) of dimethyl sulfone in comparison to grain-fed beef, while the grass-fed steaks possessed a higher concentration (P<0.05) of toluene in comparison to grain-fed steaks, but not differing from chicken. Dimethyl sulfone and toluene have been tied to grass-fed beef and chicken flavor profiles (Tansawat et al 2013).

**Conclusion:** The results from the functional brain connectivity in the reward pathways and the chemical components of the different treatments indicated a trend for grain-fed beef to be the most different from grass-fed beef and chicken. Moreover, tying brain activity to the flavor and chemical components in meat can be vital in understanding consumer's preferences not observed in behavior alone. Therefore, these results can provide a basis to determine the ability to track reactions within the functional connectivity in the brain and the chemical aspects of different steaks to determine and understand consumer's preferences and the true value of beef and chicken.

**Keywords:** fMRI, Food Technology, Functional Connectivity, Prefrontal Cortex, Volatile Flavor Compounds
EFFECTS OF REPLACING SUPPLEMENTAL SUCROSE WITH BEEF DURING MID TO LATE GESTATION ON MATERNAL HEALTH AND FETAL DEVELOPMENT USING A SOW BIOMEDICAL MODEL

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Objectives: The objectives of this study were to investigate the influence of substituting supplemental sucrose with beef on maternal health and fetal development using a sow biomedical model.

Materials and Methods: Multiparous crossbred sows (BW = 222 kg; n = 21; rep = 3) were individually housed from d 30 to 111 (± 0.58) of gestation. From d 30 to 39, a complete sow ration (corn-soybean meal-based, CSM) was fed at 1% of d 30 gestational BW. On d 39, daily dietary ration was adjusted to 1% of d 39 gestational BW which was fed daily at 0700 h from d 40 to 110 (± 0.58). Sows were randomly assigned to 1 of 4 isocaloric supplement treatments; 126 g CSM to serve as a control (CON, n = 5), 110 g cooked ground beef (BEEF, n = 6), 85.5 g sucrose (SUCR, n = 5), or 54.8 g BEEF and 42.7 g SUCR (B+S, n = 5). Dietary supplements were fed daily at 1100, 1500, and 1800 h from d 40 to 110 (± 0.58). Blood was collected via jugular venipuncture from sows on d 29 and 111 (± 0.58). Blood chemistry was immediately analyzed, and serum samples were collected for lipid panel and insulin concentrations. Bodyweights were measured on d 30, 39, 54, 68, 82, 96, and 111 (± 0.58). Tenth rib and last rib SQ fat depth were measured on d 35, 70, and 110 (± 0.58) via ultrasound. Sows were euthanized on d 111 (± 0.58). Reproductive tract (RT), pancreas, kidney, liver, heart, heart fat, lung, semimembranosus and abductor (SM), and semitendinosus (ST) weights were collected and recorded from each sow. Two median weight male and female fetuses were selected from each sow for tissue collections. Fetal tissue collection was the same as sows with the addition of testes and no RT weight. A repeated measures design, with sow as the repeated measure, was modeled using the MIXED procedure of SAS using compound symmetry variance covariance matrix. Sow data fixed effects were replicate, sow, and treatment. Fetal data fixed effects were replicate and fetal weight category. Covariates were determined for each individual trait depending on goodness of fit. A treatment by day interaction was used for sow data while a treatment by sex interaction was used for fetal data. Alpha level was 0.05.

Results: Dietary treatment did not influence gestational BW (P ≥ 0.99), SQ fat depth (P ≥ 0.09), blood chemistry (P ≥ 0.21), or serum concentrations (P ≥ 0.07). Dietary treatment did not influence sow tissue weight (P ≥ 0.42). Compared with CON, BEEF fetuses had greater fetal BW (P = 0.01), crown to rump length (P = 0.01), nose to crown length (P < 0.01), heart girth (P = 0.02), and abdominal girth (P = 0.05). Dietary treatment did not influence fetal growth characteristics of median weight male and female fetuses (P ≥ 0.23). Compared with BEEF, SUCR fetuses had heavier liver weights (31.43 ± 2.06 and 40.13 ± 2.09, respectively; P = 0.04). There was a dietary treatment by sex interaction for fetal kidney weight with BEEF males having lighter kidney weights compared with all other interactions (P = 0.03). Dietary treatment did not influence any other fetal tissue weight (P ≥ 0.09).

Conclusion: Beef and/or sucrose supplementation during mid-to-late gestation has minimal effects on swine maternal health and fetal development. Differences in fetal liver and kidney weights should be examined further. Further research is needed to determine the effect of gestational supplementation on human health and development.

Keywords: beef, biomedical model, sucrose, swine
Objectives: The objective of this study was to determine the relationship between consumer demographic characteristics and willingness to pay for beef.

Materials and Methods: Data were collected from consumers (n = 4,080) from April to December 2018 in conjunction with consumer eating quality assessments in Lubbock, TX. All beef samples were prepared and demographics and willingness to pay (WTP) questionnaires were administered in accordance with Meat Standards Australia protocols. The following demographic characteristics were collected: age, gender (GEN), occupation (OCC), consumption (CONS), number of adults in household (NOA), number of children (NOC), beef preferences (PREF), preferred degree of doneness (DOD), income (INC), education (EDU), and heritage (HER). At the conclusion of a tasting session, which consisted of 7 beef samples prepared and served as steaks, smoked brisket, or fajita strips, consumers were asked how much they would pay for each of the four quality levels [Unsatisfactory (UNS), Good everyday (GOOD), Better than everyday (BTE), and Premium (PREM)], using line scales anchored from $0/lb. to $40/lb. Data were analyzed using the STEPWISE option of PROC REG of SAS. Variables had to meet a 0.15 significance level for entry and to remain in the model. Willingness to pay data were analyzed using PROC GLIMMIX of SAS with fixed effects of quality level, cook method, and their interaction (α = 0.05).

Results: Regression analysis revealed that demographic characteristics accounted for 6, 7, 6, and 7% of the variation in willingness to pay for UNS, GOOD, BTE, and PREM quality beef, respectively (P < 0.01). For UNS, increasing AGE, CONS, NOA, PREF, and DOD were positively linked with WTP, while GEN, NOC, INC, and EDU were negatively linked with WTP (P < 0.15). Increasing CONS, NOA, and PREF elevated WTP for GOOD quality, while AGE and EDU had a negative impact (P < 0.15). For BTE quality, NOA, PREF, INC, and GEN positively influenced WTP, while AGE, NOC, and EDU reduced WTP (P < 0.15). Finally, increasing CONS, NOA, PREF, and INC resulted in greater WTP of PREM quality beef, but AGE and NOC were negatively linked (P < 0.15).

An interaction between quality level and cook method was observed for WTP (P < 0.01). Consumers were willing to pay the most for PREM quality with significant differentiation between each quality level (PREM > BTE > GOOD > UNS). Overall, consumers were willing to pay $17.84, $12.96, $8.65, and $3.80 for PREM, BTE, GOOD, and UNS, respectively. However, within quality level, consumer WTP varied due to cook method. For PREM and UNS WTP, consumers were willing to pay more (P < 0.05) for samples cooked as steaks and fajitas than as brisket. For BTE and GOOD WTP, consumers were willing to pay more (P < 0.05) for samples cooked as steaks than as brisket, but WTP of fajita samples was similar (P > 0.05) to the other cook methods.

Conclusion: Demographic characteristics can account for a small proportion of the variation in consumer WTP for beef products. Increasing age, number of children, and education consistently had negative impacts on WTP, regardless of quality level. Conversely, increasing beef consumption and preferences, along with number of adults lifted WTP across all quality levels. Cook method also influenced consumer WTP within each quality level.

Keywords: beef, consumer, demographics, regression, WTP
Objectives: The Australian meat industry exports over 70% of its beef, with a large portion going to the US. Due to the popularity of fajita meat in the US, there is an opportunity to export value-added fajita cuts from Australia to the US. A consumer study was conducted to measure sensory differences between five muscles subjected to two different enhancement solutions.

Materials and Methods: Five muscles were collected from cattle at a commercial abattoir in Rockhampton, Australia. The muscles included were top round cap/gracilis (n=81), inside skirt/transversus abdominis (n=81), outside skirt/diaphragm (n=95), flank/rectus abdominis (n=81), and sirloin flap/obliquus externus abdominis (n=81). The muscles were vacuum packaged and shipped refrigerated to Texas Tech University for processing. All muscles were cut into equal halves, and then assigned to no enhancement (CON), phosphate enhancement (PHOS), sodium bicarbonate (SBC) enhancement. Muscles were vacuum tumbled to 115% of green weight with their respective solution. Muscles were cooked and sliced into 1.3-cm strips, 5-cm long, and kept warm until serving. The samples were cooked to a medium degree of doneness (71°C) and evaluated for juiciness, flavor liking, and overall liking on 100-mm line scales. Data were analyzed using PROC GLIMMIX of SAS using MSA carcass grade, muscle, enhancement, and their interactions as fixed effects (α = 0.05).

Results: No interactions were detected for any eating quality traits (P > 0.05). MSA grade only influenced tenderness (P=0.04), where Classic (4*) had greater (P < 0.05) tenderness scores than Premium (5*) and ungraded cuts but did not differ (P > 0.05) from Selected (3*). Muscle influenced all palatability traits (P < 0.0001). The sirloin flap (obliquus abdominis internus) steaks had the highest tenderness score (73.7), juiciness score (66.7), flavor score (67.5) and overall liking score (68.6), differentiating itself from the other 4 cuts (P < 0.0001). The top round cap/gracilis had the lowest tenderness scores (49.2), juiciness score (44.7) and overall liking score (51.2) (P<0.01). Also, enhancement method influenced tenderness and juiciness (P < 0.0001). Between the phosphate enhancement, sodium bicarbonate enhancement and non-enhanced samples, the sodium bicarbonate samples were rated the highest for tenderness 64.1) (P < 0.0001). Moreover, clean enhanced fajita samples rated highest for overall liking (64.0), with phosphate being similar (63.2). The control samples were ranked the lowest in tenderness (46.7), juiciness (42.7), flavor (44.2) and overall liking (43.9).

Conclusion: The sirloin flap/obliquus externus abdominis samples were rated highest in all palatability scores, while the top round cap/gracilis had the lowest tenderness, juiciness and overall liking scores. Between the 3 enhancement treatments, the sodium bicarbonate enhancement was significantly the highest rated on tenderness and juiciness. The sirloin flap/obliquus externus abdominis samples that are enhanced with the sodium bicarbonate treatment could maximize the highest palatability scores from consumers. The innovation muscle, the top round cap/gracilis, was rated the lowest of the five muscles in every palatability category but could improve scores through a sodium bicarbonate enhancement.

Keywords: Australia, Consumer preference, Enhancement, Fajita, Palatability
OBJECTIVES: Advances in food technology provide numerous benefits including improvements in sustainability, quality, and food security. However, consumers often perceive such technologies as risky, even when extensively vetted for safety. Neuroimaging has the potential to reveal how the consumer brain processes information about technologies and how this processing relates to their attitudes and risk perception. The current study used functional magnetic resonance imaging (fMRI) to examine how brain activation during processing of infographics about food technologies related to subsequent ratings of risk and attitudes. Based on neuroeconomic research, we hypothesized that the ventromedial prefrontal cortex (vmPFC) would track positive attitudes for the technologies due to its role in computing subjective value and positive affect. In contrast, we predicted that the lateral PFC would track perceptions of risk associated with the technologies due to its role in processing conflict and uncertainty.

MATERIALS AND METHODS: Participants (n = 53; 31 Female; Age 18 - 43) completed a neuroimaging study at Texas Tech Neuroimaging Institute. Participants were scanned while viewing 6 different food technology infographics in 30s blocks: hormone implants, antibiotics, vaccines, GMOs, animal welfare technology, and sustainability technologies. Between viewing blocks, participants answered attitudes and risk perception questions for each technology. The scans were analyzed using a mixed effect implemented in FSL’s FEAT software and corrected for multiple comparisons (p < .05) using cluster-based thresholding with a primary threshold of z = 3.1 (p < .001).

RESULTS: Participants had lower attitudes and higher risk perception for antibiotics and hormones relative to GMOs and vaccines (risk perception: t(52) = 5.07, p < .001; attitudes: t(52) = 8.35, p < .001) and animal welfare and sustainability technologies (risk perception: t(52) = 6.60, p < .001; attitudes: t(52) = 7.65, p < .001). Consistent with our predictions, a cluster in lateral PFC (1496 voxels, p < .001) was positively associated with between-infographic differences in risk perception (and negatively associated with attitudes) such that it was most highly activated for the hormones and antibiotics and less so for the lower perceived risk technologies. Additionally, we observed a cluster in vmPFC (648 voxels, p < .001) that was positively associated with attitudes and thus was most highly activated for the lower perceived risk and higher attitude technologies. Several additional areas were associated with risk and attitudes including lateral parietal cortex, precuneus, occipital, and middle temporal gyrus (p < .05).

CONCLUSION: Our results present a critical step forward in understanding how consumers process information about food technologies. We found areas of the vmPFC tracked positive attitudes and lateral PFC tracked perceptions of risk and lower attitudes. These findings are important because they suggest that PFC regions may contribute to how consumers process information about food technologies, which can affect how they retain and use information to update their beliefs. Future research should examine whether fMRI may be useful prospectively for predicting consumer responses to information campaigns about food technologies.

KEYWORDS: Attitudes, fMRI, Food Technology, Human Subjects, Prefrontal Cortex
EFFECTS OF DRY HEAT COOKERY METHOD AND QUALITY GRADE ON THE PALATABILITY OF BEEF STRIP LOIN STEAKS
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Objectives: Cooking meat using a clamshell grill has become common in university research settings due to speed, relative low cost, and acceptable repeatability. However, other cooking methods such as charbroiling and salamander grills have also become a popular method in the hotel and restaurant industry. The objective of this experiment was to evaluate the effect of different dry heat cooking methods on beef palatability across a range of USDA quality grades.

Materials and Methods: A consumer panel (n = 288) was conducted at Texas Tech University. Strip loin steaks from four different USDA quality grades (Prime, upper 2/3 Choice, lower 1/3 Choice, and Select) were cooked using one of four cooking methods: electric clamshell grill (CLAM), flat top gas grill (FLAT), Charbroiler gas grill (CHAR), or Salamander gas broiler (SAL). After cooking to medium degree of doneness (70-72°C), steaks were cut into cubes (1.3-cm × 1.3-cm × steak thickness), and two cubes were served immediately to 6 predetermined consumers from each steak. Each consumer evaluated 8 samples, representing half of the 16 possible quality grades × cooking method treatment combinations. Consumers scored juiciness, tenderness, flavor liking, and overall liking using electronic ballots with the zero-point anchors labeled as extremely dry, extremely tough, dislike flavor extremely, and dislike overall extremely and the 100-point anchors labeled as extremely juicy, extremely tender, like flavor extremely, and like overall extremely. Also, consumers rated each sample as either acceptable or unacceptable for each palatability trait.

Results: There were no interactions between the cooking method and quality grade for any of the palatability traits (P > 0.05). Steaks cooked on CHAR had greater (P < 0.05) flavor and overall liking scores, as well as a greater percentage of samples (P < 0.05) that were considered acceptable overall compared to the other cooking methods. Steaks cooked on FLAT were scored lower (P < 0.05) for tenderness and juiciness compared with all other cooking methods. Steaks cooked on CLAM, SAL, and CHAR were scored similarly for tenderness and juiciness (P > 0.05). Steaks cooked on FLAT were scored lower (P > 0.05) than CHAR and SAL for overall liking. Steaks cooked on CLAM had lower (P < 0.05) flavor liking scores than CHAR and SAL. Prime samples had greater scores (P < 0.05) than Low Choice and Select, which were similar (P > 0.05), for tenderness, juiciness, flavor liking, and overall liking, but Prime did not differ from Top Choice (P > 0.05) for any palatability traits.

Conclusion: These results indicate cooking method had a significant impact on consumer palatability ratings, and those results were consistent across a range of quality grades. Even though these cooking methods are all classified as dry heat cookery methods, consumers in this study were able to detect differences in tenderness, juiciness, flavor liking, and overall liking. This may be due to increased cooking times or differing types of heat transfer possessed by the various cooking methods. These data suggest cooking steaks by CHAR resulted in the most desirable eating experience, and cooking steaks on FLAT and CLAM were less desirable. However, the low eating satisfaction of FLAT can be linked to low tenderness and juiciness, whereas CLAM liked less due to low flavor liking.

Keywords: Consumer Perception, Cooking methods, USDA quality grade
CHEF AND CONSUMER EVALUATION OF THE DEGREE OF DONENESS OF BEEF STROP LOIN STEAKS COOKED TO SIX ENDPOINT TEMPERATURES

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Objectives: The objective of this study was to assess if visual degrees of doneness (DOD) are in-line with current published cooking temperatures and to assess differences in perceptions between consumers and chefs.

Materials and Methods: Twenty-four paired beef strip loins (IMPS #180) representing four quality grades [Prime, Top Choice, Low Choice, Select] and an additional 12 enhanced Select strip loins were fabricated into 2.54 cm thick steaks and used in the study. Steaks were randomly assigned to one of six DOD: very rare (55°C), rare (60°C), medium-rare (63°C), medium (71°C), well done (77°C), or very well done (82°C). Following cooking, a photograph of the cut steak surface was taken immediately using a digital camera (Canon PowerShot SX620 HS). A digital survey for chefs and consumers was created for the electronic evaluation of the pictures of the internal surface of the cooked steaks. Chefs (n = 83) and consumers (n = 1,134) were asked to assess the DOD of digital steak pictures representing multiple DOD and quality grades. Participants were also asked several questions related to how they determine DOD when cooking steaks, about their use of thermometers, and the temperatures they associate with each DOD.

Results: There were no quality treatment effects (P > 0.05) for any DOD for the images evaluated. Between 14 and 44% of chefs categorized the steak images as the DOD to which it was cooked. For all DOD, 9 to 48% of chefs classified the steak images as 2 or more DOD from the DOD to which the steak was cooked. Of the 1,134 consumers, 27 to 35% of consumers categorized steaks as appropriate DOD. For all DOD, 16 to 36% of consumers identified steaks as 2 or more DOD higher or lower than the DOD that the steak was cooked. When chefs were asked how they determined DOD when cooking beef steaks, 66% of chefs reported using feel or firmness, whereas 28% stated they use a thermometer. Within the chefs that reported use of thermometers, 15% indicated the specific temperature they used was pull-off the heat temperature and 13% used carry-over cooking temperature. To assess DOD when cooking beef at home, 54% of consumers reported they used color, 16% used feel or firmness, and 10% used time. Additionally, 3% of consumers responded that they do not determine DOD. Only 16% of consumers reported using temperature or food thermometer for determining the correct DOD when cooking beef. Consumers that answered to using a food thermometer were then prompted to state the temperature they utilize, being either pull off the heat temperature (69%) or temperature following the post-cooking temperature rise (31%). However, 48 to 61% of consumers that stated they use a thermometer then reported they did not know the temperatures that correspond with each DOD. Additionally, only 14 to 32% of consumers that utilized peak temperatures matched the NCBA temperatures.

Conclusion: Although consumers do not have a good understanding of beef cooking temperatures, they are able to identify DOD of steaks cooked to specified endpoint temperatures. Additionally, chefs do not consistently use the same method when determining DOD and are unable to accurately identify DOD of steaks cooked to specified endpoint temperatures. This lack of uniformity between chefs and consumers on DOD determination can create challenges for foodservice establishments to successfully meet consumer DOD expectations.

Keywords: beef, chef, consumer, degree of doneness
Objectives: The objective of this study was to understand consumer perception of beef color and marbling using eye tracking equipment.

Materials and Methods: A total of 158 consumers from the Bryan/College Station, TX area were recruited to observe images of raw steaks and report overall, color, and marbling liking. The official USDA Small 5 grading card image was edited by an experienced photographer (Adobe Photoshop CC, San Jose, CA) to create different degrees of color and marbling. This allowed all other intrinsic attributes of the steak image (i.e. shape and ribeye area) to be consistent across all edited images, therefore minimizing conclusions to focus on exclusively marbling or color differences. Consumers viewed two scenarios of pictures. Scenario 1 consisted of three images with Average Choice marbling in color scores of 8, 6, and 4 (Behrends, 2004) that correspond to dark, ideal, and light color categories, respectively. Scenario 1 was designed to understand consumer perception of beef color. Scenario 2 displayed three images of similar color (ideal; color score 6) and differing degrees of marbling (Average Choice, Low Choice, and Select). Images were presented on a 1920 x 1080 pixels computer screen while a Tobii TX-300 eye-tracking device collected data at a rate of 600 Hz. Each scenario was exposed for 10 seconds before automatically advancing to slides where consumers reported their overall, color, and marbling liking of each image on a 9-point hedonic scale where 1= dislike extremely and 9= like extremely. Between each slide, filler slides were placed for three-second intervals with a target randomly placed in the top left, top right, bottom left, or bottom right. Consumers were instructed to stare at the target until the next slide appeared. This was intended to randomize where the consumers would begin their observations. Each image within the slide was defined as an area of interest (AOI) to collect eye-tracking metrics to compare the images within each scenario. Metrics included time to first fixation (TTFF), time spent, revisits, and fixation counts.

Results: In scenario 1, consumers liked for overall and color liking the ideal colored image and rated the light-colored image lowest ($P < 0.0001$). Consumers fixated on the dark and ideally colored images before the light. Additionally, more time was spent observing the dark and ideally colored images compared to the light ($P < 0.0001$). The number of revisits and fixation counts were greatest for the ideal colored image followed by the dark image and were lowest for the light-colored image. In scenario 2, consumer overall and marbling liking was highest for Average and Low Choice images. Consumers rated the Select image lowest for overall and marbling liking ($P < 0.0001$). Eye tracking data was reflective of these findings. The Low Choice image was viewed the fastest with more time spent viewing, attracted more revisits, and accounted for greater fixation counts compared to the Average Choice and Select images ($P < 0.0001$).

Conclusion: These findings confirm the use of eye tracking equipment can provide additional insight into the factors that drive consumer acceptability and therefore potentially increase beef consumption. Implementing this tool in future studies will provide information on consumers’ cognitive behavior that cannot be observed solely through hedonic measures.

Keywords: beef color, beef marbling, cognitive behavior, eye tracking
OBJECTIVES: The objective of this study was to determine the impact of feeding consumers of varying degree of doneness (DOD) preferences steaks cooked to multiple DOD on their perceptions of beef palatability.

Materials and Methods: Paired Low Choice strip loin steaks \( (n=360) \) were randomly assigned a DOD of either rare \((60°C)\), medium-rare \((63°C)\), medium \((71°C)\), medium-well \((74°C)\), or well-done \((77°C)\). Consumer panelists \( (n=283) \) were prescreened to participate in panels based on their DOD preference of either rare, medium, or well-done. In the first round of serving, consumers were served one sample from each of the five DOD, under low-intensity red incandescent lighting to mask any DOD differences among samples. Round 2 testing procedures were identical to round 1, except consumers were served under white incandescent lights, allowing for the consumers to visually evaluate the DOD of samples during testing. Consumers evaluated samples for tenderness, juiciness, flavor, and overall liking on continuous line scales. Screening the consumers beforehand for DOD preference allowed for a measure of the impact of “missing” the consumer’s ideal DOD and quantification of the impact of both under and overcooking steaks on consumer beef palatability ratings.

Results: There were no consumer preference \( \times \) DOD interactions or consumer preference effects for tenderness, juiciness, and flavor \((P>0.05)\) when steaks were evaluated under both lighting types. As expected, within the red-light testing, as cooking temperature increased, overall liking decreased \((P<0.05)\). The sensory cue of sight significantly impacted palatability ratings. Within the white-light testing, the consumer preference \( \times \) DOD interaction for overall liking was marginally significant \((P=0.078)\). Consumers that preferred rare and medium rated rare and medium-rare the greatest \((P<0.05)\) and well-done the lowest \((P<0.05)\) for overall liking. However, as the consumers DOD preference increased, the more their ratings differed than in the red-light test. For consumers that preferred well-done, there were no differences \((P>0.05)\) among DOD for overall liking within the white-light test. But, when tested under the red-light, well-done consumers rated rare and medium-rare with the greatest \((P<0.05)\) overall liking, with well-done having the least \((P<0.05)\) overall liking, being similar \((P>0.05)\) only to medium. As for the change in ratings when compared to the consumers preferred DOD, when steaks were undercooked, they were rated higher \((P<0.05)\) and when steaks were overcooked, they were rated lower \((P<0.05)\), regardless of the consumer’s DOD preference. For all ratings, when steaks were cooked below the consumer’s preference, there were no differences \((P>0.05)\) among the ratings, all of which were rated higher \((P<0.05)\) and when steaks were cooked four DOD over the consumer’s preferred DOD being rated tougher and lower \((P<0.05)\) for flavor liking than steaks cooked to their preferred DOD.

Conclusion: Regardless of the consumers DOD preference, undercooking had a positive effect versus their preferred DOD, and overcooking negatively impacted ratings. Therefore, it is better for steaks served at restaurants to err on the side of being undercooked in order to maximize the consumers eating experience.

Keywords: beef, consumer, Degree of doneness, Palatability
Objectives: Cattle can be managed differently during the backgrounding segment, which may alter long-term animal and carcass characteristics. Therefore, the objectives of this study were to 1) measure carcass composition over time, and 2) determine the effect of different backgrounding diets on animal growth and carcass characteristics.

Materials and Methods: Angus and Angus × Simmental crossed calves (n=65) were stratified by dam age, birth date, weaning weight, breed, and sex post weaning in a completely randomized design to one of three treatments: 1) perennial pasture (PP; grazing quack grass, orchard grass; smooth brome grass, red clover, and alfalfa); 2) summer annual cover crop (CC; grazing cereal oats, purple top turnips, hunter forage brassica, and graze forage radish); and 3) dry lot (DL; bunk fed a haylage ration consisting of 28 NEm Mcal/50.8 kg DM) during backgrounding for 55 d. Concluding backgrounding, the CC and PP treatments were transported to pens where all treatments were sorted by gender and acclimated to a finishing ration over a period of 14 d and continued receiving 3 step-up diets over the next 25 d. Two pens during the finishing segment were utilized to house heifers and steers, respectively. The heifers were top dressed with melengestral acetate till harvest, which was determined by targeting a common backfat thickness per treatment. From backgrounding to harvest, cattle were weighed to determine body weight (BW), average daily gain (ADG) and hip height (HH) measurements were recorded every 28 d. Five periodic carcass ultrasound measures were recorded to evaluate ultrasound rib eye area (uREA), rib fat thickness (uRFT), and percent intramuscular fat (uIMF). At harvest, carcass measurements included hot carcass weight (HCW), LMA, 12th rib backfat (FT), kidney, pelvic and heart fat (KPH), marbling and maturity score and objective color (L*, a*, b*). Statistical analyses were conducted using mixed model procedures and animal weaning weight was used as a covariate. Least square means were computed and separated using least significant differences when treatment effects were significant at α ≤ 0.05.

Results: Cattle ADG, uREA, uRFT, and HH did not differ (P ≥ 0.05) among treatments from backgrounding to harvest (Table 1). Cattle in DL were heavier (P ≤ 0.05) in BW than CC and PP, which were similar (P ≥ 0.05). Percent uIMF was greater (P ≤ 0.05) for DL and similar (P ≥ 0.05) to PP though CC was lower (P ≤ 0.05) and similar (P ≤ 0.05) to PP.

Image:

Table 1. Least squares mean performance responses and ultrasound-measured composition (averaged across all periodic measurements) according to backgrounding treatment

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW, kg</td>
<td>DL</td>
<td>368a</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>357b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>349b</td>
<td></td>
</tr>
<tr>
<td>ADG, kg</td>
<td>DL</td>
<td>1.17</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>1.08</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>uREA, cm²</td>
<td>DL</td>
<td>51.03</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>51.23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>48.77</td>
<td></td>
</tr>
<tr>
<td>uRFT, cm</td>
<td>DL</td>
<td>0.46</td>
<td>0.384</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>uIMF, %</td>
<td>DL</td>
<td>3.94⁴</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>3.36⁴</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>3.53⁴</td>
<td></td>
</tr>
<tr>
<td>HH, cm</td>
<td>DL</td>
<td>114</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>113</td>
<td>0.396</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>113</td>
<td></td>
</tr>
</tbody>
</table>

¹ Least squares means within a row with different superscripts differ (P ≤ 0.05).
² Perennial pasture (PP; grazing quackgrass, orchardgrass; smooth brome grass, red clover, and alfalfa); 2) summer annual cover crop (CC; grazing cereal oats, purple top turnips, hunter forage brassica, and graze forage radish); 3) dry lot (DL; bunk fed a haylage ration consisting of 28 NEm Mcal/50.8 kg DM) during backgrounding for 55 d.
³ Probability of difference among least square means.

Conclusion: Treatments utilizing different backgrounding diets influence average body weights and ultrasound intramuscular adipose. Cattle grazing forages have lighter body weights and lower ultrasound intramuscular adipose though, cattle grazing perennial pastures were most variable in carcass ultrasound intramuscular adipose.
Keywords: carcass characteristics, cattle, meat quality, ultrasound
Meat Goat Performance, Carcass Traits, and Meat Characteristics of Kid Meat Goats Supplemented with Sunn Hemp or Concentrates on Pasture

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Objectives: Feed is a large input cost to a goat operation (Gillespie et al., 2013) so the optimal time to supplement pasture grazing impacts the economic return on the feed investment. The objective of this study was to compare growth, carcass traits, and goat meat properties of weaned kid goats on pasture with access to sunn hemp followed by concentrate feed 50 days prior to slaughter or supplementation with concentrates and switching to sunn hemp 50 days prior to slaughter.

Materials and Methods: Savanna (n=23) and Savanna-Kiko (n=14) kid meat goats from the Louisiana State University meat goat herd were ranked by weight within each breed into groups of the four heaviest goats, next four heaviest goats and continuing until all goats were assigned into four groups. The two treatments were sunn hemp and native pasture or native pasture supplemented with 16% crude protein feed daily at 3% of the average group body weight with two replications of each treatment. After 50 days, the animals were switched to the opposite treatment. Goats were weighed weekly and linear dimensions were measured prior to overnight fasting and humane slaughter at day 100 at an average live weight of 27.2 kg. Temperature and pH of the M. Semimembranosus were measured after hide removal and 1 h, 3 h and 24 h after stunning. Carcasses were chilled overnight at 2°C before determination of carcass characteristics (McMillin and Pinkerton, 2008), the M. Longissimus dorsi area and body wall thickness at the 13th thoracic vertebrae, and L*, a*, and b* color of the M. Rectus abdominis flank muscle and M. Longissimus dorsi. Right sides were fabricated into USDA IMPS food service style cuts with an additional transverse cut between the 4th and 5th ribs. Consistent with previous experiments, M. Semimembranosus muscles were vacuum packaged and held at 4°C for 7 d before grilling on a conveyor oven to an internal temperature of 75°C. Cook yield was determined as cooked weight divided by raw weight. Three 1.27-cm cores were removed parallel to the muscle grain for Warner-Bratzler shear force. Data were analyzed with effects of treatment, breed, replication, and interactions by R-studio aov function with separation of least squares means and significance set at P < 0.05.

Results: Savannah goats were heavier than Savannah-Kiko goats through the 100-day trial and finished on concentrate compared with those finished on sunn hemp, but average daily gain was not different (P>0.05) with feed or breed. The only difference among the carcass traits were dressing percentages of 50.81% with the concentrate and 48.13% with sunn hemp (P<0.05). Boneless lean yield and shear force were not different (P>0.05) with treatment or breed.

Conclusion: The minor differences in results did not clearly distinguish between the supplementation methods to improve growth, carcass traits, or meat characteristics of the two types of kid meat goats.

References:

Keywords: Carcass Traits, Goat, Shear Force, Sunn hemp
EVALUATION OF PEARL MILLET WITH AND WITHOUT SOYBEAN HULL SUPPLEMENTATION FOR FORAGE-FINISHED BEEF PRODUCTION SYSTEMS

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Objectives: The objective of this research was to evaluate pearl millet, a warm-season annual grass, with and without soybean hull supplementation for forage-finished beef production systems in the Southeast.

Materials and Methods: Each year, 32 Angus-crossbred steers (339 ± 40 kg) were randomly assigned to one of four finishing treatments. Treatments were arranged in a 2 x 2 factorial and included two varieties of pearl millet, ‘Tifleaf 3’ (PM) and ‘Exceed’ brown mid-rib (BMR), and two levels of soybean hull supplementation, 0 and 0.75% of body weight d⁻¹. Steers were on treatments for 90 and 84 d during the summers of 2017 and 2018, respectively, at the University of Georgia Department of Animal and Dairy Science Beef Research Unit located near Eatonton, GA. Shrunken weights were taken at initiation and termination of the finishing period and average daily gains (ADG) were calculated. At the end of the finishing period, steers were harvested under USDA inspection and carcass data was collected 24 h postmortem from the right side of each carcass. Striploins were then removed from the right side, vacuum packed, and allowed to age for 21 d prior to fabrication. Striploins were fabricated into 2.54-cm steaks and allocated to meats proximate (n = 1), 0 through 7 days of simulated shelf life (n = 8), trained sensory panel (n = 2), and instrumental tenderness analyses (n = 2). All data were analyzed using PROC GLIMMIX in SAS v. 9.4.

Results: Supplementation increased ADG over forage alone (P < 0.01) however, hot carcass weights were increased by supplementation in the PM steers only (P < 0.05). No treatment differences were observed for marbling score (P = 0.61), overall maturity (P = 0.49), 12th rib fat thickness (P = 0.21), ribeye area (P = 0.1668), and subjective fat color (P = 0.93). Objective carcass lean color values for L* and subjective lean color scores were different (P < 0.05). Treatment effects were also observed for carcass lean maturity scores (P < 0.05). No treatment differences were observed for meats proximate analysis (P > 0.05), instrumental tenderness as measured by Warner-Bratzler shear force (P = 0.94), initial and sustained tenderness (P = 0.66 and P = 0.29, respectively), beef and off-flavor intensities (P = 0.83 and P = 0.36, respectively), or juiciness (P = 0.54) as measured by a trained sensory panel. No treatment differences (P > 0.05) were observed for lipid oxidation or color change (Delta E) within any day of simulated shelf life. Calculated values for hue, chroma, and redness were unaffected (P > 0.05) by treatment within day of simulated shelf life.

Conclusion: Results indicate pearl millet is a viable forage option for forage-finished beef systems and soybean hull supplementation improves animal performance over forage alone with minimal impacts on carcass characteristics, meat quality, and shelf life.

Keywords: forage-finished beef, pearl millet, soybean hulls
25- EFFECTS OF LOW-STRESS WEANING ON CALF GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS

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Objectives: The objective of this study was to compare the influence of two low stress weaning methods with conventional weaning on post-weaning performance and carcass characteristics of beef steers.

Materials and Methods: Angus x Simmental crossbred steer calves (n=90) from a single source were stratified by body weight and dam age into three groups; one treatment was randomly assigned to each group: ABRUPT (calves isolated from dams on the day of weaning), FENCE (calves separated from dams via a barbed wire fence for 7 d prior to completely weaning), and NOSE (nose-flap inserted and calves remained with dams for 7 d prior to completely weaning). At d+7 post-weaning calves were transported to a commercial feedlot where they received standard step-up and finishing rations typical for a Northern Plains feedlot. To understand the influence of each weaning method on haptoglobin (an acute-phase protein), blood samples were collected via coccygeal venipuncture at d -7 (PreTreat), 0 (Weaning), and +7 (PostWean) from a subsample of calves (n=10 per treatment) and analyzed using a bovine haptoglobin ELISA kit. Body weights (BW) were recorded on study d -34 (PreWean), -7 (PreTreat), 0 (Weaning), 7 (PostWean), 32 (Receiving), 175 (Ultrasound), and 253 (Final) and average daily gains (ADG) were calculated between each time period. On d 175 post-weaning BW were recorded, and ultrasound fat thickness and intramuscular fat were determined and utilized to project marketing dates. Carcass measurements were recorded at the time of harvest and included hot carcass weight, 12th rib backfat, ribeye area, USDA Yield Grade and Quality Grade, and marbling score. Haptoglobin, BW, and ADG data were analyzed as repeated measures using the ante-dependence covariance structure in the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) for effects of weaning treatment, day, and their interaction; birth weight was included as a covariate for ADG and BW. Carcass traits were analyzed for the effect of weaning treatment using the MIXED procedure. Separation of least-squares means was performed using LSD with a Tukey’s adjustment and assuming an alpha level of 0.05.

Results: Weaning method interacted (P < 0.0001) with time period for ADG and BW. Calf BW increased in all treatments until the PostWean period, wherein BW decreased (P < 0.0001) in ABRUPT and NOSE and was maintained (P > 0.05) in FENCE. From the Receiving to Final time periods BW increased similarly (P > 0.05) for all treatments. Calf ADG was greater (P < 0.01) in calves in the NOSE treatment at Weaning than ABRUPT or FENCE. In the PostWean period, the FENCE calves had ADG that was not different (P > 0.05) than zero but was greater (P < 0.0001) than the negative ADG of ABRUPT and NOSE calves. During the Receiving period ADG was greater (P < 0.05) for ABRUPT compared to NOSE and FENCE. Time influenced (P < 0.001) haptoglobin concentration. No difference in haptoglobin was observed between the PreTreat and Weaning or PostWean periods; however, haptoglobin concentration was greater (P < 0.001) at PostWean compared to Weaning. Weaning method did not influence (P > 0.05) carcass measurements.

Conclusion: Collectively these data suggest low stress weaning methods do not significantly improve post-weaning growth performance or carcass merit compared to calves weaned using conventional methods.

Keywords: beef, carcass, growth performance, haptoglobin, low-stress weaning
BACTERIOPHAGE INTERVENTION EFFECTIVELY KILLS LISTERIA ON FOOD CONTACT SURFACE MATERIALS
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Objectives: Listeria is a pathogenic bacterium that is widespread in nature and can enter food processing plants through many vectors, like raw materials, process waste and personnel. Food processors work hard to keep Listeria out of the environment, but it can at times be found from food contact surfaces to floor drains. The sanitation can be compounded when equipment is pitted or cracked creating a harborage or niche in which Listeria can grow. Many control strategies for cleaning and biofilm removal have been put into place but may not suffice in eliminating Listeria from the food contact surface or environment. Bacteriophages are now being used to tackle these pathogens in food processing environments. Since they only target specific bacteria, they are harmless to humans, animals and plants, while effectively eliminating Listeria.

This study determines the efficacy of a commercially available bacteriophage product, PhageGuard Listex, against Listeria on commonly found materials in food processing plants (stainless steel and UHMW polyethylene). Efficacy was determined by applying two phage concentrations, as well as two exposure times.

Materials and Methods: Overnight cultures of L. monocytogenes ATCC13832 and L. innocua ATCC51742 were mixed in equal parts to create a Listeria cocktail (2x10^9 CFU/cm^2). Sterile coupons (100cm^2) of stainless steel or UHMW polyethylene were artificially inoculated with the cocktail at 2.5µL/cm^2 and left to dry at 37°C until completely dry. Subsequently, coupons were treated with 2x10^7 or 1x10^8 Plaque Forming Units (PFU)/cm^2 using a spray system and incubated at room temperature for 1 and 3 hours, before retrieval and enumeration of bacteria on selective agar plates. Sample size n:3. Results were analyzed using two-way ANOVA, with Dunnett’s multiple comparisons test on the normalized data.

Results: A dose dependent response to the phage treatment was observed, where an increasing phage concentration resulted in an increase in Listeria kill on both surfaces. On stainless steel, a treatment dose of 2x10^7 PFU/cm^2 resulted in a statistically significant bacterial reduction of 1.27 log after 1 hour (p value <0.0001), while application of 1x10^8 PFU/cm^2 showed a 2.16 log reduction (p value <0.0001). On UHMW polyethylene, a bacterial reduction of 0.47 log was observed 1 hour after applying 2x10^7 PFU/cm^2, while the application of 1x10^8 PFU/cm^2 led to a reduction of 1.95 log. However, these reductions were not statistically significant (p value>0.05). After 3 hours of treatment, the reductions were slightly higher in both materials (table 1). After this time, the difference between control and 5% treatment on UHMW polyethylene obtained a p-value <0.05.

Image: Table 1. Log reduction of Listeria cells after application of two bacteriophage concentrations, measured at 1 and 3 hours post phage treatment.

<table>
<thead>
<tr>
<th>Treatment (PFU/cm^2)</th>
<th>Stainless steel (bacterial reduction, log)</th>
<th>UHMW polyethylene (bacterial reduction, log)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 hour</td>
<td>3 hours</td>
</tr>
<tr>
<td>2x10^7</td>
<td>1.27 ± 0.13</td>
<td>1.42 ± 0.17</td>
</tr>
<tr>
<td>1x10^8</td>
<td>2.16 ± 0.16</td>
<td>3.38 ± 0.24</td>
</tr>
</tbody>
</table>

Conclusion: Phage technology is an easy and safe intervention which can be used as an additional tool to control Listeria in processing environments. The above results indicate that the commercially available phage solution, PhageGuard Listex, can reduce Listeria contamination on food contact surfaces by 0.4 to 3.4 logs after 3 hours of treatment.

Keywords: Food contact surface, Food Safety, Listeria control, stainless steel, UHMW polyethylene
Objectives: The purpose of this study was to evaluate the functionality of potato starch (PS), rice starch (RS), and plum concentrate (PC) as a replacement for phosphates in clean label curing brines, determined by the industry significant attributes of smokehouse yields, sensory analysis, and color scores.

Materials and Methods: Fresh inside ham pieces (Semimembranosus + Adductor) (n= 80), USDA-IMPS # 402F, were denuded and split into halves. Inside ham pieces were randomly assigned to one of four treatments including: a control containing traditional curing ingredients (CON), and three treatments with natural curing alternatives containing either plum concentrate (PC), potato starch (PS), or rice starch (RS) as phosphate replacement. Clean label treatment hams (CLT) were evaluated in conjunction with a traditional processed ham control (CON). The control brine was made with the addition of phosphate; whereas, the three clean label treatment brines received phosphate replacement inclusion via the vacuum tumbler. The ham pieces from all treatments were injected to approximately 125% of their fresh weight using a multi-needle injector. Hams were vacuum tumbled with a target post tumble weight of 130%. Inclusion rates for treatments included 2.25% (PS, RS) and 1.1% (PC) of the projected final meat block weight. Hams were then tumbled for 2 hours at -15 mm Hg and 12 RPM (industry standard). Hams were cooked to an internal temperature of 62.7°C without the addition of smoke and chilled in accordance with USDA-FSIS Appendix B. They were then vacuum packaged and held under refrigeration (4°C) for 21d. Hams were evaluated for smokehouse yields, sensory analysis, and color scores. Ham samples were evaluated for: initial and sustained juiciness, initial and sustained tenderness, off flavors, ham flavor intensity, and mouth feel. Ham slices were held vacuum packaged, under refrigeration for an additional 7d, and then evaluated for L*, a*, b* color space values at 28d post cooking to simulate a retail setting. Differences in treatment results were analyzed using the MIXED models procedure of SAS.

Results: Hams treated with PS had the highest cooking and overall yield (P < 0.05), PC hams had the lowest cooking and overall yield (P < 0.05), and RS hams were comparable to CON. The CLT were darker and less red than CON (P < 0.05). Similarly, CON had the highest a* value (P < 0.05) indicating a significant redder color compared to PS, RS, and PC; additionally, CON had a higher b* (P < 0.05) compared to clean label treatments. The CON had decreased tenderness compared to CLT (P < 0.05). For all other sensory attributes CLT was comparable to CON. Trained sensory analysis determined all phosphate replacements maintained or improved sensory attributes over the control. Cooking yields were improved by PS, held similar by RS, and decreased significantly by PC when compared to the control. Both PS and RS should be considered acceptable phosphate replacements in natural curing brines.

Conclusion: Based on research presented, PS and RS are suitable replacement for phosphates in natural curing brines based upon similar or improved yields, and similar or improved sensory attributes. Due to its extreme cooking loss PC is not a recommended phosphate replacement.

Keywords: Clean Label, Phosphate, Processing Yields
28- **EDIBLE COATING AND TEMPERATURE AFFECT MEAT QUALITY OF VACUUM PACKAGED LAMB MEAT**

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**Objectives:** Packaging affects meat quality and durability because it can modify the environment around the product, creating conditions that delay deterioration reactions. During refrigerated storage of fresh meat, physical, chemical, microbiological and sensory changes may occur. Thus, in order to meet consumer needs, such as quality, convenience, and longer shelf life, it is necessary to extend the meat shelf life. An alternative is the use of edible coatings, which can be applied as primary packaging. This study aimed to evaluate the effect of chitosan and zein coatings on the meat quality of vacuum-packaged lamb meat stored for 57 days in two different temperatures.

**Materials and Methods:** *Longissimus* muscle (right and left sides) from male lambs with the same diet and genetic group obtained from five animals were cut onto 2.5cm thickness steaks, randomized equally and distributed into three treatments: control (no coating), coated with chitosan (1% w/v)/ 0.5% glycerol (w/v) solubilized in 1% lactic acid (v/v) and coated with zein (4% w/w)/ 0.5% pink pepper oil (w/w) solubilized in 70% ethanol. Samples were then vacuum packaged (permeability rate: 2000 cm³/m²24 h), stored for 57 days at two different temperatures (1°C and 5°C) and evaluated every 14 days by the following analyses: pH, instrumental color, water holding capacity (WHC), shear force, and TBARS - lipid oxidation. Lamb meat coated with zein or chitosan were submitted to a difference from the control test (the sample without any coating). Data were analyzed by ANOVA, and when a significant difference was found, SNK and Dunnet tests were applied for the quality analyses and sensory difference respectively. For color analysis, \( \Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \) was also calculated.

**Results:** Coating, temperature and time showed significant differences (p<0.05) for some of the studied variables except for WHC. A triple interaction was also found for all variables. At 1°C, \( \Delta E \) from chitosan samples showed low values (\( \Delta E =1.95 \)), meaning that color differences would not be noticed by time up to 29 days, although at 57 days values were 12.68. At the same temperature, zein containing samples when compared between 1 and 57 days, \( \Delta E \) values varied from 5.51 to 11.42 where color changes were noticeable. At the end of 57 days, chitosan coated samples showed lower values of L* (lighter) and a* (less red) compared to zein coated and control samples. Generally, shear force values showed lower values by times, although chitosan showed higher values at 5°C. pH values varied from 5.09 to 5.48, temperature and coating did not affect this parameter, only time. For TBARS values, the highest value (0.238 mg MDA kg⁻¹) was found in the chitosan sample at 57 days at 5°C. Samples containing zein, for both temperatures, showed lower TBARS values if compared with chitosan. In this study, chitosan had a negative effect to lipid oxidation and shear force with higher values if compared to the others. In the difference from control test, lamb meat coated with zein was considered different with an average value=4, which means moderate/great difference, (p<0.05) from chitosan and control samples.

**Conclusion:** Zein was more effective for showing lower values of TBARS and for not affecting shear force if compared to chitosan and control samples and can be used as an alternative for edible coating.

**Keywords:** Chitosan, Color, Oxidation, Shelf life, Zein
Objectives: The processed potato ingredient tested in this study was a commercially available ingredient (O’Brien’s Best; Botaniline Foods, LLC) that consists of skinned, sliced potatoes that were cooked to an exact time/temperature to enhance physiochemical properties. The objective of the study was to assess the technological properties of beef emulsion modeling systems prepared with the novel processed potato ingredient (O’Brien’s Best).

Materials and Methods: The meat used in this study was lean ground beef from one master batch of beef that was targeted to 90% lean and 10% fat. The meat batter formulations contained 20% water, 6.15% spice/seasoning, 0.18% Prague powder, and 0.0035% sodium erythorbate, and varying quantities of sodium tri-polyphosphate, salt (NaCl), and binders (processed potato, tapioca starch, or all-purpose binder). In total, eight treatments were formulated and manufactured on three separate, independent occasions (N = 24 experimental units; n = 3 replications). Three treatments were formulated with the novel processed potato ingredient (formulated without phosphate, 0.635% NaCl, and either 5, 10, or 15% the processed potato ingredient). Three treatments were formulated with commercially sourced tapioca starch (formulated without phosphate, 0.635% NaCl, and either 5, 10, or 15% commercial tapioca starch, which was tested to be 78% starch purity). Two treatments were formulated with a commercial formulation [formulated with 0.30% sodium tri-polyphosphate, 10% all-purpose binder (a multi-ingredient proprietary blend binder from Herman Laue Spice Company Inc.; Uxbridge, Ontario), and 1.905% NaCl, or 1.270% NaCl]. Parameters tested were cooking loss, proximate composition of cooked meat batters, texture profile analysis of cooked meat batters, and instrumental color of uncooked and cooked meat batters. Data were analyzed with the GLIMMIX procedure of SAS v9.4 with a fixed effect of treatment and a random effect of replication. Least square means were separated using the PDIFF option with a Tukey-Kramer adjustment. Differences were considered statistically different at $P < 0.05$.

Results: Cooking loss was not different ($P = 0.44$) among treatments and ranged from 0.64% to 0.77%, indicating acceptable stability for all emulsion formulations in the study. Proximate composition revealed significant differences ($P < 0.05$) in moisture, protein, ash, and other components (carbohydrates), while lipid content was unaffected. Texture profile analysis revealed that textural properties were generally unaffected ($P > 0.05$) by treatment, with the exception of less gumminess ($P < 0.05$) and less chewiness ($P < 0.05$) in processed potato formulated emulsions compared with the tapioca starch and commercially formulated emulsions. Instrumental color of uncooked emulsions was affected to a greater degree than instrumental color of cooked emulsions. Yet, when tapioca starch was included at high levels (> 10%) in cooked emulsions lightness ($L^*$) and yellowness ($b^*$) were greater ($P < 0.05$) compared with emulsions formulated with the processed potato ingredient and with the commercial formulations.

Conclusion: In summary, the technological properties (cooking loss, texture profile analysis, and instrumental color) of beef emulsion systems were largely unaffected by the processed potato ingredient (despite removal of phosphates and less NaCl) and performed similar to the commercial formulations.

Keywords: beef emulsions, ingredient formulation, potato
PROCESSING CHARACTERISTICS AND SENSORY ATTRIBUTES OF BACON MANUFACTURED FROM SEVEN VALUE-ADDED CUTS OF BEEF

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Objectives: There is great opportunity for the beef industry to add value to cuts that are currently marketed as low value cuts (i.e. cuts from the chuck, round, and flank/plate). The objective was to evaluate the processing characteristics and sensory attributes of bacon manufactured from seven different cuts of beef.

Materials and Methods: The seven cuts evaluated included the brisket (IMPS#120), the clod heart (IMPS#114E; divided horizontally into two halves; referenced as the wide half or silverskin side and the narrow half or non-silverskin side), the flank (IMPS#193), the outside flat (IMPS#171B), and the short plate (IMPS#121A; broken down into the deboned short rib half and the navel half). The cuts were injected using a standard commercial bacon cure (water, salt, corn syrup solids, sodium phosphate, sodium erythorbate, sodium nitrate, sodium bicarbonate, and glycerin; Herman Laue Spice Company Inc.; Uxbridge, Ontario, Canada) to a targeted rested pump uptake of approximately 20% (+/- 3%). The injected cuts were cooked to an internal temperature of 62˚C in a smokehouse (ScottPec, Guelph, Ontario). Following cooking, cuts were cooled to 4˚C and then sliced into 4.0 mm slices using a deli slicer. Slices were vacuum packaged, boxed, and stored at 4˚C for zero, thirty, sixty, or ninety days. Following the allotted storage period, slices were stored at -20˚C until evaluation of sensory attributes and cooking loss. Slices were cooked at 204˚C for 15 minutes in a convection oven. Processing characteristics were conducted in six or seven replications for each cut. Sensory evaluation was conducted on three randomly selected samples for each cut at each of the four storage times (the same samples within each cut was used at each storage time). Processing data were analyzed using PROC GLIMIX of SAS (v9.4) with fixed effect of cut and random effect of replication. A trained descriptive sensory panel of 6-8 panelists evaluated the differences in oxidative flavor and aroma (using a 4-pt nominal scale), and differences in beef flavor intensity, muscle fiber toughness, and connective tissue amount (using magnitude estimation). Sensory data were analyzed as repeated measures using PROC GLIMMIX of SAS (v9.4) with fixed effect of cut, storage day, and their interaction, and random effects of session, panelist, and replication.

Results: As expected, dimensions and processing weights differed (P < 0.01) among cuts. Rested pump uptake was not different (P = 0.29) among cuts. Smokehouse yield was greater (P < 0.05) for the brisket, outside flat, and short plate (both halves) compared with the clod heart (both halves) and flank. Bacon slice cooking loss and sensory characteristics are presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Bacon slice cooking loss and sensory analysis of bacon manufactured with different beef cuts. Main effects of cut after 0 d, 30 d, 60 d, and 90 d of storage.</th>
</tr>
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<tbody>
<tr>
<td>Brisket</td>
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<tr>
<td>Cooking loss, %</td>
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<tr>
<td>Beef flavor intensity</td>
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<tr>
<td>Muscle fiber toughness</td>
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<tr>
<td>Connective tissue amount</td>
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<tr>
<td>Oxidative flavor</td>
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<td>Oxidative aroma</td>
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Means lacking a common superscript letter within a row are different (P < 0.05).

Conclusion: Overall, this research indicated that a variety of beef cuts can be used to manufacture beef bacon. The differences in sensory properties that were quantified in this study, allow manufacturers to tailor their cut selection to the sensory properties most valued by their consumers. All cuts exhibited oxidative stability when stored up to 90 days.

Keywords: beef bacon, beef processing, processing yields, sensory evaluation, value-added meats
EFFECTS OF ENHANCEMENT TECHNIQUES OF BEEF FLANKS ON THE PALATABILITY OF FAJITA MEAT
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Objectives: Value added products are typically enhanced either through needle injection or vacuum tumbling, and both techniques carry certain benefits, whether that be more even distribution of the brine or improved palatability. However, it is unknown if tumbling itself can improve palatability without the addition of a marinade. Moreover, there is merit in determining if eating quality can be further improved by using both needle injection and vacuum tumbling. Therefore, the purpose of this study was to determine how different enhancement techniques influence palatability traits such as tenderness, texture, flavor, juiciness and overall liking of the rectus abdominis muscle when cooked and prepared for fajita meat.

Materials and Methods: USDA Select beef flank steaks (rectus abdominis) were procured from a commercial beef abattoir and processed at 10 d postmortem. Steaks (n=100; 20/treatment) were assigned randomly to 1 of 5 different treatments: untreated control (CNT), vacuum tumbled control without marinade (TCNT), vacuum tumbled with marinade (TUMB), injected with marinade (INJ), and injected with marinade plus vacuum tumbled (IPT). In addition, non-enhanced USDA Choice flanks were used as a warm-up sample and to provide linkage across panel nights. Flanks were cooked to 72°C, sliced into 1.3-cm strips approximately 5-cm long, and kept warm until serving. Consumers (n=200; 50/day) evaluated samples for tenderness, juiciness, flavor liking, texture, saltiness, and overall liking. Consumers were also asked if each trait was acceptable, as well as their willingness to pay (WTP) for each sample at retail.

Results: Treatment influenced (P < 0.01) the rating and acceptability of all palatability traits, overall liking, and WTP. Consumers similarly scored IPT and INJ more tender, juicier, and liked those samples more overall compared to all other treatments (P < 0.05). As a result, consumers were willing to pay more for IPT and INJ compared to all other treatments (P < 0.05). Although tenderness, juiciness, and flavor liking were intermediate for TUMB, consumers found the saltiness and overall liking of TUMB similar (P > 0.05) to IPT and INJ; however, consumers were not willing to pay as much for TUMB as IPT. Consumers scored CNT and TCNT similarly lower for tenderness, juiciness, flavor liking, saltiness (not salty enough), and overall liking compared to all other treatments, which resulted in lower WTP for these two treatments (P < 0.05). Acceptability generally followed the same trends as the ratings for each palatability trait.

Conclusion: Inclusion of a marinade or brine solution was critical for the eating quality of fajita samples, as evidenced by the outperformance of CNT, which was not enhanced, and TCNT, which was tumbled but without a brine solution, by all other treatments. The delivery method of the brine solution was not as important to eating quality as the presence of a marinade, as IPT, INJ, and TUMB were all similar for overall liking. Injection plus tumbling improved tenderness, juiciness, and flavor liking scores over tumbling alone, but did not significantly improve those traits in comparison to injection alone. Therefore, enhancement influenced palatability and the acceptability of those traits. However, minimal differences were observed between tumbling and need injection as long as a brine solution was included.

Keywords: Enhancement, Fajita, Injection, Marinating, Palatability
Objectives: Processed meats have high fat contents that have been linked to adverse effects on human health. The purpose of this study was to generate low-fat meat products using the combination of hot-boning (HB), crust-freeze-air-chilling (CFAC) (HB-CFAC), and cold-batter mincing technologies.

Materials and Methods: Twelve commercial pigs (4 pigs/replication) were obtained locally and processed in a traditional way. Skinless, boneless, fresh pork ham (IMPS#402G) was harvested and subjected to either hot-boning (HB) at one-hour post-mortem or chill-boning (CB) at 24 hours post-mortem. All pork ham muscles were cut into one-inch wide strips and subjected to crust-freeze-air-chilling (CFAC). The resulting strips were 3-min pre-chopped and 6-min post-chopped for full-fat batters (FF), using 65% ham muscle of CFAC, 15% pork back-fat, 16% ice, 2% salt, and 2% starch. For low-fat batters (LF), the strips were similarly chopped with the same ingredients except 0% pork back-fat and 31% ice. Data in three replications were evaluated by one-way ANOVA, using PASW 18 statistic program and a completely randomized design. A post-hoc analysis was performed using Duncan’s multiple range test to evaluate differences of fat content and protein functionality among treatments at $P < 0.05$.

Results: After chilling, the pH 6.27 of HB-loin muscles at an hour post-mortem was significantly higher than that pH 5.63 of CB-loin muscles at 24 h post-mortem ($P < 0.05$). Similarly, the pH 6.0 of cooked HB-gels was higher than the pH 5.7 of cooked CB-gels, regardless of fat content ($P < 0.05$). The 65% moisture and 11 – 12% fat in full-fat gels (HB-FF and CB-FF) were lower and higher, respectively, than 76 – 78% moisture and 1.6 – 3.0% fat in low-fat gels (HB-LF and CB-LF), regardless of boning type. Cooking yield (%) was improved in HB-gels more than CB-gels. In responding to the cooking yield, the lowest and the highest expressible moistures were found in HB-FF gels and CB-LF gels, respectively. Both HB-FF and HB-LF gels showed higher values for hardness, cohesiveness, and gumminess than CB-FF gels, with the least value found in CB-LF gels. These results indicated that the cold-batter mincing of HB-muscles provided higher protein functionality and gel-forming ability than that of CB-muscles so that fat was reduced without textural quality loss ($P < 0.05$). The next step of this research is to generate fatty/creamy-like texture by chopping low-fat ham muscles at sub-zero temperatures for extended times, resulting in small and uniform protein particle sizes.

Key words: hot-boning; crust-freeze-air-chilling; cold mincing; low fat; protein functionality
THE EFFECT OF SPECIALTY SALTS ON COOKING LOSS, TEXTURE PROPERTIES, AND INSTRUMENTAL COLOR OF BEEF EMULSION MODELING SYSTEMS

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Objectives: Salt plays an integral role in meat processing, and reduction or exclusion will have negative impacts on water holding capacity and binding function of protein and fat. Specific to meat emulsions, NaCl is used in the formulation due to its effect on the solubilization (extraction) of myofibrillar meat proteins, which allow the formation and stabilization of the interfacial matrix during manufacture and preparation. While previous research has addressed preservation (shelf-life and oxidation attributes) and flavor (sensory attributes) when using specialty salts in meat products, the application of specialty salts in meat emulsions has never been addressed in a scientific manner. Therefore, the purpose here was to evaluate the incorporation of different levels and types of specialty salts on the physicochemical and textural characteristics of beef emulsions.

Materials and Methods: Three specialty NaCl salts (premium sea salt, pink sea salt, and grey sea salt) were added to beef emulsion modeling systems at three different inclusion levels (0.70%, 1.00%, and 1.30%) and then compared with commercially sourced white salt. Salt (NaCl) purity levels for commercially sourced white salt, premium sea salt, pink sea salt, and grey sea salt were 99.8%, 99.8%, 95.2%, and 94.9%, respectively. Cooking loss, emulsion stability, proximate composition, pH, texture profile analysis, and instrumental color of the emulsions were evaluated with three independent replications from one batch of ground beef. One batch of ground beef was used to properly control for confounding factors such as beef source and day of manufacture. Treatment was applied to one of twelve 500-g base emulsions (without artificial food dyes, preservatives, spices, and seasonings) containing beef (according to the level of salt added), water (28.14%), oil (8.00%), starch (2.00%), and phosphate (0.35%) for each replication (36 total experimental units). Data were analyzed with PROC GLIMMIX of SAS with fixed effects of salt type, salt inclusion level, and their interaction, and the random effect of replication. Least square means were separated using the PDIF option with a Tukey-Kramer adjustment, and was further separated using an orthogonal set of estimate statements to analyze linear and quadratic effects for salt inclusion level. Differences were considered different at \( P \leq 0.05 \).

Results: Emulsion stability and cooking loss were primarily affected \((P < 0.01)\) by salt inclusion level rather than salt type \((P > 0.13)\). Stability increased and cooking loss decreased as salt inclusion level increased (linear \(P < 0.01\)). Proximate composition of cooked meat emulsions trended differently as salt increased from 0.70% to 1.30% salt inclusion level for the different salt types. Moisture increased and lipid decreased for commercial white salt, while moisture decreased, and lipid increased for all three of the specialty salts. Hardness, springiness, gumminess, and chewiness of emulsions increased as the level of salt increased for all the treatments and were greatest \((P < 0.0001)\) in all treatments at the 1.30% salt inclusion level, however, no differences were observed between the salt types.

Conclusion: Overall, salt inclusion level, rather than salt type, had significant effects on the solubilization of protein and dispersion interactions of the emulsions, which affected physicochemical and functional properties.

Keywords: beef emulsion modeling, emulsion stability, meat processing, specialty salt
THE EFFECT OF BREADFRUIT (ARTOCARPUS ALTILIS) FLOUR ON COLOR OF COMMUNICATED BEEF COMPARED WITH OTHER FLOUR SOURCES

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Objectives: Novel, non-allergenic ingredients with properties that improve the quality of processed meat products are needed for the meat industry. The objectives of this study were to investigate the effect of breadfruit (Artocarpus altilis) flour on color of comminuted beef compared with other flour sources.

Materials and Methods: Flour sources included breadfruit, corn, soy, tapioca, and wheat. All flours were obtained commercially and were unmodified. Lean beef (from the same commercially sourced batch targeted to 90% lean and 10% fat), 10% ice, 1.5% salt, and flour sources at two inclusion levels (2.5% and 5%) were mixed using a bowl chopper to prepare beef patties for evaluation. The ground beef was manufactured into 115 g patties that were placed on a retail display shelf under continuous LED lighting at 4°C for 7 days. Lighting was measured periodically during the study and LUX was ensured to be between 1612.5 lux and 2152.0 lux. Objective CIE L* (lightness), a* (redness), and b* (yellowness), chroma, and hue scores were collected with a Minolta CR-400 Chroma meter (Konica Minolta Sensing, Inc., Osaka, Japan) utilizing a D65 light source and a 0° observer with an aperture size of 8 mm on each day of the simulated retail display. This study was conducted in three independent replicates for each treatment. Statistical analyses for parameters (L*, a*, b*, chroma, and hue) were conducted using the MIXED procedure of SAS with fixed effects of flour source*inclusion level, day, and their interaction. Least square means were separated using the PDIFF option with a Tukey-Kramer adjustment. Differences were considered statistically different at \( P < 0.05 \).

Results: The interaction of storage day and treatment significantly \( (P \leq 0.001) \) affected a*, b*, chroma, and hue. There was not an interaction of storage day and treatment for L*. Both the main effect of storage day and the main effect of treatment significantly \( (P < 0.01) \) affected all the attributes measured in this study. Mean L* over the display period of beef patties prepared with 2.5% breadfruit flour were not different \( (P = 0.95) \) compared with control samples. There was no significant difference between the mean hue over the 7-day display period of the beef patties prepared with 2.5% breadfruit flour compared with control samples. a* decreased at different rates for each treatment throughout the display period. Beef patties prepared with 2.5% and 5% breadfruit flour were redder (greater a*; \( P < 0.05 \)) compared with other treatments and control samples over the 7-day display period. To the contrary, a* values of beef patties prepared with soy flour were less than \( (P < 0.05) \) other treatments and the control samples on day 0 and day 1 and remained constant at lower values as the display period increased.

Conclusion: Breadfruit flour improved the redness of comminuted beef products immediately and prevented discoloration for a longer period. The results indicate that breadfruit flour can effectively improve initial color and stability of color in processed beef products. More research is warranted to further investigate the mechanism of action of breadfruit flour in governing the color properties of comminuted beef products.

Keywords: beef color, breadfruit flour, comminuted beef, ingredient
Objectives: Meat color is extremely influential in purchasing decisions as consumers associate a bright-red color with freshness. The type of finishing diet can influence beef color. Previous studies have shown that grass-finished cattle have darker muscle color than grain-finished cattle. With the use of modified atmospheric packaging (MAP), beef purveyors are able to vary the gas compositions within a package and enhance beef color. However, limited studies have determined the effects of modified atmospheric packaging on grass-finished beef color. The objective of this study was to determine how finishing diet and packaging type affects the color of the longissimus dorsi (LD) muscle.

Materials and Methods: During the stocker period, all of the cattle were on a forage diet. Cattle were then randomly assigned to either a conventional grain-based diet or an alfalfa pasture diet for finishing. Both conventionally and pasture-finished cattle were fed for 91 d. Cattle were slaughtered on the same day at a commercial beef processing facility under normal conditions and chilled for approximately 30 hours. After grading, one strip loin from each carcass was collected and transported to Oklahoma State University. At 11 d postmortem, one steak (n = 60) from each strip loin was vacuum packaged and randomly assigned to display. Those steaks were then randomly assigned to PVC, HiOx-MAP (80% oxygen and 20% carbon dioxide), or CO-MAP (0.4% carbon monoxide, 69.5% nitrogen, and 30% carbon dioxide) packaging and were displayed under retail conditions for 5 d. Muscle darkening (MD), muscle color (MC), and surface discoloration (SD) were all analyzed by a trained panel (n = 6). MD was evaluated only on d 0 and MC and SD were scored once every 24 hours for 0, 1, 2, 3, and 4 d. Lipid oxidation was measured by thiobarbituric acid reactive substances (TBARS) assay on d 4. Data were analyzed using the Mixed Procedure of SAS.

Results: There was a significant display day by finishing diet by packaging interaction (P < 0.05) for muscle color and surface discoloration. There was also a significant finishing diet by packaging interaction (P < 0.05) for muscle darkening. Steaks packaged in HiOx-MAP remained the most stable in color and the brightest cherry-red colored throughout display time (P < 0.05) compared with other packaging types. PVC was the most discolored (P < 0.05) on d 3 and 4 when compared to HiOx-MAP and CO-MAP with the grain-finished PVC packaged steaks showing the most discoloration on d 4. Pasture-finished steaks packaged in CO-MAP displayed the darkest colored muscle (P < 0.05) on d 0. Steaks packaged in PVC had a higher amount of lipid oxidation (P < 0.05) compared with other packaging types.

Conclusion: These results indicate that HiOx-MAP more effectively maintains the desired beef color of bright cherry-red for pasture-finished beef. The results also indicate that the use of appropriate packaging type can minimize the losses due to discoloration of steaks from either grain or grass-finished beef.

Keywords: Beef Color, Grain-Finished, Grass-Finished, Packaging
**Objectives:** The objective of this study was to determine if an increased brine temperature could impact smokehouse yield, sensory characteristics, and color scores of bacon.

**Materials and Methods:** Fresh pork bellies (n = 30) were randomly assigned to one of three brine temperatures: -1°C (COLD), 10°C (MED), and 21°C (WARM). Bellies were injected using a multi-needle injector at 13% of the green weight containing a 1.5% salt inclusion level. All bellies were heat treated in a smokehouse to 50°C. Bellies were chilled for 24 h to an internal temperature of 4°C. After chilling, weights were measured to calculate smokehouse yield. Bellies were tempered to -4°C, sliced 4 mm in thickness, and vacuum packaged into 0.22 kg packages. Samples from each treatment were placed under UV lighting to mimic a retail setting. Trained sensory and color panels were conducted on d 1, 7, 14, 21, 28, and 35. Panelists evaluated sliced bacon packages for cured color intensity, cured color characterization, cured color fading, and off odor. Samples were cooked in a convection oven for 15 minutes at 177°C and were evaluated for saltiness, oxidized flavor, and flavor intensity. Data were analyzed using the MIXED models procedure of SAS. Least-squares means were computed for each dependent variable, and statistically separated by a pair-wise t-test with predetermined α = 0.05.

**Results:** Green weight pump percentage, smokehouse weight percentage, and chilled weight percentage for all treatments were similar (P > 0.05). Trained sensory panel results revealed no significant differences (P > 0.05) for salt flavor between treatments on d 1, 28, and 35. The MED brine was more acceptable than the COLD and WARM brines for salt flavor on d 7 and 14 (P < 0.05). Oxidized flavor on d 1, 7, 14, 21, and 28 were similar for all treatments (P > 0.05), but by d 35 the COLD treatment had significantly less oxidized flavor than the MED and WARM treatments. No significant differences (P > 0.05) were found for flavor intensity between treatments for each day. No differences (P > 0.05) were found between treatments on d 1, 7, or 14 for cured color intensity and characterization. However, on d 21 and 35 the MED brine temperature had the most intense cured color (P < 0.05). On d 35, cured color characterization for the MED brine revealed a darker cured color (P < 0.05) compared to the COLD treatment but was similar to the WARM treatment. Cured color fading showed no differences (P > 0.05) between treatments on d 1, 7, 14, 21, and 28. On d 35 the COLD brine exhibited significantly (P < 0.05) higher levels of cured color fading compared to both the MED and WARM brines. No significant differences were found between treatments for all days for off odor (P > 0.05); however, d 35 was significantly higher than all other days within treatments (P < 0.05).

**Conclusion:** Processing yields were not significantly affected by brine temperature. Salt flavor and flavor intensity were not affected by brine temperature. In conclusion, cured meat color and oxidized flavor can be affected by brine temperature.

**Keywords:** Bacon, Brine Temperature, Processing Yields
37- SPOILAGE MICROBIOTA OF BEEF THROUGHOUT VARIOUS PHASES OF PROCESSING
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Objectives: This study aimed to evaluate the spoilage microbiota of beef throughout various processing steps and identify key differences in the microbiome associated with each phase of processing.

Materials and Methods: In each of three replicates, products representing each phase of processing were made from the same uniform meat block (beef shoulder clods): T1-ground beef; T2-fresh sausage; T3-cooked links; T4-beef franks; T5-sliced bologna; T6- bologna with HPP treatment; T7-bologna with lactate/diacetate. Raw treatments were evaluated every 3 days for 21 days, and cooked treatments were evaluated every 14 days for 112 days. Heat treated products were cooked to an internal temperature of 71 °C and chilled overnight at 4 °C. Parameters for HPP were 600 MPa for 3 min. Aerobic (APC), anaerobic (AnPC), lactic acid bacteria (LAB), and psychrotrophic (PPC) plate counts were measured. Microbial communities were evaluated using high throughput 16S rRNA gene sequencing on the Illumina MiSeq platform. Reads were processed using QIIME, binned into operational taxonomic units (OTUs) at 97% similarity, and assigned taxonomy using the Greengenes database as reference. Alpha and beta diversity of bacterial communities were analyzed using QIIME and R. Alpha diversity was estimated using observed OTUs and Chao1 estimates, and beta diversity was determined using the weighted and unweighted UniFrac distance matrices. Raw and cooked samples were analyzed independently for plate counts and alpha diversity.

Results: There was a treatment by storage time interaction for AnPC in cooked samples (P = 0.003), where T3, T4, and T7 increased from day 28 and 42. In raw samples, there was a main effect of storage time on APC, AnPC, LAB, and PPC (P < 0.001), where growth increased over time. In cooked samples, there was a main effect of storage time on APC, LAB, and PPC, and a main effect of treatment for APC and LAB (P < 0.030). Higher APC and LAB counts were observed in T5, while a general increase in APC, LAB, and PPC was seen throughout storage time. There were main effects of treatment and storage time on Chao1 and Observed OTUs in raw samples (P < 0.023) and a main effect of treatment in cooked samples (P < 0.009). In raw samples, bacterial richness was greater in T2 compared to T1, and generally decreased throughout storage time. In cooked samples, richness was the greatest in T3 and T4, the least in the T5, and T6 and T7 were intermediate. There were main effects for treatment and storage time on the bacterial community structure according to the weighted UniFrac distance matrix (P < 0.004) and a treatment by storage time interaction for the unweighted UniFrac distance matrix (P = 0.031). For the weighted UniFrac, T1 and T5 samples formed a cluster relatively separate from the other treatments, while T2 formed an additional cluster by itself. For the unweighted UniFrac, T1, T2, and T5 formed a cluster separate from the other samples, with increased storage times being further separated from the other samples.

Image:

PCoA Plot of Weighted (a) and Unweighted (b) UniFrac Distance Matrices
Conclusion: Results from this study indicate that the microbiota of cooked, sliced, bologna is somewhat similar to that of raw ground beef, whereas fresh sausage, cooked links, and bologna with HPP and antimicrobial treatments are different from the former. Treatments where microbial growth was reduced had a significantly different microbial composition compared to those with greater amounts of growth.

Keywords: beef, microbiota, spoilage
Objectives: Enhancement of beef with non-meat ingredients is a common practice to improve both palatability and chemical characteristics. However, the delivery method of brine solutions has not been well studied and could play a role in the activity of certain ingredients, ultimately influencing meat characteristics. This study was designed to determine if different enhancement methods impacted the overall physical and chemical properties, including pH, percent pick-up, slice shear force (SSF), and cooked moisture content, of enhanced (water, salt and sodium tripolyphosphate) rectus abdominus.

Materials and Methods: USDA Select beef flank steaks (rectus abdominus) were procured from a beef abattoir and processed at 10 d postmortem. Steaks (n=100; 20/treatment) were denuded and assigned randomly to one of the five treatments: untreated control (CNT), vacuum tumbled without marinade (TCNT), vacuum tumbled with marinade (TUMB), needle injected with marinade (INJ), and injected with marinade plus vacuum tumbled (IPT). Initial weight and pH were collected pre-enhancement for TUMB, INJ, and IPT. Samples were weighed again immediately after enhancement and 20 min after enhancement. Three weights were collected for IPT: pre-enhancement, post-injection and post-tumble. After flank enhancement, they were sliced in half parallel to the muscle fiber. One half was designated for laboratory analysis. The halves were then frozen and thawed 24 h prior to cooking. A 50-g raw sample was obtained from each flank prior to cooking for SSF to analyze raw moisture content. Each flank was cooked to an internal temperature of 72ºC and allowed to rest for 3 min prior to slicing for SSF.

Results: Treatment influenced final pH (P<0.01), with final pH increasing in INJ, TUMB, and IPT. Differences were noted in final pH between treatments; INJ had the highest pH (6.15), followed by IPT (6.06), TUMB (5.83), CNT (5.76), and TCNT (5.71), with a difference observed between each treatment (P<0.05). Treatment also impacted (P<0.01) SSF. The addition of marinade through injection and tumbling reduced (P<0.05) SSF values, as CNT and TCNT had greater SSF values compared to all other treatments. Injection further reduced SSF values, as INJ and IPT had lower SSF values compared to TUMB (P<0.05). Cooked moisture was also influenced (P<0.01) by treatment. IPT and TUMB had greater moisture percentage compared to all other treatments; INJ was intermediate, and CNT and TCNT similarly had lower moisture percentage than the remaining treatments (P<0.05). Of the three treatments that involved marination, initial and final percent pick-up and drip loss were all influenced by treatment (P<0.01). Initially, INJ (14.5%) had the greatest percent pick-up, IPT was intermediate (12.9%), and TUMB had the lowest percentage (11.8%). However, drip loss was greatest for INJ (2.3%), intermediate for TUMB (0.2%), and lowest for IPT (0.0%). Final percent pick-up was now greatest for IPT (12.9%), intermediate for INJ (11.9%), and lowest for TUMB (11.5%).

Conclusion: Enhancement methods can influence physical and chemical traits in terms of moisture, SSF and pH. Injection influenced shear force more than tumbling, whereas tumbling had greater effects on moisture than injection. Combining injection with tumbling had the most positive effect on shear force as well as moisture retention.

Keywords: Enhancement, Fajita, Injection, Marination, Vacuum Tumble
Objectives: Beef from cull cows has been traditionally perceived as low-quality/value meat due to its inferior flavor and tenderness. Given the negative consumer perception of highly processed fresh meat, there is a need to develop a natural post-harvest aging system to improve eating quality attributes of beef products, particularly from cull cows. Dry aging has been practiced for decades as a traditional and natural butchery process, which is also known to improve palatability characteristics. Thus, the main objective of this study was to evaluate the impact of different dry-aging methods on meat quality, microbiological properties and palatability attributes of loins from cull cow beef.

Materials and Methods: Paired beef loins from 13 carcasses (Holstein, 30+mo) were obtained at 5d postmortem, divided into 4 equal length sections and randomly assigned to four aging methods: wet-aging (WA), dry-aging (DA), dry-aging in water permeable bag (DWA) and UV-light dry-aging (UDA; 2 treatment/day, 5 J/s/treatment). Sections were aged for 28d at 2°C, 65% RH and 0.8 m/s air flow. After aging, dry-aged sections (DA, DWA and UDA) were trimmed of dehydrated surface, and trim loss and total saleable yield were recorded. The pH, proximate composition, shear force, water-holding capacity, initial color (instrumental and trained panelist), lipid oxidation (2-thiobarbituric acid reactive substances, TBARS), microbial properties (aerobic plate count (APC), lactic acid bacteria (LAB), and yeast and mold (YM) counts) and trained sensory evaluation (11 panelists) were determined. Experimental design was a balanced complete block design. All data were analyzed using PROC MIXED procedure of SAS, and least squares means for all traits were separated (P<0.05).

Results: DA and UDA had a substantial moisture loss during the aging process, accompanied with higher trim loss compared to other methods (P<0.05). This resulted in DA having the lowest yield followed by UDA, DWA and WA with the highest saleable yield (P<0.05). No significant differences were observed on cook loss, WBSF and TBARS between the treatments. DWA had the lowest pH out of all treatments (P<0.05). UDA had the lowest moisture content and highest drip loss (P<0.05). Color measurement showed that both DA and WA had significantly higher L* and lower b* values compared to UDA and DWA (P<0.05). However, a* and lean surface color were not significantly different between the treatments (P>0.05). For the trim, UDA had the lowest microbial growth among all treatments (P<0.05). For the lean, UDA had the lowest count for LAB (P<0.05), WA had the lowest in YM (P<0.05) and no difference was found for APC between treatments (P>0.05). Trained sensory panelist found that UDA and WA had higher fat and sour flavor (P<0.05), and a trend (P=0.07) of higher oxidized flavor when compared to DWA and DA.

Conclusion: The results showed that dry-aging would result in no adverse impact on shear force, cooking loss, initial color and lipid oxidation of mature beef loins. Further, sour and oxidized flavor was lower in dry-aged beef, indicating its potential as value adding process. UV light application minimized microbial growth during dry-aging process, although more analyses are needed to understand its full impact on dry-aged meat quality. Further studies on determining the consumer acceptability as well as flavor-related compound analyses are currently under investigation.

Keywords: beef loin, cull cow, dry aging, sensory evaluation, UV light
Objectives: Dry-aging is a traditional butchery process, but currently, it has been more practiced in a niche market as a value-adding process. As dry aging involves placing primal/sub-primal sections under a controlled refrigerated condition without packaging materials, the formation of the dried surface (crust) is inevitable due to moisture evaporation. A considerable portion of the crust is to be trimmed off as waste, which is one of the major drawbacks of dry aging. While the beef crust may still exert its functional/technological properties, no information is available regarding the efficacy of utilizing beef crust as a potential food ingredient. Thus, the objective of this study was to determine the physicochemical and functional properties of beef crust from dry-aged beef loins processed under various dry-aging conditions.

Materials and Methods: Paired bone-in beef shell loins from 13 cull cow carcasses (C-maturity) were obtained at 5d postmortem, divided into 2 sections and assigned to four aging treatments: wet-aging (WA), dry-aging (DA), dry-aging in water-permeable bag (DWA) and dry-aging under UV-light (UDA; 5 J/s/12 hrs per day). Beef sections were aged for 28d at 2°C, 65% RH and 0.8 m/s air flow. After aging, the crusts were separated and beef samples from WA and initial (aged for 0 d, INI) were collected for comparison. In three independent batches, the crust samples were freeze-dried and powdered. Moisture contents of samples were measured before lyophilization. Emulsification capacity, salt-soluble protein solubility, emulsifying activity index, and surface hydrophobicity were determined. CIE* color attributes, lipid oxidation (TBARS), and protein oxidation (carbonyl and thiol contents) were measured. The PROC MIXED procedure of SAS was used to analyze the data. Significance level of least square means was set at the confidence level of 95%.

Results: Beef crusts from dry-aged loins had lower moisture contents compared with WA and INI (P<0.05), while no difference between dry-aging methods was found (P>0.05). The crust samples had lower L* and chroma values than WA and INI (P<0.05). Emulsification capacity of DA, DWA, and UDA were lower than WA and INI (P<0.05), with DA being the lowest (P<0.05). In general, the crust had a significantly higher salt-soluble protein solubility compared to WA, while no difference between crusts and INI was found (P>0.05). For emulsifying activity index, DA exhibited higher values than DWA, UDA and WA (P<0.05), and was comparable to INI (P>0.05). DA and INI had higher surface hydrophobicity values than the other samples, which could possibly explain the results of emulsifying activity index. A trend of higher TBARS values was found in all dry-aged crusts than WA and INI (P=0.0688). The crust from dry aging had a higher carbonyl content compared to WA (P<0.05), while thiol contents were not affected by the treatment (P=0.1092).

Conclusion: The results from the current study indicate that beef crusts exert its functional and technological properties, which could be superior or at least equivalent to wet-aged or unaged beef samples. This study provides novel insight into the potential feasibility and utilization of beef crust from dry-aged beef as a value-added product. Further studies determining the practical application of beef crust as a novel food ingredient (e.g. meat emulsion or beef patty) are in progress.

Keywords: Beef crust, Functional properties, Oxidation
RETAIL DISPLAY LIGHTING AND PACKAGING TYPE MAY INFLUENCE BEEF FLAVOR AND OXIDATIVE STABILITY
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Objectives: This study aimed to evaluate the impact of retail display lighting and packaging type on beef flavor and lipid oxidation in five muscles.

Materials and Methods: Subprimals (n=40 strip loins, 60 shoulder clods, 60 tenderloins, 24 inside rounds, 60 top butts) were randomly collected from separate carcasses. At 7d postmortem muscles (Longissimus lumborum, LL; Triceps brachii, TB; Psoas major, PM; Semimembranosus, SM; Gluteus medius, GM) were fabricated and sliced to 2.54cm steaks. Per muscle, 120 steaks were randomly assigned to packaging treatments: vacuum rollstock (ROLL); high-oxygen (80% O2/20% CO2; HIOX); overwrapped in a motherbag with carbon monoxide (0.4%CO/30%CO2/69.6%N2; CO); and traditional overwrap (OW), which was vacuum packaged until immediately prior to display. Packages were stored in the dark at 2°C an additional 13 days prior to retail display, then were displayed under fluorescent lights (FL) or light-emitting diodes (LED) with a third treatment in dark storage (DARK). All were held in their respective light treatments at 2°C for 72h, then assigned for trained panelists or chemical analysis, vacuum packaged and frozen at -20°C. For sensory analysis steaks were thawed to 4°C and cooked to 71ºC. Panelists (n=8) were trained to evaluate twelve flavors, overall juiciness and tenderness, which were scored on a 100-point scale (0=not present; 100=extremely present). Lipid oxidation of raw steaks was quantified as 2-thiobarbituric acid reactive substances (TBARS; mg malondialdehyde (MDA)/kg beef).

Results: No three-way interaction (P≥0.10) or lighting effect (P≥0.09) was observed for trained panels or TBARS. Cardboard flavor had a muscle-lighting interaction (P=0.02). In GM, FL had greater (p<0.05) cardboard than other lighting; in other muscle types lighting was similar. Muscle×packaging influenced three attributes (P≤0.02). Steaks in ROLL were sweeter (p<0.05) than other packaging in GM, PM and TB; ROLL was juicier (p<0.05) than other packaging in GM, PM, and SM. Across all packaging types tenderness was greatest for PM, while SM was least tender (p<0.05) in CO, HIOX and OW packaging. Packaging influenced nine flavors (P≤0.01); ROLL was greatest in beef ID, bloody/serumy, fat-like, umami, and salty, while HIOX scored greatest for oxidized, bitter, and sour. Brown/roasted was greatest (p<0.05) in HIOX and CO. Muscle impacted liver-like flavor (P=0.01), which was lower (p<0.05) in SM than all other muscle types; LL, TB, PM and GM were similar (p>0.05) for liver-like. Packaging influenced TBARS (p<0.01); HIOX had the greatest concentration of MDA, followed by CO, OW and ROLL with the lowest (p<0.05). Muscle influenced TBARS (P<0.01), where TB was greatest (p<0.05), followed by SM, PM, and GM, which were similar (p>0.05); LL had the lowest MDA concentration. Oxidized (P<0.01, r=0.34), cardboard (P<0.01, r=0.30), bitterness (P<0.01, r=0.23), and sourness (P<0.01; r=0.22) were positively correlated with TBARS, while beef ID (P<0.01, r=-0.23), umami (P<0.01, r=-0.23), and tenderness (P<0.01; r=-0.21) were negatively correlated.

Conclusion: Retail display lighting did not directly influence sensory characteristics or lipid oxidation; lighting only impacted cardboard flavor in an interaction with muscle type. These results suggest after 72h retail display, flavor differences between steaks of similar muscle and packaging displayed under LED or fluorescent lights may not be distinguishable.

Keywords: LED, Retail display lighting
**Objectives:** The objective of this study was to develop pork sausages with reduced salt content using the pre-rigor pork ham to have similar product quality to regular-salt (1.5%) sausages.

**Materials and Methods:** Pork ham with pre-rigor (< 1 hr after slaughter) and post-rigor (> 1 day after slaughter) were purchased at the local market. Sausages containing pre-rigor pork hams with various salt contents (0~1.5%) were manufactured and compared to the post-rigor sausages with regular salt (1.5%). To confirm the states of pre-rigor and post-rigor, pH and temperature of pork hams were measured. pH, color, cooking loss (CL, %), expressible moisture (EM, %), textural properties, lipid oxidation (TBAR), protein oxidation (VBN) of the sausages were measured, while the protein solubility and sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) of meat batter were measured. The experiment design was one-way analysis of variance at a significant level of 0.05.

**Results:** The pre-rigor ham had higher pH and temperature than the post-rigor ham, as expected. Protein solubility of pre-rigor sausages was higher than those with reduced salt concentrations (<1.0%). However, no differences in CIE color values (L*, a*, b*), CL, TBARS, and VBN were observed among treatments. EM (%) of pre-rigor sausages with 0.5 and 1.0% salt were similar to those with pre-rigor sausages with 1.5% salt. Textural properties of sausages were not different between pre-rigor with various salt levels (0.5~1.5%) and post-rigor sausages with 1.5% salt. High intensity of myosin heavy chain band was shown in pre-rigor meat batters as compared to the post-rigor ones.

**Conclusion:** Pre-rigor sausages containing 1.0% salt had similar characteristics to those with post-rigor with 1.5% salt. This result indicated that the amount of salt on sausages could be reduced by approximately one-third of regular-salt (1.5%) level without detrimental effects.

**Keywords:** Low-salt, Pork ham, Post-rigor, Pre-rigor, Sausage
Objectives: Imported meat products are commonly used in the value-addition sector of the US meat industry. Non-meat ingredients, such as sodium tripolyphosphate (STP), are often introduced into imported subprimals by the processor to mitigate potential palatability issues. Although STP can positively affect palatability attributes, its use in meat products can be concerning to some consumers. Our objectives were to determine the effects of enhancement with phosphate or alternative functional ingredients on the palatability of three imported Australian beef subprimals.

Materials and Methods: Ribeye rolls, strip loins, and eye of rounds were collected from carcasses (N=69) at two commercial abattoirs in Australia. Subprimals were shipped under vacuum in a commercial refrigerated vessel at 0 to 2 °C to the USA, where they were transported to Texas Tech University for processing. External fat, connective tissue, and accessory muscles were removed from subprimals, leaving the longissimus thoracics (LT), longissimus lumborum (LL), and the semitendinosus (ST). Muscles were then portioned into six equal sections. One section served as a non-enhanced control (CON), while the remaining five were injected to 112% of green weight with water, salt, and 1 of 5 ingredients: STP, sodium bicarbonate (SBC), sodium carbonate (SC), native potato starch (PS), or beef flavoring (BF). Sections were cut into steak pieces (5 × 5 × 2.5-cm thick) and frozen at 90 d postmortem. Thawed samples were cooked on a clamshell grill using a fixed time cooking schedule targeting a medium degree of doneness, cut into 2 equal portions, and served warm to 2 consumers. Panelists (n=1,380) evaluated each sample for tenderness, juiciness, flavor and overall liking on anchored 100-mm lines scales. Each consumer evaluated 6 test samples from the treatment combinations arranged in a predetermined, balanced order. Sensory data were analyzed using the GLIMMIX procedure of SAS using muscle, ingredient, and their interaction as fixed effects and abattoir as a random effect (α=0.05).

Results: No interactions were detected between muscle and ingredient (P≥0.44); however, both muscle and ingredient affected (P<0.01) consumer sensory ratings. The LL and LT similarly (P>0.05) scored more tender, with greater flavor and overall liking (P<0.05) than the ST. The LT was juicier than LL, which was intermediate, and ST was the least juicy (P<0.05). Samples that were not enhanced were scored lower (P<0.05) for all measured palatability attributes compared to all other treatments, except STP and CON had similar tenderness scores (P>0.05). Of the injected samples, STP resulted in lower (P<0.05) consumer sensory scores than all other treatments. Consumers rated SBC, SC, and PS as the most tender samples (P<0.05). Samples enhanced with SBC and SC were juicier (P<0.05) than all other treatments except PS. The flavor of SC was liked more (P<0.05) than all other treatments except SBC and PS. Samples from SBC, SC, and PS had greater (P<0.05) overall liking than STP and CON, but PS and BF were similar (P>0.05).

Conclusion: Ultimately, these results revealed that several alternative functional ingredients can be used to improve palatability scores of imported Australian beef while generating eating quality outcomes that are similar or superior to injection with STP.

Keywords: Beef, Consumer, Enhancement, Muscle, Phosphate
Objectives: Dark-cutting carcasses occur when muscle pH does not decrease sufficiently during rigor mortis because of antemortem glycogen depletion. Typical dark-cutting beef have a pH > 6.0, however, atypical dark-cutting (ADC) beef have a pH around 5.7 - 5.9 but have a darker lean color similar to dark-cutting beef. Previous studies noted that greater muscle pH in dark-cutting beef increase oxygen consumption and decrease myoglobin oxygenation. However, limited research has determined the biochemical basis of ADC. Therefore, the objectives of this study were to characterize the biochemical basis of ADC beef carcasses and to utilize modified atmosphere packaging (MAP) and rosemary enhancement to improve appearance during retail display.

Materials and Methods: Strip loins from ADC and USDA Low Choice (C) carcasses were selected from a commercial beef processing plant and transported to the Food and Agricultural Products Center in Stillwater, Oklahoma. Control (C) and ADC steaks (prior to enhancement and packaging) were utilized to measure pH, color, oxygen consumption, and proximate compositions. Loin sections were cut into halves and randomly assigned to combinations of packaging types and enhancement treatment. Packaging included high-oxygen MAP (HiOx-MAP; 80% oxygen and 20% carbon dioxide), carbon monoxide MAP (CO-MAP; 0.4% CO, 69.6% N, and 30% CO2), and PVC. Enhancement includes 0.1% rosemary oleoresin pumped to 10% of loin green weights. Following enhancement and packaging, steaks were displayed under retail conditions for six days to measure color changes using a HunterLab spectrophotometer. The data were analyzed using the Mixed Procedure of SAS, and the experiment was replicated 13 times (n = 13).

Results: There were no differences for initial pH or proximate compositions (P < 0.05) between C and ADC. However, ADC had lower initial lightness (L* values), redness (a* values), and red intensity (chroma) compared with C. Further, ADC had greater (P< 0.05) oxygen consumption than C. There was a significant packaging x enhancement x display time interaction resulted for L*, a*, and chroma. CO-MAP and HiOx-MAP in combination with rosemary enhancement improved (P < 0.05) redness of ADC by 61.7% and 42.3%, respectively, compared with ADC in PVC packaging. Similarly, MAP and enhancement improved lightness (L* values) and chroma compared with ADC in PVC. By day 6 of display, enhanced ADC steaks packaged in both HiOx-MAP and CO-MAP had similar color parameters to control choice steaks; however, non-enhanced ADC steaks had significantly lower a* (P < 0.0001) and chroma (P < 0.01) values when packaged in HiOx-MAP when compared to both C and enhanced ADC.

Conclusion: The results suggest that ADC beef has greater oxygen consumption than C steaks even at similar muscle pH. Use of modified atmospheric packaging in combination with enhancement has the potential to improve surface color of ADC beef.

Keywords: Atypical Dark-Cutter, Beef Color, Oxygen Consumption, Packaging
Objective: The objective of the study was to identify optimal concentrations of NaL, NaE and NaB applied to beef trimmings to assess their impact on quality of ground beef patties.

Materials and Methods: Beef trimmings (~50kg) were fabricated from beef forequarters (N=5) 14 days postmortem, combined and aerobically stored (5°C) for an additional 6 days to simulate the collection, storage, transportation and receipt of a combo of beef trimmings. A $2^3$ central composite response surface design (RSM) was used to generate 15 treatment combinations containing NaL (0.1–1.5 M), NaE (0.1–0.6 M), and NaB (0.1–1.5 M) with water used as a control. After aerobic storage, the beef trimmings (~20% fat) were coarse ground (12 mm) and the treatment/control solution applied to the coarse ground trimmings (~454 g) at 2% (w/w). The trimmings were reground (3 mm) and 120g of treated sample was placed into a petri dish and overwrapped with oxygen permeable film (OTR: 21,700 cc/m²/24h at 25°C) to form patties. The patties (2 per treatment/control) were stored under simulated retail conditions: 5°C, cool white fluorescent light (200–300 lux) and analyzed at day 0, 3, 6 and 9 of storage to assess the effectiveness of each treatment in preventing further quality deterioration. Objective color ($L^*$, $a^*$, $b^*$), 2-thiobarbituric acid (TBA) determinations, GC-MS for off-odor assessment and aerobic plate counts (APC) were conducted. The least squares means of results were generated by one-way ANOVA and Tukey HSD to identify significant differences (P<0.05) between treatment and control patties. For RSM and multivariate RSM analyses, the data was used to generate total quadratic polynomial linear regression models and contour plots to determine the optimum ingredient concentrations for the solution.

Results: The $a^*$ values of treated indicated a redder surface color from day 0 to day 9 (P<0.05). No difference was observed for treated and control patties for TBA and hexanal counts on day 0. The TBA values for all treatments reduced lipid oxidation compared to the control on day 3, 6 and 9 (0.47 – 0.58 vs 0.71, 0.51 – 0.58 vs 0.74 and 0.45 – 0.62 vs 0.74, respectively; P<0.05). No differences were observed for treated and control patties for APC from day 0 to day 6, except on day 9 (8.10 vs 8.21 Log$_{10}$ CFU/g; P<0.05). Based on these results, $a^*$ and TBA values were used to conduct RSM analyses for day 3 and 6. Day 9 was excluded due to a significant lack of fit. The predicted value of hexanal was 0 for all treatments. The prediction of TBA values found optimum ingredient concentrations on day 6: NaL (0.74 M), NaE (0.35 M) and NaB (1.00 M) ($R^2 = 0.77$, respectively; P <0.05). The prediction of $a^*$ values on day 3 and 6 did not identify optimum ingredient concentrations for any treatment solution ($R^2 = 0.94$ and 0.78, respectively; P <0.05). Multivariate RSM was conducted to overlap the contour plots of $a^*$ and TBA values at day 3 and 6 to better approximate the optimal ingredient concentrations for $a^*$ values. The proximal optimum concentration ranges of solutions based on the analysis were 0.3–0.5 M NaL, 0.35 M NaE and 1 M NaB with predicted $a^*$ values > 11 and TBA values < 0.52.

Conclusion: Results of this study suggest that a combination of NaB, NaE, and NaL can be applied to improve color stability, reduce lipid oxidation, and control off-odor of ground beef patties.

Keywords: Beef trimmings, color, lipid oxidation, off-odor
EFFECT OF ENHANCEMENT OF TWO BEEF MUSCLES WITH PHOSPHATE OR ALTERNATIVE FUNCTIONAL INGREDIENTS ON THE EATING QUALITY OF US BEEF

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Objectives: Consumers are increasingly searching for more natural and healthier foods that avoid ingredients like phosphates (“clean label”). The objective of this study was to determine the effects of enhancement ingredients and quality grade on the eating quality of longissimus lumborum and semitendinosus.

Materials and Methods: Strip loins (n = 36) and eye of rounds (n = 31) were collected from beef carcasses to equally represent USDA Prime, Average Choice, and Select quality grades at a commercial packing facility in Omaha, NE. Subprimals were shipped under refrigeration (0 to 2 °C) to the Texas Tech University for processing. Subprimals were trimmed of all accessory muscles, external fat, and connective tissue, leaving longissimus lumborum (LL) and semitendinosus (ST). Each subprimal was equally portioned into 6 sections. One section served as a non-enhanced control (CON), while the remaining 5 sections were injected with 112% of green weight with water, salt, and either sodium tripolyphosphate (STP), native potato starch (NPS), sodium carbonate (SC), sodium bicarbonate (SB), or beef flavoring (BF). Sections were cut into steak pieces (5 × 5 × 2.5-cm thick) and frozen at 40 days postmortem. Steak pieces were cooked to a targeted medium degree of doneness on a clamshell grill using a fixed time cooking schedule. Each sample was portioned and served warm to 2 consumer panelists. Panelists (n = 1,380) rated each sample for tenderness, juiciness, flavor, and overall liking on an anchored 100-mm line scale. During a session, panelists evaluated 6 samples representing each treatment combination, arranged in a predetermined, balanced order. Data were analyzed using PROC GLIMMIX (SAS) with fixed effects of muscle, enhancement, quality grade, and their interactions (α = 0.05).

Results: No two-way or three-way interactions were detected for any palatability trait (P > 0.05). Enhancement ingredients influenced tenderness, juiciness, flavor, and overall liking (P < 0.01), regardless of muscle or quality grade. Samples from SC and SB had greater (P < 0.05) tenderness scores than samples enhanced with any other ingredient, except PS. Meanwhile, CON samples were the least tender, and STP was scored lowest for tenderness of the enhanced treatments (P < 0.05). Samples enhanced with BF, SC, and SB were rated juicier than STP and all enhanced samples were rated juicier than CON (P < 0.05). Samples enhanced with BF, SC, SB, and NPS were all similarly rated with greater flavor and overall liking than STP (P < 0.05), which was intermediate, and CON had the lowest flavor and overall liking compared to all other treatments (P < 0.05). Quality grade also affected tenderness, juiciness, flavor and overall liking (P < 0.05). Prime samples received the greatest ratings for all traits, over Average Choice, which was intermediate, and Select samples were scored lowest for all palatability traits. Lastly, muscle influenced all palatability traits (P < 0.01). Longissimus lumborum samples were more tender, juicier, more flavorful, and liked more than semitendinosus samples (P < 0.01).

Conclusion: Results showed consumers liked alternative functional ingredients over enhancement with phosphate and non-enhanced beef. This shows clean label ingredients are not only effective in increasing palatability but had superior eating quality over enhancement with phosphate.

Keywords: beef, consumer, enhancement, muscle, quality grade
47- UTILIZATION OF CONVENTIONAL AND HIGH OLEIC SOYBEAN OIL OLEOGELS STRUCTURED WITH RICE BRAN WAX TO REPLACE PORK FAT IN MECHANICALLY SEPARATED CHICKEN-BASED BOLOGNA SAUSAGE

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Objectives: The objective of this study was to assess the quality and organoleptic attributes of bologna formulated with soybean oil/rice bran wax (RBW) oleogels made with either conventional (CO) or high oleic (HO) soybean oil as pork fat replacers.

Materials and Methods: Six bologna treatments were manufactured using combinations of mechanically separated chicken and a lipid source to achieve a finished product fat target of 25.5%. The lipid sources used were: (1) 90% CO:10% RBW oleogel (C90); (2) 97.5% CO:2.5% RBW oleogel (C97.5); (3) 90% HO:10% RBW oleogel (H90); (4) 97.5% HO:2.5% RBW oleogel (H97.5), (5) liquid CO (CO); and (6) pork back fat (PF; control treatment). Treatments 1–5 were designed to replace 100% of the pork fat, which was approximately 41% of total fat. Treatment effects on emulsion stability, cook/chill yields, instrumental texture (Texture Profile Analysis [TPA] and incisor puncture) and color (CIE L*a*b*), lipid oxidation (TBARS), and sensory parameters were evaluated over a storage period of 98 d at 0–1°C. The experiment was replicated three times. Statistical analysis was conducted as a mixed model using JMP Pro 13.2.0 (SAS Institute, Cary, NC).

Results: No treatment effects were observed for fat loss in emulsion stability, but CO resulted in significantly higher (P<0.05) water loss, suggesting a less stable batter. L* instrumental color values revealed that PF was significantly darker (P<0.05) and CO and C97.5 were significantly lighter (P<0.05) than all other treatments. a* values were also highest (P<0.05) for PF and lowest (P<0.05) for CO and C97.5. b* values were highest (P<0.05) for PF and lowest (P<0.05) for C97.5. This agrees with sensory color analysis, which found color intensity to be highest (P<0.05) in PF and lowest (P<0.05) in CO. TPA parameters (firmness, cohesiveness, springiness, resilience, chewiness) were not significantly different (P>0.05) among treatments. No treatment effects were observed for incisor peak force values (P>0.05). There were no treatment effects for the following sensory parameters: sensory bologna aroma, other aroma, texture, moistness and other flavor. However, bologna flavor was significantly higher (P<0.05) for PF than for CO, H90 and C97.5, but not than for H97.5 and C90. No storage time effects were observed in sensory analysis (P>0.05). There were significant (P<0.05) treatment effects on lipid oxidation, with TBARS values being lowest for PF and CO; however, none exceeded 0.29 mg malondialdehyde/kg over the length of the study, indicating acceptable oxidative stability for all treatments throughout the entire storage period. Microstructure analysis showed fat globule size was larger in PF and smaller in CO than in all other treatments, which could be partly responsible for the lower emulsion stability observed.

Conclusion: Oleogels made with either high oleic or conventional soybean oil resulted in bologna products of similar quality and organoleptic properties, indicating they are easily interchangeable for this application. Use of high oleic soybean oil, however, would result in a product with a more favorable fatty acid profile. Pork fat replacement with liquid oil, while possible, could result in more unstable raw batters, less desirable color and lower flavor intensity.

Keywords: Bologna, Fat replacement, Oleogels, Rice bran wax, Soybean oil
Meat and Poultry Quality

IMPACT OF MYOGLOBIN OXYGENATION STATE AT FREEZING ON COLOR STABILITY OF FROZEN BEEF

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Objectives: Meat color is the number one factor influencing consumer purchase decisions. The emerging market of frozen meat emphasizes the need to understand beef surface discoloration and the ideal parameters of freezing beef to retain a superior color. Therefore, the objectives of this study were to determine the impacts of oxygenation level and frozen storage duration on frozen beef color.

Materials and Methods: USDA Choice strip loins (n=36) were aged for 4 d or 20 d. Steaks were randomly assigned to a myoglobin state [deoxymyoglobin (DeOxy; immediately packaged), low oxygenation (LoOxy; oxygenated in air for 30 minutes), and high oxygenation (HiOxy; packaged for 24 h in 80% O2)]. Steaks were then vacuum packaged in oxygen permeable or impermeable film and immediately frozen (-20°C). Following either 0, 2, 4, or 6 months of frozen storage, steaks were removed from the packaging and immediately analyzed for instrumental color (L*, a*, b*), delta E (magnitude of difference in the L*, a*, b* color space), subjective discoloration, lipid oxidation (via thiobarbituric acid reactive substances - TBARS), oxygen penetration, percent oxymyoglobin, metmyoglobin, and deoxymyoglobin (via spectrometer), and redness (calculated as 630nm/530nm). Data were analyzed using PROC Glimmix procedure in SAS as a split-split-plot with an incomplete block and a 2 x 3 factorial.

Results: HiOxy steaks had greater oxygen penetration and the highest a* values compared to DeOxy and LoOxy steaks regardless of packaging (P<.0005). Conversely, DeOxy steaks exhibited the lowest oxygen penetration and a* values regardless of film (P<.0005). HiOxy steaks at 4 d had higher a* values than DeOxy and LoOxy at all storage times (P=.0118). HiOxy steaks had the highest delta E values compared to DeOxy and LoOxy in permeable packaging and with increasing storage time an increase in delta E for the HiOxy steaks was observed (P=.0010). Redness and percent oxymyoglobin were highest for HiOxy steaks within each storage period (P<.0002). HiOxy and LoOxy steaks were similar in percent oxymyoglobin when in permeable packaging film. HiOxy steaks had the highest percent oxymyoglobin and DeOxy had the lowest percent oxymyoglobin within each aging and storage period (P<.01). Conversely, DeOxy steaks had the highest percent metmyoglobin and HiOxy had the lowest percent metmyoglobin when packaged in impermeable film (P<.0001). Lowest percent metmyoglobin values were from the 4 d HiOxy steaks at 2, 4, and 6 months of storage (P=.0188). The HiOxy 20 d steaks had the highest discoloration compared to 4 d aging and more discoloration than all other myoglobin treatments at 6 months of storage (P<.0001). Lipid oxidation increased with storage time (P=.0169). HiOxy 20 d aged steaks exhibited the highest TBARS values at 2, 4, and 6 months (P=.0224). HiOxy and LoOxy were similar in discoloration and lipid oxidation except with the HiOxy 20 d (which were less desirable).

Conclusion: HiOxy steaks exhibit a brighter and deeper cherry red color compared to the DeOxy steaks. HiOxy steaks were superior or similar when compared to LoOxy steaks but displayed more detrimental effects when frozen storage was extended. Based on the results, HiOxy steaks aged for 4 d give a superior red color for extended storage with few unfavorable effects. However, it is not advised to freeze deoxygenated steaks and expect a cherry red color through frozen storage.

Keywords: discoloration, oxymyoglobin, storage
**49- DRY AGING OF HIGH ULTIMATE PH BEEF**

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**Objectives:** Dry aging is a process in which water is removed from the meat by evaporation. As meat loses water, the flavor compounds are concentrated, resulting in stronger flavor. Meat pH may be important when dry aging as it relates to the ability of muscle to bind water. Therefore, this study aimed to evaluate pH effects on water loss when dry aging and the effects on meat quality characteristics. Dry aging of dark cutting (DC) beef may improve flavor and increase yield.

**Materials and Methods:** Six USDA low Choice and six dark cutting (DC) carcasses with the same degree of marbling were selected and boneless strip loins from both sides were obtained. Longissimus muscle pH was measured, and carcasses were classified as DC (pH = 6.69), or control (pH = 5.47). Then, strip loins from each animal were assigned to 2 aging methods (wet or dry). The 4 treatments included 2 dry aging (DRY and DRY-DC) and 2 wet-aging treatments (WET and WET-DC). Dry aging occurred in individual dry-aging chambers at 50% relative humidity and 2200 RPM fan speed. The chambers (86 cm Length x 48 cm Width x 35 cm Height) have built-in weighing scales that can continuously monitor weight loss (± 5g). Wet and dry-aged loins were aged in the same cooler for 45 d at 1°C. After aging, loins were fabricated into steaks and evaluated for trim loss, yield, tenderness (WBSF), color, discoloration, lipid oxidation, and sensory analysis (flavor) via triangle test (n=32). Steaks assigned for color and lipid oxidation were placed under retail display (RD) at 2°C for 7 d. Rate of moisture loss and color data were analyzed as a split plot design with repeated measures. The TBARS data were analyzed as a split-plot design. All the other data were analyzed as a completely randomized design. Chamber (loin) was considered the experimental unit. Data were analyzed using the PROC GLIMMIX procedure of SAS with α = 0.05.

**Results:** Wet-aged treatments had lower moisture loss, trim loss and higher yield than dry-aged treatments (P < 0.05). However, no differences in rate of moisture loss (P = 0.51), total moisture loss (P = 0.96), trim loss (P = 0.69), or yield (P = 0.75) between DRY-DC and DRY were found. There were no differences among treatments for WBSF (P = 0.67). In general, DRY-DC and WET-DC steaks had the lowest lightness (L*) values, redness (a*) values (Figure 1a), and yellowness (b*) values over the first 5 days of RD (P < 0.05). Discoloration scores for DC steaks remained low throughout the RD period (Figure 1b). DRY steaks had greater TBARS values than any other treatment at 0 d RD. At 4 and 7 d of RD, DRY-DC and WET-DC steaks had the lowest TBARS values, DRY steaks had the highest, while WET was intermediate (P < 0.001). Results from the triangle test indicated a detectable difference between DRY-DC versus DRY (P = 0.01), DRY-DC versus WET-DC (P = 0.01), DRY-DC versus WET (P = 0.01), and WET-DC versus WET (P < 0.01). Panelists frequently made unsolicited comments which suggested inferior eating satisfaction associated with DC flavor (wet or dry), although they were not asked questions regarding preference.

**Conclusion:** Ultimate pH did not affect the rate and total moisture loss in dry aged beef. Results suggest that neither yield nor flavor were positively affected by dry aging of DC beef.

**Keywords:** dark cutters, flavor, meat, palatability, sensory
Objectives: Premature browning is a condition where the interior of patty/steak will appear fully cooked before the temperature necessary to kill foodborne pathogens is reached. Previous research reported that approximately 50% of ground beef retailed in the US is susceptible to premature browning. Myoglobin form present in the interior of steak or patties determines the cooked color appearance. Although previous studies noted that myoglobin denaturation is primarily responsible for the cooked color appearance, limited knowledge is currently available about the effect of temperature on oxymyoglobin and metmyoglobin denaturation properties. The objective of the current study was to determine the effects of myoglobin forms on thermal stability using circular dichroism spectroscopy.

Materials and Methods: Oxymyoglobin and metmyoglobin solutions at pH 5.6 in 50 mM sodium phosphate buffer were incubated in a continuous heat increment water bath for 10 min. At specific temperature points (65, 71, 73, and 76°C), myoglobin denaturation was determined by changes in myoglobin concentration and by protein unfolding (fluorescence and absorbance) methods. The myoglobin thermal stability was also determined by circular dichroism spectroscopy. Changes in secondary protein structure were determined every 2°C from 52 to 92°C. The data were analyzed as completely randomized using the Mixed Procedure of SAS. A significance level of 0.05 was used to determine differences between means.

Results: Oxymyoglobin had greater (p < 0.05) unfolding (as indicated by absorbance changes) than metmyoglobin at all temperatures. However, at 65, 71, and 73°C there were no differences (p > 0.05) in fluorescence intensities between myoglobin forms. Circular dichroism spectroscopy indicates that oxymyoglobin is more heat labile than metmyoglobin.

Conclusion: The results indicate that oxymyoglobin had greater denaturation and unfolding than metmyoglobin. Use of appropriate myoglobin denaturation quantification technique will help characterize premature browning.

Keywords: Cooked Meat Color, Denaturation, Myoglobin, Premature Browning
Objectives: Aging is a method for improving some sensory characteristics of meat, enhancing flavor and tenderness. The effect of aging in tenderness is well known but not well established in the flavor of dry-aged beef. This study aimed to evaluate the meat quality, volatile compounds profile and consumer preference between fresh and dry aged beef.

Materials and Methods: Longissimus thoracis and lumborum muscles (right side) from five steers of Canchim (5/8 Charolais x 3/8 Zebu) breed fed with the same pellet diet (25% peanut shell; 69.23% corn grain; 2.27% soybean meal; 1% sodium bicarbonate; 1.50% minerals; 1.00% urea and 0.03% monensine in dry matter) were used. Animals were slaughtered at 36 months of age with 562 kg of average weight. After 24 hours postmortem, from the muscles of approximately 30 cm length, half of each was deboned, cut into 2.5 cm width steaks (“fresh”). The other half, which were bone-in beef loins, were maintained at 1±1 °C and 70% relative humidity (“dry-aged”) in a refrigerated chamber for 28 days, deboned and trimmed. Fresh and dry-aged samples were analyzed for meat quality (color, pH, water holding capacity, cooking loss, and Warner-Bratzler shear force). The remainder of these samples were vacuum packaged and frozen for sensory and volatile compounds analyses. Volatile compounds extracted by Solid-phase microextraction technique (SPME) were analyzed by Gas Chromatography/ Mass Spectrometry (GC-MS). Consumer paired preference was performed in two sessions, where the preferred sample should be chosen and analyzed by using a table Standard Test Method for Directional Difference Test (ASTM E2164 - 08). Meat quality and volatile compounds results were analyzed by t-test.

Results: Color, pH, and shear force were significantly different (p<0.05) between fresh and dry aged samples. Higher values (p<0.05) of a* (20.6) and b* (16.8) parameters were found in the dry aged meat meaning greater red color intensity in the dry aged samples. Fresh samples showed the lowest values (5.45). The shear force values were lower (p<0.05) for dry aged samples (3.60 kgf) if compared to fresh samples (7.9 kgf). A total of 58 volatile compounds were found in fresh and dry aging meat: 13 hydrocarbons (22.4%), 12 aldehydes (20.7%), 9 ketones (15.5%), 8 alcohol (13.8%), 6 aromatic compounds (10.3%), carboxylic acid (8.6%), 3 sulfur compounds (5.2%), 1 lactone (1.7%) and 1 pyrazine (1.7%). Thirty-nine compounds were common to both treatments being 37 of them with odoriferous importance. Only 3 compounds (2-ethyl, 1-hexanol, 3-ethyl-3-hexene, and octane) were found only in fresh meat. Thirteen compounds were found only in the dry aged meat samples, being the main ones of odoriferous importance: methional (cheddar cheese), heptanoic acid (cheese), 2, 3-butanediol (cocoa butter), dimethyl disulfide (kale), furan, tetrahydro-2-methyl- (roasted, crusted beef and chicken), butanoic acid (rancid), dimethyl trisulfide (sulfureous, grassy) and 3-Octanone (musty, mushroom, moldy and fermented cheese). In the paired preference test, 71 from 78 consumers preferred the dry aged sample, mentioning mainly the reason for the choice the tenderness and flavor.

Conclusion: Dry-aged beef showed enhanced tenderness and red color compared to fresh beef. Many volatile compounds of odoriferous importance were found in the dry aged beef which contributes to its unique flavor, explaining why it was more preferred in this study.

Keywords: Beef, flavor, GC-MS, sensory, tenderness
Objectives: Tenderness is an important sensory attribute that influences consumers’ overall eating satisfaction and repurchase decisions of beef. However, beef tenderness is a muscle-specific and highly variable trait, with different muscles from the same carcass exhibiting considerable variations. Retailing single-muscle beef cuts, based on quality and palatability traits, can improve value of carcasses. Postmortem wet aging of beef subprimals under vacuum packaging is a widely used industry practice in the U.S. to improve beef tenderness. Although beef muscles differ in their biochemical attributes, different muscles undergo similar aging procedure because wet aging is generally performed on the subprimals. While beef muscles may respond differentially to wet aging, the effects of aging time on tenderness of three economically important beef hindquarter muscles, i.e., longissimus lumborum (LL), psoas major (PM), and semitendinosus (ST), are yet to be examined. Therefore, the objective of the current study was to examine the effect of aging on tenderness of beef LL, PM, and ST muscles.

Materials and Methods: The LL, PM, and ST muscles were excised (24 h postmortem) from both sides of eight (n = 8) beef carcasses (USDA Choice; A maturity) and was further separated into two equal-length sections, resulting in four muscle sections per carcass. The muscle sections were vacuum packaged and randomly assigned to aging at 2°C for either 0, 7, 14, or 21 days. At the end of each aging period, 2.5-cm steaks were fabricated. The steaks were cooked to an internal temperature of 71°C and chilled to 4°C overnight. Six cylindrical cores (1.27-cm of diameter) parallel to the muscle fiber orientation were obtained from each steak with a hand-held coring device. Shear force was determined by shearing each core with V-shaped blade of Warner-Bratzler shear device, and the values were recorded as the peak force (N). The main effects of muscle source and aging days, and their interactions were analyzed using the Mixed Procedure of SAS. The least square means for protected F-tests ($P < 0.05$) were separated by using least significant differences and were considered significant at $P < 0.05$.

Results: Muscle source and aging days influenced ($P < 0.05$) the tenderness, with an improvement ($P < 0.05$) in tenderness observed with aging. Moreover, a muscle x aging day interaction ($P < 0.05$) was observed for tenderness. Shear force of LL decreased ($P < 0.05$) with aging, although there was no difference ($P > 0.05$) in tenderness between 7 and 14-day aged LL. However, aging beyond 7 days did not improve ($P > 0.05$) the tenderness of already tender PM steaks. On the other hand, improvement ($P < 0.05$) in tenderness was observed in ST until 14 days. After 21 days of aging, LL was the most tender, while ST remained the toughest ($P < 0.05$).

Conclusion: The results indicated that different muscles in beef hindquarters responded differentially to postmortem aging, and the processors could optimize aging time depending on the muscles to improve beef tenderness.

Keywords: aging, beef tenderness, muscle-specificity
**Objectives:** Dry-aged beef is in high demand in the Brazilian market. The raw material used for dry-aged normally comes from high quality beef, and the production of this raw material can vary during the year. The viability of dry aging a previously frozen beef is very important to this market. So, the present study aimed to evaluate the effects of freezing and thawing, before and after dry-aging on losses, physical-chemical and microbial characteristics of beef.

**Materials and Methods:** Twelve pairs of striploins (left and right-side) from Nellore cattle were collected at 3 days postmortem in a commercial beef plant and sent to the Meat Laboratory at the University of Campinas. Both left and right strip loins were divided in half, and each of the four sections per animal were randomly assigned to one of four treatments: never frozen dry-aging (Dry); dry-aging followed by steak fabrication and freezing/thawing (4 °C/24 h) (Dry+F); freezing before aging, fast thawing (20 °C/15 h) followed by dry-aging (FT+Dry); freezing before aging, slow thawing (4 °C/48 h) followed by dry-aging (ST+Dry). The aging process was performed at 2ºC and 70% relative humidity for 28 days. Weight losses (thawing, evaporation and trimming) and physical-chemical analyses (pH, water activity, moisture, TBARS, cooking loss and Warner-Bratzler shear force) were evaluated for all treatments, while microbial analyses were evaluated only for the Dry, FT+Dry and ST+Dry treatments. The data was analyzed using the software Statistica for ANOVA one-way and means (±SEM) were tested by Tukey test at 5% significance.

**Results:** Samples from the Dry+F treatment had lower ($P < 0.05$) thaw loss (1.1±0.1%), followed by FT+Dry (3.7±0.4%) and ST+Dry samples (5.4±0.3). Freezing samples before dry-aging resulted in (28.5±0.8%) greater weight loss during aging ($P < 0.05$) compared to never-frozen and frozen after dry-aging samples (24.2±0.7%), with no differences in trimming loss ($P > 0.05$). Freezing had no effect on pH, TBARS and WBSF ($P > 0.05$). FT+Dry and ST+Dry samples had lower water activity, moisture and cooking loss values compared to Dry and Dry+F ($P < 0.05$). In this study, microbial counts were not affected by freezing/thawing methods ($P > 0.05$). The highest counts, found at the end of aging, were 3.54 log CFU/g of total bacterial count (FT+Dry), 5.05 log CFU/g of psychrotrophic microorganisms (ST+Dry), 2.56 log CFU/g of lactic acid bacteria (ST+Dry), 1.8 log CFU/g of *Enterobacteriaceae* (FT+Dry) and 3.02 log CFU/g of yeasts and molds (Dry). The mold genus isolated were *Aspergillus* sp. and *Cladosporium* sp.

**Conclusion:** Results indicate that freezing loins before dry-aging increases losses without affecting the microbiological counts. Conversely, freezing steaks after dry-aging maintains the physical-chemical characteristics when compared to never-frozen dry-aged steaks. Thus, despite no impact on microbial counts, freezing samples before dry-aging is not recommended due to the higher levels of weight loss, while freezing steaks after dry-aging can be an alternative to extend the shelf-life.

**Keywords:** dry aging, freezing, thawing
COLOR AND LIPID STABILITY OF DRY AGED BEEF DURING RETAIL DISPLAY

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Objectives: There has been an increased interest in merchandising dry-aged steaks at the retail level. Further understanding of the influence of the dry aging process on meat color and lipid stability is needed to ensure dry-aged beef products can be merchandised without adverse impacts on retail display life. Therefore, this study aimed to determine color and lipid stability of steaks from dry-aged beef loins over 7 days (d) of retail display.

Materials and Methods: Sixteen USDA low Choice boneless strip loins were assigned to one of four aging treatments: vacuum (Wet), dry-aging at 50% relative humidity (RH) (RH50), dry-aging at 70% RH (RH70), or dry-aging at 85% RH (RH85). Dry-aged loins were placed in each assigned dry aging chamber, while wet aged counterparts were aged in vacuum bags in the same cooler. Loins were aged for 42 d at 1°C. After aging, loins were trimmed of dehydrated lean/fat and fabricated into steaks. Steaks were trimmed of subcutaneous fat, and placed on foam trays, overwrapped with oxygen permeable film and placed under retail display (RD) conditions for 7 d at 2°C. Objective color measurements were taken once daily from d 0 to 7 of RD. Trained visual color panelists (n = 6) evaluated surface discoloration from d 0 to 7 of RD once daily. Lipid oxidation was measured via thiobarbituric acid reactive substance assay (TBARS) at 0, 4 and 7 d of RD. Color data were analyzed as a split-plot repeated measures design with treatment as the whole-plot and RD time as the repeated measures. TBARS data were analyzed as a split-plot design with aging treatment as the whole-plot, and RD time as the split-plot. In this study, chamber (loin) was considered the experimental unit. Data were analyzed using the PROC GLIMMIX procedure of SAS with α = 0.05.

Results: For all three-color scales, a RD effect was found (P < 0.001). In general, L*, a* and b* values decreased as RD time increased, regardless of the aging treatment. Wet-aged steaks had higher L* (P < 0.05), a* (P < 0.05), and b* values (P < 0.001) than any other dry-aged treatment. No differences in L*, a*, and b* values among dry aging treatments were found (P > 0.05). A 2-way interaction between treatment and RD for discoloration was observed (P < 0.05). No differences were found among treatments over the first 2 d of RD (P > 0.05). Samples began to diverge on day 3 of RD. Dry-aged steaks had greater discoloration scores (P < 0.05) than wet-aged steaks at 4, 5, 6 and 7 d of RD. However, no differences in discoloration scores among RH treatments were found. There was a RD effect on TBARS values (P < 0.001). Greater TBARS values were found as RD progressed from d 0 to d 4 and d 7, regardless of the aging treatment. A treatment effect was observed for lipid oxidation (P < 0.05). Dry-aged steaks had higher TBARS values than wet-aged steaks. No differences in TBARS values among dry aging treatments were found.

Conclusion: Dry aging of beef resulted in decreased lightness and redness values and increased lipid oxidation compared to wet aging. Results suggest that with prolonged RD dry aging of beef has the potential to reduce color and lipid stability compared to wet-aging and thus reduce display life. Dry-aged steaks met the 20% discoloration threshold and overcame the acceptability threshold of 2.28 mg of malonaldehyde/kg at d 4 of RD, indicating that dry-aged steaks can be merchandised in the retail level for 3 d without detrimental effects on color and lipid oxidation.

Keywords: discoloration, dry aging, lipid oxidation, meat, shelf life
RELATIONSHIP BETWEEN RELATIVE HUMIDITY AND MOISTURE LOSS IN DRY AGED BEEF
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Objectives: The objective of this research was to assess the impact of low relative humidity (RH) during dry aging on moisture and trim loss, tenderness, and flavor. The working hypothesis was that rapid drying would create a hard crust on the meat surface that could reduce moisture release over time, thereby reducing weight loss, enhancing tenderness (by retaining more water), and altering flavor when compared to dry aging at higher RH.

Materials and Methods: Sixteen USDA low Choice boneless strip loins were assigned to one of the four aging treatments: vacuum (Wet), dry-aging at 50% RH (RH50), dry-aging at 70% RH (RH70), or dry-aging at 85% RH (RH85). Loins were placed in individual dry aging chambers and aged for 42 days at 1°C and 2200 RPM fan speed. A computerized dry aging system was designed and built that is capable of measuring and precisely controlling RH (± 1%), temperature (± 0.5°C), and air velocity (± 0.1m/s). The chambers have built-in weighing scales that can continuously monitor weight loss (± 5g). All measured data can be saved on the connected computer in intervals of 1 s. After aging, loins were trimmed of dehydrated fat/lean and evaluated for trim loss. Loins were fabricated anterior to posterior, cut into steaks and evaluated for water activity (a_w), Warner-Bratzler shear force (WBSF), and by sensory analysis to detect flavor differences via triangle test (n = 32). Rate of moisture loss was analyzed as a split plot design with treatment as the main plot and days of aging as the repeated measures. All the other data were analyzed as a completely randomized design. Chamber (loin) was considered the experimental unit. Data were analyzed using the PROC GLIMMIX procedure of SAS with α = 0.05.

Results: There was a treatment by day interaction for rate of moisture loss (P < 0.001). A faster rate of moisture loss was found for RH50 when compared to RH85 on the first day of aging (P < 0.001), while RH70 was intermediate. Loins dry-aged at RH50 and RH70 had higher rates of moisture loss than RH85 on days 2 and 3 of aging (P < 0.05). By day 4, no differences in rate of moisture loss among RH treatments were found (P > 0.05). Wet-aged samples had lower moisture loss (P < 0.001), trim loss (P < 0.001) and higher yield (P < 0.001) than all dry-aged treatments. However, there were no differences among RH treatments for total moisture loss (P > 0.05), trim loss (P > 0.05) and yield (P > 0.05). Steaks from dry-aging treatments had lower a_w values (P < 0.001) than steaks from the Wet group. No differences in a_w values among RH treatments were found (P > 0.05). There was a location effect for a_w values. Samples from the ventral region of the steak had lower a_w values than samples from the central and dorsal region (P < 0.001). There were no differences among treatments for WBSF (P > 0.05). Results from the triangle test indicated that there was a detectable difference between Wet and RH70 (P < 0.05). However, there was no detectable difference between RH50 and RH85 (P > 0.05).

Conclusion: Results suggest that no such case hardening effect occurs when dry aging beef, even when the RH was kept very low (50%) and the total weight loss was 23%. Instead, the lower RH results in more rapid moisture loss at the beginning of the aging process without significantly affecting the total amount of moisture loss. Trim loss, yield, tenderness and flavor were not affected by relative humidity during dry aging.

Keywords: dry aging, flavor, meat, palatability, sensory
CORRELATION AMONG GROUND BEEF LIPID CONTENT, COLOR, AND LIPID OXIDATION OVER A 7-DAY SIMULATED RETAIL DISPLAY PERIOD

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Objectives: Ground beef is more susceptible to lipid oxidation compared to whole muscle beef cuts. This is due to its smaller particle size and greater surface area, which makes the meat products more prone to be exposed to various environmental factors during production. The objective of this study was to determine the relationships among ground beef lipid content, instrumental color, visual discoloration, and lipid oxidation over a 7d simulated retail display period.

Materials and Methods: Beef inside rounds (IMPS #168) from the right sides of steer carcasses (n=63) were collected from a commercial processing facility and delivered to the U of Guelph Meat Science Laboratory for further analyses. Each inside round was trimmed of all subcutaneous fat and connective tissue, and then fabricated into ground beef patties (113 g/patty) at two targeted fat addition levels (no added fat and 25%). Lean ground beef (no added fat) was made by grinding cubes of inside round muscle through a Sirman Master 90 Y12 meat grinder (Sirman USA, Franklin Park, IL). Regular ground beef (25% added fat) was made by grinding cubed round muscle with an additional 25% subcutaneous fat that originated from the rib primal of the same carcass. For the simulated retail shelf life study, 2 crust frozen patties (crust frozen for 1 hour to improve packaging ability) were placed on a Styrofoam meat tray with a soaker pad and overwrapped with PVC film. In total, there were 4 trays of patties per ID (2 trays/targeted fat level). Trays were placed under two LED lights (52 watts, 1850 lumens, color temperature of 4000K, 1612.5 to 2152 lux) at 4°C and the locations on shelves were changed every 24 hours. Minolta L*, a*, b* color and subjective surface discoloration were evaluated every 24 hours for 7 days. Lipid peroxidation of patties before and after the retail display was estimated using thiobarbituric reactive substances (TBARS; mg MDA/g fat). Lipid content of patties was quantified using Soxhlet extraction with petroleum ether. Summary statistics and Pearson correlation coefficients were determined using the PROC CORR procedure of SAS. Correlations were regarded as weak at r < |0.35|, moderate at |0.36| ≤ r ≤|0.67|, and strong at r ≥ |0.68|.

Results: Lipid content in the 126 ground beef samples evaluated in this study ranged from 3.47% to 30.43% (16.30% ± 6.18%). A moderate and significant correlation was observed between lipid content and change in TBARS values (r = -0.59, P < 0.0001). Similarly, an increase in lipid content is moderately correlated with a decrease in a* values (r = -0.58, P < 0.0001) and an increase in surface discoloration after a 7d display period (r = 0.53, P < 0.0001). Δ TBARS values was weakly correlated with Δ L* (r = 0.24, P < 0.01), Δ a* (r = 0.11, P = 0.25), and visual discoloration (r = -0.16, P = 0.09). Finally, Δ a* was strongly correlated with surface discoloration values at d7 (r = -0.76, P < 0.0001).

Conclusion: An increase of lipid content in ground beef had a moderate association with decreased redness, greater surface discoloration, and less change in lipid oxidation over a 7d simulated retail display period. Color values were not great predictors of lipid oxidation values and trained technicians often equated visual discoloration in beef to a deviation from the desired cherry red color.

Keywords: color, correlation, ground beef, Lipid oxidation
THE IMPACTS OF FEEDING NATURSAFE (AN IMMUNE SUPPORT PRODUCT) ON BEEF QUALITY

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Objectives: NaturSafe® (Diamond V, USA) is a Saccharomyces cerevisiae fermentation product developed as an animal feed supplement for the further manufacture of nutritionally balanced feeds for beef cattle. This immune support product (Association of American Feed Control Officials number 96.8, 73.046 and International Feed Name number 7-05-520, 8-08-034) has been specifically formulated to optimize beef cattle health and performance, antibiotic stewardship, and food safety. Research has shown that NaturSafe supports optimal rumen and liver health, overall health and immune function, consistency of feed intake, daily gain, feed conversion, and antibiotic effectiveness. As no research previously has assessed the impacts of this feed ingredient on the quality of meat, the objective of this research was to characterize the effects of feeding NaturSafe on meat quality characteristics in beef.

Materials and Methods: Crossbred steers (N=60, n=12 per treatment; mean hot carcass weight = 421 kg), through an antibiotic free production system, were individually fed diets containing 12, 15, or 18 g/d of NaturSafe or a control diet without (-AB) antibiotics or a control with antibiotics (+AB; 330 mg monensin + 110 mg tylosin-steer-1·d-1) for 112 days. Strip loins were collected and aged for 13 or 29 d postmortem prior to fabrication. Steaks (m. Longissimus) were then evaluated for Warner-Bratzler shear force, pH, sarcoplasmic calcium concentration, troponin-T degradation, fatty acid profile, proximate composition, sarcomere length, total collagen and insoluble collagen. After each aging period, steaks were evaluated for lipid oxidation, and color characteristics (L*, a*, b*, discoloration percentage, and percentage surface oxymyoglobin, metmyoglobin and deoxymyoglobin), during and/or after a 7 d simulated retail display period. A subset of samples at various aging and retail display periods were analyzed for lactic acid bacteria (LAB), psychrotrophic plate counts (PPC), and aerobic plate counts (APC). Animal was considered the experimental unit and hot carcass weight and marbling score were used as covariates in the analysis.

Results: Treatment had no effect on pH, sarcomere length, troponin-T degradation, fatty acid profile, proximate composition, total collagen, insoluble collagen, LAB, PPC, APC, lipid oxidation, oxymyoglobin percentage, or metmyoglobin percentage. Meat from cattle fed 18 g/d of NaturSafe was (1) equal to –AB controls and had higher shear force values compared to all other treatments (P<0.01), (2) had higher (P<0.05) sarcoplasmic calcium levels than +AB controls and cattle fed 12 g of NaturSafe/d, (3) was redder (higher a* values, P<0.05) than all other treatments, and (4) was yellower (higher b* values, P<0.01) than the 12 or 15 g dose and the –AB control. There were no differences among treatments fed NaturSafe for lightness (L*) at either aging time. There were no differences for meat from animals fed 12 or 15 g NatureSafe/d, except deoxymyoglobin percent and discoloration, which were both minimal. Discoloration values were low for all treatments (<10%).

Conclusion: These data indicate that feeding NaturSafe had few discernible effects on meat quality characteristics.

Keywords: beef quality, dietary supplement
EFFECTS OF REPLACING ANTIBIOTICS IN FINISHING CATTLE DIETS WITH PLANT-BASED ADDITIVES ON MEAT QUALITY AND SENSORY ATTRIBUTES

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Objectives: Limited research has investigated the effects of plant-based additives fed to feedlot cattle beyond cattle growth performance and carcass characteristics. Thus, the objective of this study was to investigate the effects of feeding antibiotic supplements versus essential oils and/or benzoic acid to finishing cattle on meat quality and sensory attributes of the longissimus thoracis (LT) muscle.

Materials and Methods: Crossbred steers (N = 63) were placed into 3 blocks based on initial weight. Within each block, 1 of 5 treatments were randomly applied using an Insentec feeding system for 98 days: (1) control (CON) diet (no supplement); (2) monensin/tylosin (M/T) diet (monensin supplemented at 33 mg/kg on dry matter (DM) basis; tylosin supplemented at 11 mg/kg on DM basis); (3) essential oils (EO) diet (supplemented at 1.0 g/steer/day); (4) benzoic acid (BA) diet (supplemented at 0.5% on DM basis); and (5) combination (COMBO) diet (essential oils supplemented at 1.0 g/steer/day and benzoic acid supplemented at 0.5% on DM basis). Beef rib (IMPS#107) sections from the right side of carcasses were collected from a commercial processing facility and transported to the U of Guelph meat science laboratory and processed into 2.54 cm LT steaks. pH and objective color were collected for the LT steaks at 6 d post-mortem. Samples for cooking loss and shear force were aged for 7 d and 14 d post-mortem. Samples for sensory were aged for 7 d post-mortem. Duplicate 5 to 6g homogeneously blended LT samples were analyzed for moisture content by forced-air convection oven drying at 100˚C for 24 hours (Method 950.46, AOAC, 2000). Lipid content of the dried samples were determined by Soxhlet extraction with petroleum ether, followed by 24 hours of oven drying at 100˚C. Cooking loss was measured after cooking samples to an internal temperature of 72˚C. Warner-Bratzler shear force (WBSF) was measured on 1.3 cm diameter cores that were cut parallel to muscle fibers. Meat quality results were analyzed as a randomized complete block design (RCBD) with fixed effects of treatment, block and their interaction using PROC GLIMMIX of SAS. For sensory analysis, 8 highly trained panelists evaluated the tenderness, juiciness, chewiness, beef flavor intensity, and off-flavor intensity of steaks using a 15-cm line scale. Each steak was cooked to 68˚C and served to each panelist as two 1-cm cubes. Results were analyzed as a RCBD with the fixed effects of treatment, panelist, and their interaction and the random effect of session.

Results: There were no significant differences (P > 0.07) among treatments in this study for pH, objective color, % moisture, WBSF, or cooking loss of LT samples. Ribeye from the CON diet had significantly less % crude fat (P = 0.05) compared to other treatments. There was an effect of diet on the tenderness, chewiness, juiciness and beef flavor intensity of steaks as determined by the panelist. Specifically, CON and COMBO steaks were tougher, chewier and less juicy. All steaks had strong beef flavor, especially the BA steaks. Off-flavors were barely detectable.

Conclusion: Results showed that EO and BA when fed to finishing cattle do not affect meat quality. Trained panelists reported steaks in the M/T, EO, and BA diet were tender, juicier, and had stronger beef flavors. Potential off-flavors and off-aromas in finishing feed did not translate to beef products.

Keywords: beef quality, beef sensory, benzoic acid, essential oils
A COMPARISON OF WATER CHILLING AND AIR CHILLING ON POULTRY SHELF LIFE

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Objectives: In the U.S. water immersion chilling (WC) is commonly used to chill poultry, while the E.U. utilizes air chilling (AC). With demand for poultry continuing to rise, poultry products with longer shelf life and less food waste will be needed. Meanwhile, widespread efforts to reduce natural resource and energy expenditures, such as water, as a means of enhancing sustainability, exist across the meat industry, including the poultry industry. Therefore, the objective of this study was to compare the impact of WC and AC on the shelf life and meat quality of bone-in and boneless chicken breast.

Materials and Methods: A total of 256 eviscerated non-chilled chicken carcasses were obtained from a commercial processing facility in California and transported to the UC Davis meat laboratory within two hours. Carcasses were randomly and evenly assigned to either water immersion chilling (WC) or air chilling (AC) and then were evenly assigned to be fabricated into bone-in (BI) or boneless (BL) breast. The breast samples were subsequently packaged onto polystyrene trays, overwrapped, and placed into cardboard boxes for dark storage at 4°C for either 7d (phase 1) or 14d (phase 2). Then breast samples were placed into a retail display case maintained at 4°C for 3d. Instrumental color measurement was performed every 12 hours during retail display. Microbial analysis was conducted for samples collected upon arrival, post chilling, post-fabrication, after dark storage at 4°C for 7d or 14d and after 3d retail display (n=10 per sampling point per treatment). A panel of 8 untrained participants were asked to evaluate the color and their willingness to purchase (for example color: desirable, acceptable, unacceptable). Analysis of variance was conducted to evaluate the effect of chilling method and storage time on all dependent variables using Proc Mixed in SAS (version 9.4).

Results: The WC chicken possessed lower psychrotrophic bacterial counts (1.05 log CFU/g) pre-fabrication than the AC chicken (2.12 log CFU/g), indicating that WC may remove a portion of the psychrotrophic bacteria. However, no difference in mesophilic bacterial counts was observed between the two treatments for pre-fabrication samples. The WC chicken and AC chicken, regardless of fabrication type, reached the end of shelf life (7 log CFU/g) at the 14d. The BL samples, regardless of chilling method, had lower total microbial counts throughout storage and display than the BI samples, since the removal of the skin physically removed the general microbial population as well. In terms of objective color, the a* and b* values were higher for AC breast, suggesting that AC breast was more red and yellow than WC breast through the display time. Chilling method did not have an impact on subjective color measurement. During phase 1, untrained panelist considered the color of BL chicken breasts more desirable than the BI breasts. During phase 2, regardless of chilling method or fabrication type, the desirability of color by untrained panelist decreased as display time increased.

Conclusion: The results indicate that chilling method had a minimal impact on the shelf life in terms of the microbial counts. Although AC chicken breast tend to be more yellow based on objective color measurement, consumers did not detect a distinct color difference of chicken treated with air chilling or water chilling.

Keywords: Air Chilling, Chicken Breast, Chilling Method, Shelf life, Water-immersion
INFLUENCE OF POSTMORTEM AGING AND STORAGE CONDITIONS ON TENDERNESS OF GRAIN AND GRASS FINISHED BISON STRIPLION STEAKS


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Objectives: The objectives of this study were to: 1) compare the influence of postmortem aging on tenderness of striplion steaks from grain- and grass-finished bison, and 2) compare the influence of freezing on tenderness of striplion steaks from grain- and grass-finished bison.

Materials and Methods: Bison heifers were randomly assigned to finishing treatments: Grain-finished (n=30, backgrounded on pasture and finished for 130 days with ad libitum access to grass hay, alfalfa and a corn and dry distiller's grain concentrate prior to slaughter) or Grass-finished (n=30, remained on pasture until slaughter). Heifers were slaughtered at approximately 28 mo of age, and striplions were removed from both sides of the carcass posterior to the 12th rib separation and fabricated into 2.54-cm steaks. One steak was removed from each striplion (n=60), vacuum packaged and stored fresh for 14 d at 4°C. Four additional steaks were fabricated from each striplion, aged for 4, 7, 14, or 21 d, vacuum packaged, and frozen for approximately 3 months. Warner-Bratzler Shear Force (WBSF) was utilized to determine objective tenderness. Frozen steaks were thawed at 4°C for 24 h before cooking. All steaks were weighed prior to cooking to an internal temperature of 71°C. Internal temperature was monitored using a digital thermometer placed near the geometric center of each steak. After cooking, all steaks were reweighed to determine cook loss and cooled to room temperature (20°C). Five to six 1.27-cm cores were removed from each steak and sheared once perpendicular to the muscle fiber orientation and peak force was recorded. A texture analyzer with a Warner-Bratzler attachment was used to assess instrumental tenderness. An average shear force value was then calculated for each steak. For Objective 1, cook loss and shear force data were analyzed as repeated measures using the ante-dependence covariance structure in the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) for effects of finishing treatment, aging, and their interaction; peak temperature was included as a covariate. For Objective 2, shear force data were analyzed for the effects of finishing treatment, storage treatment and their interaction using the GLM procedure of SAS. For both objectives, the interaction was not significant and omitted from the final model. Separation of least-squares main effect means was performed using LSD with a Tukey's adjustment and assuming a level of 0.05.

Results: Steaks from grain finished bison heifers had tendency to be more tender (P = .0552) and had less cook loss (P < .0001) than steaks from grass finished heifers. Tenderness of all steaks improved (P < .0001) with postmortem aging. Aging time also influenced cook loss (P = .0199). Cook loss was greater (P = .0133) at day 4 than day 7 and tended to be greater (P = .0561) at day 4 than day 21. Frozen storage improved tenderness (P < .0001) and increased cook loss (P < .0001) of bison steaks compared to fresh storage.

Conclusion: Collectively this data indicates postmortem aging, storage conditions, and finishing systems influence meat tenderness of bison striplion steaks. Grain-finishing resulted in reduced cook loss and tended to improved tenderness of bison steaks compared to grass-finishing. Additionally, holding bison steaks in frozen storage improved tenderness, but also increased cook loss.

Keywords: bison, frozen storage, grain finished, grass finished, tenderness
OBJECTIVES: The objective was to evaluate the effect of supplementing alpha- and gamma-tocopherol vitamin E isoforms with corn oil and tallow on carcass characteristics and meat quality of pigs grown to heavier weights (>150kg).

MATERIALS AND METHODS: Individually fed pigs (n=72; 36 barrows, 36 gilts; 28.55 ± 1.16 kg) were randomly assigned to 12 dietary treatments in a 2 × 6 factorial arrangement. Fat treatments were tallow and corn oil (5%). The vitamin E treatments included four levels of α-tocopheryl-ace (ATA; 11, 40, 100, and 200 ppm) and two levels of mixed tocopherols (primarily γ-tocopherol; 40 and 100 ppm). Pigs were humanely slaughtered at approximately 150 kg. 45 min pH was taken at the 10th rib. After 24 h chill (4 °C), carcass measurements were taken (carcass length, backfat depth at 1st rib, last rib, 10th rib and last lumbar, loin muscle area, and 24 h pH at the 10th rib). In addition, wholesale weights from the Boston butt (IMPS #406), shoulder picnic (IMPS #405), loin (IMPS #412), and belly (IMPS #408) and spareribs were recorded. Furthermore, bellies were divided into eight sections and the average depth was taken at each section and the vertical and lateral belly flex was measured. Drip loss was determined by suspending a 1.3cm chop at 4 °C for 48 hours and purge loss was determined from approximately 2kg vacuum packaged loin muscle sections at 0, 7, 14 and 30d. Objective (Hunter Lab Colorimeter XE Plus) and subjective (NPPC color, marbling and firmness scores) measurements were taken at the 10th rib. Data analysis were performed in SAS by least squares analysis of variance using the generalized linear model as a randomized complete block design. The individual pig served as the experimental unit and results were reported as least square means.

RESULTS: There were no differences in dressing percentage, 24 h pH, backfat depth, loin muscle area, primal cuts, purge loss, and drip loss between the two vitamin E isoforms. Fat treatments did not affect dressing percentage, 45 min and 24 h pH, backfat depth, loin muscle area, primal cuts, purge loss, drip loss as well as objective and subjective color. Although not significant (P=0.07), pork from the γ-tocopherol pigs had a lower pH than the ATA treatment. The γ-tocopherol supplementation tended to have a lighter subjective color (P=0.06) as well as increased L*, decreased a* , and increased the hue angle calculations at 7d shelf-life. The belly depth was greater (P=0.01) along with higher lateral (P<0.01) and a lower vertical (P<0.01) flex for pigs fed tallow.

CONCLUSION: In conclusion, feeding tallow to heavy weight pigs (150 kg) could improve belly firmness. Also, α-tocopherol did not improve shelf-life stability and gamma-tocopherol could negatively affect subject and objective pork loin color.

KEYWORDS: Fat, Heavy Slaughter Weight Pigs, Isoforms, Tocopherol, Vitamin E
DETECTION OF DIFFERENCES IN COOK LOSS AND TENDERNESS OF AGED PORK CHOPS COOKED TO DIFFERING DEGREES OF DONENESS USING SOUS-VIDE

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Objectives: The objective was to determine the ability to detect differences in cook loss and Warner-Bratzler shear force (WBSF) value between chops aged for differing time periods and cooked to varying degrees of doneness in a sous-vide style cooker.

Materials and Methods: Loins (n = 68) from pigs humanely slaughtered at the University of Illinois Meat Science Laboratory were separated between the 10th and 11th rib into anterior and posterior sections. The posterior section was cut into 6 separate 2.54 cm thick chops. The middle 4 chops were randomly designated for aging of 3 days and cooked to 63°C, aged 7 days and cooked to 63°C, aged 14 days and cooked to 63°C, or aged 14 days and cooked to 71°C. Chops (n = 272) were cooked by placing them in a water bath with an immersion circulator set to the desired end-point temperature for 90 min. Cook loss was calculated for each chop by measuring initial and final weight, and accounting for packaging weight. Four cores measuring 1.25 cm in diameter were cut parallel to the muscle fibers from each chop and analyzed for WBSF. Data were analyzed using a 1-way ANOVA. Least squares means were separated using the probability of difference (PDIFF) option in the MIXED procedure of SAS.

Results: Cook loss increased as aging period or degree of doneness increased. Among chops cooked to 63°C, chops aged 3 days had 1.14 percentage units less (P < 0.01) cook loss than those aged 7 days, and chops aged 7 days had 1.13 percentage units less (P < 0.01) cook loss than those aged 14 days. Among chops aged for 14 days, chops cooked to 71°C had 10.06 percentage units greater (P < 0.001) cook loss than chops cooked to 63°C. Differences in tenderness were also detected between aging periods. Among chops cooked to 63°C, chops aged 3 days required 0.27 kg more (P = 0.02) force to shear than those aged 7 days, but chops aged 7 days did not differ (P = 0.15) from those aged 14 days. End-point cooking temperature had a greater effect on tenderness, with chops aged 14 days and cooked to 71°C requiring 0.83 (P < 0.001) kg more force than those aged 14 days and cooked to 63°C. Previous studies have reported a decrease in Warner-Bratzler shear force between 7.10-21.29% when comparing early (1-3 days) and mid (7 or 9 days) aging and decreased between 3.53-15.38% when comparing mid and late (14-21 days) aging. In the present study, Warner-Bratzler shear force decreased 9.00% from early-to-mid aging and 5.86% from mid-to-late aging.

Conclusion: Overall, these data indicate sous-vide is an acceptable cooking method for use in experiments as expected differences in cook loss and WBSF were detected in chops aged to differing time points or cooked to differed degrees of doneness.

Keywords: aging, Pork, Sous-vide, tenderness
HEAT MITIGATION STRATEGIES FOR FINISHING BEEF CATTLE DURING THE SUMMER IN THE SOUTHEASTERN UNITED STATES REDUCES HEAT LOAD AND IMPROVES WEIGHT GAIN, BUT DOES NOT INFLUENCE MEAT QUALITY

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Objectives: The objective of this research was to determine the effect of heat mitigation strategies on meat quality when finishing cattle under heat stress conditions.

Materials and Methods: Forty-five Angus crossbred steers (446±23 kg) were blocked by weight and randomly assigned to 1 of 3 finishing environments: shaded with fan (CWF), shaded without fan (CNF), or outside no shade (OUT). For 92 d steers were individually fed a corn-based total mixed ration and were weighed every 3 wk. Environmental monitors (Kestrel Instruments) were used to quantify heat load index (HLI) and accumulated heat load units (AHLU). When the first treatment group averaged 613 kg all steers were harvested. Carcass quality and yield data were collected 24 h postmortem. Strip loins were removed from the right side of each carcass at 24 h postmortem, vacuum packaged, and aged (2±1°C) for 5 d. Strip loins were then fabricated into 2.54-cm steaks anterior to posterior. The first steak was designated for proximate analysis, followed by two steaks for slice shear force (14 and 21 d aging), two steaks for other analyses, and the remaining 7 steaks were randomly assigned to shelf life (SL) for 6 days following 28 d of wet aging. Steaks were vacuum packaged and held (2±1°C) for their respective days of aging. After 28 d, shelf life steaks were opened, placed in Styrofoam trays with PVC overwrap, and placed in retail display cases (1±2°C). Steaks were frozen (-20°C) once they reached their assigned day of wet aging or simulated shelf life. Objective color L* (lightness), a* (redness), b* (yellowness), and isobestic wavelengths were recorded daily (±2 h). Hue, chroma, DE, and deoxymyoglobin (%Dmb), oxymyoglobin (%Omb), and metmyoglobin (%Mmb) were calculated. Data were analyzed using a mixed model (JMP v.13; SAS) and means were separated using LSmeans at a=0.05.

Results: Environmental monitors showed that CWF and CNF had lower HLI and AHLU (P<0.01) than OUT. Final weights were greater for CWF than OUT (P=0.02) while CNF was similar (P=0.17) to both. Similar results were observed for hot carcass weights where CWF > OUT (P=0.03), and CNF was similar to both (P=0.23). Treatment differences were not observed for USDA yield grade (P=0.38), dressing percent (P=0.93), kidney pelvic heart fat (P=0.89), ribeye area (P=0.47), backfat thickness (P=0.49), marbling score (P=0.71), overall maturity (P=0.92), or subjective lean color (P=0.16). No differences in fat color scores were observed between CNF and OUT (P=0.95) while CWF were whiter (P≤0.04) than both. Protein analysis showed CWF had more protein than OUT (P=0.01) while CNF was similar to both (P≥0.90). No differences were observed for lipid content (P=0.99), ash (P=0.39), or moisture (P=0.92). Treatment nor day of aging affected slice shear force (P=0.45 and P=0.53, respectively). While treatment differences were not observed for a*, b*, hue, chroma and DE (P=0.51, P=0.65, P=0.18 P=0.57, and P=0.57, respectively). Treatment values for L* were lighter for CNF than CWF (P=0.04), while OUT was similar to both (P≥0.14). There were no differences for %Dmb, %Omb, and %Mmb (P=0.24, P=0.32, and P=0.39, respectively) among the treatments.

Conclusion: Results indicate that heat stress mitigation is a viable method to improve weight, however, does not impact the quality of the meat.

Keywords: beef, heat stress, meat quality
Objectives: Electrical stimulation (ES) prior to rigor mortis accelerates postmortem glycolysis, resulting in rapid postmortem depletion of glycogen and can partially simulate the physiological conditions created by stress. The objective of this study was to evaluate the influence of two levels of high voltage electrical stimulation on incidence of dark cutters, temperature decline, muscle pH, glycolytic potential and meat quality.

Materials and Methods: Fifty beef carcasses were chosen at 3 collection times over 7 hours; 14 at collection 1, 18 at collection 2, and 18 at collection 3. One side of each carcass received either 40 (E40) or 80 (E80) volts of ES. The paired side of each carcass served as a control and did not receive ES (C40 or C80). Temperature data loggers were placed into the sirloin of both sides of the first 4 carcasses from each collection period to monitor temperature decline. Muscle pH was measured on the longissimus muscle at 1, 12, 24, and 72 hours postmortem. Steaks were fabricated from the longissimus lumborum for determination of WBSF, cook loss, glycolytic potential (GP), and objective color. Data were analyzed using PROC Mixed of SAS with fixed effect of treatment and random effect of carcass. Analysis of carcass temperature decline was conducted with control carcasses pooled to one treatment to better evaluate the effect of ES on temperature decline. Temperature data, WBSF, and pH were considered repeated measures. Significance was determined at $P < 0.05$.

Results: No dark cutting carcasses were observed in this study. A time by treatment interaction was observed for carcass temperature decline ($P < 0.001$) where ES sides stayed warmer for longer than control sides. A treatment by time interaction was observed for pH decline ($P < 0.001$) with C40 sides having an increased pH at 1 hr postmortem compared to E80 sides. Carcass characteristics did not differ among treatments ($P > 0.05$). A treatment effect was observed for WBSF values ($P = 0.006$) with ES sides being more tender than C40 sides. A day effect was observed ($P = 0.009$) with steaks aged for 7 days being less tender than steaks aged for 14 days ($P = 0.007$). Cook loss did not differ among treatments ($P > 0.05$). A difference in cook loss by aging period ($P = 0.014$) was observed. Steaks aged for 3 days had less cook loss than steaks aged for 7 days (17.3% vs 18.8% respectively; ($P = 0.017$) and tended to have less cook loss than steaks aged for 14 days (18.3%; $P = 0.065$). Glucose, lactate, and overall GP measurements did not differ among treatments ($P > 0.05$). Objective L* values for E80 sides were greater than C40 ($P = 0.0009$) and C80 ($P < 0.0001$), and E40 values were greater than C40 ($P < 0.0001$). Objective a* values for E80 sides were greater than C40 ($P = 0.002$) and C80 ($P = 0.035$), and E40 values were greater than C40 ($P < 0.0001$). Objective b* values were greater for E80 than C80 ($P = 0.005$) and C40 ($P = 0.001$), and E40 was greater than C40 ($P < 0.0001$).

Conclusion: These data suggest ES does not influence the incidence of dark cutters. However, utilization of an ES system can improve tenderness of steaks in addition to producing brighter, more red beef products. The results of this study indicate that similar quality characteristics can be obtained using 40 or 80 volts of ES. Therefore, beef packing plants applying ES to carcasses may be able to reduce voltage without sacrificing quality.

Keywords: beef, electrical stimulation, glycolytic potential, quality, temperature decline
**CHARACTERIZATION OF CAECAL MICROBIOTA IN BROILERS THAT DIFFER IN GENETIC STRAIN, NUTRITION, AND DEVELOPMENT OF WOODY BREAST**

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**Objectives:** Woody breast (WB) meat from broilers has undesirable textural characteristics, including, crunchiness and stickiness. Genetic, nutritional, and environmental factors are associated with the mechanism of WB development. A diverse microbiota plays an important role on the growth performance and health of the host, and greater than 900 species of bacteria have been isolated in the gastrointestinal tract of chicken. However, minimal information is known about the microbiota in the guts of broilers that yield WB meat. Therefore, the objective of this research was to characterize and compare the bacterial diversity of caecal microbiota in broilers with normal and woody breast fillets.

**Materials and Methods:** The Institutional Animal Care and Use Committee of Mississippi State University (IACUC-16-542) reviewed and approved all protocols. One-day-old mixed sex broilers from two strains (A2 and B2) were raised in 32 pens in a chicken house. Birds of each strain were randomly assigned to 16 pens (15 birds per pen) and 8 pens were fed a control diet and 8 pens were fed an amino acid reduced diet (digestible lysine, total sulfur amino acids, and threonine reduced by 20% as compared to the control diet). After 8 weeks of growth, 4 male broilers with normal breast (1 chick per pen) and 4 male broilers with WB (1 chick per pen) determined by palpation were selected for each treatment (breed × diet). The cecum samples were collected after birds were euthanized and bled. DNA was extracted and amplified using universal primers that target the V3–4 regions of bacterial 16S rRNA for sequencing in Illumina MiSeq. Raw sequences were processed, and the quality was filtered using the default parameters of Quantitative Insights into Microbial Ecology (QIIME 2). Differences between species were assessed using the unpaired two-tailed Student t-test assuming unequal variance at alpha = 0.05.

**Results:** Data suggested that the most abundant phyla in all samples were Firmicutes, followed by Bacteroidetes and Proteobacteria. Accounting for both abundance and evenness of the species present in each sample (alpha diversity), results indicated that there was no difference (P>0.05, pairwise Kruskal-Wallis test) in the diversity of gut microbiota between two phenotypes (normal vs. woody), two strains (A2 vs. B2) or two diets (control vs. reduced). However, principal coordinate analysis plots (beta diversity) revealed that the samples were clustered based on the phenotype rather than by the strain or diet. These results revealed that the microbiota of each bird with normal breast was more similar to each other than the microbiota of birds with WB. Among all species (300-400) identified, no difference (P<0.05) existed in bacterial abundance between the two genetic strains. However, 16 and 13 species were differentially abundant (P<0.05) between normal and woody breast and between control and reduced diet treatments, respectively. In the ceca of WB birds Selenomonas bovis (12.6%) and Bacteroides plebeius (12.3%) were the top two predominant bacteria; however, the relative abundances of these two bacteria were only 5.1% and 1.2% in normal birds, respectively.

**Conclusion:** Differences in the microbiome may be associated with the development of WB. Further studies are needed to investigate the potential mechanism and how to reduce broiler WB incidence by regulating their gut microbiota.

**Keywords:** 16S rRNA sequencing, Broiler breast meat, Gut microflora, QIIME 2
Objectives: Woody or wooden breast (WB) is an emergent myopathy of broilers and is macroscopically characterized by hardened areas of the Pectoralis major muscle (Sihvo et al., 2013). Woody broiler breast fillets can result in harder texture, higher pH, lower amounts of proteins, lower water-holding capacity, and increased cook loss when compared to normal breasts (Mazzoni et al., 2015; Soglia et al., 2015). The impaired meat quality of WB has been reported to be closely associated with improved nutrition and fast-growth rates (Petracci et al., 2015; Meloche et al., 2015). The present research compared the proteome of normal and woody breast muscle from broilers that were fed with either a control diet or an amino acid (AA)-reduced diet.

Materials and Methods: Mixed-sex broilers were assigned to 16 pens (15 chicks per pen) and fed with control or reduced AA diets (20% reduction of digestible lysine, total sulfur amino acids, and threonine). At 8 weeks of age, live broilers were evaluated manually for WB myopathy. Within each diet group, 4 male broilers with normal breast and 4 male broilers with WB were selected (one bird in each pen) and euthanized using CO₂ gas. The breast muscle from the cranial portion was immediately sampled after bleeding and snap-frozen in liquid nitrogen. All experimental procedures were approved by the Institutional Animal Care and Use Committee of Mississippi State University (IACUC-16-542). Whole muscle proteins of normal and woody breast were extracted from frozen samples of three birds within each treatment. Two-dimensional gel electrophoresis (2-DE; 6 gels per treatment) coupled with image analysis and mass spectrometry were used to investigate differences in the expression levels of proteins (more than 2.0-fold intensity differences) from chicken breast muscle. Differences were evaluated using Student’s t-test at a confidence interval of 95%.

Results: When the broilers were fed with the control diet, 10 proteins were expressed differentially between normal and woody breasts. Apolipoprotein A-I, desmin, annexin A2, annexin A5, and ubiquitin carboxyl-terminal hydrolase were overexpressed (P<0.05) in WB. Peptidyl-prolyl cis-trans isomerase, four and a half LIM domains protein 1 isoform X3, and an uncharacterized protein were only present in WB muscle, but not in normal chicken breast. Two proteins, keratin, type II cytoskeletal 8 and alpha-1,4 glucan phosphorylase, were overexpressed (P<0.05) in normal chicken breast. These differentially expressed proteins were involved in glycolytic metabolism, cell structure, and cellular defense. Interestingly, only one protein (heat shock protein beta-1) was expressed differentially between normal and woody breasts when broilers were fed with the AA-reduced diet. This protein was overexpressed (P<0.05) in WB samples and found to play a role in stress resistance and actin organization.

Conclusion: The protein profiles of normal and woody chicken breast samples were different, which might help explain the changes in meat quality. Essential amino acid intake resulted in minimizing difference in protein profiles between normal and woody chicken breasts.

Keywords: Broiler, Meat quality, Myopathy, Nutrition, Proteome
Objectives: Since 2013, woody breast (WB) has been a prevalent meat quality defect in the broiler industry, affecting 30-40% of chicken breast meat from broilers with live weights greater than 4.2 kg. Woody breast results in a loss over $200 million annually due to decreased yields and product value. WB samples are lighter, more yellow in appearance, and are characterized by a greater pH and cooking loss than normal breast meat. The objective of this research was to evaluate and compare the instrumental quality traits of normal and WB fillets over storage time to determine if the WB condition dissipates over storage time. Dissipation was defined by the change of severely woody to moderately woody breasts or the change of moderately woody to slightly woody or normal breasts.

Materials and Methods: Ninety chicken breast samples, 30 from each of the following breast meat categories (normal, moderately woody, and severely woody) were collected from a commercial processing plant on 5 separate occasions for evaluation of dissipation, purge loss and shear force from day 1 (d1) through day 5 (d5). A 3 × 6 factorial structure (WB severity × storage time) with 5 replications within a randomized complete block design (sampling occasions as blocks) with subsamples was utilized to evaluate the effects of WB severity (normal, moderate, severe) and storage time (d 0, d 1 to d 5) on dissipation, purge loss and shear force (d 0 and d 5) (SAS version 9.4, NC, USA).

Results: Results indicated that dissipation was observed on moderate and severe woody breast over storage time. After 5 days of storage at 2-4 °C, 84% of SEV WB fillets dissipate to MOD WB, which was greater (P<0.05) than all other storage times. In comparison, only 40-52% of the MOD WB fillets dissipated to slight WB or NOR breasts after 3-5 days of storage. Purge loss increased throughout storage time for NOR, MOD, and SEV chicken breast meat. In addition, purge loss was less (P<0.05) for NOR than SEV WB after 1, 2, and 4 days of storage. However, after 5 days of storage, no difference (P>0.05) existed in purge loss among NOR, MOD, and SEV WB meat. Shear force was greater (P<0.05) for NOR than MOD and SEV WB meat on day 0 in the upper, middle, and lower portions of the breast. By day 1, there were no differences (P>0.05) in shear force among the 3 breast meat severities. After 2, 3, 4, and 5 days of storage, the upper position (cranial part) of SEV WB fillets had greater (P<0.05) shear force than NOR fillets.

Conclusion: In conclusion, the dissipation that occurred in WB meat over refrigerated storage was mainly visual and did not improve overall meat quality.

Keywords: Chicken Breast, Meat Quality, Myopathy, Purge loss, Shear Force
POST-EXSANGUINATION VASCULAR RINSING OF MARKET HOGS AND CULL DAIRY COWS ON MEAT QUALITY.

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Objectives: The objectives from two separate studies were to determine the meat quality effects of Rinse & Chill® (RC) on market hogs slaughtered under less than ideal harvest conditions (heat stress, warm harvest area, limited cooler air movement) and the impact of RC on commercially harvested cull dairy cows having different body condition scores (BCS).

Materials and Methods: Immediately after bleeding, market hogs were conventionally chilled (C, n = 12) or RC processed (RC, n = 13; MPSC Inc.) at the University of Wisconsin harvest facility. RC carcasses were vascularly rinsed (10 % of live weight) with an isotonic chilled solution (3°C; 98.5% water; balance: glucose, polyphosphates, maltose). Carcasses were scalded rather than skinned. Carcass temperature (0-24h), carcass cooler shrink, and pH (0.5, 1, 2, 4, 6, 24h) were recorded. At 24 h postmortem (PM), muscles (picnic shoulder, PS; M. Longissimus et lumborum, LL) were further processed (PS: chops, ground pork; LL: chops, ground pork), packaged (polyvinyl chloride, PVC; vacuum, VAC) and displayed continuously (3°C, 1615 lux; 1, 4, 7d PM). Color measurements (CIE L*a*b*, chemical states of myoglobin) along with pH, moisture fat free (MFF), water holding capacity (WHC), oxygen consumption, total pigment, TBARS and hexanal content were determined. Warner-Bratzler shear force on chops aged 4d PM (2°C) were cooked (71°C, endpoint temperature) according to AMSA guidelines.

Carcasses from cull dairy cows with two different BCS (Lean, LE; Light, LI) were conventionally chilled (n= 10 each BCS) or RC processed (n= 12 each BCS). Muscles (M. Longissimus et lumborum, LL; M. Triceps brachii, TB) were ground (19mm, 3mm plates), packaged (PVC, VAC) and displayed or stored in the dark. Color, chemical states of myoglobin, pH, temperature, fat content and total pigments were determined. Data were analyzed using PROC MIXED procedures (SAS Institute).

Results: RC resulted in a lower (P < 0.05) pH during the first 4h compared to C. RC ground picnic shoulder was redder (CIE a*), lighter (CIE L*), had greater deoxymyoglobin and less metmyoglobin compared to C (P < 0.05). However, the RC ground loin had less (P < 0.05) oxymyoglobin than C. RC chops (LL) were lighter (CIE L*) and had less deoxymyoglobin compared to C (P < 0.05). RC ground pork had greater (P < 0.05) oxygen consumption. RC pork had lower (P < 0.05) TBARS and hexanal values compared to C. RC did not (P > 0.05) affect cooler shrink, moisture content when assessed on an MFF basis, WHC, purge, cook loss, total pigment and WBS force. RC resulted in a lower (P < 0.05) pH at each time PM than C. C (LE) had a lower pH than C (LI), however pH was not affected by BCS for RC. Generally, RC resulted in lower temperatures during chilling (24h). In LE and LI cows, RC produced greater redness (CIE a*, P < 0.05) associated with blooming and display times. RC LE beef resulted in greater (P < 0.05) oxymyoglobin during all display times, however, RC LI had higher (P < 0.05) deoxymyoglobin on 7d. No differences were found in total pigments.

Conclusion: For pork packing facilities that harvest during heat stress times and have less than ideal carcass cooler conditions, RC has the potential to improve color in certain cuts and reduce lipid oxidation. RC on lower quality BCS cull dairy cows has the opportunity to improve color and potentially decrease the incidence of dark cutting beef.

Keywords: Hog, Beef, Vascular Rinsing, Color
Impact of Woody Breast Severity on the Sensory Properties and Acceptability of Chicken Products


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Objectives: The woody breast (WB) myopathy has caused economic losses in excess of $200 million annually to the poultry industry due to undesirable textural attributes and decreased functionality. This hardened muscle is also associated with other undesirable traits, such as white striping. This research was conducted to evaluate the impact of WB severity and genetic strain on consumer acceptability and sensory attributes of baked and fried broiler breast meat and elucidate the consumer acceptability of tumble-marinated, fajita meat made from broilers with normal (NOR), moderate (MOD) and severe (SEV) WB meat.

Materials and Methods: For descriptive analysis (n=7 panelists, 10 panels) on baked and fried chicken, 3x5 factorial arrangements within randomized complete block designs with four replications were utilized to evaluate three severities of woody breast and the five different genetic strains that are most commonly used in the poultry industry. When significant differences (P<0.05) occurred among treatments, Duncan's multiple range test was utilized to separate treatment means. For consumer acceptability of baked chicken (n=123 panelists), fried chicken (n=125 panelists), and fajita meat (n=127 panelists), randomized complete block designs with two replications were used to determine the impact of strain and severity on acceptability.

Results: For baked chicken, SEV breasts were chewier, juicier, crunchier, and more cohesive (P<0.05) than NOR and MOD breast samples. For fried chicken, SEV breasts were less tender and chewier (P<0.05) than NOR breasts. In addition, SEV breasts were more cohesive and juicier, but less mushy (P<0.05) than NOR and MOD breasts. For fried chicken samples, SEV breasts were crunchier (P<0.05) than MOD breasts, which were crunchier (P<0.05) than NOR breasts. The texture and overall acceptability of NOR baked breasts and fajita meat were preferred by consumers (P<0.05) over SEV breasts. In contrast, the SEV breasts were preferred (P<0.05) over the NOR breast meat for the fried chicken formulation. No differences existed (P>0.05) in acceptability among genetic strains in baked or fried chicken breasts. The baked chicken consumer panelists were divided into 7 distinct clusters based on their sensory evaluation ratings. Cluster analysis indicated that 49% of panelists preferred NOR breast fillets, 21% preferred SEV, and 30% had no preference between NOR and WB (MOD, SEV) samples. The fried chicken consumer panelists were divided into 5 clusters, of which 65% preferred WB (MOD, SEV) over NOR, 29% preferred strain B over strain A, and 11% preferred strain A over strain B. The fajita chicken meat consumer panelists were divided into 5 clusters, of which 75% of panelists liked NOR breast samples, 72% liked MOD samples, and 45% liked SEV samples.

Conclusion: Results indicated that WB severity had a greater impact on sensory attributes and consumer acceptability than genetic strain. Higher WB severity created an undesirable texture that negatively impacted the acceptability of baked meat. However, the increased crunchiness and cohesiveness due to woodiness had a positive impact on the fried chicken acceptability. Results indicated that a large percentage of consumers rated baked, fried, and fajita samples as acceptable regardless of whether NOR or WB (MOD, SEV) meat was used, but some consumers did not like baked or fajita meat that was made from SEV WB meat.

Keywords: Chicken Breast, Cluster Analysis, Cooking Methods, Descriptive Analysis, Meat Quality
**LIPID OXIDATION AND COLOR STABILITY OF SPICED AND UNSPICED PORK SAUSAGE WITH A NOVEL ANTIOXIDANT MIXTURE OF ROSEMARY EXTRACT AND PHOSPHOLIPASE A2**

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**Objectives:** The objective of this study was to measure the loss of redness and onset of lipid oxidation in pre-rigor pork sausage containing synthetic antioxidants (Syn) compared to rosemary extract (R), and a combination of R with different concentrations of phospholipase A2 (R+P) over both light display and frozen storage.

**Materials and Methods:** Our work examined pre-rigor spiced and unspiced pork sausage. Tissue from sows for both spiced and unspiced sausage was coarse ground and cooled to 1-3°C with dry ice within one-hour post-exsanguination. Water, treatments and seasonings were added, and the sausage stuffed within two hours post-exsanguination for spiced sausages. Water and treatments were added 24 hours post-exsanguination for the unspiced sausage. Sausages were stored in the dark at -20°C (to 110 and 245 days for unspiced and spiced, respectively) prior to light display. Sausages were sampled for color and lipid oxidation on approximately 40-day intervals of -20°C dark storage and 7-9 days of light display (5°C).

In spiced sausage, R (type HT-P) was added at 200 ppm, PLA2 was added at 0.4 ppm. Butylated hydroxyanisole (BHA), propyl gallate (PG) and citric acid (CA) were each added at 0.01% of the estimated fat and collectively formed the Syn treatment. Spices consisted of sucrose, ginger, coriander, nutmeg, white pepper, and MSG. In unspiced sausage R was added at 200 ppm, PLA2 added at 0.4 ppm and 10 ppm, and BHA, CA and PG added at the same levels as in spiced sausage. Color stability was measured based on redness (a*). Peroxide values (PVs) were measured spectrophotometrically, headspace hexanal was measured via gas chromatography (GC) and alpha tocopherol depletion was measured with HPLC fluorescence detection as markers of lipid oxidation. Total lipids were fractionated to gravimetrically quantify neutral lipids, free fatty acids and polar lipids and to measure PVs in the aforesaid fractions. Unspiced sausages were only stored for 110 days because of rampant lipid oxidation and loss of color.

**Results:** In spiced sausage, R and R+P displayed better color stability than both the control (no antioxidant, C) and Syn. Syn displayed the lowest hexanal values. R had the highest PVs and both Syn and R+P were significantly lower. Free fatty acids were the most heavily oxidized fraction on an oil basis, while neutral lipids were the most oxidized lipid on a weight basis. Alpha tocopherol did not deplete through 245 days in spiced sausage but was not detected in the unspiced sausage.

In unspiced sausage, R+P was examined at two different levels (0.4 ppm and 10 ppm PLA2). R+P (10 ppm) exhibited lower headspace hexanal than R alone and R+P at both levels performed as well as Syn. In addition, R+P at both levels displayed significantly better color stability than R alone and was as good as Syn.

**Conclusion:** In conclusion, R+P decreased lipid oxidation (compared to R) and enhanced color stability (compared to R) and offer an alternative to synthetic antioxidants in pre-rigor pork sausage. Furthermore, spiced pork sausage displayed mean redness values above 9 through 245 days, compared to only 75 days in unspiced sausage.

**Keywords:** Antioxidants, Color, Lipid oxidation, Pork sausage
THE IMPACT OF SELECTION USING RESIDUAL AVERAGE DAILY GAIN AND MARBLING EPDS ON GROWTH PERFORMANCE AND CARCASS TRAITS IN ANGUS STEERS

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Objectives: Profitability in the beef industry has narrow margins regulated by revenue from output traits like growth and carcass merit, but profitability is also largely impacted by input expenses like feed costs. Selecting for improvements in feed efficiency during the finishing phase, one of the most feed intensive segments of the industry, can help to mitigate those input costs. This study compared growth performance, feed efficiency, body composition, and carcass characteristics in Angus steers (n=321) from bulls divergently selected for feed efficiency and marbling.

Materials and Methods: Angus sires were selected based on high (10th percentile or better) and low (85th percentile or worse) residual average daily gain (RADG) EPD as well as high (5th percentile or better) and average (near 50th percentile) marbling (MARB) EPD. These criteria resulted in a 2x2 factorial design with four breeding lines: high RADG/high MARB, high RADG/average MARB, low RADG/high MARB, low RADG/average MARB. Data were analyzed using MIXED procedures of SAS with RADG and MARB as main effects. Significance was set at α=0.05. Generation was also analyzed, where generation one (GEN1) steers were from a selected sire while generation two (GEN2) steers were from a selected sire and a selected dam.

Results: Ultrasound and carcass data revealed no differences (P≥0.12) in 12th rib backfat thickness from weaning through slaughter for the RADG EPD groups. Yield grade and dressing percent did not differ (P≥0.56) across RADG or MARB groups. At the beginning and end of the feeding trial, the high RADG (P≤0.02) group had larger ultrasound ribeye area (REA) than the low RADG group. Carcass REA tended (P=0.08) to be larger in the high versus low RADG steers. During the feedlot trial and through slaughter, body weight was heavier (P≤0.006) for the high versus low RADG steers but did not differ (P≥0.44) across MARB EPD. Feed efficiency measures did not differ (P≥0.32) across RADG or MARB groups apart from the tendency (P=0.08) for residual feed intake to be lower in the high versus low RADG steers. Marbling scores differed (P≤0.04) across RADG and MARB groups with the low RADG steers and the high MARB steers having improved marbling. The quality grade distribution across MARB EPD revealed that the average MARB steers graded 73% Choice and 25% Prime while the high MARB steers graded 56% and 42%, respectively. Slice shear force did not differ (P≥0.32) across RADG or MARB EPD. Body weights tended (P=0.06) to be heavier at the start of the feeding trial for GEN1 versus GEN2 steers. Total gain, average daily gain, and feed to gain (F:G) differed by generation (P≤0.007) with increased rates of gain and reduced F:G in the GEN2 versus GEN1 steers. Body weights did not differ (P=0.72) across GEN at the end of the feeding phase. Backfat thickness at the start and end of the feedlot phase was less (P≤0.03) and marbling score was improved (P=0.02) in the GEN2 versus GEN1 steers, respectively.

Conclusion: These results suggest that selection using RADG EPD has negligible impacts on meat quality; and that progress in selection for efficiency can be achieved while advancing carcass quality and value. Furthermore, continued divergent selection for feed efficiency and marbling has the potential to improve feed efficiency through advancements in the rate of gain, while enhancing carcass merit through marbling.

Keywords: Angus, Feed Efficiency, Marbling, Residual Average Daily Gain, Residual Feed Intake
Objectives: This study was aimed to determine postmortem color of longissimus muscle in pork carcasses at various anatomical locations from the anterior to the posterior of the pork loin.

Materials and Methods: Six gilts at market weight were harvested at the Mississippi State University Meat Science and Muscle Biology Laboratory. The right loins were separated from the shoulder by making a straight cut between the 2nd and 3rd ribs, from the ham by making a straight cut from through two ventral points, 1.2 cm from the tenderloin and 2.5 cm from the longissimus muscle. The loins were then cut into 19 2.5-cm bone-in chops to expose the longissimus muscle and then allowed to bloom for 2 hr. The chops were identified by the distance of their anterior surfaces to the anterior surface of the loins from which they were cut. Color of the longissimus muscle (L*, a*, b*, and reflectance spectra) was measured by a Hunter Lab MiniScan 4500L spectrophotometer (Hunter Associates Inc, Reston, VA) with illuminant A, 10° observer angle, and 25-mm aperture size on the anterior surface of the pork chops. Hue angle, chroma, and percentages of deoxymyoglobin, oxymyoglobin, and metmyoglobin were also calculated. Differences in color at 19 locations, Pearson’s correlation coefficients among color measurement, and prediction models for color parameters by location (cm) were determined by the MIXED procedure of SAS 9.4 (SAS Institute, Cary, NC) using the linear mixed model with distance or location being the fixed effect and loin being the random effect. The coefficients of determination were estimated by the covariance parameters and the F values for fixed effects, which are the ratios of fixed effect variance to the residual variance.

Results: Location had a great effect on the lightness, redness, and percentages of deoxymyoglobin and oxymyoglobin in longissimus muscle ($P \leq 0.028$). Lightness from location 0 to 9 followed a quadratic relationship with distance (lightness $= 54.75 + 1.26 \times \text{distance} - 0.05 \times \text{distance}^2$; $R^2 = 0.97$; $P < 0.001$) and had a positive correlation with hue angle ($r = 0.83$; $P < 0.001$). Redness from location 0 to 18 followed a quadratic relationship with distance (redness $= 22.19 - 0.24 \times \text{distance} + 0.005 \times \text{distance}^2$; $R^2 = 0.99$; $P < 0.001$) and had a positive correlation with oxymyoglobin percentage ($r = 0.52$; $P < 0.001$) and chroma ($r = 0.93$; $P < 0.001$). The oxymyoglobin percentage was greatest at the anterior (1 – 5; 69 to 73%) and least at midpoint of the loin (10 – 13; 63 to 65%; $P < 0.001$); whereas the percentage of deoxymyoglobin was opposite ($P < 0.001$). No location effect was found for metmyoglobin percentage ($P = 0.137$).

Conclusion: Anatomical location has a great impact on the color of the longissimus muscle, which is important for the evaluation of pork quality.

Keywords: hog, loins, Longissimus muscle
INFLUENCE OF COOK METHOD AND DEGREE OF DONENESS ON BEEF FLAVOR ATTRIBUTES IN ROUND STEAKS
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Objectives: It has been well established that cooking method, marbling level, and cooked internal temperature endpoint affect beef flavor, the most important driver of consumer acceptance. However, beef cuts respond differently to cooking method and cooked internal temperature endpoint based on their inherent chemical characteristics.

Materials and Methods: Treatments were: beef cuts (inside round, bottom round, and eye of round); USDA beef quality grade (upper two-thirds Choice and Select); cooking methods (pan grill, stir fry, stew no marinade, stew marinade, and roast); and internal cook temperature endpoints (58°C, 70°C, and 80°C). The pan grill cook method included 0.25 and 0.75 in samples from each muscle type. The stir fry cook method treatment was limited to 0.25 in cuts, which were cut into 1.00 in strips prior to cooking. The marinated and non-marinated stew cook method treatments included 0.25 and 0.75 in samples from each muscle. These samples were then cut into 0.25 x 1.00 x 1.00 in and 0.75 x 1.00 x 1.00 in samples prior to cooking. Stew marinated samples were marinated with 118 mL water, 90 mL lemon juice, 30 mL canola oil, 5 mL salt, and 2.5 mL pepper. Two lb roasts were cut from bottom round and eye of round subprimals and inside round subprimals were cut into 2.00 in roasts prior to cooking. An expert descriptive beef flavor and texture attribute panel evaluated each sample using 16-point scales for flavor and texture attributes. Warner-Bratzler shear force (WBSF) were determined. The trained panel results and WBSF values were analyzed using Proc Means and Proc GLMMIX procedures of SAS (version 9.4, SAS Institute, Cary, NC) with a predetermined alpha of 5%.

Results: Quality grade impacted flavor for the inside round (P < 0.05). USDA quality grade had minimal effect on tenderness as expected, as beef round cuts are highly active muscles in the animal and contain considerable amounts of connective tissue. Cooking method and internal cook temperature endpoint, or cooking time for the stewing cooking treatment, impacted beef flavor to a greater extent (P < 0.05). When pan fried, thicker cuts resulted in more positive flavor attributes. For cuts that were roasted, cooking to higher internal temperatures resulted in higher levels of beef identity, roasted, and umami flavors and less serumy/bloody flavors, as well as decreased tenderness (P < 0.0001), especially in inside round roasts. Marinated round cuts were more tender than their non-marinated counterparts (P < 0.0001). Cuts that were thinner and had longer cooking times were more tender but had more off-flavor attributes (P < 0.05).

Conclusion: Cut thickness, cooking method, length of cooking or internal cook temperature endpoint, and presence of marinade affected flavor and texture of bottom round, eye of round, and inside round cuts. This data will be useful in providing consumer and food service personnel recommendation on how to maximize the flavor and texture of beef round cuts.

Keywords: beef flavor, Beef round, Bovine myology, Descriptive Analysis, sensory evaluation
74- FLUCTUATIONS IN THE MICROBIAL COMMUNITY AND THE VOLATILE ORGANIC ACIDS CREATED DURING AEROBIC STORAGE OF GROUND BEEF

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Objectives: Degradation due to microbial and chemical mechanisms occurs throughout the storage life of ground beef. These pathways are intertwined and the microbial community and the volatile organic acids (VOCs) that evolve in ground beef are dynamic. Evaluation of microbial growth using traditional culture-dependent techniques can be misleading due to the presence of unculturable organisms. Therefore, utilizing culture-independent techniques allows for a more thorough understanding of the microbial community within a meat matrix during storage life. The objective of this study was to employ 16s rRNA amplicon sequencing and VOC identification using GC-MS to explore diversity and changes of the microbial community and VOC production during shelf-life of ground beef.

Materials and Methods: Finely ground beef (80/20) was procured from beef processing facilities in the West (one lot) and Midwest (two lots). The lots were separated into three physically separate replicates. Ground beef lots were transported in chub packaging to Colorado State University (Fort Collins, CO), and the chubs were stored in the dark at 2°C for either 16/17 days or 23/24 days. After dark storage, chubs were reground, and 454g fluff packs were placed on polystyrene trays before overwrapping with polyvinyl chloride film. The trays were placed in retail display cases maintained at 2-4°C for five days. Samples were collected every day of retail display for evaluation of the microbial community and VOC development. Following standardized extraction, 16S rRNA amplicon sequencing was used to explore microbial communities. Sequencing data were analyzed using the programs in the QIIME2 (version 2018.4) pipeline. Similarly, volatile organic compounds were extracted prior to analysis of targeted VOCs using a GC-MS. The project was designed as a split-plot design and was analyzed using R packages (version 3.4.3), lme4, lmerTest, and emmeans. Least squares means were separated using an alpha of 0.05.

Results: The top orders of bacteria found in the meat samples were from Enterobacteriales, Lactobacillales, and Pseudomonadales. No differences (P≥0.05) in Faith’s Phylogenetic Diversity Index, or a measure of diversity of the bacterial species within a sample, were observed between days 0, 2, and 4 of retail case display. A targeted analysis identified eighteen VOCs associated with ground beef spoilage. In previous studies, the presence of hexanal, acetoin and acetic acid are identified as spoilage indicators. Hexanal, Acetoin and acetic acid increased (P≤0.05) over the five days of retail display.

Conclusion: The use of 16s rRNA amplicon sequencing technology is a relatively recent tool that has rapidly advanced the study of microbial deterioration during beef storage and shelf-life. Moreover, the combination of 16s rRNA amplicon sequencing and identification of VOCs in this study, afforded an exploration of the relationship between chemical and biological changes which occur during ground beef storage. These analytical technologies, when used in unison, can highlight the dynamic relationships and evolution of chemical and biological constituents in ground beef. Further research in ground beef shelf-life should incorporate such measures.

Keywords: 16S rRNA sequencing, GC-MS, ground beef, quality, Shelf life
Objectives: The objective of this study was to evaluate the effects of extended wet-aging on the beef flavor profile of grass and grain-fed Australian strip loins.

Materials and Methods: Strip loins (HAM 2140) were collected from grass and grain finished cattle (n=50) at a commercial abattoir near Brisbane, Australia. Subprimals were portioned into sections and assigned randomly to 1 of 3 postmortem aging periods (45, 70, or 135 d). Portions were individually vacuum packaged and shipped refrigerated (0-4°C) to Texas Tech University in Lubbock, TX. Upon arrival, the strip loin sections were sorted into respective aging groups of 45D, 70D, and 135D and stored at 1-2°C. On each respective day, sections were fabricated into 2.54-cm steaks, vacuum packaged and frozen (-21°C). Electric clamshell grills were used to cook thawed (held at 2-4°C for 24 h) steaks to a medium degree of doneness (71°C); cooked temperatures were recorded. Steaks were cut into cubes and evaluated by trained panelists (n=6) for descriptive sensory attributes using a 100-mm anchored line scales (0 = slight, 50 = moderate and 100 = strong).

Results: The sour flavor was the only trait where an interaction between diet and postmortem aging was detected ($P < 0.01$). Samples aged 135 d from both grass and grain were similarly ($P > 0.05$) scored with a stronger ($P < 0.05$) sour flavor than all other treatment combinations, which did not differ ($P > 0.05$). Aging impacted ($P < 0.01$) beef flavor ID, liver-like, metallic, rancid, green-hay, umami, and bitter flavors, as well as overall juiciness and overall tenderness. For beef flavor ID, 45D aging resulted in the greatest intensity ($P < 0.05$), while 70D samples were intermediate, and 135D samples were the least intense. For liver-like, metallic, rancid, green-hay, and bitter flavors, 135D samples had the strongest flavor, while 70D samples were intermediate, and 45D samples had the weakest flavor intensity ($P < 0.05$). For umami, 45D samples had stronger ($P < 0.05$) umami flavor than 135D samples, but 70D samples did not differ from either 45D or 135D ($P > 0.05$). Panelists rated 70D and 135D samples juicier ($P < 0.01$) than 45D samples, but 70D and 135D did not differ ($P > 0.05$). For overall tenderness, panelists rated 135D samples more tender ($P < 0.05$) than 45D and 70D, which were similar ($P > 0.05$). Diet impacted ($P < 0.05$) bloody/serumy, liver-like, green-hay, and bitter flavors. For bloody/serumy and liver-like, the grain fed treatments resulted in greater ($P < 0.05$) flavor intensity than grass fed treatments. However, grass fed samples had stronger ($P < 0.05$) green-hay and bitter flavors compared to grain fed samples. Diet and aging had no effect ($P > 0.05$) on fat-like or sweet flavors.

Conclusion: Extending postmortem aging of Australian beef strip loins from 45 to 135 d resulted in decreased beef and umami flavors, along with concurrent increased detection of off-flavors, such as liver-like, rancid, and sour. Diet influenced fewer flavor traits than postmortem aging, but grass-fed samples still had stronger green-hay flavor, as would be expected. Based on these results, aging beef strip loins 135 d is not recommended based on reduced beef flavor and increased off-flavor detection.

Keywords: beef, flavor, wet aging
**Influence of Beef Production System Technology on Calpain-1 Autolysis and Troponin-T Degradation**

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**Objectives:** Beef production systems utilize implants and beta-agonists to improve beef cattle feed efficiency and promote muscle growth. Warner-Bratzler shear force values can be greater in strip loin steaks from cattle treated with implants or beta-agonists. Calpain-1 degrades myofibrillar proteins post-mortem, thus altering calpain-1 activation or autolysis which can influence meat tenderness and proteolysis. The objective of this study was to determine the impact beef production system technologies on calpain-1 autolysis and troponin-T degradation as an indicator of tenderness formation and postmortem proteolysis.

**Materials and Methods:** From a larger study, beef striploins (n=16, n = 4/treatment) from cattle finished utilizing four different production systems were collected for analysis: 1) no antibiotics (NA; receiving no technology); 2) non-hormone treated cattle (NHTC; fed 300 mg monensin and 90 mg tylosin during the finishing phase); 3) implant (IMPL; same technologies as NHTC and administered a series of three implants including a low-potency calf implant [36 mg zeranol], a moderate-potency initial feedyard implant [80 mg trenbolone acetate and 16 mg estradiol], and a high potency finishing implant [200 mg of trenbolone acetate and 20 mg estradiol]; and 4) all previous technologies plus fed a beta-agonist (IMBA; same technologies as IMPL and fed 200 mg ractopamine hydrochloride per steer per d). Striploins were vacuum packaged, aged for 7 d, and frozen. Western Blots were conducted for calpain-1 autolysis and troponin-T degradation (30 kDa). Abundance of calpain-1 bands and troponin-T degradation product was normalized by a reference on each gel. Treatments were evaluated in PROC MIXED of SAS 9.2 where least squares means and SEM were computed and separated using least significant differences (PDIFF) when tests for fixed effects were significant at \( P < 0.05 \) and trending \( P \leq 0.10 \).

**Results:** Calpain-1 autolysis differed \( (P<0.05) \) in the IMPL group compared to the NHTC group for both active, 78 kDa band, and the fully autolyzed, 76 kDa band. The IMPL group had a greater percentage \( (P=0.0048) \) of active calpain-1 and a lower percentage \( (P=0.0048) \) of fully autolyzed calpain-1 compared to the NHTC group. Also, a trend was detected when comparing both the active, 78 kDa band, and fully autolyzed, 76 kDa band, in the IMBA and IMPL group where the IMPL group had a greater percentage \( (P=0.0727) \) of active calpain-1 and a lower percentage \( (P=0.0727) \) of fully autolyzed calpain-1. Production system did not influence \( (P>0.05) \) 30 kDa troponin-T product abundance.

**Conclusion:** These data indicate level of technology may play a role in the activation and autolysis of calpain-1 from the 80 kDa inactive form to the 78 kDa active product and finally to the 76 kDa autolyzed product. Calpain-1 autolysis was not measured; however, these data suggest calpain-1 autolysis in the IMPL group may be limited compared with NHTC and IMBA groups. Consequently, calpain-1 may remain in the 78 kDa active form in the implanted cattle, actively degrading myofibrillar proteins. However, production system did not influence troponin-T 30 kDa degradation products. Further analysis of the rate of calpain-1 autolysis and troponin-T degradation at different days of postmortem aging could provide further evidence that different beef production technologies impact calpain-1 autolysis and postmortem proteolysis.

**Keywords:** beef production, beta agonist, calpain, implants, troponin-T
EFFECTS OF PYRUVIC ACID, SUCCINIC ACID, AND OREGANO ESSENTIAL OIL ON SALMONELLA, NATURAL MICROFLORA, AND QUALITY OF RAW GROUND CHICKEN

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Objectives: The growing stringency of regulations related to pathogens in raw poultry and increasing consumer demand for more natural food ingredients makes it imperative to explore alternative antimicrobial agents. The aim of this study was to assess the anti-Salmonella effect of combinations of succinate or pyruvic acid with oregano essential oil in raw ground chicken. Additionally, their effect on natural microflora and quality of ground chicken over simulated retail display was evaluated.

Materials and Methods: Nalidixic acid (NA) adapted Salmonella Typhimurium was inoculated on skin-on broiler breast meat pieces. The antimicrobial treatments given to meat were 2 and 3% pyruvic acid (PA) or monosodium succinate (SA) in combination with 0.5% essential oil (EO). Agar at the concentration of 0.05% was added to water used to prepare antimicrobial solutions to disperse the essential oil. Mode of antimicrobial treatment was 30 s dip. The meat was then ground and evaluated for pathogen reduction. Data were analyzed using 1-way ANOVA. Surviving Salmonella were recovered on XLT-4 with 50 ppm NA. Non-inoculated meat was similarly treated with antimicrobial dip and ground. Ground chicken was packaged in foam trays with PVC overwrap, and evaluated for mesophilic aerobic plate count (APC), psychrotrophic count (PC), pH, instrumental color (CIE L*, a*, and b*), and expressible moisture over 8 days of simulated retail display. A factorial design was assigned to the experiment with antimicrobial treatments and display days as the fixed effect factors. Data were analyzed using a mixed general linear model that considered replicates as a random effect in addition to the mentioned fixed effects. All trials were conducted in three replicates.

Results: Maximum reduction obtained in Salmonella counts from ground chicken was 1.52 log CFU/g and 0.98 log CFU/g, resulting from 3% SA + 0.5% EO, and 3% PA + 0.5% EO, respectively. Three percent SA + 0.5% EO treatment resulted in ground chicken with ca. 1.2 log CFU/g lower APC on day 8 that was significantly lower (P<0.05) than all other treatments. This treatment also resulted in less pH variation over the entire shelf life duration and lighter color of ground meat on day 8.

Conclusion: These results indicate that combination of monosodium succinate and oregano essential oil provides effective reduction of Salmonella and improved raw quality of ground chicken. This antimicrobial combination can be employed as a clean label ingredient for raw chicken applications.

Keywords: essential oil, ground chicken, organic acids, Salmonella
EFFECTS OF DIVERGENTLY SELECTED BROILER LINES FOR MEAT COLOR ON PSEUDOMONAS GROWTH UNDER SIMULATED RETAIL DISPLAY

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Objectives: Selection of broilers based on \( L^* \) values have affected the meat pH of broiler breast meat. The objective is to determine if the selection of \( L^* \) values have affected \textit{Pseudomonas} ssp. growth under simulated retail display.

Materials and Methods: Broilers from the 13th generation of three different lines (n=30/line) selected for high \( L^* \) (HMC), low \( L^* \) (LMC) and a random bred control (RBC) were harvested at 7 weeks of age. Carcasses were weighed and deboned after a 4 h postmortem (PM) chill. Parts were weighed to determine parts yield based on chilled carcass weight. Meat pH was determined 24 h PM and 24 h drip loss was determined. Split breasts were weighed, packaged, displayed under simulated retail conditions, and sampled on display days 0, 1, 2, and 3 for instrumental color and microbial count of \textit{Pseudomonas} ssp.

Results: Chilled carcass weight was greater \((P<0.05)\) in the HMC and RBC lines than the LMC line. Percent yield of breast, wing, leg and rack were not different \((P>0.05)\) among the three lines. The LMC and RBC lines had greater \((P<0.05)\) tenderloin yield compared to the HMC line. The LMC line had greater \((P<0.05)\) meat pH followed by the RBC line and then the HMC line. The HMC line had greater \((P<0.05)\) \( L^* \), \( b^* \) and hue values followed by RBC line and then LMC line. The LMC line had greater \((P<0.05)\) \( a^* \) values and oxymyoglobin ratio followed by RBC line and then LMC line. There was no difference \((P>0.05)\) in chroma among the three lines. After 24 h PM, the HMC line had more \((P<0.05)\) percent drip loss than the LMC and RBC lines but there was no difference \((P>0.05)\) in package drip loss from the start of simulated display to end of simulated display among the three lines. On each display day, the LMC line had increased counts of \textit{Pseudomonas} ssp. compared to the RBC and LMC lines. Counts of \textit{Pseudomonas} ssp. was similar between RBC and LMC lines on display days 0, 2 and 3 with RBC line having increased counts on display day 1 compared to the HMC line. There was a weak correlation \((r=0.12)\) between meat pH and counts of \textit{Pseudomonas} ssp.

Conclusion: Selection for \( L^* \) affected chilled carcass weights and percent yield of tenderloins, but not any other part yields. The growth of \textit{Pseudomonas} ssp. is affected by the lines selected for \( L^* \) but the relationship of meat pH and the growth of \textit{Pseudomonas} ssp. is weak.

Keywords: Broiler breast meat, Meat Color, pH, spoilage
QUALITY DIFFERENCES IN WOODEN BREAST MEAT MARINATED WITH COMMERCIAL INGREDIENTS
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Objectives:
Wooden breast (WB) is a Pectoralis major muscle myopathy that impacts the quality of broiler breast meat, which is a current significant challenge for the poultry industry. While WB has been thoroughly researched in recent years, there has not been a resolution to this issue. Therefore, it is necessary to explore potential solutions to mitigate the undesirable characteristics of WB. The objective of this research was to evaluate differences in quality between chicken breasts classified as normal (NOR), moderately woody (MOD), and severely woody (SEV) that were marinated with control (water), traditional (sodium phosphate and salt), or clean label (potassium carbonate and salt) marinades.

Materials and Methods:
Chicken breasts from broilers were graded NOR, MOD, SEV based on the severity of WB (Tijare et al., 2016). Breasts were sized to 30 ± 2 mm to control variability in breast thickness. Three separate treatment marinades were applied to 40 lb batches of each WB severity 24 h postmortem. Treatments were tumbled for 30 mins at 12 rpm under vacuum (20-25 mmHg). Tumble yields were measured. The breasts were individually frozen in a CO2 cabinet to -62.2°C and stored at -17.8°C. A 3 × 3 factorial structure within a randomized complete block design with 3 replications of 40 lbs (day 1, day 2, day 3) were used to evaluate the impact of marinade (control, traditional, clean label) and WB severity (NOR, MOD, SEV) on tumble yields. Similarly, a 2 × 3 factorial structure was used to analyze the effect of marinade (traditional and clean label) and WB severity (NOR, MOD, SEV) on sensory attributes.

Results:
When averaged over WB severity, the clean label marinade had a greater tumble yield (P<0.05) than the traditional marinade. When averaged over marinade, the NOR had a greater tumble yield (P<0.05) than the MOD and SEV treatments, which did not differ from each other (P>0.05).

Descriptive sensory results revealed that both marinated SEV were crunchier and less tender (P<0.05) than MOD and NOR, and MOD was less tender (P<0.05) than NOR. The clean SEV was chewier (P<0.05) than all MOD and NOR treatments, but the traditional SEV was only chewier (P<0.05) than the NOR. Interaction was significant (P<0.05) for mushy, initial juiciness, and overall juiciness. These attributes differed (P<0.05) for WB severity but not marinade treatment. When averaged over marinade, NOR was mushier than the MOD, which was mushier than the SEV, and the SEV and MOD were juicier than NOR.

Consumer acceptability results indicated that clean and traditional SEV were less acceptable (P<0.05) than MOD and traditional NOR; no difference (P>0.05) existed between MOD and NOR for both marinades. In addition, when averaging over WB severity, the traditional marinade was preferred (P<0.05) over the clean label marinade. Thus, differences in WB severities were more apparent in the clean label than the traditional marinade, which indicates that even though the clean label samples were tender, it may not be advisable to utilize that marinade formulation in place of traditional marinades with SEV woody breast meat.

Conclusion:
The use of salt and sodium phosphate or potassium carbonate in a marinade improves eating quality characteristics of MOD and SEV woody breast. However, differences remain between NOR and SEV in tenderness, gumminess and crunchiness that negatively impact the consumer acceptability of broiler breast meat.

Keywords: Consumer Preference, Marination, Meat Quality, Tumble Yield, Wooden Breast
Objectives: The objective of this study was to investigate the effects of extended wet ageing on the flavor characteristics, of grass and grain fed Australian beef lumbarum thoracis.

Materials and Methods: Cube rolls (HAM #2244) were collected from grass and grain fed cattle (n=30) at a commercial abattoir near Brisbane, Australia. Cube rolls were vacuum packaged and shipped under refrigeration (0-2ºC) to Texas Tech University. Each cube roll was cut into 2.5-cm steaks and labelled according to position from posterior to anterior end. Steaks were vacuumed packaged, stored through the appropriate postmortem ageing period (35, 45, 55, or 65 d postmortem), and then frozen until further analysis. One steak from each cube roll was used for trained descriptive flavor analysis with 8 trained panelists comprised of mostly graduate students from Texas Tech University. Flavor attributes of cooked steaks were scored using 100-point anchored line scales (0 = none, 50 = moderate and 100 = strong).

Data were analyzed used PROC GLIMMIX of SAS with diet, postmortem ageing, and their interaction as fixed effects and panelist as a random effect. Final temperature was tested as a covariate for all the flavor attributes.

Results: An interaction was detected only for the bitter flavor and overall juiciness (P<0.03). Beef flavor ID, fat-like, metallic, umami, and sweet were not influenced by diet or postmortem ageing (P>0.05). Ageing influenced bloody serumy flavor (P<0.05) with 45 d samples having greater flavor than 55 d samples, but not differing (P>0.05) from any other ageing period. Diet and ageing influenced rancid flavor (P<0.05), with grass fed samples having a stronger rancid flavor than grain fed samples. Samples aged 65 d had a stronger rancid flavor than 45 or 55-d samples, and 35-d samples had the lowest rancid flavor. Diet and ageing influenced grassy flavor (P<0.05), again being stronger in grass than grain fed samples. Samples aged 35 d had a weaker (P<0.05) grassy flavor than any other ageing period, which did not differ (P>0.05). Diet and ageing had an effect on liver-like flavor (P<0.05) with stronger flavors in grain than grass fed samples and liver-like flavor increasing with postmortem ageing time. Sour flavor was affected by diet only (P<0.05) with grass fed samples having stronger sour flavor than grain fed samples. Ageing had an effect on overall tenderness (P<0.05); samples aged 35 d were least tender, and samples aged 45 d were more tender than 55 d samples but did not differ from 65 d samples.

Conclusion: The results suggest that beef flavor as measured by beef flavor ID and umami were not impacted by extended ageing; however, some off-flavors grew stronger as ageing time extended. Flavor attributes such as rancid, grassy, sour were stronger in grass than grain fed samples, but grain fed has a stronger liver-like flavor. Ageing influenced both overall tenderness and juiciness, but typically not in a linear fashion

Keywords: Aging, beef, diet, flavor
INFLUENCE OF ZINC AND RACTOPAMINE HYDROCHLORIDE SUPPLEMENTATION ON BEEF CARCASS CHARACTERISTICS AND QUALITY ATTRIBUTES OF AGED RIBEYE STEAKS


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Objectives: Growth promoting technologies such as the beta agonist ractopamine hydrochloride (RAC) and nutritional practices such as increased zinc (ZN) supplementation have potential to positively impact beef cattle growth. However, the impact of these strategies (RAC and ZN) on meat quality is unclear. The objective of this experiment was to determine the extent to which ZN and RAC supplementation in the diets of finishing beef steers influence carcass characteristics and meat quality of aged longissimus steaks.

Materials and Methods: Crossbred Angus steers (~431 kg initial body weight) from a single source were fed one of four diets in GrowSafe bunks. Steers were assigned to diets based on growth potential (Gene Max gain score) and initial body weight: control (CON-NO; 30 ppm Zn (NRC requirement); n=7), ZN supplementation (SUPZN-CON; 150 ppm ZN (60 ppm ZnSO₄, 60 ppm Zn-AA); n=7), RAC supplementation (CON-RAC 300 mg/hd/d; 30 ppm Zn; n=6), and ZN supplementation combined with RAC supplementation (SUPZN-RAC; 150 ppm ZN (60 ppm ZnSO₄, 60 ppm Zn-AA), RAC 300 mg/hd/d; n=7). Zn treatments were fed for the entire 90 d trial. RAC supplementation occurred for the final 28 d of the feeding trial. At finishing weights (~739 kg), steers were harvested at a commercial processing facility. Yield and quality data were collected. Whole rib sections were collected 6 d postmortem, transported to the Iowa State University Meat Lab, and fabricated into 2.54 cm thick steaks. Temperature, pH, Hunter L, a, and b values, and proximate analysis (moisture, fat and protein) were measured at 6 d postmortem on the longissimus muscle. Pairs of adjacent steaks were vacuum packaged, aged for 7, 14, 28 or 42 d, and frozen until quality evaluation. At the completion of aging and storage; purge, pH, Hunter L, a, and b values, marbling scores, cook loss, and Warner-Bratzler Shear Force (WBS) values were measured on each pair of steaks. Data were analyzed using the PROC MIXED procedure of SAS version 9.4 with fixed effect of treatment. Initial body weight was used as a covariate for hot carcass weight (HCW) analysis. HCW was used as a covariate for analysis of ribeye area, fat thickness (FT), kidney, pelvic and heart fat percentage, yield grade, and d 6 marbling score. FT was used as a covariate for d 6 pH and temperature measurements.

Results: Supplementation of Zn and RAC resulted in a greater HCW and REA with decreased fat thickness, marbling scores, and yield grades than CON-NO. Zn only supplementation had greater redness at 6 and 7 d postmortem. RAC supplementation resulted in increased WBS values at 7, 14, and 28 but no differences were observed at 42 d aging. No differences in KPH, pH, temperature, L and b value, proximate analysis and purge were determined between treatments at any d aging.

Conclusion: The results demonstrate that supplementation of ZN and RAC increased carcass yield. However, RAC inclusion negatively impacted WBS values unless aged for greater than 28 d. The data reveal that WBS differences exist between treatments. The molecular explanations for these differences should be defined in order to understand how ZN and RAC inclusion impact tenderness development.

Keywords: Beef, Ractopamine Hydrochloride, Tenderness, Zinc
Objectives: Our objectives were to determine how hot carcass weights affected temperature decline and pH decline of carcasses, and subsequently shear force, juiciness and color of steaks.

Materials and Methods: Carcasses (n = 59) were selected at a commercial abattoir over five collection days at approximately 45 minutes after exsanguination and sorted by hot carcass weight. Carcasses were separated into light (< 363 kg), medium (363 to 408 kg), or heavy (> 408 kg) weight groups. Temperature decline was monitored with a data logger for 24 hours with one probe inserted into the longissimus muscle at approximately the 6th rib and one probe inserted directly into the center of the semimembranosus muscle. Muscle pH was measured in the longissimus and semimembranosus muscle at 0, 4, and 24 hours after carcasses were moved into chill coolers. After approximately 24 hours of chilling, ribeye area, 12th rib fat, KPH, and USDA Quality and Yield Grades were collected. Ribeye rolls (IMPS 112A) and inside rounds (IMPS 160A) were transported to the North Dakota State University Meat Laboratory and aged in vacuum packaging for 14 days. Ribeye and rounds steaks were fabricated for Warner-Bratzler shear force and color analysis. Color analysis was determined on each steak using a Minolta colorimeter after a 30-minute bloom time. A 50 g sample was collected for drip loss analysis. Data were analyzed using the mixed procedure of SAS.

Results: Longissimus muscle temperature at 4 hours was less ($P = 0.02$) in light carcasses compared with heavy weight carcasses and semimembranosus muscle temperature was less ($P < 0.001$) in light and medium weight carcasses compared with heavy weight carcasses. There were no differences in pH decline ($P \geq 0.16$) among hot carcass weight groups. There were no differences in fat thickness, KPH or marbling score ($P \geq 0.12$) among hot carcass weight groups. Longissimus area ($P = 0.0002$) was larger and USDA final yield grade was greater ($P = 0.04$) among hot carcass weight groups. There were no differences in drip loss, cook loss or WBSF in either longissimus or semimembranosus muscles ($P \geq 0.10$) among carcass groups. Color data indicated that ribeye and round steaks from heavy weight carcasses were redder than steaks from light weight carcasses ($P \leq 0.02$).

Conclusion: Hot carcass weight did not have an influence on objective measures of meat palatability traits; however, carcass weight did have an effect on color.

Keywords: beef, hot carcass weight, shear force
Objectives: Postmortem aging of fresh pork loins improves tenderness through protein degradation. Sarcomere length (SL) of postmortem muscle can vary between animals, and this could impact access and efficacy of proteinases to degrade proteins within, but not outside of the myofibril. The relationship between SL and protein degradation is not well documented in pork. Therefore, the objective of this experiment was to compare protein degradation of troponin-T with desmin and SL in aged pork loins over 21d.

Materials and Methods: Paired sides of fresh pork loins (n=20) were collected 1 d postmortem. Criteria for inclusion in the study were a pH between 5.85 and 6.10 and a visual color score (NPPC) between 3 and 4. Eight loin chops (2.54 cm) containing only the longissimus muscle were fabricated. Two chops from each pair of loins were aged for 1, 8, 14 or 21 d and immediately evaluated. After aging, chops were cooked to 68 °C and Warner-Bratzler shear force (WBSF) was measured. Whole muscle proteins were solubilized from samples at each aging period (10mM sodium phosphate, pH 7.0 and 2% wt/vol sodium dodecyl sulfate). Abundance of degraded troponin-T (30 kDa) and intact desmin (55 kDa) in the whole muscle sample was determined by immunoblotting. Abundance of troponin-T degradation product and intact desmin was normalized by a reference sample on each gel. A helium-neon laser diffraction method was used to determine SL (total of 36 SL per sample were recorded). The distance between primary diffraction bands was used to calculate SL. Correlation coefficients were determined using PROC CORR of SAS 9.4 and significance determined by P<0.05.

Results: Overall and across all days aging, SL was not strongly correlated to intact desmin (r=-0.198; P=.07) or troponin-T degradation (r=0.236; P=.04). Troponin-T degradation was not detected at d1 in any samples but overall and across all days was highly correlated with WBSF (r= -0.671; P<0.01)). Intact desmin was correlated with WBSF (r= 0.661; P<0.01). Across all samples, SL was correlated with WBSF (r= -0.445; P<0.01). Intact desmin and troponin-T degradation were correlated (r=-0.818; P<0.01).

Correlations within day of aging revealed that protein degradation was not significantly correlated with WBSF at d 1. In contrast, troponin-T degradation was correlated (P<0.01) with WBSF at 8, 14, 21 d postmortem (r= -0.733, -0.641, and -0.772, respectively). Similarly, intact desmin was correlated (P<0.01) with WBSF at 8, 14, and 21 d postmortem (r= 0.447, 0.553, and 0.824, respectively). SL was correlated (P<0.01) with WBSF at each d postmortem (r= -0.445, -0.562, -0.714, and -0.512, respectively).

Conclusion: The correlation results suggest that SL is consistently correlated with WBSF across aging periods and is more strongly correlated with WBSF early postmortem than protein degradation. After aging, troponin-T degradation and intact desmin demonstrate greater correlations with WBSF than SL. Finally, SL correlation to troponin-T and desmin were generally similar and not strong, suggesting that SL does not affect the efficacy of proteinases to degrade proteins within the myofibril differently than extra-myofibrillar proteins.

Keywords: Desmin, Pork, Sarcomere Length, Tenderness, Troponin-T
Objectives: The aim of this study was to determine the cause of why hen carcasses turn red upon freezing in contrast to meat-type male pheasants.

Materials and Methods: Hen pheasant carcasses \((n = 5)\) that were visibly red on the outside and larger meat-type pheasants \((n = 5, \text{not red})\) from the same harvest day at a commercial plant were obtained. The frozen carcasses in their original, sealed plastic bag were brought to the University of Wisconsin Meat Science Laboratory and stored in a \(-25^\circ\text{C}\) freezer prior to being semi-thawed for about 24 h \((4^\circ\text{C})\). Breast muscles \((M. \text{pectoralis major})\) were collected, cut into similar sections \((\text{approx. } 2.5 \text{ cm} \times 2.5 \text{ cm} \times 1.5 \text{ cm})\), vacuum-packaged in a Nylon/PE vacuum bag, and stored in the \(-25^\circ\text{C}\) freezer. The frozen samples were ground \((9.5 \text{ mm plate})\). Skins were trimmed of excessive fat prior to pulverization in liquid nitrogen. Instrumental color, pH, proximate composition, myoglobin content \((\text{myoglobin-based methodology, Mb})\), and muscle fiber type determination were conducted. All data were analyzed using the PROC MIXED procedure of the SAS statistical analysis software. Dependent variable means were separated \((P < 0.05)\) by pairwise comparisons using the PDIFF option.

Results: Hens exhibited greater redness \((\text{CIE } a^*, 4.87)\) and were darker \((\text{CIE } L^*, 53.33)\) than the meat-type pheasants \((\text{CIE } a^*, 4.31 \text{ and } \text{CIE } L^*, 55.74)\) on frozen/semi-thawed breast muscles \((P < 0.05)\), whereas no difference was observed in the yellowness \((\text{CIE } b^*)\) between the different pheasant types \((P > 0.05)\). The highest pH \((6.38)\) and Mb \((1.89 \text{ mg/g})\) values were obtained from the skin of the hen carcasses compared to the skin of the meat-type pheasants \((\text{pH } 6.21, \text{Mb } 1.22 \text{ mg/g})\). In addition, the breast muscle of the hens had a higher pH and Mb content. The hen skin exhibited the highest moisture and protein content as well as a lower fat content than the skin from meat-type pheasants. The intermediate fiber \((\text{IIA})\) type was the only type found in the pectoralis major muscles, regardless of the different pheasant types.

Conclusion: The results of the current study reveal that hen carcasses had more red pigmentation and exhibited significantly higher pH values, redness, and Mb level than the meat-type pheasants. In this regard, a higher pH might suggest hens were more stress-susceptible which produced the darker red meat. Also, higher ultimate pH values could protect myoglobin and hemoglobin from denaturation. A major part of the darkening might be related to the lower amount of fat within the skin which may have facilitated transparency to the darker, more red breast muscle. Genetics or production practices differences did not appear to alter muscle fiber types. Our findings suggest that the more intense red appearance may be associated with the presence of hemoglobin rather than myoglobin. Future evaluation of the effects of soaking pheasant skin with various pH solutions and scalding variations on the physicochemical properties of collagen may merit investigation.

Keywords: pheasant, meat color, darker red appearance, freezing
Objectives: To determine the effect of sire breed, Angus or Hereford, on steer offspring performance and carcass traits of predominately Angus cows.

Materials and Methods: Over six years, 342 fall-calving, mixed aged Angus and Angus-crossbred cows were bred to either Angus or Hereford sires. Cattle were housed with access to pasture at the University of Arkansas’ beef research unit. Calves were processed at birth and weaned early-to-middle of May. After weaning, steers grazed at the farm for two months before being transported to the West Texas A&M research feedlot, located in Canyon, Texas and remained there until harvest. Steers were harvested when a minimum backfat thickness of 1.0 cm was achieved. For harvest, steers were transported to a meat processing plant in Friona, Texas. Carcass data was collected for analysis. For analysis and results, steers with Angus sires were referred to as Angus steers and steers with Hereford sires were referred to as Hereford steers.

Results: Hereford steers had greater (P<0.05) birth weight than Angus steers. The adjusted weaning weight was greater (P<0.05) for Angus steers than Hereford steers. Angus steers had greater hot carcass weight (P<0.05) and ribeye area (P<0.05) compared to Hereford steers. Hereford steers had higher (P<0.05) yield grade than Angus steers. There was no difference (P>0.05) in backfat thickness between Angus and Hereford steers. Angus steers had higher(P<0.05) marbling number score than Hereford steers. The number of months from birth to harvest was longer (P<0.05) in Angus steers compared to Hereford steers.

Conclusion: Sire breed affected various carcass traits of steers from cows that were predominately Angus.

Keywords: Breed, Carcass Traits, Sire
Objectives: In chicken harvest, the post-harvest chilling process is a crucial step for food safety. Most facilities use either water immersion chilling (WC) or air chilling (AC) to rapidly cool the chicken. A holistic assessment of the consequences of each method to meat quality and shelf life is necessary to determine the impacts of each method. To address this knowledge gap, a multi-faceted project was conducted to determine how the chilling system influenced the microbial ecology and subsequent deterioration of chicken breasts.

Materials and Methods: The study was conducted using a 2x2x2 factorial design to evaluate the impacts of chilling method (AC vs WC), fabrications method (bone-in vs boneless; BI vs BL), and cold storage period (7 vs 14 days) on the microbial ecology of chicken breasts. A total of 256 chicken carcasses were used for this study. Carcasses were obtained from a commercial processing plant following dressing and a single antimicrobial treatment. Twenty carcasses were removed for sampling as warm carcasses, and the remaining 236 were divided into eight groups for processing (AC-BI, AC-BL, WC-BI, WC-BL tray-wrapped for 7- and 14-day storage). Collection time-points included: warm, post-chilling, post-fabrication, post-storage, and after 3-day retail display. Microbiome samples were collected at each sampling using a PBS rinsate. Then, samples were further processed for microbiome analysis following standard methods, sequenced for the V4 region of the 16S rRNA gene, and analyzed using the QIIME2 pipeline.

Results: There were significant differences in microbial diversity between different chilling methods, fabrications methods, and cold storage times. Both chilling methods were different from the warm carcasses based on alpha diversity metrics, though the two chilling methods were not different from each other. However, there were differences in the beta diversity between all three groups. Storage day significantly altered the faith’s phylogenetic alpha diversity but had no impact on Shannon’s alpha diversity. By both metrics, the diversity was reduced with increased length of storage, suggesting that a few organisms begin to dominate the product during dark storage. The fabrication methods also resulted in significantly different diversities when phylogenetic metrics (Faith’s, unweighted UniFrac) were used. The products that were sampled prior to dark storage, regardless of chilling method, were dominated by Enterobacteriaceae, while those that were subjected to cold storage were dominated by Pseudomonadaceae. In the stored samples, AC samples tended to have a greater abundance of Moraxellaceae and Enterobacteriaceae than WC.

Conclusion: These results suggest that different treatments of chicken breasts, including chilling, fabrication, and storage time, all correspond with changes to the product microbiome. These data will be combined with microbiology, physiochemical, nutritive, and taste and color data as well as a technoeconomic analysis to provide a deeper understanding of impacts of processing methods on poultry quality and shelf life.

Keywords: Chicken Breast, Chilling Method, Microbiome
Objectives: Whole muscle cuts from cows are often less tender than cuts from young fed beef due to increased collagen cross-linking associated with animal age. The injection of a rinse solution through the carotid artery following exsanguination has been shown to improve tenderness. The objective of this study was to compare the effect of a post-harvest rinse of an isotonic solution through the circulatory system on tenderness of steaks from cows.

Materials and Methods: Cows (n = 28) were randomly assigned to carcass treatments. The carcass treatments consisted of non-rinsed control (n = 14) and a rinsed (n = 14) treatment, where a chilled isotonic solution (MPSC, Inc., St. Paul, MN) was rinsed through the carotid artery and veins following exsanguination. The isotonic solution consisted of water, glucose, maltose and phosphates. Both control and rinsed treatments were electrically stimulated. At two days postmortem, strip loins were removed from one side of each carcass. Strip loins were fabricated into 2.54 cm steaks at 3 d postmortem and objective color measurements (L*, a* and b*) were recorded on a single steak after a thirty-minute bloom period. Steaks were vacuum packaged and aged at 4 °C for 7, 14, and 21 d. Following aging, steaks were frozen (-20°C) for future analysis. Warner-Bratzler Shear Force (WBSF) was used to measure tenderness. Frozen steaks were thawed at 4°C for 24 h before cooking. Internal temperature was monitored on all steaks using a digital thermometer that was placed in the center of each steak. Steaks were cooked on an electric clamshell grill to an internal temperature of 71°C. Peak cook temperature was recorded for each steak. Following cooking, steaks were cooled at 4°C and allowed to equilibrate to room temperature (20°C). Six cores (1.27 cm) were removed from each steak and sheared perpendicular to the muscle fiber orientation. The peak force was recorded for each core and the average calculated for each steak. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Shear force data were analyzed as a repeated measure with time and treatment as fixed variables. Color data were analyzed as a completely randomized design using treatment as the fixed variable. Statistical significance was considered at an alpha of $P < 0.05$ and trends at $0.05 \leq P < 0.10$.

Results: There was no interaction ($P = 0.6068$) between treatment and postmortem aging day. Steaks from the rinsed treatment were more tender ($P = 0.0005$), than steaks in the control treatment (3.51 ± 0.168 kg vs. 4.41 ± 0.174 kg, respectively). Postmortem aging influenced ($P = 0.0310$) tenderness. Steaks aged 7 d were less tender ($P = 0.0087$) than steaks aged for 21 d (4.18 ± 0.155 kg vs. 3.72 ± 0.156 kg, respectively), while 14 day steaks did not differ ($P > 0.05$) from those aged 7 or 21 d. Objective color was not impacted by rinse treatment ($P > 0.05$).

Conclusion: These data suggest that the application of a post-harvest rinse with an isotonic solution through the circulatory system improves the tenderness of cow steaks but does not influence objective color.

Keywords: aging, circulatory rinse, cow, post-harvest, tenderness
OBJECTIVES: Consumer acceptability in meat flavor is one of the driving factors of acceptability. Many studies have found factors that affect beef flavor, but little is known about variability of major beef cuts in the retail meat case where meat is displayed, and customers can choose from.

MATERIALS AND METHODS: Four beef cuts (chuck roast, top sirloin steaks, top loin steaks, and 80/20 ground beef) were obtained from retail stores in Miami, Los Angeles, Portland, New York, and Denver within a two-month period. The study wanted a variety of samples that were from different production systems or contained certain claims that would be available to customers. The meat was shipped with dry ice and stored at -9°C. For evaluation steaks, roasts, and ground beef were thawed 24 hrs at 4°C. Prior to cooking, chuck roasts were cut 10.16X12.7cm from the center of the roast. Each ground beef sample was formulated into 3, approximately 150g patties. Chuck roasts were placed in a roasting pan on a roasting rack and 2 cups of water. Beef steaks and ground beef patties were cooked on a stovetop grill and cooked to 71°C, steaks and patties were flipped when temperature reached 35°F. Chuck roasts were cut into 1.27cm cubes with no visible connective tissue, fat, or outside browning. Steaks were cut into 1.27cm cubes with no connective tissue or fat. Ground beef patties were cut into 6 wedges. Panelists were served either 2 wedges or 2 1.27 cm samples for evaluation. An expert trained descriptive flavor and texture sensory panel was conducted where panelists evaluated beef flavors and textures. Beef flavor and texture attributes were analyzed using SAS (version 9.4, SAS Institute, Inc., Cary, NC) and principal component (PCA) bi-plots were generated using XLSTAT (Addinsoft, Inc., Long Island City, NY) using $P<0.05$.

RESULTS: Chuck roasts were associated with bloody/serumy flavor aromatics. Ground beef patties were clustered with fat-like, overall sweet, green hay, and buttery flavor aromatics. Top sirloin steaks samples were more highly associated with off flavors such as liver, cardboardy, and sour flavor aromatics. Top loin steaks were clustered with positive attributes such as umami, beef flavor identity, and brown, roasted flavor aromatics. For the PCA biplot, factor 1 accounted for 60% and factor 2 accounted for 28% of variation. Ground beef was higher ($P<0.0001$) in brown, fat like, green hay, sour milk/sour dairy, flavor aromatics, and had more salty and sweet basic taste than the other cuts. Ground beef patties had the least amount ($P<0.0001$) of bloody/serumy, metallic, and liver like flavor aromatics. Chuck roasts had the least ($P<0.0001$) beef flavor id, brown, roasted flavor aromatics and salt and umami basic taste. Sirloin steaks had the lowest ($P<0.0001$) fat like flavor aromatic and the highest levels ($P<0.0001$) of burnt and cardboardy flavor aromatics and bitter and sour basic taste. Sirloin steaks and chuck roasts had more metallic and liver like ($P<0.0001$) flavor aromatics than other cuts. Top loin steaks were intermediate in flavor attributes.

CONCLUSION: Flavor descriptive attributes of four beef cuts differed. Results indicated that chuck roasts and top sirloin steaks were associated with negative flavor attributes. Ground beef contained sweeter, fat like attributes with exceptions of green hay, while top loin steaks were associated with more positive beef flavor attributes.

KEYWORDS: None
Objectives: The objective of this study was to quantify pork quality attributes in the retail meat case nationwide. Similar evaluations were conducted in 2012 and 2015. The comparisons of the benchmarking projects show trends in pork products in nationwide retail stores.

Materials and Methods: Eighty-five stores representing 26 retailers in 15 cities were visited. Subjective color score (1-6) and subjective marbling score (1-10) on center-cut loin chops was assessed by an experienced grader under lighting of the self-serve meat case. Four individual loin chops with at least 50% lean exposed were randomly selected for evaluation from ten retail packages for each brand and enhancement type. Preference was given to boneless, 2.5 cm-thick center-cut loin chops where available. Ten additional packages of chops for each brand and enhancement type were evaluated in-store and purchased. Each of the purchased packages were labeled and each chop within a package was identified for later evaluation. The purchased packages were subsequently placed inside a cooler and transported to a temporary lab station where chops were again subjectively evaluated for color and marbling under controlled lighting and evaluated in the center of the loin muscle for instrumental color (CIE L*, a*, and b* color space values) using a calibrated Minolta Colorimeter and a Hunter Colorimeter. Chops were then vacuum sealed and immediately placed in the freezer. The samples were later packed in a cooler with dry ice and shipped to the University of Florida on dry ice. After arrival, they were placed in frozen storage until thawed for cooking and shearing. Chops were weighed prior to and after cooking on open hearth, adjustable heat grills until reaching 65 °C. then evaluated for slice shear.

Data was analyzed using the mixed procedure in SAS (v. 9.4, SAS Institute, Cary, NC). The model included enhancement type (EN or NON), and the interaction between enhancement type as fixed effects. Package nested within store, brand, and purchased (yes or no) was fit as a random effect.

Results: The USDA AMS defined “Tender” as having a minimum threshold values for slice shear as 20.0 kg and “Very Tender” at 15.3 kg, respectively. Sixteen percent of the instore evaluated and purchased retail packages were enhanced (247 and 119 retail packages, respectively). Means for instore enhanced (EN) and non-enhanced (NON) chops were 2.52 and 2.70 for subjective color and 2.25 and 2.65 for subjective marbling, respectively. Means for chops purchased for EN and NON chops under controlled lighting were: subjective color (2.07 and 2.25), subjective marbling (1.89 and 2.21), Minolta L* (56.35 and 56.86), Minolta a* (15.48 and 15.61), Hunter L (56.99 and 58.69), Hunter a (13.98 and 15.08), cook loss (13.02 and 15.64 %), and slice shear (12.68 and 15.63 kg).
Conclusion: Results indicate extensive variation for color, marbling, cooking loss and tenderness exists in the pork meat case. Enhancement continues to improve tenderness though less enhanced pork is found in the marketplace. However, regardless of enhancement, the average value for slice shear of center loin chops were quite tender.

Keywords: Benchmarking Audit, Consumer, Pork Quality, Retail Store
Objectives: The objective of this study was to determine the influence of packaging type on production of beef flavor volatile compounds.

Materials and Methods: Beef strip loins (IMPS #180) and top sirloin butts (IMPS #184) were selected from USDA Low Choice carcasses (n = 40, 20/subprimal). Seven d postmortem, subprimals were fabricated into 2.54 cm representative steaks of the Longissimus lumborum (LL) and Gluteus medius (GM). Steaks were then placed into one of four randomly assigned packaging treatments: carbon monoxide motherbag (0.4% CO/ 30% CO₂/ 69.6% N₂; CO), high oxygen modified atmosphere packaging (80% O₂/20% CO₂; HIOX), traditional polyvinyl chloride overwrap (OW), and rollstock (ROLL). Steaks designated for the OW treatment were placed in ROLL treatment until retail display. Steaks were aged in the absence of light for 14 d, then subjected to a 48-h retail display under fluorescent lighting in coffin cases. Following retail display, steaks were immediately vacuum packaged and frozen at -20°C until further analysis. Prior to volatile compound analysis, steaks were thawed at 2-4°C. Steaks were then cooked to 71°C using clamshell grills. Immediately after cooking, six 1.27 cm cores were removed, then minced using a coffee grinder. Five g of sample was weighed into a glass vial, sealed, then analyzed using gas chromatography-mass spectrometry. Compounds evaluated were chosen from major flavor pathways.

Results: Three compounds, carbon disulfide, 2-pentylfuran, and benzaldehyde elicited a packaging type × muscle interaction (P ≤ 0.048). Carbon disulfide was present in the highest concentration (P < 0.05) in CO GM and ROLL LL steaks, but was present in the lowest amount (P < 0.05) in OW GM and ROLL GM steaks. For benzaldehyde, HIOX GM steaks produced the greatest concentration (P < 0.05) compared to all other treatments, with the exception of ROLL LL, which was similar (P > 0.05). A similar trend existed for 2-pentylfuran, as high oxygen GM steaks produced over three times higher concentrations (P < 0.05) of 2-pentylfuran compared to all other treatments. Nine compounds, primarily lipid derived, were impacted by a packaging main effect (P ≤ 0.043). For 2-propanone, pentane, and hexanoic acid, methyl ester, HIOX packaging produced the greatest concentration (P < 0.05) compared to all other treatments. Additionally, HIOX steaks produced a greater amount (P < 0.05) of methanethiol than OW or ROLL steaks. High oxygen steaks produced more (P < 0.05) 1-pentanol, 1-octen-3-ol, and nonanal than CO steaks, but were similar to ROLL and OW steaks. Carbon monoxide packaging produced the greatest amount (P < 0.05) of 2,3-butanediol compared to all other treatments. Five compounds were impacted by the muscle main effect (P ≤ 0.039). The GM steaks produced a greater concentration of 2,3-butanedione (P = 0.011), 3-hydroxy-2-butanone (P = 0.002), octanoic acid (P < 0.001), and dodecanal (P = 0.021) than the LL steaks. The LL produced a greater amount of decanal (P = 0.039) than the GM.

Conclusion: These results indicate packaging and muscle each impact flavor, however, packaging effects are primarily lipid derived and muscle more readily impacts Maillard product production. Additionally, HIOX packaging produces a large amount of lipid derived compounds from degradation and oxidation, which may form the basis for its negative flavor profile. This indicates HIOX packaging should be avoided to produce more positive flavor notes in beef.

Keywords: Beef, Flavor, Gas Chromatography - Mass Spectrometry, Packaging, Volatile Compounds
Objectives: Potential applications of chicken meat with woody breast (WB) condition in further processing products could provide processors alternatives to face this meat quality problem. The objective of this study was to evaluate the effect of the use of broiler breast fillets at varying degrees of WB severity on instrumental texture characteristics of deli loaves.

Materials and Methods: A total of 270 breast fillets were collected from birds processed according to commercial practices and classified based on a scoring system for degree of hardness using tactile evaluation in three WB categories (0 or 0.5 as normal-NOR; 1 or 1.5 as mild-MIL, and 2, 2.5 or 3 as severe-SEV). Instrumental compression analysis was performed to validate subjective scores. Nine treatments with three replicates of deli loaves were prepared: 100% NOR (T1), 66.67% NOR + 33.33% MIL (T2), 66.67% NOR + 33.33% SEV (T3), 33.33% NOR + 66.67% MIL (T4), 33.33% NOR + 66.67% SEV (T5), 100% MIL (T6), 66.67% MIL + 33.33% SEV (T7), 33.33% MIL + 66.67% SEV (T8), and 100% SEV (T9). Chicken breast muscles (cranial region) separately by treatment were trimmed, cut, tumble marinated [20% (wt/wt) marinade pickup target; final product concentration of 1.25% sodium chloride and 0.45% sodium tripolyphosphate], stored, stuffed (diameter: 100 mm; length: 290 mm; 2.3 kg), and cooked (core temperature reached 75°C). Texture profile analysis (TPA: hardness, cohesiveness, springiness, and chewiness) was performed using a texture analyzer (TA.XT Plus, Texture Technologies Corp.). Additionally, cook loss, color (L*, a* and b*), and reduction in diameter and length were evaluated in cooked deli loaves. Data were analyzed using a one-way ANOVA with treatment factor fit as fixed effect.

Results: With exception to T1 through T4 treatments, the hardness of chicken loaves increased (P<0.05), whereas the cohesiveness decreased [(P<0.05) as WB severity increased in the meat added to the product formulation. Furthermore, the cook loss significantly increased (P<0.05) as WB increased in the meat incorporated into the product. The use of affected meat with WB condition at SEV levels (T9) or meat combinations at MIL and SEV levels (T7 and T8) yielded non-uniform deli loaves with higher levels of cook loss (>13%, P<0.05), different color parameters and higher levels of reduction in diameter (>8%, P<0.05) and length (>5%, P<0.05) in comparison with NOR samples. However, the mixture of non-affected meat with WB meat at MIL (up to 67%) and SEV (up to 33%) levels did not show a significant difference compared to NOR samples in terms of hardness, cook loss, color, and reduction in dimensions.

Conclusion: These data indicate that there is an important effect of the use of broiler breast fillets with WB characteristics on the texture profile of deli loaves. There is evidence of the poor functionality associated with the inclusion of WB meat in deli loaves in terms of water holding capacity, color, and texture. Although additional research is needed, the combination of breast fillets of regular quality (NOR) with those presenting WB condition at MIL (up to 67%) or SEV (up to 33%) levels could be considered by processors as an alternative in commercial chicken deli loaf formulations due to the inclusion of WB meat at higher levels can result in reduced product quality.

Keywords: Meat Quality, Poultry Products, Processing, Texture Profile Analysis, Wooden Breast
Objectives: The objective of the study was to assess the evolution of the bloom color in beef aged for 8 days to establish the moment of measurement in which values of L*, a* and b* stabilize and are representative of the characteristic color of the meat from beef fed different diets.

Materials and Methods: In the current study, eight young Pirenaica bulls were used. The bulls were born and reared on a private commercial Protected Denomination Origin (PDO)-approved farm located in the region of Navarra (Northern Spain). After weaning at approximately 4 months of age, the calves were administered the same diet until month 12. The bulls were separated in two groups and each of group was fed a different energy level diet (High energy, H: 2,914.2 kcal/kg vs Low energy, L: 2,548.4 kcal/kg) until slaughter at 18 months of age. Diet was based on barley (H: 26% vs L: 22%), corn (H: 50% vs L: 45%) and soja (H: 17% and L: 17%). The research was conducted under the highest standards of humane care and use of animals in accordance with European guidelines (EU, 2010). Longissimus dorsi muscle was removed after 24 hr. post-mortem from the left side of the carcasses, pH was measured, and the meat was transported to the Meat Science Laboratory at the Public University of Navarra (Pamplona, Spain) under refrigeration. Steaks were aged in vacuum for 8 days post-mortem, which is the typical period for this type of meat under the PDO Ternera de Navarra. After aging, L*, a*, and b* were recorded every 3 minutes (5 repetitions per sample) for 102 minutes with a Minolta CM2002 Spectrophotocolorimeter. Data were analyzed using the Linear General Model procedure with the IBM SPSS Statistics 24, and significance was determined at P < 0.05.

Results: pH values were 5.56 (H) and 5.50 (L) (P < 0.05) thus, no DFD meat was observed. Color differed depending on diet (L*H: 28.88 vs L*L: 34.26, P < 0.01; a*H: 26.33 vs a*L: 18.11, P < 0.001; b*H: 11.58 vs b*L: 7.94, P < 0.001) even if the initial pigment content was not statistically different (H: 5.34 mg/g vs L: 4.74 g/g; P = 0.107). In fact, beef from the H diet showed higher a* and b* values, and lower L* values than beef from the L diet (P < 0.05). Nonetheless, the time of stabilization for a practical color measurement did not differ between diets.

Conclusion: In conclusion, despite the effect of diet on the initial beef color differences, the results of the current study showed that 15 min of meat exposure to oxygen is the minimum in either cases prior to taking measurements of color on beef aged 8 days.

Keywords: blooming, beef, color, diet
Objectives: Prolonged photoperiod (light) is a common practice in the broiler industry to maximize feed intake, growth and yield. Several studies, however, have found negative impacts of extended photoperiod on animal welfare-related characteristics (e.g. leg abnormalities). While the previous research has primarily focused on animal growth/welfare aspects, the effect of photoperiod on functional properties and quality attributes of broiler meat has not been evaluated. Thus, this study was aimed to determine functional properties, physicochemical attributes and oxidative stability of ground meat from broilers reared under different photoperiod conditions.

Materials and Methods: Ross 308 broiler chicks (n = 432) were assigned to 4 rooms with 6 pens per treatment, which were equipped with one of the following photoperiods (T20, T18, T16, and T12; the hours of lighting per day), started from day 15. At 42 d of age, the broilers (n=12/treatment) were randomly taken, slaughtered and chilled for 24 h at 2°C. At 1 day postmortem, tenderloins and leg muscles were separated from the carcasses and stored at -40°C until further processing. In three batches, meat samples were ground using 1/4 in plate and formed into patties (100 g each). The ground samples were measured for pH, protein solubility, emulsion activity index, protein denaturation, salt-induced water uptake and subsequent cooking loss and final yield. The patties were displayed at 2°C under light (lx 1,800) and color stability, lipid oxidation (TBARS) and thiol contents were examined. The patties were also measured for purge/cooking loss and texture profile analysis (TPA). All data were analyzed using the PROC MIXED procedure of SAS (v.9.4). Means were separated using least significant differences (P< 0.05).

Results: T20 samples had the lowest sarcoplasmic protein solubility among treatments, while T18 had a lower myofibrillar protein solubility compared to other treatments (P<0.05). The emulsion activity index of T20 was higher in sarcoplasmic fraction than T12 (P<0.05). T20 group also had a lower extractable protein concentration compared to other treatments, which subsequently resulted in an increase in protein denaturation (P<0.05). T20 samples had a lower value of pH, salt-induced water uptake, and cooking loss, while T18 had a lower final yield than T16 and T12 (P<0.05). No differences in physicochemical traits of patties were found between treatments, indicated by TPA, purge and cooking loss results (P>0.05), however T20 had a greater display weight loss than T12 (P<0.05). T20 patties maintained the highest L* and hue angle values during entire display, which could be attributed to its inferior water-holding capacity (P<0.05). Both lipid (TBARS) and protein oxidation (thiol content) were increased with display (P<0.05), but no significant photoperiod effect was found (P>0.05).

Conclusion: The results from the present study indicate that extended photoperiod would result in adverse impacts on functional/technological properties and oxidative stability of broiler meat. This is the first study reporting the importance of broiler housing condition (photoperiod) and its subsequent impacts on final meat quality and processing properties. The findings would provide insights into development of mitigating strategies for the poultry industry to prevent quality deteriorations of broiler meat due to the extended photoperiod.

Keywords: broiler photoperiod, functionality, further processing, oxidative stability, physicochemical property
Objectives: Consumer research has consistently shown that consumers over-cook pork creating a subpar eating experience. In 2011, the USDA/FSIS changed the internal doneness temperature from 71.1°C to 62.8°C. However, how tenderness and water-holding capacity is affected in pork chops and roasts differing in thickness and color score cooked to 62.8°C is unknown. Understanding these relationships from chops and roasts cooked to 62.8°C is crucial to the pork industry.

Materials and Methods: Boneless and bone-in pork loins were purchased commercially on 3 selection trips to represent the National Pork Board subjective color scores of 2 and 4. The tenderloin was removed from the bone-in loins and randomly assigned to treatments. The sirloin and blade ends were removed, and bone-in ribeye chops were cut to either 1.3, 1.9 or 2.5 cm thick. Twelve chops were cut from each loin with a portion of the rib bone present in each chop. The blade end of the boneless loins was removed, and blade chops were cut to either 1.3, 1.9 or 2.5 cm. Three blade ends within color score were used to obtain 12 chops. The boneless center-cut chops were cut to either 1.3, 1.9 or 2.5 cm. Each boneless loin was cut into 12 chops. Boneless loin roasts (0.9 and 1.8 kg roasts) were cut from color score 4 boneless loins. Whole boneless center-cut loin roasts were cut into 2.7 kg roasts from the color score 2 loins. Prior to cooking, drip loss, pH and raw color were determined. Chops were then cooked to 62.8°C either by baking, grilling, pan frying, or pan-sautéing. Roasts were cooked to 62.8°C either by baking or grilling. Internal temperature was monitored by inserting an iron constantan thermocouple into the geometric center of the chop or roast. Cook yield, cook time, tenderness assessed by Warner-Bratzler shear force, and cooked internal color were determined. Each of the 24 treatments for each type of chop (2 colors x 3 thicknesses x 4 cooking methods) and the 8 roast treatments (4 weights x 2 cooking methods) were replicated 20 times.

Results: Cooking method and chop thickness affected cook yield and cook time. Baked chops had the longest cooking times and sautéed chops had the highest cook yields ($P<0.05$). Grilled chops had the highest ($P<0.05$) cook loss. The color score 4 blade and boneless chops were more tender than the color score 2 chops ($P<0.05$). However, for bone-in chops, the inverse was reported ($P<0.05$). Thickness had minimal effect on tenderness for the boneless chops ($P<0.05$). Although bone-in and boneless, baked chops had the longest cooking times, they were the most ($P<0.05$) tender. Baked whole boneless roasts had higher cook yield and longer cook times from grilled whole boneless roasts ($P<0.05$). For boneless loin roasts (0.9 kg), baked roasts had higher cook yields, longer cook times, were tougher, and had a redder internal cook color than boneless loin roasts that were grilled ($P<0.05$). Heavier boneless loin roasts had lower cook yield, longer cook times, and were tougher compared to lighter weight boneless loin roasts ($P<0.05$). Baked tenderloins had higher cook yield, longer cook times and were redder in internal color than grilled tenderloin roasts ($P<0.05$).

Conclusion: Overall, this study revealed that color, cooking method, and thickness impacted drip loss, cook yield, cook time, cooked color, and tenderness of blade, boneless, and bone-in chops, tenderloins, and roasts.

Keywords: Pork Quality, tenderness
Objectives: To determine the impact of sorting beef carcasses at the packer level by ribeye area, instead of sorting subprimals by weight, to provide more consistent products for the end user via foodservice and retail channels.

Materials and Methods: Instrument grading technology was used to select 100 USDA Choice, yield grade 2 or 3 sides, and 100 USDA Select, yield grade 2 or 3 sides. Carcass sides were sorted into one of five ribeye area (REA) categories, as outlined in Table 1.

Table 1
Ribeye area (REA) categories and associated acceptable REA ranges.

<table>
<thead>
<tr>
<th>REA Category</th>
<th>LM area (cm²)</th>
<th>Allowable range (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>77.4</td>
<td>74.8 to 80.6</td>
</tr>
<tr>
<td>2</td>
<td>83.9</td>
<td>81.3 to 87.1</td>
</tr>
<tr>
<td>3</td>
<td>90.3</td>
<td>87.7 to 93.5</td>
</tr>
<tr>
<td>4</td>
<td>96.8</td>
<td>94.2 to 100.0</td>
</tr>
<tr>
<td>5</td>
<td>103.2</td>
<td>100.6 to 106.4</td>
</tr>
</tbody>
</table>

USDA Choice carcass sides were fabricated to remove beef rib, ribeye, lip-on (IMPS 112A) and beef loin, strip loin, boneless (IMPS 180) from each USDA Choice. Beef loin, tenderloin, full, side muscle on, partially defatted (IMPS 189B) subprimals were procured from each USDA Select side. Subprimals were weighed, trimmed to specification, and passed through a 3-D visual analysis portioning machine and to obtain scan data for a variety of portioning outcomes generated by simulation software.

Results: Based on input from our foodservice collaborators, 1.25 inches (3.18 cm) was identified, for ribeye and strip loin steaks, as the targeted optimal thickness to meet consumer expectations. After evaluation of multiple portioning outcomes, it was determined that a 14.00-ounce (396.89 g) portion, for each REA category, most consistently delivered the preferred steak thickness identified previously. REA categories 1 and 2 most frequently produced desirable thickness and portion weight outcomes in ribeye and strip loin steaks. Statistical analysis of number of portions per subprimal stratified by portion weight and portion thickness revealed differences \((P < 0.05)\) across all REA area categories in both ribeyes and strip loins. As portion weight and thickness increased, steak portion number tended to decrease. In tenderloins, an optimal steak thickness of 1.75 to 2.00 in (4.45 to 5.08 cm) was identified as optimal. Most frequently, 8, 9, and 10-ounce (226.80, 255.15, and 283.50 g) portions met the targets for optimal portion weight and thickness parameters. For tenderloins, number of portions by portion weight showed significant differences \((P < 0.05)\) in all ribeye area categories with the exception of 7-ounces (198.45 g) and showed no differences when stratified by portion thickness. In this investigation, USDA Choice carcasses \((r = 0.76)\) and USDA Select carcasses \((r = 0.56)\) expressed moderate correlation between REA area and hot carcass weight.

Conclusion: Results of the present study suggest strip loin, ribeye, and tenderloin subprimals from carcasses possessing a ribeye area ranging from 74.8 cm² to 87.1 cm² offered the greatest level of utility when portioned for use in foodservice and retail sectors. Further research is warranted to continue examining the merit of sorting carcasses by ribeye area at the packer level, but results of this study suggest that there is potential for improved consistency and utility of subprimals in the foodservice and retail sectors.

Keywords: beef quality, beef utility, instrument grading, ribeye area
EFFECT OF DIFFERENT ANTIMICROBIAL APPLICATIONS ON COLOR STABILITY OF GROUND PORK

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Objectives: The purpose of the study was to evaluate color changes during dark storage of ground pork following application with one of three different antimicrobial interventions to pork trim.

Materials and Methods: Treatments included a control (no antimicrobial), lactic acid (LA; 3%), PAA+Titon™ [sulfuric acid and sodium sulfate (pH 1.3) combined with peracetic acid (350 ppm)], PAA+Acetic [peracetic acid (400 ppm) with 2% acetic acid]. Four 22.7-kg batches of pork trim were treated with one intervention, ground [coarse (3/16") followed by a fine (1/8") grind] and packaged in 454-g rollstock vacuum packaging (n=40/treatment). After random assignment to an aging time (0, 7, 14, 21, or 28 days), product was held under dark storage at 2-4°C. On each storage day, samples (n=8/treatment) were opened and L*, a*, and b* values were taken using a HunterLab Miniscan XE spectrophotometer at 0 min, 10 min, and 20 min for bloom color analysis, with hue angle [arctangent (b*/a*)] and chroma [(a* + b*)1/2] calculated from a* and b* values. For pH, 5 g of sample and 90 ml of distilled water were homogenized and analyzed with a bench top pH probe. Finally, fat, moisture, and protein percentage were determined using a FOSS FoodScan. Statistical analysis was conducted using the GLM procedure of SAS with a means separation using the Tukey adjustment and significance set at P < 0.05.

Results: Proximate analysis of the ground pork in this study showed 20.04 ± 1.13% for fat, 61.15 ± 1.11% for moisture, and 16.83 ± 0.39% for protein content. For initial pork color, at 0 min, LA had greater L* values compared to PAA+Titon™ at 0d, 7d and 14d (P < 0.05), but no treatment differences were detected in L* values at 21d and 28d (P >0.05). After ten minutes of bloom time, PAA+Titon™ maintained the highest chroma value throughout all aging days (P <0.05) demonstrating the most color intensity. At 21d PAA+Titon™ increased blooming properties through 20min (P <0.05), based on a*, while control samples had no bloom development (P >0.05). At 21d and 28d aging LA hue angle was highest (P <0.05) indicating more potential metmyoglobin discoloration. PAA+Titon™ presented the highest pH values compared to all the other treatments for each day during the storage period except for day 14, while LA presented lower values compared to all the other treatments for each day (P <0.05).

Conclusion: As an organic acid application on pork trim prior to grinding, PAA+Titon™ demonstrates positive effects on color of ground pork based on color and pH values, after post-grinding storage.

Keywords: antimicrobial, bloom color, chroma, hue angle
Objectives: Greater knowledge of variance and relationships of pork carcass parameters could be used to improve performance, efficiency, and profitability of the pork industry. Previous research has investigated the correlation between pork carcass parameters; however, there are still many misunderstandings, particularly in commercially representative pigs. Thus, the purpose of this study was to examine the correlation and variance of carcass weight, fat depth, muscle depth, and predicted lean yield in commercial pigs.

Materials and Methods: The second largest commercial pig slaughter facility in Ontario slaughtered approximately 1.5 million pigs in 2018. Carcass data (hot carcass weight, fat depth, muscle depth, and predicted lean yield) from 1,025,572 pigs was used for this study with pigs slaughtered on each production day of 2018 (between January 2, 2018 and December 31, 2018). Hot carcass weight was reported immediately following slaughter as a head-on weight, and fat depth and muscle depth were measured with a Destron PG-100 probe (International Destron Technologies, Markham, Ontario). The equation used for predicted lean yield was the Canadian Lean Yield equation (CLY (%) = 68.1863 – (0.7833 × fat depth) + (0.0689 × muscle depth) + (0.0080 × fat depth²) – (0.0002 × muscle depth²) + (0.0006 × fat depth × muscle depth). Pearson product moment correlation coefficients were calculated among all parameters using RStudio version 1.1.456 and R version 3.5.1 statistical software. Correlation coefficients were considered significantly different from 0 at P < 0.05. Correlations were considered weak (in absolute value) for r < 0.35, moderate for 0.36 ≤ r ≤ 0.67, and strong for r ≥ 0.68. Linear regression models were created between parameters that had meaningful relationships using the RStudio statistical software. Gnuplot version 5.2 was used to create scatter plots to allow for better visualization of the correlation between meaningful parameters.

Results: The mean ± standard deviation for fat depth, muscle depth, hot carcass weight, and predicted lean yield were 18.27 ± 4.12 mm, 65.69 ± 9.06 mm, 105.93 ± 8.39 kg, and 61.03 ± 1.91 %, respectively. We observed weak positive correlations between fat depth and hot carcass weight (r = 0.27; P < 0.0001), and between muscle depth and hot carcass weight (r = 0.17; P < 0.0001). We obtained a weak negative correlation between predicted lean yield and hot carcass weight (r = -0.21; P < 0.0001). The predicted lean yield equation used for this set of pigs included measurements for fat depth and muscle depth, so strong correlation between these parameters was expected. We obtained a moderate positive correlation between muscle depth and predicted lean yield (r = 0.39; P < 0.0001) and a strong negative correlation between fat depth and predicted lean yield (r = -0.96; P < 0.0001).

Conclusion: Results from this dataset revealed that hot carcass weight was generally not correlated with fat depth, muscle depth, or predicted lean yield. The conclusion of this study based on the current dataset is that pigs do not reach a weight threshold where they consistently become fatter or heavier muscled.

Keywords: commercial pork, correlation, fat depth, muscle depth, pork carcass weight
EVALUATION OF VARIABILITY OF INSTRUMENTS USED IN PORK LOIN QUALITY ASSESSMENTS

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Objectives: It has been historically proven that when measuring instrumental color, the magnitude of the color value will differ between instruments types, (i.e., HunterLab and Minolta). However, it is not known whether variability of readings within machine differs between machine type when measuring instrumental color or pH. It is also not known if pH or color values from one machine can be used to predict values from a second machine. The objectives were to 1) evaluate the effect of machine on the variability of instrumental color and pH measurements of boneless pork loins and 2) determine if color or pH measurements from one machine type can be used to predict measurements from a second machine type.

Materials and Methods: Two different sets (n1 = 253 and n2 = 294, respectively) of loins from a commercial processing facility were measured for instrumental color analysis. Loins were evaluated on the ventral face at the approximate location of the 10th rib at 22 hrs postmortem. Instrumental color was measured using a Minolta CR-400 Chroma meter equipped with a D65 illuminant, 2° observer, 8mm aperture, and calibrated with a white tile specific to the machine, but the first set were measured with an open aperture while the second used a closed aperture. The HunterLab was equipped with a 10° observer, 25 mm port and calibrated with a black and white tile specific to the machine for both sets. Ultimate pH was measured on three additional sets of loins (n1 = 249, n2 = 170, and n3=285 for each group, respectively) using two separate pH meters. Color and pH data were analyzed using the MIXED procedure of SAS as a 1-way ANOVA with two levels (Minolta and Hunter for color, Meter A and Meter B for pH). Variances for each treatment were calculated using the means procedure and tested for homogeneity using the Levene’s test of the GLM procedure. Means and variances were considered different at P ≤ 0.05. Coefficients of determination (R²) were calculated using the REG procedure between Hunter and Minolta readings and between pH meters.

Results: Redness, Chroma and hue angle had greater variability (P < 0.01) when measured using the open aperture Minolta than HunterLab, while only chroma (P = 0.04) and hue angle (P < 0.01) had greater variability when using the closed aperture Minolta compared with the HunterLab. Variability of other traits did not differ between machines. For each set of loins, pH variability was greater for meter B than meter A. R² values between the HunterLab and open aperture Minolta were 0.42 for lightness, 0.41 for redness, 0.27 for yellowness, 0.28 for saturation, and 0.18 for hue angle. R² values between the HunterLab and closed aperture Minolta were 0.42 for lightness, 0.42 for redness, 0.33 for yellowness, 0.24 for saturation, and 0.04 for hue angle. Meter A was able to predict between 17% - 21% of variation in Meter B.

Conclusion: Overall, variability was generally not different between color machines, while pH meters had different variabilities between machines and on days of measurement. Neither color instruments nor pH meters were able to predict values from other instruments of different types well enough for practical use.

Keywords: color, instrumental color, pH, Pork, variation
Objectives: Our objectives were to determine the degree of normality in selected volatile compound samples, the improvement to normality transformations may make, and the changes in interpretation transformations could induce.

Materials and Methods: Beef strip loins (n = 32) were sliced 3.81 or 1.27 cm thick. Steaks were cooked on an electric flat grill set at either 176°C or 232°C to an internal cook temperature of 71°C. Cubes (1.27 square) were transferred to a 470 mL glass jar and the static headspace was collected with SPME for 2 h. The SPME was injected into a multi-dimensional GC/MS identification of volatile aroma compounds. Volatiles were selected with a MS quality score above 75 and occurred in a minimum of 10% of the total steak samples. Absence of an observation for a volatile compound may be due to treatment effect, instrumentation limits, or simply missing from the sample. To analyze the normality of volatiles, representative volatiles selected were benzaldehyde, methyl-pyrazine, nonenal, and 2-octanone, as they were present in 95, 63, 42, or 20% of the total steak samples, respectively. These selected volatiles were then subjected to square root, log₁₀, or Box-Cox transformations. If a volatile was absent in a steak sample, that cell was designated as either a missing value (MV) or as a zero (0). Shapiro-Wilk, box-plot, and normality distribution plots were used to measure normality for each of the volatiles across all conditions. Brown-Forsythe and Bartlett’s tests were used to determine homogeneity of variance.

Results: Volatiles designated as a zero when no GC total ion counts (TIC) were present had residuals within treatment cells that were not normally distributed (P < 0.05). Volatile compounds nonenal and 2-octanone were normally distributed (P > 0.05) when empty cells were designated as MV, but benzaldehyde and methyl-pyrazine were not (P < 0.05). Square-root transformation of the data resulted in all the data designated with MV to be normally distributed (P > 0.05) while data with empty cells designated with 0 were unchanged and not normal (P < 0.05). Furthermore, Box-Cox transformations of MV data had lambda values of 0.23, 0.11, 0.18, and 0.10 for benzaldehyde, methyl pyrazine, nonenal, and 2-octanone, respectively. Brown-Forsythe and Bartlett’s test indicated that as the percentage of volatiles present decreased, the treatment mean responses became less homogeneous in their variance (P < 0.05) as indicated by the fact that only benzaldehyde upheld the assumption of homoscedastic behavior (P > 0.05).

Conclusion: Analysis of volatile aroma compounds from cooked beef results in numerous missing values in the data, and by nature the data are not normally distributed, nor do they have homogenous variance as a result. Analyzing data with missing values rather than zeroes improves normality and additionally, transformation of the data using square root or Box-Cox significantly improved normality but had only minor impact on homogeneity of variance. ANOVA F-ratios were consistently highest on data that were entered with missing values rather than zeroes and were not transformed. Care should be taken analyzing volatile GC data to take into account the basic assumptions regarding the data and steps can be taken to conform to those assumptions.

Keywords: beef, GC-MS, homogeneous variance, normality, statistics
Objectives: Woody breast (WB) myopathy reduces the utility and value of breast meat for the broiler industry. It is hypothesized that WB meat may be included in comminuted products to increase utility and ultimately add value to the broiler industry. Information on the textural and quality characteristics that WB inclusion has on further processed products is limited in the literature. The objective of this research was to evaluate the quality of sausage made with WB meat of varying degrees of severity.

Materials and Methods: For each of three replications, broiler breast meat (normal, moderate WB, and severe WB) and chicken abdominal fat were obtained from a commercial poultry processor. Breast meat was coarse ground (19-mm) and combined with fat (targeting 15%) to produce 10-kg batches representing 25%, 50%, and 100% moderate WB meat, 25%, 50%, 100% severe WB meat, and a 100% normal control. The batches were then re-ground (4.8-mm), mixed for 1 min with 1.5% salt, and stuffed into 35-mm natural casings. Links were placed in individual bags, cooked to 70°C in a waterbath, and allowed to cool to room temperature before hardness, cohesiveness, springiness, gumminess, and chewiness were evaluated using texture profile analysis. Individual sausage links were weighed before and after cooking and cook loss was calculated. Data were analyzed using SAS version 9.3 with a fixed effects design with replication as a random effect.

Results: Sausage hardness tended to be softer ($P = 0.06$) as WB inclusion rate and severity increased. Cohesiveness and springiness values were similar between treatments ($P = 0.53, P = 0.95$, respectively). Gumminess decreased ($P < 0.05$) as severity and inclusion of WB increased indicating a lack of bind, which was further supported by the decline in chewiness ($P < 0.05$). The raw 25% moderate WB and 50% severe WB sausage links were similar in lightness values ($L^*$) to the normal sausage links. In cooked sausage, 25% and 50% inclusion of WB meat regardless of severity were similar in lightness values ($L^*$) compared to the 100% normal formulations.

Conclusion: With no difference in cook loss ($P = 0.08$), the data presented indicates that moderate and severe WB meat can be included in the formulation of linked sausages to increase utility and value of broiler WB meat.

Keywords: Broiler, Color, Sausage, Texture, Woody breast
Objective: To evaluate quality attributes of beef *longissimus dorsi* (LD) during 15 days of simulated retail display using surface and internal bioelectrical impedance analysis (BIA) measurement techniques.

Materials and Methods: The experiment was designed as a split-plot with loin as the whole-plot and paired steaks as the sub-plot. Display day (DD) was treated as the sub-plot treatment. Postmortem age time (PM) and DD were treated as fixed effects. Beef strip loins (*N* = 18; IMPS #180), obtained from 3 commercial processors (PM = 27, 34, or 37 d), were fabricated into 12 2.54-cm thick steaks (*N* = 216). Steaks were subdivided into 6 consecutively cut pairs and pairs were randomly assigned to one of 6 display days: 0, 3, 6, 9, 12, and 15. For all pairs, one steak was allocated to microbiological analysis and pH and the paired steak for BIA, objective color assessment, proximate composition, and TBARS. Surface BIA (S-BIA) and internal BIA (I-BIA) assessment were compared. Steaks were packaged on styrofoam trays with a moisture absorbent pad, overwrapped with polyvinyl chloride film, and displayed under fluorescent lighting at 0-4°C in coffin-style retail cases.

Results: There was a PM × DD interaction (*P* < 0.05) for S-BIA values. From d 0 to 12 of display, steaks aged 27 d had higher (*P* < 0.05) S-BIA values than steaks aged 34 and 37 d; however, on d 15 of display, steaks aged 34 d had 22% higher (*P* < 0.05) S-BIA values than steaks aged 37 d, but had similar (*P* > 0.05) values compared to steaks aged 27 d. There was no PM × DD interaction (*P* < 0.05) for I-BIA values; however, an effect on PM and DD was found (*P* < 0.05). Steaks aged 27 d were 17% higher for I-BIA values (*P* < 0.05) than 37 d, but similar (*P* > 0.05) to steaks aged 34 d. For all PM aging times, d 0 had the lowest (*P* < 0.05) I-BIA values among all display days with 81.44. D 3 was the second lowest (*P* < 0.05) and 8% higher than d 0 for I-BIA values. D 6 was 16% higher (*P* < 0.05) than d 3 but similar (*P* > 0.05) to d 9 and d 12. D 12 and D 15 were similar (*P* > 0.05). There was a DD × BIA method interaction (*P* < 0.05). On d 0, 3, and 6, BIA values were different (*P* < 0.05); however, after d 6 onward, BIA values were similar (*P* > 0.05). Covariance component was smaller in I-BIA than S-BIA. There were no PM × DD interactions (*P* > 0.05) for *a* and *b* values; however, there was an interaction for *L* values. Postmortem aging had no effect (*P* > 0.05) on *L*; however, an effect on *a* and *b* was found (*P* < 0.05). For APC populations, there was a PM × DD interaction (*P* < 0.05). No PM × DD interaction or PM effect (*P* > 0.05) were found for TBARS; however, there was a DD effect (*P* < 0.05). There was no PM day × DD interaction (*P* > 0.05) or PM day (*P* > 0.05) for moisture content. Display day (*P* < 0.05) had an effect on moisture content. Moderate negative correlations occurred between S-BIA values and *a*, *b*, and moisture content with -0.48, -0.46, and -0.46, respectively; and -0.51, -0.48, and -0.43, respectively, for I-BIA. Conversely, moderate positive correlation was found between S-BIA values and APC and TBARS with 0.34 and 0.53, respectively; and 0.29 and 0.51, respectively, for I-BIA.

Conclusion: I-BIA has potential for use to assess shelf-life of retail steaks and it was more precise than S-BIA; however, I-BIA may translocate bacteria into the muscle. Protein degradation and WHC should be evaluated to better understand BIA changes over time.

Keywords: beef, bioelectrical impedance, shelf-life attributes
The Influence of Mitochondria Enzyme Activity on Beef Tenderness

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Objectives: Among all eating quality attributes, tenderness is often described as the most important factor dictating the overall acceptance of cooked beef, as well as, future decision to repeat purchase. While many intrinsic and extrinsic factors impact end-product tenderness, variation in tenderness is usually attributed to the extent of postmortem proteolysis occurring during meat aging. Evidence from the literature indicates that muscle fiber type composition is a major source of variation in the rate and extent of postmortem proteolysis. One of the major differences that distinguishes muscle fibers is the content of mitochondria. Typically, red muscle (slow-oxidative) is characterized by greater amounts of mitochondria than white muscle (fast-glycolytic). As part of the calcium buffering system, mitochondria sequester large quantities of calcium to maintain a constant cytosolic calcium level. We hypothesized that mitochondria may delay the activation of μ-calpain, the major protease responsible for postmortem proteolysis, through preventing the increase in cytosolic calcium concentration.

Materials and Methods: To test our hypothesis, beef longissimus thoracis muscle samples were collected at 30 min and 16 d postmortem. The 30 min samples were immediately snap frozen in liquid nitrogen and stored at −80 °C, while the 16 d samples were used to determine Warner-Bratzler shear force (WBSF) values. Based on WBSF values, the samples were allocated into less tender (average WBSF = 5.3 kg; n = 8) or more tender (average WBSF = 2.3 kg; n = 8) categories. Succinate dehydrogenase (SDH) abundance, citrate synthase (CS) activity, phosphofructokinase (PFK) activity, and glycogen phosphorylase (GP) activity were compared between the two categories using the 30 min samples. Collected data were analyzed using a Student’s t-test and considered significant at P ≤ 0.05.

Results: Our results showed that SDH abundance and CS activity (mitochondrial biomarkers) were significantly greater (P = 0.01 and 0.003, respectively) in less tender samples when compared to more tender samples. On the other hand, PFK and GP activities (glycolytic biomarkers) were greater (P < 0.05) in the more tender than less tender steaks.

Conclusion: While not a cause and effect relationship, these data indicate that mitochondria content likely plays a role in development of beef tenderness.

Keywords: Beef tenderness, Fiber type, Mitochondria
INVESTIGATING THE ETIOLOGY OF INCREASED INCIDENCE OF SOUR KNUCKLES IN COMMERCIAL BEEF PROCESSING FACILITIES

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Objectives: Cattle weights have increased during the last couple of decades and have not always been accompanied by improvements in facility capabilities and management. Alongside quality issues of color, tenderness, and water holding capacity, issues such as sour muscles and bone taints are now appearing with great frequency in the meat industry. Development of off-flavor/sourness in deep muscles such as knuckles (vastus femoris, vastus lateralis, vastus medialis, and rectus femoris) has been a long-standing issue in the beef industry, however, has not been well characterized. Therefore, the objective of this study was to investigate the cause, and characterize sour odor associated with beef knuckles using microbial, odor panel, and gas chromatography-mass spectrometric (GC-MS) analyses.

Materials and Methods: Knuckles (n = 10) identified as having no sour odor (control), slight odor, or severe odor were collected from the fabrication line of a commercial beef processing plant. Sponge samples of synovial fluid and femur surface of the round were also obtained at the time of collection, for determination of anaerobic sporeformer counts. The collected knuckles were transported on ice to the laboratory where they were aseptically separated into two halves, with one half destined for microbial, odor, and GC-MS analyses on the day of collection (day 0) and the other half for the same analyses after 35 days of vacuum packaged storage at 2°C (day 35). For microbial analysis, 15 g of tissue was excised from the muscle surface and was analyzed for aerobic plate counts (Petrifilm Aerobic Count plates) and lactic acid bacteria counts (Lactobacilli MRS agar). Samples (5 g) for GC-MS were held at -80°C until analysis. The remainder of the sample was diced and used for trained odor panels. Data were analyzed using the ANOVA function in R (v. 3.5.1.), with a significance level of alpha = 0.05. Upon finding significant differences (P < 0.05) the means function was used to determine differences between groups.

Results: Irrespective of sourness classification of the knuckles, similar (P > 0.05) anaerobic sporeformer counts were obtained for the synovial fluid and femur surface. Additionally, muscle tissue samples from control, slightly sour and severely sour knuckles had similar (P > 0.05) aerobic plate counts and lactic acid bacteria counts. Odor panelists identified differences (P < 0.05) for all attributes between control and sour knuckles (slight and severe) on day 0. Similarly, on day 35, differences (P < 0.05) were observed between control, slightly sour, and severely sour knuckles for all attributes, with severe receiving the highest score for all categories. GC-MS results showed no differences (P > 0.05) between control and sour knuckles for propionic, butyric, isobutyric, and acetonic acid.

Conclusion: Microbiological analysis found no differences in culturable organisms between control, slight, and severely sour knuckles on day 0 or day 35. However, odor panelists were able to identify differences between control and sour knuckles even after 35 days in vacuum packaging. GC-MS analysis did not indicate a statistical difference in the abundance of volatiles between the treatments, probably due to high variations within treatment groups.

Keywords: Beef Quality, Gas Chromatography-Mass Spectrometry, Sour Knuckles
Objectives: Pork continues to be a significant source of highly valued animal protein for the growing global population. Due primarily to the push for lean yield in the US swine industry, there is a demand from consumers for higher quality pork, while producers continue to desire improved yields. The purpose of this study is to determine the effects of gender and slaughter endpoint on carcass quality and composition attributes for pork from lean yield and meat quality sire lines.

Materials and Methods: Boars from a meat quality line (MQL) and a lean yield line (LYL) were mated to females from a commercial swine genetics company. Pigs were farrowed, weaned, and processed according to a typical industry protocol at the University of Georgia Swine research unit. As the pigs reached approximately 23 kg, three pigs from each gender within a litter were selected and randomly assigned a slaughter weight of 113, 136, or 159 kg. When the pigs reached their assigned slaughter weight, they were harvested at The University of Georgia Meat Science and Technology Center under inspection. A total of 151 pigs from 26 litters (13 per sire line) were evaluated. After carcasses were chilled for 24 h, carcass length was measured, and carcasses were then ribbed. Tenth rib back fat (TRBF), last rib back fat (LRBF), loin pHu, carcass muscle score (CMS), NPPC color and marbling scores, Hunter L*a*b*, loin eye area (LEA), and temperature were measured in the longissimus dorsi (LD). Primal and subprimal weights were collected and recorded from the fabricated carcass. Length, width, and depth (thickness) as well as firmness of the skinless belly was assessed. Samples were removed from the LD anterior to the 11th rib for proximate analysis, drip loss, Warner-Bratzler, and slice shear force collection. Data were analyzed using PROC MIXED procedures in SAS with the fixed effects of sire line, gender, and slaughter endpoint and their interactions. LSMEANS were generated and separated using LSD.

Results: Backfat thickness (TRBF and LRBF) was higher in MQL ($P<0.01$) than LYL, and lower in females ($P<0.01$) than males. The LYL had a greater LEA ($P<0.01$) than MQL, and females had a larger LEA ($P<0.01$) than males. Marbling and firmness scores (NPPC) were greater in MQL ($P<0.01$) than in LYL. As a percent of carcass weight, loin and ham weights were higher for LYL ($P<0.01$) than MQL; however, belly weight was greater for MQL ($P<0.01$) when compared to LYL. Belly dorsal firmness was greatest in MQL lines with slaughter weight of 159 kg ($P<0.01$). Belly dimensions increased ($P<0.01$) as slaughter weight increased. Proximate analysis of the LD showed that lipid content was higher ($P<0.01$) and moisture content was lower ($P<0.01$) in the MQL compared to LYL. Protein levels of the LD were lower from pigs slaughtered at 113 kg ($P<0.01$) than both 136 kg and 159 kg. Shear force, by both measurements, was lower in chops from pigs slaughtered at 113 kg ($P<0.01$) compared to those slaughtered at 136 and 159 kg. Percent fat free lean was greater ($P<0.01$) in LYL, females, and pigs slaughtered at 113 kg compared to MQL, males, and pigs slaughtered at 136 and 159 kg, respectively.

Conclusion: Overall, there were meat quality advantages for the MQL, but they occurred at the expense of yield, where LYL is superior. Increasing slaughter weights increased primal and subprimal weights and reduced lean yield but had little effect on carcass quality.

Keywords: Carcass Yield, Pork Quality, Sire Line, Slaughter Weight
Objectives: Any deviation from the bright-red color of beef can lead to discounted price or consumer rejection. Fresh beef lean color is influenced by pH. Various packaging techniques have been developed to enhance the lean color of beef steaks. Therefore, the objective of the current study was to evaluate the effects of modified atmospheric packaging on three different beef muscle pH categories.

Materials and Methods: The three categories evaluated for this study were: Normal (pH = 5.57 ± 0.1; N-pH), Moderately high (pH = 5.70 ± 0.09; M-pH), and High (pH = 6.39 ± 0.03; H-pH). The pH was taken on the carcass, at the 12th and 13th rib interface within 72 h of harvest at a commercial beef processing plant. Strip loins were fabricated from each carcass (n = 12) and sent to Oklahoma State University for further analysis. Strip loins were then cut into 2.54 cm steaks and randomly assigned to 1 of 3 packaging treatments: polyvinyl chloride overwrap (PVC), carbon monoxide modified atmosphere packaging (CO-MAP; 0.4% CO, 69.6% N, and 30% CO2) and high-oxygen modified atmospheric packaging (HiOx-MAP; 80% O2, and 20% CO2). Visual color measurements for muscle color (MC; 1= extremely bright cherry-red and 7 = extremely dark red), and surface discoloration (SD; 1= no discoloration [0%] and 7 = extensive discoloration [81-100%]) were recorded on d 2, 4, and 6 of retail display by a trained panel. Data were analyzed using the Mixed Procedure of SAS.

Results: For all pH treatments, PVC packaging possessed the darkest muscle color (P < 0.05) score compared to CO- and HiOx-MAP. When comparing N-pH, M-pH, and H-pH values, CO-MAP had approximately a 27.3%, 22.2%, and 25.3% improvement in muscle color, indicating a brighter lean color compared to PVC. Additionally, HiOx-MAP had approximately a 10.9%, 17.4%, and 16.5% improvement in muscle color score for N-pH, M-pH, and H-pH, respectively. When packaging steaks in either CO- or HiOx-MAP there was no significant difference (P > 0.05) between d 4 and 6 of retail display for muscle color. However, there was a significant (P < 0.05) darkening in muscle color for steaks packaged in PVC from d 4 to 6 of retail display. By the 4th d of retail, N-pH steaks packaged in PVC had 38.3% and 39.0% greater (P < 0.05) surface discoloration than CO- and HiOx-MAP, respectively.

Conclusion: These results suggest that packaging steaks of different pH categories in CO- or HiOx-MAP can improve the surface color compared to PVC packaging.

Keywords: Beef Color, Modified Atmospheric Packaging, Muscle pH
Objectives: Marbling impacts eating quality and consumer preference of beef as it intensifies flavor, and improves tenderness and juiciness. Triglycerides are the predominate lipid in beef and are considered neutral fatty acids, whereas polar fatty acids are found in the phospholipid portion of beef. Diet of cattle during the finishing period can impact type and saturation of fatty acids in meat.

The objective of this research was to evaluate differences in neutral and polar lipid fatty acid content from grass-fed and grain-fed beef of varying quality grades sourced from New Zealand and the United States, respectively.

Materials and Methods: Beef strip loins (n = 200) representing two fed cattle types (n = 100/finishing type: grass-finished and grain-finished) and five different USDA quality grades (n = 20 per quality grade: USDA Standard, Select, Low Choice, “Top” Choice: High and Average Choice, and Prime) were acquired from beef processing facilities in New Zealand (grass-fed) and Nebraska (grain-fed). A face steak was cut from the anterior end of each strip loin for fatty acid analysis. Face steaks (n = 200) were frozen and stored at the Gordon W. Davis Meat Science Laboratory until further fabrication. Samples were thawed for 12 to 24 hours, trimmed of subcutaneous fat and connective tissue and ground. The ground sample was frozen in liquid nitrogen and homogenized for fatty acid analysis. Lipids were extracted, fractionated into neutral lipid (NL) and polar lipid (PL), derivatized to fatty acid methyl esters and determined by gas chromatography. Statistical analyses were conducted using the procedures of SAS (Version 9.3; SAS Inst. Inc., Cary, NC). Treatment comparisons were tested for significance using PROC GLIMMIX with α = 0.05.

Results: Interactions of cattle diet x marbling level affected the overall concentrations (mg/g) of NL saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) (P < 0.05). Saturated fatty acid and MUFA NL concentration decreased as marbling level decreased, as grain-finished Prime was higher (P < 0.05) than all other treatments. Grain-finished and grass-finished Standard had the lowest (P < 0.05) SFA and MUFA NL concentration compared to all other treatments. Concentration of PUFA NL was higher (P < 0.05) for grain-finished Prime than grain-finished Top Choice and grass-finished Prime. No difference was found between grain-finished Low Choice and Select and grass-finished Top Choice NL concentration (P > 0.05), however all were higher (P < 0.05) than grass-finished and grain-finished Standard and grass-finished Select. A cattle diet x marbling level interaction affected the overall PL concentrations of SFA and MUFA (P < 0.05), but not PUFA (P > 0.05). Generally, polar fatty acid content increased as marbling increased for SFA and MUFA. Grain-finished PUFA PL concentration was higher (P < 0.05) than grain-finished samples. Additionally, PUFA PL concentration increased as quality grade decreased (P < 0.05).

Conclusion: In conclusion, polar and neutral fatty acid content increased with increasing quality grades except for PL polyunsaturated fatty acids. Additionally, grain-finished beef steaks generally contained a higher SFA and MUFA NL concentration than grass-finished beef steaks for all quality grades except Low Choice and Top Choice.

Keywords: fatty acid, grain finished, grass finished, lipid, marbling
Objectives: This objective was to determine if variations in beef sampling techniques utilized by meat researchers have a significant impact on beef muscle measurements during aging.

Materials and Methods: Ten beef short loins (IMPS 180) were purchased from a commercial packing plant within 48 hours of slaughter. Loins were transported to the NDSU Meat Science laboratory where they were mapped into four sections from most anterior (1) to most posterior (4). Within sections, two, 40-g samples were removed; one sample was vacuum packaged (SMALL-VAC) and the other sample was stored in a wire-closure sealed bag (SMALL-BAG). The remaining whole short loin was vacuum packaged. All samples and whole short loins were stored at 4°C for 10 days. At 10 days, the short loins were sampled again where one, 40-g sample was removed from each mapped section (WHOLE-VAC). Purge loss was measured by weighing each sample prior to packaging treatment and at the end of the 10-day aging period; percentage change in weight was calculated. Troponin-T degradation was determined by western blot. Briefly, protein was extracted in an SDS-phosphate buffer, separated by SDS-PAGE under reducing conditions, and transferred to PVDF membranes. Western analysis was done using an anti-troponin-T antibody (clone JLT 12), and immunoreactive bands (Band 1 = doublet ~42 to 45 kDa; Band 2 = doublet ~ 36 to 38 kDa, Band 3 = 30 kDa) were analyzed for differences in density. Sarcomere length was determined using HeNe laser diffraction. Thinly sliced samples (~50 to 100 mg) were placed in a sucrose-phosphate buffer and subjected to beadmill homogenization. A drop of the homogenate was placed on a glass slide, diffraction patterns were measured, and sarcomere length was calculated. Thiobarbituric acid reactive substances (TBARS) were assessed using a colorimetric assay. Analysis was conducted using Proc Mixed procedure of SAS where storage type, section location, and their interaction were used as fixed effects.

Results: There was a storage type by section interaction ($P = 0.017$) that occurred with purge loss. SMALL-VAC samples released more purge than SMALL-BAG from the more posterior samples. Troponin-T Band 1 tended to be less ($P = 0.07$) in WHOLE-VAC samples compared with SMALL-VAC and SMALL-BAG. There was a storage type by section interaction ($P = 0.02$) where the most posterior SMALL-BAG samples had greater Band 2. There were no differences ($P ≥ 0.25$) in Band 3 between treatments. There was no difference ($P = 0.29$) in sarcomere length due storage type. However, there was a difference ($P = 0.01$) in sarcomere length between sections, where the shortest sarcomeres were in the center of the strip loin and longest sarcomeres on either end. There was a storage type by section interaction ($P = 0.02$) for TBARS where concentration was greatest in the most posterior portion of SMALL-BAG compared with WHOLE-VAC.

Conclusion: Collection of smaller samples for aging studies may not be representative of samples aged in a whole primal cut and may influence research outcomes.

Keywords: aging, beef, sampling
Objectives: The objective of this study was to utilize mass spectrometry (MS) instrumentation to define flavor differences in beef strip loin steaks cooked on five different surface temperatures.

Materials and Methods: USDA Select strip loins (n = 30) were selected from carcasses at a commercial major packing plant in Texas. After aging 14d, the loins were cut into 2.54 cm thick steaks, randomly assigned a grill surface temperature of 149, 177, 204, 232, or 260°C, individually vacuum-packaged and frozen at -10°C until analysis. Steaks were cooked on an electric flat top grill pre-heated to the corresponding temperature treatment. Steaks were turned at an internal temperature of 35°C and removed at 71°C (medium degree of doneness). Cubes (1.3cm x 1.3cm x steak thickness) representative of those served to a trained sensory panel were frozen and held at -80°C until further analysis. For GC/MS analysis, the samples were weighed and placed in a 473 mL glass jar with a Teflon lid held in a water bath at 60°C for 2h. The collection of volatiles from the headspace was done with a solid phase micro-extraction (SPME) sampler and a multidimensional GC/MS. For HPLC/MS-QTOF analysis, frozen samples were homogenized in a blender and 2g were mixed with 8 mL acidified acetonitrile (0.1% formic acid). The supernatant was exposed to dSPE Enhanced Matrix Removal and dried with 3.5 g MgSO₄. Samples were analyzed at a 1:5 dilution using reverse-phase chromatography on an Agilent 6545 LC/MS-QTOF with a gradient mobile phase in both positive and negative ion modes. Data were analyzed as linear and(or) quadratic effects (P < 0.05) with grill surface temperature as the independent variable. Least squares means, discriminant analyses, and partial least squares regression analyses for compounds were calculated.

Results: Both octane (gasoline aroma) and undecane (allspice aroma) increased (P < 0.02) linearly with grill temperature. With the exception of pentanal (fermented wine aroma), which decreased (P = 0.027) as grill temperature increased, all other aldehyde compounds increased (P < 0.05) linearly as the grill temperature increased. Pyrazines (roasted, coffee, and nutty aromas) and ketones (fruity, fatty aromas) generally increased (P < 0.03) as grill temperature increased. 2,3,5-trimethyl-6-ethyl pyrazine, 2,3-diethyl-5-methyl pyrazine, 2,5-dimethyl pyrazine and 3,5-diethyl-2-methyl-pyrazine were only present when the grill temperature reached 260°C. Non-volatile compounds (n = 247 positive ion and 140 negative ions) were identified. Significant (P < 0.05) patterns of increasing intensity with increased grill temperature were observed in sugar-amino derivatives such as betaine, 2-dimethylamino-5,6-dimethylpyrimidin-4-ol, and (S)-N-(4,5-dihydro-1-methyl-4-oxo-1H-imidazol-2-yl) alanine. A point of inflection was observed at a grill temperature of 232°C across a majority of increasing compounds, suggesting a critical temperature for the regulation of flavorful products from the Maillard reaction.

Conclusion: Volatile and non-volatile compounds known to contribute to positive flavor attributes associated with the Maillard reaction are considerably influenced by grill surface temperature. It appears that a grill temperature from 204 to 232°C is optimal for generation of volatile and non-volatile flavor compounds.

Keywords: Grill Temperature, Mass Spectrometry
Objectives: Pork quality is a combination of many different attributes, including color, intramuscular fat percentage (IMF), pH, drip loss, and tenderness. Currently, in the pork industry, color and marbling of the whole loins are commonly assessed subjectively by a trained evaluator according to the National Pork Board's color and marbling standard cards (NPB, 2011). However, subjective color (SCS) and marbling (SMS) scores can be influenced by lighting and evaluator fatigue. Colorimeters are a common technology that are utilized for measurement of color in the meat industry but have their limitations as they only measure a small portion of the surface and cannot separate lean and fat tissue. Ether extract is commonly used for crude fat determination, but it requires a longer time for analysis and a sample that will be consumed by the process. Computer vision system (CVS) is a technology that has been applied in the food industry and is a non-invasive, efficient, and consistent method. Therefore, the objectives of this study were to compare pork color and marbling measured from the whole loin versus its individual chops and to compare the results from different pork quality measurement methods on the same sample.

Materials and Methods: Whole pork loins (n=1400) were obtained from 6 major pork processing plants, with SCS, SMS, Hunter L, a, and b, and CVS images being collected on the ventral side of the loin in the plant. Samples were vacuum packed, shipped, and stored at 4 °C for 14 d. Then whole loins were sliced into chops and the 3rd (A) and 10th (B) rib chops were evaluated for SCS and SMS after a 10 min bloom. After SCS and SMS evaluation, Hunter L, a, and b, and CVS images were collected. The A and B chops were vacuum packaged, shipped, trimmed, freeze dried, and then evaluated for crude fat percentage (CF%) using ether extract method. The CF% of the whole loin was estimated as the average of the A and B chops. From the CVS images, lean and fat pixels were segmented to estimate L*, a*, and b* of the lean tissue and CVS IMF.

Results: A lower L* was found for both CVS and colorimeter when evaluating the whole loin (63.06 & 53.63, respectively) compared to the average of A and B chops (68.65 & 58.10, respectively). However, for SCS, individual chops, on average, were darker than the whole loin (2.88 vs. 2.67, respectively). Of all color measurements, Hunter L had the highest correlation when comparing the whole loin to A and B chops (r = 0.72 and 0.72, respectively). When comparing marbling results of the whole loin to the A and B chops, a moderate correlation was found using both SMS (r = 0.67 and 0.60, respectively) and CVS IMF (r = 0.52 and 0.54, respectively). When comparing methods, CVS L* had a stronger correlation with Hunter L than SCS for the whole loin and A and B chops. (r = 0.40 vs. 0.34, 0.82 vs. 0.47, and 0.84 vs. 0.40, respectively). For IMF, SMS had a stronger correlation with CF% than CVS IMF (r = 0.48 vs. 0.34, 0.62 vs. 0.39, and 0.54 vs. 0.38, respectively).

Conclusion: These results show great potential for CVS to be used in evaluating pork quality, specifically color and marbling. Additionally, it is possible to predict individual chop color and marbling based on the ventral side of the loin. Further research should be conducted to look at more technologies that can predict pork quality attributes.

Keywords: Computer vision system, Pork quality
**Objective:** The objective of this project was to explore metabolomic predictors that could determine the potential of beef strip loin steaks differing in quality grade, aging time, and degree of doneness to develop positive flavors.

**Materials and Methods:** USDA Select (n = 18) and USDA Upper 2/3 Choice (n = 18) beef strip loins (IMPS 180) were collected from a processing plant. Loins were halved, and each half was wet aged for either 10 or 20 d in a cooler kept at 2°C. After aging, loins were cut into 2.54 cm steaks, individually vacuum packaged and stored in a freezer at -40°C. Prior to cooking steaks were thawed in a 4°C cooler for 12 to 24 hours. Steaks were cooked on a flat top griddle set to 204.4°C (±11.1°C) to one of three degrees of doneness: 63°C (medium rare), 71°C (medium) or 80°C (medium well). A six-member expert trained descriptive attribute panel was trained on 16 major attributes, 4 other attributes, and 3 texture attributes from the beef lexicon (Adhikari et al., 2011) for six days prior to testing. Panelists were trained to scale each attribute on a sixteen-point intensity scale (0 = none, 15 = extremely intense). Panelists were seated in a breadbox-style booth under red lighting to eliminate degree of doneness bias. Portions from one raw steak from Quality Grade (QG) × aging combination from each loin was used for high performance liquid chromatography (HPLC) analysis. Samples were homogenized and extracted with a water/acetonitrile solution before being filtered. The lipid fraction was removed via solid phase extraction. Samples were then centrifuged and injected into the HPLC. Data was analyzed as a factorial arrangement of a completely randomized design.

**Results:** USDA Choice steaks had more intense beef flavor identity, brown, roasted, fat-like, salty, sweet, sour, umami, buttery, and overall sweet flavors and were juicier and more tender compared to USDA Select steaks, which were more intense in metallic and bitter flavors (P < 0.05). Steaks aged for 20 days were juicer and more tender than 10-day aged steaks (P < 0.05). However, 20-day aged steaks also had more intense sour, liver-like, and musty earthy/humus flavors and a less intense brown flavor compared to 10 d aged steaks (P < 0.05). Steaks cooked to 80°C had more intense beef identity, brown, roasted, and umami flavors than steaks cooked to a lower degree of doneness (P < 0.05). Steaks cooked to either 63°C or 71°C had more intense bloody, metallic, and sour flavors and are juicier and more tender than steaks cooked to the higher degree of doneness (P < 0.05). The HPLC analysis of raw steak samples indicated a total of 54 compounds appeared in at least 80% of one treatment. Additionally, there were 2 peptides and 1 sugar that were significantly (P < 0.05) upregulated in the Choice, 20-d-aged strip loins. Additionally, 14 compounds were identified that were shared across all four QG x aging combinations. This included 11 peptides, 2 phospholipids, and 1 heterocyclic aromatic hydrocarbon.

**Conclusion:** These compounds could be indications of the potential for steaks to form positive flavor attributes found in USDA Choice steaks and 20-d aged steaks as described by trained panel analysis.

**Keywords:** aging, Degree of doneness, Metabolomics, Quality Grade, sensory
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Objectives: The influence of breed type, residual feed intake (RFI) and post-mortem aging on meat and carcass quality attributes and intramuscular connective tissue characteristics were examined in the bovine Triceps brachii, a high connective tissue muscle from the chuck. The hypothesis that selection for low RFI in beef cattle increases beef toughness, increases collagen content and reduces collagen heat solubility of the Triceps brachii was tested.

Materials and Methods: Seventy-one beef steers from Angus (n=23), Charolais (n=24) and Angus crossbred (n=24) genetics were used. Each breed had high RFI and low RFI steers (n=12). Muscles collected were aged for 3- and 13-days post-mortem (dpm). Final animal live weight, grade marbling, intramuscular pH, water holding capacity (WHC), intramuscular fat, cooking loss, drip loss, protein, temperature, moisture, color, RFI, and Warner Bratzler shear force (WBSF) data were collected for carcass and meat quality measurements. Total collagen, collagen heat solubility, and collagen cross-link Ehrlich’s chromogen (EC) of the isolated perimysium were quantified. Data were analyzed using a split-plot experimental design procedure (R software 3.4.1) with breed and RFI as main effects in the whole plot and postmortem aging included at the subplot level.

Results: Final weight was significantly greater for Charolais (683 ± 9.58 kg) than Angus (554 ± 9.65 kg) and Angus crossbred (568 kg ± 9.58 kg) steers (P = 0.017), and grade marbling score was higher for high RFI (421 ± 19.85) than for low RFI steer carcasses (385 ± 19.82) (P = 0.001). No significant effects of breed type and RFI (P > 0.05) were observed on meat quality attributes. WBSF value at 3 dpm (3.72 kg) was significantly higher than at 13 dpm (3.21 kg) (P < 0.005). Collagen solubility was significantly higher at 13 dpm (25.88%) than at 3 dpm (18.03%) (P < 0.005). Total collagen and wet endomysium were positively correlated (r = 0.44) as were total collagen and EC in raw muscle (r = 0.76), EC and wet perimysium (r = 0.42) and WBSF and EC at 13 dpm (r = 0.27) (P < 0.005). Total collagen and collagen solubility at 3dpm (r = -0.36) and 13 dpm (r = -0.63) were negatively correlated, as were EC and solubility at 3 dpm (r = -0.38) (P < 0.005).

Table: Least square means (± standard error of the mean) for WBSF, soluble collagen, and collagen solubility of Triceps brachii muscles at 3 and 13 days post-mortem aging (dpm).

<table>
<thead>
<tr>
<th>Measurements (unit)</th>
<th>Aging periods</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 dpm (n = 71)</td>
<td>13 dpm (n =71)</td>
</tr>
<tr>
<td>WBSF (kg)</td>
<td>3.7 ± 0.08a</td>
<td>3.2 ± 0.08b</td>
</tr>
<tr>
<td>Soluble collagen (mg/g raw meat)</td>
<td>1.3 ± 0.18b</td>
<td>1.8 ± 0.18a</td>
</tr>
<tr>
<td>Collagen heat solubility (%)</td>
<td>18.0 ± 4.2b</td>
<td>25.9 ± 4.2a</td>
</tr>
</tbody>
</table>

a, b Least Square Means within a row lacking a common letter differ at P ≤ 0.05

Conclusion: Increasing postmortem aging periods reduced WBSF and increased collagen heat solubility of the Triceps brachii muscle. With no effect of RFI on meat quality measurements, the production cost can be reduced by selecting for low RFI animals without sacrificing product quality.

Keywords: Meat quality, Triceps brachii muscle, physio-chemical properties, beef toughness
112: EVALUATION OF BEEF STEAK EXUDATE DIFFERING IN QUALITY GRADE AND POST-MORTEM AGING TIME
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Objectives: Evaluate absorbance and metabolite differences of beef exudate from raw beef steaks differing in quality grade and post-mortem aging time.

Materials and Methods: USDA Select (SE; n = 18) and USDA Choice (CH; n = 18) beef strip loins were aged for 7d, cut into 2.54 cm thick steaks, and randomly assigned a post-mortem aging duration of either 10 or 20d post-mortem (n = 72 total). Steaks were individually packaged on d7 and frozen on the assigned day at -20°C until time for analysis. Steaks were thawed for 24h at 4°C before 2 mL of exudate was collected from each bag upon removal of the steak. The exudate was frozen at -80°C until further analysis. For analysis of absorbance, 0.5 mL of thawed exudate was diluted with 4.5 mL ultra-pure water and centrifuged. Then, 200 μL of the dilution was pipetted in triplicated onto a 96 well plate. Absorbance was read at a range of 350-700nm wavelengths. A dilution of 1:20 beef exudate: ultra-pure water was filtered and used for metabolite analysis. Using a HILIC column, 5 μL were injected into an organic mobile phase gradient and analyzed using an Agilent 6545 LC/MS-QTOF in positive mode. Data were analyzed using a two-factorial design with quality grade and post-mortem day of aging as fixed effects with an alpha of 0.05. Loin was included as a random effect. Least squares means, correlations, and principal component analysis were used to discriminate data.

Results: CH exudate had greater (P< 0.05) absorbance than SE at wavelength ranges of 350-404, 423-467, and 491-508 nm. For the range of 350-598nm, CH exudate tended (P< 0.10) to have a greater absorbance than SE exudate. No differences (P> 0.05) were detected at all other wavelengths analyzed between quality grade. Post-mortem aging had no effect (P> 0.05) on wavelength absorbance. Of the total metabolites present (n = 33) in the samples, no differences (P> 0.05) were observed amongst fixed effects. Only three metabolites exhibited a 2-fold change in expression, observed as a down-regulation from SE to CH exudate. With age, nearly two-thirds of the metabolites (n = 19) tended to increase in intensity. Tritriacetyloctacosanoate was unique to SE exudates.

Conclusion: Beef exudate tends to be influenced by quality grade more than post-mortem aging duration. Accordingly, exudate samples from raw steaks may be classified by quality grade no matter the duration of aging time.

Keywords: Beef exudate, Mass Spectrometry, Spectrophotometry
EVALUATING PIG PERFORMANCE, CARCASS MERIT AND PROCESSED PORK QUALITY WHEN CHESTNUTS AND ACORNS ARE FED TO DUROC-INFLUENCED PIG GENETICS DURING LATE FINISHING

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Objectives: The objective of this study was to determine the effects of feeding chestnuts and acorns on growth performance, carcass quality and further processed products of Duroc/Duroc crossbred finishing barrows.

Materials and Methods: Barrows (n = 30) were individually housed in pens, blocked by body weight and randomly assigned to one of three treatments: control (n = 10), inclusion of acorns at 15% of the diet (n = 7), inclusion of chestnuts at 15% of the diet (n = 13). Pigs were fed ad libitum for 28 d prior to harvest. Feed refusal and individual pig weights were collected every 7 d and used to calculate average daily gain (ADG), gain-to-feed (G:F), and average daily feed intake (ADFI). Following harvest, carcass quality was determined by objective color (L*, a* and b*), fat composition and marbling scores. Fat samples were removed from four fat depots (backfat, seam, jowl, kidney and pelvic) and analyzed for fatty acid composition. Sample chops were removed between the 10th and 11th rib of the left side of each carcass and analyzed for fatty acid composition, moisture and fat content. Bellies were removed from the left side of each carcass, further processed into bacon slabs and analyzed for slice quality, fatty acid composition, moisture and fat content. Carcass characteristics and bacon quality were analyzed using GLM procedure of SAS. Growth performance and fatty acid composition were analyzed using MIXED procedure of SAS. Significance was determined at P-value < 0.05.

Results: No differences were detected for ADG and ADFI across treatments (P > 0.05). Barrows fed chestnut diets had a greater G:F when compared to control (P < 0.05) or acorn fed barrows (P < 0.05). Dietary treatments did not impact (P > 0.05) carcass characteristics or carcass quality. Inclusion of chestnuts or acorns within the diet did not impact (P > 0.05) moisture and fat content of chops and bacon slices (P > 0.05). Moreover, feeding acorns led to similar concentrations (P > 0.05) of palmitoleic acid (16:1) and linoleic acid (18:2n6c) when compared to the control diet. However, feeding diets containing acorns led to greater proportions (P < 0.01) of palmitoleic acid and linoleic acid similar to barrows fed diets containing chestnuts. No difference (P > 0.05) for stearic acid (18:0) were observed between control and chestnut treatments, however, both were found to have greater amounts (P < 0.01) of stearic acid when compared to the acorn treatment. Acorns increased (P < 0.01) the total concentration of omega-6 fatty acids (n-6) when compared to chestnut diets, but no differences (P > 0.05) were observed between acorn and control diets. Inclusion of acorns reduced (P < 0.05) total saturated fatty acids (SFA) when compared to control and chestnut treatments; however total polyunsaturated fatty acids (PUFA) were increased (P < 0.05) when acorns were included in the diet. When evaluating PUFA:SFA ratio, no differences (P > 0.05) were found between control and chestnut diets. Including acorns in the diet, resulted in an increased (P < 0.05) PUFA:SFA ratio.

Conclusion: Inclusion of acorns and chestnuts did not negatively impact carcass characteristics, carcass quality or bacon quality, nevertheless, including acorns altered overall fatty acid composition while minimal differences were observed between diets containing chestnuts and the control.

Keywords: acorns, chestnuts, fatty acid, pork
114-CHARACTERIZING PORK QUALITY OF CARCASSES WITH AN AVERAGE WEIGHT OF 119 KG


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Objectives: Between 1995 and 2018, average hot carcass weight of U.S. pork carcasses increased from 82 kg to 96 kg, which is an increase of approximately 17%. At current rates, pork carcasses in the U.S. will weigh on average, 105 kg by the year 2030 and over 118 kg by 2050. Although this represents an increase in throughput efficiency due to increases in economy of scale, projecting continued increases in the future raises some concerns. Therefore, the objective was to characterize pork quality of carcasses ranging from 78 to 145 kg with a mean weight of 119 kg.

Materials and Methods: Carcass composition, such as hot carcass weight (HCW), back fat depth and loin depth were measured on 666 carcasses. Additionally, loin quality measurements, such as pH, loin instrumental and visual color, and iodine value of clear plate fat were measured on approximately 90% of the total population. Ham quality, 14 d aged loin and chop quality measurements, and loin chop slice shear force (SSF) were evaluated on approximately 30% of the total population. Finally, myosin heavy chain fiber type determination was completed on approximately 50 carcasses selected from carcasses ranging from 97 to 133 kg. The slope of regression lines and coefficients of determination between hot carcass weights and quality traits were calculated using the REG procedure in SAS and considered significantly different from 0 at P ≤ 0.05.

Results: As HCW increased loin depth (β1 = 0.2496, P < 0.0001), back fat depth (β1 = 0.1374, P < 0.0001), loin weight (β1 = 0.0345, P < 0.0001), chop weight (β1 = 1.6626, P < 0.0001), and ham weight (β1 = 0.1044, P < 0.0001) increased. There was a decrease in estimated lean (β1 = -0.0751, P < 0.0001) and iodine value (β1 = -0.0923, P < 0.0001) as carcass weight increased, however, HCW only accounted for ≤ 24% (R² = 0.24) of the variation in estimated lean and iodine value. Additionally, there were no significant differences in glutus medius pH (β1 = 0.0009, P = 0.30) or instrumental lightness (β1 = 0.0301, P = 0.15), redness (β1 = -0.0036, P = 0.73) or yellowness (β1 = 0.0058, P = 0.57) of the ham as carcass weight increased. As carcass weight increased, 1 d loin instrumental yellowness (b*) increased (β1 = 0.0092 P < 0.01), however HCW only explained 1% of the variation in b*. Heavier carcasses were more tender (decreased SSF of chops cooked to 71°C, (β1 = -0.0674, P < 0.0001), although HCW only explained 9% of the variation in SSF. Total cook loss of chops used for SSF determination decreased as HCW increased (β1 = -0.0512, P < 0.0001), and HCW explained 15% (R² = 0.15) of the variation in total cook loss. There were no significant differences in fiber type percentage, type 1 (β1 = -0.0170, P = 0.81), 2a (β1 = -0.0786, P = 0.23), 2x (β1 = -0.0201, P = 0.80), or 2b (β1 = 0.1224, P = 0.37), or fiber type area, type 1 (β1 = -26.6331, P = 0.22), 2a (β1 = -40.7257, P = 0.07), 2x (β1 = -46.9459, P = 0.25), or 2b (β1 = -26.2537, P = 0.38) as HCW increased.

Conclusion: Due to the lack of variation explained by HCW (≤ 15%), pork quality traits are not expected to be compromised as HCW continues to increase. The results suggest that increasing HCW to 119 kg did not have detrimental effects on pork quality attributes.

Keywords: color, heavy pigs, hot carcass weight, pork quality, tenderness
VOLATILE COMPOUNDS OF LAMB LONGISSIMUS AND SEMIMEMBRANOSUS FROM AUSTRALIA, NEW ZEALAND, AND THE UNITED STATES

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Objectives: Differences in production practices based on country of origin create distinct differences in palatability of lamb from both the loin and the leg. The objective of this study was to identify volatile compounds which influence flavor across lamb leg and loin chops sourced from three countries of origin.

Materials and Methods: Lamb loins (IMPS #232 1 x 1; \( n = 30 \) / treatment) and legs (IMPS #233A; \( n = 60 \) / treatment) were sourced from Australia (AUS), New Zealand (NZ), and the United States (US). Product was fabricated to isolate the longissimus lumborum (LL) from the loins and the semimembranosus (SM) with adductor from the legs. Muscles were trimmed of external fat and connective tissue and fabricated into 2.54-cm thick chops, vacuum packaged individually, and frozen. A subset of samples (\( n = 15 \) / treatment) for volatile compound analysis were thawed at 2-4°C for 24 h, cooked to a medium degree of doneness, frozen, and powdered. Volatile compounds were extracted via SPME from powdered samples and analyzed using GCMS. Data were analyzed as a 2 x 3 factorial design with muscle, country of origin (COO), and their interaction as fixed effects with a significance level of \( \alpha = 0.05 \).

Results: Differences in volatile compounds of all classes were largely related to COO. Of the 36 lipid-derived compounds, 18 were affected by COO (\( P < 0.05 \)) and 11 were affected by the interaction of muscle and COO (\( P < 0.05 \)). Where the interaction was significant, US LL and SM samples generally produced greater concentrations of volatile compounds than other treatments (\( P < 0.05 \)), especially in compound classes including alcohols, \( n \)-aldehydes, and ketones. Of the alkanes evaluated, only pentane was greater in US samples compared to other samples (\( P < 0.05 \)) and was more than double the concentration produced in NZ and AUS samples. Alkenes did not follow the general trend of being increased in US samples. P-xylene was elevated in SM samples compared to LL samples (\( P < 0.01 \)), and toluene was greater in NZ samples compared to US and AUS samples (\( P < 0.05 \)). D-limonene was decreased in AUS samples compared to US and NZ samples. Of the 18 Maillard-derived compounds identified, 13 were affected by COO (\( P < 0.05 \)), 3 were affected by muscle (\( P < 0.01 \)), and 3 were affected by the interaction of COO and muscle (\( P < 0.05 \)). Of the Strecker aldehydes, 3-methylbutanal and 2-methylbutanal were both affected by both COO (\( P < 0.01 \)) and muscle (\( P < 0.05 \)). US samples produced the greatest concentration of these compounds (\( P < 0.05 \)) and AUS samples produced the least (\( P < 0.05 \)). Samples from LL produced more of these compounds than SM samples (\( P < 0.05 \)). Ketones including acetoin and 2,3-butanedione, which contribute positively to flavor in meat, were highly elevated in US samples compared to AUS and NZ (\( P < 0.05 \)). Sulfur-containing compounds were generally greater in non-domestic product than US samples, except for dimethyl sulfide, which was greatest in US SM samples and least in NZ LL and AUS SM samples (\( P < 0.05 \)). Pyrazines were generally elevated in NZ samples compared to AUS samples (\( P < 0.05 \)), with US samples intermediate (\( P > 0.05 \)).

Conclusion: Country of origin is a strong influencer of flavor compounds in lamb. This is likely attributable to global differences in production system including, but not limited to, diet, genetics, sex, and postmortem handling and will influence the perception of flavor by consumers.

Keywords: Country of Origin, Flavor, Lamb, Volatile Compounds
EVALUATING DIETARY INCLUSION OF HIGH OLEIC SOYBEAN MEAL AND OIL ON BROILER PERFORMANCE AND LIPID QUALITY

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Objectives: The objective of this study was to evaluate the effect of dietary inclusion of high oleic soybean meal and oil on broiler performance and lipid quality.

Materials and Methods: Male Ross 308 broiler chicks (n=160) were sorted by weight and randomly assigned to one of two treatments containing 10 replicate pens with 8 broilers each. Treatment groups consisted of a control corn-soy diet that included commodity soybean meal and oil (CON) and a corn-soy diet containing high oleic soybean meal and oil (HO). Broilers received, ad libitum, a two-phase diet consisting of starter (d0-21) containing 5% oil and grower (d21-42) containing 3% oil. Pen weight (PW) and feed intake (FI) were recorded on days 0, 21, and 42 and used to calculate feed to gain ratio (F:G). Broilers were slaughtered on d42, after which carcasses were weighed and fabricated. Weights of fabricated parts were recorded for carcass yield. Samples of breast and thigh meat were taken for fatty acid profile analysis, which was conducted using a modified version of methods by Folch et al. (1957) and Morrison and Smith (1964). To measure lipid oxidation, boneless, skinless breast halves chosen randomly from each pen were placed on Styrofoam trays and overwrapped with oxygen permeable, polyvinyl chloride and placed in retail storage (4°C) and used for collection of thiobarbituric acid reactive substances (TBARS) on day 1, 3, and 5 of storage. Data was analyzed using PROC GLM procedure in SAS, with level of significance set at P < 0.05.

Results: CON pens had a greater (P < 0.002) change in weight (23480.61 g. vs 21829.39 g.), however, the CON treatment had an increase in FI (P < 0.0003) compared to the HO treatment (29841.74 g. vs. 27405.68 g). Thus, there was no significant difference (P = 0.22) in F:G between treatments. While there was no difference (P = 0.39; P = 0.71) in percent carcass yield or breast yield, the CON treatment had a higher (P = 0.01) percent thigh yield compared to the HO treatment (16.36% vs 15.86%). Results of lipid oxidation showed there was an effect of day (P <0.0001), but no treatment or interaction effects were observed. Diet changed (P < 0.0001) the proportion of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) in breast and thigh meat. HO treatment increased the proportion of MUFA and decreased the proportion of PUFA and SFA in both breast and thigh meat. Both breast and thigh samples from the HO treatment had increased (P < 0.0001) proportions of oleic acid (C18:1) and decreased proportions of linoleic acid (C18:2) compared to the control. Inclusion of HO soybean meal and oil in broiler diets resulted in increased uptake of MUFA (C18:1) and decreased PUFA (C18:2) in both breast and thigh meat, while having no impact on broiler feed efficiency.

Conclusion: Pull through effect of HO acid seen in fatty acid analysis of broiler meat shows the ability to serve as a mechanism to increase oleic acid inclusion in human diets. Oleic acid needs are potentially related to omega-3 fatty acid needs which are shown to have health benefits related to cardiac health in humans among other things. Studies have shown that increases in oleic acid in diets can lead to an increase in omega-3 fatty acids.

Keywords: broilers, fatty acid, high oleic, lipid oxidation
Objectives: The objective of this study was to evaluate differences in fatty acid (FA) composition of NZ beef finished on fodder beet (Beta vulgaris subsp. vulgaris L.; FB) or traditional grass diets and US grain-finished beef.

Materials and Methods: Strip loins (n=240) were selected from a commercial abattoir in NZ representing two feeding treatments (FB, non-FB) and expected low and high eating quality (primarily based on marbling) following a nationwide feeding trial to finish beef steers using FB. Selection resulted in four treatments: FB low quality (FBL), FB high quality (FBH), non-FB low quality (NFBL), and non-FB high quality (NFBH). Additionally, sides of beef (n=120) representing USDA Top Choice (TCH) and Select (SEL) were sourced from a commercial abattoir in the US. Loins were fabricated prior to 21 d postmortem to isolate the longissimus lumborum (LL); these were sliced into 2.5 cm steaks, vacuum packaged, and stored at 2-4°C until 21 d or 35 d postmortem and frozen on the appropriate day. Lipids were extracted from a subset of samples via chloroform: methanol extraction then separated into polar and neutral fractions. Fatty acid methyl esters were evaluated using GC-FID. Data were analyzed with a 2-way ANOVA at a significance level of α= 0.05 and treatment, aging, and the respective interaction as fixed effects.

Results: Aging influenced percent saturated FA (%SFA; P<0.01), monounsaturated FA (%MUFA; P<0.01), and polyunsaturated FA (%PUFA; P=0.01). An increase in %MUFA and %PUFA at 35 d compared with 21 d (P<0.01) corresponded with a decrease in %SFA at 35 d (P<0.01). Treatment also influenced %PUFA (P<0.01). NFBL contained the greatest %PUFA (P<0.05). TCH and FBH contained less %PUFA than all treatments except SEL (P>0.05). Treatment and aging also affected palmitic and stearic acids (P<0.01), which make up the greatest portion of SFA. The proportion of palmitic acid was least in SEL (P<0.05) and greater in FBH than NFBH and TC (P<0.05). US treatments had lower proportions of stearic acid than NZ treatments (P<0.05). Both palmitic and stearic acids were of greater proportions in 35 d samples than 21 d samples (P<0.05). Oleic acid contributes largely to total FA and was affected by the interaction of treatment and aging (P=0.04). At 35 d, NZ treatments had greater proportions of oleic acid than at 21 d (P<0.05). The proportion of oleic acid was least in SEL at both aging times. Of the PUFA, linoleic was affected by treatment (P<0.05) and was greatest in SEL and TC (P<0.05); FB treatments had the lowest proportion of linoleic acid (P<0.05). Treatment and aging affected α-linolenic acid (P<0.01). NFBL and NFBH had a greater proportion than both FB and US treatments (P<0.05); both FB treatments had greater proportions of α-linolenic than US treatments (P<0.05). Proportion of α-linolenic acid was elevated with 35 d aging (P<0.05). Treatment affected proportions of long chain PUFA (P<0.05) with TCH and SEL having lower proportions than NZ treatments (P<0.05). Low quality NZ treatments had the greatest proportions of long chain PUFA (P<0.05).

Conclusion: While finishing diet does affect fatty acid composition of beef strip steaks, finishing on FB produces a similar FA composition to non-FB grass. Total lipid content is also responsible for variation in FA composition. As lipids oxidize during aging, a shift towards more unsaturated FA occurs, leading to a decrease in %SFA.

Keywords: Fatty acid, Feeding, Fodder beet


118-EFFECTS OF DRY HEAT COOKING METHOD AND QUALITY GRADE ON THE COMPOSITION AND OBJECTIVE TENDERNESS AND JUICINESS OF BEEF STRIP LOIN STEAKS

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Objectives: The objective of this study was to evaluate instrumental measures of tenderness and juiciness of beef strip loin steaks representing four different USDA quality grades cooked using four dry heat cooking methods.

Materials and Methods: Strip loins (n=12/quality grade) were collected from four USDA quality grades [Prime, Top (upper 2/3) Choice, Low (lower 1/3) Choice, and Select]. At 21 d post mortem, strip loins were cut into 2.5 cm thick steaks and stored at -20°C until analysis. The most anterior steak was used for compositional analysis and every three adjacent steaks were grouped and assigned randomly to one of four different dry heat cooking methods [electric clamshell grill (CLAM), flat-top gas grill (FLAT), charbroiler gas grill (CHAR), and salamander gas broiler (SAL)]. Objective measures for raw samples included proximate composition and for cooked samples included cooking loss, pressed juiciness (PJP), and slice shear force (SSF) after the sample was cooked to a medium degree of doneness (70-72°C). In addition, consumers assessed attributes for each sample on an electronic ballot with a 100-point continuous line scale for juiciness, tenderness, flavor liking, and overall liking. Proximate data were analyzed using the GLIMMIX procedure of SAS with quality grade as the fixed effect. All other data were analyzed as split-plot design with quality grade as a whole plot factor, the strip loin as the whole plot unit, and cooking method as a subplot factor.

Results: USDA Quality grade influenced fat, moisture, and protein percentage (P<0.01). As expected, there was a fat percentage difference (P<0.05) between each grade with a decline from Prime to Select samples. Therefore, Select had a greater (P<0.05) moisture percentage than any other quality grade, and an inverse relationship was observed as there was an increase in moisture between each grade from Select to Prime (P<0.05). Select and Low Choice had greater (P<0.05) protein percentage than Top Choice or Prime, which were similar (P>0.05). As expected, an inverse relationship between increased marbling levels and decreased SSF scores were also observed resulting in a negative correlation between fat and objective tenderness (r = -0.15; P<0.05). In addition, fat was positively associated with consumer palatability scores (r >0.21; P<0.01). Cooking method influenced (P<0.01) cooking loss, but did not impact SSF or PJP (P>0.19). CLAM had lower (P<0.05) cooking loss than FLAT, SAL, and CHAR, which did not differ from each other (P>0.05). The lower cooking loss of CLAM could be related to the shorter cooking times compared to the other methods. Pressed juiciness percentage was not influenced by quality grade, cooking method, or their interaction (P>0.19) and was not related to any objective or subjective measures of palatability (P>0.05). Slice shear force was not influenced by quality grade, cooking method, or their interaction (P>0.15); however, SSF was related (r ≤0.18; P<0.05) to tenderness, juiciness, flavor and overall liking.

Conclusion: In the current study, quality grade influenced the composition of raw samples, yet, quality grade coupled with different dry heat cooking methods did not influence objective measures of tenderness or juiciness.

Keywords: Beef, Cooking methods, consumer, USDA quality grade
**Meat and Poultry Safety**

**119-LISTERIA MONOCYTOGENES CONTROL USING CLEAN-LABEL INGREDIENTS**

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**Objectives:** World’s largest outbreak of listeriosis in South Africa last year, remind us that *Listeria monocytogenes* contamination and growth is still of major concern in refrigerated RTE meats. The same time customers demand for clean label food safety solutions. Provian NDV, a fermented vinegar based powder, was developed to provide a clean label solution that inhibits *Listeria monocytogenes* during long term refrigerated storage.

This document describes the effect of chemical derived acetates and Provian NDV, a novel vinegar based product, on the inhibition of *Listeria monocytogenes* in a cooked meat application.

**Materials and Methods:** Five treatments of cured deli-style ham were tested. The pork ham contained 72-74% (w/w) moisture, 1.75±0.1% (w/w) salt, and pH 6.2-6.4, 156 mg/kg sodium nitrite and 547 mg/kg sodium erythorbate. The treatments included a control without antimicrobials and different concentrations of a chemically derived acetates (0.5% and 0.75%) and Provian® NDV (0.5%, 0.65%). Cooked products were surface-inoculated with 3-log10 CFU/g of a cocktail of 5 strains of *Listeria monocytogenes* from the culture collection of Food research institute, Wisconsin University including serotypes 4b, 1/2a, and 1/2b. All strains were isolated from RTE-cooked meat products. Inoculated slices (100g/package) were vacuum-packaged and stored at 4°C and 7°C for 8 to 12 weeks. Per treatment triplicate samples were assayed by enumerating on modified Oxford Agar. One way ANOVA was used to analyze significance, p<0.05. Except from the triplicate repeat, this study was conducted twice independently (trial 1, 5 treatments in triplicate and trial 2 including same treatments, also in triplicate.)

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

**Image:**

- **Relative growth of Listeria in addition of Chemical Acetates and Neutralized Vinegar Powder at 4°C**
- **Relative growth of Listeria in addition of Chemical Acetates and Neutralized Vinegar Powder at 7°C**
**Conclusion:** This study confirms the efficacy of acetates on the inhibition of *Listeria monocytogenes*. Next, this study shows that a product based on natural fermented vinegar, Provian NDV, has a comparable growth inhibitive action in a cured ready-to-eat ham. This illustrates that most relevant serotypes (4b, 1/2b and 1/2a) of *Listeria monocytogenes* can be controlled using an ingredient based on natural fermented vinegar.

**Keywords:** clean label, Food Safety, Listeria control, sodium reduction
120-EFFICIENCY OF COMMERCIAL BACTERIOPHAGES ON STEC O157:H7 POPULATIONS IN BEEF KEPT UNDER VACUUM AND AEROBIC CONDITIONS.

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Objectives: High event period (HEP) is a specific time length when processing facilities experience an elevated rate of STEC contamination. STEC contamination during beef fabrication is assessed by sampling trim combos usually using N60, N60 plus, or CSD cloth methods. However, beef primals produced during high event periods can also be affected and must be assessed. A common industry practice consists in reworking primals by removing them from vacuum sealed bags, treating with antimicrobials, repackaging, and then test for STEC. In this study, we evaluated the efficiency of bacteriophage and organic acid applications on contaminated beef kept under vacuum and aerobic conditions.

Materials and Methods: Antimicrobials used in this study included: PhageGuard E (PGE, 10⁸ PFU/ml, Bacteriophage solution from Micreos Food Safety BV), peroxycetic acid (PAA, 400 PPM), and lactic acid (LA, 4.5% at 50°C). STEC O157:H7 strains included: ATCC® 35150™ (stx1 and stx2 positive), ATCC® 43895™ (stx1 and stx2 positive), ATCC® 43894™ (stx1 and stx2 positive), and Micreos 128. Bacteriophage killing efficiency was determined for individual strains in vitro. Fresh rose meat (Cutaneous trunci) was cut into 100 cm² and stored at 7°C. Meat samples (n=160, 5 reps, 2 experimental units per rep) were randomly assigned to a 4x2x2 factorial whereas fixed effects were antimicrobial treatment (Control, PGE, PAA, and LA), packaging (V - vacuum and NV – aerobic), and lysing time (30 min and 6 h). Samples were inoculated with 500 µL of a STEC cocktail containing all 4 strains and after 30 min at 7°C under vacuum or wrapped in permeable film, samples were treated with 500 µl PGE, sterile buffered peptone water (BPW, Control), LAA, or PAA. Samples were then re-vacuumed or re-wrapped with oxygen permeable film and kept either for 30 min or 6h at 7°C. After refrigeration, samples were swabbed and homogenized in 1mL of BPW. The swab content was serially diluted and spread-plated onto LB agar plates for bacterial enumeration. Data were analyzed using SAS as a completely randomized design.

Results: In vitro killing efficiency was 98.3%, 96.7%, 97.2%, and 98.2% for Micreos 128, ATCC® 43894™, ATCC® 43895™, and ATCC® 35150™ strains, respectively. When analyzing the effects of antimicrobials, packaging, and lysing time, a three-way interaction was observed (P = 0.035). Under aerobic conditions for 30 min, PGE reduced STEC in beef by approximately 1.4 log CFU/cm² whereas organic acids reduced by 0.5 log. Similar results were observed when samples were kept for 6 h. Under vacuum conditions for 30 min, PGE significantly reduced STEC by 1 log, whereas no significant effects were observed when treating beef with PAA and LA. Under vacuum conditions for 6h, PGE significantly reduced STEC loads by 1.4 log, whereas LA reduced by 0.6 log and no differences were observed between control and PAA treatments.

Conclusion: Bacteriophage applications on beef contaminated with STEC yielded the lowest counts when compared to PAA and LA. Although organic acids led to a significant decrease of STEC loads in beef kept under aerobic conditions, bacteriophage application led to the lowest counts. Similar to reworking and testing primals produced during a HEP, while under vacuum conditions, bacteriophage significantly reduced STEC loads whereas no or minimal effects of organic acids were observed.

Keywords: bacteriophage, high event period, lactic acid, PAA
Objectives: Recent reports of an extremely heat resistant but non-pathogenic beef *Escherichia coli* strain, AW 1.7, raised concerns over the adequacy of cooking ground beef to 71°C in Canada. The objective of this study was to assess the adequacy of the current cooking recommendations for ground beef in relation to heat resistant *E. coli*.

Materials and Methods: In total, 8 potentially heat resistant *E. coli* strains (4 generic and 4 *E. coli* O157:H7) from beef along with *E. coli* AW1.7 were included in this study. Heat resistance of the strains was first evaluated by decimal reductions at 60°C (D values), the time required to have a log reduction of the bacterial population at 60°C. The more heat resistant strains of each group (*E. coli* 62 and 68, and *E. coli* O157 J3 and C37) were further assessed for their heat resistance when grown in Lennox Broth without salt (LB-NS), LB + 2% NaCl and Meat Juice (MJ). Then, the two most heat resistant *E. coli* O157 strains (J3 and C37) and *E. coli* AW 1.7 were each introduced to extra lean ground beef (100 g) in vacuum pouches for determination of their D-values at three temperatures, 54, 57 and 60°C, from which a z-value for each strain was derived. The thermal characteristics of all three strains were fed into a predictive model to determine the process lethality of cooking burgers to 71°C with resting for up to 5 min. Finally, inactivation of the most heat resistant *E. coli* strain AW1.7, assessed in this study and reported in the literature, in ground beef was validated by grilling burgers containing 6.20 ± 0.24 log CFU/g of the organism to 71°C without or with a resting of 3 or 5 min.

Results: The D values for these strains varied from 1.3 to 9.0 min, with J3 and AW1.7 being the least and most heat resistant strains, respectively. The D 60°C values for *E. coli* 62 and 68 were similar and were not affected by growth medium, while the heat resistance of the strains was first evaluated by decimal reductions at 60°C (D 60°C-value), the time required to have a log reduction of the bacterial population at 60°C. The more heat resistant strains of each group (*E. coli* 62 and 68, and *E. coli* O157 J3 and C37) were further assessed for their heat resistance when grown in Lennox Broth without salt (LB-NS), LB + 2% NaCl and Meat Juice (MJ). Then, the two most heat resistant *E. coli* O157 strains (J3 and C37) and *E. coli* AW 1.7 were each introduced to extra lean ground beef (100 g) in vacuum pouches for determination of their D-values at three temperatures, 54, 57 and 60°C, from which a z-value for each strain was derived. The thermal characteristics of all three strains were fed into a predictive model to determine the process lethality of cooking burgers to 71°C with resting for up to 5 min. Finally, inactivation of the most heat resistant *E. coli* strain AW1.7, assessed in this study and reported in the literature, in ground beef was validated by grilling burgers containing 6.20 ± 0.24 log CFU/g of the organism to 71°C without or with a resting of 3 or 5 min.

Conclusion: It has been predicted that 2% of *E. coli* from beef may carry heat resistant genes. The findings in this study, along with the very low level of total *E. coli* expected in ground beef in Canada, suggest that cooking ground beef to 71°C should be adequate to ensure the safety of such products.

Keywords: Cooking recommendations, *E. coli*, Ground beef, Heat Resistance
DOES TREATING BEEF SUBPRIMALS WITH UV-LIGHT REDUCE PATHOGENS AND IMPACT QUALITY?
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Objectives: To evaluate reduction of pathogens and impact on quality parameters of beef strip loins treated with pulsed-Ul light.

Materials and Methods: Inoculum was prepared as a cocktail of three non-pathogenic, rifampicin-resistant E. coli Biotype I surrogates. Strip loins were halved, inoculated, individually vacuum packaged, and assigned to one of three pulsed-light UV treatments: (1) light height 5 cm, belt speed 15 Hz; (2) light height 28 cm, belt speed 15 Hz; and (3) light height 28 cm, belt speed 25 Hz. Microbiological samples were obtained and enumerated pre- and post-treatment (n = 90; 3 UV treatments ✕ 5 strip loin halves per treatment ✕ 2 sampling times (pre/post treatment) ✕ 3 replications).

To evaluate quality parameters, a control group was added to the three UV treatments. Uninoculated strip loin halves (n = 48) were fabricated, packaged, and assigned (n = 12 strip loins halves per treatment) to one of the four treatment groups. Within each group, n = 3 strip loin halves were assigned a storage time (0, 7, 14, or 21 d). After treatment, three steaks from each strip loin half (approximately 2.54-cm thick; n = 192 total steaks) were cut and individually packaged for analyses: (1) trained aroma and color panel, (2) steak surface pH, purge pH, purge quantification, and objective color, and (3) aerobic plate counts.

Data were analyzed using JMP Pro (SAS Institute Inc., Cary, NC). The fit model function was used for analysis of variance, and least squares means comparisons were conducted when appropriate using Student’s t-test with an alpha-level 0.05.

Results: No differences were seen (P > 0.05) in reductions of E. coli surrogates among the three UV treatments, with all reductions less than 1-log. No differences (P > 0.05) in aroma scores among treatment groups were noted, although differences in aroma attribute scores occurred between aging times. Panelists scored samples highest (P < 0.001) for bloody/serumy on d 0 than any other aging time. Conversely, sour dairy and spoiled intensified over time with d 21 samples receiving the highest scores (P < 0.001). Although trained panelists’ responses for lean color score did not differ (P = 0.277) among UV treatments, scores for percent discoloration did (P = 0.014). Notably, percent discoloration scores for d 0 were statistically higher than other aging times, meaning that discoloration diminished as aging continued. No statistical differences were identified for L*, a*, or b* values across UV treatments. Between aging times, differences were seen (P < 0.001) for a* and b* values, with d 0 having the lowest values for both. For purge and pH, the surface pH of steaks was higher on days 0 and 7 and began to decrease, showing statistical similarities on days 14 and 21. The amount of purge (g) steadily increased as steaks aged. APC counts were not found to differ due to UV treatment but generally tended to increase as storage times lengthened.

Conclusion: Pulsed-Ul light on chilled subprimals resulted in low microbial reductions, however, this technology could be beneficial if used in addition to other antimicrobial interventions. Initial discoloration was identified but improved as steaks aged. While APCs tended to increase over the course of storage, as did purge, no differences due to UV treatments were seen. Further research is warranted to determine if different treatment parameters would result in greater microbial reductions.

Keywords: beef, food safety, intervention, pulsed-light UV
Objectives: Creating artisanal, dry salami products is an increasing trend for charcuterie companies in the United States. These raw, ready-to-eat products are required by USDA-FSIS to have a scientifically valid HACCP system addressing relevant biological hazards. To our knowledge, no literature exists for the validation (at least a 5 Log_{10} reduction of pathogens per FSIS) of salami products containing duck. Therefore, an experiment was designed to validate the safety of duck salami. The objectives of this study were to validate the safety of fermented and dried duck salami and to investigate if a duck salami manufacturing processes could achieve a 5 LOG_{10} (CFU/g) reduction of *Salmonella* spp., *Listeria monocytogenes*, and *Campylobacter* spp.

Materials and Methods: Duck trim and pork belly (70% duck trim, 30% pork belly) were placed in a mixed culture bath approximating three liters. The culture bath was made by growing individually and then combining three strains each of *Salmonella* spp. and *Listeria monocytogenes*, two strains of *Campylobacter jejuni*, and one strain of *Campylobacter coli*. After inoculation, meat was air dried (30 min @ 23°C), tumbled with one liter of 2.5% Beefxide® antimicrobial treatment (lactic and citric acid and hydrogen peroxide), and placed in a walk-in cooler (2-4°C) overnight. After inoculation and antimicrobial treatment (~24 h), the meat was ground (6mm grinding plate) and seasoned with salt (2.5%), cure (NaNO$_3$ & NaNO$_2$), spices, and starter culture. The ground duck-pork mixture was stuffed into 55mm collagen casings, fermented for 48 hours (23°C, 95% rH), and dried (12°C, 75% rH) to ~45% weight loss (approx. 5 weeks). Salamis were then vacuum packaged and stored at 23°C (approx. 4 weeks). Three independent replications were conducted, and pathogen concentrations, pH, and water activity (a$_w$) were analyzed at days 0, 1, 2, 3, 5, 10, and weekly until day 66 during each replication. Critical parameters for production included a final pH less than 5.3 and final a$_w$ less than 0.90.

Results: A 5 LOG_{10}(CFU/g) reduction was achieved for all three pathogens. *Salmonella* achieved a 5.47 LOG$_{10}$(CFU/g) (p<0.0001) reduction by day 38, *Listeria monocytogenes* achieved a 5.20 LOG$_{10}$(CFU/g) (p<0.0001) reduction by day 59, and *Campylobacter* achieved a 6.85 LOG$_{10}$(CFU/g) (p<0.0001) reduction by day 45. Final reductions of 7.03 (p<0.0001), 5.90 (p<0.0001), and 7.19 (p<0.0001) LOG$_{10}$(CFU/g) were achieved for *Salmonella* spp., *Listeria monocytogenes*, and *Campylobacter* spp., respectively. During the entire fermentation and drying process, populations of each species never increased by more than 1 LOG$_{10}$(CFU/cm$^2$). A final pH of 5.11 and a final a$_w$ of 0.81 were also achieved.

Conclusion: The results of this study indicate that the parameters used to ferment and dry this product are able to achieve a 5 LOG$_{10}$(CFU/g) reduction of each pathogen to validate the safe production of duck salami.

Keywords: Campylobacter, Duck Salami, Listeria monocytogenes, Salmonella
ANTIMICROBIAL INTERVENTIONS TO REDUCE SHIGA TOXIN-PRODUCING ESCHERICHIA COLI (STEC) SURROGATE POPULATIONS ON BEEF STRIPLOINS INTENDED FOR BLADE TENDERIZATION

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Objectives: Blade tenderization (BT) is used in the beef industry to improve tenderness of steaks prepared from subprimals but can translocate surface pathogens to the interior of meat. Application of antimicrobial solutions on the surface of subprimals prior to blade tenderization can reduce the risk of translocation of surface microorganisms. The objectives of this research were: 1) evaluate the efficacy of antimicrobial interventions applied to inoculated (surrogate Escherichia coli) beef striploins prior to blade tenderization; and 2) examine the transfer of E. coli from inoculated striploins to subsequent non-inoculated subprimals.

Materials and Methods: The anterior portion of whole muscle beef striploins (30.48 cm) were inoculated (lean side) across a 10 cm band with a ca. 8.00 log CFU/mL cocktail containing non-pathogenic, rifampicin-resistant surrogate STEC strains (BAA-1427, BAA-1428, BAA-1429, BAA-1430, and BAA-1431). The inoculated striploins were sprayed with (i) levulinic acid (5.0%) + sodium dodecyl sulfate (0.50%) (LVA+SDS), (ii) peroxyacetic acid (2,000 ppm; PAA; FCN 1666), (iii) acidified sodium chlorite (1,200 ppm; ASC), or (iv) lactic acid (4.5%; LA) by passing through a spray cabinet and blade tenderized, along with an inoculated, non-sprayed control (CON). To evaluate the potential for cross-contamination of subsequent subprimals, an inoculated striploin (for each treatment) was blade tenderized followed by a non-inoculated beef striploin. For each striploin, surface and subsurface samples (2.54 cm wide) were collected from three different locations including the anterior, middle, and posterior end of each striploin. A total of 30 striploins across three replications were randomly assigned to treatment stratification. Sponge samples were also collected from the blade tenderizer (plate of the blade unit and blades) after each treatment group. Data were analyzed using Proc Mixed (SAS Inst., v.9.4; Cary, NC) as a completely randomized split-plot design. Microbial counts for all samples were log transformed and then analyzed for the main effects of antimicrobial treatment, location (anterior to posterior and surface or interior), and their interaction. Differences were considered significant at $\alpha \leq 0.05$.

Results: PAA was more effective in reducing E. coli populations (1.80 log CFU/g; $P \leq 0.05$) and had lowest recovery of the microorganism from the striploin sub-surface compared to other treatments, followed by LVA+SDS (1.00 log CFU/g). E. coli populations gradually decreased ($P \leq 0.05$) on the surface and subsurface as sampling moved anterior to posterior. However, E. coli populations were similar ($P > 0.05$) on the posterior end of inoculated striploins and the anterior end of the subsequent, non-inoculated striploins, indicating transfer of microorganisms from one striploin to the following striploin. E. coli populations of 3.03 log CFU/cm² and 2.47 log CFU/cm² were recovered from the plate of the blade unit and the blades of the blade tenderizer. E. coli populations recovered from the plastic plate (3.46 log CFU/cm²) and blades (2.87 log CFU/cm²) of the blade tenderizer were the similar ($P > 0.05$) for all treatment groups except for PAA (1.41 log CFU/cm² and 0.97 log CFU/cm², respectively).

Conclusion: These results showed that PAA and LVA+SDS can be used to improve the safety of blade tenderized beef.

Keywords: Antimicrobial interventions, Beef, Escherichia coli, Non-intact, Surrogate
Objectives: The objective of this study was to determine the impact of intervention treatments on the organoleptic properties of ground pork during shelf-life.

Materials and Methods: Pork trimmings were divided into 22 kg batches for each individual treatment (n=4 batches). Treatments included control (no intervention), PAA+Titon™ [Sulfuric acid and sodium sulfate (pH 1.3) combined with peracetic acid (350 ppm)], PAA+Acetic [Peracetic acid (400 ppm) with 2% acetic acid], and LA [Lactic acid (3%)]. After application of each designated treatment, trimmings were ground (coarse and then fine ground) and packaged into 454-g vacuum packaged rollstock packaging. Each package was then stored in dark storage for 0, 7, 14, 21 and 28 days at 2-4°C (n= 8 packages per treatment and time combination). Once each package had reached their designated storage length, packages were removed from storage for sampling. Shelf-life measurements taken included TBARS, raw product odor acceptability, aerobic plate count and psychrotrophic plate count bacterial enumeration. All bacterial enumeration data were converted into log₁₀ for statistical analysis, and the PROC MIXED procedure of SAS was used to determine differences between least squared means (SAS Inst. Inc., Version 9.4, Cary, NC). Odor acceptability was determined using a PROC FREQ.

Results: For aerobic plate counts (APC), in the ground pork product, a treatment by day interaction occurred (P=0.007). Psychrotrophic bacterial counts did not differ by treatment or sampling day (P>0.05). PAA+Titon™ and LA had decreased lipid oxidation compared to PAA+Acetic and control pork samples over the 28 d of storage. Lipid oxidation didn’t change for all 4 treatments on days 0, 14, 21, and 28; however, there was an unexplainable spike in lipid oxidation for samples on day 7. Overall pork odor acceptability differed by storage length (P=0.02), but not by treatment (P>0.05). Overall Pork odor acceptability decreased as storage length increased. Acidic off-odor differed by storage length (P=0.002), but not by treatment (P>0.05). Acidic off-odor increased as storage length increased. Overall oxidation off-odor did not differ by treatment or aging (P>0.05). Sweaty off-odor development differed by aging day (P=0.01) but not by treatment (P>0.05). Sweaty off-odor reached its highest point within day 14 and 21 and then decreased. An increasing sour off-odor development differed by ground pork storage length (P=0.001), but not by treatment (P>0.05).

Conclusion: There were no dramatic negative organoleptic changes to pork trim when treated with selected organic acid interventions prior to grinding, meanwhile there is organoleptic changes by storage length.

Keywords: aerobic plate counts, antimicrobials, odor, pork trimming, TBARS
ANTIMICROBIAL RESISTANCE IN RETAIL GROUND BEEF WITH AND WITHOUT A “RAISED WITHOUT ANTIBIOTICS” CLAIM


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Objectives: The occurrences of human bacterial infections complicated by antimicrobial resistance (AMR) have increased in recent decades. Concerns have been raised that food-animal production practices that incorporate antimicrobials contribute significantly to human AMR exposures since food-animal production accounts for approximately 81% of U.S. antimicrobial consumption by mass. Although empirical studies comparing AMR levels in meat products, including ground beef, are scant ground beef products with Raised without Antibiotics (RWA) label claims are perceived to harbor less AMR than “conventional” (CONV) products with no label claims regarding antimicrobial use. The objective of this research was to determine AMR levels in retail ground beef with and without an RWA label claims.

Materials and Methods: Retail ground beef samples were obtained from 6 U.S. cities. Samples were obtained on the following dates: 9/18/2017, 10/30/2017, 11/27/2017, 1/29/2018, 3/5/2018, and 6/11/2018. A total of 599 samples were obtained. Samples with a “Raised without Antibiotics” or USDA Organic claim (N = 299) were assigned to the RWA production system. Samples lacking a “Raised without Antibiotics” claim (N = 300) were assigned to the CONV production system. Each sample was cultured for the detection of five antimicrobial resistant bacteria (ARB). Genomic DNA was isolated from each sample and qPCR was used to determine the abundance of ten antimicrobial resistance genes (ARGs). The impacts of production system and city on ARB detection were assessed by the Likelihood-ratio chi-squared test. The impacts of production system and city on ARG abundance was assessed by two-way ANOVA.

Results: Tetracycline-resistant Escherichia coli (CONV = 46.3%; RWA = 34.4%) and erythromycin-resistant Enterococcus (CONV = 48.0%; RWA = 37.5%) were more frequently (P < 0.01) detected in CONV. Detection of 3rd generation cephalosporin-resistant E. coli (CONV = 5.7%; RWA = 1.0%), vancomycin-resistant Enterococcus (CONV = 0.0%; RWA = 0.0%) and methicillin-resistant Staphylococcus aureus (CONV = 1.3%; RWA = 0.7%) did not differ (P = 1.00). The blaCTX-M ARG was more abundant in CONV (2.4 vs. 2.1 log copies/gram, P = 0.01) but the tet(A) (2.4 vs. 2.5 log copies/gram, P = 0.02) and tet(M) (3.6 vs. 3.9 log copies/gram, P < 0.01) ARGs were more abundant in RWA, aadA1, blaCMY-2, mecA, erm(B), and tet(B) abundances did not differ significantly (Figure 1) (P > 0.05). Abundances of aac (6’)-Ie-aph (2’)-Ia and blaKPC-2 were not analyzed since they were quantified in less than 5% of the samples.

Conclusion: U.S. retail CONV and RWA ground beef harbor generally similar levels of AMR since only 5 of 15 AMR measurements were statistically different between production systems. Three AMR measurements were higher in CONV, while 2 AMR measurements were higher in RWA. These results are in general agreement with a recently published study authored by our group that examined antimicrobial resistance in CONV and RWA ground beef obtained from U.S. foodservice suppliers (Vikram et al., J. Food Prot. 81:2007-2018. 2018.). Together these studies suggest that antimicrobial use during U.S. cattle production has minimal to no impact on human exposure to AMR via ground beef.

Keywords: antibiotic resistance, antimicrobial resistance genes, antimicrobial resistant bacteria, ground beef, Raised without Antibiotics
**Objectives:** The shiga toxin-producing *Escherichia coli* (STEC) has been involved in a series of outbreaks around the world. Organic acids, such as lactic acid, have been used in meat plants to control STEC. However, STEC has shown its capacity to survive in low acid environments, which may compromise the effectiveness of organic acid interventions. Similarly, STEC may also survive in human stomach fluid (pH 1.5 – 3.5), which can potentially result in clinical infections. Thus, the objective was to compare the ability of acid-resistant (AR) STEC to survive in inorganic and organic acid at different pH levels.

**Materials and Methods:** For this study, five AR STEC strains were used to make an inoculum for the study. The AR STEC inoculum was challenged in acidified TSB with lactic acid (2% at pH 3.2; 5% at pH 2.8) and TSB with hydrochloric acid (HCl; to simulate human stomach acid) at pH 1.6, 2.8, 3.2 and 3.5 for 2, 4, 6, and 8 h at 37°C. After the acid challenge, the survival bacteria counts were plated on TSA plates and incubated for 48 h at 37°C. The complete experiment was repeated five times. The data was analyzed using the generalized linear model of the SAS 9.4.

**Results:** The AR STEC showed a distinct ability to survive in organic and inorganic acid, even with the same pH. Exposure of AR STEC to HCl with pH 3.2 and 3.5 for 8 h resulted in the highest (*P <0.01*) survival counts across all the treatments. When AR STEC was challenged with HCl at pH 1.6, no survival cells were recovered on TSA plates after 4 h. No additional reduction of AR STEC was observed when exposure time to HCl at pH 2.8 and 3.2 was increased. However, no growth (*P <0.01*) of AR STEC was observed after exposure to lactic acid at the same pH by time.

**Conclusion:** Lactic acid (2% and 5%) effectively controlled the growth of AR STEC in pure culture. However, if AR STEC can survive through the meat production chain, they may survive in the human stomach for an extended period when the pH is higher than 1.6. The results of the study emphasize that it is necessary to eliminate AR STEC before they enter the human body, as they are more resistant in inorganic acid, such as the HCl found in human stomach fluid.

**Keywords:** Acid resistant STEC, Inorganic acid, Organic acid
Objectives: Beef primals produced during high event periods (HEP) can also be affected by STEC contamination requiring microbial assessment. Commonly, primals are retreated with antimicrobials after removal from vacuum bags, then repackaged and tested for STEC. In this study, we evaluated the efficiency of bacteriophage, ultraviolet light, and organic acids on contaminated beef kept under vacuum and aerobic conditions.

Materials and Methods: The effects of antimicrobial interventions Peroxyacetic acid (PAA, 400 PPM), Ultraviolet light (UV, 30 s at 2.5±0.3 cm height), Acidified Sodium Chlorite (ASC, 1200 ppm), and bacteriophage (P, 7 MS phages at 10⁸ PFU/ml) against STEC (O157:H7 and O145, O121, O111, O103, O45, O26) were evaluated on beef. Fresh m. cutaneous trunci was fabricated into 100 cm² samples (n=154), which were randomly assigned to 11 treatments including Control, P, UV, ASC, PAA, and combinations P+UV, P+PAA, P+ASC, UV+PAA, UV+ASC, PAA+ASC. Treatments were tested under vacuum and aerobic conditions. Samples were inoculated with a STEC cocktail comprised of 7 strains to yield 3 log CFU/cm². Samples were vacuumed or overwrapped with oxygen permeable film. Samples were unpackaged and treated with buffered peptone water (BPW, Control) or individual or combined antimicrobial treatments prior to re-packaging. After 1 hour at 7°C, samples were swabbed, homogenized in 1 mL of BPW, serially diluted and spread-plated for bacterial enumeration. Data was analyzed using SAS as a completely randomized design.

Results: Overall, treatments including MS phages significantly decreased STEC populations in beef under vacuum and aerobic conditions (P<0.0001). Under vacuum, individual phage application, combinations between phage and UV, ASC, and PAA plus UV+ASC provided optimal STEC reduction on beef surface. Phage and PAA combination led to the lowest STEC load (1.49 log reduction). When analyzing contrasts, treatments with phage significantly decreased STEC loads when compared to other treatments (P<0.0001) and control (P<0.0001). STEC loads recovered from treatments without phage and control were statistically similar at P=0.32. Under aerobic conditions, individual treatments UV and ASC and combinations including UV+PAA, and PAA+ASC were statistically similar to the control. Inclusion of phage in treatments gradually decreased STEC loads when combined with ASC, PAA, and UV. Phage and UV combination led to the lowest STEC load (1.46 log reduction). Contrast analysis showed that treatments with phage significantly decreased STEC loads when compared to other treatments (P<0.0001) and control (P<0.0001). STEC loads recovered from treatments without phage and control were statistically similar at P=0.07.

Conclusion: Individual or combined applications of MS phages on beef surface contaminated with STEC provided optimal antimicrobial effect under vacuum or aerobic conditions. Although organic acids and UV combinations did reduce STEC populations, treatments that included phage yielded the lowest STEC loads. Only phage interventions gave optimal reduction effects under vacuum conditions. Antimicrobial treatments based on individual phage cocktails and their combinations with ASC, UV, and PAA significantly reduce STEC when treating primals produced during HEP.

Keywords: bacteriophage, High Event Period, O157:H7, organic acids, STEC
VALIDATION OF A RESTRUCTURED BEEF JERKY PRODUCT AND PROCESS TO REDUCE PATHOGEN LOADS AND IMPROVE SHELF STABILITY IN ETHIOPIA
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Objectives: Animal-sourced foods (ASFs), such as meat, provide nutrients that are beneficial for physical and cognitive development, especially in developing countries. Despite Ethiopia containing Africa’s largest inventory of livestock, market structure and inefficiencies in livestock and meat industries contribute to low-per capita consumption of meat. The combination of extensive periods of fasting from ASFs, knowledge gaps in hygienic handling and sanitation, lack of infrastructure and preservation, and weakly enforced food safety regulations contribute food safety risks in an already protein-deficient population. The objective of this study is to develop a dried beef jerky procedure that will reduce pathogen loads in meat, improve shelf stability, and increase access to ASFs in Ethiopia.

Materials and Methods: Challenge studies were performed to validate a restructured jerky production process for control of five serotypes of Salmonella enterica (Saint Paul, Anatum, Typhimurium, Newport, Dublin) and three strains of E. coli O157:H7, within the constraints of equipment and ingredients available in Ethiopia. A traditional Ethiopian spice mixture was added to lean ground beef (94% lean, 6% fat), and in separate trials apple cider vinegar and pureed raisins were incorporated at varying percentages of the overall weight. The ground meat mixture was formed into strips and dehydrated to achieve a_w of less than 0.70 for shelf stability and samples were plated for enumeration before and after drying. A consumer taste panel was conducted with treatments (0% and 15% raisin inclusion) to determine the acceptability of Ethiopian consumers. Sixteen Ethiopian consumers (10 men and 6 women) were asked to answer study-related questions and evaluate jerky products on visual appeal, texture, off-flavor, and overall liking on a 10-point hedonic scale.

Results: Vinegar inclusion negatively impacted log CFU reductions of S. enterica as the control demonstrated significantly higher (P=0.04) reductions than treatments including vinegar at 0.5, 1, and 2%. Including 15% raisins (w/w) in the meat and spice mixture resulted in an increased (P<.0001) log CFU reduction of S. enterica (5.41 CFU/g) versus the control (4.44 CFU/g) and all treatments achieved greater than 6-log CFU/g reduction of E. coli O157:H7.

Conclusion: Including raisins reduces S. enterica loads versus the control and all formulations exceeded a 6.0 log CFU/g reduction of E. coli O157:H7, in a restructured beef jerky product. A restructured jerky product could provide butchers with an additional marketing avenue and opportunity to reduce waste and pathogen loads in beef. Ethiopian consumers would also have an option for a commercially available, shelf-stable product which could provide additional protein to their diet that is easy to store and transport.

Keywords: Africa, Animal-source foods, Beef, Food Safety, Food Safety Risk
**Objectives:** Pathogen Reduction; Hazard Analysis and Critical Control Point systems final rule mandates establishments to seek and adopt antimicrobial interventions that can help in reducing the prevalence and most probable number of Salmonella in their meat and poultry products. Bacteriophages can aid in this challenge as they can invade and kill specific target pathogenic bacteria on food products. Effective kill by phages relies on the appropriate phage application technique. Correct dose, good distribution on the food surface area and adequate dwell time are key factors which influence phage-bacteria contact and thereby phage efficacy.

This study determined the efficacy of a commercially available phage product, PhageGuard S consisting of 2 phages, FO1a and S16. Different pick up levels, blend and hold times (chosen based on regulatory restriction and process limitations) as well as spray versus dip treatment methods were tested.

**Materials and Methods:** Overnight culture streptomycin resistant *Salmonella enterica enterica* Enteritidis C (Se13) was diluted and inoculated at a concentration of $2 \times 10^4$ CFU/cm$^2$ or CFU/g on parts of chicken fillet and held for 10 minutes for bacterial attachment (duplicate samples per time point). Subsequently, contaminated parts were spray treated with one phage concentration ($10^8$ Plaque Forming Units/g) at 0.5%, 1% or 3% pick up (v/w) or water (control) and blended for 5, 10 and 20 minutes before immediate grinding and retrieval of bacteria (latter blend time sample was held for 24 hours before grind). Another set of contaminated fillet parts were treated by dipping in 5% phage solution (at 1% pick up, $10^8$ PFU/g) and held for 1, 5, 10 and 20 minutes, and 1 and 24 hours at 40 °F (4 °C) before retrieval of bacteria. Enumeration of bacteria was done on selective agar plates and reductions were calculated relative to water treated control.

**Results:** The application of phages $10^8$ PFU/g via spray on chicken parts at 3% pick up and 20 minutes blend time resulted in $0.9 \log_{10}$ CFU/g log reduction of *Salmonella*. Additional hold time of 24 hours before grind resulted in $1.1 - 1.2 \log_{10}$ CFU/g kill at lower and higher pick up of 0.5% and 3%. Dip treatment resulted higher Salmonella reduction of $1.2 \log_{10}$ CFU/cm$^2$ within 5 minutes of $10^8$ PFU/cm$^2$ phage application and up to $2.3 \log_{10}$ CFU/cm$^2$ $\log_{10}$ reduction when held for 24 hours. Overall, the spray technique, showed a dose response effect where increasing pick up and blend time resulted in an increasing Salmonella kill in ground product. However, dip technique resulted in more effective Salmonella kill in shorter dwell time. All values are mean value of two individual experiments.

**Conclusion:** The above results indicate that the commercially available phage solution, PhageGuard S either via spray or dip method reduces Salmonella contamination on meat and poultry parts by $1.2 - 2.3 \log_{10}$ respectively. Thereby is an effective intervention in reducing risks and allowing for increase in consumer safety. Dip technique works better than spray due to better distribution on meat surface. Longer hold and/or blend time after phage treatment results in more kill.

**Keywords:** bacteriophage, ground turkey, parts, poultry processing, Salmonella
Objectives: Due to developing meat trade issues associated with use of the beta-agonist ractopamine hydrochloride (RH) as a growth-promoting agent in livestock production, this project was developed to provide recommendations of best practices to beef cattle producers in the United States who intend to export to China. This study is critically important in better understanding the bioaccumulation and depletion of RH in live animals, and how this may relate to depletion in differing tissues upon animal harvest.

This study was designed to determine dose response and depletion curves in the lower gastrointestinal (GI) tract of fistulated (i.e., cannulated - both rumen and duodenal) steers either receiving or not receiving ractopamine hydrochloride as part of the daily ration. There were originally five steers in this study, but due to performance challenges and scarring issues, one animal was removed from the study for a total of four test subjects.

Materials and Methods: In the dose and depletion study, four steers (n = 2 not receiving RH and n = 2 receiving RH at the approved dosage) were assessed from -3 days (still receiving RH if on the RH treatment) to 13 days post-withdrawal to determine the amount of RH present and length of time required for RH to clear the GI tract should a contamination event of low levels occur. Residues were quantified using liquid chromatography mass spectrometry (LC-MS).

Results: For the dose and depletion study, RH residues were quantified in rumen fluids, rumen solids, fecal material, and duodenal fluids. Overall, the RH present in the two control steers (which did not receive RH) declined from approximately 30 ppb in all matrices three days before withdrawal to below the limit of quantitation at the end of withdrawal. Furthermore, samples tended to be below the limit of quantitation by day 4 post-withdrawal. The steers that received RH also exhibited a decline of RH throughout the withdrawal period for all matrices (e.g. 5,800 ppb in rumen fluids at day -3 versus 1.81 ppb 13 days post-withdrawal).

Conclusion: The dose and depletion study results suggest that RH declines rapidly in the lower GI of beef cattle, with levels below detection by day four. There are events in which RH declines and then spikes, so further research may be necessary to determine why this rapid increase occurs.

Keywords: Depletion and bioaccumulation, Fistulated steers, Ractopamine
Objectives: This research was conducted to evaluate the killing efficiency of the Mello-Shebs (MS) O157:H7 bacteriophage against three strains of STEC O157:H7 in vitro and on beef surface under aerobic conditions.

Materials and Methods: Killing efficiency of bacteriophage MS O157:H7 (University of Nevada, Reno – Meat Science library) was tested against three strains including ATCC® 43895™ (stx1 and stx2 positive), ATCC® 43894™ (stx1 and stx2 positive), and Micreos 128. To determine the efficiency of the phage in vitro, each strain of STEC O157:H7 was incubated at 37°C overnight and then diluted to achieve 1500 CFU/mL. Subsequently, 0.1 ml of this dilution for each strain was plated onto 1.6% LB agar plates. The experimental plates received 0.1 ml of phage solution at 10^8 PFU/ml, in quadruplicate. The plates were incubated at 37°C for 24 h and the resulting colonies were counted and compared to controls to determine killing efficiency of the phage against each STEC strain. In order to evaluate the effect of bacteriophage application on beef, m. cutaneous trunci (rose meat, IMPS 194) were sourced from a USDA inspected facility, fabricated into 100 cm^2 and randomly assigned to either control or treatment groups. Samples acclimated to 7°C were inoculated with a STEC cocktail to result in a contamination level of approximately 3 log CFU/cm^2 on meat surfaces after swabbing. After bacterial attachment for 30 min at 7°C, control samples were treated with sterile buffered peptone water (BPW) and experimental samples were treated with the phage solution at 10^8 PFU/ml. After dwelling for 1 hour at 7°C, samples were swabbed and the resulting 1 mL was thoroughly vortexed, serial diluted, and plated onto LB plates. The plates were incubated at 37°C for 24 h and the resulting colonies were counted. Data was analyzed as a completely randomized design in SAS. Means were separated by LSMEANS and differences were indicated by using DIFF functions.

Results: In vitro killing efficiency of bacteriophage MS O157:H7 was determined to be 85%, 98.89%, and 97.16% for ATCC® 43895™, ATCC® 43894™, and Micreos 128 strains, respectively. On beef, bacteriophage application significantly decreased STEC loads by 0.626 log CFU/cm^2 (P=0.0184, SEM = 0.21).

Conclusion: Bacteriophage MS-O157:H7 applications as an antimicrobial on beef reduces STEC O157:H7 populations on contaminated beef. Commercial applications of this bacteriophage may improve STEC control in meat products, however, having this treatment combined with other interventions such as organic acids or UV light treatment may increase the killing efficiency of STEC populations, warranting further research to determine industry applicability.

Keywords: bacteriophage, MS O157:H7, STEC
Objectives: To perform an in-plant validation of a lactic acid immersion (2-5%) intervention in 6 different subprimals on the fabrication floor.

Materials and Methods: Swab samples (n=324) were taken before and after intervention application from six different processing lines. Each subprimal had a 500 cm² area swabbed using sterile materials. Each repetition included 18 samples per line, 9 before and 9 after intervention, for a total of 108 samples per repetition. Swab samples were immediately chilled and shipped overnight to the TTU Food Microbiology laboratory for microbial analysis. Samples were stomached at 230 rpm for 30 seconds and for each subprimal, 3 individual samples were composited into one. Serial dilutions were performed and 1ml of each composite was plated onto Enterobacteriaceae, aerobic plate count, Escherichia coli and coliform Petrifilms in duplicate. Counts were transformed into LogCFU/cm² and statistical analysis was performed to determine differences between before and after treatment samples with a 0.05 probability threshold.

Results: Microbial counts of all four microorganisms evaluated were significantly reduced (P < 0.05) after the lactic acid immersion (2-5%) intervention application in subprimals. Total coliform counts before and after treatment were 0.31 and 0.06 LogCFU/cm² respectively. Enterobacteriaceae counts in the subprimals were in average 0.40 LogCFU/cm² before interventions and 0.06 LogCFU/cm² after intervention application. Overall aerobic plate counts were 1.77 LogCFU/cm² before intervention and 1.14 LogCFU/cm² after intervention. Generic E. coli counts after intervention were lower than the detection limit (< 1 CFU/20 cm²).

Conclusion: Based on data collected, it is reasonable to conclude that the lactic acid immersion intervention is effective in reducing common microbial indicators on subprimals inside the fabrication floor, improving the safety of the product.

Keywords: Indicator microorganism, Intervention, Lactic Acid, Validation
**Objectives:** The objective of the experiment was to evaluate the effects of drying, lactic acid spray, and a certain marinade application on the survival of generic *Escherichia coli* on Biltong.

**Materials and Methods:** Frozen eyes of round (IMPS #171C) were obtained from a local beef purveyor. The eyes of round were thawed (at 4°C), trimmed of extra fat and connective tissues, and cut into strips (L x W x T; 6 in x 2 in x 0.75 in). The experiment was divided into 2 groups and replicated once. Experiment 1 was further sub-grouped into 3 treatments: a) negative control (NC), b) negative control for dip treatment (NCD), and c) inoculated group (I). Experiment 2 was sub-grouped into 6 treatments: a) negative control (NC), b) negative control for dip treatment (NCD), c) positive inoculated control (PIC), and inoculated treatments d) marinated (M), e) 2% lactic acid spray (LA), and f) marinated and lactic acid spray (MLA). For both experiments 1 and 2, 12 strips of biltong were randomly selected for each treatment (n = 36 for experiment 1; n = 72 for experiment 2). The inoculated samples were dipped for 30 seconds in a cocktail (5-log) of 4 different strains of nalidixic adapted *Escherichia coli* (beef isolates) and allowed 2 hours for attachment at 4°C. The lactic acid was sprayed to each side of the respective biltong and allowed a 10-minute resting period. Marinade was applied to respective treatment groups by dipping, rubbing, and incubating overnight (at 4°C). All samples were kept in a smokehouse in a controlled environment with drying cycle at 78°F and 60% relative humidity. Experiment 1 was incubated in the smokehouse for a total of 12 days and experiment 2 was incubated for 9 days total. Samples from each treatment group were removed on days 0, 2, 5, 7, 9, and 12 (experiment 1 only) for microbiological sampling and analysis. Samples were homogenized, serially diluted, enumerated on TSA plus 200 ppm nalidixic acid, and incubated at 35°C for 18-24 hours. Colonies were counted after 24 hours and colony counts were transformed into log_{10} CFU for reporting.

**Results:** The data for experiment 2 showed that the treatments LA, M, MLA, and PIC were able to achieve a 2.5-3 log_{10} CFU reduction after 9 days of drying. The M and MLA treatments exhibited a 2-3 log_{10} CFU reduction after 2 days of drying as compared with LA and PIC that showed a similar reduction in microbial counts after 9 days of incubation. The NC and NCD treatment groups resulted in no microbial growth from day 0 till day 9 of incubation. The data for experiment 1 showed that there was a 1 log_{10} CFU reduction of *E. coli* in treatment group I. The NC and NCD groups did not show microbial growth from day 0 till day 9 of incubation. The water activity decreased overtime to 0.722 for experiment 1 and 0.711 for experiment 2. Overall, the M and the MLA samples appeared to have the greatest and quickest killing effect on generic *E. coli*.

**Conclusion:** Results from these experiments suggest that the combination of drying with a lactic acid spray and marinade application causes a decrease in the *E. coli* population on Biltong during incubation for 9 or 12 days. While the results show that there may be a small decrease from drying alone, the greatest decreasing effect appears to be the combination of the drying, lactic acid, and marinade. Future work will include additional replicates and experiments with pathogens such as *E. coli* O157:H7.

**Keywords:** Beef Jerky, Biltong, Drying, Escherichia coli
**Objectives:** Shiga toxin-producing *E. coli* (STEC), which are often found in the intestinal tract of cattle and in their fecal matter, are among the most common foodborne pathogens of concern in beef production. Contamination from the fecal matter, both directly and indirectly, during harvest may compromise the safety of the beef products, which can have devastating impact on consumers and producers alike. While the microbial load present in cattle fecal matter may change as the cow matures, previous research has generally focused on analysis of the pathogen load late in the life cycle of cattle. There is merit in the analysis of this load earlier in the life cycle of cattle, as this may serve to subsequently control the pathogen load during later stages of production. As such, this study aims to assess the prevalence and characteristics of STEC in beef cattle production at the early post-weaning stage.

**Materials and Methods:** Rectal fecal samples from post-weaning cattle (*n*=68) were collected. Ten grams of each sample was mixed and manually homogenized with 90mL tryptic soy broth (TSB) with added phosphates. The homogenized samples were spread-plated on CHROMagar STEC plates and incubated at 35°C for 24h before enumeration. To determine STEC prevalence, the homogenized samples were incubated at 42°C for 6 hours, and streaked onto a second set of CHROMagar STEC plates, which were incubated at 35°C for 24h. Colonies with a purple coloration were STEC-positive. Two random STEC-presumptive colonies from each sample were tested via subsequent PCR amplification and gel electrophoresis to confirm the presence of *stx1*, *stx2*, and/or *eae* genes.

Acid-resistant strains of presumptive STEC colonies from the enriched samples were collected and inoculated into TSB for recovery. One hundred microliters of the inoculated sample were then transferred into TSB without dextrose and incubated at 35°C for 24h, and finally challenged in acidified TSB without dextrose (pH=3.50) for 1h and 6h. One hundred microliters of each survival sample were plated onto tryptic soy agar (TSA), and incubated at 35°C for 48h.

**Results:** The fecal samples had an average 4.79 ± 1.24 log CFU/g (ranging 2.30 to 6.83) of STEC colonies. All samples were STEC-positive, as all samples had at least one of the three genes tested for (*stx1*, *stx2*, *eae*). All sixty-eight samples were confirmed positive for gene *stx1*, 12% (8 of 68) samples were confirmed positive for *stx2*, 62% (42 of 68) of samples were confirmed positive for *eae*, and 12% (8 of 68) were positive for all three genes. Of 67 samples tested for acid resistance, 34% (23 of 67) survived after six hours in acidified growth media (pH = 3.50).

**Conclusion:** This study provided preliminary data on the pathogen load of early post-weaning cattle. The prevalence of acid resistance shown may be a possible cause of concern, as these surviving bacteria can survive high acidic conditions. This may expedite the spread of acid-resistant pathogens within the food supply chain as acidic antimicrobial chemicals become ineffective in reducing pathogen populations. These results may be used as a baseline for future research regarding STEC prevalence or acid resistance aimed at reducing pathogen load in beef cattle production. Given the prevalence of acid resistance, further development is recommended for non-acid post-harvest antimicrobial interventions to reduce the presence of acid resistant STEC.

**Keywords:** Acid resistant STEC, Beef, Food Safety, STEC
**Anti-Salmonella Effects of Pyruvic and Succinic Acid in Combination with Oregano Essential Oil**

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**Objectives:** Effective decontamination approaches will aid in improving safety of poultry products and help processors comply with pathogen performance standards. Increasing consumer demand for clean label and more natural ingredients presents a scope to explore alternative decontamination approaches for meat and food contact surfaces. This study aimed to evaluate the antimicrobial efficacy of combinations of pyruvic acid (PA), succinic acid (SA), and oregano essential oil (EO) against *Salmonella Typhimurium* in suspensions, cells inoculated on raw chicken, and cells attached to steel.

**Materials and Methods:** Minimum bactericidal concentration (MBC) assays were conducted in Mueller-Hinton broth (5 ml). Bacterial cells were added to broth suspensions of antimicrobial agents or their combinations. A contact time not exceeding 10 s was provided. Surviving bacteria were recovered on tryptic soy agar (TSA). Bacterial inactivation was confirmed by enrichment in D/E broth. Experiment involved completely randomized design with each concentration of organic acid and essential oil being considered as one level. Data were analyzed using 1-way ANOVA. Aqueous solutions of PA, SA, EO, and the mixtures of PA+EO and SA+EO were prepared using 0.05% agar to suspend the essential oil. Skin-on raw chicken breast meat pieces (2.5 cu cm) were used as a substrate to inoculate nalidixic acid (NA) adapted *Salmonella* cells. Pieces were treated with antimicrobial agents for 30 s by dipping, and surviving *Salmonella* were recovered using D/E broth on XLT-4 agar with 50 ppm NA. Four different experiments with variable acid and essential oil concentrations were carried out and data were analyzed using 1-way ANOVA. Each experiment included an inoculated untreated control. Stainless steel coupons (2 x 5 cm) were used as a substrate for *Salmonella* attachment. Cells were allowed to grow and attach on coupons submerged in tryptic soy broth for 24 h. Coupons were rinsed to remove planktonic cells. Attached cells remaining on the coupon were dip treated with antimicrobial agents for 5 min. Surviving cells were recovered on TSA. For antimicrobial treatments leading to no cell recovery, additional experiments were carried out. The recovery broth was enriched in tryptic soy broth and streaked on TSA to confirm inactivation. Three different experiments were conducted while including their respective inoculated and untreated controls and analyzed using 1-way ANOVA. All experiments were conducted in three replicates.

**Results:** MBC for PA was found to be PA (0.5%), SA(3%), EO (0.04%), PA+EO (0.25 + 0.02 %), SA+EO (0.25 + 0.02 %), respectively. 1% PA + 0.08% EO combination produced the maximum reduction (1.42 ± 0.11 log CFU/cm²) followed by 6% SA + 0.08% EO (1.02 ± 0.08 log CFU/cm²) in *Salmonella* populations on raw chicken. More than 6 log CFU/coupon of attached *Salmonella* were inactivated by mixtures of 0.25% PA + 0.02% EO and 1.5% SA + 0.02% EO.

**Conclusion:** The combinations of PA+EO and SA+EO both exhibited strong anti-*Salmonella* activity in cell suspensions, on cells attached to stainless steel, and were effective in reducing *Salmonella* populations on raw chicken. Therefore, these antimicrobial combinations merit further research for raw poultry, meat, and other sanitation applications.

**Keywords:** biofilms, essential oil, organic acids, poultry processing, Salmonella
Objectives: The objective of this study was to determine if immunosuppression altered Salmonella (SAL) translocation from the GI tract subsequently contaminating the carcass during fabrication.

Materials and Methods: Weaned Holstein steer calves (n=20; BW=102±2.7 kg) received dexamethasone (DEX; n=10; 0.5mg/kg BW), a synthetic glucocorticoid, or saline (CON; n=10; 0.5mg/kg BW) for 4 d (from d-1 to d 2) via a jugular catheter prior to oral inoculation of nalidixic acid resistant Salmonella Typhimurium (3.4x10^6 CFU/animal) via milk replacer on d 0. Fecal swabs were obtained daily to ensure SAL infection. Blood was collected to assess hematological markers of immunosuppression. Upon harvest (d 5), the ileum, cecal content, lymph nodes (ileocecal, mandibular, popliteal and prescapular), and synovial (stifle, coxofemoral and shoulder) swabs were collected for the isolation of the inoculated strain of SAL. The trim obtained during fabrication was then ground separating both fore and hind quarters of each carcass. Ground beef samples were collected using a random grab method then combined for a composite sample for each fore quarter and each hind quarter for every carcass. The sample were diluted with 225ml of PBS

Results: Following inoculation, 100% of DEX calves shed the experimental strain of SAL for 5 d, 90% of CON calves shed from d 1 to 3, and 100% of CON calves shed from d 4 to 5. A treatment by tissue interaction (P<0.01) was observed for SAL in tissues collected at harvest. Greater (P<0.001) concentrations of SAL were quantified from the cecum of DEX calves (3.86 ± 0.37 log10 CFU) than CON (1.37 ± 0.37 log10 CFU); There was no difference in SAL concentrations between DEX and CON calves in ileal tissue (P=0.07), nor ileocecal (P=0.57), mandibular (P=0.12), popliteal (P=0.99), or prescapular (P=0.83) lymph nodes. Salmonella was isolated from the stifte joint of one calf in the CON group; however, SAL was not isolated from any other joint fluids sampled. The prevalence of SAL in the ground beef samples was recovered in 7 of the 80 (8.75%) samples taken. This is important to note as it was 3.3% of swabs collected from the CON treatment and the opportunity exists for stifle joint fluid to come in contact with meat during hind quarter fabrication.

Conclusion: The observed data suggests that the grab method for ground beef sampling may not be a correct quantification of overall presence of SAL in a ground beef sample. Therefore, further studies are needed to determine the effectiveness of pathogen sampling methods on ground beef.

Keywords: Food Safety, ground beef, Lymph Nodes, Salmonella, Synovial Fluid
Muscle and Lipid Biology and Biochemistry

138-PH VARIABILITY AND ITS RELATIONSHIP WITH SARCOMERE LENGTH AND FREE CALCIUM IN BEEF FROM COMMERCIAL CATTLE IN PUERTO RICO

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Objectives: Research conducted at the University of Puerto Rico noted that beef with elevated pH values (>5.86) resulted in more tender meat (P≤0.05). It has been established that proteolytic degradation mechanisms can be influenced by pH and calcium concentration in muscle. Beef with pH values ≥5.86 is classified as Dark Firm and Dry (DFD) but there are negative implications associated with greater pH values. However, observations indicating increased tenderness with increased pH raise the question: can variations in pH be associated with differences in sarcomere length (SL) and free calcium concentration (FCC)? Therefore, the objectives of this project were to: (1) document pH distribution; (2) determine the incidence of DFD; and (3) evaluate the relationship between pH, SL, and FCC in commercial cattle harvested in Puerto Rico.

Materials and Methods: Longissimus lumborum samples (n = 51) were obtained and background information was noted including number of permanent incisors (PI), type (Dairy or Beef), and gender. The pH values were used to categorize beef into the following groups: Low (≤5.40), Normal (5.41 to 5.59), High (5.60 to 5.85) and DFD (≥5.86). Meat was flash frozen, powdered, and placed on a microscope slide and a Helium-Neon laser was used to determine SL. A subset of samples was sent off and prepared at the University of Nebraska-Lincoln for FCC quantification (Ward Laboratories; Kearney, NE) with an inductively coupled plasma emission spectrometer (iCAP 6500 Radial; Thermo Electron, Cambridge, UK). All statistical analyses were conducted in SAS (9.4). The Proc FREQ was used to determine pH category distributions and incidence of DFD. The Proc GLIMMIX and Tukey adjustment (α=0.05) were used to determine the effects of number of PI, type, and gender on pH category, SL and FCC. The Proc CORR was used to evaluate the relationship between pH category, SL and FCC.

Results: The pH category distribution for the current samples was as follows: 3.92% Low, 41.18% Normal, 35.29% High and 19.61% DFD. The SL ranged from 1.69 to 1.46 mm with an average of 1.53 mm. The FCC ranged from 132.19 to 31.39 mM with an average of 64.23 mM. Longer sarcomeres were detected in cattle with eight and zero PI (1.57 and 1.56 mm, respectively); cattle with two and four PI had intermediate SL (1.53 and 1.52 mm, respectively), and cattle with six PI had the shortest sarcomeres (1.51 mm; P=0.03). Dairy cattle had longer sarcomeres relative to beef cattle (1.56 vs. 1.52 mm; P=0.02). Dairy cattle tended to have increased FCC relative to beef cattle (70.72 vs. 58.38 mM; P=0.08). Also, FCC tended to be greater within the Normal and Low pH categories relative to the High and DFD categories (72.36 vs. 57.31 mM; P=0.06). The SL and FCC had no relationship (P>0.05) within the Low, Normal and High pH categories. However, DFD beef had longer SL (0.78; P=0.01), while having decreased FCC (-0.66; P=0.04).

Conclusion: Over half (54.90%) of the beef samples analyzed fell into the High and DFD pH categories, with nearly 20% being classified as DFD. Although, a clear relationship was not established between SL and FCC within the Low, Normal or High pH categories, the results indicate that the increased pH in samples surpassing the DFD threshold correspond to longer sarcomeres and decreased free calcium.

Keywords: free calcium, pH, sarcomere length
Objectives: Ractopamine is a beta-adrenergic agonist approved as growth promotant in beef cattle, and it increases muscle deposition while limiting fat deposition. Dietary ractopamine causes a muscle fiber shift in cattle, and the biochemistry of mitochondria in postmortem beef skeletal muscles is influenced by fiber type. Therefore, dietary ractopamine may potentially affect mitochondrial functionality. Nonetheless, the influence of ractopamine on beef skeletal muscle mitochondrial proteome has not been evaluated. Therefore, the objective of this study was to examine the effects of ractopamine on mitochondrial proteome of postmortem longissimus lumborum (LL) from beef cattle.

Materials and Methods: Pen-housed crossbred steers were fed either a corn-based basal diet (CON) or a diet top-dressed with Optaflexx 45 (Elanco Animal Health) to provide 400 mg of ractopamine hydrochloride/steer per day (RAC). Ractopamine was fed the last 28 days prior to the harvest. The animals were harvested, and carcasses were chilled for 24 h. The LL muscle samples were obtained from nine (n = 9) RAC and nine (n = 9) CON carcasses. Mitochondrial proteome was analyzed using two-dimensional electrophoresis, and the digital gel images were analyzed. The protein spots exhibiting more than 1.5-fold intensity differences (P < 0.10) between RAC and CON were subjected to in-gel tryptic digestion and were identified by tandem mass spectrometry.

Results: Seven differentially abundant proteins were identified in the mitochondrial proteome. Three proteins were over-abundant (P < 0.10) in RAC, whereas four spots were over-abundant in CON. The proteins over-abundant in RAC mitochondrial proteome was complement component 1 Q subcomponent-binding protein, very long-chain specific acyl-CoA dehydrogenase, and aconitate hydratase. On the other hand, ATP synthase subunit beta, prohibitin, cytochrome b-c1 complex subunit 1, and thioredoxin-dependent peroxide reductase were over-abundant in CON samples. The differentially abundant proteins belong to four functional groups; i.e., energy metabolism (ATP synthase subunit beta, cytochrome b-c1 complex subunit 1, and aconitate hydratase), chaperone activity (complement component 1 Q subcomponent-binding protein and prohibitin), antioxidant activity (thioredoxin-dependent peroxide reductase), and lipid metabolism (very long-chain specific acyl-CoA dehydrogenase).

Conclusion: Dietary ractopamine impacts mitochondrial proteome in postmortem beef LL muscle and influences the abundance of proteins involved in cellular metabolism and protective mechanisms. The increased protein synthesis and leanness previously reported in ractopamine-fed cattle may be attributed to the decreased expression of enzymes involved in respiratory electron transport pathways and the increased expression of enzymes involved in lipolysis.

Keywords: Longissimus lumborum, Mitochondrial proteome, Ractopamine
140- THERMAL STABILITY OF BEEF MYOGLOBIN IS COMPROMISED BY REACTIVE LIPID OXIDATION PRODUCTS

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Objectives: Brown color of cooked meat is the result of heat-induced denaturation of myoglobin (Mb). The denaturation temperature of Mb is governed by its redox state in raw meat; metmyoglobin (MMb) undergoes denaturation at a lower temperature than oxymyoglobin (OMb) and deoxymyoglobin (DMb). The secondary products of lipid oxidation, such as the 4-hydroxy-2-nonenal (HNE), compromise Mb redox stability and can thus impact cooked meat color. While previous investigations extensively studied lipid oxidation-induced Mb redox instability, studies are yet to be undertaken to examine the relationship between lipid oxidation and Mb thermal stability. Therefore, the objective of the present study was to investigate the direct influence of lipid oxidation (using HNE as a model aldehyde) on thermal stability of beef Mb at typical meat conditions.

Materials and Methods: Beef Mb was purified, and OMb was incubated with HNE (0.15 mM Mb + 1.0 mM HNE) at pH 5.6 and 4°C for 21 d. The controls consisted of OMb plus a volume of ethanol used to deliver HNE to treatments. The samples were scanned spectrophotometrically from 650 to 500 nm on d 0, 7, 14 and 21, and MMb formation was calculated. The Mb samples were removed on d 0, 7, 14 and 21, and were digested with trypsin. The tryptic peptides were analyzed using liquid chromatography tandem-mass spectrometry (LC-MS/MS) for detecting HNE adduction sites. The thermal stability of Mb in the presence of HNE was assessed on d 0, 7, 14 and 21 by determining the percentage myoglobin denaturation (PMD) at 71°C in a water bath for 10 min. The experiment was replicated three times (n = 3). The effects of HNE on Mb redox and thermal stabilities during incubation were evaluated using the mixed procedure of SAS. The differences among means were detected at the 5% level using the least significant difference (LSD) test.

Results: While MMb formation increased (P < 0.05) during the storage in both control and HNE-treated samples, the oxidation was higher (P < 0.05) in HNE-treated samples. The PMD values increased (P < 0.05) in both treatments during the storage, and the HNE-treated samples exhibited greater (P < 0.05) PMD than the controls throughout the storage. Additionally, the PMD difference between HNE-treated and control samples increased over time. The LC-MS/MS analyses indicated that the number of histidines adducted by HNE increased with storage. HNE adducted four histidines (positions 24, 36, 93, and 152) on d 7, whereas five (positions 24, 36, 64, 93, and 152) and six (positions 24, 36, 64, 93, 113, and 152) residues were adducted on d 14 and 21, respectively.

Conclusion: The mass spectrometric data indicated that thermal stability of beef Mb was compromised by reactive lipid oxidation products. The HNE addition at the distal histidine (position 64), which is critical to heme stability, observed on d 14 and 21 as well as the increased number of histidines adducted by HNE on d 14 and 21 could be the possible reasons for the increased PMD on these time points. The addition of HNE to histidines can alter the heme protein’s tertiary structure and thus exposes the heme to oxidation, thereby accelerating the formation of MMb, which is more susceptible to thermal denaturation than the ferrous Mb redox forms.

Keywords: Cooked color, Lipid oxidation, Myoglobin, Thermal stability
Objective: Cooking ensures safety and enhances the palatability attributes of meat. Denaturation of myoglobin results in the dull-brown color of cooked meats. The denaturation of sarcoplasmic proteins is influenced by the degree of heat treatment, and their solubility is decreased with an increase in the endpoint cooking temperature. While previous studies examined the relationship between myoglobin denaturation, cooked color, and internal temperature in beef, investigations are yet to be undertaken to characterize the association between endpoint temperature, sarcoplasmic proteome, and color attributes in cooked steaks. Therefore, the objective of the present study was to examine the influence of endpoint cooking temperature (60°C and 71°C) on sarcoplasmic proteome and internal color of beef longissimus lumborum (LL) steaks.

Materials and Methods: Eight (n = 8) beef LL muscles (14 d postmortem; USDA Choice) were obtained from a commercial packing plant. Two 2.5-cm thick steaks were fabricated from the center of the muscles and were cooked to internal endpoint temperature of 60°C (C-60) or 71°C (C-71) in a clam-shell grill. Cooked steaks were immediately cooled in slushed ice, sliced parallel to the grilled surface, and internal redness (a* value) and color stability (R630/580) were evaluated instrumentally. Sarcoplasmic proteome from the interiors of the cooked steaks was analyzed using 2-dimensional electrophoresis, and the gel images were digitally analyzed. The protein spots exhibiting more than 2.5-fold intensity differences (P < 0.05) between C-60 and C-71 were subjected to in-gel tryptic digestion and were identified by tandem mass spectrometry.

Results: The C-60 steaks demonstrated greater (P < 0.05) a* and R630/580 than their C-71 counterparts. Seven differentially abundant proteins were identified and were over-abundant (P < 0.05) in C-60 compared to C-71. The differentially abundant proteins belong to 6 functional groups, i.e., transport proteins (serum albumin and hemoglobin), energy metabolism (adenylate kinase isoenzyme 1), chaperones (heat shock protein beta-1), antioxidant (thioredoxin-dependent peroxide reductase), glycolytic enzymes (fructose-bisphosphate aldolase B), and protease (cytosol aminopeptidase).

Conclusion: The findings indicated that the endpoint cooking temperature influences the internal cooked color and the sarcoplasmic proteome profile of beef LL steaks. The overabundant proteins in steaks cooked to 60°C may be utilized as potential biomarkers for undercooked beef, which is a source for foodborne infections.

Keywords: Cooked color, Longissimus lumborum, Sarcoplasmic proteome
Objectives: Vitamin E is a lipid-soluble antioxidant that can inhibit lipid oxidation and improve beef color stability. The effect of vitamin E on fresh beef color, from the standpoint of lipid oxidation-induced myoglobin oxidation, have been extensively studied. However, the influence of vitamin E on sarcoplasmic proteome profile of beef skeletal muscles is yet to be investigated. Therefore, the objective of this study was to examine the effect of dietary vitamin E on sarcoplasmic proteome of postmortem beef longissimus lumborum (LL) muscle.

Materials and Methods: Crossbred heifers, managed with a GrowSafe feeding system, were fed ad libitum corn-based diet containing either no supplemental (CONT) or 1,000 IU vitamin E/heifer per day (VITE) for 89 days. The animals were harvested, and carcasses were chilled. The LL muscle samples were obtained from the carcasses of nine (n = 9) VITE and nine (n = 9) CONT heifers 24 h postmortem. The muscle samples were individually vacuum-packaged and frozen at –80°C for proteome analysis. Sarcoplasmic proteome was analyzed using two-dimensional electrophoresis, employing immobilized pH gradient strips (pH 3-10; 17 cm) in the first dimension and 12% sodium dodecyl sulfate polyacrylamide gel electrophoresis in the second dimension. The gels were scanned, and the digital gel images were analyzed. The protein spots exhibiting more than 1.5-fold intensity differences (P < 0.10) between VITE and CONT were subjected to in-gel tryptic digestion and were identified by tandem mass spectrometry.

Results: Five differentially abundant spots were identified using mass spectrometry, and all the spots were over-abundant in CONT. The proteins in the differentially abundant spots were antioxidant proteins (thioredoxin-dependent peroxide reductase, peroxiredoxin-6, and serum albumin) and glycolytic enzymes (beta-enolase and triosephosphate isomerase). The antioxidant proteins minimize oxidation of lipids and proteins in muscle matrix, whereas the glycolytic enzymes generate NADPH, which helps maintain the antioxidant proteins in their reduced forms.

Conclusion: The strong antioxidant protection offered by vitamin E could have possibly led to less expression of antioxidant proteins as well as glycolytic enzymes that generate antioxidant metabolites in the VITE group, whereas the lack of such protection in CONT group may have led to increased expression of these proteins in the skeletal muscles.

Keywords: Longissimus lumborum, Sarcoplasmic proteome, Vitamin E
Objectives: To compare lipid (malondialdehyde [MDA], 4-hydroxy-2-nonenal [HNE]) and protein (carbonyl content [CAR]) oxidation products and determine their influence on color stability in two bison muscles (longissimus lumborum [LL; color stable] and psoas major [PM; color labile]).

Materials and Methods: A total of 10 longissimus lumborum (LL) and 10 psoas major (PM) from five A1 grade bison carcases were obtained from a commercial slaughter plant within 48 h post-mortem. From each muscle, a 10-cm thick piece was removed and sub-sampled for evaluation of pH, MDA (by thiobarbituric acid assay), HNE (by ELISA) and CAR (by 2,4-dinitrophenylhydrazine). These measurements allowed the establishment of a baseline for the different oxidation products. The remainder of the muscles were cut into two equal portions, and each portion was vacuum-packaged and assigned to an ageing period of 7 and 14 d at 2°C. At the end of each ageing period, each muscle portion was removed from their packages, pH measured, and steaks obtained for sensory (muscle and discoloration scores) and instrumental color measurements (L*, a* and b*) over 5 days of retail display, and for estimation of MDA, HNE and CAR. After 5 days in retail display and following color and pH measurements the steaks were removed and collected for MDA, HNE and CAR determination. Data were analyzed as a completely randomized design with a split-split plot arrangement. Additionally, correlation and regression analysis were performed to identify the influence of the measured attributes on color.

Results: Regardless of the ageing time, LL showed greater redness and lower surface discoloration by instrumental (a* value; $P = 0.04$) and sensory ($P < 0.01$) color evaluation than PM at the end of the retail display. Furthermore, LL exhibited lower MDA, HNE and CAR content compared to PM ($P < 0.05$). A three-way interaction (muscle x ageing time x retail day display) was detected on MDA content, where PM presented a higher level of MDA with increasing ageing time and retail display than LL ($P = 0.02$). The pH was not different between LL and PM ($P > 0.05$) steaks. In both muscles, Pearson ($r$) and Spearman ($rs$) correlation coefficients indicated that MDA was the oxidation compound showing the highest correlation to a* ($r = -0.78$; $P < 0.01$) and discoloration ($rs = 0.81$; $P < 0.01$) scores, followed by a moderate correlation with HNE and CAR ($r$ or $rs < 0.7$; $P < 0.01$). The pH did not exhibit correlation with color traits, except for lightness, in both muscles. For the stepwise regression analysis, the main variable entered into the equation for predicting a*, color and discoloration score in PM muscle was MDA with an $R^2$ of 0.72, 0.75 and 0.78, respectively, while for LL muscle, MDA presented an $R^2$ of 0.62, 0.68 and 0.66; respectively. The pH, HNE and CAR only explained an additional 2% of the variation in those attributes.

Conclusion: The results of color attributes corroborated that bison LL is a color-stable muscle due to the lower level of protein and lipid oxidation products developed during storage and retail display compared to PM muscle, which is considered color-labile muscle. The MDA seemed to have remarkable importance in the color deterioration than HNE and CAR, particularly in bison PM muscle.

Keywords: Bison, color stability, discoloration mechanisms, longissimus lumborum, psoas major
MYOGLOBIN MODELING TO STUDY SPECIES-SPECIFIC DIFFERENCES IN THE DISTANCE BETWEEN HEME IRON AND PROXIMAL AND DISTAL HISTIDINES
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Objectives: Species-specific differences in amino acid sequence influence myoglobin redox properties. Previous studies reported that the number and location of histidine residues can influence myoglobin redox stability. However, limited knowledge is currently available on the species-specific differences in the distances between the proximal (His 93) and distal (His 64) histidines and the heme iron in myoglobin. The objective of the current research was to utilize homology-based modeling to determine the distances between the proximal and distal histidines and the heme iron in the myoglobins from beef, pork, goat, bison, sheep, water-buffalo, venison, and emu.

Materials and Methods: The homology-based modeling was conducted using the Iterative Threading Assembly Refinement server (I-TASSER), which identifies the homologous structure models of myoglobins (beef, pork, goat, bison, sheep, water-buffalo, venison, and emu) from Protein Data Bank (PDB) using an algorithm named Local Meta-Threading-Server. The secondary structure of the target protein was predicted based on sequence information from the Protein Secondary Structure PREDiction algorithm. The lowest free energy conformations of the proteins were determined by SPICKER (a clustering approach to identify near-native protein folds). Refinement of the low free energy conformations were done by using Fragment Guided Molecular Dynamics simulations and ModRefiner. Prediction of the ligand-binding site of the target proteins were made by COACH algorithm. The distances between histidines (His 64 and His 93) and the iron in the heme group in the predicted structure of eight different species were determined using PyMOL, a computer software used for molecular visualization.

Results: The homology-based modeling has shown that despite having 80% sequence similarity and conserved histidine residues (His 64 and His 93), the distance between the distal histidine (His 64) and heme iron varied between 4.3-5.5 Angstrom. Pork myoglobin has the shortest distance, and beef myoglobin has the longest distance. The distance between the proximal histidine (His 93) to the heme varied between 1.9 to 3 Angstrom; sheep myoglobin had the shortest and bison had the longest.

Conclusion: The results suggest that in addition to the inherent differences in muscle biochemistry, variations in myoglobin structure also contributes to species-specific differences in meat color.

Keywords: Histidine, Meat Color, Myoglobin
Objectives: To determine the influence of corn supplementation of beef cows during winter and their impact on offspring beef quality attributes.

Materials and Methods: Forty-seven multiparous Angus beef cows carrying male calves were assigned randomly to two dietary treatments: corn supplementation at 0.2% BW (SUP; n = 24) vs. non-supplementation (NSUP; n = 23) at d 110 of gestation for 22 wks. *Ad-libitum* access to low-quality forage was provided to both groups. At 7 days post-calving, a muscle biopsy was collected from the *longissimus dorsi* muscle (LD) of each calf for muscle fiber typing. Offspring were managed as a single group from nursing through to the backgrounding phase. Thereafter, the steers were placed in the feedlot and assigned to 4 pens (blocks) based on BW and offered *ad-libitum* access to a 100% corn silage-based ration (76.97% TDN, 11.07% CP), salt and minerals. When the steers reached a final BW of 615 kg (~16 mo of age), they were slaughtered in a commercial abattoir. A second LD muscle biopsy sample was obtained at 45 min postmortem (PM) for muscle fiber typing. At 96 h PM, striploins (n= 42) were collected, aged for 14 d and samples obtained for Warner Bratzler shear force (WBSF), proximal composition, myofibril fragmentation index (MFI), collagen analysis and objective colour evaluation. Data were analyzed as a randomized block design.

Results: Immunofluorescent analysis for the myosin heavy chain (MHC) isoform on the proportion of the fiber type or fiber dimensions was not influenced by maternal dietary treatment at both ages (*P* > 0.05). However, regardless of maternal dietary treatment, the proportion of fiber type IIA decreased while type IIAX increased in samples from steers at 16 mo of age compared with samples from steers at 7 d of age. No differences were observed between dietary treatment groups in proximate composition (*P* = 0.8), MFI (*P* = 0.29), or collagen content (*P* = 0.98); however, WBSF values tended to be higher in steers from SUP cows than steers from NSUP dams (*P* = 0.07). Maternal dietary treatment had no influence on objective colour evaluation at the retail display (*P* > 0.05). Objectives traits were not affected by dietary treatment x display time interaction (*P* = 0.92).

Conclusion: Our findings indicate that corn supplementation of cows during mid to late gestation has minimal effects on muscle fiber type and beef quality of their offspring. Thus, corn supplementation of low-quality forage offered during mid to late gestation did not have detrimental effects on muscle fibers and meat quality of offspring.

Keywords: beef, carcase outcome, corn supplementation, muscle fiber type, myofibrillar fragmentation index
MODIFICATIONS OF MEMBRANE PHOSPHOLIPIDS IN RESPONSE TO EXTENDED AGING FROM PORK LOINS
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Objectives: It is well established that fresh meat shelf-life deteriorates during aging process. We hypothesize that part of the shelf-life reduction is due to membrane phospholipid deterioration through phospholipase activity and/or phospholipid oxidation during aging. Therefore, the objective of this study was to characterize the modifications/deterioration of phospholipid classes/species in pork loins from 3 different aging periods.

Materials and Methods: Loins from 20 carcasses were collected at a commercial harvest facility in the Midwest one day postmortem from carcasses of Duroc sired crossbred pigs. Four chops from each carcass containing only the longissimus muscle were vacuum packaged and aged at 4°C for 1, 8, and 21 d. A sensitive approach based on electrospray ionization tandem mass spectrometry was used to comprehensively analyze phospholipid composition using the lipid extract from each sample at each aging period (n=60). Unsaturation index (UI; measurement of the number of double bonds) for each phospholipid species class was also calculated to quantify fatty acyl chain unsaturation for each sample in each aging period.

Results: Total phospholipid quantity in pork loins was not different between 1d and 8d aged chops but decreased significantly from 8d to 21d of aging (806.6 vs. 297.5 nmol phospholipid/mg lipid; P<0.01). On the other hand, the mol% data (distribution of each phospholipid species in relative % of total phospholipid) revealed that phosphatidylinositol (PI) and phosphatidylserine (PS) increased in mol% from 1d to 21d of aging in pork loins (P<0.01). This increase was mainly due to the increase of PI 38:4 (primarily 18:0/20:4) and PS 36:2 (primarily 18:0/18:2) between 1d and 21d samples (P<0.01). The results showed that phospholipid degradation products like lysophosphatidylcholine (LPC) mol% rose quickly after short term aging (8d) but remained constant through the rest of the 21d aging period (P<0.01). Conversely, lysophosphatidylethanolamine (LPE) was unaltered between 1d and 8d of aging but decreased between 8d and 21d aged pork loins (P<0.01). The mol% of phosphatic acid (PA) also increased between 1d and 21d aged pork loins (P<0.05). Extended aging did not alter the mol% of total phosphatidylcholine (PC), ether-linked PC (ePC), sphingomyelin (SM), phosphatidylethanolamine (PE) or ether-linked PE (ePE; P>0.05). Surprisingly, UI revealed the exact opposite trend as the mol% data. The UI of PI and PS decreased (P<0.01) from 1d to 21 d of aging in pork loins due to the disappearance of many minor PI and PS species with very long chain fatty acids and multiple double bonds such as PI 42:10 and PS 44:10. There was also a slight increase of PC UI after 8 days of aging in pork loins (P<0.01). The UI for LPC, ePC, SM, LPE, PE, ePE and total phospholipid were not altered in any of the aging periods (P>0.05).

Conclusion: These results confirmed our hypothesis that phospholipids undergo extensive degradation during aging. The data also indicated that the majority of phospholipids in pork loins may maintain integrity over short period aging (1-8d). Among the phospholipid classes, PI and PS were slightly more resistant to deterioration compared with the others due to their ability to modify fatty acyl chain saturation. Additional investigations are necessary to define the role of phospholipid modifications in fresh pork shelf-life and flavor.

Keywords: Aging, Lipid oxidation, Lipidomics, Phospholipid, Pork
POTENTIAL MECHANISMS FOR MARBLING CONTENT DIFFERENCES IN M. LONGISSIMUS DORSI FROM WAGYU AND BRAHMAN CATTLE

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Objectives: Intramuscular fat (marbling) affects consumer perceptions of meat quality. Recent studies indicated that intramuscular adipocytes are derived from fibroadipogenic progenitors (FAPs), a type of bipotent mesenchymal progenitor cells in extracellular matrix of muscle fiber. Platelet-derived growth factor receptor alpha (PDGFRα) is a marker in identifying FAPs. The amount of PDGFRα positive cells refers to the abundance of FAPs, a key factor determining the intramuscular adipogenic efficiency of the animal. In addition, it has been shown that both satellite cells and skeletal muscle fibers regulate the activity of FAPs. In this study, we aimed to identify some underlying mechanisms for the differences in intramuscular fat accumulation between Wagyu, a high marbling breed, and Brahman, a low marbling breed, through a comparison study.

Materials and Methods: Five cattle of each breed approaching mature body composition (Wagyu born January to May 2017; Brahman two 2-year-old and three 3-year-old, born April 2017 and 2015) were selected for this study. Biopsy samples of M. Longissimus muscle (LM) were taken after local anesthesia between the 12th and 13th ribs. Fresh samples were frozen in isopentane chilled by liquid nitrogen immediately after trimming fat and connective tissue. Other samples were fixed for 4 hours in ice-cold 4% paraformaldehyde, soaked overnight in 30% sucrose solution, and then processed in Optimal Cutting Temperature embedding medium. Frozen samples were stored at -80°C before cryosectioning (5 μm) at -25°C for immunochemical staining. Unfixed muscle tissue sections were only used for muscle fiber determinations by rinsing with 1X Tris Buffer Saline (TBS) 3 times 5 minutes each before blocking in 10% goat serum and 1% bovine serum albumin, followed by overnight incubation with primary antibodies at 4°C. Subsequent secondary antibody staining at room temperature for 1 h. TBS/T (0.3% Triton) was used for membrane permeabilization to identify satellite cells, FAPs, and basement membrane. Mounting media containing 4,6-diamidino-2-phenylindole (DAPI) was used for nucleus staining. Primary antibodies against PDGFRα, paired box 7 (PAX7), laminin, and different isoforms of skeletal muscle myosins were used to identify FAPs, satellite cells, basement membrane, and different types of muscle fiber, respectively. All the sections were visualized under a Nikon fluorescence microscope, and images were analyzed by Image J software to identify different muscle fiber types and positive signals of PDGFRα and PAX7. Minimum diameter of each muscle fiber type was the average of 30 randomly selected fibers per section. Data were analyzed with R-studio using ‘t.test ()’ function with the critical value being equal to 0.05.

Results: Wagyu muscle demonstrated a greater (P=0.01) number of FAPs compared with Brahman muscle. A trend toward a higher (P=0.06) abundance of satellite cells in Wagyu muscle than in Brahman muscles was also identified. No differences were found in muscle fiber diameter or muscle fiber type composition between these two breeds of cattle.

Conclusion: The greater number of FAP cells observed in the LM of Wagyu cattle than in Brahman cattle suggests that the higher marbling content of Wagyu meat is at least partially attributed to the more abundant adipogenic progenitor cells, which increases the capacity and efficiency of intramuscular adipogenesis in Wagyu cattle.

Keywords: Adipogenesis, FAPs, Marbling
**Objective:** The objective of the study was to determine if a vitamin A deficient diet during beef finishing influences calpain 1 activation during meat aging.

**Materials and Methods:** Sixty-four steers of approximately 7 months of age were subjected to a 14-d acclimation period followed by a 95-d growing period on a low vitamin A diet (1017 IU vitamin A/kg DM) designed to deplete liver vitamin A stores. Steers were assigned to a randomized complete blocked design with a $2 \times 2$ arrangement of treatments (breed: commercial Angus, $n = 32$, and purebred Simmental, $n = 32$; and a Low Vitamin A diet or a control diet). The low Vitamin A (LVA) treatment was a finishing diet with no supplemental vitamin A (723 IU vitamin A/kg DM). The control (CON) treatment was the LVA diet plus supplementation with 2200 IU vitamin A/kg DM for a total of 2,923 IU vitamin A/kg DM. Serum retinol concentrations were monitored at the beginning and end of treatment. Upon completion of finishing, steers were slaughtered in two groups at a commercial plant. After fabrication, boneless strip loins (IMPS 180) were collected and transported to NDSU. Samples (approximately 40 g) were collected from the anterior portion of the strip loin on d-2 and d-7 of aging and immediately frozen. Protein was extracted from meat samples in fractionation buffers to yield sarcoplasmic and myofibrillar portions, separated by SDS-PAGE, and transferred to PVDF membranes. Immunoblot analysis was done using anti-desmin (d-2 and d-7) and anti-calpain 1 (d-2) antibodies, and results were visualized and documented. A pooled control was run on all membranes and set to a value of one for normalizing results. All experimental data were analyzed using the Proc Mixed procedure of SAS with breed of steers, dietary treatments, their interaction and slaughter date used as a fixed effect.

**Results:** Calpain 1 autolysis in the sarcoplasmic protein fraction of the d-2 aged loin samples were not affected by treatment or breed. The myofibrillar protein fraction from Angus loins had greater ($P = 0.02$) accumulation of the 76-kDa calpain 1 autolysis product than that from the Simmental loins; the myofibrillar fraction of the loins from the LVA treatment tended ($P = 0.07$) to have more 76-kDa calpain 1 autolysis product than that from the CON. There were not any differences ($P > 0.19$) in the 80-kDa calpain 1 band or the 78-kDa calpain 1 intermediate autolysis product in the myofibrillar fraction. There was a treatment by breed interaction ($P = 0.01$) for desmin in the d-7 aged loins where Angus loins from the CON treatment had less accumulation of the 46 kDa band than Angus loins on the LVA treatment and Simmental loins from either treatment.

**Conclusion:** Vitamin A restriction increased protein proteolysis in Angus but not in Simmental steers. The increased calpain 1 autolysis in Angus vs. Simmental, regardless of Vitamin A treatment, indicates a genetic difference that may be the driver for the increased protein degradation in steers a restricted vitamin A diet.

**Keywords:** beef, calpain, vitamin A
Objectives: Dark-cutting beef is a meat quality defect in which meat does not display the marketable bright-red color. Although previous studies have indicated that the ultimate pH of dark-cutting beef is greater than normal, the mechanistic basis for the occurrence is not clear. Various mitochondrial and glycolytic enzymes/proteins are involved in muscle metabolism and lowering of pH. However, limited knowledge is currently available on the muscle protein profile differences between dark-cutting and normal-pH beef. The objective of the current study was to identify proteins related to the development of the dark-cutting condition by comparing the protein expression differences between dark-cutting and normal-pH beef.

Materials and Methods: Dark-cutting and normal-pH beef samples were collected from six (n = 6) different animals after slaughter. Tissue samples (0.5 g) were digested in 5 mL of lysis buffer. Tissue lysates were homogenized, boiled, sonicated using a bioruptor and centrifuged at 10,000 g for 10 min. Samples were digested with trypsin/Lys-C overnight at 37°C, after which additional 2 µg/mL of protease was added and digestion was continued for another 8h. The resulting trypsinolytic peptides were acidified to 1% trifluoroacetic acid and purified by solid phase extraction with C18 affinity media. Protein expression profiles of both dark-cutting and normal-pH beef samples were determined using LC-MS/MS mass spectrometry-based proteomics. Collected raw data instrument files were searched against a bovine proteome database of 23,968 bovine proteome sequences using MaxQuant (V.1.5.3.8). Differential protein expression analysis was done in Perseus (V.1.5.1.3). Ingenuity pathway analysis (IPA) was utilized to determine the significant pathways of the differentially expressed proteins in dark-cutting and normal-pH beef. Gene ontology enrichment pathway analysis was performed to determine the main functions of the differentially expressed proteins in dark-cutting and normal-pH beef identified in our samples.

Results: Mass spectrometry analysis identified 1,148 proteins, and 97 of these proteins were differentially expressed between normal-pH and dark-cutting beef (P < 0.05). Fold change of 1.5 was observed for 29 proteins. Dark-cutting beef had 19 abundant proteins, while normal-pH beef had 10 abundant proteins. The majority of the upregulated proteins in dark-cutting beef were involved in mitochondrial functioning and metabolism, while the majority of the down-regulated proteins were important in glycogen degradation, calcium signaling, α-adrenergic signaling, n-NOS-signaling and the proteasome pathways.

Conclusion: The results identify new protein biomarkers associated with dark-cutting and suggest new mechanistic explanations for the dark-cutting phenotype.

Keywords: Dark-Cutting, Mass Spectrometry, Meat Color, Proteomics
**Characterization of the Cofactors Involved in Non-Enzymatic Metmyoglobin Reduction In-Vitro**

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**Objectives:** Consumers' meat purchasing decisions are strongly influenced by color. Myoglobin is the primary meat pigment that contributes to meat color. Myoglobin consists of an iron-containing heme ring and amino acids in the form of globin chains. Both the state of the heme iron and the type of ligand affect meat color. The consumer-preferred bright cherry-red color oxymyoglobin is formed when the iron is in the ferrous state and oxygen bind to the heme. The oxidation of oxymyoglobin or deoxymyoglobin results in the formation of the brown color, ferric metmyoglobin. Predominant metmyoglobin accumulation negatively impacts consumer purchasing choices. Although muscle type and pre- and post-harvest factors can influence meat discoloration, meat has an inherent ability to reduce metmyoglobin through enzymatic pathways, mitochondria-mediated pathways, and non-enzymatic mechanisms. In the enzymatic pathway, an electron from NADH is transferred to metmyoglobin by an enzyme and an electron carrier; while in mitochondria-mediated pathway, an electron from the electron-transport chain is transferred via cytochromes. Previous research speculated the role of non-enzymatic pathway in meat color; however, limited studies have characterized the cofactors present in a meat system. The objectives of this study were to characterize cofactors in non-enzymatic metmyoglobin reduction and determine the effect of storage temperature and postmortem muscle pH in-vitro.

**Materials and Methods:** Purified equine metmyoglobin was reduced in the presence of combinations of electron carriers and donors. Methylene blue and cytochrome c were evaluated as the electron carriers, and NADH and ascorbate were considered as the electron donors. The cofactors were held at 4 and 25°C to determine temperature effects on the reduction of metmyoglobin, and the same cofactor combinations were evaluated at pH of 5.2, 5.6, 6.0, and 6.4 to reflect postmortem muscle pH. Spectrophotometry was utilized to monitor the rates of metmyoglobin reduction. The experiments were replicated five times, and the data were analyzed using the Mixed Procedure of SAS.

**Results:** The results indicated that methylene blue was a significantly more effective electron carrier than cytochrome c with both electron donors, ascorbate and NADH. EDTA had no impact on the non-enzymatic metmyoglobin reducing the ability of methylene blue (P = 0.91). Temperature and pH had cofactor specific effects on the non-enzymatic reduction of metmyoglobin. Lower temperature resulted in an increased non-enzymatic metmyoglobin reduction for methylene blue regardless of electron donor (ascorbate, P = 0.03, NADH, P = 0.04). As pH increased, the non-enzymatic metmyoglobin reducing activity reduced significantly in the presence of NADH and methylene blue.

**Conclusion:** In conclusion, the characteristics of the cofactors at specific temperatures and pH impacted the non-enzymatic reduction of metmyoglobin. Further, current in-vitro research indicated that non-enzymatic metmyoglobin reduction is possible at lower temperature and meat pH.

**Keywords:** Meat Color, Metmyoglobin Reduction, Myoglobin
Objectives: Rinse & Chill® (RC) is a process applied early postmortem that provides the ability to manipulate muscle metabolism and can have a positive impact on meat quality traits. This study aimed to evaluate the effect of RC on pH decline, shear force, sarcomere length and cooking losses on different cull dairy cow carcass grades. Investigate the ability of different substrates to modulate contractile response as an indirect measure of metabolic activity on beef early postmortem.

Materials and Methods: For each carcass grade (lean, LE; light, LI), ten carcasses were conventionally chilled (CC) and twelve carcasses were chilled using RC technology (MPSC Inc.). The RC process involved infusion of a chilled isotonic solution (98.5% water; balance: glucose, phosphates, and maltose) through the vascular system, beginning in the arterial and exiting the venous side of the vasculature. Shear force and cooking losses were measured on Longissimus dorsi steaks aged (7 d). Sarcomere length (SL) was determined by a laser diffraction method. Animal served as the experimental unit and data were analyzed with a PROC MIXED procedure. For contraction measurements, a muscle-fiber bundle from the Sternomandibularis muscles (n=14) was collected from cull dairy cows in a commercial packing plant, 15 minutes after bleeding. The muscle bundle was attached to a force transducer (FT-302, iWorx, Dover, NH). Stimulation electrodes were used to elicit a supramaximal electrical stimulus at a frequency of 50 V, 0.1 Hz (HCS-100 stimulator, iWorx). Muscle weight was standardized, and length was adjusted to obtain maximum twitch-tension output. After 3 minutes of rest in a test solution, 200 stimuli were given, and the contractile response was recorded. Four solutions were tested (A=RC, B=Fructose, C=Sodium phosphate, D=Dipotassium phosphate; substrates added at 1% except fructose 1.5%). Descriptive means for initial peak twitch force, final peak twitch force, percentage decline and percentage half-time decline were calculated to determine the response associated with each solution.

Results: RC reduced (P<0.05) shear force by 51.9% (6.79 kgf CC) and 55.8% (8.50 kgf CC) for LI and LE cows, respectively. LI cows were more tender than LE for CC (6.79 vs 8.50 kgf; P<0.05). RC compared to CC had longer SLs (LE: 1.80 vs 1.44µ; P<0.05) and LI (1.80 vs 1.40µ; P<0.05). Purge and cooking losses were not affected by chilling method. The contractile responses of the muscle after the exposure to the solutions were slightly different. The average percentage decline of peak twitch force was higher for solution B, followed by solutions A, D, C (54.8%, 53.5%, 48.0%, 43.4%, respectively). Furthermore, the same pattern was observed for the average percentage decline at half time of the test (82.5%, 80.4%, 78.1% and 74.7%, respectively).

Conclusion: Packing plants that harvest cull dairy cows have the potential to dramatically improve tenderness and thereby merchandize a greater amount of whole muscle cuts as a result of the application of the Rinse & Chill®. This improvement may be associated with accelerating postmortem glycolysis, thereby limiting cold shortening, although enhanced proteolysis may also be involved. Continuous electrical stimulation of isolated muscle-fiber bundles while being soaked in selected test solutions led to decreased and somewhat varied contractile force responses suggesting the potential to modify muscle metabolism.

Keywords: Chilling method, cull dairy cow, muscle contraction, tenderness, tissue bath
APOPTOTIC AND PROTEOLYTIC ATTRIBUTES AND METABOLIC CHANGES IN POSTMORTEM MUSCLES FROM PIGS SUBJECTED TO POST-WEANING TRANSPORT AT DIFFERENT SEASONS

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Objectives: Post-weaning transport of pigs was commonly practiced in the swine industry, however, adversely impact animal growth and well-being due to concurrent stress from weaning and transport. Further, our recent study found that post-weaning transport may have long-term effects on final pork quality attributes in terms of inferior texture and water-holding capacity. Heat shock proteins (HSPs) are anti-apoptotic chaperone proteins, protecting against apoptosis under a variety of cell death stimuli including postmortem muscle conversion process. While a potential role of apoptosis in meat tenderization has been proposed, how early life stress influences apoptotic/proteolytic process and metabolism of postmortem muscles is largely unknown. Thus, the study objective was to evaluate apoptotic and proteolytic attributes and metabolomic changes in postmortem muscles of market weight pigs exposed to early life transport/weaning stress at two seasons.

Materials and Methods: Two repetitions of newly weaned pigs (N= 480) were transported for 12 hours in a trailer truck during July 2016 (SUMMER) and April 2017 (SPRING) in north-central Indiana. Upon reaching market weight, 10 animals were randomly chosen from each season and slaughtered in January 2017 and September 2017, respectively. Pairs of longissimus dorsi and psoas major muscles from each carcass were separated at 1d and 7d postmortem. Proteolytic and apoptotic factors including desmin, troponin T, calpain 1, HSP27, and αβ-crystallin were quantified using Western-blot assays, and mitochondria membrane permeability (MMP) was evaluated. Metabolome profiles of 1d samples were analyzed using the GC-TOF-MS/MS platform. Multivariate analyses PCA and PLS-DA were used to determine changes of metabolites. Data were analyzed using PROC MIXED of SAS to compare the traits across season, muscle, and aging effects.

Results: Previously, SUMMER pigs were reported showing decreased body weight, muscling, and fat deposition, as well as increased shear force and water loss during aging. In the present study, SPRING muscles exhibited increases in calpain 1 autolysis and structural protein degradation, coincided with accelerated apoptosis shown as higher MMP compared to the SUMMER counterparts (P<0.05). Moreover, PCA and PLS-DA clustering indicated distinct metabolome profiles affected by season and muscle. Seasonal effect mainly altered lipid, glucose, and nitrogen metabolism. A group of 16C to 18C fatty acids were increased in SPRING, probably due to increased lipid anabolism during warm growing/finishing season. Changes of urea, ornithine, aspartic acid, and 5’-methylthioadenosine suggested increased amino acid catabolism in SUMMER, corroborating the decreased lean and fat accretion. Seasonal changes of key metabolites related to stress response, including histidine, GABA, and ascorbic acid, suggested increased stress defense in SUMMER pigs, which implied the suppression of apoptotic and proteolytic activities.

Conclusion: Taken together, SUMMER pigs showed suppressed onset of apoptosis with compromised growth and meat quality, possibly due to alternations in seasonal metabolic response. This may in turn affect the proteolytic potential of early postmortem muscles. Further studies elucidating the involvement of apoptotic process in proteolytic activities in postmortem muscles should be warranted.

Keywords: apoptosis, calpain, heat shock protein, proteolysis, seasonal metabolism
Objectives: *Longissimus lumborum* (LL) and *psoas major* (PM) are important muscles in beef hindquarters that exhibit variation in meat quality attributes. Postmortem metabolism (muscle-to-meat conversion) affects biochemical properties of muscles and in turn influence the meat quality. Although previous research has indicated that variation in the proteome profile of LL and PM post-rigor influences meat quality attributes such as tenderness and color stability during retail display, limited research has examined the influence of early postmortem metabolism on meat quality. Tandem mass tag (TMT) labeling is a chemical labeling approach used for accurate mass spectrometry-based quantification and identification of biological macromolecules. Therefore, the objective of this study was to use TMT labeling to examine proteome profile variation between beef LL and PM during the early postmortem period.

Materials and Methods: Muscle biopsy samples were collected from carcasses (n = 4) at 45 min, 12 h, and 36 h postmortem from a commercial beef processing facility. Samples were frozen immediately in liquid nitrogen and stored at -80°C until proteomic analysis. Proteome was analyzed using TMT label containing ten different isobaric compounds with the same mass and chemical structure composed of an amine-reactive NHS-ester group, a spacer arm, and a mass reporter. After labeling and peptide fractionation, all the samples were multiplexed and ran through the Orbitrap Velos mass spectrometer equipped with a Nanospray Flex ion source to identify differentially abundant proteins. The proteins exhibiting 1.5-fold or more intensity difference and a statistical difference (P < 0.05) between LL and PM or within the muscles during the postmortem were reported as differentially abundant.

Results: Seventy differentially abundant proteins (P < 0.05) were identified from three comparisons between the muscles (31 proteins in PM 45 min vs. LL 45 min, 41 proteins in PM 12 h vs. LL 12 h, 49 proteins in PM 36 h vs. LL 36 h). However, no difference (P > 0.05) in protein expression within a muscle was observed during these time points. The differentially abundant proteins were mainly involved in oxidative phosphorylation and ATP-related transport, tricarboxylic acid cycle, NADPH regeneration, fatty acid degradation, muscle contraction, calcium signaling, chaperone activity, oxygen transport, as well as degradation of the extracellular matrix. At early postmortem, overabundant anti-apoptotic proteins in LL could cause high metabolic stability, enhanced autophagy, and delayed apoptosis, while overabundant metabolic enzymes and pro-apoptotic proteins in PM could accelerate the reactive oxygen species generation and programmed cell death.

Conclusion: Differentially abundant proteins between LL and PM during the early postmortem were primarily associated with cellular metabolism and programmed cell death. The greater oxidative and color stability in LL compared to PM could be related to the increased expression of anti-apoptotic proteins and the decreased expression of metabolic enzymes and proapoptotic proteins in LL.

Keywords: Color stability, Early postmortem, Proteome, Tandem mass tag labeling
Objectives: Mitochondrial function in postmortem muscle is affected by decreasing oxygenation. Functional properties relating to energy production and integrity of mitochondria may influence development of meat quality characteristics. Therefore, the objective was to evaluate changes in mitochondrial function in oxidative and glycolytic muscles during the first 24h postmortem.

Materials and Methods: Steers (n = 6) of primarily Angus (80 to 100%) genetics were harvested at approximately 18.5 months and 630 kg live weight. Samples from the longissimus lumborum (LL) and diaphragm (Dia) were collected at 1, 3, and 24h postmortem. Fresh-preserved muscle samples were permeabilized using saponin, and muscle bundles (2-4 mg) were transferred to a high-resolution oxygraph for respiration measurements (oxygen consumption rate, OCR, pmol/sec/mg of tissue). Samples were assessed in duplicate under hyperoxia. First, pyruvate and malate were added to support the TCA cycle and assess leak respiration. Then, ADP was added to support electron flow through complex I. The influence of glutamate on NADH production (complex I) was tested, followed by complex II activation by succinate. Integrity of the mitochondria outer membrane was tested with cytochrome c. Next, an uncoupler (FCCP) was added to force the electron transport system (ETS) to maximum capacity. Citrate synthase (CS) activity (nmol/min/ mg tissue) was determined in frozen samples and used as a marker of mitochondria content. Subsequently, respiration data were normalized to CS activity (pmol/sec/ U CS) to account for differences in mitochondria content. Coupling efficiency of oxidative phosphorylation was calculated as 1 – (Leak / ADP-stimulated oxidative phosphorylation capacity). Raw and normalized OCR were analyzed in a randomized block design, with slaughter date as block and fixed effects of muscle, time, and the interaction. Time was considered a repeated measure.

Results: Muscle type affected (P = 0.0002) leak OCR, with Dia showing a higher rate than LL. After ADP was added, mitochondria from Dia exhibited higher OCR at all times tested and at all steps, with OCR being 4 times higher after FCCP addition. Mitochondrial content, evidenced by greater (P < 0.0001) CS activity in Dia, largely explained differences in OCR between muscles. After OCR was normalized to CS activity, the 1 and 3h postmortem OCR from Dia and LL were similar (P > 0.05). However, at 24h postmortem, OCR after ADP, glutamate, and FCCP additions were greater (P < 0.05) in Dia mitochondria. Time, but not muscle, affected cytochrome c response. At 1h postmortem, cytochrome c increased OCR by 6.6%, supporting that mitochondria outer membrane integrity is not compromised. However, cytochrome c response at 3h postmortem increased 52.4%, indicating outer membrane damage. Coupling efficiency is different between muscles (P = 0.005) with Dia exhibiting greater efficiency.

Conclusion: Despite inherent metabolic differences between the LL and Dia, mitochondria from both muscles are intact and coupled at 1h postmortem. However, by 24h postmortem, functional properties of LL mitochondria are reduced compared to Dia. Declining mitochondrial function may be associated with calcium overload, mitochondrial fragmentation, and protease activation.

Keywords: beef, metabolism, muscle, respirometry
155-POSSIBLE ROLE OF MYOGLOBIN IN REGULATING CALPAIN-1 ACTIVITY IN POSTMORTEM BEEF MUSCLE
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Objectives: Previous research revealed a relationship between meat color and beef tenderness and indicated that myoglobin can inhibit calpain-1 in solution. The objective of this study was to determine the extent to which myoglobin and beef color are associated with calpain activity and beef tenderness.

Materials and Methods: Beef Longissimus dorsi samples from the left side of Holstein beef carcasses (n = 21) were collected immediately post exsanguination on the processing floor for 0 h analyses. Muscle temperature and pH was measured at 0, 24, and 48 h postmortem. After USDA quality and yield grade determination, steaks (n = 6) were removed from the right side of each carcass (n = 21) at 48 h for analyses at 48 and 336 h postmortem. Color (L*, a*, and b* values), surface myoglobin redox forms, metmyoglobin reducing activity (MRA), total myoglobin concentrations, slice shear force (SSF), Warner-Bratzler shear force (WBSF) were measured. Calpain-1 concentrations and autolysis were determined via Western blot at 0, 48, and 336 h.

Results: Decline in muscle pH was 6.4, 5.8, and 5.6 at 0, 24, and 48 h, respectively. Shear force values at 48 h were 73.19 N for WBSF and 384.21 N for SSF and at 336 h were 48.75 N for WBSF and 260.47 N for SSF. Myoglobin reducing activity at 336 h was positively correlated to WBSF at 48 h and negatively correlated to calpain-1 concentration at 0 h (P < 0.05; Table 1). Color measurements of L* and b* at 48 h were moderately correlated with WBSF at 336 h (P < 0.05; Table 1). The b* measurement at 336 h showed a moderate relationship to calpain-1 concentration at 0 h (P < 0.05; Table 1).

Table 1. Correlations (P values) between selected color and tenderness measurements (n = 21)

<table>
<thead>
<tr>
<th></th>
<th>WBSF 48 h</th>
<th>WBSF 336 h</th>
<th>SSF 48 h</th>
<th>Calpain 1 0 h</th>
<th>Calpain 1 48 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myoglobin 0 h</td>
<td>0.386</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myoglobin 48 h</td>
<td></td>
<td></td>
<td></td>
<td>-0.476</td>
<td>(0.029)</td>
</tr>
<tr>
<td>MRA 48 h</td>
<td>0.381</td>
<td>(0.084)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRA 336 h</td>
<td>0.457</td>
<td>(0.037)</td>
<td>0.371</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L* 48 h</td>
<td></td>
<td></td>
<td></td>
<td>0.469</td>
<td>(0.032)</td>
</tr>
<tr>
<td>b* 48 h</td>
<td></td>
<td></td>
<td></td>
<td>0.469</td>
<td>(0.032)</td>
</tr>
<tr>
<td>b* 336 h</td>
<td></td>
<td></td>
<td></td>
<td>3.472</td>
<td>(0.031)</td>
</tr>
</tbody>
</table>

Conclusion: Moderate correlations between color and tenderness measurements taken at 48 h with those taken at 336 h were discovered indicating that myoglobin may impact calpain-1 in vivo.

Keywords: Calpain activity, Meat Color, Myoglobin, Tenderness
INVESTIGATION OF THE FATTY ACID PROFILE OF THE M. RHOMBOIDEUS DERIVED FROM BOS INDICUS CATTLE

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Objectives: Research has shown the m. Rhomboideus (Rho) from purebred Bos indicus (BI) to be unique in its proximate chemical composition, indicated by increased lipid deposition. Thus, potential for the deposition of mono- (MUFA) and poly-unsaturated (PUFA) fatty acids exists. The objective of this study was to assess the fatty acid composition of the intramuscular (IMF) and subcutaneous (SQF) depots in the Rho from BI crossed cattle.

Materials and Methods: Three replications of 4 USDA Choice (Ch) and 4 USDA Select (Se) Rho muscles were selected from the right half of split carcasses (N=24). Selection parameters were >7.62-cm hump height, >7.62-cm width, >25.4-cm length, weight range: 2-4-kg. Muscles were removed from carcasses and vacuum packaged. After a 14-d aging period, Rho muscles were fabricated, 2.54-cm serially cut steaks (anterior to posterior), trimmed to 0.254-mm fat thickness. Steaks were assigned identification tags and designated for analysis. Rho steaks were used for proximate composition (n=2), trained sensory analysis (n=2), Warner-Bratzler shear force (WBS, n=1), collagen content (n=1), and fatty acid composition of IMF and SQF (n=1). Steaks for trained sensory analysis were also used for color measurements and cook yield. Data were analyzed using a 2-sample t-test. Sensory data were analyzed using a linear fit model with order as a random effect. All data analyzed using JMP v14.0.0. A predetermined significance level of P<0.05 was used.

Results: Total MUFA, PUFA and saturated fatty acid (SFA) percentages of IMF were not significant (P>0.05) between Ch Rho muscles (43, 7.2, 47.1%, 0.89, respectively) and Se Rho muscles (43.0, 6.3, 50.7%, 0.86, respectively). Mean averages across both quality grades for total MUFA, PUFA, SFA, and MUFA:SFA (42.2, 6.8, 48.9%, 0.87, respectively) in Rho IMF were similar to reported FAC averages of Bos taurus (BT) longissimus dorsi IMF (47.8, 4.4, 47.8%, 1.0, respectively).
Total MUFA percentage (49.1 vs 45.4%) and MUFA:SFA ratio (1.1 vs 0.9) were significantly higher (P<0.001) in Ch SQF compared to Se SQF. However, total PUFA percentage (4.3 vs 3.7%) and SFA (50.3 vs 47.0%) were significantly higher (P<0.02) in Se SQF compared to Ch SQF. Mean averages across both quality grade for total MUFA, PUFA, SFA, and MUFA:SFA (47.4, 4, 48.6%, 0.99, respectively) in SQF were similar to reported fatty acid averages of BT brisket SQF (56.8, 3 and 35.9%; 1.47, respectively).
Protein content (19.4 vs 18.6%) was higher (P<0.02) for Ch than Se Rho muscles. L* value (50.2 vs 47.9) was larger (P<0.001) for Se. Ch Rho muscles contained greater amounts (P<0.001) of total, insoluble, and soluble collagen (21.8, 21.5, 0.3 mg/g, respectively) compared to Se Rho muscles (13.8, 13.7, 0.1 mg/g, respectively). Ch Rho muscles were more tender (P<0.001) as determined by WBS values (2.6 vs 3.1 kg). trained sensory analysis, pH, fat, moisture, a* and b* color values between quality grades were not different (P>0.05).

Conclusion: Differences were not seen for fatty acid composition between Ch and Se Rho IMF fat. However, higher percentages of total PUFA were found in both Ch and Se Rho IMF compared to reported longissimus dorsi IMF. Additionally, Ch Rho SQF contained higher percentages of total MUFA. However, Se Rho SQF contained higher percentages of total PUFA and SFA. Higher percentages of SFA were found in both Ch and Se SQF compared to reported brisket SQF SFA values.

Keywords: Bos indicus, collagen, fatty acid composition, rhomboideus
Objectives: The conversion of muscle to meat is largely controlled by postmortem energy metabolism and pH decline. These biochemical changes influence activity of enzymes implicated in proteolysis and meat tenderization. Therefore, our objective was to investigate pH decline, muscle energy metabolism, and protease activation in functionally distinct bovine muscles.

Materials and Methods: Steers (n = 6) were harvested at approximately 18.5 months and 630 kg live weight. Samples from the longissimus lumborum (LL) and diaphragm (Dia) were taken at 1, 3, and 24h postmortem, immediately frozen using liquid nitrogen, and stored in ultra-freezer until analysis. Muscle pH was obtained using a pH meter at the same time points. Myosin heavy chain composition (I, IIA, and IIX) was determined using gel electrophoresis. Substrate (residual glycogen), as well as glycolytic metabolites, glucose, glucose-6-phosphate, and lactate, were quantified by enzymatic methods; muscle ATP at 1 and 3h was also determined. Western blotting was used to evaluate protease activation (calpain-1 and caspase-3). Data were analyzed using a randomized block design, with slaughter date as block. Animal within slaughter date was considered as random effect and fixed effects of muscle, time, and the interaction tested. Time was considered a repeated measure.

Results: Diaphragm contained a greater percentage of slow myosin heavy chain compared to LL (80% vs. 12%, respectively). Consistent with fiber type, LL contained greater glycogen than Dia at 1h (P < 0.05), but not at subsequent times postmortem. Overall, a greater decline in glycogen occurred in LL. Accordingly, lactate concentration increased markedly in LL postmortem and to a lesser extent in Dia (interaction effect; P < 0.01). Although muscles exhibited similar lactate content at 1h, at 24h the LL showed elevated lactate relative to Dia (88 vs 53 µmol/g tissue, respectively). Accumulation of glucose and glucose-6-phosphate were affected by muscle (P < 0.01) and time (P < 0.01), with greater final content in LL compared to Dia. Muscles exhibited different patterns of postmortem pH decline (muscle × time, P < 0.0001). Initially, pH of LL was higher than Dia (P < 0.01) and remained different at 3h (P < 0.05); but by 24h, pH values were similar. Content of ATP was influenced by muscle (P < 0.01) and time (P < 0.01), with greater initial ATP in LL compared to Dia. Muscles exhibited different patterns of postmortem pH decline (muscle × time, P < 0.0001). Calpain-1 autolysis was similar at all times in Dia, whereas autolysis increased in LL from 3h to 24h postmortem. Caspase-3 was identified by one band (32 kDa) that represents the zymogen (procaspase-3). Procaspase-3 content is affected by muscle (P < 0.01), with Dia containing greater content than LL.

Conclusion: Although the Dia is considered a slow muscle, it exhibited a more rapid pH decline and lower ATP levels than LL early postmortem. These parameters were expected to coincide with more rapid calpain-1 autolysis in Dia, but this was not the case. Further work is necessary to understand the interaction between pH decline, muscle type, and postmortem proteolysis.

Keywords: calpain-1, caspase-3, muscle fiber type, pH
Objectives: To determine the immediate effect of 4 different antimicrobials sprays on the microbial growth of indicator bacteria naturally present on pork loins after 24h storage under dark and refrigerated conditions.

Materials and Methods: Boneless pork loins samples were obtained from a commercial facility and tested for the natural presence of microbial indicators to serve as a baseline of microbial loads ("Initial"). Loins were randomly assigned to one of the 4 different antimicrobials (BoviBrom 225 ppm, BoviBrom 500 ppm, FIT Fresh 3 ppm, washing solution 750-ppm) as well a control (water) (n=24 per treatment). Whole loins were equally divided into 5 equal sized sections and randomly assigned to one of the five treatments. After a 30-second spray application with a manual pump, swabs were immediately collected ("5-min") and sections were vacuum packed and stored for 24 hours under refrigeration. After the storage period, swabs were also enumerated for the indicators ("end"). For each of the sections, microbial indicators were enumerated before and after treatment as well as at the end of the storage time. Swabs (100 cm²) were taken from the surface of either the boneless loins/section using sterile sponges pre-moistened in 25 ml of buffered peptone water (BPW) and sterile templates. After swabbing, sponges were stomached (2 min at 230 rpm), serial dilutions in BPW blanks were conducted, and the following indicators were evaluated: Lactic Acid Bacteria (LAB-M; mesophiles), Total Aerobic Plate Counts (TAPC-M; mesophiles) and Total Aerobic Plate Counts (TAPC-P; psychrophiles). Counts were log transformed for statistical analysis, and the PROC GLIMMIX procedure of SAS was used to determine differences between least squared means (SAS Inst. Inc., Version 9.4, Cary, NC).

Results: The statistical analysis showed that for TAPC-M there was no statistical difference between "initial" and "end" samples for all treatments (>0.05); However, there was a significant difference observed for the "5-min" samples, with BoviBrom at 500 ppm showing an immediate reduction as well as after 24 hours (<0.05). For TAPC-P there was no significant difference for "initial", "5-min" and "end" samples. For the LAB-M there was no statistical difference among treatments in each swabbing period (>0.05). The 750-ppm washing solution also reduced the TAPC-M after a 24-hour storage period.

Conclusion: No significant differences were observed in the levels of LAB-M in any of the sampling periods (P>0.05). However, there was an effective microbial reduction in TAPC-M using BoviBrom 500 ppm and the 750-ppm washing solution during the "5min" sampling. Interestingly, samples treated with the 750-ppm washing solution showed and immediate increase ("5-min") in TAPC-M populations, even though these levels were lower than the initial point after 24 hours.

Keywords: antimicrobials, BoviBrom, indicators, loins, Pork
Objectives: As been widely used in food processing, sodium salt has served important functions in meat processing. However, according to World Health Organization (WHO), global population has dangerously high consumption of sodium – on average 9-12 g salt/day (2016). High dietary sodium intake and insufficient potassium intake have been associated with elevated risk of high blood pressure and cardiovascular disease in global population. Driven by the increased awareness of the impact of high sodium intake on health, customers have been continually seeking low-sodium or reduced-sodium in their daily diets. This situation represents challenges and opportunities for manufacturers to address formulation for low-sodium, functionality and processing efficiency while maintaining good quality and taste profile of their products. The objective of this study was to evaluate the functionality of phosphate salt as a sodium reduction tool in frankfurters formulation with 30% sodium reduction level. Cooking yield (%) and purge (%) over five weeks of refrigerated storage were evaluated.

Materials and Methods: The control formula is based on the application from LATAM region, which contains 2.0% sodium chloride and 0.5% sodium tripolyphosphate, leading to about 1084 mg/100g sodium content level in final products. The following sodium reduction strategy was used and evaluated to achieve 30% sodium reduction level: 30% sodium reduction through the dual effects of potassium chloride and the specialty phosphate tool containing a balanced mix of potassium and sodium phosphate. Ingredients for the control formula and sodium reduction formula are summarized as follows:

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Control (%)</th>
<th>Sodium Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanically Deboned Meat</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Pork Trim (90:10)</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Pork Trim (80:20)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Water</td>
<td>12.7</td>
<td>12.7</td>
</tr>
<tr>
<td>Other Binders*</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>Seasoning</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Sodium Tripolyphosphate</td>
<td>0.5</td>
<td>--</td>
</tr>
<tr>
<td>Specialty Phosphate Tool</td>
<td>--</td>
<td>0.5</td>
</tr>
<tr>
<td>Smoke Flavoring</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>Curing Ingredients**</td>
<td>0.07</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*soy protein, tapioca starch, and dextrose
**sodium erythorbate, sodium nitrite, sodium nitrate

The frankfurters samples were prepared and cooked to reach internal temperature of 160 °F (71.1 °C). Samples were showered with cool water for 15 minutes before cooking yield (%) was evaluated. The samples were vacuum-packed and stored under refrigerated condition for 5 weeks to evaluate the purge.

Results: By reducing 30% sodium, sodium reduction treatment showed no significant difference (P > 0.05) in cooking yields and purge over storage. Phosphate salt and sodium/potassium salt are the main contributor to ionic strength. Ionic strength of the combination of phosphate and potassium/sodium salt were evaluated in solution. With sodium reduction, the brine was still able to maintain similar ionic strength to the control. (Ionic Strength of Control: 33.8 ms; Ionic Strength of Sodium Reduction Group: 34.7 ms.)

Conclusion: Focused on the market and regulatory drivers to reformulate processed meats with lower sodium content, this study has showed specialty phosphate salts can be a feasible alternative tool to achieve sodium reduction (up to 30%) through reformulation. By working together with other essential muscle foods ingredients, reformulation with specialty phosphate salts was able to maintain basic functionality characteristics such as ionic strength in muscle proteins, while deliver essential products characteristics.

Keywords: ingredient formulation, phosphate, sodium reduction
160-CONTROL OF LISTERIA MONOCYTOGENES OUTGROWTH IN SLICED UNCURED POULTRY DELI MEAT USING VERDAD® OPTI N80
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Objectives: The aim of this study was to demonstrate the antimicrobial efficacy of Verdad® Opti N80 (CSV) in inhibiting Listeria monocytogenes outgrowth in uncured chicken deli slices.

Materials and Methods: Ground chicken breast was vacuum tumbled with brine solution containing water, salt, starch, chicken broth, and varying levels of natural antimicrobial intervention. The control treatment contained no antimicrobial and the treatment groups were prepared using 3.5% and 4.5% CSV, respectively. Each treatment was vacuum tumbled for 60 minutes, stuffed in 60 mm casings, and cooked to an internal temperature of 74°C. Individual strains of Listeria monocytogenes were grown in two consecutive overnight cultures (BHI broth 16-18 hours at 35°C). Five strains were combined in equal parts to create a cocktail. Treatments were sliced and independently inoculated with 100 µL of cocktail inoculum and evenly distributed to achieve approximately 2 log CFU/g. Inoculated samples (ca. 25g) were vacuum packaged and incubated at 40°F for 85 days. Duplicate samples of each treatment were individually plated at regular time intervals (bi-weekly) and enumerated for L. monocytogenes using modified Oxford agar (35°C for 48 hours). For all the treatments, water activity, pH, and moisture content were analyzed at day 0, subsequent pH measurements were recorded at every pull date.

Results: Treatments with 3.5 % CSV and 4.5% CSV demonstrated cook yields greater than control treatment. The pH values were similar for different treatments indicating no major impact on ionic strength of the formulations. The incorporation of 3.5 % and 4.5 % CSV natural antimicrobial intervention arrested the outgrowth of L. monocytogenes compared to the control treatment. The control treatment had greater than 2 log CFU/g outgrowth by day 15, whereas both the CSV treatments remained at the initial inoculated levels for L. monocytogenes till 85 days of storage.

Table 1: Cook yield, water activity, pH, and moisture for different antimicrobial treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cook yield</th>
<th>A_w</th>
<th>pH</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>94.7</td>
<td>0.9786</td>
<td>6.209</td>
<td>74.67%</td>
</tr>
<tr>
<td>3.5% CSV</td>
<td>98.1</td>
<td>0.9694</td>
<td>6.270</td>
<td>73.47%</td>
</tr>
<tr>
<td>4.5% CSV</td>
<td>97.5</td>
<td>0.9705</td>
<td>6.233</td>
<td>73.05%</td>
</tr>
</tbody>
</table>

Conclusion: This research provides the evidence for the antimicrobial performance of the natural solution, Verdad® Opti N80, in uncured poultry deli meat.

Keywords: Antimicrobial interventions, Listeria control, Listeria monocytogenes
Objectives: To assess the antimicrobial performance of vinegar-based products on raw chicken to extend shelf life.

Materials and Methods: Commercially purchased raw chicken breasts were submerged in one of four treatments: control (no dip), 300 Grain Vinegar Adjusted to pH 3.5 (Trt A), Corbion Modified Vinegar and Enhancer Solution (Trt B), and Corbion Modified Vinegar and Enhancer Solution (Trt C). Chicken breast samples were submerged in each treatment solution independently and agitated for 30 seconds. After being allowed to drip for one minute, chicken breasts were individually sealed into bags with a modified atmosphere (0.4% CO₂, 29.6% CO₂, and 70.0% N₂) and stored at 4°C. At each sampling pull date, five chicken breasts from each treatment group were sampled individually. Individual chicken breast samples were placed in a sterile bag to which 100 mL of neutralizing buffer was added, and the bag was shaken to adequately cover and rinse all sides of the chicken breast. Appropriate dilutions were performed, and samples were enumerated on lactic acid bacteria 3M Petrifilm™ (LAB, 30°C for 5 days) and aerobic plate count 3M Petrifilm™ (APC, 35°C for 2 days). Sampling was carried out on days 1, 6, 13, 20, and 30.

Results: Microbial populations of APC (Table 1) increased in control precipitously early in storage and continued to unacceptable levels by day 6. On day 20, both Trt B and Trt C demonstrated the lowest APC populations (5.58 and 4.53 log CFU/sample, respectively).

Image:
Table 1. Aerobic plate count of raw chicken on day 20 storage.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Aerobic Plate Count log CFU/Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Control - no dip</td>
<td>&gt;10*</td>
</tr>
<tr>
<td>2 300 Grain Vinegar Adjusted to pH 3.5 (Trt A)</td>
<td>8.62</td>
</tr>
<tr>
<td>3 Corbion Modified Vinegar and Enhancer Solution (Trt B)</td>
<td>5.58</td>
</tr>
<tr>
<td>4 Corbion Modified Vinegar and Enhancer Solution (Trt C)</td>
<td>4.53</td>
</tr>
</tbody>
</table>

Minimum detection limit of 1.52 log CFU/sample. *Control had >10 log CFU/g on day 6, and was not measured any further.

Conclusion: Extending the shelf life of raw chicken is advantageous both for commercial purposes and as a means to reduce food waste. Application of vinegar-based interventions to treat raw chicken can increase product shelf life up to 21 days and provides a clean label solution. This study provides the evidence to substantiate the antimicrobial efficacy of Corbion Modified Vinegar and Enhancer Solutions (Trt B and Trt C) and provides viable clean-label alternatives to extend shelf life of raw chicken.

Keywords: Antimicrobial interventions, Chicken Breast, Shelf life, spoilage
Objectives: This study evaluated the efficacy of lactic acid compared to other organic acid classes at reducing Salmonella on pork.

Materials and Methods: Commercially purchased pork belly skins were trimmed to 4 × 4 in. samples. Individual strains of Salmonella enterica subsp. enterica serovars Enteritidis, Typhimurium, and Heidelberg were grown in two consecutive overnight cultures (BHI broth 16-18 hours at 35°C). Five strains were combined in equal parts to create a cocktail and diluted to 4.5 log CFU/mL for inoculation. Cocktail inoculum (2 mL) was evenly distributed onto samples (room temperature) using a sterile cell spreader and allowed 30 minutes for attachment. Following attachment period, three individual samples were dipped independently in 300 mL of assigned treatment solution with agitation for 30 seconds. Antimicrobial treatments included a control (no dip), deionized (DI) water, 5% lactic acid, 200 ppm peroxyacetic acid (PAA), 5% citric acid, and 5% acetic acid. Following dip treatment, each sample was allowed a 10-minute drip time. Three cores (3.8 cm²) were excised from each 4 × 4 in. sample were combined in a sterile filter bag. Each bag was diluted 1:1 in Dey-Engley neutralizing broth, stomached for 30 seconds, serially diluted, and enumerated on xylose-lysine-tergitol 4 (XLT-4) agar with a tryptic soy agar (TSA) overlay for 48 hours at 35° C.

Results: Application of various antimicrobials, as well as DI water reduced Salmonella populations (Table 1). However, 5% citric acid and 5% acetic acid showed no significant difference (p>0.05) compared to DI water treatment. Overall, the greatest Salmonella reduction (1.98 log CFU/cm²) was observed in 5% lactic acid, which significantly (p<0.05) reduced populations compared to control and DI water treatment groups.

Image:
Table 1: Populations of Salmonella on inoculated pork belly following administration of intervention

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Salmonella population (log CFU/cm²)</th>
<th>Salmonella reduction compared to control (log CFU/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.30±α</td>
<td>*</td>
</tr>
<tr>
<td>DI Water</td>
<td>2.60±α</td>
<td>0.70</td>
</tr>
<tr>
<td>5% Lactic Acid</td>
<td>1.32±ε</td>
<td>1.98</td>
</tr>
<tr>
<td>200 ppm PAA</td>
<td>1.67β</td>
<td>1.63</td>
</tr>
<tr>
<td>5% Citric Acid</td>
<td>2.67θ</td>
<td>0.63</td>
</tr>
<tr>
<td>5% Acetic Acid</td>
<td>2.06β</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Conclusion: Salmonella is a pathogen of concern in pork, and the United States Department of Agriculture (USDA) launched an exploratory sampling program to better understand Salmonella prevalence in pork. This regulatory emphasis, as well as market demands, have led pork processors to re-assess the viability of lactic acid as a potential intervention tool. These results confirm that lactic acid is effective at controlling Salmonella on pork. While PAA was also efficacious, lactic acid achieved a significantly greater reduction and has benefits for workers and regulatory personnel. Specifically, exposure to dilute PAA may cause irritation and often requires specific engineering controls. In comparison, the long-established use of lactic acid has not deemed the use of such controls necessary. This study validates the use of Purac® FCC 88 as an antimicrobial intervention to provide Salmonella lethality in pork.

Keywords: Antimicrobial interventions, Pork, Salmonella
Objectives: The objective of this study was to assess the efficacy of Verdad® Avanta™ Y100 (VCF) on marinade retention in fresh whole chickens without giblets (WOGS) during 20 days of storage at 40°F.

Materials and Methods: Fresh WOGS were injected at 20% pump level of marinade solution containing water, salt, sugar, chicken broth, spices, and different yield enhancement treatments including: (A) Control, (B) 0.35% Combined sodium phosphate and carrageenan (PC), and (C) 1.05% VCF. WOGS were enhanced via injection with an individually prepared marinade treatment, allowed a 10-minute drip time, aerobically packaged, and incubated for 20 days at 40°F. Marinade retention was recorded throughout storage and calculated as percent of original pump level (20% target pump). On day 10, WOGS from all treatment groups were randomly selected and cooked to a minimum internal temperature of 183°F (breast) and 175°F (thigh) for cook yield evaluation.

Results: Table 1 outlines the treatment structure as well as pH, cook yield, and marinade retention data for the study. Both 0.35% PC and 1.05% VCF treatments resulted in increased marinated meat pH values compared to control. This substantial increase in pH value has a positive impact on water holding capacity. Both treatments resulted in marinade retention greater than control throughout the storage period. PC-treated WOGS showed the most marinade retention at days 10, 14, and 20 compared to other treatments. However, VCF-treated WOGS had the most marinade retention at day 3. At days 10 and 14, VCF treatment provided greater marinade retention compared to control, and maintained 88% of the marinade retention of PC-treated WOGS. Additionally, VCF-treated WOGS had the highest cook yield value among all treatments.

Conclusion: This research substantiates the efficacy of Verdad® Avanta™ Y100 as a yield enhancement alternative to sodium phosphate and carrageenan, thus providing the industry with a natural, clean label yield enhancement solution to improve marinade retention and cook yields in fresh marinated poultry.

Keywords: Cook Yield, Fresh Poultry, Yield Enhancement
Objectives: The objective of this study was to evaluate the efficacy of Verdad® Avanta™ Y100 (VCF) for shelf life extension within fresh injected whole chickens without giblets (WOGS) stored at 4°C.

Materials and Methods: Fresh untreated WOGS were injected at 20% pump with either (A) control marinade or (B) marinade with 1.05% VCF. The base chicken marinade consisted of water, salt, sugar, chicken broth, and spices, and the marinades for each treatment were prepared separately. WOGS were injected, allowed a drip time of 10 minutes, then weighed to ensure the 20% pump target was achieved. Chickens were then packaged and stored aerobically for 20 days at 4°C. Sampling was performed at days 0, 7, 11, 18, and 20 of incubation. At each sampling period, 3 chickens from each treatment were evaluated. Each bird was placed in a poultry rinsate bag, whereupon 400mL of buffered peptone water (BPW) was applied. Samples were shaken for 60 seconds, and the diluent was collected. Appropriate dilutions of the collected sample diluent were made and plated on aerobic plate count (APC) Petrifilm™, which was enumerated after incubation at 35°C for 48 hours. Moisture and water activity were measured at day 0. pH data was collected at each sampling period for the dark meat, light meat, and skin from each treatment group.

Results: The use of VCF resulted in lower bacterial growth than the control treatment for the duration of the study. At day 20, APC populations in control and VCF-treated WOGS increased by 5 and < 2 log CFU/mL from starting APC counts, respectively. By day 20, control treatment exhibited unacceptable characteristics of visual spoilage. VCF-treated WOGS maintained APC populations of < 4 log CFU/mL throughout the study duration of 20 days. VCF-treated WOGS show a systematic increase in pH value, with the potential for enhancing cook yield and sensory characteristics.

Table 1: Aerobic Plate Count and pH of Whole Injected WOGS

<table>
<thead>
<tr>
<th>Treatment</th>
<th></th>
<th>Breast Meat pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>Control (log CFU/mL)</td>
<td>VCF (log CFU/mL)</td>
</tr>
<tr>
<td>0</td>
<td>1.98</td>
<td>1.99</td>
</tr>
<tr>
<td>7</td>
<td>3.39</td>
<td>2.51</td>
</tr>
<tr>
<td>11</td>
<td>4.23</td>
<td>1.70</td>
</tr>
<tr>
<td>18</td>
<td>7.06</td>
<td>3.29</td>
</tr>
<tr>
<td>20</td>
<td>6.99</td>
<td>3.70</td>
</tr>
</tbody>
</table>

Conclusion: The short shelf life of raw chicken severely limits the supply chain flexibility for the meat industry. Shelf life extension provides the industry with the opportunity to minimize food waste and maintain product quality. This study validates the efficacy of Verdad® Avanta™ Y100 for the extension of shelf life in fresh injected chickens.

Keywords: Antimicrobial interventions, Fresh Poultry, Shelf Life Extension
Objectives: The objective of the study was to determine the functionality of potato starch by-product (PS) as a phosphate replacement in cooked turkey breasts for cook yield, subjective color, objective color, and consumer acceptability.

Materials and Methods: Four inclusion levels of PS (0.2%, 0.5%, 0.7%, and 1%) were tested along with a negative control (no phosphate; NEG) and a positive control (sodium phosphate; POS). Frozen turkey breasts (NAMI #P2015; n = 36) were delivered to the University of Idaho Meat Science Laboratory, thawed for 10 days at 2°C, pumped with their respective treatment solutions to 110% of green weight, and placed in individual vacuum sealed cook-in bags. Turkey breasts were tumbled for 30 minutes, cooked to an internal temperature of 73.9°C, and chilled overnight at 2°C. On d 0, external color was measured on all turkey breasts, and a single breast from each treatment was randomly selected for initial internal color, cook loss, and consumer sensory panel. The remaining turkey breasts were displayed in a glass-fronted retail display case at 3°C for 21 d to simulate retail display. On d 21, the same analysis was conducted as 0 d. Continuous data were analyzed using MIXED procedure of the Statistical Analysis System (SAS Institute, Inc., Cary, NC) whereas binomial data were analyzed using the GLIMMIX procedure; significance was determined at \( P < 0.05 \).

Results: The model was not significant \( (P = 0.19) \) with regard to cook yield percentage and therefore no mean comparisons were able to be made. External color on d 0 was not different \( (P > 0.05) \) between treatments. Internal yellowness was greater \( (P < 0.01) \) in breasts formulated with 1% PS than all other treatments, whereas redness was greater in POS and 0.7% PS breasts than all other treatments. Subjective color analysis indicated the greatest amount \( (P < 0.01) \) of two-toning on the cut surface was the 1% PS followed by the 0.7% PS with NEG and 0.2% PS having the least amount of two-toning. Consumer taste panel evaluations were not different between treatment for mean overall acceptance, juiciness, or tenderness. There were significant off-flavors observed between treatments \( (P < 0.001) \). The 0.7% PS had the most detectable off-flavor and was greater than all other treatments \( (P < 0.05) \). The NEG treatment had the least frequency of detectable off-flavors \( (P < 0.05) \). The 0.7% PS had the most frequency of detectable off-flavors with nearly 35% of the respondents reporting.

Conclusion: In conclusion, PS could be an acceptable replacement for POS in cooked turkey breasts if used at levels that do not impart an off-flavor.

Keywords: Color, Cook loss, consumer panel, Turkey breast
Objectives: The objective of the current study was to determine the efficacy of dipping pork trimmings in acetic acid on Salmonella reduction.

Materials and Methods: Pork loins were purchased from a commercial purveyor and trimmed of external fat and connective tissues, leaving only the longissimus muscle, which was further cut into 2.5 cm (W) × 2.5 cm (L) × 1.3 cm (H) cubes. Pork cubes were randomly assigned to a negative control (no inoculation, no dipping; NEG), a positive control (inoculation, no dipping; POS), acetic acid dipping at 21 °C (ACC) and acetic acid dipping at 50 °C (ACH) with a 15-, 45-, or 75-s dipping duration (n = 10 per treatment × time combination). Two inoculation levels, 10⁸ Colony Forming Unit (CFU)/cube of bioluminescent gene-modified (Lux) or 10⁵ CFU/cube of nalidixic acid-resistant Salmonella enteritica serovar Typhimurium, were inoculated onto pork cubes to determine the antibacterial effects of each treatment condition by in vivo bioluminescence imaging system (IVIS) or direct CFU measurement on XLD agar, respectively. In experiment 1, the cubes were dipped for 15 s to measure the reduction effects by employing both IVIS and CFU. In experiment 2, cubes were dipped with three dipping durations and the CFU were calculated. The common logarithm of Lux and CFU were calculated and analyzed by the GLIMMIX procedure of SAS v9.4 (SAS Institute Inc., Cary, NC). Actual probability values were reported.

Results: In experiment 1, at 10⁸ inoculation level, ACC and ACH reduced the growth of Salmonella by 1.8 and 1.6 log, respectively (P < 0.001) without treatment difference (P = 0.207). However, at 10⁵ inoculation level, ACC and ACH reduced Salmonella by 0.2 and 0.3 log, respectively (P ≤ 0.026). In experiment 2, at 10⁵ inoculation level with three dipping durations, the ACH treatment reduced Salmonella by 0.9 log more than the ACC treatment (P < 0.001). The 75-s dipping duration was the most effective, providing a reduction of 0.7-log more than the 15-s duration (P = 0.001). No 2-way treatment × time interaction was observed (P = 0.104).

Conclusion: The present study suggests that the pork trimmings be dipped into 3% acetic acid solution at 50 °C for at least 75 s to ensure the safety of further processed pork products.

Keywords: acetic acid, pathogen contamination, pork trimmings, Salmonella reduction
Objectives: The study objectives were to compare the deep (D) vs. superficial (S) portions of the beef top round (NAMI #169A PSO1), semimembranosus (SM) muscle, for tenderness, lipid oxidation, and color.

Materials and Methods: In order to simulate the retail setting, USDA Choice top rounds (n = 12) were purchased from a commercial food distributor and delivered to the University of Idaho Meat Science Laboratory under refrigeration. Top rounds were aged for 21 to 24 days from their pack date prior to removing the SM for subsequent analysis. Four steaks were cut from each SM proximally to distally. To account for steak location, steaks were systematically assigned to one of the following analyses; Warner-Bratzler Shear Force (WBSF) measurement, lipid oxidation using the Thiobarbituric Acid Reactive Substances (TBARS) method, subjective and objective color analysis on the whole steak in order to calculate color uniformity (two-toning), and subjective and objective color of a steak separated into D and S portions. The separating cut was made approximately two inches from the superficial edge of the steak. After cutting, WBSF steaks were cooked on clamshell grills to an internal temperature of 71°C. Steaks were then chilled overnight before 6 cores were sheared perpendicular to the muscle fiber direction on a WBSF machine. Steaks were sampled and evaluated for TBARS on days 0 and 4 of retail display, while color was evaluated subjectively and objectively on days 0, 1, 2, 3, and 4 of retail display. Steaks used for TBARS and color analysis were placed on white Styrofoam trays, overwrapped with an oxygen permeable PVC film, and displayed in a glass-fronted retail display case at 3°C for 4 days to simulate retail display. Data were analyzed using the mixed models procedure of the Statistical Analysis System (SAS Institute, Inc., Cary, NC) and significance was determined at \( P < 0.05 \).

Results: Mean Warner-Bratzler shear force values were lower (\( P = 0.0012 \)) in the S (4.2 kg) than the D (5.2 kg) portion of the SM. On day 0, D and S portions had similar TBARS values (0.172 vs 0.118 mg MDA/kg Meat); yet, by day 4, the D portion had substantially greater TBARS values than the S portion (0.497 vs 0.194 mg MDA/kg Meat; treatment x day of retail display interaction, \( P < 0.0001 \)). The D portion was lighter (higher \( L^* \); \( P < 0.0001 \)) colored than the S portion. Furthermore, the D portion became less red compared to the S portion during simulated retail display (treatment x day of retail display interaction; \( P < 0.0001 \)). The whole steak had greater levels of two-toning initially, as well as throughout the 4 days of retail display, compared to the D and S portions (treatment x day of retail display interaction; \( P < 0.0001 \)). Therefore, cutting top round steaks into a D and S portion would result in the steaks being more uniform in color. Additionally, the S portion has longer shelf-life as well as improved tenderness compared to the D portion.

Conclusion: In conclusion, the S portion may be able to generate a premium compared to the whole steak at the retail level because of its superiority in color to the D portion and more uniform color compared to the whole steak.

Keywords: Color, Lipid oxidation, Tenderness, Top round
Objectives: Dry aging treatments impart unique flavors desirable by a segment of the population. Ground beef offers flexibility of use at a lower price point. There is potential to add value to lower priced beef cuts by dry aging them and incorporating them into premium grinds. However, the long dry aging period could allow growth of key pathogens. To determine the risk, the prevalence and potential for growth must be assessed. The effect of a dry aging treatment on the population of \textit{Salmonella} and \textit{Listeria monocytogenes} was studied.

Materials and Methods: An in-plant assessment of \textit{E. coli} O157:H7, \textit{Salmonella}, and \textit{Listeria monocytogenes} was conducted by swabbing both the fat and lean sides of 25 ribeye rolls or striploins before direct plating and finally enriching samples. Beef shoulder clods were purchased and used to simulate dry aging. The product was cut into 10 cm x 10 cm blocks before inoculating both fat and lean surfaces with a cocktail mixture containing two strains of \textit{Listeria monocytogenes} and five strains of \textit{Salmonella} at a rate of $10^3$ CFU/cm$^2$. Blocks were allowed to dry for 15 min between inoculation of sides and before suspension in a refrigerator (4°C) with a circulating fan and 70-80% humidity. Surfaces were removed at a depth <5mm for collection and plating on selective media at 0, 1, 7, 14, 21 and 28 d post inoculation. Two sides of six blocks were used at each time point; the experiment was replicated a second time. Data were analyzed to test the effect of time, side, and their interaction for each pathogen; replication was a random variable.

Results: Samples collected in a commercial facility showed no occurrence of \textit{E. coli} O157:H7 or \textit{Salmonella}, but three presumptive \textit{Listeria monocytogenes} colonies were found in the quantitative analysis. The plant does not process ready-to-eat products, the main concern with \textit{Listeria monocytogenes}. Since all product will be trimmed and cooked prior to consumption, and with the low amount of \textit{Listeria monocytogenes}, the risk associated with \textit{Listeria monocytogenes} is relatively low. To validate use of the dry aging treatment on sub-primals to be used for ground beef, the microbial population of the key pathogens used during inoculation must not increase over the treatment period. \textit{Salmonella} levels on d 1 and 14 were similar ($P=0.53$), but numerically less than d 0, and lower ($P=0.0028$) on d 1, 21, and 28. There was an effect of side of inoculation; the fat side had significantly higher ($P=0.046$) \textit{Salmonella} levels over the duration of the study. This suggests that \textit{Salmonella} may have had slightly better attachment to fat at inoculation, but it had no bearing on growth dynamics thereafter. There was no day by side interaction detected ($P=0.51$). \textit{Listeria monocytogenes} showed a similar overall trend; counts were similar on d 7, 14, and 21 ($P=0.079$), and numerically less than d 0, whereas counts were lower ($P=0.014$) on d 1 and 28. No effect of side ($P=0.21$) or a day by side interaction ($P=0.66$) were observed.

Conclusion: Overall, \textit{Salmonella} and \textit{Listeria monocytogenes} did not increase during the 28d aging period, indicating that dry-aged beef trim is not higher risk than fresh beef trim. Thus, additional risk mitigation steps may not be necessary during processing of dry aged versus fresh ground beef.

Keywords: dry aging, \textit{Listeria monocytogenes}, \textit{Salmonella}
EVALUATION OF THE REDUCTION OF ESCHERICHIA COLI O157:H7 SURROGATES IN BEEF RIBEYE ROLLS AT 54.4°C

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Objectives: E. coli infections are a primary source of gastroenteritis requiring strict cooking and handling procedures for meat producing companies as directed by the USDA. This study evaluated the reduction of Escherichia coli O157:H7 surrogates in a low temperature cook process at a local medium-large meat processor. This is one of three microbial validation projects; the other projects will investigate Clostridium perfrigens and Salmonella spp. The objective of maintaining meat quality (rare color) throughout cooking processes urges the study of low temperature cook processes to determine their efficacy in microbial control.

Materials and Methods: This study was completed in three replications each consisting of a sample size of n=25. Four strains of Escherichia coli (American Type Culture Collection, ATCC® BAA-1427, 1428, 1429, and 1431), each approved as a surrogate for E. coli O157:H7, were used in this study. Each surrogate was grown separately. Inoculations of surrogates were prepared utilizing 800 ml of distilled water mixed with 24 g of TSB and inoculated with surrogates. The inoculations were incubated at 37°C for 24 hours prior to application. The surrogates were mixed together to make a cocktail just prior to inoculation of meat. Seventy-five (25 per replication) ribeye rolls (IMPS 112-A) were removed from vacuum bags and trimmed. Initial samples were taken to determine initial microbial load prior to inoculation. The pH and temperature were taken in raw meat, after spraying with antimicrobial, and after brining. The pH and temperature of the brine was also recorded. Meat was inoculated with 90 mL of inoculum and was distributed evenly on the surface with a sponge on a stick. The inoculum was allowed to dry for 30 minutes prior to sampling for inoculation load. Ribeye rolls were then sampled 15 minutes after going through an antimicrobial spray. Samples for raw meat, initial inoculated meat, and after antimicrobial spray were taken from the surface of the ribeye roll (approximately 100g). Following sampling, the ribeye rolls were pumped with a brine solution (sugar, salt, and proprietary ingredients) to 15%. The meat was vacuum-packaged in cook-in bags and allowed to sit in a cooler to mimic the longest period of time from packaging until it would be placed in the smokehouse. Ribeye rolls were cooked according to Appendix A at 54.4°C for 112 minutes, and chilled until the internal temperature was below 4.4°C. Final cooked and chilled samples were taken by cutting a 4 cm steak from the center of the roast. All samples were packaged and sent to Food Safety Net Services (FSNS) for culturing on coliform film. At FSNS 25g of meat and 225 mL of BPW were stomached, serial dilutions were done and plated on coliform petrifilm and allowed to incubate for 24-48 hrs. Results were analyzed using the proc GLM procedure of SAS, determining the LSMean and StdError as well as Microsoft Excel.

Results: Initial inoculation loads after inoculation were 6.5 logs and all cooked and chilled samples had less than 1 log. Therefore, the mean log reduction was 5.1 with a standard error of 0.04 from inoculation to post-cook over the three replications.

Conclusion: The results suggest that this cook method is sufficient to reduce E. coli O157:H7 in whole-muscle beef ribeye rolls. This information would be beneficial to companies looking to preserve meat quality while utilizing a low temperature cook process.

Keywords: Appendix A, beef, E. coli, Ribeye Roll
Objectives: Metmyoglobin reducing activity (MRA) is an inherent muscle biochemical property that can influence color stability. Hence, MRA is used in color research to better understand meat color changes. A greater postmortem muscle pH can affect inherent biochemical properties, including the conventional methodologies to determine MRA. The MRA methodology described in the American Meat Science Association Color Guide utilize changes in nitric oxide induced-metmyoglobin level pre- and post-incubation. However, a greater muscle pH can limit initial metmyoglobin formation. Hence, the methodology discussed in the AMSA color guide may not provide accurate results. Therefore, the objectives of this research were to compare different conditions to induce initial metmyoglobin formation.

Materials and Methods: In the first objective, normal-pH and dark-cutting steaks were dipped in 0.3% (level recommended in the AMSA color guide) and 1% nitrite solution to induce metmyoglobin formation. Metmyoglobin formed steaks were blotted dry, vacuum packaged, and incubated at 30 °C to induce metmyoglobin reduction. In the second experiment, 1% ferricyanide solution was used as an oxidizing agent. The methodology used in objective 1 was used to measure MRA. The experiments were replicated three times and the data were analyzed using the Mixed Procedure of SAS.

Results: There was no effect (P > 0.05) of nitrite concentration on MRA of dark-cutting beef. However, when 1% ferricyanide was used as an oxidizing agent, initial metmyoglobin was more (P < 0.05) in dark-cutting beef compared with 0.3% sodium nitrite solution.

Conclusion: The results suggest that the use of a strong oxidizing agent can impart more metmyoglobin formation in high-pH/dark-cutting beef.

Keywords: Dark-Cutting Beef, Meat Color, Metmyoglobin Reduction, Myoglobin
NIX PRO COLOR SENSOR PROVIDES COMPARABLE COLOR MEASUREMENTS TO HUNTERLAB COLORIMETER


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Objectives: Meat color is the most important quality attribute that influences consumer purchase decisions. Monitoring color to maximize shelf life and consumer acceptability is routinely used in meat science research. The HunterLab MiniScan EZ (HunterLab) colorimeter is the widely used industry standard for objectively measuring meat color. This device can collect tristimulus values of CIE $L^*$ (lightness), $a^*$ (redness), and $b^*$ (yellowness) for color measurements based on the light reflectance from the meat surface. While the HunterLab colorimeter serves as an accurate measure of meat color, it is relatively expensive and bulky. The Nix Pro Color Sensor (Nix) colorimeter is a less expensive and smaller handheld device that can capture the CIE $L^*$, $a^*$, $b^*$ values which can be downloaded to a smartphone app. However, limited research has been performed to compare the efficiency of these colorimeters for measuring beef color. Therefore, the objective of this study was to investigate the capabilities of the Nix colorimeter as an additional resource for objective fresh beef color measurements.

Materials and Methods: The longissimus dorsi muscle from one side of A maturity beef carcasses ($n = 200$) were evaluated using the HunterLab and Nix colorimeters. Carcasses were allowed approximately one hour to bloom after being ribbed (between the 12th and 13th rib) prior to color measurements. Three (technical replicate) scans were obtained using the HunterLab colorimeter (illuminant A and 10° standard observer) and the mean readings were recorded. A series of independent technical replication (3, 5, 7, and 9) scans were obtained using the Nix colorimeter with illuminant A and 10° standard observer as well. The differences in color measurements between colorimeters were analyzed by using the Bland Altman Limits of Agreement and CORR (correlation) procedure of SAS with $\alpha < 0.05$.

Results: Correlation between the HunterLab and Nix was highest for $a^*$ value (redness) with 3 scans ($r = 0.85$, $P < 0.01$), followed by 7, 5, and 9 scans ($r = 0.84$, 0.82, and 0.82, respectively; $P < 0.01$). Additionally, $L^*$ values (lightness) were highly correlated for all the scanning series ($r = 0.79$-0.81; $P < 0.01$). Similar to $a^*$ values, 3 scans with the Nix for $b^*$ values (yellowness) demonstrated the best correlation with HunterLab ($r = 0.83$; $P < 0.01$), whereas the 5, 7, and 9 scans were still highly correlated ($r = 0.79$-0.82; $P < 0.01$). The Bland Altman Limits of Agreement analysis indicated that the mean difference in $a^*$ values using 3 scans of both colorimeters was -1.68, whereas it was -0.91 for $L^*$ values and 0.25 for $b^*$ values. Moreover, the analysis indicated good agreement between the Nix and the Hunterlab colorimeters for all the color parameters.

Conclusion: Three replicate scans using the Nix was highly correlated with color measurements using the HunterLab colorimeter and can serve as an acceptable additional resource for objectively measuring beef color. The Nix provides an opportunity for a less expensive, more mobile, and multipurpose device. Although these colorimeters are not equivalent, the Nix could be an adequate method for objective beef color measurements and is comparable to the HunterLab.

Keywords: beef color, HunterLab colorimeter, Nix colorimeter
Objectives: Woody breast is a myopathy observed in chicken breast meat (*Pectoralis major*) characterized by its tough and rubbery texture. However, the exact causation of woody breast texture is still unknown. We hypothesize that sarcoplasmic reticulum (SR) dysfunctionality early postmortem results in rapid leakage of intracellular calcium may partially contribute to the abnormal meat texture observed in woody breast meat. The objective of this preliminary study was to investigate this hypothesis.

Materials and Methods: Fourteen Ross line broiler breast fillets (7 severe woody breast and 7 normal) were collected at 3 h postmortem from a commercial processing plant located in the southeast United States. The 7 woody breast samples also exhibited moderate to severe white striping. The 7 normal samples did not exhibit any signs of white striping or woody breast. Each sample was trimmed, weighed, vacuum packaged and frozen at -20°C at approximately 8 hrs postmortem. One 1.9 cm strip across the cranial end of each fillet was fabricated and pulverized in liquid nitrogen to measure sarcomere length (Laser Scan Confocal Microscope with a 100x/NA 1.4 objective), calpain activity (immunoblotting for µ-calpain autolysis), proteolysis (immunoblotting for troponin-T degradation) and collagen content (hydroxyproline content). Purge was also collected from each sample to evaluate protein (bicinchoninic acid assay) and free calcium concentration (atomic absorption).

Results: Woody breast fillets were heavier than normal chicken breast fillets (522.9 vs. 446.9 g; P<0.05). Woody breast samples tended to have shorter sarcomeres (1.70 vs. 2.02 µm; P=0.0543) and less intact troponin compared to normal breast samples (relative intact troponin-T band density: 49.98 vs. 56.97%; P=0.0515) at 8 hrs postmortem. It was interesting to note that no µ-calpain band was detected through immunoblotting for both the woody breast and normal samples at 8 hrs postmortem. Other studies have found similar results as poultry µ-calpain autolyzed at a much rapid rate than µ-calpain in mammalian species. In addition, the purge from woody breast samples also had higher levels of free calcium compared to normal samples (6.2 vs. 4.2 nmol calcium/mg protein; P<0.05). Lastly, there was more collagen present in the woody breast samples compared to normal chicken breast samples (3.89 vs. 2.08 mg collagen/g muscle tissue; P<0.05).

Conclusion: The results indicated that the cause of texture abnormality of woody breast may be the combined effects of more calcium being released from the SR early postmortem resulting in shorter sarcomere length and more collagen being deposited in the chicken breast meat. Additional research with the focus on SR integrity and functionality as well as collagen crosslinks are needed to further elucidate the basic mechanism of woody breast texture formation.

Keywords: calcium, calpain activity, sarcomere, troponin-T, woody breast
173-CONSUMER SENSORY EVALUATION OF BEEF TOP SIRLOIN CAP STEAKS FROM FOUR USDA QUALITY GRADES

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Objectives: The objective of this study was to evaluate the influence of quality grade on the palatability of beef top sirloin cap (biceps femoris) steaks.

Materials and Methods: Four quality treatments [Prime, Top Choice (Modest and Moderate marbling), Low Choice and Select] were equally represented (n = 15/treatment) from beef top sirloin caps (IMPS # 184D). Sirloin caps were fabricated into 2.5 cm steaks from posterior to anterior following a 28-day aging period and randomly assigned to one of 3 analysis methods: Warner-Bratzler shear force (WBSF), fat and moisture analysis, and consumer sensory analysis. Steaks were cooked on a clamshell grill (Cuisinart Gridler Deluxe, Model GR-150, East Windsor, NJ) to a peak medium (71°C) degree of doneness monitored using a thermometer (Super-Fast Thermopen, ThermoWorks, American Fork, UT). Consumers (N = 118) evaluated each sample for juiciness, tenderness, flavor liking, and overall liking on a 0 to 100-point continuous line scales. Additionally, consumers rated each trait as either acceptable or unacceptable and classified all samples as one of 4 quality levels: unsatisfactory, everyday quality, better than everyday quality, or premium quality. Data were analyzed as a completely randomized design with the fixed effect of quality treatment.

Results: Consumers rated Top Choice, Low Choice, and Select similar (P < 0.05) for overall like, however, Prime rated (P < 0.05) higher than all other treatments. Also, Prime and Top Choice were similar (P > 0.05) for flavor liking, with Low Choice and Select also similar to Top Choice (P > 0.05). There was no difference (P > 0.05) among the quality treatments for tenderness and juiciness ratings. Similar to the rating results, when evaluating the percentage of samples rated acceptable for each palatability trait, no differences (P > 0.05) were found among quality treatments for tenderness, juiciness, and flavor, with all traits rated over 71.5% acceptable. However, a greater (P < 0.05) percentage of Prime samples were rated acceptable overall compared to Low Choice and Select. Additionally, there was no difference (P > 0.05) among the quality treatments for the percentage of samples classified as unsatisfactory. Consumers perceived a similar (P > 0.05) percentage of Top Choice and Low Choice samples at each quality level. Moreover, Prime had a greater percentage (P < 0.05) of samples perceived as Premium Quality than Select. For WBSF, there were no differences (P > 0.05) among treatments. Prime steaks had a similar (P > 0.05) moisture percentage as all other treatments, with Select having the greatest (P < 0.05) percentage of moisture compared to Top Choice and Low Choice. Furthermore, Top Choice and Low Choice had a similar (P > 0.05) percentage of fat, with Prime having the highest (P < 0.05) fat percentage and Select having the lowest (Prime > Top Choice = Low Choice > Select).

Conclusion: These results indicate that quality grade has minimal impact on the palatability of beef top sirloin cap steaks. Therefore, food service does not need to pay the extra premiums associated with a higher grading product, as consumers will experience the same eating experience as with lower quality grades.

Keywords: beef, consumer, marbling, palatability, top sirloin cap
EFFECT OF DIFFERENT PHOTOPERIODS ON QUALITY ATTRIBUTES AND OXIDATIVE STABILITY OF BREAST MEAT (M. PECTORALIS MAJOR) FROM BROILERS

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Objectives: In the broiler industry, high photoperiod (the duration of light exposure per day) regimes have traditionally been utilized to increase yield of breast meat, as well as maximize feed intake and growth rate in the growing period. However, recent literature reports this practice may have adverse effects on broiler welfare, resulting in impaired mobility and increased incidence of leg abnormalities. However, little information available in the current literature regarding effects of photoperiod on meat quality attributes and oxidative stability of broiler meat. Thus, the objective of this study was to evaluate the quality characteristics and lipid/protein oxidative stability of breast meat from broilers that were exposed to different photoperiod combinations.

Materials and Methods: A total of 432 Ross 308 broiler chicks were allocated among 4 rooms each subjected to one of the following photoperiod treatments (hours Light: Dark): 20L:4D, 18L:6D, 16L:8D and 12L:12D, with 6 pens per treatment. At d 42, 2 broilers per pen (12 broilers/treatment) were randomly selected, harvested and air chilled for 24 h at 2 °C. At 1 day postmortem, paired breast muscles (M. pectoralis) were collected for the meat quality analyses such as, water-holding capacity (drip/purge/cook loss), Warner-Bratzler shear force (WBSF), and display color for 7 d under fluorescent light (1,450 lx). Lipid oxidation was assessed via the TBARS assay and protein oxidation by thiol content measured at d 1 and d 7 of display. The experimental design was randomized complete block design. Data were analyzed using the PROC MIXED procedure of SAS, and means were separated using least significant differences (P<0.05).

Results: Photoperiod had no effect on fillet yield and pH (P>0.05). No significant difference in WBSF was found between treatments, although 12L:12D had a trend of higher WBSF (P=0.08). Higher moisture loss during carcass chilling was found in carcasses from 20L:4D compared to 16L:8D and 12L:12D treatments (P<0.05). No other measure of water-holding capacity was affected, though the 16L:8D treatment demonstrated a trend of higher freezing/thawing loss compared to other treatments (P=0.06). Proximate moisture, protein and lipid contents were unaffected by photoperiod (P>0.05), but higher ash was observed in 16L:8D over 20L:4D and 18L:6D (P<0.05). Different photoperiod combinations affected color stability of breast meat during display (P<0.05). Of note, fillets from 20L:4D maintained highest L* and hue angle, and least a* values (P<0.05), indicating inferior color stability compared to other treatments. Oxidation increased with display, and fillets from 20L:4D and 18L:6D had higher TBARS over 12L:12D (P<0.05); no photoperiod effect was observed in thiol content (P>0.05).

Conclusion: Results suggest 20L:4D photoperiod regimes may be detrimental to meat quality, as carcasses from this treatment group had higher moisture loss during chilling, and color measurements characterized these fillets as being paler and more discolored than other treatments. Fillets from 12L:12D maintained lower TBARS than 20L:4D and 18L:6D, suggesting photoperiod regimes allowing more hours of dark may be beneficial in improving oxidative stability. Further studies determining the effects of photoperiod on quality and protein functionality of chicken meat for processing technological would be highly warranted.

Keywords: broilers, meat quality, oxidative stability, photoperiod
EVALUATION AND SAFETY VALIDATION OF DEHYDRATING METHODS FOR GOAT MEAT IN RURAL MALAWI

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Objectives: This study was conducted to evaluate the dehydration methods of goat meat based in Malawi and the effects on food safety.

Materials and Methods: Goat meat was prepared as ground, minced, and whole muscle strips. Samples were treated with 6% lemon juice marinade, 6% vinegar marinade, or salt rub. During phase 1, dehydration of the meat was performed with a solar dehydrator (n=108), electric oven (n=108) or drum oven (n=108). Qualitative data on the three drying methods was collected from a panel of students from Mzuzu University, Malawi, on the practicality of each method in a local rural setting. Additionally, visual observations were conducted 30 days prior to drying for the presence of mold and insects to give an indication of shelf life. Phase 2 was performed at Texas Tech University in Lubbock, Texas where whole muscle strips of lamb were submerged in a five-strain *Escherichia coli* surrogate cocktail of *Escherichia coli* for five minutes, allowed thirty minutes for cell attachment, then dried using an electric and drum oven, replicating the dehydration procedure in Malawi. For each replicate (n=2), attachment samples (n=10), samples dried in the electric oven (n=10) and samples dried in drum oven samples (n=10) were aseptically plated on MacConkey agar with a TSA overlay and enumerated for *E. coli*.

Results: In phase 1, mold growth was observed on 15.7% (34/216) of samples dried in the solar dehydrator and drum oven. Of those positive for mold, 32.4% (n=11) were minced, and 67.6% (n=23) were whole muscle strips. No samples dried using the electric oven displayed mold (0/108). No samples displayed insects. Based on qualitative data that was gathered, top reasons to dry goat meat using the drum oven include “not requiring electricity” and “drum ovens are a common piece of equipment in villages”. Top reasons against using a drum oven include “unequal distribution of heat” and “high level of oversight required during drying”. Top reasons to dry goat meat using electric oven include “fast drying time”, “uniform distribution of heat”, and “limited oversight required”. Top reasons against using electric oven to dry goat meat include “requiring electricity” and “low knowledge of electric oven operation in a community setting”. Top reasons to use the solar dehydrator to dry goat meat include “not requiring electricity or firewood” and “limited oversight required”. Top reasons against using the solar dehydrator to dry goat meat include “slow drying time” and “uneven heat distribution due to time of day and shadows”. In phase 2, a 5-log reduction was observed for all electric oven treatment replicates (100%, 2/2) and half drum oven (50%, 1/2) replicates. However, variation in the reduction of *E.coli* is a direct result of weather and fuel provided to the drum oven.

Conclusion: Electric drying oven displayed the most consistent results for shelf life and safety. However, in rural Malawi, dehydrating methods should be chosen on a case by case basis.

Keywords: Africa, Food Safety, food security, goat meat, Malawi
176-EFFECTS OF DRY AND WET AGING ON QUALITY ATTRIBUTES OF USDA CHOICE AND PRIME STRIP LOINS
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Objectives: This study aimed to investigate the effects of dry aging on sensory parameters and flavor-correlated attributes such as lipid oxidation and fatty acid profile of USDA Choice and Prime strip loins. Beef that undergoes dry-aging processes is usually merchandised as a product with enhanced tenderness, juiciness and flavor. This study aimed to investigate the effects of dry aging on sensory parameters and flavor-correlated attributes such as lipid oxidation and fatty acid profile of USDA Choice and Prime strip loins.

Materials and Methods: A total of 48 short loins (IMPS 174; 24 Prime and 24 Choice) were commercially acquired and assigned to a 2x2x2 factorial design. Fixed effects were aging method (dry and wet), USDA quality grade (Choice and Prime), and aging time (21 and 42 d). Dry-aged samples were held at 2°C ±2, humidity was maintained at 80-85%, and air speed at 2 m/sec. Wet-aged samples were stored under same temperature in their original vacuum sealed bag. After aged, strip loins were fabricated into 2.54-cm steaks. Samples were evaluated for sensory attributes, cooking loss, lipid oxidation and fatty acid profile. A trained-panel of 8 members evaluated juiciness, tenderness, connective tissue amount, off-flavor intensity, and presence off-flavor descriptors. Lipid oxidation was evaluated by measuring thiobarbituric acid reactive substances, and fatty acid profile was estimated by gas chromatography. Data were analyzed using SAS.

Results: Cooking loss was not affected by any fixed effect. For sensory analysis, an interaction between USDA grade and aging method was observed for tenderness (P = 0.0006). When wet-aged, Prime steaks were more tender than Choice steaks. Within USDA-Prime grade, wet-aged steaks were more tender than dry-aged steaks. For Choice steaks, dry aged was more tender than wet-aged. An interaction between USDA grade and aging method was also observed for connective tissue amount (P = 0.0021). Panelists scored higher connective tissue amount values for wet-aged Prime steaks when compared to wet-aged Choice steaks. Within USDA-Prime grade, wet-aged steaks had more connective tissue than dry-aged steaks. For juiciness, only grade effect was significant (P=0.0054) whereas Prime steaks were juicier than Choice. When evaluated for off-flavor intensity, only aging time effect was significant (P=0.0368). Steaks aged for 42 d had higher off-flavor intensity than steaks aged for 21 d. When evaluating descriptors, higher frequency of bitter flavor was identified by panelists on steaks aged for 42 d when compared to 21 d (P = 0.045). Higher frequency of metallic descriptor was also observed by panelists on wet-aged samples when compared to dry-aged (P=0.0418). Higher values of C20:3n6 and C20:1n9 were observed in samples aged for 42 d when compared to 21 d, whereas wet aged steaks had higher concentrations of C20:1n9, PUFA and n6:n3.

Conclusion: Minimal effects of aging method were observed on sensory attributes. USDA grade seems to play a more important role on flavor development than aging method. Extending aging time may increase off-flavor intensity, which is commonly associated to higher lipid oxidation. However, in this study, we did not observe significant effects of aging method, grade, and aging time on lipid oxidation, possibly, because before cooking, external dry surface of steaks was trimmed. Some fatty acids may contribute to presence of off-flavor descriptors in beef.

Keywords: dry aging, flavor, sensory evaluation, tenderness
Objectives: This research is designed to validate a novel clean-in-place type antimicrobial ice-based meat grinder sanitation method.

Materials and Methods: Four different types of antimicrobial ice were prepared from peracetic acid (PAA, 350 mg/L) and combination PAA with 2% FreshFX® (PAAF), 2% Paradigm® (PAAP) and 2% lactic acid (PAAL). The grinders were inoculated by processing 400 g beef trim containing 400 µl of E. coli O157:H7 or S. Typhimurium DT 104 suspensions at 8.4 to 8.7 (high inoculation) and 5.3 to 5.5 (low inoculation) log CFU/mL. Each meat grinder was then treated by processing 1000 g of antimicrobial ice and 500 mL of corresponding antimicrobial solution. At the end of each treatment, 400 g un-inoculated beef was processed through the meat grinder, and the resulting ground beef was then analyzed for the presence of target pathogens by direct plating and after enrichment. Efficacies of antimicrobial ice-based treatments were compared with 1000 g deionized water ice + 500 mL deionized water (DI), and no treatment (NT) controls.

Results: All antimicrobial ice treatments were able to reduce cross-contamination to non-detectable levels from the meat grinders inoculated at the low levels of pathogens, but after enrichment, target pathogens were detected in all the samples. Recoveries from the meat grinder inoculated with high levels of pathogens ranged from 5.95 to 3.50 log CFU/g and 5.86 to 3.46 log CFU/g for E. coli O157:H7 and S. Typhimurium DT 104, respectively. All antimicrobial ice treatments were significantly (p ≤ 0.05) more effective in reducing cross-contamination in comparison of NT and DI controls. The microbial reductions achieved by different antimicrobial ice treatments were not significantly (p ≤ 0.05) different from each other.

Conclusion: The antimicrobial ice-based meat grinder sanitation technique could effectively reduce foodborne pathogens from meat grinders without needing meat grinder disassembly.

Keywords: antimicrobial, Antimicrobial interventions, meat grinder, sanitation
EVALUATION OF THE CHANGES IN COMPOSITION OF PORK CHOPS DURING COOKING

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Objectives: The objective was to determine the change in extractable lipid concentration during cooking of boneless pork chops to different endpoint temperatures. Intramuscular fat (IMF) concentration of pork chops changes during the cooking process when chops are cooked to 63°C, water is lost thereby concentrating extractable lipid. When chops are cooked to 71°C, water is lost, but it was hypothesized that lipid is lost as well. This would result in less variability in IMF of cooked chops compared with raw chops. This reduction in variability may explain the lack of sensory perception differences between chops with substantial marbling and chops with little marbling. This is important because consumers use marbling to make purchasing decisions. The hypothesis was that the range in IMF would be lessened after cooking due to moisture loss and potentially lipid loss at higher cooking temperatures. Ultimately, the variation in IMF in cooked pork chops would be less than that of fresh pork chops.

Materials and Methods: Pork loins (152 total) were used by cutting 3 consecutive chops from each loin. Chop 1 was evaluated raw (not cooked), chop 2 was cooked to 63°C, and chop 3 was cooked to 71°C before evaluation for IMF. These chops were divided into 3 separate bins based on raw IMF percentages. The low group consisted of chops with an IMF percentage equal to or less than 3%, the average group consisted of IMF percentages between 3 and 4% and the high IMF group consisted of chops with an IMF greater than 4%. Moisture and IMF were determined using duplicate 10 g samples from each chop. Samples were dried and IMF was determined with the chloroform-methanol solvent method. Cook loss was calculated by weighing chops before and after cooking. Warner-Bratzler Shear Force (WBSF) was determined by shearing 5 cores from each chop. Data were analyzed using a one-way ANOVA with the fixed effect of IMF level. Means were separated using a probability of difference statement and considered significantly different at $P < 0.05$.

Results: Raw high IMF chops (4.94%) had greater ($P < 0.0001$) IMF than average IMF chops (3.51%). Raw average IMF chops (3.51%) had greater ($P < 0.0001$) IMF than low IMF chops (2.47%). High IMF chops cooked to 63°C (5.59%) had greater ($P < 0.0001$) IMF than average IMF chops cooked to 63°C (4.17%). Average IMF chops cooked to 63°C (4.17%) had greater ($P < 0.0001$) IMF than low IMF chops cooked to 63°C (3.39%). High IMF chops cooked to 71°C (6.12%) had greater ($P < 0.0001$) IMF than average IMF chops cooked to 71°C (4.55%). Average IMF chops cooked to 71°C (4.55%) had greater ($P < 0.0001$) IMF than low IMF chops cooked to 71°C (3.88%). Additionally, WBSF was not different ($P \geq 0.32$) among high, average or low groups when cooked to 63°C or 71°C. Cook loss was not different ($P \geq 0.31$) among high, average, or low groups when cooked to 63°C or 71°C. However, WBSF (2.77 kg) and cook loss (18.70%) was less in chops cooked to 63°C than when cooked to 71°C (3.10 kg, 23.37%).

Conclusion: The hypothesis was that the range and variability in IMF would be lessened after cooking due to moisture loss and potentially lipid loss at higher cooking temperatures. This was not the case and the differences in IMF percentages persisted even after cooking. Furthermore, WBSF and cook loss did not differ among chops categorized as high, average, and low IMF categories. Ultimately, IMF percentage of raw or cooked chops did not affect tenderness.

Keywords: Cook loss, Degree of doneness, Intramuscular fat, Marbling, Tenderness
Comparing Heat Shock Proteins in Angus and Brahman Cattle and Their Effect on Tenderness

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Objectives: Heat shock proteins (HSP) are biomarkers of stress and perform chaperoning functions to fold, unfold, and refold proteins after heat stress. Brahman are more heat tolerant than Angus, while Angus beef has been associated with greater palatability than Brahman. The objectives were to determine if HSP content in the longissimus lumborum differs between Angus and Brahman and examine how HSP content relates to the eating quality of beef.

Materials and Methods: Angus and Brahman steers (n = 12 per breed) were finished during summer in Florida and harvested at approximately 17 months of age. Samples of longissimus lumborum were collected at 1 hour after exsanguination and were immediately immersed in liquid nitrogen. Samples were then pulverized, diluted in extraction buffer, and homogenized. The protein samples were assayed to assess protein concentration and subsequently diluted to equal concentrations for loading into acrylamide gels. Proteins were separated by gel electrophoresis, and western blotting was used to evaluate content of αβ-crystallin, HSP27, HSP60, HSP70, and HSP90. Target bands were detected and quantified using LI-COR Odyssey and target signal was normalized to total protein stain. Tenderness was evaluated in 14d-aged steaks using Warner-Bratzler shear force (WBSF) and a trained sensory panel. Data were analyzed using one-way ANOVA and Pearson correlations were conducted for content of HSPs and objective and subjective tenderness.

Results: HSP27, HSP60, and HSP70 did not differ between breeds (P > 0.05); however, HSP90 and αβ-crystallin were greater (P=0.005) in the longissimus lumborum of Angus compared to Brahman. Even though WBSF did not differ (P = 0.29) between breeds, breed affected (P < 0.0001) sensory tenderness. Content of αβ-crystallin was associated with sensory tenderness (r² = 0.52, P = 0.0098).

Conclusion: Longissimus dorsi from the Angus were contained more αβ-crystallin and HSP90 than Brahman. Elevated concentrations of both αβ-crystallin and HSP90 could be breed related or may have been influenced by the season they were harvested. While WBSF was not affected by breed, panelists rated Angus steaks as more tender after aging for 14d. Content of αβ-crystallin is associated with tenderness; however further work is necessary to determine if this small HSP affects proteolysis.

Keywords: Bos indicus, proteolysis, thermotolerance
OBJECTIVES: This study was aimed to determine how electrostatic spray of natural antioxidants impacts chemical quality of grass-finished beef strip steaks.

MATERIALS AND METHODS: Twenty certified grass-finished beef loins from ten animals were purchased from a certified grass-fed beef purveyor. Two loins of the same animals were cut into sixteen 2.5-cm thick steaks (eight steaks per loin) without the gluteus medius muscle. A factorial arrangement of 4 treatments, including a negative control (no spraying; NEG) and 1000-ppm of electrostatic spray of cherry extract rich in ascorbic acid (ES-ACE), electrostatic spray of rosemary and green tea extract rich in polyphenols (ES-RGT), and pressurized spray of ACE (PS-ACE), and 2 retail time points (0 and 5 d) was randomized within an animal, resulting in two steaks receiving a treatment × day combination within an animal. Five loins were randomly selected for chemical analyses (n = 10 per treatment × day combination). Meat antioxidants were extracted in methanol. The extracted antioxidants were reacted with ABTS+ radical cation (2,2′-azino-bis(3-ethylbenzthiazoline)-6-sulphonic acid diammonium salt) solution diluted to an absorbance of 0.85 to measure Trolox Equivalent Antioxidant Capacity (TEAC) at 734 nm. The extract was also reacted with Folin-Ciocalteu (FC) reagent to measure total phenolic compounds at 765 nm. Thiobarbituric acid reactive substances (TBARS) were extracted in 10% trichloroacetic acid and reacted with thiobarbituric acid and the resulted pigment was measured at 532 nm. Data were analyzed by the GLIMMIX procedure of SAS v9.4 and actual probability was reported.

RESULTS: On d 0, NEG steaks had less FC values than all treatment steaks (P < 0.001), of which the ES_ACE steaks had 14 and 100% more than PS_ACE and ES_RGT steaks, respectively (P ≤ 0.005). Only ES_ACE steaks had greater FC value than NEG steaks on d 5 (P < 0.001). As a result, TEAC value of ES_ACE steaks was 17 and 75% more than that of PS_ACE and ES_RGT steaks (P ≤ 0.005) and remained greater than that of NEG steaks on d 5 (P = 0.064). Greater antioxidant capacity in ES_ACE and PS_ACE steaks decreased lipid oxidation by 56% (0.9 µg MDA/kg less in ES_ACE steaks in contrast to the other treatments (P < 0.001).

CONCLUSION: Electrostatic spray of cherry extract rich in ascorbic acid was the most effective antioxidant application to prevent lipid oxidation in grass-finished beef strips steaks.

KEYWORDS: Electrostatic Spray, Natural Antioxidant
EFFECT OF ELECTROLYTE ADMINISTRATION ON CARCASS WEIGHT AND PH DECLINE OF AUSTRALIAN FEEDLOT LAMBS

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Objectives: This study was conducted to determine how the administration of electrolytes to Australian feedlot lambs would affect the carcass weight and pH decline.

Materials and Methods: Australian feedlot lambs (n=200) were weighed (LW = 59.0 ±2.7 kg) prior to the first administration of electrolyte and assigned randomly to 1 of 4 treatment groups (n = 50/group). Treatment groups consisted of no electrolyte (CON), a commercially available electrolyte (E1; Generade, Mount Barker, SA, 5251), an electrolyte formulated by a consulting nutritionist (E2), and experimental electrolyte formulation (E3). Electrolyte formulation was proprietary but contained the following ingredients: sodium bicarbonate, sodium chloride, potassium compounds, magnesium compounds, glucose and lysine. Electrolytes were delivered through the feed at specified dosage rates per treatment of 100ml/d (E1), 50 g/d (E2), and 17g/d (E3) for 4 days. The administration of E2 and E3 began after weighing and sorting on d 1; E3 was started on d 3 and was only fed for 2 days prior to slaughter. Half of each treatment group was assigned to 1 of 2 consecutive harvest days with equal representation among treatments. Individual live weights were recorded after 4 days and prior to transportation to the abattoir. Individual live weights were recorded upon arrival at the abattoir and again immediately before slaughter to determine transportation shrink and shrink during holding at the abattoir. Hot carcass weights were recorded. Longissimus pH was recorded when carcasses first entered the chiller following slaughter and were recorded again at 60 min and 120 min to monitor pH decline over the course of two hours. On the following day after chilling, cold carcass weights were recorded, and cooler shrink was calculated.

Results: Treatment influenced all live weights (P < 0.01). The use of electrolytes in comparison to the control had a significant impact on the four-day gain, as E3 lambs had greater gain than E1 or CON prior to transportation. All lambs administered an electrolyte maintained the live weight advantage over CON through pre-slaughter live weight collection; however, E2 and E3 were similar for transport shrink percentage, but were both greater (P < 0.05) when compared to E1 and CON, which were also similar. HCW, CCW, and cooler shrink percentage were not influenced by electrolyte treatment (P ≥ 0.25).

No interaction between treatment and time was detected for pH (P = 0.07), suggesting pH declined at similar rates; however, CON had greater (P< 0.05) pH values (6.00) than any of the electrolyte-treated lamb carcasses (5.79-5.89), regardless of time postmortem.

Conclusion: Results suggest the administration of the various electrolytes does create live weight differences between the treatments and especially apart from CON, as evidenced by the improved four-day gain and transportation shrink. Electrolytes, however, did not affect carcass weights. The intended usage for electrolytes should reduce stress, therefore resulting in a positive influence on meat quality by reducing the incidence of high pH and dark cutting. Although the administration of electrolytes did not affect the decline of pH, it did influence the ultimate pH value. The CON had greater final pH, indicating that the use of electrolytes on Australian feedlot lambs can benefit meat quality.

Keywords: Electrolyte, Lamb, pH
Meat and Poultry Quality
182- IMPACTS OF CHILLING DURATION ON MARBLING SCORE, SHRINKAGE, AND LEAN COLOR IN BEEF CARCASSES
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Objectives: This study was aimed to determine the effects of chilling duration on marbling score, shrinkage, and lean color of beef carcasses.

Materials and Methods: Ten beef carcasses of USDA Choice to Prime were selected at a commercial beef processing facility, randomly ribbed on either left or right side at 24 h, and evaluated repeatedly by a USDA grader at 24, 48, 72, and 96 h for quality grade, yield grade, and marbling score. Carcasses were hung in a cooler at 0 to 3 °C, 3.1 m/s of wind speed, and 153 lux of fluorescent light. Ribeye temperature was recorded on both ribbed and un-ribbed sides of a carcass. Marbling score was converted to a numerical scale (200 = Practically Devoid, 300 = Traces, 400 = Slight, 500 = Small, 600 = Modest, 700 = Moderate, 800 = Slightly Abundant, 900 = Moderately Abundant, 1000 = Abundant). Hot carcass weight and daily cold carcass weight were recorded to calculate shrinkage. Lean color (L*, a*, and b*), surface reflectance spectra (400 to 700 nm), and pH were recorded only at 72 and 96 h. Surface deoxymyoglobin, oxymyoglobin, and metmyoglobin percentages were calculated using the reflectance spectra according to AMSA guidelines. Statistical analysis was performed by the GLIMMIX and the PANEL procedures of SAS 9.4 (SAS Institute Inc., Cary, NC). Actual probability values were reported.

Results: At 24 h, in both ribbed and un-ribbed sides, ribeye temperature reached 2.7 to 3.3 °C after 24-h chilling and all carcasses were graded with marbling score ranging from 620 to 800 (mean = 710; standard deviation = 73). Compared with 24 h, marbling score did not change at 48 h (P = 0.443) but was increased by 10 points at 72 h (P = 0.023) and by 21 points at 96 h (P = 0.014). Carcass weight was increased by 0.6% by 48 h, 1.1% by 72 h, and 0.4% by 96 h (P ≤ 0.007) compared with 24 h; however, such an increase was caused by a malfunction of the spray-chill system, which continuously sprayed the carcasses for 96 h instead of intermittently for 24 h. The L* value (lightness) was increased from 40.2 to 43.4 (P = 0.014) and so were surface metmyoglobin and deoxymyoglobin by 1% from 72 to 96 h (P = 0.035 and 0.0121, respectively); however, such a small increase has no biological significance. The pH value remained constant at 5.6 from 72 to 96 h. The regression analysis by the PANEL procedure indicated that the marbling score in this dataset could be predicted by chilling time, as follow: marbling score = 740 + 0.3 × time (h) (R² = 0.98; P < 0.001 for both the intercept and slope).

Conclusion: The findings suggest that 96-h chilling increases marbling score of beef carcasses and such an increase (20 points) can potentially allow the carcasses borderline on a higher grade to be graded higher without negatively affecting shrinkage, lean color, and pH.

Keywords: beef, chilling duration, marbling score
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