# Meat Science and Muscle Biology: Fresh Meat Quality of Ruminants, Nonruminants and Poultry

**T164   Brazilian commercial cuts yield of crossbred beef bulls slaughtered at different body masses.**   R. Mello*[1], A. C. de Queiroz[2], F. D. de Resende[3], M. H. de Faria[3], P. V. R. Paulino[2], and G. R. Siqueira[3], [1]*Universidade Federal de Santa Maria*, *Santa Maria, RS, Brazil*, [2]*Universidade Federal de Viçosa*, *Viçosa, MG, Brazil*, [3]*Agência Paulista de Tecnologia dos Agronegócios*, *Colina, SP, Brazil*.

The aim of the present experiment was to study the effects of genetic groups and slaughter end points on commercial meat cuts yield. Thirty-six young (20 mo) bulls, 18 crossbred F1 Red Angus × Nellore (1/2 RA 1/2 N) and 18 F1 Blonde D'Aquitaine × Nellore (1/2 BA 1/2 N) were used. The young bulls were feedlot finished and slaughtered at 480, 520 and 560 kg of shrunk body weight (SBW). A completely randomized experimental design of a 2 × 3 (2 genetic groups × 3 slaughter weights) factorial arrangement with 6 replicates was used. The pistola from right side of each carcass was dissected into crude and trimmed cuts and trimmed fat for predicted commercial cuts yield. Data were analyzed with SAS software using initial SBW as a covariate. The table below shows the least squares means of dependent variables. The 1/2 BA 1/2 N young bulls had a higher relative yield (% of pistola) of trimmed top sirloin butt than 1/2 RA 1/2 N young bulls. As the slaughter weight increased, the crude loin and top sirloin cap, and trimmed cube roll, strip loin, and top sirloin cap increased; however the trimmed fat from loin and top sirloin butt increased also. Besides, the interaction between GG and SW was significant ($P > 0.05$) for trimmed fat from tenderloin (data not shown), where the 1/2 BA 1/2 N had increase of trimmed as the slaughter weight increased, while the 1/2 RA 1/2 N outcome was virtually unchanged. Thereby, crossbred F1 Blonde D'Aquitaine × Nellore young bulls and heavier animals produced more saleable meat than F1 Red Angus × Nellore and lighter animals.

Table 1. Least squares means

|  | Genetic Group (GG) | | Slaughter Weight (SW) | | |
| --- | --- | --- | --- | --- | --- |
|  | ½ RA ½ N | ½ BA ½ N | 480 | 520 | 560 |
| **Crude cuts** |  |  |  |  |  |
| Loin | 13.5 | 13.4 | 12.1[b] | 14.2[a] | 14.0[a] |
| Top sirloin cap | 2.5 | 2.5 | 2.1[b] | 2.7[a] | 2.6[a] |
| **Trimmed cuts** |  |  |  |  |  |
| Cube roll | 3.7 | 3.6 | 3.2[b] | 3.5[b] | 4.1[a] |
| Strip loin | 6.7 | 6.8 | 6.2[b] | 7.3[a] | 6.6[b] |
| Top sirloin butt | 4.7[B] | 4.8[A] | 4.8 | 4.7 | 4.7 |
| Top sirloin cap | 1.8 | 1.9 | 1.6[b] | 2.1[a] | 2.0[a] |
| **Trimmed fat** |  |  |  |  |  |
| Loin | 3.1 | 3.1 | 2.6[b] | 3.4[a] | 3.3[a] |
| Top sirloin butt | 1.4 | 1.4 | 1.2[b] | 1.5[a] | 1.5[a] |

Within a row, means followed by different capital and small letters differ ($P < 0.05$), respectively, among GG and SW by Tukey test.

**Key Words:** boneless cuts, breeds, saleable meat

**T165   Brazilian primal cuts yield of crossbreed beef cattle slaughtered at different end points.**   R. Mello*[1], F. D. de Resende[2], A. C. de Queiroz[3], M. H. de Faria[2], F. Maldonado[2], and G. R. Siqueira[2], [1]*Universidade Federal de Santa Maria*, *Santa Maria, RS, Brazil*, [2]*Agência Paulista de Tecnologia dos Agronegócios*, *Colina, SP, Brazil*, [3]*Universidade Federal de Viçosa*, *Viçosa, MG, Brazil*.

The objective in this trial was to assess the basic cuts yield of finished crossbred feedlot beef bulls and slaughtered at different body masses. Thirty 6 young (20 mo) bulls, 18 crossbred F1 Red Angus × Nellore (1/2 RA 1/2 N) and 18 F1 Blonde D'Aquitaine × Nellore (1/2 BA 1/2 N) were used. The young bulls were finished on feedlot and slaughtered at 480, 520 and 560 kg of shrunk body weight (SBW). A completely randomized experimental design in a 2 × 3 (2 genetic groups × 3 slaughter weights) factorial arrangement with 6 replicates was used. Primal cuts were predicted for each carcass using separation (forequarter, thin flank, pistola) on the right side of the carcass. Data were analyzed with SAS software using initial SBW as a covariate. The table below shows the least squares means of Brazilian primal cuts yield. Cuts yield ranged on average from 40.9 to 42.5% of forequarter, 11.2 to 11.9% of thin flank and 45.7 to 47.8% of pistola. There were no effect ($P > 0.05$) of genetic group (GG), slaughter weight (SW) and its interaction (GG × SW) on relative yield (%) of the primal cuts. Thus, finishing of crossbred F1 Blonde D'Aquitaine or Red Angus versus Nellore young bulls on feedlot and slaughter at 480, 520 and 560 kg produced carcasses with the same primal cuts yield.

Table 1. Least squares means

|  | Genetic Group (GG) | | Slaughter Weight (SW) | | |
| --- | --- | --- | --- | --- | --- |
|  | ½ RA ½ N | ½ BA ½ N | 480 | 520 | 560 |
| Forequarter, % | 41.7 | 41.1 | 41.3 | 40.9 | 42.0 |
| Thin flank, % | 11.7 | 11.5 | 11.4 | 11.6 | 11.8 |
| Pistola, % | 46.6 | 47.4 | 47.3 | 47.5 | 46.2 |

**Key Words:** bone-in cuts, feedlot, young bulls

**T166   Portions of high value cuts in carcasses of different beef cattle in the Czech Republic.**   J. Riha*[1], J. Bezdicek[1], M. Homola[2], E. Vacatko[2], and J. Subrt[3], [1]*Agrovyzkum Rapotin Ltd.*, *Vikyrovice, Czech Republic*, [2]*Research Institute for Cattle Breeding, Ltd.*, *Vikyrovice, Czech Republic*, [3]*Mendel University in Brno*, *Brno, Czech Republic*.

The aim of this study was to assess the effect of breed on highly valued parts of carcasses. The study was carried out with 45 Blonde d'Aquitaine, 40 Piemontese, 48 Hereford and 52 Galloway bulls. After slaughter, the following cuts were evaluated: round, strip loin, tender loin and shoulder blade (boneless). The age of slaughtered animals, and their corresponding BW ranged from 312 to 699 d and 395.2 to 811.9 kg, respectively. Highly valued meat was weighed (in kg) and presented in percent of carcass halfbodies (HC). General regression models (GRM) design with breed as fixed categorical and slaughter age and BW as fixed continuous effects were used for statistical analysis. Coefficients of determination calculated for each model ranged from 0.173 (strip loin) to 0.587 (tender loin). According to the model, round percentage was reduced (*$P < 0.05$; **$P < 0.001$) in the following ascending order: Piemontese (22.82%) > Blonde d'Aquitaine (20.85%) > **Hereford (17.64%) > Galloway (16.85%). For strip loin, tender loin and boneless shoulder blade the order was Blonde d'Aquitaine (4.41%) > Piemontese (4.36%) > Galloway (4.08%) > *Hereford (3.58%); Piemontese (1.83%) > Blonde d'Aquitaine (1.69%) > **Galloway (1.32%) > **Hereford (1.71%) and Piemontese (8.59%) > Blonde d'Aquitaine (8.01%) > *Galloway (7.38%) > **Hereford (6.51%), respectively. The highest percentage of cut with regard to weight and age of bulls was found for Piemontese bulls. From this screening study, it is evident that Piemontese and Blond d'Aquitaine bulls (which however have also more subtle

constitution) have a higher portion of valued cuts than extensively kept ones (Hereford and Galloway) with regard to model correction of weight and age. Selected designed models (e.g., for tender loin) seem to be suitable for prediction of high value cuts portion with usage of the described effects.

**Key Words:** beef cattle, high value cuts, prediction of cutting parts using GRM

**T167    Predicting retail product yield of Nellore bulls using live animal measurements.**    S. L. Silva*[1,3], R. C. Gomes[1], J. U. Tarouco[2], M. N. Bonin[1], P. R. Leme[1], and J. B. S. Ferraz[1], [1]*Universidade de Sao Paulo (FZEA), Pirassununga, SP, Brazil*, [2]*Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil*, [3]*FAPESP, Sao Paulo, SP, Brazil*.

Information regarding retail product yield (RPY) for beef cattle is of great importance for genetic evaluation programs based on carcass merit. Equations using carcass or live animal measurements to predict RPY have been developed mainly based on steers data with little information about its use for young bulls that are mostly used in genetic evaluation programs. Therefore, the aim of this work was to evaluate the accuracy of RPY estimates in young Nellore bulls obtained by using an equation originally developed in our laboratory based on data of Nellore steers. Thirty-eight Nellore young bulls (23 mo old) finished in feedlot (485 ± 37kg of shrunk body weight (SBW) at slaughter) were ultrasound scanned for 12th-rib Longissimus muscle area (ULMA) and backfat thickness (UBFT), and rump fat (URF) determinations, within 3–5 d prior slaughter. The left side of each carcass was deboned into retail cuts according to Brazilian standards, with the excess of fat trimmed to approximately 5 mm. Predicted retail product weight (RPW, kg = $-36.28367 + 0.36485*SBW - 0.74324*ULMA$; $R^2 = 0.93$; SEP = 7.36) and percentage (RPP, % = $70.38312 - 0.00716*SBW + 0.07257*ULMA - 0.10939*UBFT - 0.15077*URF$; $R^2 = 0.34$; SEP = 1.24) were calculated and compared with actual RPW and RPP. The averages of actual and predicted RPW and RPP averaged 196.6kg and 192.4kg, and 71.7% and 70.8%, respectively. Prediction equations underestimated both RPW (bias = $-4.2$kg) and RPP (bias = $-0.91$%). Coefficients of determination between predicted and observed RPW and RPP were 0.77 and 0.44, respectively. These results suggest that prediction equations developed from steers can be used with similar accuracy to predict RPY in Nellore bulls. Further studies including a greater number of RPY data in young bulls are necessary to verify the accuracy of these models and their usefulness for use in genetic evaluation programs.

**Key Words:** beef, ultrasound, zebu

**T168   Mixed model analysis of non-linearity between cooking loss and aging time plus other effects.**   A. Dufek*[1], J. Subrt[2], J. Simeonovova[2], and M. Homola[3], [1]*Research Institute for Cattle Breeding, Ltd., Vikyrovice, Czech Republic*, [2]*Mendel University in Brno, Brno, Czech Republic*, [3]*Agriresearch Rapotin Ltd., Vikyrovice, Czech Republic*.

We used the package nlme in the R software for description and statistical analysis of non-linear relationship between cooking loss and aging time. The relationship was described by the asymptotic regression model "cooking loss = Asym+(R0-Asym) exp[-exp(lrc)Time]" with 3 physically meaningful parameters: R0 = the response at slaughter time, lrc = logarithm of the rate constant and Asym = a response that approaches a horizontal asymptote. After the basic model was formed, we put random effects into the model at nested levels: i) subject (animal), ii) subjects within sires and iii) sires within years. Age, fattening system (extensive vs. intensive), length of hind quarter, weight of carcass, ratio

between length of fore and hind quarter, weight proportion of the LM in the carcass and status (bulls, steers) were put into the model as fixed effects. We selected the effects to test the hypotheses from the aspects of beef production and anatomy since the LM is of high value as well as important for constitution. The LM was divided into 4 samples and individually vacuum packed. One of the samples was analyzed 48 h post-mortem. The other 3 samples were stored at 2–4°C for 16, 30 and 44 d. Cooking loss was determined by weighing the samples before and directly after cooking in a water bath at 70°C for 1 h. Percentage of cooking loss was calculated. Values of the parameters for the basic model including all animals (n = 46) were R0 = 25.33%, lrc = −2.38, Asym = 34.12%. The random effects analyses showed that only the subject affected the Asym and R0 significantly (tested with AIC). Analyses of fixed effects produced following results: higher values for age resulted in higher Asym ($F = 15.15$, $P = 0.0002$) and R0 ($F = 3.59$, $P = 0.06$). Higher values for length of hind quarter resulted in lower Asym ($F = 5.83$, $P = 0.017$). The Asym of extensively fattened animals was 3.88% higher ($F = 5.05$, $P = 0.026$) and the R0 −1.21% lower than for intensively fattened animals. Steers had −2.57% lower Asym than bulls ($F = 3.99$, $P = 0.047$). The results revealed that fattening system, age and length of animals significantly affect cooking loss in aged beef.

**Key Words:** mixed, non-linear, beef

**T169    Epinephrine-induced MMP expression in muscle cells is uncorrelated with AMPK signaling.**   M. C. Cha and P. P. Purslow*, *University of Guelph, Guelph, Ontario, Canada*.

Acute stress at or around the point of slaughter is known to impact on post-mortem development of pH and subsequent meat quality. One signaling pathway involved in the stress response is AMP-activated protein kinase (AMPK), which regulates energy metabolism in muscle and post-mortem glycolysis. Elevated levels of epinephrine (adrenaline) in the circulation are also known to increase matrix metalloproteinase (MMP) expression in muscle. MMPs are proteases (MMPs) that control the degradation of connective tissue. Post-mortem degradation of intramuscluar connective tissue by MMPs could affect sub sequent meat toughness. Using a cell culture model, we have therefore investigated: (1) whether epinephrine increases the expression of MMPs from muscle cells and fibroblasts isolated from muscle, and (2) any relationship changing MMP expression may have to AMPK signaling. Mouse skeletal fibroblasts (NOR-10) and myoblasts (C2C12) in plate culture with DMEM medium were treated with or without 11 nmol/L or 55nmol/L doses of epinephrine for 2 or 6 hours. The intracellular and secreted expression of MMPs was determined by zymography and AMPK expression was examined by immune blotting. Intracellular MMP-3 expression was increased in muscle cells by both the high and low doses of epinephrine at longer (6 hour) treatment times. Intracellular MMP-2 and MMP-13 expression were also amplified by the lower dose, longer time epinephrine treatment in the myoblasts. AMPK expression was elevated only at the shorter treatment time at both epinephrine dose levels and in both cell lines. At the higher epinephrine dose level only and at short incubation times, fibroblasts also show transient expressions of MMP-2 and −13.
The time-course of MMP expression from muscle cells is not well correlated to the time-course of AMPK activity. Fibroblasts respond only to the higher level of epinephrine and on a much shorter timescale, better correlated to AMPK activity.

**Key Words:** muscle, proteolysis, collagen

**T170  Measurement of purge protein composition as an indicator of beef tenderness.**  B. C. Bowker*, J. S. Eastridge, and E. W. Paroczay, *USDA-ARS, Beltsville, MD*.

The objective of this study is to determine if the protein composition of the purge moisture collected from vacuum-packaged beef can be used as a potential indicator of meat tenderness. Frozen beef striploins (n = 12) were each divided into 3 sections which were thawed, vacuum packaged, and aged at refrigerated temperatures. After 0, 7, and 14 d of aging, purge moisture was collected from the vacuum packages and analyzed for protein content using a biuret assay and protein composition using SDS-PAGE. Steaks were also removed at 0, 7, and 14 d of aging for Warner-Bratzler shear force (WBS) determination. With aging from 0 to 14 d, WBS decreased ($P < 0.0001$) from 5.8 to 3.4 kg shear force. Purge losses at d 7 and 14 were 5.8% and 8.4%, respectively. The amount of purge loss between 0 and 14 d was significantly correlated (r = −0.3707) to the decrease in WBS from d 0 to 14. The protein content of the purge moisture collected after 0, 7, and 14 d was similar, however, the protein composition of the purge changed with aging. SDS-PAGE analysis of collected purge samples demonstrated that 10 protein bands increased ($P < 0.05$) in relative abundance with aging and 4 protein bands decreased ($P < 0.01$) with aging. The relative abundance of 5 protein bands, ranging from 65 to > 250 kDa, were negatively correlated to WBS (r = −0.5072 to −0.6759). The relative abundance of the 45 and 38 kDa protein bands were positively correlated to WBS (r = 0.5700 and 0.6215, respectively). Furthermore, the relative abundance of the 45 kDa protein band measured in the purge moisture collected at d 0 was significantly correlated to WBS at d 14 (r = 0.7692). While these data do not indicate a cause and effect relationship between sarcoplasmic proteins and tenderness, the data suggest that purge protein composition may be an indirect indicator of WBS and that the water-soluble protein fraction of beef muscle may be useful in the development of rapid, non-invasive methodologies for predicting beef tenderness.

**Key Words:** beef tenderness, purge, protein composition

**T171    Effect of oxidative stress on collagen turnover by bovine intramuscular fibroblasts.**  A. C. Archile*[2,1], S. P. Miller[1], I. B. Mandell[1], M. C. Cha[1], and P. P. Purslow[1], [1]*University of Guelph, Ontario, Canada*, [2]*University of Zulia, Maracaibo, Venezuela*.

Intramuscular collagen is responsible for the background toughness in cattle. Vitamins E and C may increase collagen turnover, but handling of cattle may reduce vitamin concentrations in muscles, impeding the removal of reactive oxygen species (ROS) and leading to what is known as oxidative stress. Fibroblasts synthesize collagen and regulate its turnover by the production of matrix metalloproteinases (MMPs) responsible for collagen degradation. The aim of this work was to study the effect of oxidative stress on the ability of intramuscular fibroblasts to turnover old collagen and synthesize new collagen. Fibroblasts were isolated from *longissimus dorsi* (LD) and *semitendinosus* (ST) muscles from a yearling animal and grown in DMEM, 10% serum, 5% $CO_2$. Fibroblasts were treated for 24 h with 1) 0.1 or 0.01 mU/mL xanthine oxidase /500 $\mu M$ xanthine (X/XO), and 2) 0.5 or 5 $\mu M$ of hydrogen peroxide ($H_2O_2$). Control group cells received no treatment. MMP-2 activity secreted into the media was analyzed by gelatin zymography. Total collagen synthesis (TC) in cell lysates was measured using the collagen Sircol assay. Analysis included 2-way ANOVA, Fisher's LSD and Pearson bivariate correlation. There was a different pattern in the response of fibroblasts from the 2 muscles to ROS. Concentrations of 0.01 mU/mL X/XO and 5 $\mu M$ $H_2O_2$ induced ($P < 0.05$) the activation of MMP-2 in LD cells, while for ST cells no effect was observed for any treatment. No effect was observed in the inactive Pro-MMP-2 precursor

levels for any muscle and treatment. In general, ROS slightly lowered TC, more so in LD-derived cells than in ST cells. No relation ($P > 0.05$) between Pro-MMP-2 and TC was found for cells from either muscle, while for LD cells, MMP-2 activity showed a negative correlation ($P < 0.05$) with respect to TC. Oxidative stress may decrease net collagen turnover in intramuscular fibroblasts and this could lead to decreased collagen solubility in some muscles. Thus, oxidative stress is an environmental/dietary factor that might affect meat quality.

**Key Words:** oxidative stress, collagen turnover, meat quality

**T172  Phenotypic differences in MMP activity between fibroblasts from three beef muscles.**    A. C. Archile*[2,1], M. C. Cha[1], and P. P. Purslow[1], [1]*University of Guelph, Ontario, Canada*, [2]*University of Zulia, Maracaibo, Venezuela*.

It has been found that muscles from the same beef carcass may respond differently to the same stimulus. This might cause difficulties when looking for a production system to render meat tender. The aim of this work was to study phenotypic differences in the expression of matrix metalloproteinases (MMP) among intramuscular fibroblasts from 3 beef skeletal muscles. To our knowledge intramuscular fibroblasts from beef animals have not previously been characterized. Fibroblasts were isolated from *longissimus dorsi* (LD), *semitendinosus* (ST) and *sternomandibularis* (SMD) muscles from a yearling animal and grown in DMEM + 10% FCS. All cultures were serially sub-cultured and cell behavior studied from passages 1 to 15. Cell lifespan and doubling times were evaluated for each cell line. After reaching 80% confluence, cells were supplied with fresh DMEM for 24 h. Then, media were collected and analyzed for MMP-2 activity by zymography. Data were analyzed by 2-way ANOVA and Fisher's LSD. At all passages, LD-derived cells had the largest ($P < 0.0001$) doubling time in comparison to SMD and ST; cells from these last 2 muscles also differed significantly ($P < 0.001$). Cultures derived from ST displayed longer ($P < 0.05$) lifespan compared with cells from the other muscles. Cells from ST presented higher ($P < 0.0001$) levels of active MMP-2 in comparison to LD and SDM, which were also different ($P < 0.0001$) from each other. No statistical differences ($P > 0.05$) in pro-MMP-2 expression were found between any cell lines; however, the total expression of this enzyme was higher for ST. These results suggest that fibroblasts from different locations are phenotypically different and so may respond differently to the same growth or nutrition stimulus in vivo, causing differences in accumulation and maturity of collagen, and hence its degree of turnover, which may affect meat tenderness. These findings are of significance when selecting a strategy for improving meat tenderness by manipulation of animal growth, as a strategy applied to the whole animal may work for some muscles but not for others.

**Key Words:** fibroblast heterogeneity, collagen turnover, matrix metalloproteinases

**T173  Myofibril fragmentation index of the longissimus muscle of Senepol and Charolais crossbred bulls.**   L. del Valle-Mercado*, A. Casas, D. Cianzio, M. Pagan, and G. Ortiz-Colón, *University of Puerto Rico, Mayaguez, Puerto Rico, United States*.

The objective of this experiment was to determine whether there was a difference in the Myofibril Fragmentation Index (MFI) of longissimus muscle (LM) samples obtained from Senepol (n = 12) and Charolais (n = 14) crossbred bulls. Calves were weaned at 9 mo (266.5 kg) and then raised under grazing conditions until harvest at 22 mo (499.6 kg). From each bull 2 LM subsamples were cut in 1 cm $^2$ pieces and homogenized using a Polytron PT1600E homogenizer (30,000 rpm) in cold (4°C)

homogenizing buffer (100 m$M$ KCl; 7 m$M$ KH$_2$ PO$_4$; 18 m$M$ K$_2$ HPO$_4$; 1 m$M$ EDTA; 1 m$M$ NaN$_3$ [pH 7.0]). The Biuret reagent assay was use to determine LM homogenates protein concentrations. All muscle homogenates were diluted to a constant protein concentration of 0.5 mg/mL of homogenization buffer. Subsequently, the absorbance of each LM homogenate was determined at a specified wavelength of 540 nm (Thermo Spectronic Genesys). Absorbance results were multiplied by 200 to determine MFI values. The obtained MFI values were different among crossbreds ($P = 0.012$). Senepol crossbred bulls showed MFI values of 43.89 (SE 4.52) while Charolais crossbred bulls showed MFI values of 30.09 (SE 2.77). Because previous studies have associated higher MFI values with more tender meat, our data suggests that Senepol crossbred bulls might have more tender meat than Charolais crossbred bulls.

**Key Words:** beef tenderness, MFI, Senepol

**T174    Effect of brine enhancement and mechanical tenderization on consumer sensory characteristics of cow semimembranosus steaks.**    J. M. Popowski*, R. B. Cox, T. J. McNamara, and P. Nelson, *University of Minnesota, Twin Cities*, *St. Paul*.

The purpose of this research was to evaluate the effect of brine enhancement by means of mechanical tenderization on an underutilized cut from the dairy cow carcass. Additionally considered was a comparison of enhanced and tenderized dairy cow beef to traditional fed beef. Beef was evaluated from both dairy cull (CUL) carcasses and fed (FED) beef carcasses. Processing treatments included a control (CON) and a brine enhancement by means of mechanical tenderization (BRN) of the semimembranosus muscle. Beef semimembranosus from both CUL and FED beef carcasses were obtained from the University of Minnesota Meat Laboratory and cut into roasts (60 roasts, 5 per each of 3 replications, approximately 1kg each). FED and CUL roasts were then randomly assigned to CON and BRN treatments. BRN roasts were placed in a commercial meat tumbler with 15% (w/w) brine (water and sodium tripolyphosphate) to create an enhanced roast with a phosphate level of 0.2%. Roasts and brine were tumbled for 30 min. BRN and CON roasts were then individually vacuum packaged and allowed to equilibrate at 4°C for 24 h before being cut into steaks (2.54 cm thick), individually vacuum packed, and frozen (−20°C) until further use. Steaks were thawed at 4°C for 36 h and cooked in an electric oven (180°C) to an internal temperature of 71°C. Each cooked steak was then cut into cubes (1cm −1cm − 1 cm). Sensory evaluation was carried out by an untrained consumer panel. One–hundred–12 consumers rated overall liking, flavor liking, texture liking, off-flavor, juiciness, and toughness of sample from all treatments and replications. BRN scores were higher than CON for overall liking ($P < 0.001$), flavor liking ($P = 0.002$), and texture liking ($P < 0.001$) for CUL steaks, but not FED. BRN scores were lower than CON for juiciness ($P = 0.001$) and off-flavor intensity ($P = 0.01$) in CUL steaks, but not FED. Overall liking ($P < 0.001$) and texture ($P < 0.001$) scores were higher for FED steaks compared with CUL. Results indicate there may be potential to market whole-muscle products from the cow round with mechanical tenderization and enhancement.

**Key Words:** beef, cull, enhancement

**T175    Fatty acid composition including *cis*-9, *trans*-11 CLA of cooked ground lamb.**    G. Davila-El Rassi*[1], V. Banskalieva[1], and M. Brown[2], [1]*R. M. Kerr Food and Agricultural Products Center, Oklahoma State University*, *Stillwater,* [2]*USDA-ARS, Grazinglands Research Laboratory*, *El Reno, OK*.

Little information is available on effect of cooking on health-promoting fatty acids (FA) such as *cis*-9, *trans*-11 conjugated linoleic acid (CLA) and ω-3 polyunsaturated fatty acids (PUFA). The objective of this study was to examine the impact of broiling per se on the FA composition of ground lamb of 2 different muscles with special emphasis on CLA. Samples were prepared from trimmed, ground steaks of m. *Longissimus lumborum* (LL) and m. *Semimembranosus* (SM) from forage-fed Suffolk × Katahdin lambs. Patties were broiled in a conventional oven, at 205°C, for 6.15 min on each side to internal temperature of 71°C. Raw and cooked patties were subjected to proximate and FA analyses. Data were analyzed by mixed model procedures with linear models including fixed effects of treatment (raw vs. cooked, subunit), muscle type (sub-subunit) and treatment by muscle type. After broiling fat content increased from 2.83 to 4.98% ($P < 0.001$), and from 3.89 to 6.04% ($P < 0.001$), respectively for SM and LL patties, whereas no changes in levels of total saturated, monounsaturated and polyunsaturated FA were observed for either muscle type. No treatment differences were found in percent CLA (0.53–0.58%, raw vs. cooked) or CLA as mg/g fat in SM (6.45–6.72, raw vs. cooked) and in LL (6.2–5.9, raw vs. cooked) patties. However, content of CLA as mg/100 g of cooked lamb increased from 18.1 (raw) to 33.2 ($P < 0.01$) and from 24.05 (raw) to 35.8 ($P < 0.001$), respectively for SM and LL patties. Average over muscles, a trend ($P < 0.1$) for lower proportion of vaccenic acid in cooked (1.64%) vs. raw meat (2.15%) was observed. The ratio ω-6 PUFA/ω-3 PUFA slightly increased from 5.7 (raw) to 6.0 (cooked) ($P < 0.01$) and from 5.8 (raw) to 6.1 (cooked) ($P < 0.01$), respectively for SM and LL patties. Results imply that broiling did not cause thermal degradation of CLA levels and that a serving portion (100g) of cooked lamb provides over 34 mg of CLA. Despite the small changes of ω-6 PUFA/ω-3 PUFA ratio broiling could be considered as a method preserving the nutritional value of lamb.

**Key Words:** lamb, cooking, fatty acids

**T176    Effects of maternal metabolizable protein supplementation during late gestation on ovine fetal muscle calpain and calpastatin activities.**    J. D. Magolski*[1], W. L. Keller[1], T. M. Jeske[1], C. A. Schwartz[1], L. A. Lekatz[1], J. D. Kirsch[1], C. S. Schauer[2], K. A. Vonnahme[1], and K. R. Maddock-Carlin[1], [1]*North Dakota State University*, *Fargo*, [2]*Hettinger Research Experiment Center, Hettinger, ND*.

To investigate the effects of maternal supplementation of MP during late gestation on calpain and calpastatin activities in fetal muscle, multiparous ewes (n = 30) were randomized to receive 75% (LOW), 100% (CON), or 125% (HIGH) of MP requirements from d 100 until d 130 of gestation. On d 130, ewes were slaughtered, and fetuses were necropsied. Longissimus thoracis (LT) and semimembranosus (SM) were collected (20 g) and analyzed for calpastatin activity by casein assay and calpain activity by casein zymograms. μ-Calpain autolysis was evaluated by Western blotting. Ewes carried singletons and twins; however, only singletons were analyzed. Calpastatin activity did not differ ($P \geq 0.21$) among treatments. Casein zymograms showed no treatment differences ($P \geq 0.80$) for μ-calpain or m-calpain activities. Autolysis of μ-calpain in the SM was greater in the HIGH group compared with that in the CON group as indicated by smaller percentage of the ($P = 0.01$) 80 kDa band. Calpastatin activity and specific activity were greater ($P < 0.01$) in the LT (4.02 units/mL ± 0.10; 58.48 units/mg ± 1.51) than in the SM (3.31 units/mL ± 0.10; 47.07 units/mg ± 1.51). Additionally, autolysis was occurring at a greater ($P < 0.01$) extent in the SM than in the LT as indicated by the disappearance of the 80 kDa band (21.72 vs. 27.51 ± 1.84) and the accumulation of the 76 kDa autolysis product (46.27 vs. 39.77 ± 1.66). Therefore, maternal supplementation of MP

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during late gestation did not affect calpastatin activities in fetal skeletal muscle, but increased μ-calpain autolysis in HIGH compared with CON may indicate differences in protein accretion. However, there were differences in calpain and calpastatin activities between muscles during late gestation with the LT having greater calpastatin activity and less μ-calpain autolysis, possibly indicating a difference in rate of protein accretion between muscles.

**Key Words:** fetal muscle, metabolizable protein, calpain

**T177    Hyperplastic muscle growth occurs from birth to weaning in pigs.**    J. M. R. López[1], C. Pardo[2], and G. Bee*[2], [1]*Unidad de nutrición animal, Estación Experimental del Zaidín (CSIC), Granada, Spain*, [2]*Agroscope Liebefeld Posieux, Research station ALP, Posieux, Switzerland*.

Pig myogenesis is a biphasic phenomenon with the sequential formation of 2 generations of fibers termed primary (P) and secondary (S) fibers. Currently, it is believed that total number of fibers (TNF) is fixed at birth. However, there are indications that at birth between P and S fibers very-small diameter fibers containing embryonic and fetal myosin heavy chain isoforms exist. They represent a different population of myotubes, designated tertiary myotubes and might contribute to hyperplastic growth after birth. The goal of this study was to establish if TNF remains constant from birth to weaning. For the trial 8 pairs of Swiss Large White female littermates with a similar birth weight (1.41 ± 0.113 kg; $P = 0.82$) were used. One piglet of each pair was sacrificed either at birth or at weaning at d 28 of age (BW: 6.93 ± 0.527 kg). Subsequently, internal organs and the semitendinosus (ST) muscles were collected and weighed. Histological analyses were performed on the ST using the mATPase staining procedure after pre-incubation at pH 10.2. This allowed identifying the muscle cross-sectional area, TNF, number of P and S fibers and the S/P ratio of the dark (STD) and the TNF of the light (STL) portion of the ST. Relative to slaughter weight, the spleen and ST were 90 and 26% heavier ($P < 0.01$), respectively, whereas lungs, liver, heart and kidneys were 17, 16, 30 and 24% lighter ($P < 0.06$) at weaning than at birth. From birth to d 28 of age TNF increased in the STD (151020 vs. 235191; $P < 0.01$) but not in the STL (395497 vs. 405836; $P = 0.83$). The increase resulted from both a greater number of P (4597 vs. 6605; $P < 0.01$) and S fibers (146423 vs. 228586; $P < 0.01$) with no changes in the S/P ratio (32 vs. 35; $P = 0.25$). Overall the TNF of the ST was only numerically greater (546517 vs. 641028; $P = 013$) in weaned than newborn piglets. This preliminary data suggest that the TNF of parts of muscles are not fixed at birth. Further studies needs to determine whether the potential of an increase in TNF can be already observed in the muscles of new born pigs and whether the development of these fibers can be stimulated during postnatal growth.

**Key Words:** muscle development, semitendinosus, pigs

**T178    Relationship between average litter weight and intralitter weight variability on myogenesis in newborn piglets.**    C. Pardo[1,2], M. Kreuzer[2], and G. Bee*[1], [1]*Agroscope Liebefeld Posieux, Posieux, Switzerland*, [2]*ETH Zurich, Institute of Plant, Animal and Agroecosystem Sciences (IPAS), Zurich, Switzerland*.

A high variability in total litter birth weight (BtW) has been reported in common litter sizes (10–15 piglets). Limitations in uterine efficiency may affect the development not only of low BtW piglets but also that of the entire litter. The aim of this study was to elucidate the relationship between average litter BtW and intra-litter variability on semitendinosus (ST) development in newborn piglets and postnatal growth from birth to weaning. From multiparous sows, 7 litters with a high (H: > 1.7 kg)

and 7 litters with a low (L: < 1.3 kg) average litter BtW were selected. At farrowing 2 females/litter were sacrificed: from H-sows those with the medium (HM) and lowest (HL) BtW and from the L-sows those with the medium (LM) and highest (LH) BtW. The mATPase staining after pre-incubation at pH 4.3 or 10.2 was used to identify muscle cross-sectional area (CSA), total number of fibers (TNF), number of primary and secondary fibers of the dark and light (STL) portion of the ST. ADG during lactation and BW at weaning of the remaining piglets were determined for each gender. Data were analyzed with PROC MIXED using BtW groups as fixed factor. Three contrasts were established: HM vs. LM and LH, respectively, and HL vs. LH. For H- and L-sows the realized average litter weight/piglet was 1.74 and 1.23 kg (13.3 and 14.8 piglets/litter, respectively). Compared with H-sows, female piglets from L-sows grew slower (236 vs. 293 g/d; $P < 0.01$) and were lighter at weaning (8.54 vs. 10.34 kg; $P < 0.04$). At birth HM-piglets were heavier than LM- and LH-piglets (1.73 vs. 1.27 and 1.57 kg; $P < 0.07$) whereas BtW was similar in HL- and LH-progeny (1.42 vs. 1.57 kg; $P < 0.15$). The STL and by that the ST from HM piglets was larger (CSA: STL = 58 vs. 44 mm²; ST = 85 vs. 67 mm²; $P \leq 0.05$) and tended to have more TNF (STL = 380 vs. 308 × 10³; ST = 540 vs. 467 × 10³; $P < 0.10$) than LM-piglets. In conclusion, low gestation efficiency resulting in a lower total litter weight not only affects the development of low but also of medium BtW offspring. Interestingly, female but not male progeny from L-sows grew slower during lactation than those from H-sows.

**Key Words:** birth weight variation, myogenesis, litter weight

**T179    Influence of genotype and slaughter weight on carcass and meat quality of Iberian pigs.**    M. Sánchez*[1], J. Viguera[1], M. I. Gracia[1], J. Peinado[1], A. Robina[2], and J. Ruiz[2], [1]*Imasde Agroalimentaria S.L., Madrid, Spain*, [2]*Universidad de Extremadura, Cáceres, Spain*.

A total of 48 pigs (50% castrated males and 50% castrated females) were used to evaluate 2 different genotypes: Duroc1 × Iberian (DR1×IBE) and Duroc2 × Iberian (DR2×IBE) and 2 slaughter weights: 145 and 155 kg BW on carcass traits, composition and color of meat, and fatty acid profile of subcutaneous fat. Data were analyzed as a completely randomized design using PROC GLM of SAS. The model included the terminal sire genotype and slaughter weight as main effects. DR1×IBE pigs showed higher backfat thickness than DR2×IBE pigs (52.7 vs. 46.3 mm; $P < 0.05$). However, no ($P > 0.05$) differences between genotypes were found for carcass, ham, shoulder and loin yields, in the composition or the color of meat and the fatty acid profile of the subcutaneous fat. As expected, pigs slaughtered at 155 kg BW had greater backfat thickness (53.7 vs. 45.3 mm; $P < 0.01$) and carcass yield (81.52 vs. 79.80%; $P < 0.01$), but lower ham and shoulder yields (17.95 vs. 19.16% and 11.64 vs. 12.37%, respectively; $P < 0.01$) than pigs slaughtered at 145 kg BW. Loins from heavier pigs tended to have higher redness value (10.05 vs. 9.26; $P = 0.07$) than lighter pigs, but no differences were observed in lightness and yellowness of loin. Finally, the increase in slaughter weight decreased the level of saturated fatty acids (33.78 vs. 32.14%; $P < 0.01$) and increased that of the monounsaturated fatty acids (54.29 vs. 55.68%; $P < 0.01$) in the subcutaneous fat. Our data indicate that an increase in the slaughter weight of Iberian pigs from 145 to 155 kg BW improved carcass yield and positively altered the fatty acid profile toward a more unsaturated subcutaneous fat.

**Key Words:** Iberian pig, carcass traits, fatty acid profile

**T180    Effect of birth parity and sex on carcass traits and meat quality characteristics in crossbred pigs.**    G. D. Kim*[1], J. Y. Jeong[2], K. Y. Seo[1], E. Y. Jung[1], H. S. Yang[1], and S. T. Joo[1], [1]*Division of Applied*

*Life Science (BK21 Program), Graduate School of Gyeongsang National University, Jinju, Gyeongnam 660-701, Republic of Korea*, [2]*Swine Scientic Technique Center, Jinju National University, Jinju 660-758, Republic of Korea*.

The effect of birth parity and sex on carcass traits and meat quality characteristics were studied on crossbred (Landrace × Korean native pig) pigs, with age ranging between 182 and 195 d. 182 males and 158 females of pigs from 3 different birth parities were investigated. The females and third parity pigs grew slower than males and first or second parity pigs. However, there are no significant ($P > 0.05$) differences in carcass weight (kg) among the different sexes and birth parities. Backfat thickness (mm) at 3 points (4th-5th thoracic vertebrae, 11th-12th thoracic vertebrae and vertebrae thoracic-lumber vertebrae) were higher in females (33.8, 29.3, and 27.0mm, respectively) than in males (31.1, 24.8, and 22.6mm, respectively) ($P < 0.01$). The third parity pigs had higher loin eye area (22.10cm2) and lower backfat thickness (30.16mm) at 4th-5th thoracic vertebrae than the others ($P < 0.05$). The males and third parity pigs had higher pH value (5.83) at 24h postmortem ($P < 0.05$). Lightness (L* value) and yellowness (b* value), intramuscular fat content (%), and sarcomere length (Î1/4m) were higher in females than in males, while moisture content (%) was higher in males ($P < 0.05$). Intramuscular fat content (3.41%), redness (a* value, 7.97) and yellowness (b* value, 3.30) were higher in third parity pigs than in the other parities, however, moisture content (73.22%) and drip loss (1.09%) were lower in third parity pigs ($P < 0.05$). The results suggest that females and third parity pigs which exhibited the lowest growth performance, have higher fat content and lower moisture content.

**Key Words:** birth parity, sex, crossbred pig

**T181    Carcass quality of pigs vaccinated against gonadotropin releasing factor compared to surgically castrated males and gilts from two different sire lines.**    J. I. Morales[1], M. P. Serrano*[2], L. Cámara[2], J. D. Berrocoso[2], J. P. López[1], and G. G. Mateos[1], [1]*Copiso S.A., Soria, Spain*, [2]*Universidad Politécnica de Madrid, Madrid, Spain*.

A total of 360 pigs was used to study the influence of gender (immunocastrated males, IM; surgically castrated males, CM; intact females, IF) and terminal sire line (Top York; Tempo) on carcass and meat quality of pigs slaughtered at 125 kg BW. The female line used was Large White × Landrace in all cases. The IM pigs received 2 doses of Improvac (76 and 124 d of age, 7 wk before slaughter). Backfat thickness (BF) was measured the day of slaughter in live pigs, using an ultrasound scanner, and postmortem, using a flexible ruler. Meat samples were taken at m. *Longissimus dorsi* and analyzed by NIR. Treatments were arranged factorially (3 × 2) with 6 replicates (10 pigs/pen) per treatment. The IM pigs had less carcass yield than IF and CM (77.2 vs. 79.1 and 78.7%; $P < 0.001$). Also, IM and IF had less BF than CM ($P < 0.001$) when measured by ultrasound scanner or after slaughter. The correlation coefficient between the in vivo and the postmortem methods was $r = 73\%$ ($P < 0.001$). Fresh (14.8 vs. 14.6 vs. 14.5%) and trimmed (13.2 vs. 13.0 vs. 12.9%) ham yields were higher for IF than for CM with IM being intermediate ($P < 0.05$). Also, IF had higher loin yield than IM and CM ($P < 0.01$). Meat from IM and CM had more intramuscular fat (3.93 and 4.03 vs. 3.52%; $P < 0.01$) than meat from IF. No differences between sire lines were observed for carcass yield, BF or $pH_{24}$. Crossbreds from Top York presented higher fresh (14.8 vs. 14.5%; $P < 0.05$) and trimmed (13.2 vs. 13.0%; $P < 0.05$) ham yield but lower loin yield ($P < 0.01$) than crossbreds from Tempo. Meat from Tempo crossbreds had more intramuscular fat content than meat from Top York crossbreds (4.01 vs. 3.64%; $P < 0.01$). We conclude that IM and CM present similar values for carcass and meat quality traits. Crossbreds with Top York sire line had better carcass quality but poorer meat quality than crossbreds of Tempo sire line.

**Key Words:** immunocastration, gender, sire line

**T182    The influence of cage housing system and laying hen strain on breast meat quality traits.**    K. Juurlink*[1], A. McMillan[1], R. Ofori[1], B. Rathgeber[2], and M. Jendral[1], [1]*Nova Scotia Agricultural College, Truro, Nova Scotia, Canada*, [2]*Agriculture Agri-Food Canada, Truro, Nova Scotia, Canada*.

The influence of cage housing system and laying hen strain on breast meat quality traits was determined for 3 strains of laying hens (Shaver White (SW), Lohmann Lite (LL), Lohmann Brown (LB)) housed in conventional cages, and furnished colony units, and processed under commercial conditions. During the laying period, hens were either housed in conventional battery (CONV) (60 cm × 55 cm) (n = 24 cages per strain; 5 hens per cage) or furnished colony cages (COL) (240 cm × 110 cm) (n = 12; 4 per strain; 40 hens per cage). COL contained a nestbox (60 cm × 55 cm), 3 hardwood, semi-circular perches (240 cm × 5 cm) and a dustbathing facility (60 cm × 20 cm). Hens were slaughtered at 80 weeks and 25 hens per colony cage, and all 5 hens in 9 conventional cages per strain were randomly selected for 17 and 30 min postmortem determination of right breast (pectoralis major) pH and color (lightness (L*), redness (a*) and yellowness), respectively. At 24 h post mortem, left breast (pectoralis major) samples were collected from the same hens to determine shear force values. Data were analyzed using the Mixed model of SAS with significance accepted at $P \leq 0.05$. Breast meat was paler in color in CONV than COL (51.69 vs. 56.72; $P = 0.02$). In Col, LL and LB hens exhibited higher redness values than SH hens (5.99 and 5.12 vs. 2.73; $P = 0.01$). These results suggest that breast meat color may be affected by bird movement in different housing systems, and by genotype.

**Key Words:** laying hen, furnished cages, meat quality

**T183    Effect of ultimate pH on the chemical properties of proteins in turkey breast meat.**    J. Chan*, D. A. Omana, and M. Betti, *University of Alberta, Edmonton, AB, Canada*.

A major challenge facing the turkey industry is the increasing occurrences of pale, soft, exudative (PSE)-like meat. PSE-like meat results in paler color and reduced protein functionality. In contrast, dark, firm, dry (DFD)-like meat results in darker color and shorter shelf life. Hence, the objective of this study was to determine the chemical properties of proteins in turkey breast with different ultimate pH at 24 h postmortem ($pH_{24}$) so as to improve utilization of these types of meat. Turkey breasts from Hybrid Toms were collected from a local processing plant at 24 h postmortem. Sixteen breasts for each class (pale, normal, dark) were selected based on lightness (L*) values. Further selection of 8 breasts from each class was made based on $pH_{24}$. Samples were within values: pale (L*>51, pH<5.7), normal (46< L* <51, 5.9< pH <6.0), and dark (L*<46, pH>6.3) and referred to as low, normal, and high pH meat, respectively. Analyses were conducted on fresh minced samples. Data were analyzed using analysis of variance and means were separated using Tukey's HSD. The extent of myosin denaturation was similar as a function of $pH_{24}$ as revealed by $Ca^{2+}$- ATPase enzyme activity. Total and sarcoplasmic (SP) protein solubility was significantly (P<0.0001) higher in high pH meat. SP protein hydrophobicity (Ho) showed only marginal changes as a function of $pH_{24}$. However, high pH meat showed significantly (P<0.05) higher myofibrillar protein Ho and reactive sulfhydryl groups compared to low pH meat indicating lesser degree of protein denaturation. The difference in $pH_{24}$ had no significant effect on

total sulfhydryl groups. Protein oxidation was not evident as a function of $pH_{24}$ as shown by carbonyl content. In conclusion, low and normal pH meat showed similar chemical properties whereas high pH meat was found to have higher solubility and hence expected to have better functional properties. Thorough understanding of these properties will assist industry in developing strategies to improve meat quality and protein functionality, thus preventing yield losses.

**Key Words:** pale, dark, pH, chemical properties, turkey

**T184    The effect of turkey breast meat pH on fatty acid profile of polar lipids and susceptibility to oxidation.**    P. K. Hong*, J. Chan, D. A. Omana, and M. Betti, *University of Alberta, Edmonton, AB, Canada*.

High prevalence of PSE-like turkey meat is one of the major challenges for meat processors. However, there are limited studies on the muscle membrane fatty acid content and its oxidative stability in turkey meat with different pH. In this study, fatty acid profile and lipid oxidation level in polar lipid of turkey (Hybrid Tom) breast meat were investigated. Initially, 3 groups (pale, normal & dark) of turkey breasts (16 pieces each) were screened in a local processing plant at 24 h postmortem based on lightness ($L*$). Eight breasts from each were further selected based on the following criteria: pale ($L*>51$, pH<5.7), normal ($46< L* <51$, $5.9< $pH $<6.0$) and dark ($L*<46$, pH>6.3) and were referred as low (LpH), normal (NpH) and high (HpH) pH meat respectively. All samples were minced and stored at 4°C until use. Total fat was first extracted by the Folch method; polar lipid was separated by silica gel column followed by gas chromatography detection. Lipid oxidation in turkey meat was determined by induced thiobarbituric acid reactive substance (TBARS) values, expressed as nmol malondialdehyde/mg protein (MDA). Data were analyzed using One-way ANOVA test and means were separated by Tukey′s HSD. Results showed that polar lipid from each group differed in the fatty acid composition as they were influenced by meat pH. LpH polar lipid had significantly lower levels of polyunsaturated fatty acids (PUFA) ($P < 0.01$), particularly linoleic acid (C18:2n-6) ($P < 0.001$), total n-3 ($P < 0.05$) and total n-6 fatty acids ($P < 0.05$). For HpH, the highest PUFA level ($P < 0.01$) including total n-3 ($P < 0.05$) and n-6 fatty acids ($P < 0.05$) content were recorded. The TBARS value in LpH meat confirmed that lipid oxidation level was the lowest among the three turkey meat groups (0.17-0.37), followed by HpH (0.24-0.51) and NpH (0.32-0.85). In conclusion, low levels of polyunsaturated fatty acids were found in LpH meat. Our results indicated that different meat pH values are more than a function of short-term antemortem stress.

**Key Words:** turkey, pH, fatty acid, TBARS, lipid oxidation

**T185    Exploring the biochemical basis of dfd in broiler breast and thigh meat.**    S. Dadgar*[1], H. L. Classen[2], T. G. Crowe[3], and P. J. Shand[1], [1]*Department of Food and Bioproduct Sciences*, [2]*Department of Animal and Poultry Sciences*, [3]*Department of Agricultural and Bioresource Engineering*, *Saskatoon, SK, Canada*.

The effect of acute cold exposure on muscle energy reserve at slaughter and its relation to post-mortem glycolysis and the incidence of dark, firm and dry (DFD) breast and thigh meat was investigated. Male broilers (160) were exposed to temperatures of −9 to −15 (cold-stressed; CS), or +20°C (control) for 3 h before slaughter. Glycolytic potential (GP) and pH of breast and thigh muscles were determined at different times post-mortem from selected birds. Activity of adenosine monophosphate-activated protein kinase (AMPK) in breast meat was assessed at 0 min

post-mortem. Color, water binding capacity (WBC) and processing cook yield (PCY) were measured. Data were analyzed using ANOVA option of the GLM procedure of SAS. Classification of breast and thigh meats were based on ultimate pH ($pH_u$) and lightness ($L*$): normal breast ($pH_u$ < 6.1, $L*$ > 46) and thigh ($pH_u$ < 6.4, $L*$ > 44); DFD breast ($pH_u$ > 6.1, $L*$ < 46) and thigh ($pH_u$ > 6.4, $L*$ < 44). The total AMPK was similar for normal and DFD breast, but phosphorylated AMPK, indicative of its activity, could not be detected. DFD breast meat was darker, higher in $pH_u$, WBC and PCY ($P < 0.05$ for each), but not ($P > 0.05$) different in initial pH compared with normal meat. DFD thigh meat had higher ($P < 0.05$) initial and ultimate pH, and darker color compared with normal meat. Energy reserve at slaughter (GP) was almost exhausted in DFD (15 μmol/g) compared with normal (76 μmol/g) thigh meat, suggesting lack of substrate availability resulted in DFD thigh meat. However, GP was lower in DFD breast of CS birds (67 μmol/g) compared with DFD meat of control birds (87 μmol/g), which was not significantly ($P < 0.05$) different from normal meat of CS and control birds (92 and 102 μmol/g respectively), indicating that incomplete post-mortem glycolysis may contribute to DFD in breast meat. Thigh and breast meat from CS birds showed a higher incidence of DFD than that of control birds (85 and 42% versus 0 and 20%). GP for breast meat, but not for thigh meat, was time sensitive and showed some fluctuations over time post-mortem. In addition, GP was more highly correlated to changes in meat quality of thigh than breast meat.

**Key Words:** broilers, meat, energy reserve, DFD, cold

**T186    Comparison of four methods that measure hydroxyproline.**    H. L. Bruce* and A. Chan, *University of Alberta, Edmonton, Alberta, Canada*.

Hydroxyproline (HYP) is used to estimate collagen content of meat because it is unique to collagen, a protein associated with toughness. Neuman and Logan (1950)(NL) and Bergman and Loxley (1963)(BL) assays are popular HYP colorimetric methods and the BL assay has been modified by Parekh and Jung (1970)(PJ) and Edwards and O'Brien (1980)(EO) to decrease assay volume. Absorbance variability and stability of the BL, PJ and NL assays were compared in a randomized complete block design blocked by day with assay order randomized and balanced. Assays were performed 9 times using trans-4-HYP (Sigma Chemical Co., Oakville, Ontario) aqueous standards at 2.5, 5, 10, 20 and 40 μg HYP/mL. Absorbance of each standard was assessed 15, 30, 45, 60, 90, 120, 180 and 240 min after an initial 0 min reading using a Jasco V630 spectrometer. EO assay absorbance stability and variability were also compared with those of the BL assay in a second randomized complete block design experiment identical to the first except that each assay was performed 8 times. For each experiment, assay variability was inferred from absorbance standard deviations calculated using PROC UNIVARIATE (SAS Version 9.2, SAS Institute Inc., Cary, North Carolina). Change in color stability was determined using repeated measures within PROC MIXED of the same software ($P < 0.05$). Sources of variations included assay, HYP concentration, time after initial assay reading and their 2- and 3-way interactions. Results showed that assay stability declined with time as HYP concentration increased. All assays except EO were stable for the first 90 min at HYP concentrations less than 10 μg/mL. At 20 μg HYP/mL, absorbance changed at 15, 30, 30 and 120 min for the NL, EO, PJ and BL assays, respectively. At 40 μg HYP/mL, absorbance was stable for 15 min in the BL assay only. The BL assay is most appropriate for high HYP concentration samples or assays with large sample numbers and prolonged measurement times.

**Key Words:** collagen, meat, hydroxyproline