General Abstracts

A Real Time Computer Vision System for Beef Carcass Grading and Valuation.

A.K.W. Tong, S.D.M. Jones, S.M. Zawadski, and W.M. Robertson, Agriculture and Agri-Food Canada, Research Centre, Lacombe, Alberta T4L 1W1 and Research Centre, Lethbridge, Alberta T1J 4B1.

A real time computer vision system (CVS) for beef carcass grading and valuation was developed at Lacombe Research Centre, Agriculture and Agri-Food Canada. The CVS consists of two subsystems: a whole carcass and a cold carcass imaging system. A CCD (coupled charged device) camera is placed at some distance away from a blue surface backdrop, positioned behind a moving line of carcasses, records one and two-dimensional and angular measurements of the whole carcass on the kill floor. The cold carcass imaging system, required an operator to place a hand held CCD camera on the rib eye surface and push a button to capture image, records the traditional grading measurements at the interface between 12 and 13th rib. Carcass yield grade, quality grade, and carcass value are predicted from measurements of the whole and cold carcass imaging system. The repeatability of the CVS was evaluated from three separate studies involving repeated measurements on 44, 35, and 166 carcasses. Averaged repeatability of the CVS is 0.95, 0.97, and 0.98 for rib eye grade fat thickness, area and marbling percent, respectively. The accuracy of the CVS to predict carcass saleable yield was investigated from two separate dissection studies, involving 38 and 166 head, representing two sexes (heifer and steer), and a wide range of fatness and carcass weight. The accuracy (multiple correlation squared) of the CVS, using a subset of measurements from the whole and cold carcass imaging system to predict saleable yield was 0.95 and 0.84 for the two studies, respectively.

Color Machine Vision in Pork Quality Determination.

L. Ludas,[1] M.T. Morgan,[2] and J.C. Forrest[1], [1]School of Animal Sciences, Purdue University, West-Lafayette, IN 47907. [2]School of Agricultural and Biological Engineering, Purdue University, West-Lafayette, IN 47907.

Color perception has decisive importance on the marketability of pork. Previous studies highlighted the importance of color classification as the major factor of quality assessment. Findings of Tan (1996) gave feasible results for testing color machine vision system for its comparison with human color assessment and repeatability to determine pork chop color under laboratory conditions. A machine vision classifier in that study was created by samples previously classified by panel experts. The objective of this study was to expand and analyze the database for creating color standards for a new color vision classifier to be used in on-line industrial classification practice. A 16-expert panel was asked to evaluate color of 51 pork chop samples on a 1 to 6 scale in two repetitions 24 h post mortem. Number 1 stood for the lightest, number 6 for the darkest samples. Japanese color standards were used for reference. Same samples were recorded on computer disk using a Sony XC-711 CCD RGB camera. Color grades of 10 out of 16 experts were selected based on expert score repeatability for comparison of expert and computer grades. Average panel score, majority decision, standard deviation, minimum and maximum scores were recorded and analyzed. Computer grades were created using Tan's classifier to evaluate the necessity of retraining a new classifier. Selecting 10 of 16 experts increased panel majority decision repeatability from 84.3 to 94.1 percent. Average panel score repeatability was close to 85 percent in both rounds. Computer score repeatability showed 92.2 percent and 90.2 percent for Tan's two best classifiers. Although no number '6' samples were obtained in this study, comparison between computer scores based on Tan's 5-grade (NPPC) classification and the expert's 6-grade (Japanese standard-based) classification showed significant difference. High repeatability of computer classifiers confirm their use in industrial practice, however further data collection is needed to develop sufficient database for creating advanced neural networks and determining reference color standards on a 5-grade scale as required for the industry.

Ability of the Hunterlab Color Vision System to Augment Grading Accuracy and to Predict Tenderness of Beef.

R.C. Cannell, K.E. Belk, C.D. Bunting, J.D. Tatum, and G.C. Smith. Department of Animal Sciences, Colorado State University, Fort Collins, Colorado 80523-1171.

To augment USDA grading, "off-the-shelf" instrumentation was used to predict beef carcass composition and palatability. Samples were analyzed in three replications, each with different operators, with the Hunter Color Visions System (Hunter VIA). Intact rib samples from 192 beef carcasses-most with Slight and Small USDA marbling-were analyzed (n = 68, 45, and 79 samples per replicate, respectively). Hunter VIA values for percentage lean of the 12th rib surface were correlated (P < .05) with expert preliminary Yield Grade (r = -.34 to -.64), expert final Yield Grade (r = -.34 to -.62) and percentage lean (by dissection) of the 9th-11th rib section (r = .35 to .54). Hunter VIA values for percentage lean of dissected longissimus muscle from the 12th rib were correlated (P < .05) to expert marbling scores (r = .55 to .59) and to on-line grader USDA Quality Grade (r = .47 to .55). Hunter VIA L* values of longissimus lean were correlated (P < .05) to Warner-Bratzler shear force (r = -.28 to -.40). Regression equations combining Hunter VIA percentage area variables (a) with expert preliminary Yield Grade and carcass weight predicted expert final Yield Grade with R2 values of .53 to .81 (RMSE .32 to .36), (b) with expert marbling score predicted longissimus shear force with R2 values of .15 to .37 (RMSE .84 to .87) and (c) with carcass weight predicted ribeye area with R2 values of .33 to .50 (RMSE 1.01 to 1.08). Hunter VIA L*, a*, and b* values of longissimus lean, combined with expert marbling score, predicted shear force with R2 values of .15 to .37 (RMSE .84 to .87). Results suggest that the Hunter Color Visions System has potential, with further development, to augment on-line USDA Yield Grades and to enhance the prediction of tenderness within a narrow range of marbling scores.

Tenderness Classification of Beef.

S.D. Shackelford, T.L. Wheeler, and M. Koohmaraie, United States Department of Agriculture, Agricultural Research Service, Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska 68933.

The objective was to develop a system for automated tenderness classification of beef and determine the efficacy of that system. At the time carcasses are normally ribbed for determination of quality and yield grade, a 2.54-cm thick rib steak is removed from the 12th rib region of the right side of the carcass. The steak is trimmed of fat and bone and the longissimus is rapidly (7.33 min) cooked to an internal temperature of 70(C. A 5-cm long, 1-cm thick slice is removed from the cooked steak parallel to the muscle fibers. The slice is sheared by a flat, blunt-end blade attached to an electronic testing machine and slice shear force (SSF) value is determined. The process is completed during the 10 min that the ribeye blooms for quality grading. Thus, tenderness classification does not interfere with production rates. The repeatability of tenderness classification was .89 (n = 204). Tenderness classification conducted at 3 d postmortem on A-maturity carcasses (n = 131) predicted with 99% accuracy whether or not ribeye steaks would be rated "Slightly Tender" or higher by a trained sensory panel at 14 d postmortem. Carcasses were classified into three groups based on SSF (< 23, 23 to 40, and > 40 kg) at 3 d postmortem which differed greatly (P < .001) in mean longissimus tenderness rating (7.4, 6.7, and 4.2) and the percentage (100, 100, and 20%) of samples rated "Slightly Tender" or higher at 14 d postmortem. All ribeyes with SSF < 23 kg at 3 d postmortem were rated "Moderately Tender" or higher at 14 d postmortem. Thus, tenderness classification could be used to accurately segregate beef carcasses into expected palatability groups.

On-line Prediction of Pork Primal Cuts with Ultrasound Imaging.

J. Broendum, Royal Veterinary and Agricultural University, Denmark and National Pork Producers Council.

The Autofom is the latest approach in fully automatic on-line grading equipment. Sixteen ultrasound transducers positioned in a frame on the killing line measure the carcass. A three-dimensional ultrasound image is acquired and processed at line speeds up to 1,150 carcasses per hour. The instrument has been successful in detection of total meat percentage. This work demonstrates the performance of the Autofom in predicting the meat contents in the primals. A trial involving on-line predictions of the meat contents in the ham, the loin, the shoulder, and the belly of 148 carcasses were set up at a German abattoir. The line speed at the specific slaughter line was 650 carcasses per hour. Residual standard deviations ranging from 0.21 to 0.44 kg and r2 values ranging from 0.92 to 0.94 were reached by inclusion of the ultrasound data and the hot carcass weights. The results of the Autofom highly outperformed the Fat-O-Meater.

Relationships Between Lean Depth and Area, and Lean Weight and Percentage.

Y. Liu and J. R. Stouffer, Animal Ultrasound Services, Ithaca, NY.

Objectives of this study were to find the relationship between lean depth and loin muscle area, the significance of each in predicting pork carcass leanness, and the relationship between weight and percentage of lean. A total of 576 data from five groups of live hogs and carcasses was compiled from three studies conducted separately in 1986, 1992, and 1994 using ultrasound (Aloka 210/500V). Ultrasonic

measurements included manually-measured fat depths at the 10th rib; fat depth, muscle depth (MD), and loin muscle area (LMA) between the last 3rd and 4th ribs; and automatically-measured fat depth (aFD) and lean depth (aLD) between the 10th and last ribs using AUSKey. Carcass measurements included hot carcass weight (HCW), lean weight (wL), and lean percentage (pL). Correlations between any lean depth and LMA were between .6 to .7 ($P < .01$). The regression equation of LMA on aLD was: $LMA(cm^2) = 4.9338 + 5.9870 * aLD(cm)$ ($n = 130$, $R^2 = .47$, RSD = 3.4). This model was applied to an independent group (N = 30) for verification and the bias between LMA and predicted LMA averaged 1.80 cm^2 with a range from -3.87 to 8.84. No significant difference, however, was found between LMA and MD (R^2 differed by < 3%) to predict wL or pL after adding HCW and fat depth to models. R^2 for equations predicting wL (wR^2) could be greater than, equal to, or less than those predicting pL (pR^2), depending on the ratio of variance of pL (pSD^2) multiplied by HCW2 to the variance of wL (wSD^2), which was approximated as: $(1-wR^2) / (1-pR^2) = (pSD^2 * HCW^2) / wSD^2$. Similar R^2 would result if pL was converted to wL or vice versa. In conclusion, lean depth, and LMA were moderately correlated but equally acceptable in predicting leanness with HCW and fat depth. Regressions with different dependent variables were not directly comparable but resulted in similar R^2 after converting them to the same scale.

Objective Measures of Fat and Lean on Pork Carcasses Using the Carcass Value Technology System.

Y. Liu and J.R. Stouffer, Animal Ultrasound Services, Ithaca, NY.

The objective of this study was to evaluate the accuracy of the Carcass Value Technology (CVT) system developed by Animal Ultrasound Services. Carcass data were collected from market barrows and gilts (n = 325) slaughtered at a commercial packing facility. Carcass lean composition was estimated with longitudinal average fat depth and lean depth measured automatically from real time ultrasonic scans between the 10th rib and last rib by the AUSKey AutoD software, the core component of the CVT system. Other ultrasonic measurements were also made manually from the same carcasses to compare with automatic measurements. Results of regression analysis indicated that the optimum measurements were hot carcass weight, automatic average fat depth, and lean depth in predicting weight of lean (defatted deboned four lean cuts, $R^2 = .88$, RSD = 1.19) and weight of grade lean (weight of lean plus skinless square cut belly and side (spare) ribs, $R^2 = .92$, RSD = 1.09). Hot carcass weight was not a significant factor in predicting lean percentage (R^2 differed by < 1%). The automatic depth measurements provided more precise factors for estimation of lean than the careful manual measurements of fat depth, muscle depth, and loin muscle area. No significant difference was found between loin muscle area and muscle depth (R^2 differed by < 3%) in estimation of lean after including hot carcass weight and fat depth in models. Similar results were found in several trials of the CVT system in large commercial packing plants with chain speeds of around 1200 carcasses per hour in the United States. These results suggest that the automated and computerized ultrasound system can be used as an efficient and objective tool in a meat animal value based marketing system.

Late Postmortem Electrical Impedance Measurements for the Determination of Pork Muscle Quality.

E.B. Sheiss, J.E. Cannon, R.C. Johnson, M.T. Morgan, and J.C. Forrest, Purdue University, Department of Animal Sciences, West Lafayette, IN 47907-1151.

The use of late postmortem electrical impedance measurements to detect differences in quality characteristics of pork was investigated. Interrelationships among impedance measurements, ultimate pH (pHu) values, water-holding capacity (WHC), and lightness of porcine longissimus muscle (LM) were quantified using 36 loins. Impedance (Z) measured with a tetrapolar electrode configuration (1 kHz and .156 mA), impulse impedance (Py) measured with the Sigma Meatcheck 160, and pHu values were taken between the 10th and last rib approximately 30 h postmortem. Water-holding capacity measured by the 24 h suspended drip loss method and CIE - L* values were evaluated on a 2.54 cm thick chop. Drip loss (DL) measurements were used to classify loins into acceptable (n = 26, DL < 6.0%) and unacceptable (n = 10, DL (6.0%) categories. The Py and pHu values were greater ($P < .05$) and Z tended ($P = .06$) to be greater in the normal category. A predicted 6.0% cutoff point was determined using linear regression of DL on Z, Py, and pHu, respectively. Percentage of correct classification of loins into acceptable and unacceptable WHC groups by Z, Py, and pHu was 83.0%, 78.0%, and 80.5%, respectively. Correlations of Z, Py, and pHu with L* were -.41, -.55, and -73, respectively, while correlations with DL were -.56, -.75, and -.60, respectively. Results suggest that impedance and ultimate pH measurements may reflect different properties of postrigor muscle. Muscle impedance measurements made in the late postmortem period may be used to determine the WHC of pork.

Key Words: Pork, Muscle, Meat Quality, Electrical Properties

Carcass and Meat Quality of Broilers Fed Fermented Low and High Tannin Sorghums and Enzyme Added Rations.

C.I. Ruiz-Carrión, J.A. García-Macías, C. Rodríguez-Muela, E. Camacho, V. Santana, and F.A. Núñez-González. Facultad de Zootecnia, Universidad Autónoma de Chihuahua, Perif. Fco. R. Almada km 1, Admon. Correos 4-28, C.P. 31031, Chihuahua, Chih., México.

Forty five commercial broiler chicks were put in individual metabolic cages (five per treatment) and fed one of nine different rations containing fermented or normal low and high tannin sorghums added with ALLZYME VEGPRO (protease and celulase) and ALLZYME (amylase, protease, and celulase) enzymes in different combinations. The broilers were slaughtered at 6 weeks old and their carcasses and meat quality was measured. The average carcass weight was 950g, which is low and had an effect in the carcass characteristics as high values of neck, wings, and ribcages recorded (parts of low economic value). However, a significant effect ($P > .05$) in the lean of the drumstick was noted as well as for the breast percentage. It was apparent that the use of low tannin sorghums stimulated the growth of the low economic value cuts, while the use of high tannin sorghums does that for lean in drumsticks and breast percentage. The meat quality characteristics texture, pH, and color were statistically different, but water holding capacity, although showed variation among treatments having the control group the lowest value, was not statistically significant. However, when compared with the values reported in other works, all the quality variables measured in this work allow us to conclude that the ration used had no effect in the meat characteristics for broilers sacrificed at 6 weeks of age.

Selection for Lean Growth Efficiency: Effects on Selected Fresh and Processed Pork Quality Attributes.

E. Huff-Lonergan, S. Harris, D. Kuhlers, S. Jungst, S. Lonergan, and W.B. Mikel, Auburn University.

A line of Duroc pigs has been established at Auburn University by four generations of selection for improved lean growth efficiency. Selection in this line was made on decreased 10th-rib backfat (real-time ultrasound) and on improved feed conversion. A control line (contemporary, randomly selected pigs) was also maintained. Pigs from generations 3 and 4 were tested for the presence of the halothane genotype and all were found negative. Carcass data (4 generations, n = 165) and fresh meat quality data (generations 3 and 4, n = 59) were collected on representative barrow carcasses from each litter. A subset of hams (semimembranosus and biceps femoris) was selected for processing from generation 4 (n = 18) to begin to evaluate processed product characteristics. By generation 4, 10th-rib backfat was 1.11 cm less ($P < .001$), loineye area was 3.59 cm2 greater ($P < .001$) and lean gain/day was 36% greater ($P < .001$) in the selected line (S) compared to the control line (C). In the fresh product, longissimus dorsi (LD) from the S line had 13% lower water holding capacity (WHC) ($P < .05$), and .74% greater drip loss (DL) ($P < .001$) than did the C line. The 24-h pH measurement in the S line was .11 pH units lower ($P < .05$) compared to the C line. In the S line, the semitendinosis (ST) WHC was 10.8% lower ($P < .05$). The 15-min ($P < .01$), 30-min ($P < .05$), and 24-h ($P < .05$) pH values were lower in the S line (differences of -.19, .-12, and .-14 units, respectively) when compared to the C line. There were no significant differences in 15-min, 30-min, 45-min, or 24-h postmortem temperatures in either the LD or the ST. Processed hams were not significantly different for any of the traits measured (Hunter color, processing yields, proximate analysis, sensory panel scores). Processing functionality of specific muscles in the selected and control lines must be characterized further. However, this study shows that while improvements in lean growth efficiency and carcass composition were made in the absence of the halothane genotype, decreases in fresh pork quality were observed.

Diets that Improve Amino Acid Balance Enhance Carcass Protein Accretion Rates and Muscle Mass in Beef Cattle.

T.F. Robinson, D.H. Beermann, T.C. Perry, and D.G. Fox, Cornell University, Ithaca, NY.

Fifty crossbred steers weighing an average of 305 kg were blocked by weight into five groups. Ten served as an initial slaughter group and forty were housed in individual pens and implanted with Revalor™. Treatments consisted of dietary levels (0, 3, 6, or 9% of DM) of a mixture of undegraded intake proteins (UIP) in a corn-soy total mixed ration fed ad libitum for 112 days. The UIP mixture was formulated using the Cornell Net Carbohydrate and Protein System Model to optimize amino acid balance at the site of absorption using meat and bone meal, blood meal, fishmeal, and feathermeal. Objectives were to determine effects and optimum level of feeding this protein mixture on growth performance, carcass traits, and composition of carcass gain, and composition and tenderness of longissimus muscle in finishing steers. Carcass composition was estimated from proximate composition of the 9th through 11th rib section (Hankins and Howe, 1946). The trial was terminated when at least 75% of the cattle were expected to achieve the "low choice" USDA Quality Grade. Daily gain was 30%, 23%, and 10% higher ($P < .05$) in the 6% UIP group after 56, 84, and 112 days (significant interaction with time). Although slaughter weight, carcass traits, and carcass composition were not significantly affected by treatment, carcass protein accretion rates were 14%, 43%, and 12% greater ($P < .05$) when UIP was fed at 3, 6, and 9% levels, respectively. Weight of the longissimus in the 6th through 12th rib section was increased ($P < .05$)

8%, 18%, and 9.5% when the UIP supplement was fed at the 3, 6, and 9% levels, respectively. Feeding the UIP supplement altered neither longissimus composition nor shear force values. Results demonstrate that corn-based finishing diets for medium-frame to large-frame steers can be formulated to improve efficiency of protein use for growth and to improve rates of protein gain. Maximum anabolic response was observed with feeding the 6% level of UIP in the diet.

Tiger Striping: A Problem in Injected Meat Products.

Z. DeFreitas, D. Nicholson, K. Philp, and A. Trius, Quest International, Flavors and Food Ingredients Div.,2402 7th Street N.W., Rochester, MN 55901.

Carrageenans are used in processed meats to control purge, increase yield, and improve sliceability and texture. However, the use of hydrocolloids in injected meat products can also lead to some disadvantages, one of which is known by "Tiger striping" (TS). Tiger striping is characterized by broad opaque striations in injected meats which run parallel with the meat fibers. The striations appear as voids in the meat filled with gel and have been associated with the usage of starch and some types of manufactured carrageenans. The main objective of this study was to determine the causes of TS in injected turkey breasts. Upon examination under a microscope, a tiger stripe was observed as a densely packed region of swollen particles of binder, which was mostly associated with roller dried and alcohol precipitated carrageenans. Different types of carrageenans present different degrees of swelling as observed during our particle swelling experiments in brine. Alcohol precipitated and roller dried carrageenans swelled to a similar extent and at similar temperatures. However, semirefined carrageenans behaved very differently showing considerably less swelling. During conventional processing the carrageenan is dissolved out of the matrix, filtered, and precipitated. However in the case of a semirefined carrageenan, the cellulose matrix is left largely intact. This cellulose matrix could actually be inhibiting the carrageenan particle from swelling. This does not prevent the carrageenan from working as soluble fractions will leach into the surrounding meat and bind the meat juices upon cooling. However, the huge swelling which forces the fiber bundles apart causing TS does not occur. Studies conducted on injected turkey breasts demonstrated that semirefined carrageenan controlled purge as effective as the roller dried and alcohol precipitated carrageenans without producing TS.

Influence of Ozone and Gas Composition on Microbial Growth, Color, and Lipid Stability of Ground Beef Patties.

B.S. Smith[1,2] and K.W. Mcmillin[1], [1]Muscle Foods Laboratory, Louisiana State University Agricultural Center, Baton Rouge, LA; [2]Current address, Fairbank Farms, Ashville, NY

Previous laboratory research results indicated that 2500 ppm ozone effectively reduced E. coli and Pseudomonas sp. in agar by at least one log. In the present experiment, ground beef (85% lean) was coarsely ground and packaged in vacuum (VP) or finely ground (3.2 mm), formed into 113 g patties and packaged in modified atmospheres (MAP) of 80% O_2:20% CO_2 (O_2); 80% N_2:20% CO_2 (N_2); or 20% CO_2, 2.5% O_2, 77.5% N_2 ozonated with 2500 ppm ozone (O_3). After storage at 2°C for 10 days, ground beef in VP was finely ground and over-wrapped with PVC film on foamed polystyrene trays. Treatments O_3 and N_2 had gas atmospheres exchanged for 80% O_2:20% N_2. All packages were displayed under 2700 lux fluorescent light at 7°C. Analysis (GLM procedures of SAS) revealed no differences ($P > .10$) among N_2, O_2, and O_3 treatments for total plate, total generic *E. coli*, and total generic coliform counts. All treatments had lower ($P < .01$) counts than for patties in VP on days 5, 10, and 12 after packaging. HunterLab 'a' values (redness) and subjective scores for redness on day 10 were highest ($P < .01$) for patties in N_2 and lowest ($P < .01$) for O_2 and O_3. Patties stored in O_3 and VP were highest ($P < .01$) in beef flavor intensity and lowest in off-flavor. Patties in VP were lowest ($P < .01$) in off-odor. Patties in O_2 exhibited the greatest ($P < .01$) oxidative instability (TBARS). The influence of ozone in reducing microbial growth was not observed in this study, unlike with pure cultures inoculated on agar. The bacteriostatic influence of CO_2 was observed across all MAP scenarios as compared with VP.

Developing a Model HACCP Plan for a Small Meat Processing Facility: The Process and Implementation.

M.S. Brewer and F.K. McKeith, University of Illinois.

Model HACCP plan development in a small processing facility that slaughters, processes, and sells wholesale and retail beef, pork, and lamb was undertaken to provide a template for HACCP Plan development in the many small plants (in Illinois and other states) which will be required in 1998. HACCP plan development and implementation are a challenge for small and medium (< 50 employees) sized meat processors because of facility design (number/location of coolers), personnel constraints (each employee performs many tasks) and the lack of a quality control program into which larger processors can embed HACCP. These factors alter HACCP plan development. In this project, slaughter was addressed (separately) then processed products were categorized into 7 groups based on similarity of process.

Product descriptions were developed for each group based on formulations approved by the Illinois Department of Agriculture, then each group was flow-charted. A Hazard Analysis was conducted for each group. Critical control points were identified, and critical limits were set keeping in mind the practical aspects of a small processing facility (equipment, personnel). A monitoring system was set up such that one employee was responsible for monitoring most processes in a given area of the plant. Data logs were developed such that they could collect several types of data on one form located in one place. Verification was designed to occur on 1 or 2 days/week to minimize redirection of employees and processing down time. This poster will contain flow charts of the process, sample forms for documentation and the training and implementation schedules. In addition microbiological data will be collected in the near future as HACCP is implemented in this plant to assess the effects of HACCP and to evaluate various microbiological measures as indicators of sanitation in small plants. A copy of the HACCP manual will be available for review.

Control of *E. coli* O157:H7 in Large and Intermediate Diameter Lebanon Bologna.

K.J. Karr, C.L. Kastner, J.L. Marsden, R.K. Phebus, and D.Y.C. Fung, Kansas State University.

In January 1995, USDA/FSIS required that fermented sausage processes achieve a five-log reduction of *E. coli* O157:H7 when starting with at least 7.3 CFU/g. The objectives of this study are: 1) to determine the effects of typical Lebanon bologna thermal processing temperatures and times on reducing *E. coli* O157:H7 in large 115 mm (4-1/2") and intermediate 90 mm (3-1/2") diameter products; and 2) to evaluate the effectiveness of MacConkey Sorbitol Agar (MSA), 202 agar (KSU Food Microbiology Laboratory), and Phenol Red Agar with 1% sorbitol (PRSA) for detecting *E. coli* O157:H7. For the large diameter product, commercially prepared meat batter containing beef, salt, sugar, dextrose, spices, potassium nitrate, sodium nitrite, and starter culture (Pediococcus, Lactobacillus, and Micrococcus spp.) was mixed with a five-strain mixture of *E. coli* O157:H7 to achieve an average inoculum level of 7.79, 7.77, and 7.92 log CFU/g as determined on MSA, 202, and PRSA media, respectively. Batter was stuffed into large diameter casings and placed in a commercial smokehouse. For heat treatment 1, the fermentation cycle was 8 hr at an internal temperature (I.T.) of 80°F, then 24 hr at 100°F I.T., followed by 24 hr at 110°F I.T. Natural smoke was applied during the last 2 hr. Heat treatments 2, 3, and 4 included additional heating at 115°F I.T. for 1, 2, and 5 hr, respectively. The experiment was replicated three times. All heat treatments on all media were negative (< 1.9 log CFU/g detection limit) and negative after modified *E. coli* (mEC) selective enrichment media. Minimal variation for all product characteristics was found both within and between treatments. Overall pH was 4.4 after fermentation and moisture, protein, fat, and salt contents for all treatments were 60.8%, 22.5%, 10.6%, and 4.8%. Moisture to protein ratio was 2.7 with water activity being 0.94. This study validates that a five-log reduction of *E. coli* O157:H7 for large diameter product can be achieved using a typical Lebanon bologna protocol. The protocol for intermediate and large diameter product will be the same. However, sampling for the intermediate diameter product will be conducted throughout the entire fermentation cycle. In addition to the 42°C incubation temperature required by the USDA validation protocol, 37°C will be evaluated for the intermediate product.

The Incidence of *E. coli* on Beef Carcasses is Related to Aerobic Plate Count Levels.

G.R. Siragusa, W.J. Dorsa, C.N. Cutter, and M. Koohmaraie, United States Department of Agriculture, Agricultural Research Service, Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska 68933.

The relationship between the carcass microbial load (as measured by the aerobic plate count per unit area) and the frequency of isolation of biotype 1 *E. coli* on beef carcasses was studied. Analysis of 590 pre-fabrication beef carcass samples taken in two processing plants demonstrated an association between the mesophilic aerobic plate count (APC) class and the incidence of obtaining an *E. coli* positive sample. Beef carcasses were sampled from two separate plants, one a fed cattle operation and the other a cow/bull plant. Samples were obtained by sponging and analyzed for APC and *E. coli*. Samples were classified into APC levels ($0 < 2$, ≥ 2 and < 3, ≥ 3 and < 4, ≥ 4 $\log_{10}$ CFU/cm^2). Chi square analysis of the resulting contingency table indicated an association between the APC class and the incidence (presence or absence) of an *E. coli* positive sample. Within APC class four samples (> 4 $\log_{10}$ CFU/cm^2), 96% were positive for the presence of *E. coli*, whereas this percentage decreased in the lower APC classes, decreasing to an *E. coli* incidence rate of 15% in APC class one ($0 \geq 2$ $\log_{10}$ CFU/cm^2). The data highlights the potential for using near real time microbial monitors which indicate the APC for monitoring critical control points in the beef dressing process prior to the fabrication stage.

Parameters Affecting the Efficacy of Spray Washes Against *Escherichia coli* O157:H7 and Fecal Contamination on Beef.

C.N. Cutter, W.J. Dorsa, and G.R. Siragusa, United States Department of Agriculture, Agricultural Research Service, Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska 68933.

A series of progressive experiments was conducted with a model carcass washer using tap water and 2% acetic acid sprays to determine if tissue type, inoculation menstruum, bacterial level, or spray temperature affect removal of bac-

teria from beef carcass tissue during spray washing. For the first experiment, pre-rigor (15 min post-exsanguination), post-rigor (24 h post-exsanguination), or post-rigor, frozen (-20°C, 7 days), thawed, lean beef carcass tissue (BCT) was inoculated with bovine feces and subjected to spray washing (15 s, 56°C) with water or acetic acid. Spray washing with either compound resulted in bacterial populations that were similar for pre-rigor and post-rigor BCT; however, remaining bacterial populations from spray-treated post-rigor, frozen BCT were significantly ($P \leq .05$) less than for the other two tissue types. For the second experiment, pre-rigor, lean BCT was inoculated with *Escherichia coli* O157:H7 suspended in bovine feces or physiological saline and spray washed (15 s, 56°C) with water or acetic acid. Bacterial populations were reduced to similar levels with acid sprays, regardless of menstruum. For the third experiment, *E. coli* O157:H7 in feces was used to contaminate pre-rigor, lean BCT to obtain different initial bacterial levels (7, 5, 3, and 1 $\log_{10}$ CFU/cm^2). Spray washes (15 s, 56°C) with acetic acid reduced the level of the pathogen to 2.51 and 0.30 $\log_{10}$ CFU/cm^2 when initial bacterial levels were 7 and 5 $\log_{10}$ CFU/cm^2, and to undetectable levels when initial bacterial levels were 3 and 1 $\log_{10}$ CFU/cm^2. In a fourth experiment, water or acetic acid (15 s), ranging from 30 to 70°C was applied to beef tissue contaminated with *E. coli* O157:H7 in feces. Remaining bacterial populations were not different between the water treatments or between the acid treatments at any temperature. While variables such as bacterial level and inoculation menstruum may affect the efficacy of spray washing with organic acids, these results indicate that tissue type or spray temperature do not.

Control of *E. coli* 0157:H7 in Dry, Fermented Sausage Using Low Temperature Thermal Processing and *Lactobacillus plantarm* Starter Culture.

W.H. McCauley, N. Ahmed-Kotrola, J.L. Marsden, R.K. Phebus, C.L. Kastner, and M.E. Dikeman, Kansas State University.

Dry, fermented sausage was thought to be free of foodborne pathogens until an outbreak of *Escherichia coli* O157:H7 occurred in commercial dry-cured salami in 1994. In this study a mixture of 70% pork and 30% beef with 25% fat was blended with salt, nitrite, spices, and dextrose, then ground through a 0.32 cm plate. A five-strain mixture of *E. coli* O157:H7 was inoculated into the meat batch at a level of ca. 8 $\log_{10}$ colony forming units/g (CFU). *Lactobacillus plantarum* starter culture was then added according to manufacturer's instructions and the batter was stuffed into 36 mm collagen casings. Fermentation was for 16 h at 30°C internal temperature and 90% relative humidity (RH). Thermal processing was for 1 h at 53.3°C internal temperature and 90% RH immediately after fermentation for those sausages thermally processed. Drying was after fermentation and thermal processing at 10 to 12.8°C and 57 to 63% RH. *E. coli* O157:H7 levels were assayed on MacConkey Sorbitol agar (MSA) and on Phenyl Red agar base with 1% sorbitol added (PRSA). Fermentation combined with drying was not able to significantly reduce ($P > 0.05$) *E. coli* O157:H7 levels on either recovery media. Only a 0.47 and 0.82 $\log_{10}$ CFU/g reduction was achieved on MSA and PRSA, respectively. Heat treatment ($P \leq 0.05$) reduced levels of *E. coli* O157:H7 on both media, although inclusion of a thermal processing step was not sufficient to achieve the 5 log reduction of *E. coli* O157:H7 required by USDA/FSIS for a dry, fermented sausage process. More cells of *E. coli* O157:H7 were recovered ($P \leq 0.05$) using PRSA at all stages of production except from the raw batter. Differences in recovery between the two media were greater after thermal processing, than at any other processing stage. It was concluded that MSA does not recover heat injured cells of *E. coli* O157:H7 and PRSA is a better media to use in validation studies.

Inactivation of Pathogenic Bacteria by the Chemical Dehairing Process Proposed for Use on Beef Carcasses During Slaughter.

L.R. Graves Delmore, J.N. Sofos, G.R. Schmidt, and G.C. Smith, Department of Animal Sciences, Colorado State University, Fort Collins, CO 80523-1171.

Chemical dehairing is a newly patented technology that is designed to remove the hair, dirt, and feces from the hides of beef carcasses prior to hide removal. It is hypothesized that such technology would introduce less dirt and feces to the slaughter floor than conventional slaughter/dressing procedures, thereby reducing the overall contamination of beef carcasses. To evaluate the efficacy of the proposed chemical dehairing process to inactivate high levels (10^7 to 10^8) of pathogenic bacteria associated with the hides of beef carcasses a pilot study was conducted. Fresh hide samples from the tail region of beef carcasses were inoculated with fresh bovine feces containing either *Escherichia coli* O157:H7 (8 strain mixture), Listeria monocytogenes (6 strain mixture isolated from meat products), or *Salmonella spp.* (5 isolates recovered from commercial beef slaughter operations). Samples were chemically dehaired, under laboratory conditions to simulate commercial dehairing, using a twelve step batch process with sodium sulfide (10%) as the active agent and hydrogen peroxide (3%) as the neutralizing agent. Samples were evaluated for aerobic plate counts (APC), total coliform counts (TCC), and selective pathogen enumeration using MacConkey Sorbitol agar, Lithium-Chloride-Phenylethanol-Moxalactam agar, and Bismuth Sulfite agar, respectively. APC of hide samples inoculated with *E. coli* O157:H7 were reduced by 4.3 logs from 8.1 log CFU/cm^2, while TCC were reduced by 6.6 logs from 7.6 log CFU/cm^2. Log reductions achieved in APC and TCC for hide samples inoculated with L. monocytogenes were 3.7 and 3.5 log CFU/

cm^2, respectively, reduced from 8.2 and 4.4 log CFU/cm^2, respectively. APC and TCC for hide samples inoculated with *Salmonella* were reduced by 3.5 and 3.6 log CFU/cm^2, respectively from initial counts of 7.8 and 4.3 log CFU/cm^2, respectively. Overall, chemical dehairing successfully reduced numbers of bacterial pathogens inoculated with feces on beef hide samples.

Key words: Beef Carcass, Bacterial Decontamination, Chemical Dehairing

The Microbial Profile of Refrigerated Subprimals from Beef Carcasses that Have Received Hot Water, Alkaline, or Organic Acid Wash Interventions Prior to Contamination with Bacterial Pathogens.

W.J. Dorsa, C.N. Cutter, and G.R. Siragusa, United States Department of Agriculture, Agricultural Research Service, Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska 68933.

The effect of lactic acid (LA), acetic acid (AA), trisodium phosphate (TSP), 72°C water (HW), and 32°C water (W) washes on bacteria populations introduced to beef carcass surfaces post-treatment was determined up to 21 d at 4°C vacuum packaged storage. Beef carcass short plates were collected from cattle immediately after harvest and subjected to the above treatments or untreated (C). Short plates were then inoculated with low levels (ca.< 2 $\log_{10}$) of *Listeria innocua, Salmonella typhimurium, E. coli* O157:H7, *Clostridium sporogenes* contained in a bovine fecal cocktail. In general, growth of these four bacteria, aerobic bacteria, lactic acid bacteria, and pseudomonads was suppressed or not observed when LA or AA treatments were used. TSP treatments performed somewhat similarly, but to a lesser extent, and in many cases bacteria grew equally well on untreated beef surfaces. The present study demonstrates hot water or water washes offer little suppression of pathogen growth during subsequent storage. The use of a final lactic or acetic acid wash during the processing of beef carcasses offers some residual efficacy in suppressing pathogen proliferation during refrigerated storage should these bacteria be introduced immediately after carcass processing.

Consumer Preferences for Ground Lamb of Varying Fat Levels and Grind Size.

E.R. Behrends, M.F. Miller, L.L. Behrends, and C.B. Ramsey, Texas Tech University.

Ground lamb of two final grind sizes (5 and 8-mm) and four fat levels (targets of 10, 15, 20, and 25%) was provided to consumers (n = 65) as machine-formed patties or as chubs to determine their ratings and acceptability of grind sizes and fat contents. A trained sensory panel also rated the patties for palatability traits. Patties made at home from chubs were preferred by consumers over the machine-formed 4-mm- thick patties weighing .11 kg. Consumers rated patties of the 5-mm grind size higher than the 8-mm grind size in visual appearance and visual overall desirability. Grind size did not affect the sensory acceptability of the patties by consumers. Trained panelists rated three of the six palatability traits higher for the 5-mm grind than for the 8-mm grind. Consumers scored the two higher fat levels more juicy but lower in overall desirability and much lower in visual appearance than the 10 or 15% fat blends. Consumers did not like the greasy mouthfeel of the higher fat 20 and 25% fat blends. Trained panelists found that the 10 and 15% fat formulations differed only in flavor intensity with the lower fat content rated least intense in flavor. Trained panelists found no palatability differences between the 20 and 25% formulations. Overall, these results indicate that the fat content of ground lamb patties should not exceed 15%. The lower fat blends were superior to fat contents above 20% in overall desirability and visual appearance. This research shows that ground lamb should be ground through a 5-mm plate for the second grinding and that the fat level should not exceed 15%.

Controlling Lipid Oxidation in Precooked Pork Crumbles.

E. Mills, and V. Fishell, Penn State University, Room 16, Meat Laboratory, University Park, PA 16802.

Preparation and packaging options and elevated dietary vitamin E were investigated in an effort to better control lipid oxidation in precooked pork crumbles. Crumbles were manufactured by heating ground pork trimmings in a steam kettle. Liquid fat and water were drained and crumbles were rinsed with hot (90°C) water. Vacuum or gas flush (70%/30% N_2/CO_2) packaging were effective in delaying lipid oxidation when applied immediately following cooking. After two weeks of refrigerated storage, TBARS (thiobarbituric acid reactive substances) values for cooked crumbles were 1.6, 2.0, and 8.8 mg/kg respectively for vacuum, gas flush and aerobic packages. Elevated dietary vitamin E delays lipid oxidation in precooked pork crumbles. Lipid oxidation, occurring within 30 minutes following cooking for aerobic packaged product, was reduced by 1.63 TBARS for pork from vitamin E supplemented pigs. A feeding duration of four weeks immediately prior to slaughter is needed to achieve maximum effect of dietary vitamin E. Manufacturing procedures used in preparation of cooked meat crumbles lead to very rapid onset of lipid oxidation following cooking. Rapid application of vacuum or gas flush packaging immediately following cooking offers good protection against lipid oxidation but is hard to achieve in a timely fashion. Elevated dietary vitamin E effectively delays lipid oxidation in cooked pork crumbles and has the potential to extend the time during which effective packaging can occur.

Growth Response of Muscle Fibers to the Expression of an Igf-I Transgene Targeting Skeletal Muscle in Pigs.

G. Bee, M.B. Solomon, and V.G. Pursel, Meat Science Research Lab and Gene Evaluation & Mapping Lab, USDA, ARS, Beltsville, MD 20705.

Transgenic (T) pigs were produced with a fusion gene composed of avian skeletal α-actin regulatory sequences and a cDNA encoding human insulin-like growth factor-I (IGF-I). This transgene directs IGF-I expression specifically to striated muscle. The objective of the present study was to determine if this transgene would alter skeletal muscle fiber morphology. Founder T-pigs expressing IGF-I were mated to non-transgenic pigs to produce G1 progeny. At 120 kg body weight, carcass muscle samples (left side) from the gluteus medius (GM), longissimus (LM) and serratus ventralis (SV) were obtained from 7 transgenic and 6 control boars. Muscle samples were treated with the combination staining procedure for succinic dehydrogenase and myofibrillar acid ATPase. Fibers were classified on the basis of stain reaction as SO, FOG, and FG. Fiber area and distribution were determined. From the same tissues native gel electrophoresis of isomyosin was carried out. The major myosin isoforms found in the muscles were two slow (Sm_1, Sm_2), two fast (Fm_3, Fm_2), and one intermediate (Im). In T-pigs, all muscles had more FG and fewer FOG while GM and SV muscles also had fewer SO. The LM had more SO fibers than control pigs. In T-pigs fiber area were increased from 9.4 to 26.6 % compared to control pigs. The magnitude of increase in fiber area was greatest for SV ($P < .05$). According to the histochemically assessed distribution of the muscle fiber types, the proportion of the slow isomyosin forms was decreased in the GM and SV of the T-pigs compared to the control, whereas the fast forms were increased. Within the slow and fast isomyosin forms the Sm_2 was decreased and the Fm_2 of the GM was increased in the T-pigs compared to the control. A significantly higher amount of Fm_3 was found in the SV of the T-pigs. These results suggest IGF-I expression stimulated muscle hypertrophy of all fiber types, influenced the distribution of fiber types and altered the distribution of slow and fast isomyosin in GM and SV muscles.

Tenderness Properties of Cooked Beef Patties as Influenced by Animal Maturity, pH, Fat Content and Endpoint Temperature.

B.W. Berry, M.E. Bigner, and H. Zuckerman, Meat Science Research Laboratory, ARS-USDA, BIdg. 201, BARC-E, Beltsville, MD 20705.

Five separate formulations of ground beef patties were processed to represent differences in animal maturity, muscle pH, fat content, and hot vs cold processing. Frozen patties were cooked on electric griddles to either 68 or 71°C. Tenderness properties were assessed by means of a ten-member trained panel and by various shear force-related properties. Patties manufactured from hot processed, high pH muscle received the highest sensory ratings for tenderness, while patties from dark-cutting, high pH muscle possessed the lowest tenderness ratings. High pH did not influence peak load expressed as kg, but increased values expressed as N for patties from dark cutting beef. However, patties from dark cutting beef had the lowest post-peak energy and stress/strain values ($P < .01$). Using the same source of beef materials, 20% fat in patties reduced peak energy values compared to 10% fat, but did not influence other sensory or instrumental tenderness measurements. Firmness (evaluated by sensory panel during first three chews) decreased as a result of increasing endpoint temperature only for low-fat patties made from mature cow beef. However, instrumental measures of shear force (peak load, peak energy) decreased for this formulation as a result of higher endpoint temperature. Peak load values expressed as kg also decreased between 68 and 71°C for 20% fat patties. Cooking times were longest for dark cutting, high pH patties, while cooking yields were highest for hot processed, high pH patties. It would appear that control of postmortem muscle pH may be important in altering tenderness of cooked patties. Slight increases in endpoint temperature (68 vs 71°C) do not greatly affect tenderness. However, both sensory and instrumental measures of tenderness are needed to fully assess formulation effects on beef patty tenderness.

New Technology to Instantaneously Tenderize Meat.

M.B. Solomon,[1] J.B. Long,[2] J.S. Eastridge,[1] H. Zuckerman,[1] and B.W. Berry[1], [1]Meat Science Research Laboratory, ARS, USDA, Beltsville, MD 20705, USA, [2]Hydrodyne, Inc., San Juan, PR 00936, USA.

The organoleptic trait most affecting consumer acceptance of meat is tenderness. As the meat industry moves towards producing leaner meat products, the amount of fat is decreased, resulting in increased variations and inconsistencies in meat palatability, especially tenderness. The Hydrodyne process uses a small amount of explosive to generate a sonic shock wave in liquid media (water). In less than a millisecond, the shock wave passes through objects in the water that are an acoustic match (mechanical impedance) with water. The shock wave reflects off any object in the water that has a mechanical impedance mismatch with it. Portions of boneless muscle sections representing a variety of the major muscles of the carcass were encapsulated/evacuated in Cryovac® bags. The meat was supported against the steel wall of the Hydrodyne tank so that the ensuing wave reflects back through the meat to intersect the incoming wave. One hundred to 350 grams of explosive were used to determine the amount of explosive required to achieve significant tenderization. Results indicate significant improvement in tenderness for meat from beef, pork, and lamb. Re-

ductions in shear force with magnitudes of 30 to 80% improvements have been observed. The tougher the piece of meat the greater the magnitude of improvement is observed.

Reduction of *Salmonella seftenberg* and *Escherichia coli* on Pork Exposed to Ultraviolet Light.

E. Wong,[1] R.H. Linton,[1] D. Gerard,[2] [1]Department of Food Science, Purdue University, W. Lafayette, IN 47907-1160. [2]Department of Animal Sciences, Purdue University, W. Lafayette, IN 47907-1160.

The USDA Pathogen Reduction Act requires mandatory testing for generic *Escherichia coli* and *Salmonella spp*. on meat and poultry in slaughtering and processing operations. Criteria established for these microorganisms must be met in compliance with published regulations. Pathogen reduction strategies must be studied that reduce microorganisms that are a concern to food safety. The objective of this study was to evaluate the effect of ultraviolet light on *E. coli* and *S. seftenberg* survival. Surfaces of trypticase soy agar, pork skin, and pork muscle were inoculated with either *E. coli* or *S. seftenberg* and exposed to various intensities (20, 50, 80, 100, 500, and 1000 $\mu W/cm^2$) of UV light. Microbial reductions for each condition were determined by analyzing initial and final counts for both strains. The final counts were determined after 2 min for *S. seftenberg* and 16 min for *E. coli* on agar surface and after 32 min for the remainder of the treatments. Microbial survival curves were constructed for each microorganism and surface at intensities of 100 $\mu W/cm^2$ and 1000 $\mu W/cm^2$. Greatest microbial reduction was observed at intensities 100 (W/cm^2 or greater ($P < .05$) across all surfaces. After exposure to 100 $\mu W/cm^2$, the logarithmic microbial reduction on agar, pork skin and pork muscle surfaces for *S. seftenberg* were 7.4, 3.8, and 1.9, respectively. Similarly, *E. coli* reduction for agar, pork skin and muscle was 5.0, 1.6, and 1.5, respectively. After exposure at 1000 $\mu W/cm^2$, on the same surfaces, logarithmic microbial reductions were 7.8, 4.7, and 2.0 for *S. seftenberg* and 6.2, 3.3, and 1.9 for *E. coli.* Survival curve slopes were significantly different ($P < .05$) for each surface in the following cases: a) *S. seftenberg* (100 and 1000 $\mu W/cm^2$), and b) *E. coli* (1000 $\mu W/cm^2$). In each case, the highest negative slope corresponded to agar surface followed by pork skin and muscle. When *E. coli* was exposed to 100 $\mu W/cm^2$, survival curve slope for agar surface was higher ($P < .05$) than pork skin or muscle; no differences ($P > .05$) were detected in survival curve slopes of pork skin or muscle. In general, utilization of UV light was more effective in reducing *S. seftenberg* compared to *E. coli*. This study demonstrates that UV light can be used as an alternative for reducing microorganisms on meat surfaces. However, to determine the optimum time and intensity of exposure, it is necessary to consider the effect of these treatments on quality attributes as well as aspects of design and applicability to the slaughtering and processing operations.

Microbial Evaluation of MPSC's Rinsing & Chilling Technique in Beef Carcasses.

N. Kotrola, V. Venkat, J. Kotrola, J. Marsden, R. Phebus, and M. Pullen, Kansas State University.

A patented whole carcass procedure to improve meat quality has been designed and tested. Three trials were conducted to determine the potential for systemic bacterial contamination from use of MPSC's technique. Trial 1 was conducted to determined the highest possible level of fecal contamination at the infusion-site associated with the use of a catheter. The catheter was sanitized, then dipped in fresh fecal fluid for 10 sec and rinsed with 10 ml Butterfield's Phosphate Diluent. The rinse solution was tested for total aerobic plate counts and *E. coli* counts using Petrifilm™ agar. Trial 2 was conducted to determined the bactericidal effect of the MPSC infusion fluid. The solution was filtered and exposed to UV light for 4 min. Duplicate tubes of chilled solution were inoculated with two levels (10^2, 10^3) of antibiotic-resistant K-12 *E. coli* (ATCC 3160). The inoculated solutions were monitored for *E. coli* levels on Tryptic Soy Agar with 1000 ug trimethoprim/streptomyocin (TSA +) and Petrifilm™ agar. In trial 3, three intact beef carcasses were infused following exsanguination by pumping chilled MPSC solution equal to 10% of their body weight, containing K-12 *E. coli* (1.3×10^9 CFU, 1.64×10^9 CFU, 6.34 x 108 for animals 1, 2, 3, respectively) into the carotid artery. 200 ml of fluid and blood samples were aseptically collected for K-12 *E. coli* analysis using direct plating method utilizing TSA +. In addition, samples of individual muscles (rump, brisket, flank , shoulder, neck) and internal organs (heart, liver, kidney, spleen) samples were aseptically collected in sterile bags from each animal, ground, and triplicate subsamples (100 g) were analyzed using the three tube Most Probable Number (MPN). Trial 1 indicated that the maximum weight of feces present on the catheter was equal to 0.15 g with a maximum load of 5×10^5 CFU. Trail 2 showed that MPSC's solution is highly bacteriocidal with an avg. of 63.5 to 88% reduction on the microbial load. Trial 3 showed that the avg. level of K-12 *E. coli* in the solution leaving the nozzle contained 4.83×10^2 CFU/ml. The total number of K-12 *E. coli* detected in blood samples was 3.9×10^3 CFU/ml, evidence that the organism was passed throughout the circulatory system. No detectable *E. coli* were isolated from the muscle samples, and only one of the kidney subsamples tested positive for the tagged *E. coli* (0.09 MPN/g). In conclusion, MPSC seems to be a safe processing method that can be implemented in beef processing plants provided that HACCP programs and Total Quality Management are in place.

Differences in Pork Color Measurements.

D.J. Meisinger,[1] K. Scheller,[2] and R.N. Goodwin[1], [1]National Pork Producers Council, Des Moines, IA. [2]Pig Improvement Company, Franklin, KY.

Pork color, especially of the loin muscle, is economically important for the export trade. As the pork industry increases attention on pork quality it is likely that color will become economically important for the domestic market as well. Hunt et al. stated in the Guidelines of Meat Color Evaluation that instrumental color measurements should only be used to represent relative color differences, not absolute descriptions of color. Instruments to measure color are becoming more popular with different orifice sizes and varying calibration plates being used in different applications. NPPC and PIC conducted a study at Hormel Foods in Austin, MN using different colorimeters and spectrophotometers with different heads calibrated in different ways. The machines were: 1) Minolta CR300, 8mm orifice, clay standard, 2) Minolta CR300, 8 mm orifice, white standard, 3) Minolta CR310, 50 mm orifice, white standard, 4) Minolta CR310, 50 mm orifice, clay standard, and 5) Hunter spectrophotometer, 1 in head, white standard. Measurements were taken at various locations including the rib end of the loin, eighth rib of loin, thirteenth rib of loin, and ham end of the loin. The data was evaluated with a linear statistical model with machine and day fixed effects. Differences between machines were significant ($P < .05$) for all measurements and day differences were significant for most measurements. Relatively large differences were found between machines at each loin location. Partial correlations, produced by a multivariate model, were significant ($P < .05$) and indicated relatively large differences in the loin by location. Loin color in the middle of the loin is paler than the loin end measures.

Photographic Guidelines for Pork Display Color Stability.

V. Venkat, M.C. Hunt, and D.H. Kropf, Kansas State University.

Meat color is an important quality parameter influenced by many factors prior to and during display. Pictorial color references would help train visual color panelists for display studies. Color standards have been developed for pork quality (NPPC), but not for display color stability. We developed pictorial references for evaluation of display color stability of boneless pork loin chops. Loin sections from ten carcasses were vacuum packaged and stored for eight days at 3°C. Longissimus muscle color ranged from normal, lighter and darker than normal, to non uniform in appearance. Chops were placed in styrofoam trays, over-wrapped with polyvinyl chloride film, and displayed at 3°C under deluxe warm white fluorescent lighting (1614 lux) for seven days. Slides were taken daily using tungsten film (ASA 160), a photographic gray card and tungsten lighting (3400°K). CIE L*a*b* values (Illuminant C) were measured daily for chops using a LabScan 2000 Spectrocolorimeter. Hue angle and chroma were calculated, and pH of the muscles was measured. Slides were selected for series representing the gradual color deterioration during display. Each photographic series ranged from 1 (initial) to 5 (most discolored). Chops that had lighter pigmentation developed tan/brown color faster than darker colored chops. Initial values for L*, a*, and b* ranged from 50/10/21 to 57/7/21 for darker and lighter colored chops, respectively. Values for a* and chroma decreased and hue angle increased as color deteriorated while changes in L* and b* followed no consistent pattern. Conversion of these slides into photographic prints should be useful references for fresh pork color stability studies.

Reducing the Incidence of PSE Pork in Pigs that are Monomutant for the Halothane Gene Using Vitamin-Mineral Supplementation and Accelerated Chilling.

C.R. Kerth, M.A. Carr, J.C. Brooks, M.P. Miller, and C.B. Ramsey, Texas Tech University.

Pigs that were confirmed to be either monomutants (MON, n = 49) or noncarriers (NON, n = 28) of the halothane gene were fed a standard finishing diet until they reached 86 kg. Barrows and gilts within either the MON or NON groups were randomly assigned to either a control diet (containing 11 IU/kg vitamin E (0)), or one of three treatment diets, 311 IU/kg vitamin E (300), 611 IU/kg vitamin E (600), or 911 IU/kg vitamin E (900), until they were slaughtered (114 kg). Treatment diets also supplemented 50 mg riboflavin, 50 mg Vitamin C, .3 mg selenium, 150 mg manganese, 75 mg copper, 150 mg zinc, and 900 mg magnesium per kilogram of the standard diet. Carcass sides were assigned to either a normal chilling procedure (NC, 4°C for 24 h), or an accelerated chilling procedure (AC, -20°C for 1.5 h then 4°C for 22.5 h). Neither genotype nor diet affected average daily gain ($P > .05$). Vitamin E concentration in the muscle increased ($P < .05$) in each of the 0, 300, 600, and 900 diets (4.6, 5.9, 6.5, and 7.6 (g/g, respectively). Carcasses from NON pigs had 0.25 cm less backfat at the 10th rib compared to MON pigs ($P < .05$). Ham cooking loss was improved by all of the Vitamin E supplemented diets compared to the 0 diet ($P < .05$). Drip loss was lower ($P < .05$) in loins from the 0 and 300 diets than loins from the 600 and 900 diets. Cooking loss was 2.4% higher in loin chops from MON pigs compared to NON pigs ($P < .05$). Freezer chilling improved ($P < .05$) both initial and sustained juiciness in loin chops from MON pigs to the same level as loin chops from either chill treatment in NON pigs. Sustained tenderness and overall mouthfeel scores for loin chops were improved ($P < .05$) by all of the Vitamin E supplemented diets compared to the 0 diet. Supplementing finishing diets with at least 600 IU Vitamin E and mineral supplementation and/or freeze chilling can decrease losses associated with PSE meat and improve juiciness.

Effect of Freezer Chilling Time on Pork Quality.

M.P. Springer, M.F. Miller, C.B. Ramsey, A.D. Herring, and M.A. Carr, Texas Tech University.

Market hogs (n = 81) were slaughtered at the Premium Standard Farms facility at Milan, MO. Carcasses were either normally chilled (NC) or placed in a -32°C freezer for accelerated chilling (AC) for 60, 90, 120, or 150 minutes. Loin and ham temperature and pH were monitored every hour after slaughter for 6 h and then again at 24 h. Loins and inside hams were evaluated for quality and processing characteristics. Loin pH was highest in the carcasses that were exposed to AC for longer than 60 min, but this difference was not present after 24 hours. AC improved ($P < .05$) loin color, texture, and firmness scores, but length of time in the freezer did not affect these attributes. AC did not affect ($P > .05$) pH, color, texture, firmness, or L*a*b* values of fresh hams; purge, drip, or thaw loss of fresh products; sensory scores of loins or processed hams (except initial juiciness); water holding capacity of processed hams; processing characteristics of hams; or cooking losses and Warner-Bratzler shear values for hams and loins. AC caused loins to be less ($P < .05$) white (higher L* value) and have lower b* values (less yellow) than NC loins. AC affected WHC in fresh hams and loins ($P < .05$). Bound water was highest in the 120-and 150-min groups for hams and loins. These data show that improvements in pork quality can be made using freezer accelerated chilling.

A Profile of Kansas Meat Processors.

M.K. Schoenbeck and E.A.E. Boyle, Department of Animal Sciences, 216 Weber Hall, Kansas State University, Manhattan, Ks 66506.

To develop a profile of Kansas meat processors that would depict establishment characteristics, the products produced, business goals, and provide a baseline allowing for future assessment of the impact of HACCP, a survey was conducted. A cover letter explaining the purpose of the survey and confidentiality assurance was included. Surveys were randomly numbered and included a stamped, self-addressed return envelope. Reminder postcards were mailed to plants who had not yet returned their survey one week after surveys were initially mailed. Of 221 surveys mailed to state, federal and custom plants in Kansas, 53.9% responded to the three page, twenty-three question survey. Fifty percent of the state plants responded to this survey. A typical state inspected plant in Kansas was found to employ ten or fewer full-time employees (91.2%), 40.3% of owner/plant managers completed high school, while 47.9% have worked towards or completed a college degree, was brought up in the business (60.6%), does not use a computer in their business (65.8%), and is a member of a state or national meat trade organization (67.6%). While 19.2% of state owners/plant managers have completed an undergraduate degree, 63% of owners/plant managers from federal plants have an undergraduate degree and 30.0% have a graduate degree. The average employee turnover in Kansas state inspected plants was 10.5%, while turnover in federal and custom plants was 28.2% and 13.1%, respectively. The typical state facility was constructed in the 1950's and has been since renovated. The average year of construction for federal plants was 1970. Over 80% of the state plants that responded produced fresh and processed products, however most do not have separate packaging areas. HACCP has not been implemented in 97% of the state plants that responded, although 50% have begun HACCP planning. HACCP educational material and delivery strategies need to be designed to accommodate processors having state inspected facilities.

Elevation of Live Animal Calcium Levels: A Unique Approach for Improving Beef Tenderness.

J.B. Morgan, F.N. Owens, D.R. Gill, and H.G. Dolezal, Department of Animal Science, Oklahoma State University.

Studies in progress at Oklahoma State University are evaluating the effects of supplemental vitamin D_3 on Warner-Bratzler shear values (WBS) of longissimus muscle from feedlot steers. Longissimus muscle steaks from 162 crossbred steers were obtained and aged for 7, 14, or 21 days. Steaks were broiled to an internal temperature of 70°C, allowed to cool to room temperature, and eight 1.27 cm core samples were obtained and sheared. In Experiment 1, 118 steers (529 kg mean weight) from two trails were supplemented with 0 or 5 million IU of vitamin D_3 per day for 5 days immediately prior to slaughter. Vitamin D_3 supplementation resulted in lower WBS values after 7 days of postmortem aging (4.38 vs. 4.71 kg; $P < .05$); no differences were observed at 14 days (3.86 vs. 4.04 kg; $P = .22$) or 21 days of postmortem aging (3.59 vs. 3.58 kg; $P = .95$). In Experiment 2, 44 steers (571 kg mean weight) from two studies were supplemented with 0 or 7.5 million IU of vitamin D_3 for 10 days immediately prior to slaughter. Supplementation lowered WBS at 7 days (4.21 vs. 5.15 kg; $P < .05$), 14 days (3.82 vs. 4.40 kg; $P < .05$), and 21 days of postmortem aging (3.51 vs. 4.04 kg; $P < .05$). Plasma calcium concentration at slaughter tended to be greater (10.4 vs. 9.3 mg/dl; $P < .10$) for steers that received supplemental vitamin D_3 in Experiment 1. Presumably, an increase in activity of protease's associated with the calpain system during postmortem aging is responsible for the increased meat tenderness.

The Use of Vitamin D_3 to Improve Beef Tenderness.

J.L. Montgomery, F.C. Parrish, Jr., D.C. Beitz, R.L. Horst, E.J. Huff-Lonergan, and A.H. Trenkle. Iowa State University.

A hypothesis was proposed in which short term oral administration of high concentrations of dietary vitamin D_3 would cause increased calcium for greater calpain activity during postmortem aging. As a consequence greater calcium

activated calpain activity to degrade certain myofibrillar proteins would increase tenderness. The objective of this study was to determine the effects of feeding (bolusing) two concentrations of vitamin D_3 (5 and 7.5 X 10^6 IU/animal/d) on changes in beef steak tenderness. Thirty continental crossbred steers were randomly allotted to three treatment groups in one pen. One group served as a control, two other groups were administered vitamin D_3 by bolusing daily for eight days prior to slaughter. Blood samples were collected at the same time daily and at the time of slaughter for the determination of calcium content. Cattle were slaughtered two days after the last vitamin D_3 bolusing. Strip (LL) and top round (SM) muscles were excised from each carcass 72 hours postmortem and aged for three, seven, fourteen, and twenty one days for subsequent Warner-Bratzler shear force determinations. Concentrations of plasma calcium from cattle treated with 5 and 7.5 million IU of vitamin D_3 were higher ($p < .05$) than controls from day five (10.13 & 9.98 vs. 9.20 mg Ca/100 ml plasma) through day ten (11.02 & 12.18 vs. 9.16 mg Ca/100 ml plasma). LL steak from cattle fed supplemental doses of vitamin D_3 had lower ($p < .05$) Warner-Bratzler shear values (2.80 & 2.70 kg) at day 14 postmortem than controls (3.25 kg). SM steak from the vitamin D_3 groups also had lower ($p < .05$) Warner-Bratzler shear values (3.37 kg) at postmortem day 14 than control (3.91 kg) cattle. LL and SM steaks of vitamin D_3 cattle showed more pronounced evidence of proteolysis than controls as observed on Western blots. Therefore, the use of supplemental doses of vitamin D_3 prior to slaughter will improve tenderness of grain-fed cattle.

Key Words: Beef, Tenderness, Vitamin D, Calcium

Effect of Foodservice Cookery Method, Portion Size, Endpoint Cooking Temperature, and Marination on Tenderness and Cooking Characteristics of Pork Loin Chops.

J.L. Dunn, T.D. Pringle, and S.E. Williams, University of Georgia, Athens, GA

In the foodservice environment, there is an increased use of rapid cookery systems (e.g. Clam Shell) in order to decrease preparation time. This research was conducted on typical foodservice pork loin chops to determine the effects of cooking method, portion size, endpoint cooking temperature, and marination on shear force values and cooking yields. Chops (n = 160) were assigned to the following treatments: cookery method (Clam Shell, CS vs Farberware, FB), portion sizes (4 vs 6 oz), endpoint temperatures (68 vs 75°C), and marination treatment (marinated vs non-marinated). Cooking was replicated over 5 days and Warner-Bratzler shear force was measured 24 hours post-cooking. Data were analyzed by general linear models for a completely randomized design. As expected, the chops cooked by CS had shorter ($P < .01$) cook times than FB (6.0 vs 14.9 min). Cook times (8.5 vs 12.6 min) were shorter ($P < .01$) and thaw and cook losses were lower ($P < .05$) for 4 oz compared to 6 oz chops. Chops cooked to 68°C required less ($P < .05$) cooking time, and had lower ($P < .05$) visual degree of doneness scores (medium rare vs medium) and cook loss than chops cooked to 75°C. Marination was the only main effect to impact tenderness, causing a decrease ($P < .05$) in shear force values (2.30 vs 2.59 kg). Marination also decreased ($P < .05$) cooking time, and degree of doneness, and increased ($P < .05$) thaw loss. Marinated chops cooked on the CS had significantly lower shear values and cook loss than the combination of all other marination and cooking treatments. Cooking time was similar ($P > .05$) for the 4 oz chops regardless of marination, and lower ($P < .05$) than the 6 oz marinated chops which were lower ($P < .05$) than the 6 oz non-marinated chops. These data suggest that using a rapid cookery method in combination with marination can improve shear values, cooking times, and cooking yield.

Binding Behavior of Filamin to Myofibrils.

W. Chiang and M.L. Greaser, University of Wisconsin-Madison, Muscle Biology Laboratory, Madison, WI 53706.

Experiments were conducted to determine if biotinylated filamin could bind to myofibrils or exchange with endogenous filamin. The concentration of myofibrils was constant for all reactions and the concentration of biotinylated filamin was varied. After 3 hours incubation, the myofibrils were sedimented by centrifugation, and the concentration of filamin in the supernatant was determined by binding to actin in microtiter plates. A binding curve was constructed by plotting bound fraction (mg biotinylated filamin/mg myofibril) versus equilibrium concentration of unbound filamin. A biphasic binding curve was observed. The bound fraction of biotinylated filamin increases as the unbound filamin concentration is increased until the bound fraction reaches a plateau around 0.1 μM of unbound filamin. The bound fraction, however, increases again with higher unbound filamin concentrations. The second increase might be due to filamin aggregation. Fluorescence depolarization was performed to determine the critical concentration of filamin aggregation. The results show that the polarization value (p) increases when the filamin concentration is greater than 0.1 μM. Thus it appears that endogenous filamin can exchange when incubated with biotinylated filamin in vitro and the additional binding at high concentrations of filamin is due to filamin aggregation.

Identification and Purification of a High Molecular Weight Bovine Skeletal Muscle Calpastatin.

S.M. Lonergan, E. Huff-Lonergan, and D.M. Payne, Department of Animal and Dairy Sciences, Auburn University, Auburn, AL 36849.

Bovine skeletal muscle calpastatin has been hypothesized to posses a regulatory role in both myofibrillar protein turnover in living muscle and postmortem proteolysis and ten-

derization. In order to investigate these hypotheses, our objective was to purify skeletal muscle calpastatin to homogeneity. Bovine semimembranosus muscle (5 kg) was extracted in a Tris-EDTA buffer (pH 8.35) containing a cocktail of protease inhibitors. Initial purification procedures included ion-exchange chromatography, boiling, and phenyl sepharose chromatography as previously employed for calpastatin from other sources. Specific activity of partially purified calpastatin was 400 units/mg. Several FPLC (Pharmacia Biotech) strategies were used to characterize calpastatin and purify the protein to homogeneity. Calpastatin was eluted from a Mono Q column between 150 and 175 mM NaCl, with a peak specific activity of 1500 units/mg. A product of similar purity was eluted from Phenyl Superose between 1.1 and 0.8 M ammonium sulfate. Chromatofocusing (Mono P) yielded a calpastatin peak between pH 4.2 and 3.5. Gel filtration with a tandem column arrangement (Superose 6/12) yielded a final preparation with a specific activity of 1700 units/mg and indicated a molecular mass between 670 and 370 kDa. However, SDS-PAGE and immunoblotting identified a single immunoreactive band at 130 kDa from gel filtration fractions. Our results suggest that native calpastatin from bovine skeletal muscle may be a multimeric protein. Formation of a homo-oligomer may alter calpain/calpastatin interactions and, ultimately, calpastatin regulation of calpain-initiated proteolysis in antemortem and postmortem muscle.

Expression of Muscle-specific Calpain 3 Is Developmentally Regulated and Correlates with α-Actin Expression in Porcine Skeletal Muscle.

S. Ji, B. Losinski, G.M. Willis, G.R. Frank, S.G. Cornelius, and M.E. Spurlock, Purina Mills, Inc., St. Louis, MO 63144.

The physiological function of the muscle-specific calpain 3 (skm-calpain or p94) is unknown. However, there is evidence that mutations in the gene cause limb-girdle muscular dystrophy type 2A, and of a possible involvement in the maintenance of myofibrillar integrity. The objective of this study was to evaluate developmentally p94 expression (relative to skeletal α-actin) in porcine muscle. Total cellular RNA was extracted from whole pig fetuses at 3, 5, and 7 wk of gestation (n = 6), and from longissimus muscle at 15 wk of gestation (n = 6). Muscle samples were also obtained at birth, 2 wk of age, and at 23, 55, 107, and 162 kg BW (n = 12). The p94 mRNA was quantified in 20 μg total RNA by a ribonuclease protection assay using a 350 bp porcine p94 riboprobe. α-Actin mRNA was measured by slot blot analysis using a full length human α-actin cDNA probe. Both transcripts were standardized to sample 18S rRNA. Fetal p94 expression was detectable by 5 wk of gestation and increased markedly (20-fold, $P < 0.0001$) by 7 wk. This increase preceded the initial increase in α-actin expression. In skeletal muscle samples, p94 mRNA declined (55%, $P < .001$) from 15 wk gestation to 2 wk postnatally. However, expression increased ($P < .0001$) 3-fold from 2 wk of age to 23 kg BW (approximately 7 wk of age) and maximized at 107 kg BW. Skeletal α-actin mRNA was evident by 3 wk gestation and similar in abundance at 3, 5, and 7 wk gestation. Muscle expression increased 2.5-fold from 15 wk gestation to birth ($P < .005$), decreased 28% ($P < .016$) from birth to 2 wk postnatally, increased 86% ($P < .0008$) from 2 to 7 wk of age, and plateaued thereafter. A decrease in expression of both p94 and α-actin from 15 wk gestation to 2 wk postnatally likely reflects the stress associated with birth and adaptation to the new environment. p94 and α-actin expression was highly correlated ($r = .89$, $P < .0001$). These data indicate that p94 and α-actin are developmentally regulated in conjunction with muscle growth.

Molecular Properties of Synemin and its Interactions with Specific Proteins in the Muscle Cell Cytoskeleton.

S.W. Sernett, R.M. Bellin, T.W. Huiatt, and R.M. Robson, Muscle Biology Group, Iowa State University, Ames, IA 50011.

Synemin, which was previously thought of as an intermediate filament associated protein (IFAP), has been sequenced and identified as an intermediate filament (IF) protein. The cDNA sequencing revealed that synemin contains the alpha helical rod domain characteristic of IF proteins, a short N-terminal head domain, a long C-terminal tail domain, and a large 3' untranslated region of unknown function. Our hypotheses are that synemin 1) interacts with major IF proteins, such as desmin, by forming heteropolymers via their rod domains, and 2) that the long C-terminal tail domain is able to extend from the surface of the 10 nm diameter IF core and interact with proteins present in the myofibrillar Z-lines and in the costameres at the sarcolemma. We have examined the molecular interactions of both intact synemin, and of the expressed fragments of synemin with cytoskeletal proteins such as desmin, alpha-actinin, and vinculin. By using Western blot overlays and co-sedimentation assays, we have found that purified synemin interacts with the integral Z-line protein, alpha-actinin, and with the costameric protein, vinculin. The expressed rod domain of synemin interacts with itself and with purified desmin, consistent with the hypothesis that synemin is able to form heteropolymers with major IF proteins. These results suggest synemin may act as an important crosslinking protein contributing to organization and integrety of muscle cells by helping desmin IFs anchor 1) adjacent myofibrils to each other and 2) the peripheral layer of myofibrils to the muscle cell membrane.

Representational Difference Analysis of Differences in Skeletal Muscle mRNA Expression Between Callipyge and Non-Callipyge Lambs.

M.E. Doumit, C.W. Ernst, T.P. Smith, and M. Koohmaraie, USDA-ARS U.S. Meat Animal Research Center, Clay Center, NE.

Lambs expressing the callipyge phenotype have greater muscle mass, less fat, and less tender meat than non-callipyge lambs. We wished to test the hypothesis that the phenotype can be related to differences in gene expression between affected muscles of callipyge and non-callipyge lambs. The technique of representational difference analysis (RDA) of mRNA was chosen due to its high sensitivity for identifying differentially expressed genes (Hubank and Schatz, 1994. Nucleic Acids Res. 22, 5640-5648). This technique involves the production of "amplicons" from each type of muscle, which are compared in reciprocal reactions in which callipyge or non-callipyge mRNA is used as "tester" or "driver" for PCR-based subtraction. In this way, messages that are under- or over-represented in either class of tissue can be detected. In this study, mRNA was isolated from longissimus muscle from 8-week-old lambs classified as callipyge (n = 3) or non-callipyge (n = 3) based on visual inspection of musculature. Live weights were 15.7 ± .3 and 14.9 ± .4 kg and longissimus weights were 255 ± 15 and 201 ± .4 g for callipyge and non-callipyge lambs, respectively. Amplicons were produced by PCR after ligation of adapter oligonucleotides to digested, double-strand cDNA made from each class of muscle mRNA. Amplicons were used in multiple rounds of subtraction by RDA. To evaluate the sensitivity of the assay, the protocol was applied to a sample of cDNA to which digested bacteriophage DNA had been added to provide a known difference between samples (~1% of total tester). Using this technique, no differences in the level of specific mRNAs between the callipyge and non-callipyge muscles could be found, although the presence of bacteriophage DNA was easily detected in the control sample. This result suggests that callipyge and non-callipyge longissimus muscles have approximately the same complement of mRNA at 8 weeks of age.

Effect of Postmortem Storage on the Z-Line Region of Titin.

C. Boyer-Berri and M.L. Greaser, University of Wisconsin-Madison, Muscle Biology Laboratory, Madison, WI 53706

The objective of these study was to determine if any postmortem change occurred in the region of titin anchored to the Z-line. Single myofibrils were prepared from bovine muscles (*Cutaneus trunci, Masseter, Psoas major*, and *Rectus abdominis*), and compared between different aging periods (0, 1, 2, 4, 8, and 16 days). Myofibrils were stained with a primary antibody directed to a 56 kDa titin fragment (FERE) located 50 to 80 nm from the center of the Z-line and a Texas Red labeled secondary antibody. The fluorescence pattern was observed using a light microscope and images were captured with a CCD camera and IP Lab software. Unaged myofibrils from all four muscles stained band at the Z-line. Postmortem time did not significantly affect the total amount of fluorescence in the sarcomere but the pattern was altered. The relative fluorescence intensity at the Z-line decreased while that in the I-band increased gradually, suggesting the translocation of some titin epitopes during the aging period. However, most of myofibrils still exhibited a single band pattern with the maximum of the intensity at the Z-line after 16 days. Only few myofibrils showed a two-band pattern on each side of the Z-line after 8 or 16 days of aging. Our results suggested that 1) a cleavage could occur in a region of titin very close to the Z-line releasing the FERE epitope in the I-band, 2) this cleavage does not affect all titin molecules since the maximal fluorescence intensity usually remained at the Z-line, and 3) the rearrangement of this region of titin appears unlikely as an explanation of variations in muscle tenderness since no significant differences have been shown between muscles.

The Effect of Electrical Stimulation on Rigor Development, Calpastatin Activity, and Tenderness in Avian Red and White Muscle Fibers.

S.R. McKee, C. Zocchi, G.J. Veeramuthu, and A.R. Sams, Department of Poultry Science, Texas A&M University, College Station, TX 77843-2472.

In experiment one, 75 broilers were electrically stimulated at the neck (450 mA, 2 s on/1 s off for 15 s) and 75 broilers were used as controls (unstimulated). *Pectoralis* (Pec, white fibers) and *Femerotibialis internus* (Fem, red fibers) were analyzed for pH (0 h, 0.5 h, 1 h, 2 h, and 24 h) and fragmentation (24 h). *Pectoralis* and *Adductor longus* (red fibers) were analyzed for calpastatin activity (0 h, 0.5 h, 1 h, 2 h, and 24 h). ES-*Pec* muscles exhibited lower pH at every time interval except 24 h. However, no differences in pH were observed between ES and control *Fem* during the 24 h period. Myofibrillar fragmentation was increased in ES-*Pec* muscle, but not in ES-*Fem.* There were no differences in calpastatin activity between ES-treatments for either muscle. In experiment 2, 36 broiler chickens and 36 White Pekin ducks received postmortem ES at the neck (450 mA, 2 s on/1 s off for 15 s) and 36 birds of each species were used as unstimulated controls. *Pec* from broiler and ducks (red fibers) were harvested at 15 min, 1 h, and 24 h postmortem (PM) and analyzed for pH, R-value, calpastatin activity, shear value, and sarcomere length (SL). ES broilers had lower muscle pH by 1 h and higher R-value by 15 min PM than controls. ES-duck muscle had lower pH and higher R-value by 15 min PM compared to controls. ES had no effect on calpastatin activity in broilers or ducks; however, activity decreased over time in broiler muscle but not in duck muscle. ES-broiler *Pec* had lower shear values at 1 h PM and lower

cook loss, but ES did not affect tenderness or cook loss in ducks. No consistent treatment effect on SL was observed for either species. These results suggest red fibers of broiler thigh and duck *Pec* may have less potential for tenderization from ES as compared to the white fibers of broiler *Pec*.

Fresh Ham Quality Relationship to Breed, HAL Genotype, Sex, and Slaughter Day.

C. Cloud, E.P. Berg, R.N. Goodwin, L.L. Christian, R.K. Miller, and K.D. Pollok, Texas A&M University, College Station, TX; National Pork Producers Council; Des Moines, IA; and Iowa State University, Ames, IA.

Purebred gilts (221) and barrows (279) representing the breeds of Yorkshire, Duroc, Hampshire, Spot, Chester-White, Poland China, Berkshire, and Landrace were evaluated for two HAL genotypes (nm, mm). Pigs were received at Hormel Foods commercial packing plant for seven different slaughter dates. At 24 hour postmortem, ham were removed from the carcass and a Minolta chromameter model CR-310 was used to obtain L* (HAML), a*, and b* values and reflectance (HAMMIN) from the *Gluteus medius* (GM) on the ham face. pH values from the GM (HAMPH) also were determined using a pH probe. Hams were then individually packaged and transported to Texas A&M University, College Station, TX. Upon arrival, Minolta reflectance (TXMIN) and L* (TXL), a*, and b* values were determined at three locations and reported as an average along the GM using a Minolta chromameter model CR-200 (standardized to a white tile). GM pH (TXPH) was also obtained by a pH probe. A mixed model including random effects of dam (breed) and sire (breed) and fixed effects of HAL genotype, breed, slaughter date, and sex were used to evaluate each trait. Differences ($P < .05$) between breeds were found for all traits. Differences ($P < .05$) of nm-mm were HAMMIN, HAML, REFL. No differences were found between HAL genotype and TXMIN, TXL, TXPH, and HAMPH.

Cutability of Hams as Influenced by Sex, Breed, Slaughter Day and Halothane Genotype.

K.D. Pollok, E.P. Berg, R.K. Miller, R.N. Goodwin, L.L. Christian, and C.E. Cloud, Texas A&M University, College Station, TX; National Pork Producers Council, Des Moines, IA; and Iowa State University, Ames, IA.*

Purebred barrows (n = 279) and gilts (n = 221) from the National Barrow Show, Austin, MN representing purebred breeds of Yorkshire (Y; n = 77), Duroc (D; n = 64), Hampshire (H; n = 54), Spot (S; n = 39), Chester White (CW; n = 38), Poland China (PC; n = 47), Berkshire (B; n = 107), and Landrace (L; n = 74) and three Halothane genotypes NN (n = 439), Nn (n = 51), and nn (n = 10) were slaughtered over eight weeks at Hormel Foods commercial packing plant. Carcasses were fabricated 24hr postmortem and hams from the right side were transported to the Rosenthal Meat Science and Technology Center on the campus of Texas A&M University. Hams were dissected into knife separable components (lean trim with soft tissue, subcutaneous fat, intermuscular, outside ham (*biceps femoris* and *semitendinosus*), inside ham (*semimembranosus* and *adductor*), and knuckle (*vastus* group). Halothane genotype (HAL) was determined on each animal and data were analyzed with HAL being a main effect along with sex, breed, and slaughter day. Hams from gilts were higher in percent total lean (TL), percent inside (IH) ham, percent outside (OH) ham and percent knuckle (K) than hams from barrows ($P < .05$). Hams from barrows were higher ($P < .05$) in percent total fat (TF) than gilts. Hams from breeds Y, D, and L were higher in TL ($P < .05$). Breeds S, C, PC, and B were lowest ($P < .05$) in TL. Percent total lean for breed D was similar to breeds H and L. Hams from breeds S, C, PC, and B were significantly higher in TF than breeds Y, D, H, and L. Percent inside ham was highest ($P < .05$) for breeds H and L. Breed Y had the highest ($P < .05$) OH. Additionally, breeds D and L were significantly higher in OH than H, S, C, PC, and B. There were no significant differences in TL, TF, IH, OH, and K between animals of differing HAL.

The Influence of Connective Tissue on Tenderness of *Bos indicus*-sired Steers.

S.J. Boleman, S.L. Boleman, R.K. Miller, J.O. Sanders, J.W. Kuykendall, D.K. Lunt, J.W. Savell, and S.B. Smith, Texas A&M University, College Station.

The objective of this research was to evaluate the influence of connective tissue on the tenderness of steers produced from different *Bos indicus* sires. Steers (n = 89) from 10 *Bos indicus* sires and born from Hereford cows (n = 15) or Angus cows (n = 74) were slaughtered on one of three days. USDA quality and yield grade characteristics were obtained. Warner-Bratzler shear force (kg) after 0, 7, 14, 21, 28, and 35 d of aging was determined. Collagen amount (mg/g), collagen solubility (%), lipid (%), and moisture (%) also were determined. Samples from progeny of sires displaying notable tenderness differences were selected for evaluation by electron microscopy. Sire affected ($P < .05$) hot carcass weight, fat thickness, ribeye area, kidney, pelvic, and heart fat, USDA yield grade, marbling score, and USDA quality grade; however, overall maturity was not affected ($P < .05$). Progeny from sire 10 was among the lowest for shear force values at 0, 7, 14, 21, 28, and 35 d. Breed of dam affected ($P < .05$) marbling score, kidney, pelvic, and heart fat, and collagen amount. Electron micrographs tended to display degradation of the collagen matrix with increasesd time of postmortem aging. Therefore, tenderness and carcass traits of *Bos indicus*-sired steers were influenced by sire.

Influence of Myofibrillar Protein Characteristics on Tenderness of *Bos indicus*-sired Steers.

S.L. Boleman, S.J. Boleman, R.K. Miller, J.O. Sanders, J.W. Kuykendall, D.K. Lunt, J.W. Savell, and S.B. Smith, Texas A&M University, College Station.

The objective of this research was to measure the myofibrillar protein characteristics in steers produced from different *Bos indicus* sires to determine the influence on tenderness. Steers (n = 89) from 10 *Bos indicus* sires and born from Hereford cows (n = 15) or Angus cows (n = 74) were slaughtered on one of three days. USDA quality and yield grade characteristics were obtained. Warner-Bratzler shear force (kg) after 0, 7, 14, 21, 28, and 35 d of aging was obtained. Lipid (%), moisture (%), 24 h calpastatin and sarcomere length (μm) also were determined. Electron micrographs and SDS-PAGE analyses were determined on selected samples that displayed notable tenderness differences. Offspring from Angus dams had higher (P < .05) marbling scores and kidney, pelvic and heart fat. Sire affected (P < .05) hot carcass weight, fat thickness, ribeye area, kidney, pelvic, and heart fat, USDA yield grade, marbling score, and USDA quality grade; however, overall maturity was not affected (P < .05). Progeny from sire 10 had the lowest calpastatin activity and was among the lowest for shear force values at 0, 7, 14, 21, 28, and 35 d. Sarcomere length was not influenced by sire (P > .05); sarcomere length ranged from 1.70 to 1.84 μm. Therefore, tenderness and carcass traits of *Bos indicus*-sired steers were influenced by sire.