

digesting bacteria. Variations in RDP/RDCHO were only of a sufficiently range in the forage data to develop reliable prediction equations for MPE: Daily MPE, g/kg BW = daily RDCHO g/kg BW (0.04+0.62 (RDP/RDCHO)); R square=0.83

**Key Words:** Rumen, Microbial, Protein

**1515 Effect of type of cottonseed and gossypol intake on reproduction and health of lactating Holstein dairy cows.** J.E.P. Santos\*<sup>1</sup>, M. Villaseñor<sup>1</sup>, C.H. Holmberg<sup>1</sup>, D. Ringen<sup>1</sup>, E.J. DePeters<sup>1</sup>, P.H. Robinson<sup>1</sup>, B. Bretz<sup>1</sup>, and P.W. Jardon<sup>2</sup>, <sup>1</sup>University of California - Davis, <sup>2</sup>Visalia, CA.

Objectives were to evaluate the effects of type of cottonseed on reproductive performance and health of dairy cows. Holstein dairy cows, 856, on 3 dairy farms in central California were assigned at calving to one of two treatment diets (428/treatment) based on parity, calving date and previous lactation 305-d mature equivalent milk yield in a randomized complete block design. Cows were assigned 3 to 20 days in milk (DIM) and remained on diets for 170 d. Cottonseed represented 10% of the diet DM, and treatments consisted of replacing whole Upland cottonseed (WUP) with a blend of WUP and cracked Pima (BUPCP) cottonseed (33:67). Estimated free gossypol intake was 26.2 and 17.9 g/d for BUPCP and WUP, respectively. Estrous was synchronized with two injections of PGF2a (Lutalyse) 14 d apart. Cows were inseminated after the second PGF2a injection (> 44 DIM). Within each dairy, the same technician artificially inseminated all the cows with semen from sires randomly distributed across the two treatments. Pregnancy diagnosis was performed 35 to 45 d after AI, and pregnant cows were reconfirmed at 170 DIM. A postmortem diagnosis was performed in cows that died. Treatment did not affect DIM at first AI and it averaged 58.7 d. Estrus detection after the second PGF2a injection tended to be greater for BUPCP vs WUP (56.9 vs 50.9%;  $P < 0.09$ ). In BUPCP and WUP fed cows, first AI conception rate (29.4 vs 28.2%), percentage of pregnant cows at 170 DIM (74.8 vs 79.4%), and incidence of cystic ovarian disease (8.1 vs 6.1%) did not differ. Average days open for pregnant cows was similar between BUPCP and WUP (91.0 vs 89.8). However, incidence of abortions was greater for cows fed BUPCP vs WUP (8.5 vs 4.1%;  $P < 0.05$ ). Percentage of cows dead or sold was similar, and DIM when cows left the study (dead or sold) did not differ between treatment groups. Nevertheless, cows fed BUPCP tended to have a greater incidence of lameness (17.6 vs 13.1%;  $P < 0.08$ ), but a lower incidence of mastitis (10.6 vs 18.6%;  $P < 0.003$ ) than those fed WUP. No dead cow showed any lesions compatible with gossypol toxicity. Replacement of whole

Upland cottonseed with a blend of whole Upland and cracked Pima cottonseed did not affect reproduction and health of lactating Holstein dairy cows.

**Key Words:** Cottonseed, Gossypol, Dairy cows

**1516 Bloodmeal and fishmeal addition to receiving diets.** J. W. Lehmkuhler\*<sup>1</sup>, E.E.D. Felton<sup>1</sup>, C.J. Fu<sup>1</sup>, and M. S. Kerley<sup>1</sup>, <sup>1</sup>University of Missouri.

Two experiments were conducted to evaluate the response of a 1:1 bloodmeal and fishmeal combination (BMFM) in receiving cattle. In experiment one, Simmental calves (six heifers and 30 steers) were randomly assigned to nine pens. Cattle were fed a corn and corn silage based diet. Treatments included a soybean meal (SBM) control, low, and high BMFM. Dietary CP was calculated to be 13%, 13%, and 16%, respectively. Intake was restricted during the first 21 d to model low intake responses of newly received cattle to ruminally undegradable protein (RUP) and was increased the following 25 d. Initial, mid-term, and final weights were similar ( $P > .1$ ) among treatments averaging 347, 351, and 380 kg, respectively. Similarly, no treatment differences were observed for ADG or GF during the 21d restriction period, step-up period, or for the entire receiving period. In experiment two, sixty Angus-sired calves were randomly assigned to twelve pens in a 2X2 factorial design of treatments. Treatments investigated were level of crude protein (low-13%CP vs. high-16%CP) and form of protein (SBM vs. BMFM). Diets consisted of corn, late-bloom alfalfa hay, and the pelleted supplemental treatments. Diets were fed at similar levels for all treatments for 21 d. No treatment differences ( $P > .1$ ) were observed for initial and ending weights (305 and 330 kg, respectively). Form or level of protein had no effect ( $P > .1$ ) on ADG. Average daily gain for treatments were 1.1, 1.2, 1.3, and 1.2 kg/d for the low SBM, low BMFM, high BMFM, and high SBM, respectively. Due to the similar intakes and lack of response in ADG, treatment differences were not significant for GF and averaged 0.16. Though not statistically significant, a numerical difference in the interaction for FG was observed. Feed conversions were 9.1, 6.9, 6.9, and 7.7 for the low SBM, low BMFM, high BMFM, and high SBM, respectively. We inferred that addition of RUP and level of protein may alter performance and efficiency of receiving cattle. Further studies are warranted to investigate the relationship between level and form of protein in relationship to energy intake of newly arrived cattle.

**Key Words:** feedlot, receiving, ruminant

## AMSA Graduate Student Research Posters (M.S. and Ph.D. Divisions) and AMSA General Abstracts

**1517 Oxymyoglobin and lipid oxidation in  $\alpha$ -tocopherol supplemented pork liver microsomes.** S Lee\*, A L Phillips, and C Faustman, *University of Connecticut, Storrs, CT.*

The biological antioxidant,  $\alpha$ -tocopherol, has been used endogenously or exogenously to delay oxymyoglobin (OxyMb) and lipid oxidation in meat.  $\alpha$ -Tocopherol quenches free radicals originating from lipid oxidation and this, in turn, appears to protect OxyMb against oxidation. In muscle membranes,  $\alpha$ -tocopherol is located close to membrane-bound enzymes that generate free radicals, and acts to protect membrane lipids by scavenging free radicals. An OxyMb porcine microsome model was used to study the effects of  $\alpha$ -tocopherol on OxyMb or lipid oxidation *in vitro*. Pork liver microsomes were isolated from pigs fed either a control or vitamin E-supplemented diet (Phillips et al., 2001, Meat Sci., In press), and combined with horse heart OxyMb prepared by hydroxylite-mediated reduction. OxyMb (0.15 mM) was incubated with microsomes (1mg/ml) at 25 and 37 °C, pH 5.6. During incubation, OxyMb oxidation was measured spectrophotometrically by use of a diffuse-integrating sphere, and percent metmyoglobin (MetMb) was calculated. Lipid oxidation was measured by a thiobarbituric acid reactive substances (TBARS) method. MetMb formation increased with increasing temperature, and was greater at 37 °C than at 25 °C ( $P < 0.05$ ). At 37 °C, MetMb reached 50% within 2 hours incubation, whereas 8 hours was required at 25 °C. There was no significant effect of  $\alpha$ -tocopherol on delaying OxyMb oxidation either at 25 or 37 °C. Lower TBARS were observed in microsomes from vitamin E-supplemented than control pork livers ( $P < 0.05$ ). These results differ from those observed with beef mus-

cle microsomes where both OxyMb and lipid oxidation were delayed with elevated  $\alpha$ -tocopherol levels.

**Key Words:** Oxymyoglobin, Lipid oxidation,  $\alpha$ -Tocopherol

**1518 Effect of high oil corn and vitamin E supplementation on beef steak case-life properties.** M.S. Eibs\*<sup>1</sup>, B.J. Johnson<sup>1</sup>, D.M. Wulf<sup>1</sup>, B.C. Shanks<sup>1</sup>, and T.A. Wittig<sup>1</sup>, <sup>1</sup>South Dakota State University.

The objective of this experiment was to investigate the effects of high oil corn and vitamin E supplementation on steak case-life properties. Steers ( $n = 84$ ) were fed a high concentrate diet consisting of either typical corn (C: 79.5% of ration) or high oil corn (HOC: 79.5% of ration) for 112 days with (+E) or without (-E) vitamin E supplementation during the last 50 d (1,000 IU/hd/d). Steaks (2.54 cm thick) were removed 24 h postmortem from the 12th rib and utilized in retail display panel (RDP), thiobarbituric reactive substances determination (TBARS), and tocopherol analysis. Two storage treatments were used prior to RDP: 1) domestic chilled (DC), chilled storage for 13 d postmortem; and 2) export chilled (EC) chilled storage for 34 d postmortem. Steaks were appraised for 9 d (d 0 to 8) under simulated retail meat display conditions by a 5-member panel and color was measured with a Minolta colorimeter. On d 8, TBARS of RDP samples were determined. HOC grain contained more ( $P < 0.05$ )  $\alpha$ - and  $\gamma$ -tocopherol than C grain (14.62 and 84.90 vs 8.01 and 41.68 ppm). Ribeye steaks +E contained higher ( $P < 0.05$ ) levels of  $\alpha$ -tocopherol than ribeye steaks -E. Steaks from HOC had higher concentrations of  $\gamma$ -tocopherol than C steaks ( $P$

<.01). Steaks -E had higher concentrations of  $\gamma$ -tocopherol than steaks +E ( $P < .03$ ). Rate of discoloration, as appraised by RDP, was slower ( $P < .05$ ) in HOC+E steaks than in HOC-E steaks for DC and EC storage treatments. In both the DC and EC storage treatment steaks +E had lower ( $P < .01$ ) TBARS than steaks -E. These data suggest supplementing vitamin E while feeding high oil corn in diets for finishing beef steers does not improve beef steak case-life properties beyond typical corn diets with vitamin E supplementation.

**Key Words:** High Oil Corn, Beef, Tocopherol

**1519 Evaluation of growth rate, carcass composition and meat quality of Berkshire- and Yorkshire-sired progeny.** M.J. Ritter\*, C.P. Allison, S.R. Debar, J.M. Scheffler, R.J. Tempelman, and M.E. Doumit, *Michigan State University, East Lansing, MI.*

Our objective was to examine differences in growth, carcass composition and meat quality traits of crossbred pigs. Berkshire-sired (B; n=16) and Yorkshire-sired (Y; n=16) progeny were blocked by gender, sire and weight at approximately 86 kg. Over the last 27 d of the finishing period, average daily gain (ADG) of Y pigs was 22% greater than B ( $P < .02$ ). Pigs were harvested at a commercial abattoir on two days. Carcass weights did not differ by breed, but Y carcasses were leaner at the tenth rib and last lumbar vertebra, produced heavier hams, more pounds of fat-free lean and lighter bellies than B ( $P < .01$ ). *Longissimus* muscle (LM) temperature and pH were measured at 20, 45, 180 min, and 24 h postmortem. Berkshire-sired pigs had higher 180 min and 24 h pH values. Loin chops from B had higher subjective loin color and marbling scores, and lower Minolta CIE L\* values on d 1 postmortem ( $P < .05$ ). A harvest date by breed interaction existed for suspension drip loss and 20 min LM temperature ( $P < .05$ ). This interaction is attributed to disproportionate increases in temperature and drip loss of Y LM on the second harvest day. Berkshire-sired pigs had lower fluid loss from vacuum packaged loin sections stored at 4°C for 7 d than Y ( $P < .003$ ). Yorkshire-sired pigs grew faster and produced more fat-free lean than B, but B pigs had more desirable color and better water holding capacity, presumably due to a more gradual rate of pH decline and higher ultimate pH.

**Key Words:** Meat Quality, Carcass Composition, Growth Rate

**1520 Mechanisms of vitamin D3 on tenderness of lamb.** C. T. Boleman<sup>1</sup>, J. W. Savell<sup>\*1</sup>, W. S. Ramsey<sup>1</sup>, and R. K. Peel<sup>1</sup>, <sup>1</sup>Texas A&M University.

Two trials were conducted to determine the effects of Vitamin D<sub>3</sub> (VITD) on the tenderness of lamb: Trial 1 evaluated ionized Ca levels in blood serum, percent intake (PI), and total gain (TG) on 26 rams assigned randomly to one of eight treatments of VITD. These treatments were supplemented at one of four levels: 0 (SO); 250,000 IU of VITD (S250); 500,000 IU of VITD (S500); or 750,000 IU of VITD (S750) or administered as a bolus of 0 (B0); 250,000 IU of VITD (B250); 500,000 IU of VITD (B500); or 750,000 IU of VITD (B750) for four days. There were no ( $P > 0.05$ ) differences at each day for treatment type for ionized Ca levels in blood serum. Rams assigned to the S500 treatment had lower ( $P < 0.05$ ) PI and TG than other supplemented groups. Trial 2 evaluated carcass composition by analyzing Warner-Bratzler shear (WBS) values of chops from the longissimus lumborum (LL), semitendinosus (ST), semimembranosus (SM), and biceps femoris (BF) from each of the 40 carcasses. Forty feedlot lambs were assigned randomly to one of two treatments of a control (CONT) (n=20) or 750,000 IU of VITD (n=20) and fed in a mock feedlot environment for four days before slaughter. There were no differences ( $P > 0.05$ ) for ionized blood Ca levels in blood serum. Vitamin D<sub>3</sub> content in livers and kidneys differed ( $P < 0.01$ ) between VITD vs. CONT (livers - 504.54 vs. 27.13 and kidneys - 1530.20 vs. 21.18 ng/g vitamin D<sub>3</sub>). Carcasses from VITD treated lambs had less ( $P < 0.05$ ) average fat thickness (AFT). (0.68 vs. 0.84 cm) and an increase ( $P < 0.05$ ) in overall conformation (OCS). The four muscles were removed, fabricated into chops, assigned randomly to a postmortem aging day of 5 (AG5), 10 (AG10), or 15 (AG15) for WBS determination. Chops from the LL did not differ ( $P > 0.05$ ) for WBS values for CONT vs. VITD for all aging days; however, chops from the SM and ST had ( $P < 0.05$ ) lower WBS values for VITD vs. CONT at 5d aging. Activation and acceleration of calpain dependent proteases could be responsible for

lower WBS values for AG5 chops however, VITD regulators are most likely preventing VITD from increasing Ca levels in blood.

**Key Words:** Lamb, Vitamin D, Tenderness

**1521 Lean lamb production: Bioelectrical impedance as a lean tissue evaluation method.** P. T. Berg<sup>\*1</sup>, T. C. Faller<sup>2</sup>, and M. N. Maddux<sup>1</sup>, <sup>1</sup>North Dakota State University, Main Station, Fargo, <sup>2</sup>North Dakota State University, Hettinger Research Extension Center.

The objective was to evaluate Bioelectrical Impedance (BIA) to predict weight of retail product (LN) in lambs. Carcasses (n=217) were subjected to BIA evaluation 24 h post slaughter. Resistance (Rs), reactance (Xc), length (L) between electrodes and temperature (T), and standard carcass data was recorded. Carcasses were reduced to wholesale cuts according to NAMP specifications. Cut weights were recorded before and after fat was trimmed from shoulder, rack, loin and leg. Lean was exposed over at least 85% of the surface. Sum of the four trimmed wholesale cuts (ACT) was used as dependant variable. An anatomical measurement (LNa) and a BIA based prediction formula (LNb) were developed (Proc. GLM of SAS). Formulas are: LNa = 4.8 + (0.58\*c carc wt) + (1.39\*REA) - (7.36\*12th rib fat) - (5.87\*body wall). LNb = 6.72 + (0.4818\*c carc wt) - (0.0314\*Rs) - (0.0481\*Xc) + (0.254\*L) + (0.0223\*T). R<sup>2</sup> for LNa = 0.94 and for LNb = 0.91. A second group of lambs (N=182) was used to validate the BIA formula. High R<sup>2</sup> for LNa suggested potential product loss, time and labor expenses could be minimized using LNa as dependant variable in validating LNb. LNb predictions had an R<sup>2</sup> = 0.93 when using LNa as dependant variable. Second group (n=182) was also subjected to live BIA evaluation. BIA is non-invasive, causes minimal discomfort, rapid and equipment is affordable. A BIA prediction formula was developed using Rs, Xc, L and live weight: LNI = 0.973 + 0.3118\*live wt) + (0.017\*Rs) + (0.1739\*Xc) + (0.0102\*L) The R<sup>2</sup> between LNI and LNa (dependant variable) = 0.79. Formulas, LNa, LNb, and LNI were validated on 48 Columbia lambs. Live and carcass predictions, using both anatomical and BIA measures were calculated. Dependant variable was ACT. R<sup>2</sup> values were 0.82, 0.84 and 0.80 for LNa, LNb and LNI respectively. Data indicate BIA can accurately evaluate weight of LN and has application for both value-based marketing of carcasses and in live animal selection.

**Key Words:** lamb meat, Bioelectrical impedance, evaluation

**1522 Impact of HACCP implementation on the Kansas meat and poultry processing industry.** E. Boyle<sup>\*1</sup>, D. Hoffman<sup>1</sup>, and M. Schoenbeck<sup>2</sup>, <sup>1</sup>Kansas State University, Manhattan, KS, <sup>2</sup>Food Brands, Hutchinson, KS.

Profiles were developed from surveys distributed in 1997 and 2000 to assess the impact of HACCP on federal, state and custom meat and poultry establishments in Kansas. Randomly coded surveys included a cover letter and a stamped, self-addressed return envelope. Reminder postcards were sent one week after surveys were initially mailed. Of 221 surveys sent in 1997, 51.6% responses were received, while a response of 39.1% was received in 2000 from 225 distributed surveys. Nearly 70% of respondents to the 2000 survey responded to the 1997 survey. Overall, inspection status changed for nine plants from 1997 to 2000, 82% of respondents had employees who received some form of HACCP training, 87% of plants had a HACCP program with an average of four HACCP plans per plant, and 60% of respondents spent 45 minutes or less each day filling out, filing or reviewing HACCP paperwork. There was minimal change in the amount or type of product produced as a result of HACCP. Six plant characteristics changed from 1997 to 2000 ( $P < 0.05$ ). Plant managers/owners receiving meat training through an apprenticeship declined from 22% in 1997 to 9.4% in 2000. The use of computers in meat and poultry processing businesses increased from 47.3% to 61.4%. The average year of latest plant renovation moved from 1987 (1997 survey) to 1990 (2000 survey). Nearly three-quarters of respondents had undergone renovations since their facilities were constructed. The last renovation occurred as long ago as 1960 or as recently as 2000. The percent of plants that processed franks decreased from 20% in 1997 to 9.3% in 2000. The use of a phonebook as an advertising medium increased from 42.2% in 1997 to 57.7% in 2000. From 1997 to 2000, the industry changed their emphasis on who they relied on for obtaining meat and poultry information. The use of a government inspector for information declined from 75.9% to 63.3% while consulting university resources increased from 38.9% to 64.6%. Additionally, the use of other

information sources such as the Internet increased from 2.8% to 8.9%. While there have been some changes to the Kansas meat and poultry processing industry as a result of HACCP, the overall impact on the parameters in this survey has been minimal.

**Key Words:** HACCP, Industry profile, Kansas

**1523 Development and Evaluation of an Advanced HACCP Workshop for Meat Processors.** Mindy Brashears<sup>1</sup>, Dennis Burson<sup>1</sup>, Liz Boyle<sup>2</sup>, Fadi Aramouni<sup>2</sup>, Jason Mann<sup>1</sup>, and Mark Murphy<sup>2</sup>, <sup>1</sup>University of Nebraska, <sup>2</sup>Kansas State University.

A one-day advanced HACCP workshop was developed by Extension Specialists at the University of Nebraska and Kansas State University. The overall goal of this workshop was to increase the knowledge of small meat processing establishments to enable them to more effectively manage HACCP systems in their facilities. Topics discussed in the workshop included; HACCP verification, HACCP validation and experimental design, sampling plans, USDA in-depth verification reviews (IDV), reassessment, auditing, HACCP-based inspection model programs (HIMP), and the relationship of HACCP to total quality management (TQM) programs and statistical process control (SPC). The workshop was delivered as a pilot test program to processors to ensure that the content addressed current needs of the industry. The format for topic delivery was 30 min presentations by Extension Specialists. Additionally, participants completed working group activities that allowed them to design studies to validate or change CCPs in a plan, to apply pathogen modeling programs to specific processes and to subject data collected during HACCP monitoring to SPC in order to identify trends. The participants completed an evaluation after each activity and a focus group analysis was conducted at the end of the workshop. While most participants were familiar with the topics covered, 100% of them indicated that presentations contained information that would be useful in their business. The working group exercises were also helpful to most participants with 60% and 87% of the participants indicating that the HACCP validation case studies and SPC activities would be useful, respectively. Focus group results also indicated that all topics were important to meat processors in the day to day management of their plans. They indicated that on-going HACCP training was important to them and that the advanced topics covered in this workshop should continue to be included in future advanced workshops. They indicated that one-day workshops were a good form of training because they resulted in a relatively small amount of time away from their business and kept them up to date on current issues. Based on these results, the advanced HACCP course will continue to be offered in a similar format delivered to the pilot group.

**Key Words:** HACCP, Verification, Validation

**1524 Development of a Beef Myology and Muscle Profiling Cd-rom.** S.J. Jones\*<sup>1</sup>, C.R. Calikins<sup>1</sup>, K.S. Podany<sup>1</sup>, D.E. Burson<sup>1</sup>, and B.L. Gwartney<sup>2</sup>, <sup>1</sup>University of Nebraska, <sup>2</sup>National Cattlemen's Beef Association.

The beef carcass is made up of over one hundred different muscles with different properties that affect processing characteristics and consumer acceptability. Today, the majority of the cuts found in the retail meat counter are boneless, therefore by providing the need for knowledge of the musculature of the beef animal. It is possible to develop a CD-ROM that will serve as a resource for the muscular anatomy of the beef animal. The objective of this project was to develop an electronic manual of the muscular anatomy, and a chemical and physical profile of the 39 muscles located in the chuck and round wholesale cuts. Muscle profiling data were collected in a separate project conducted by Dr Chris Calkins of the University of Nebraska, and Dr. Dwain Johnson of the University of Florida. Additional information on each muscle was collected, including: name, origin, insertion, action, innervation, blood supply, wholesale and retail cut location. Six different sections were developed to view the muscular and skeletal anatomy of the carcass: cross-sections, lateral views, sub-primal views, skeletal views and muscle and bone descriptions by scientific and common name. Using any one of the sections, one can access the data. Visual images were collected by cutting 2.54 cm cross-sections from the side of a 340 kg carcass, producing 86 cross sections. A second side was split into hind and fore quarters, then individual muscles were removed and the carcass portion was photographed. Drawings were developed for each picture, and the

muscles were identified and linked to their respective information. Using Institutional Meat Purchasers Specifications, sub-primal cuts were prepared and photographed every 22.5 degrees to obtain a 360 degree view. A strobe lighting system was used in lighting the cross-sections and lateral layers during photography. Photographs were digitized to JPEG format for use in CD-ROM development. Programming of the CD-ROM was done using HTML language and JAVA script so that the program could be used with a web browser on a computer. Drawings that were made of each cross-section and lateral view were formatted as GIF files and linked to each muscle information file. The Beef Myology and Muscle Profiling CD will be a valuable resource for both industry and academia.

**Key Words:** Beef, Myology, CD-Rom

**1525 Microbial condition of aged lamb meat treated with 1% acetic acid.** E.C. Vasconcelos<sup>1</sup>, J.F.F Zapata\*<sup>1</sup>, E.A.T. Figueiredo<sup>1</sup>, and M.A.A. Castelo-Branco<sup>1</sup>, <sup>1</sup>Universidade Federal do Cear, Fortaleza, CE, Brasil.

Organic acids intended to control microbial contamination on meat surface have been used as 1 to 2% acetic or lactic acid solutions or as a combination of both. The objective of this study was to verify the effect of a single dip in 1% acetic acid solution on microbial condition of lamb meat during aging. Lamb shoulders were collected under commercial practices and cut into meat and bone steaks about 3 cm thick. Steaks were dipped for 1 min in either 1% acetic acid solution or distilled water. Steaks were individually packaged in nylon-polyethylene bags and vacuum-sealed before storing at 1 C. On days 3, 13, 23, 33 and 48 of aging meats were analyzed for mesophilic and psychrophilic bacteria, mold and yeast, total and fecal coliform bacteria, Salmonella and sulfite-reducing Clostridia. Mesophilic and psychrophilic bacterial counts were lower ( $p < 0.05$ ) in meats treated with acetic acid on days 13 and 23 and on days 3 and 13, respectively. Although mold and yeast counts were generally lower in meats treated with acetic acid as compared with the untreated meats this effect was significant ( $p < 0.05$ ) only on days 3 and 13 of aging. On day 3 of aging treated meats were significantly ( $p < 0.05$ ) lower in both total and fecal coliform counts than untreated meats. This difference was not observed with 13, 23, 33 and 48 days of aging although the counts for these types of microorganisms were lower than  $1.2 \log \text{cfu g}^{-1}$  in this period. Meat samples were found positive for Salmonella with 3, 13 and 23 days of aging and negative with 33 and 48 days of aging. Sulfite-reducing bacteria were absent in meat samples all through the experimental period. It can be concluded that dipping lamb meat pieces in acetic acid 1% for one minute followed by vacuum packaging and cold storage (1 C) can keep low counts of mesophilic, psychrophilic, and coliform bacteria, as well as mould and yeast for 13 days. During this period, however, Salmonella is not inhibited by the acid treatment.

**Key Words:** Meat aging, Coliform bacteria, Salmonella

**1526 Comparison of recovery methods for freeze-injured Listeria monocytogenes, Salmonella Typhimurium and Campylobacter coli associated with cell suspensions and pork surfaces.** V. P. Chang\*, E. W. Mills, and C. N. Cutter, Penn State University, University Park, PA 16802.

Freezing, heating, or acidification are known to adversely affect pathogenic microorganisms on meat surfaces, resulting in either death or injury. Injured cells resulting from such treatments may not grow during conventional microbiological procedures due to the presence of compounds or dyes in the media that impair the cell's ability to repair. Therefore, quantification of injured cells is important to ensure overall treatment effectiveness. Recovery of injured cells can be accomplished by combining selective and non-selective media into a single system. With such combinations, the diffusion of the selective compounds or dyes is controlled, allowing for resuscitation of injured cells of interest, while also inhibiting the growth of undesirable background microflora. To date, very little information exists on recovery methods for freeze-injured cells associated with pork surfaces. In this study, Listeria monocytogenes, Salmonella Typhimurium and Campylobacter coli suspended in buffer or associated with pork surfaces were subjected to a freeze-thaw cycle (-15C for 24 h; 4C for 4 h). Following treatments, freeze-injured cells were plated onto media incorporating the following recovery methods: overlay (OV); thin agar layer (TAL); or Lutri plate (LP) method. Media used in this study include: Modified Oxford agar

and trypticase soy agar (TSA) for isolation of *L. monocytogenes*; Xylose Lysine Decarboxylase agar and TSA for isolation of *S. Typhimurium*; Campylobacter blood-free and Brucella agar for isolation of *C. coli*. The recovery rates for the pathogens using the TAL and OV methods following freeze treatments in cell suspensions or on pork surfaces were not statistically different ( $P>0.05$ ) from recovery rates associated with non-selective media. The results presented in this study demonstrate that OV and TAL are reliable and consistent recovery methods for isolation of freeze-injured cells. The TAL method was not only easier to perform, but also allowed for improved isolation of single colonies for further characterization. Further research will utilize the TAL method to determine the effectiveness of blast- and commercial-chilling processes to reduce pathogenic bacteria associated with pork surfaces.

**Key Words:** Pork, Freeze-injured, Pathogens

**1527 Incorporation of nisin into a collagen film retains antimicrobial activity against *Listeria monocytogenes* and *Brochothrix thermosphacta* associated with a ready-to-eat meat product.** B. J. Miller\* and C. N. Cutter, *Penn State University*.

The foodborne pathogen, *Listeria monocytogenes* (LM) is associated with a variety of ready-to-eat (RTE) meat products. Vacuum packaged, refrigerated meats also may be contaminated with spoilage organisms such as *Brochothrix thermosphacta* (BT). The antimicrobial peptide, nisin, is known to inhibit LM and BT on meats. Nisin is currently approved for use in some foods. In this study, collagen films were soaked in a nisin solution and dried to produce biologically active nisin-incorporated collagen films (NICF). Frankfurters were wrapped with NICF or collagen films without nisin (Control), vacuum packaged, heated (30 min, 100C), cooled, and inoculated with approximately  $3 \log_{10}$  CFU/g of LM or BT. Inoculated, NICF and control frankfurters were subjected to refrigerated storage (4C) for up to 14 days or temperature abused (24 h, 25C) and refrigerated (4C) for up to 14 days. Immediately after treatments and following refrigerated storage at days 4, 7, and 14, BT was reduced greater than  $1.4 \log_{10}$  CFU/g; whereas LM was not reduced greater than  $0.6 \log_{10}$  CFU/g. Following temperature abuse and 14 days of refrigerated storage, BT and LM were reduced by approximately  $1 \log_{10}$  CFU/g. This research is the first to demonstrate the incorporation of nisin into a collagen film retains activity against bacteria associated with RTE meat products.

**Key Words:** Collagen film, Nisin, Ready-to-eat meat

**1528 Survival of *Listeria* spp. following bacon processing.** L. J. Heffner\*, S. L. Flowers, S. L. Hestand, G. L. Kehres, S. Doores, E. W. Mills, and C. N. Cutter, *Penn State University*.

Some meat processors are packaging bacon and RTE meats in the same room. There is concern that because bacon is not a thoroughly cooked product, there is the potential for *Listeria monocytogenes* to survive the curing and smoking process and cross contaminate RTE meats in the packaging room. To address this issue, the individual and combined effects of bacon processing against *Listeria* spp. were reviewed. For the first experiment, pork bellies were inoculated with *Listeria innocua* to obtain approximately  $4 \log_{10}$  CFU/g. Inoculated bellies were left untreated (U), injected with sterile distilled water and smoked (liquid smoke and heat treatment to an internal temperature of 53C; IWS), injected with a cure solution (water, sodium phosphate, brown sugar, salt, nitrate, and sodium erythorbate) and smoked (ICS), or injected with cure solution only (IC). Microbiological samples were obtained immediately after treatments (day 0), after 24 hours of refrigerated storage (4C; day 1), and after 9 days of vacuum packaged, refrigerated storage (day 9). Results from the first experiment indicate that immediately following treatments and after vacuum packaged, refrigerated storage, curing alone (IC) does not afford any reductions of *L. innocua*. However, smoking with water or cure (IWS or ICS) reduces the organism greater than  $2 \log_{10}$  CFU/g ( $>99\%$ ). Subsequent microwave cooking of the bacon to simulate consumer handling resulted in no detectable growth of *L. innocua*. For the second experiment, pork bellies were inoculated with *Listeria monocytogenes* to obtain approximately  $3 \log_{10}$  CFU/g. Inoculated bellies were left untreated (U), injected with sterile distilled water and smoked (IWS), or injected with a cure solution and smoked (ICS). Microbiological samples were obtained immediately after treatments (day 0), after 24 hours of refrigerated storage (4C; day 1), and after 7 days of vacuum packaged, refrigerated storage (day

7). Results from the second experiment indicate that immediately following treatments and after vacuum packaged, refrigerated storage, *L. monocytogenes* was reduced approximately  $3 \log_{10}$  CFU/g ( $>99.9\%$ ) to undetectable levels by either the IWS or ICS treatments. This information demonstrates that the bacon process appears to significantly reduce populations of *Listeria* spp.

**Key Words:** *Listeria* spp., Bacon, Survival

**1529 Effects of Electrolyzed Oxidizing Water on Microbial Growth, Lipid Oxidation and Color of Displayed Beef during Refrigerated Storage.** Seon-Tea Joo\*<sup>1</sup>, Kumar Venkitanarayanan<sup>2</sup>, and Cameron Faustman<sup>2</sup>, <sup>1</sup>*Gyeongsang National University, Chinju, Korea*, <sup>2</sup>*University of Connecticut, Storrs, CT, USA*.

Electrolyzed oxidizing water (EO water) produced by the electrolysis of water containing sodium chloride has been reported to possess strong antimicrobial properties. The major antimicrobial elements in EO water include a low pH of 2.7, an oxidation-reduction potential of  $>1,100$  mV, and a free-chlorine level of 10 to 80 ppm. The effects of EO water on microbial growth, lipid oxidation and color of displayed beef during 4°C storage were evaluated. Beef cores (3cm diameter  $\times$  1.5cm thick) from longissimus muscle were prepared, and then dip-treated in distilled water (pH 7.2; control) or EO water (pH 2.5; treatment) for 1, 5 and 10 min at 23°C. Total plate counts, lipid oxidation (TBARS) and color (CIE L\*a\*b\*) were measured at 0, 1, 3, 6 and 9 days of storage at 4 °C. Microbial growth on beef cores was not affected by EO water treatment. The population of all samples was approximately  $7 \log$  CFU/cm<sup>2</sup> after 6 days of display. However, TBARS values of samples subjected to 5 and 10 min of EO water treatment tended to be higher than those of control and 1 min EO water treatment after 6 days. Differences in TBARS between control and 1 min EO water treatment appeared negligible. Samples subjected to EO water treatment showed slightly higher CIE a\* values compared to controls, while CIE L\* and b\* values did not appear to differ among treatments during 9 days of storage. Results were not as conclusive as earlier demonstration of antimicrobial effects of EO water on fruit/vegetables and kitchen cutting boards.

**Key Words:** Electrolyzed Oxidizing Water, Microbial Growth, Meat safety

**1530 Thermal conductivity model for predicting heat penetration in non-stirred raw rendered products.** A. K. Greene, C. S. Knight, W. B. Bridges, and P. L. Dawson\*, *Clemson University*.

Samples of raw beef, pork and poultry rendered products were collected and analyzed for percent moisture, fat, and bone. The nine mixtures of raw rendering materials were examined in heat penetration studies in a Loveless still retort using a TechniCAL CALPlex 32 Datalogger, Ecklund needle thermocouples, 300x406 two piece steel cans and TechniCAL CALSoft data collection software. Throughout the heating process, a datalogger collected heat data at 10 second intervals and recorded the data on CALSoft software (TechniCal, Inc., New Orleans, LA). All samples were processed to at least a 12D process. The computer software was programmed to use a z value of 18°F (10°C). The computer software recorded accumulated D values and reported length of time to reach a 12D process. Using the collected thermal data, models were created to describe the heat conductivity into each product mixture. The "best fit" non-linear regression model was a logistical function. A logistic function was fit for each replicate of the treatments and compared to the quadratic linear models for each replicate. In all cases, the logistic model produced a much smaller residual or Sum of Squares for Error (SSE) indicating an overall better fit than the quadratic linear model. The logistic model would be recommended for future analysis.

**Key Words:** Rendering, Thermal process, Food safety

**1531 Analyzing Plant Sanitation Processes using Statistical Process Control Techniques.** K.J.K Getty\* and J.G. Surak, *Clemson University, Clemson, SC*.

Microbiological testing is an effective tool for verifying sanitation programs in meat and poultry operations. The objectives of this study were: 1) to determine if line employees, as represented by university students and employees, not only can clean and sanitize processing equipment but

also can perform microbiological environmental sampling, which evaluates the sanitation process; 2) to develop appropriate microbiological environmental processing specifications (CFU/cm<sup>2</sup>) for equipment and facility areas; and 3) to determine if data from sampling can be analyzed using statistical process control. A 3M Quick Swab and a 15 X 10 cm template were used to swab facilities and equipment. The swab diluent was poured directly onto one of three 3M petri films (aerobic plate counts (APC); yeast and molds (YM); or *E. coli* and coliforms (EC)). Samples were collected nine times over a seven month period resulting in approximately 35 samples per each film type. The APC counts for the contact meat surfaces prior to cleaning and after cleaning ranged from 0.147 to 2.48 and <0.007 (detectable limit) to 0.25 CFU/cm<sup>2</sup>, respectively, whereas, non-contact surfaces; facility areas; and drains ranged from 0.013 to 0.68; <0.007 to 0.013; 0.153 to 1.78 CFU/cm<sup>2</sup>, respectively. The EC counts for contact surfaces ranged from <0.007 to 0.027. The YM counts for contact surfaces ranged from <0.007 to 0.127 and <0.007 to 0.207 CFU/cm<sup>2</sup> for yeast and mold, respectively. Data were analyzed using simple statistical process control tools (individual moving range control charts, and capability analysis), thus, allowing the identification of sanitation problems in the plant and development of improvement strategies by students and management. This resulted in decreased counts over time. Companies can utilize microbiological testing procedures and link the results to statistical process control techniques to improve the verification of their sanitation programs.

**Key Words:** plant sanitation, statistical process control, microbiological testing

**1532 Recombinant production of chicken egg-yolk antibodies against Enterotoxigenic *Escherichia coli* by use of a DNA vaccine.** S.H. Cho\*, P.C. Loewen, and R.R. Marquardt, *University of Manitoba, Winnipeg, MB, Canada, R3T2N2.*

DNA vaccines have been shown to elicit both cellular immunity and humoral immunity in animals. Recent reports have suggested that the administration of vaccines consisting of plasmid DNA may significantly enhance long-lasting antigen specific immune responses. The objective of this study was to investigate the efficacy of DNA vaccines against *Escherichia coli* K88 and K99 in mouse and chicken models. Mice and laying hens were injected with; DNA alone, protein alone, and DNA plus protein then the antibody titres in serum and egg yolk were determined by ELISA. The DNA plus protein injection induced higher and long-lasting antibody titre in both mice and chickens compared to that obtained with DNA or protein alone. Also the antibody titre of DNA plus protein injection after 24 weeks was nearly equal to the maximum values obtained after 8 weeks with either alone. The antibody titre after 40 week was almost 10-fold higher for the DNA plus protein injection compared to that of protein injection alone. The data demonstrates that a DNA vaccine can elicit an antibody response in both mammalian (mice) and avian (chicken) species. It also demonstrates that DNA vaccines injected with their corresponding antigen have the ability to considerably enhance subsequently antibody titre in the blood of mice and the egg-yolk of laying hens. The antibodies produced in the yolk of the chicken against *E. coli* can be used to passively control diarrhoea in young pigs and dairy calves.

**Key Words:** Egg yolk antibodies, DNA vaccines, Enterotoxigenic *Escherichia coli*

**1533 Decreasing cost in processed meat products with the addition of pork collagen.** D.R. Doerscher\*<sup>1,2</sup>, G. Prabhu<sup>1</sup>, and E. Schoenberg<sup>1</sup>, *<sup>1</sup>Proliant Inc., <sup>2</sup>Iowa State University.*

Pork collagen is a cost-effective, functional ingredient that can improve the quality of various meat products due to its water binding and gel forming capabilities. In many types of meat products, it is not only capable of improving yield, texture and purge, but it can provide cost savings as well. This is especially important from a processor standpoint because it can help improve profitability without sacrificing product quality. Cost savings are achieved by utilizing rehydrated pork collagen to replace more expensive ingredients, such as lean meat or other binders. For example, in a typical reduced fat hotdog formula, the replacement of pork 72's with 1% pork collagen hydrated 1:4 can produce yielded cost savings of approximately 2.5%. Pork collagen also performs well in other comminuted products. In a 97% fat free pork breakfast sausage with the same replacement rate, a savings of 3.8% may be obtained when ham trimmings are substituted. Increasing the usage level to 2% in these systems will also provide cost savings while maintaining product quality. The FDA recognizes pork collagen as a binder and

purge reducing food additive in meat products at usage levels up to 3.5%. However, many meat products have USDA standards limiting the use of binders and added water. Nonetheless, its use is currently permitted in non-standard meat products that permit binders as well as many types of products identified with nutrient content claims. As the use of pork collagen expands, it will be beneficial when maximizing non-meat protein in cooked sausages allowing increased flexibility in maximizing added water. This and other economic advantages of pork collagen will potentially yield high returns to the meat processor.

**Key Words:** Pork collagen, Cost savings, Processed meats

**1534 Evaluation of wet salting in the "Charqui" processing.** M. Pinto Neto\*<sup>1</sup>, H.A. Arima<sup>1</sup>, R.O. Villarreal, S.B. Toma, and M.L.Q. Andrade, *<sup>1</sup>Instituto de Tecnologia de Alimentos, Campinas, Sao Paulo, Brazil.*

"Charqui", a salted and dried beef product, very popular in Brazil, is usually obtained by wet and dry salting followed by sun drying. This product is stable at ambient temperature and is classified as intermediate moisture food. The wet salting (WS) may be done by injecting or tumbling the meat with a brine. The objective of this study was to evaluate the WS process through tumbling, using a central composite non factorial surface design. Boneless beef flank were tumbled with saturated NaCl brine (26°Baumé). The independent variables tested at two levels plus a central point included proportion brine:meat (PBM) at levels 1:0.5, 1:1 and 1:2, brine temperature (TB) at levels 10, 15 and 20°C, and tumbling time (TT) at levels 20, 30 e 40min. The dependent variables NaCl percentage (Cl%), moisture percentage (W%), water activity (aw), and pH were determined after tumbling. The data were analyzed using the package STATISTICA V.5. The mathematical models obtained were  $Cl\% = 5.6581 - 1.4062 * PBM + 0.4237 * TT + 0.2462 * PBM * TT$  and  $W\% = 70.2327 - 1.2337 * TB + 1.6687 * PBM$ . The analysis of variance (ANOVA) for Cl% indicated that the model was significant at  $p < 0.05$ , and had a R<sup>2</sup> value of 0.81. Examination of the fitted coefficients using the F test showed that PBM was significant, while TT and TB were not. The effect of PBM on the Cl%, was inversely proportional. The Cl% in the meat increased varying from 3.5% to 7.0%, as the PBM decreased. There was a positive influence of TT in Cl%, but it was negligible in the range of the experiment. W% had 63.5% (R<sup>2</sup>0.635) of its variation explained by the regression model which showed no significant lack of fit ( $p < 0.05$ ). TT and PBM had a linear effect on W%, while TB was not significant. The W% in meat decreased from 73% to 67%, as the PBM decreased and TT increased (at fixed TB 15°C). The processing variables PBM, TT and TB did not affect aw and pH.

**Key Words:** Dried meat, Salting, Charqui

**1535 Effect of freezing rate and storage on the functional properties of manufacturing beef.** M.M. Farouk\*, K.J. Wieliczko, and I. Merts, *AgResearch Ltd.*

A prior study found that freezing rate on its own does not affect the functional properties of thawed muscle proteins. This finding led us to hypothesise that it is the interaction between freezing rate and storage temperature and time that affects protein functionality. The present study was designed to validate this hypothesis. Hot-boned semimembranosus muscles (n = 24) from 12 heifers were held at 10°C until rigor. The muscles were assigned to 24 treatment combinations using an incomplete factorial design with two freezing rates (fast, 12.04 mm/h; slow; 0.56 mm/h) x 3 storage temperatures (-18, -35, -75°C) x 5 storage times (0, 3, 6, 9, 12 months). Functional properties (protein solubility, drip loss, water holding capacity, tenderness, cook loss, emulsion activity index, emulsion stability and colour) were determined. The sulphhydryl content and surface hydrophobicity of the extracted proteins were measured and the changes in soluble sarcoplasmic proteins were determined for each treatment using SDS-PAGE. Storage temperature alone had no effect on the functional properties measured. Rate of freezing alone affected only drip loss, which was higher for the slowly frozen samples. Functional properties were mainly affected by storage time and the interaction between storage time and temperature, confirming our hypothesis. It is concluded that, compared to current commercial practice, very fast freezing and ultra low temperature storage—both very expensive operations—do not improve the functional properties of frozen beef. Thus, from a product quality perspective, capital need not be spent on equipment for faster freezing and ultra low temperature storage of manufacturing meat.

**Key Words:** Beef, Freezing rate, Functional properties

**1536 High temperature conditioning prior to rigor onset does not affect the functional properties of beef subsequently chilled rapidly.** M.M. Farouk\*, A.E. Graffhuis, and K.J. Wieliczko, *AgResearch Ltd.*

This study attempts to exploit the advantages of high and low rigor temperatures to develop a processing regime that will deliver manufacturing beef of desired functionality. Non-stimulated hot-boned semitendinosus muscles were held at 30°C until rigor onset then were transferred to an immersion chiller at -5°C until the completion of rigor. Meat quality from this regime was compared to that from a standard manufacturing-beef chilling regime (blast freezing of hot-boned boxed beef, 30°C, air velocity 3 m/s) and a very fast chilling regime (packaged hot-boned individual cuts immersed in brine at -5°C). Samples from the three regimes were held at -18°C for one month, then were thawed at -1°C and analysed. Chilling regime did not affect the pH, colour, emulsion activity index, emulsion stability or protein solubility of the thawed meat. All three chilling regimes equally caused muscle shortening (sarcomere length was 1.63 to 1.73 µm) and toughening on cooking (MIRINZ Tenderometer values were 16.2 to 17.4 kgF). Chilling regime did not affect the consumer acceptability of soft jerky or roasts made from the meat. Consumers found the soft jerky to be more acceptable overall than the roasts. It is concluded that the effect of rigor temperature on muscle functionality tends to mask the effects of other factors, that electrical stimulation may have to be used for the purpose of manipulating rigor temperatures to achieve desired functionality in rapidly chilled hot-boned beef, and that cold-shortened meat which is too tough for making roast beef can be used to produce a highly acceptable soft jerky.

**Key Words:** Beef, Rapid chilling, Functional properties

**1537 Influence of beef cuts and cooking time on color properties of a beef sausage model system.** J.A. Prez-Alvarez<sup>1</sup>, J.M. Fernandez-Gins<sup>1</sup>, J. Fernandez-Lpez<sup>1</sup>, E. Sayas<sup>1</sup>, C. Navarro<sup>1</sup>, A. Aznar<sup>2</sup>, and E. Sendra<sup>1</sup>, <sup>1</sup> *Universidad Miguel Hernandez*, <sup>2</sup> *Universidad Politcnica de Cartagena*.

The influence of beef cuts (lean, dewlap, chop), and cooking time on color evolution during the cooking process was evaluated in a sausage (mortadella type) model system. Four batches of mortadella type sausage (60 units of 200g. each), were manufactured. Nine color determinations were made in each piece following the recommendations of the American Meat Science Association for color measurements in meat and meat products (CIELAB, 1976 color space). Hue (h\*) and chroma (C\*) were calculated according to the following formulas  $h = \text{atan}(b^*/a^*)$  results expressed in degrees, and  $C^* = (a^{*2} + b^{*2})^{1/2}$ . Analysis of variance (ANOVA) with two factors (meat composition: two levels 40:40:20; 20:40:40 lean: chops: dewlap respectively and cooking time 15 levels, 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70 minutes), and Tukey's studentized range test were applied to data (P<0.05). The results of this work are presented in the table. Redness and chroma increased during the cooking time, hue (h\*) and yellowness (b\*) decreased, this last coordinate was not influenced by meat composition. Lightness evolution during cooking time is related to meat composition, and the meaty system (40:40:20) showed the highest lightness and redness.

Cooking time (minutes)	Lightness (L*)	Redness (a*)	Yellowness (b*)	Chroma (C*)	Hue (h*)
0	46.34c	8.86b	13.43f	16.15d	56.88e
5	43.09ab	6.08a	12.10e	13.57b	63.33f
10	40.94a	5.29a	10.59d	11.85a	63.28f
15	41.73ab	5.36a	10.39d	11.71a	62.54f
20	41.54ab	6.37a	9.89cd	11.79a	57.15e
25	42.51ab	8.66b	9.76bcd	13.22b	49.11d
30	42.67ab	10.16c	8.83ab	13.58b	42.05c
35	43.83bc	10.68c	8.73a	14.12bc	41.63c
40	41.76ab	12.27d	8.22a	14.84c	34.24b
45	42.77ab	13.91e	8.50a	16.32d	31.53ab
50	42.85ab	14.71e	9.11abc	17.32d	31.98ab
55	42.40ab	14.91e	8.63a	17.24d	30.15a
60	42.69ab	14.48e	9.01abc	17.08d	31.90ab
65	43.59b	14.37e	8.67a	16.80d	31.14ab
70	43.18ab	14.64e	8.94abc	17.19d	31.53ab
Meat composition					
20:40:40	41.41a	10.44a	9.46b	14.51a	44.35a
40:40:20	44.15b	10.99b	9.85b	15.19b	43.42b

a-c Means within columns with the same letter do not significantly differ (P<0.05)

**Key Words:** color, beef cuts, cooking time

**1538 Antioxidant effect of dried milk mineral in fresh and cooked ground pork.** P. Jayasingh\* and D.P. Cornforth, *Utah State University, Logan, UT.*

The antioxidant effects of dried milk mineral (MM), butylated hydroxytoluene (BHT) and sodium tripolyphosphate (STP) were compared in fresh and cooked ground pork stored at 2C. In fresh ground pork, BHT (0.01% of fat) and all levels of MM (0.5, 1, 1.5, 2%) were effective antioxidants, with TBA values < 0.1 after 8 days storage at 2C compared to TBA values > 0.4 for control and samples with 0.5% STP. In cooked ground pork, 0.5% STP and 2% MM were excellent antioxidants, with TBA values < 1.0 after 15 days storage, compared to TBA values > 8 for controls and samples with BHT. Thus, MM was an effective antioxidant in both fresh and cooked pork. STP had antioxidant activity in cooked, but not in fresh ground pork. BHT had antioxidant activity only in fresh ground pork.

**Key Words:** Antioxidant, Milk, Mineral

**1539 Effect of rosemary extract, sodium lactate and film permeability on the shelf-life of vacuum packaged ground ostrich meat.** A. C. Seydim, Z. B. Gzel-Seydim, I. Y. Han, and P. L. Dawson\*, *Clemson University.*

This research studied the effects of oxygen permeability of films, sodium lactate, and rosemary extract on the shelf-life of vacuum packaged ostrich patties. Ground ostrich patties for each treatment were mixed with 0.02% rosemary extract (AO), 3.3% sodium lactate (SL) and mixture of 0.02% AO and 3.3%SL (MIX). Control (NA) samples containing no additive and samples containing additives were vacuum packaged with high oxygen transmission rate (HiOTR) (4000 cc) and low oxygen transmission rate (LoOTR) (3-6 cc) packaging materials. Samples then were stored at 3±1°C in the dark. Two packages for each treatment were selected at 0, 3, 6, and 9 days to use for pH measurement, 2-thiobarbituric acid (TBA) values, color measurements, and microbiological analysis. There was no significant effect of treatments on pH of meat under different oxygen transmission rate packages OTR (P≥0.05). The pH of ostrich patties ranged from 5.97-6.13. In LoOTR packages, no difference was found between TBA values for all treatments (P≥0.05), whereas in HiOTR packages, AO and SL were significantly different (P≤0.05) than NA and MIX. After 9 day of storage TBA value for NA packaged in HiOTR was 1.64 mg malonaldehyde/kg meat. The control sample had a microbial count of 4.3 CFU/g meat initially. In LoOTR packages, microbial populations (total cell count, coliform, *Lactobacilli* and *B. thermosphacta*) were lower than the HiOTR packages for all treatments. Increase in microbial growth for each treatment was observed during storage, whereas their growth were slowed by addition of SL and MIX to ostrich patties. Samples containing SL and MIX had lower microbial populations than AO and NA. SL and MIX treatments provided 2 log reduction in microbial population during storage in both types of package.

L\*, a\*, b\* values were compared before and after opening the packages for both package type. Total color differences ( $\Delta E$ ) were calculated and reflectance differences ( $\Delta R_{630-580}$ ) were determined. LoOTR packages had better color stability as compared to HiOTR packages. AO had significant effect on the a\* values before and after opening the packages ( $P \leq 0.05$ ). Reflectance difference data showed that LoOTR packaged ostrich patties did not lose their appealing cherry-red color during the experiment.

**Key Words:** Ostrich, Rosemary extract, Shelf-life

**1540** **Functionality of prerigor meat on the chemical, physical, and textural properties of beef patties.** J.R. Claus\*<sup>1</sup>, O. Sorheim<sup>2</sup>, and H.-J. Skarpeid<sup>2</sup>, <sup>1</sup>University of Wisconsin-Madison, <sup>2</sup>MATFORSK.

The objectives were to determine the effects of prerigor grinding, prerigor salt injection, and time of cooking on the properties of beef patties. Four patty treatments (six replications) tested were: 1) prerigor ground, patties manufactured, and immediately cooked; 2) prerigor ground, salted, stored overnight; 3) prerigor muscle injected with brine, stored overnight; and 4) postrigor ground. Treatments started with semimembranosus (SM) muscles removed (45 min postmortem) from non-electrically stimulated bull carcasses. Lean was ground through a 3-mm plate. Uncooked patties contained 1.7% sodium chloride and 13% fat. On a lean-only meat basis, patties contained 25% water and 6% starch (native). Patties were cooked to 79 C. The pH values of all treatments were different ( $P < 0.05$ ) and decreased from treatment 1 to 4 (6.23 to 5.53 raw patties; 6.28 to 5.81, cooked patties). Cooking losses were lower ( $P < 0.05$ ) for the two prerigor ground treatments (7.6% and 8.6%) than either treatment 3 (12.6%) or treatment 4 (17.9%). Protein solubility in patties from treatment 1 (67.2 mg/g) was higher ( $P < 0.05$ ) than treatment 4 (44.6 mg/g), while treatment 2 and 3 were intermediate. Instrumental cooked patty hardness values were highest ( $P < 0.05$ ) for treatment 2 (8.9 kg peak force), followed by treatment 1 (6.9 kg), treatment 3 (5.0 kg), and treatment 4 (2.7 kg). Patties manufactured from prerigor ground or injected beef were springier ( $P < 0.05$ ) than patties from postrigor ground beef. Prerigor ground patties were more cohesive ( $P < 0.05$ ) than patties from the injected or postrigor beef. Patty chewiness followed the same pattern as determined for hardness. Tomography X-ray scans of injected SM muscles indicated that sodium chloride was not uniformly distributed at the onset of rigor. This may explain the lower pH in comparison to the prerigor ground treatments. The surface of the patties from the prerigor ground beef was lighter and more yellow ( $P < 0.05$ ) than the other treatments. Prerigor beef can be used to manufacture high yielding, firm cooked patties.

**Key Words:** Beef, Patties, Prerigor

**1541** **Postharvest interventions to overcome the tenderness problems in meat from older animals.** M.B. Solomon\*<sup>1</sup>, B.W. Berry<sup>1</sup>, J. Stika<sup>2</sup>, and W.G. Moody<sup>2</sup>, <sup>1</sup>USDA, ARS, FTSL, Beltsville, MD, <sup>2</sup>Univ of Kentucky, Lexington, KY.

Previous studies using hydrodynamic pressure processing (HDP) with meat from older animals (cows) have shown no improvements in tenderness. As a result, the assumption was made that HDP affects myofibrillar tissue and not stromal tissue. It was theorized that including a tenderization treatment (e.g., blade tenderization) which might disrupt the intramuscular connective tissue and when combined with HDP might provide successful tenderization of meat from old cows and cuts of meat with excessive connective tissue. Frozen boneless rib (longissimus) muscles (N=4) from ten year old beef cows and two hot boned (<1 hr postslaughter) strip loins, immediately frozen after boning, from one three year old dairy cow were thawed for 48 h at 2 C, then cut into sections. These sections were designated as controls, blade tenderized (BT) only or BT combined with HDP (100 g of explosive @30.5 cm from the meat surface using plastic explosive containers). For the ten year old cows, BT reduced shear force 13% (5.95 vs 5.16 kg), whereas, BT+HDP reduced shear force 21% (5.95 vs 4.71 kg). For the three year old cow, BT reduced shear force 4% (5.38 vs 5.18 kg) while BT+HDP reduced shear force 17% (5.38 vs 4.49 kg). Results suggest that combining BT with HDP may overcome the tenderness problems often encountered with meat from older animals.

**Key Words:** Cow beef, Tenderness, Postharvest interventions

**1542** **Improving tenderness of beef round and sirloin muscles through pre-rigor skeletal separations.** B. C. Shanks\*, D. M. Wulf, B. J. Reuter, J. M. Bok, and R. J. Maddock, South Dakota State University.

Thirty crossbred steers were used to explore and compare tenderness improvements in beef round and sirloin muscles resulting from various methods of pre-rigor skeletal separations. Animals were slaughtered according to industry procedures and at 60 min postmortem one of six treatments was applied to each side: **A)** control, **B)** saw pelvis at the sirloin-round junction, **C)** separate the pelvic-femur joint, **D)** saw femur at mid-point, **E)** combination of B and C, and **F)** combination of B and D. After 48-h, the following muscles were excised from each side: semimembranosus (SM), biceps femoris (BF-R), semitendinosus (ST), and adductor (AD) from the round; vastus lateralis (VL) and rectus femoris (RF) from the knuckle; and gluteus medius (GM), biceps femoris (BF-S) and psoas major (PM) from the sirloin. Following a 10-d aging period, samples were removed from each muscle to determine the effect of treatment on sarcomere length and Warner-Bratzler shear force. Most skeletal separation treatments resulted in longer sarcomeres than controls for SM, AD, ST, and GM muscles. All skeletal separation treatments yielded shorter sarcomeres for the PM as compared to controls. Warner-Bratzler shear force differed among treatments for RF, ST and PM. For RF, treatments C, D, E, and F resulted in lower ( $P < 0.05$ ) shear values than for controls. Treatments B, D, and F increased shear force of the ST relative to controls ( $P < 0.05$ ). Treatment F resulted in higher shear force values for the PM than controls ( $P < 0.05$ ). Correlations between sarcomere length and shear force were found to be low and quite variable among muscles. In general, treatments increased sarcomere length of several muscles from the sirloin/round region, but had mixed effects on shear force values.

**Key Words:** Beef, Skeletal separations, Tenderness

**1543** **Relationship of Pork Quality Traits to Consumer Acceptability.** T.K. Ford\*<sup>1</sup>, R.K. Miller<sup>1</sup>, S.J. Moeller<sup>2</sup>, and R.N. Goodwin<sup>3</sup>, <sup>1</sup>The Texas A&M University, <sup>2</sup>The Ohio State University, <sup>3</sup>National Pork Producers Council.

To understand the effect of pork lean quality attributes and consumer acceptability, a centrally-located, consumer sensory study was conducted in Boston, Chicago, and Denver. Consumers were served 12 samples of either pork loin chop, inside ham chop, and chicken breast combinations. Pork was obtained from the National Pork Producers Council's Quality Lean Growth Modeling Project so that pork loin and inside ham chops varied in pH, intramuscular fat, and Warner-Bratzler shear force (kg). Chicken breasts were commercially purchased in each city. Consumers rated overall like, juiciness like, tenderness like and flavor like using 5-point, end-anchored hedonic scales. Pork consumer responses were affected by city, cut and, the interaction of city by cut ( $P < .01$ ). In Boston, cuts were rated lower in juiciness, tenderness, flavor, and overall like (3.3, 3.4, 3.3, 3.3, respectively) than consumer ratings in Denver and Chicago (3.5 and 3.5, 3.6 and 3.5, 3.4 and 3.4, 3.4 and 3.3, respectively). Consumers liked ( $P < .01$ ) the juiciness, tenderness, flavor, and overall acceptance of the chicken breasts when compared to the loin chops (3.6, 4.1, 3.6, 3.7 vs. 3.3, 3.3, 3.3, 3.2, respectively). Consumers liked ( $P < .01$ ) the tenderness and overall acceptability of the loin chops compared to the inside ham chops (3.3, 3.2 vs. 3.2, 3.2, respectively), but both chops were rated similarly for juiciness and flavor (3.3, 3.3 vs. 3.3, 3.2, respectively). pH category affected consumer acceptability. As pH increased from the low and medium pH categories to the high pH category, juiciness, tenderness, and overall like increased ( $P = .04$ , .0165, and .03, respectively). As Warner-Bratzler shear force values decreased, consumer like ratings increased for juiciness, flavor, tenderness, and overall acceptability ( $P = .0001$ ) for loin chops. Lipid category did not affect consumer sensory responses for juiciness, tenderness, flavor, and overall acceptability ( $P = .20$ , .19, .09, and .18, respectively). As pH increased, consumers liked the juiciness, tenderness, flavor, and overall acceptability of inside ham cuts ( $P < .05$ ). Consumers liked the tenderness of inside ham chops with lower Warner-Bratzler shear force values ( $P < .05$ ).

**Key Words:** pork, consumer, quality

**1544** **Repeatability of Warner-Bratzler shear values in beef steaks using three different cooking methods.** C.R. Kerth\*, L.K. Blair-Kerth, and W.R. Jones, Auburn University, Auburn AL.

Instruments used to cook steaks and chops are often inconsistent because of variability in cooking temperatures across the instrument and

from one instrument to the next. Recently research has shown that belt grills are an effective way to cook steaks and chops very rapidly with high repeatability. However, these belt grills are very expensive. The objective of this research was to compare the repeatability of WBS values from steaks that were grilled using a small kitchen clam-shell grill (GRILL), versus AMSA-recommended oven roasting (OVEN), or oven broiling (BROIL) cooking methods. These small, clam-shell grills cook by direct contact with the steaks on both sides, are inexpensive, and are readily available at department and discount stores. To test the effectiveness of these cooking methods, 12 no-roll boneless strip loins were cut into nine 2.5-cm-thick steaks starting from the anterior end. The steaks then were separated into groups of three: the three anterior steaks, the three middle steaks and the three posterior steaks. Each group of steaks was then randomly assigned one of the three cooking methods (OVEN, BROIL, OR GRILL). Steaks were cooked until they reached a final internal temperature of 71°C. Steaks cooked with the BROIL method were turned at 40°C. After cooling to less than 10°C, six 1.3-cm-diameter cores were removed parallel to the length of the muscle fiber and sheared once across the center using a WBS machine. Cooking time for the GRILL method (7.1 min) was shorter, and the OVEN method (22.8 min) was longer compared to the BROIL cooking method (17.5 min,  $P < 0.001$ ). Percent cooking loss was higher ( $P < 0.001$ ) for the BROIL method compared to either OVEN or GRILL cooking methods. However, final cooking temperatures and WBS values did not differ among cooking methods ( $P > 0.25$ ). WBS values across all cooking methods ranged from 1.5 to 7.5 kg. Repeatability of WBS was relatively high for BROIL ( $r = 0.83$ ), GRILL ( $r = 0.88$ ) and OVEN ( $r = 0.88$ ) cooking methods. These data indicate that, in addition to traditional broiling and oven roasting cooking methods, grilling beef loin steaks with an inexpensive clam-shell grill is an acceptable method for cooking steaks for research purposes.

**Key Words:** Cooking Method, WBS, Clam-shell Grill

**1545 Sample location within muscle affects pork quality measurements.** E.W. Mills\*, S.L. Flowers, and B.M. Moser, Penn State University, University Park PA.

When collecting lean for quality measurements it is customary to take samples from several locations in a muscle cross-section and assume that they represent one population of samples. The purpose of the current work is to test that assumption by evaluating variation in pork quality measurements due to location within a muscle. In the first trial two 25 mm chops were removed from the longissimus thoracis at the tenth rib of 10 market hog carcasses at 24 h postmortem. Twenty-five and 13 mm cylindrical cores were removed near the medial and lateral edges of each chop. Water holding capacity measures were made on the cores - filter paper press method for 0.5g samples from the 13 mm cores and drip loss method for 25 mm cores. Lateral edge samples gave greater ( $p < 0.01$ ) drip loss than medial edge samples after 24 h (5.02 vs. 1.87%) and after 48 h (6.08 vs. 2.63%). Filter paper press results indicated a similar trend in free water % for lateral and medial samples respectively (37.5 vs. 35.7%) but did not indicate a significant difference ( $p > 0.30$ ). In a second trial cores were removed from medial, lateral, ventral and dorsal edges of 25 mm longissimus thoracis chops at 24 hours postmortem for 10 market hogs. In addition to water holding capacity measures as in trial 1, pH, color ( $L^*$ ,  $a^*$ ,  $b^*$ ) and proximate composition were measured. Moisture, protein and fat did not vary significantly ( $p > 0.30$ ) by location. Muscle pH was higher ( $p < 0.02$ ) for medial vs. lateral and dorsal locations with no significant differences among lateral, dorsal and ventral locations. Redness,  $a^*$  value, and yellowness,  $b^*$  value, were significantly higher ( $p < 0.01$ ) for lateral vs. each other location. Percent free water was highest for lateral and ventral locations but did not differ significantly ( $p > 0.30$ ) among locations (lateral - 35.9%, ventral - 35.9, dorsal - 34.3 and medial - 33.4). Fluid loss after 48 h was greater ( $p < 0.05$ ) for lateral (5.94%) vs. medial (4.52%) or dorsal (4.68%) locations. This work shows that muscle water holding capacity and color vary with location in the cross section of the longissimus thoracis and that drip loss measurement is more sensitive than free water (filter paper press) measurement for assessing meat water holding capacity.

**Key Words:** Water Holding Capacity, Drip Loss, Color

**1546 Heat Penetration Patterns Of Biceps Femoris, Longissimus Lumborum And Semitendinosus Muscles Cooked By Electric Broiler, Electric Belt Grill, Or Forced-Air Convection Oven.** E. Obuz, E. J. Yancey, T. E. Lawrence, D. A. King, and M. E. Dikeman, Kansas State University.

The objective of our study was to investigate heat penetration patterns of beef longissimus lumborum, biceps femoris, or semitendinosus muscles cooked by an electric broiler, belt grill, or forced-air convection oven. Subprimals (beef loin, boneless strip loin; beef round, bottom) from USDA Select carcasses were purchased and divided into the respective muscles. Muscles were vacuum packaged and held at 1C for 14 days and then frozen (-37C). Each frozen muscle was sawed into 2.54-cm thick steaks, vacuum packaged, and stored until cooking. Steaks were thawed and held at 4C for 24 h before cooking and were assigned to one of three cooking treatments: an electric belt grill at 163C, a forced-air convection oven at 163C, or an electric broiler (no temperature control). All steaks were cooked to 70C and the center temperature of steaks was monitored using copper-constantan thermocouples. A temperature recorder was used to follow the cooking pattern of steaks and data from the temperature recorder for each steak were retrieved and used to calculate the heat penetration rate for each muscle as min/C. Belt grill cookery gave the highest heat penetration rate for all muscles (three to seven times faster than the other two methods). Within any given temperature range, the semitendinosus required more heat than the other two muscles, which may be explained by its fiber orientation. Up to 40C, heat penetration rate was relatively slow for all muscles. However, heat penetration rate into all muscles decreased above 40C ( $p < 0.05$ ), which likely was because of denaturation of contractile proteins starting at about 40C. The slowest heating rates occurred in the 60-70C interval and can be attributed to collagen shrinkage and protein denaturation. Heat penetration rate between 10 and 20C for the semitendinosus muscle cooked by either forced-air convection oven or electric broiler was almost three times faster than it was between 60 and 70C. Belt grill cookery did not allow us to detect muscle differences in any temperature range because heat transfer was very fast.

**Key Words:** Heat penetration, electric belt grill, forced-air convection oven

**1547 Instruments differ in estimating lightness of fresh meat.** C.P. Allison\*, R.O. Bates, M.E. Doumit, and A.M. Booren, Michigan State University, East Lansing, MI.

There are many portable instruments available to measure lightness of meat, yet their equivalence is poorly understood. The objective of this study was to determine if differences exist between CIE  $L^*$  values determined by three instruments, the Minolta chromameter (M; illuminant  $D_{65}$  with a 2° observer), the Hunter Mini-scan spectrophotometer (H; illuminant  $D_{65}$  with a 10° observer) and the ColorTec (C; illuminant  $D_{65}$ ). Color readings were taken on turkey *pectoralis superficialis* (major;  $n=80$ ), pig *gluteus medius* ( $n=60$ ), pig *gluteus accessorius* and *profundus* ( $n=60$ ) muscles. Hunter mini-scan reported twice the variation in  $L^*$  values compared to the other two devices (23.13 vs. 12.5 in pig and 6.53 vs. 3.0 in turkey). Due to this heterogeneity of variance, data were normalized to a mean of 0 and a variance of 1. Normalized values were then used for all statistical analyses. The correlations ( $r$ ) for  $L^*$  values of H versus M, M versus C, and H versus C were .90, .82 and .77, respectively and were different from zero ( $P < .0001$ ). However, the  $r$  of H with M was higher than the  $r$  of M with C and the  $r$  of H with C ( $P < .01$ ). The  $r$  of M with C was not different from the  $r$  of H with C ( $P > .05$ ). We conclude that one instrument should be used to collect data for a given evaluation or experiment, since  $L^*$  readings from different devices are not equivalent.

**Key Words:** Instrument,  $L^*$

**1548 Effects of high protein/low carbohydrate swine diets during the final finishing phase on pork muscle quality.** J.B. Bok\*, D.M. Wulf, B.C. Shanks, B.A. Reuter, and R.J. Maddock, South Dakota State University, Brookings, SD.

The aim of this study was to lower the glycogen stores in pork muscle in order to improve pork muscle quality by feeding an ultra-high protein/low carbohydrate (HIPRO) diet. Fifty barrows (average live weight = 92 kg) were assigned across five treatments and two reps (five pigs per treatment by rep combination). All barrows were fed a control diet



(13.1% CP) until their assigned treatment began. A treatment was the number of days the barrows were fed the HIPRO diet prior to harvest (0, 2, 4, 7, and 14 d). The HIPRO diet (35.9% CP) was 97% extruded soybeans. Daily feed intake and weekly live weights were recorded for all barrows. At-death blood glucose levels were determined. Muscle pH, temperature and electrical impedance were measured in the longissimus lumborum and semimembranosus muscles at 45 min, 3 h and 24 h postmortem. Glycolytic potential, Minolta L\*a\*b\* values, visual scores for color, firmness and marbling, water-holding capacity traits (drip loss, purge loss and cooking loss) and Warner-Bratzler shear force values were determined in the longissimus thoracis et lumborum. Weight gain per day decreased the longer the pigs were fed the HIPRO diet ( $P < 0.05$ ). Daily feed intake decreased during the first week on the HIPRO diet, but returned to near-control levels during the second week, which when coupled with the continued decreases in daily gain, resulted in substantial decreases in feed efficiency during the second week on the HIPRO diet ( $P < 0.05$ ). Blood glucose levels and glycolytic potentials were not lowered by feeding the HIPRO diet ( $P > 0.05$ ); and therefore, no differences in rate of pH decline or ultimate pH among dietary treatments were found ( $P > 0.05$ ). Likewise, there were no differences among dietary treatments in any of the measured meat quality attributes ( $P > 0.05$ ). Feeding barrows the HIPRO diet for a time period prior to slaughter decreased feed intake, rate of gain, and feed efficiency, and was not effective at lowering glycolytic potential or improving pork muscle quality.

**Key Words:** Pork quality, muscle glycogen, Muscle pH

**1549 Effect of supplemental fat on growth, quality, palatability, and fatty acid composition of beef from steers fed barley-potato product finishing diets.** D. J. Marks<sup>\*1</sup>, J. R. Busboom<sup>1</sup>, M. L. Nelson<sup>1</sup>, J. D. Cronrath<sup>1</sup>, L. Falen<sup>1</sup>, A. E. Koepp<sup>1</sup>, and P. S. Kuber<sup>1</sup>, <sup>1</sup>Washington State University.

The objective was to evaluate the effects of supplemental fat in finishing diets on feedlot performance, carcass and shelf-life properties, and fatty acid composition of beef. One hundred sixty-eight crossbred steers (318 2.8 kg) were allotted within weight block (3) to a randomized complete block design with a 2 x 3 + 1 factorial arrangement of dietary treatments. Main effects were level of yellow grease (YG; 0, 3, and 6%), and level of alfalfa hay (3.5 and 7%) with the added treatment of 6% tallow and 7% alfalfa hay in barley-based diets containing 15% potato by-product and 7% supplement fed for 165 d. Growth and carcass data were determined on all steers, while longissimus muscle (LM) from four randomly selected animals per pen were used for shelf-life, trained panel and fatty acid analysis. Average daily gain linearly increased ( $P < 0.05$ ) with YG from 1.5 to 1.6 0.16 kg/d and decreased ( $P < 0.05$ ) feed-to-gain from 5.9 to 5.5 0.16. Level of alfalfa hay interacted with YG on backfat, marbling score, beef color score, and percentage choice. Backfat increased with 3.5%, but not 7% alfalfa diets. Marbling was maximized at 3.5% hay, but minimized at 7% hay with the 3% yellow grease diet. There were no effects of diet ( $P > 0.1$ ) on color score, retail purge score, and L\*, a\* and b\* values. Sensory panel initial tenderness scores increased quadratically ( $P < 0.10$ ) with YG from 7.2 to 7.6 to 7.4 0.1, and decreased ( $P < 0.10$ ) with alfalfa level. Diet did not affect total fatty acid (FA) content (DM basis) of LM (143 4.5 mg/g) or fat (958 9.3 mg/g). Level of yellow grease increased CLA quadratically ( $P < 0.01$ ) in LM from 0.45 to 0.64 to 0.62 0.02 g/100g FA and fat from 0.61 to 0.835 to 0.825 0.02 g/100g FA. Yellow grease in the diet increased feedlot performance with no detrimental effects on shelf-life and increased CLA content of beef with no increase in total FA content.

**Key Words:** Barley, Yellow Grease, CLA

**1550 Sensory evaluation of pork longissimus muscle from swine fed soybean meal from Roundup Ready<sup>®</sup> or conventional soybeans.** C. L. Armstrong<sup>\*</sup>, W. B. Mikel, and G. L. Cromwell, University of Kentucky, Lexington, KY.

A study was conducted to evaluate the effects of feeding dehulled soybean meal (SBM) from genetically-modified, herbicide-tolerant soybeans containing the CP4 EPSPS protein (Roundup Ready<sup>®</sup> [RR]) or near-isogenic conventional (C) soybeans on sensory ratings, Warner Bratzler Shear (WBS) force, and cook loss of pork longissimus muscle (LM). Soybeans were grown in year 2000 under similar agronomic conditions, the RR soybeans were sprayed with Roundup<sup>®</sup>, and both were processed at the same plant. Crossbred pigs (n=100) were fed fortified

corn-soy diets containing C- or RR-SBM from 24 to 111 kg BW. Loins (n=30) were obtained from 15 barrows/treatment (three replications of five pigs/replication). Fresh LM samples were removed at 24 h post-mortem and frozen until analysis for sensory and chemical traits. Three (2.54 cm thick) chops were cooked on a Farberware grill to an internal temperature of 71 C. An experienced sensory panel evaluated each chop for juiciness, tenderness, off flavor, flavor intensity, connective tissue and overall acceptance on a scale from 1 to 8, with 8 being the most desirable. Weights were recorded before and after cooking to determine cook loss. Three 1.26 cm cores were taken from each of the two remaining cooked chops for WBS force determination. Chemical analysis showed percentage of fat between chops from the two treatments tended to be slightly higher for the RR-SBM group (3.10 vs 2.74). Sensory analysis revealed that the C-SBM versus RR-SBM treatment groups were not different ( $P > 0.05$ ) in juiciness (5.52 vs 5.58), tenderness (5.91 vs 6.10), off flavor (7.08 vs 7.18), flavor intensity (5.74 vs 5.95), connective tissue (6.54 vs 6.53) or overall acceptance (5.80 vs 6.05). Also, WBS force values (3.95 vs 3.58, kg) and cook loss (31.97 vs 30.28, %) were not different ( $P > 0.05$ ) between the two treatment groups. Thus, these results indicate that type of soybean meal in feed had no effect on product quality.

**Key Words:** Pork, Sensory, Biotechnology

**1551 Assessing Real Time Augmentation of USDA Yield Grade Application to Beef Carcasses Using Video Image Analysis (VIA) Instrumentation.** R. Steiner<sup>\*1</sup>, A.M. Wyle<sup>2</sup>, K.E. Belk<sup>1</sup>, J.A. Scanga<sup>1</sup>, J.W. Wise<sup>3</sup>, J.D. Tatum<sup>1</sup>, and G.C. Smith<sup>1</sup>, <sup>1</sup>Colorado State University, Fort Collins, CO/ USA, <sup>2</sup>Research Management Systems, Fort Collins, CO/ USA, <sup>3</sup>USDA AMS Branch, Washington, DC/ USA.

**ABSTRACT**word This study assessed the ability of two video image analysis (VIA) instruments, VIAscan<sup>TM</sup> and Canadian Vision System (CVS<sup>TM</sup>), to augment the assignment of USDA Yield Grades (YG) to beef carcasses, to the nearest tenth of a grade, under commercial operating conditions, and to test the accuracy of cutability predictions. Steer and heifer carcass sides (n = 290) were selected to vary in fatness, muscling and weight. Carcasses were assigned augmented YG (AYG), to the nearest tenth (i.e., YG 1.3, 2.6, 4.9), on an automated grading chain (360 head/hour) by each of the two VIA systems, and subsequently fabricated into closely-trimmed (.6 cm) subprimal cuts. Augmented YG that included line graders' estimates for adjusted PYG, and VIA measured ribeye area were highly correlated (r = .92 and .95 for VIAscan<sup>TM</sup> and CVS<sup>TM</sup>, respectively) with Gold Standard YG (committee of experts, at their leisure). Cutability prediction accuracy increased to levels near those achieved by expert whole YG, where VIAscan<sup>TM</sup> AYG, CVS<sup>TM</sup> AYG and expert whole YG accounted for 59, 60, and 62 percent of the variation in fabricated yields of closely-trimmed subprimal cuts, respectively. Video Image Analysis technology for use in the augmentation of USDA YG appears to be a useful tool for increasing the accuracy and objectivity of USDA YG application, as well as for improving the accuracy of prediction of subprimal yields. Augmentation of USDA YG through use of VIA instrumentation improves USDA line graders YG assignment accuracy. Assigning USDA YG to the nearest tenth would provide substantial economic benefit to the beef industry, allowing fabrication styles and inventories to be more closely managed. VIA instrumentation is a viable augmentation option for use by USDA line graders in assigning YG to the nearest tenth.

**Key Words:** Subprimal, Yield, Augmentation, Video Image Analysis

**1552 Ozonation of animal wastewater to reduce environmental impact.** J. K. Duke<sup>\*</sup>, L. W. Grimes, G. C. Skelley, and A. K. Greene, Clemson University.

Samples of wastewater from a confined animal feeding operation (CAFO) and a slaughter facility were ozonated and analyzed for reduction in biochemical oxygen demand (BOD<sub>5</sub>), chemical oxygen demand (COD), coliform bacterial content, and aerobic bacterial content. Samples from the swine farm were collected from the flush pit of a 125 head swine-feeding floor. Subsamples were collected after 0.0, 0.5, and 1.0 hr of laboratory ozonation. At the cattle packing plant (500 head per day), samples were collected from the harvest floor and from the anaerobic lagoon discharge. After transport to the laboratory, samples were ozonated for 0.0, 0.25, 0.5, 0.75, and 1.0 hr. Ten-milliliter subsamples

were collected for analysis at each time interval. BOD<sub>5</sub> and COD determinations indicated reductions across all times on all samples. Coliform and aerobic bacterial content were measured using 3M Petrifilm<sup>®</sup>. Results indicated significant reduction ( $P < 0.05$ ) in mean bacterial plate counts of 1 to 3 log for all samples over all times for both coliform and aerobic plate determinations.

**Key Words:** Wastewater, Ozonation, Environment

**1553 Reducing airborne bacteria and molds using a germicidal air cleaning system.** C.J. Cundith\*, C.R. Kerth, W.R. Jones, T.A. McCaskey, and D.L. Kuhlers, *Auburn University, Auburn AL.*

The objectives of this study were to determine the effectiveness of a germicidal air cleaning system on the reduction of airborne molds and bacteria in a controlled environment and in a meat processing plant. Components of the cleaning unit were tested to determine their individual effectiveness. The UV light alone was capable of a 4.99 log reduction in Gram-positive bacteria (*Micrococcus luteus*) and a 5.76 log reduction in Gram-negative bacteria (*Serratia marcescens*). The filter alone, filter and electrically polarized, low-density media combined and the filter, electrically polarized, low-density media and UV light combined reduced ( $P < 0.05$ ) *M. luteus* (84.0, 90.9, and 92.3% respectively) and *S. marcescens* (84.1, 87.3, and 90.2% respectively). The cleaning units were also examined for their effectiveness in reducing indigenous airborne bacteria and molds from ambient air in production conditions. Two types of cleaning units were used, a duct-mounted unit and wall-mounted console units. Testing was done at 3, 6, 9 and 24 hours after the duct-mount units were activated. The duct-mounted cleaning units reduced ( $P < 0.05$ ) airborne molds by 66.8% in the heating, air conditioning and ventilation unit, and were found to be effective ( $P < 0.05$ ) within 3 hours after activation. The console wall mounted units were tested under controlled conditions in the meat carcass chill cooler, processing room and carcass aging cooler using 1, 2, 3 or 4 cleaning units. Using 2, 3 or 4 units reduced ( $P < 0.05$ ) airborne bacteria and molds. The console units then were tested in the processing room for their effectiveness in reducing airborne bacteria and molds in production conditions. Three and four cleaning units reduced airborne bacteria (21.6 to 61.4%) and molds (20.3 to 63.2%) during production in the processing room. Without the cleaning units in the processing room, both bacteria and mold counts increased ( $P < 0.05$ ) from day 1 to day 4. These data indicate that germicidal air cleaning units containing UV light, filter, and low-density polarizing media are effective in reducing airborne bacteria and molds in a meat processing environment.

**Key Words:** Airborne, Bacteria, Mold

**1554 Development of decontamination procedures for beef trimmings.** C. S. Ebeling\*, R. K. Miller, and G. R. Acuff, *Dept. Animal Sci., Texas A&M University, College Station, TX.*

*Escherichia coli* O157:H7 has become recognized as an important food-borne pathogen, with undercooked ground beef identified as the most frequent outbreak cause. Beef trimmings present a challenge to the meat industry due to a higher degree of bacterial contamination occurring in ground beef than in whole-muscle products because of extensive handling procedures during production. Interventions are needed to reduce microbiological levels on beef trimmings. Beef trimmings of 73/27 or 50/50 lean and fat content were obtained from a commercial plant. Trimmings were randomly assigned to four treatments: control, 4% lactic acid (LA), 4% lactic acid plus hot water (LA+HW), and 4% lactic acid plus 10% trisodium phosphate plus hot water (LA+TSP+HW). Meat color was evaluated on both trimming types before and after treatment and on ground beef chubs on days 0, 7, 14, 21, and 28 of storage. The L\*, a\*, and b\* color space values were determined to measure objective color, and trained color panel was used to measure subjective color. After treatment, the lean color of all trimming types was darker ( $P < 0.01$ ) or grayer ( $P < 0.01$ ) in the LA+HW or LA+TSP+HW treated trimmings. Lean color of the ground beef was not noticeably darker ( $P < 0.05$ ) due to treatment after grinding, but the LA treatment resulted in visually darker ( $P < 0.01$ ) ground beef especially with subsequent storage time. A trained descriptive attribute panel evaluated flavor quality characteristics of the ground beef patties on each storage day. The LA treated patties had slightly lower levels of cooked beef/brothy ( $P < 0.01$ ), cooked beef fat ( $P < 0.01$ ), and grainy ( $P <$

0.01) flavors. Total aerobic plate counts (APC) were measured on excised sample after treatment and on ground samples on each storage day. The LA+HW and LA+TSP+HW treatments reduced surface APC of trimmings by  $1 \log_{10}$  CFU/cm<sup>2</sup>. However, treating beef trimming with LA reduced the APCs of the ground beef by  $1.3 \log_{10}$  CFU/g and lowered ( $P < 0.01$ ) APCs on days 7, 14, and 21 compared to control and other treatments. These treatments, especially LA+HW would be an acceptable intervention step to be further examined to assist in decontamination of beef trimmings without adversely effecting shelf-life and flavor attributes.

**Key Words:** beef, decontamination

**1555 Processing and product development of goat meat products: fermented cabrito snack stick and cabrito smoked sausage.** G.H. Cosenza\*, S.K. Williams, D.D. Johnson, and C. Sims, *University of Florida, Gainesville, FL.*

The production of high quality, value added goat meat products could increase the consumption, acceptability and marketability of goat meat. The objectives of this study were to develop a fermented cabrito snack stick and a cabrito smoked sausage containing different levels of soy protein concentrate in an effort to reduce their final product costs; conduct consumer acceptance, proximate analysis, pH, water activity and smoke-house yields and losses to evaluate and ensure quality and acceptance of these goat meat products; and to perform a comparative cost analysis to determine cost benefit of using soy protein concentrate in formulation of fermented cabrito snack stick and cabrito smoked sausage products. The levels of soy protein concentrate used to replace the goat meat were 0%, 1.75% and 3.50%. The trained panelists detected no significant "soy" off-flavor differences ( $P > 0.05$ ) between the three formulation levels of soy protein concentrate for the fermented cabrito snack stick and cabrito smoked sausage. The consumer panelists detected no significant differences ( $P > 0.05$ ) in the flavor, texture and overall acceptance attributes for the fermented cabrito snack sticks, and the cabrito smoked sausage products formulated with 0% and 3.50% soy protein concentrate. The fermented cabrito snack sticks formulated with 3.50% soy protein concentrate had a lower ( $P < 0.05$ ) fat content than the 0% level. The fermented cabrito snack sticks formulated with 0% soy protein concentrate had the highest price of \$1.31, and the 3.50% level had the lowest price of \$1.25 per 42.61g serving size. There were no differences ( $P > 0.05$ ) in moisture, fat and protein for the cabrito smoked sausage formulated with 0% and 3.50% soy protein concentrate. The addition of soy protein concentrate resulted in a \$1.30 per kg reduction in the price of the cabrito smoked sausage formulated with 3.50% soy protein concentrate (i.e., cost was \$13.49 per kg), when compared to the sausage formulated with 0% soy protein concentrate (i.e., cost was \$14.79 per kg). This project will enhance the marketability of goat meat and provide new and successful markets for Florida's goat industry.

**Key Words:** Goat Meat, Fermented Cabrito Snack Stick, Cabrito Smoked Sausage

**1556 Use of sodium citrate to enhance tenderness and palatability of pre-rigor beef muscles.** C. D. Perversi\*<sup>1</sup>, C. R. Calkins<sup>1</sup>, and J. Velazco<sup>2</sup>, <sup>1</sup>*University of Nebraska-Lincoln*, <sup>2</sup>*Instituto Tecnológico de Estudios Superiores de Monterrey, Monterrey, Mexico.*

Previous research demonstrated glycolytic inhibition enhanced beef tenderness, despite causing substantial contraction by injection and tumbling of pre-rigor muscles. This project was designed to evaluate the effects of pre-rigor treatment with sodium citrate on the tenderness and palatability of beef muscles from the thoracic limb; the muscles were injected while maintaining skeletal restraints to contraction. Thoracic limbs from 14 steers were removed within 2 hr post-mortem and pumped to 10% of muscle weight with water, 200 mM, or 400 mM sodium citrate solutions. Controls remained on the carcass during chilling. Steaks (2.54 cm thick) were removed after 24 hours from the *Infraspinatus*, *Supraspinatus*, and *Triceps brachii* muscles and were either frozen immediately or aged for 6 more days. A consumer panel evaluated palatability (juiciness, tenderness, connective tissue amount, and flavor desirability) on *Infraspinatus* and *Triceps brachii* steaks using 9-point hedonic scales. Warner-Bratzler shear force values on 1.27 cm-diameter cores were determined on all muscles. Treatment with 400 mM sodium citrate improved shear force values over the control in all three muscles (3.32 vs. 3.61 kg and 2.79 vs. 3.50 kg for d1 and d 7 *Infraspinatus*

[ $P < .10$ ]; 3.55 vs. 3.71 kg and 3.09 vs. 3.59 kg for d1 and d7 *Triceps brachii* [ $P < .10$ ]; 4.19 vs. 5.30 kg and 4.03 vs. 4.78 kg for d1 and d7 *Supraspinatus* [ $P < .05$ ], respectively). Tenderness ratings followed the same trend as shear force values. Flavor desirability ratings of beef treated with 200 or 400 mM sodium citrate were equal or superior control muscles. These data indicate that sodium citrate may be applied to pre-rigor beef muscles (constrained from contraction) to enhance tenderness and palatability.

**Key Words:** Beef, Tenderness, Palatability

**1557 Mapping intramuscular tenderness variation in four major muscles of the beef round.** B. J. Reuter\*, D. M. Wulf, B. C. Shanks, J. M. Bok, and R. J. Maddock, *South Dakota State University, Brookings, SD.*

The objective of this project was to quantify intramuscular tenderness variation within four muscles from the beef round: biceps femoris (BF), semitendinosus (ST), semimembranosus (SM), and adductor (AD). At 48 h postmortem, the BF, ST, SM, and AD were dissected from either the left or right side of ten carcasses, vacuum packaged, and aged for an additional 8 d. Each muscle was then frozen and cut into 2.54-cm-thick steaks perpendicular to the long axis of the muscle. Steaks were broiled on electric broilers to an internal temperature of 71 C. Location-specific cores were obtained from each cooked steak and Warner-Bratzler shear force was evaluated. Definable intramuscular tenderness variation (SD = 0.56 kg) was almost twice as large as between-animal tenderness variation (SD = 0.29 kg) and 2.8 times as large as between-muscle variation (SD = 0.20 kg). The ranking of muscles from greatest to least definable intramuscular tenderness variation was BF, SM, ST, and AD (SD = 1.09, 0.72, 0.29, and 0.15 kg, respectively). The BF had its lowest shear force values at the origin (sirloin end), intermediate shear force values at the insertion, and its highest shear force values in a middle region 7 to 10 cm posterior the sirloin-round break point ( $P < 0.05$ ). The BF had lower shear force values towards the ST side than towards the vastus lateralis side ( $P < 0.05$ ). The ST had its lowest shear force values in a 10 cm region in the middle, and its highest shear force values towards each end ( $P < 0.05$ ). The SM had its lowest shear force values in the first 10 cm from the ischial end (origin), and its highest shear force values in a 13 cm region at the insertion end ( $P < 0.05$ ). Generally, shear force was lower towards the superficial (medial) side than towards the deep side of the SM ( $P < 0.05$ ). There were no intramuscular differences in shear force values within the AD ( $P < 0.05$ ). These data indicate that definable intramuscular tenderness variation is substantial and could be used to develop alternative fabrication and (or) merchandising methods for beef round muscles.

**Key Words:** Beef, Intramuscular, Tenderness

**1558 Chemical characterization of beef inside and outside semimembranosus for improved color stability.** LM Sammel\*<sup>1</sup>, MC Hunt<sup>1</sup>, and DH Kropf<sup>1</sup>, <sup>1</sup>*Kansas State University.*

The color instability of the beef semimembranosus (SM) has been troublesome to the meat industry and continues to be problematic in modified atmosphere packaging. The deep or inside portion of the SM (ISM) is lighter in color and discolors faster than the superficial or outside SM (OSM). The relationships of 5 assays for metmyoglobin reducing ability with color stability were determined at 5 and 14-days of storage. Combinations of cold or hot boning with and without electrical stimulation were used to create different postmortem declines in temperature and pH for the ISM and OSM to examine effects on chemical characteristics and initial color and stability. Aerobic reducing ability and reduction of nitric oxide metmyoglobin showed less activity in the ISM than OSM, and in tissue stored 14 compared to 5 days. The assay for total reducing activity and reduction of dichlorophenolindophenol showed more activity in muscles stored 5 compared to 14 days but showed few differences between the muscle portions. Reductions of horse and bovine metmyoglobins were inconsistent between muscle portions and storage times. Aerobic reducing ability correlated best with visual panel scores and metmyoglobin accumulation in the SM. Cold-boned ISM had a slower chill rate; faster pH decline; more denatured protein; less metmyoglobin reducing ability, oxygen consumption, and water-holding capacity; and a lighter, less stable color than the OSM. Cold-boned steaks were two-toned in color and discolored by day 3 of display. Hot-boned ISM and OSM chilled at the same rate and had similar pH declines, similar chemical characteristics, and acceptable color traits up to day 5 of display.

Myoglobin concentration, heme iron, nonheme iron, and lipid oxidation did not explain differences in color stability between the ISM and OSM. Methods that chill the ISM more rapidly should produce a more uniform, stable color by conserving reducing ability and protein integrity. Extending the color life of the ISM should reduce the need for reworking and discounting after only 2 days of retail display.

**Key Words:** Semimembranosus, Metmyoglobin, Color Stability

**1559 Effects of cold shortening and cooking rate on tenderness, postmortem proteolysis, and cooking traits of beef longissimus and triceps brachii muscles.** D.A. King\*<sup>1</sup>, M.E. Dikeman<sup>1</sup>, T.L. Wheeler<sup>2</sup>, C.L. Kastner<sup>1</sup>, and M. Koochmariaie<sup>2</sup>, <sup>1</sup>*Kansas State University, Manhattan, KS,* <sup>2</sup>*Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE.*

Our study evaluated the effects of cold shortening and cooking rate on postmortem proteolysis, tenderness, and cooking traits of beef longissimus thoracis (LT) and triceps brachii, long head (TB) muscles. The LT and TB were removed at 45 min (left side) and 24 h (right side) postmortem from 12 carcasses and trimmed of fat. Muscles removed at 45 min were placed in an ice bath to induce cold shortening. At 24 h postmortem, muscles were cut into 2.54 cm steaks and assigned to aging (1 or 14d) and RAW and cooking (FAST or SLOW) treatments. Steaks were cooked at 260° C (FAST) or 93° C (SLOW). Cooking loss (CL), cooking time (CT), and Warner-Bratzler shear force (WBSF) were measured for cooked steaks. Sarcomere length (SL) and the extent of proteolysis of desmin were measured on all steaks. Rapid chilling resulted in shorter ( $P \leq .05$ ) SL. TB steaks had longer ( $P \leq .05$ ) SL than LD steaks. RAW steaks had longer ( $P \leq .05$ ) SL than cooked steaks regardless of shortening. FAST cooking resulted in shorter ( $P \leq .05$ ) SL than SLOW cooking in normal steaks, but cooking rate had no effect on shortened steaks. Generally, TB steaks required longer ( $P \leq .05$ ) CT and had higher ( $P \leq .05$ ) CL than LT steaks, and FAST cooked steaks had greater ( $P \leq .05$ ) CL than SLOW cooked steaks. Shortened steaks had less ( $P \leq .05$ ) degradation of desmin than normal steaks (31 vs. 41%, respectively). Aging for 14d increased ( $P \leq .05$ ) desmin degradation. Cold shortening resulted in much higher ( $P \leq .05$ ) and aging resulted in lower ( $P \leq .05$ ) WBSF values. SLOW cooked TB steaks were more tender ( $P \leq .05$ ) than FAST cooked TB and FAST and SLOW cooked LT steaks. These data indicate that shortened muscles undergo proteolysis, but at a slower rate than normal muscles. Cooking rate did not affect tenderness of LT steaks, but SLOW cooking resulted in lower WBSF values for TB muscles, presumably because of collagen solubilization.

**Key Words:** Beef Tenderness, Proteolysis, Cooking

**1560 Relationships between mechanical tenderness measurements and trained sensory panel attributes of beef Longissimus lumborum muscle.** T. S. Hively\*<sup>1</sup>, R. K. Miller<sup>1</sup>, D. S. Hale<sup>1</sup>, D. K. Lunt<sup>2</sup>, T. L. Wheeler<sup>3</sup>, and M. Koochmariaie<sup>3</sup>, <sup>1</sup>*Dept. Animal Sci., Texas A&M University, College Station, TX,* <sup>2</sup>*Texas Agriculture Experiment Station, McGregor, TX,* <sup>3</sup>*Roman L. Hruska U. S. Meat Animal Research Center, Clay Center, NE.*

Mechanical assessment of beef tenderness is widely used. Varying methods have been reported in the scientific literature: Warner-Bratzler shear force (WB), Allo-Kramer shear force (AK), and slice shear force (SS). In addition, trained meat descriptive attribute sensory evaluation of myofibrillar tenderness (MT), connective tissue amount (CT) and overall tenderness (OT) are used to evaluate tenderness of beef. The objective of this research was to understand the relationships between these mechanical measures of tenderness and trained meat descriptive attribute sensory panel ratings of beef tenderness. Beef steers ( $n = 63$ ) varying in live animal characteristics to induce variation in tenderness were slaughtered, electrically stimulated, and two strip loins (IMPS -180) were removed 48 h postmortem. Loins were subsequently vacuum-packaged, aged 14 d at 5C and then cut into 2.54 cm thick steaks. Within each animal, steaks were randomly assigned to one of four treatments: WB, AK, SS or trained sensory evaluation of MT, CT and OT using 8-point scales (1 = extremely tough, abundant and extremely tough; 8 = extremely tender, none, extremely tender, respectively). Steaks varied in tenderness across mechanical and sensory measures (2.4 to 7.4 kg for WB, 8.1 to 27.8 kg for AK, 7.0 to 42.4 kg for SS, 3.7 to 7.6 for MF, 4.7 to 7.9 for CT and 3.7 to 7.6 for OT). Mean measures for tenderness were 4.1 kg for WB, 13.6 kg for AK, 15.7 kg for SS, 6.3 for MT, 7.0 for CT and 6.3 for OT. The OT and WB values were correlated at -0.70 ( $P$

< 0.01) whereas OT and AK were correlated at -0.61 ( $P < 0.01$ ) and OT and SS at -0.70 ( $P < 0.0001$ ). Respective correlation coefficients between MT and WB, AK and SS were -0.70, -0.59 and -0.60; while simple correlation coefficients between CT and WB, AK and SS were -0.66, -0.60 and -0.51, respectively. As expected, correlation coefficients among sensory measures were high ( $> 0.9$ ,  $P < 0.01$ ). These data indicate that the common mechanical measurements of beef tenderness are highly correlated to each other and they are highly correlated to trained sensory measures of beef tenderness, although the apparent lower correlation between SS and OT as compare to WB and AK may be due to differences in cooking method (belt grill vs. electric grill).

**Key Words:** beef, shear force, tenderness

**1561 Quality evaluation of case-ready beef steaks from various USDA grades.** J. M. Behrends<sup>\*1</sup>, W. B. Mikel<sup>1</sup>, C. L. Armstrong<sup>1</sup>, Y. L. Xiong<sup>1</sup>, and S. Harris<sup>2</sup>, <sup>1</sup>University of Kentucky, <sup>2</sup>Cryovac/Sealed Air Corporation.

Introduction of case-ready fresh meats to the marketplace has demonstrated a need to evaluate the benefits of this technology. The objectives of this study were to evaluate visual and chemical attributes of three different USDA quality grades (High Choice and above, Low Choice, Select) and three different muscles (semimembranosus, semitendinosus, and biceps femoris) of beef steaks encased in high-oxygen (80% O<sub>2</sub>/20% CO<sub>2</sub>) modified atmosphere packaging (MAP). Steaks from each treatment group (3 muscles, 3 grades, 2 packaging types) were displayed under retail conditions for 1, 3, 5, 7, and 10 d. Three steaks from each muscle-grade-package type combination were evaluated on each day by a five-member trained panel for visual color (lean color, discoloration, overall acceptability) and analyzed with a Minolta Chroma Meter CR-300 for L\* a\* b\* values (lightness, redness, yellowness). Chemical analysis included percent metmyoglobin and lipid oxidation (TBARS). There were no grade x packaging interactions ( $P > 0.05$ ) for lean color, discoloration, overall appearance, or L\*, a\* and b\* values. However, the main effect of grades for these quality parameters was significant, with Low Choice and Select being higher than High Choice for L\* values and Low Choice being more desirable than both High Choice and Select for lean color, discoloration, overall appearance, and a\* and b\* values. There were no grade x packaging interactions for percent metmyoglobin and TBARS values, however, grade had a main effect ( $P < 0.05$ ) on percent metmyoglobin content, with High Choice being higher than both Low Choice and Select. TBARS values also differed ( $P < 0.05$ ) among grades. These findings indicate quality grade has a major influence on color stability of high-oxygen packaged beef steaks. Regardless of muscle type and grade, however, whole muscle steaks from the round can achieve an extended shelf-life by use of novel MAP technology.

**Key Words:** Case-ready, Quality, Oxidation

**1562 Diverse birth and rearing housing systems: effects on pig growth, meat quality and muscle fiber types.** J. G. Gentry<sup>\*</sup>, J. R. Blanton, Jr., J. J. McGlone, and M. F. Miller, Texas Tech University, Lubbock.

The objective of this experiment was to examine the effects of diverse birth and rearing environments on pig growth, meat quality and muscle fiber types. Barrows (n=48, 6 pigs/pen) were randomly selected from a group of indoor-born and outdoor-born pigs at weaning and placed into an indoor or outdoor growing/finishing environment. The outdoor environment consisted of 4 pens (212 m<sup>2</sup>/pig) on alfalfa pasture. The 4 indoor pens (1.2 m<sup>2</sup>/pig) had concrete slatted flooring. Pigs were slaughtered at an average weight of 114 kg at a commercial facility. Fiber type samples were taken from the *longissimus* (LD) and *semimembranosus* (SM) muscles at 4 hr postmortem and stored at -80°C until analysis. Samples (12-m thick) were stained histochemically with ATPase after acid pre-incubation (pH= 4.3) to detect I, IIA and IIB fiber types. Boneless loins were collected following 24 hr chilling and aged for 14 d. Chops (2.54 cm thick) were cut for sensory and shear force analysis. Data were analyzed using the GLM procedures of SAS (1995) with pen as the experimental unit. Outdoor-born pigs grew faster than indoor-born pigs (ADG, kg/d: .81 vs .72 .03,  $P < .05$ ). Outdoor reared pigs had more backfat, higher NPPC color scores and lower CIE L\* values than the indoor reared pigs ( $P < .05$ ). Sensory panel scores for pork flavor intensity were 6.07 and 6.48 .10 for the indoor and outdoor-born groups, respectively ( $P < .05$ ). Shear force values were lower for the group finished outdoors (2.0 vs 2.2 kg .06,  $P < .05$ ). LD and SM from

the outdoor reared group had a lower percentage of type IIB fibers (LD: 66.6% vs 73.2% 2.0, SM: 53.6% vs 65.1% 3.1;  $P < .05$ ). Type I fibers in the SM represented 13.8% and 24.6% 3.1 for the indoor and outdoor reared pigs, respectively ( $P < .05$ ). Outdoor rearing of pigs may improve pig growth, pork color and tenderness. Further studies should be conducted to link pork quality measures with muscle fiber types and environmental housing systems.

**Key Words:** Pigs, Housing systems, Pork quality

**1563 Goat kids meat quality: artificial rearing and weight at slaughter effects.** A. Arguello<sup>\*1</sup>, A. Marichal<sup>1</sup>, J.F. Capote<sup>2</sup>, and J.L. Lopez<sup>1</sup>, <sup>1</sup>Animal Production Unit, Las Palmas de Gran Canaria University, Arucas, Spain., <sup>2</sup>ICIA, La Laguna, Spain..

The objective of our study was to examine the effects of the rearing system and weight at slaughter on meat quality in young Canary Caprine Group kids. Forty twin, male kids were allotted to one of four groups based on feeding regimens: kids nursed by their dams (ND, n: 10), or kids fed a commercial milk replacer (23.7 percent CP and 22.8 percent fat) and controlled intake (CR, n: 10), and live weight at slaughter: 6 kg (WS6, n: 10), or 10 kg (WS10, n: 10). Immediately after slaughter, pH was measured on the Longissimus dorsi (LD). The carcasses were chilled at 4 C for 24 h, and pH, Warner-Brazler shear force (WBSF), color (Lightness, L, Chroma, C, Hue, H), water holding capacity (WHC), chemical composition (moisture, protein, fat, ash, collagen and his solubility), muscle fiber types proportions and their areas, were determined in the LD muscle. No interactions were observed in any parameter between rearing method and weight at slaughter. No statistic effect were founded in pH values, although the ND kids showed a higher pH values when the weight at slaughter increased, the evolution in CR kids were opposite. Compared with the WS10 kids, the LD muscle from WS6 kids had higher L ( $P < .05$ ), but no differences were founded in Chroma or Hue. Rearing method and weight at slaughter did not affect to WBSF, but a relation between WBSF and solubility collagen may be observed. The meat from ND animals were more exudative than CR kids ( $P < .001$ ), while no statistic effect was observed by weight at slaughter. The chemical composition changed lightly, reducing moisture percentage ( $P < .001$ ) and increasing protein proportion ( $P < .001$ ) in WS10, probably due to hypertrophy growth muscle fiber areas were higher. No effects were described in muscle fiber type population. The WS10 muscle fiber area was higher than WS6 ( $P < .05$ ), but in opposite the rearing system did not show statistic effects. Thus, the results show that using milk replacers in goat kids and increasing the weight at slaughter did not affect negatively to meat quality.

**Key Words:** Kid meat quality, Rearing system, Weight at slaughter

**1564 Comparison of breed and diet on factors associated with tenderness in two muscles.** P. S. Kuber<sup>\*1</sup>, J. R. Busboom<sup>1</sup>, S. K. Duckett<sup>2</sup>, D. J. Marks<sup>1</sup>, P. S. Mir<sup>3</sup>, Z. Mir<sup>3</sup>, R. G. McCormick<sup>4</sup>, C. T. Gaskins<sup>1</sup>, J. D. Cronrath<sup>1</sup>, and M. V. Dodson<sup>1</sup>, <sup>1</sup>Washington State University, Pullman, WA, <sup>2</sup>University of Idaho, Moscow, ID, <sup>3</sup>Agriculture and Agri-food Canada, Lethbridge, AB, <sup>4</sup>University of Wyoming, Laramie, WY.

The objective of this study was to evaluate attributes associated with tenderness in divergent breeds, Wagyu (**W n=12**), Limousin (**L n=12**) and F1-cross cattle (**WxL n=12**), fed two dietary treatments (either 0 or 6% sunflower oil). Data were analyzed using GLM procedures with breed and diet as main effects in a 2 x 3 factorial arrangement of treatments. Cattle were fed a barley-based diet for an average period of 259 d. Twenty-four hours post mortem (**PM**), steaks from the *longissimus* (**LD**) and *semitendinosus* (**ST**) were sliced, vacuum packed, aged (1, 3, 7, 14, 28 and 56 d **PM**) at 2°C and frozen (-40°C) until analyzed. Breed differences in Warner-Bratzler shear force (**WBS**) existed ( $P < 0.05$ ) across aging times in LD. A WBS breed x day interaction existed in ST ( $P < 0.05$ ) and tended to exist in LD ( $P = .11$ ). On d 14, W LD ( $P < 0.05$ ) required 0.77 kg less force to shear than L. Comparatively, W were more desirable in d 14 LD sensory panel sustained tenderness ( $P < 0.05$ ) than L. In the ST, WxL ( $P < 0.1$ ) required 0.60 kg less force to shear than L, but no difference ( $P > 0.1$ ) in ST panel initial or sustained tenderness was evident. Wagyu LD and ST samples were slower ( $P < 0.05$ ) in pH decline, and more rapid ( $P < 0.05$ ) in temperature decline than L or WxL. Breed and diet did not affect ( $P > 0.1$ ) free calcium (**FC**) over time (0, 1, 3, 7 and 14 d **PM**), 0 h calpastatin activity (**CA**), d 1 % collagen (**OH-Pro**), or d 1 collagen cross-linking (**HP**) in LD;

or d 1 OH-Pro and d 1 HP in ST. Western blot analysis for measuring the presence of the Troponin-T (Tn-T) 30kda fragment demonstrated more proteolysis in LD at d 3 in L than W or WxL. Breed differences in mechanical and sensory measures of tenderness existed (d 14 - LD and ST), but were not explained by FC, CA, OH-Pro, HP and Tn-T.

**Key Words:** Wagyu, Limousin, Beef Tenderness

**1565 *In-vitro* oxidation of bovine oxymyoglobin as affected by 4-hydroxy-nonenal.** A.L. Phillips\*, S. Lee, L.K. Silbart, and C. Faustman, *University of Connecticut, Storrs, CT.*

Discoloration from the desirable cherry red to brown color in fresh meat is a result of oxidation of ferrous oxymyoglobin (OxyMb) to ferric metmyoglobin (MetMb). Lipid oxidation, among other factors, influences the rate of fresh meat discoloration. 4-Hydroxy-nonenal (HNE), a known product of  $\omega$ -6 fatty acid oxidation, is very reactive toward protein and has been shown to accelerate equine cardiac OxyMb oxidation. Our objective was to determine the influence of HNE upon bovine skeletal OxyMb *in-vitro* under a variety of temperature (4, 25 and 37°C) and pH (5.6 and 7.4) conditions and to identify the adduction of HNE to OxyMb using Western Blots. Bovine skeletal muscle myoglobin (Mb) was purified from beef via ammonium sulfate fractionation and gel filtration

chromatography. OxyMb was prepared by hydrosulfite-mediated reduction and adjusted to physiologic or post-mortem pH via phosphate (pH 7.4) or citrate (pH 5.6) buffer dialysis, respectively. OxyMb (0.15 mM) was incubated with 1 mM HNE (OxyMb:HNE) at 4, 25 and 37°C; controls were aldehyde-free. Following incubation, samples were passed over a desalting column to remove unreacted HNE, scanned spectrophotometrically from 650 to 450 nm, and the percentage of MetMb calculated. Western Blot analysis was completed using control and OxyMb:HNE reacted at pH 7.4, 37°C for 2 hr. Identification of Mb bound HNE was visualized using a monoclonal antibody specific for HNE bound to histidine residues. Overall, MetMb formation increased with increasing temperatures and was greater at pH 5.6 than pH 7.4 ( $P \leq 0.05$ ). At 37°C, a prooxidant effect of HNE was seen at pH 7.4 but not at pH 5.6 when compared to control ( $P \leq 0.05$ ). At both 25 and 4°C, a prooxidant effect of HNE was seen at pH 7.4 and 5.6 relative to CON ( $P \leq 0.05$ ). Western Blots revealed that OxyMb:HNE incubated at pH 7.4, 37°C yielded OxyMb:HNE adducts at histidine residues whereas control samples showed no reaction. This research suggests that HNE accelerates *in-vitro* bovine skeletal muscle OxyMb oxidation and appears to do so, in part, via covalent modification at histidine residues.

**Key Words:** 4-hydroxy-nonenal, Oxymyoglobin, Metmyoglobin

## ADSA Dairy Foods: Products, Processing, Chemistry, Sensory

**1566 Rheological Characterization of Butter Oil Obtained from Yogurt and Milk.** Sevim Kaya\* and Ahmet Kaya, *Gaziantep University.*

Butter oil, clarified butter or anhydrous milk fat is a widely consumed food product in southeast of Turkey. The aims of the study were to investigate and compare the rheological characters of butter oil from yogurt and milk using flow curve and oscillation frequency sweep tests at various temperatures. The steady shear flow data of the butter oil samples were investigated using a rheometer HAAKE RheoStress RS1 with a cone and plate system (d:35 mm,  $\alpha :2^\circ$ ) and in combination with a Peltier/Plate TCP/P temperature control unit at temperature range of  $35-70 \pm 0.05^\circ\text{C}$ . Data were analyzed using a RheoWin Data Manager. The measurements were repeated three times, each time using a fresh sample and the average values were used to analyze data. Newtonian behavior was observed for the samples ( $r^2 \geq 0.998$ ) at the temperature range studied. Increasing temperature decreased the viscosity. Activation energies of butter oil from yogurt and milk were 21.7 and 21.6  $\pm 0.2$  kJ/mol, respectively showing that there was no difference between samples produced using different methods above the temperature  $35^\circ\text{C}$ . In addition to the temperature range studied above, another temperature range ( $35-29 \pm 0.05^\circ\text{C}$ ) was studied to observe the structural conditions of the samples analyzed using an oscillation frequency sweep test. It was found that at low frequencies the viscous behavior reflected by loss modulus is dominant whereas at high frequencies the elastic behavior reflected by storage modulus is outweighing. This shows solid like behavior of samples at higher frequencies. When the log crossover point was plotted versus temperature, below  $35^\circ\text{C}$  samples made from yogurt and milk showed different characteristics due to different fatty acid composition of the samples.

**Key Words:** Butter oil, yogurt, rheology

**1567 Acceptance of camel milk among elementary school students in Al Ain, UAE.** Isameldin Hashim\*, *United Arab Emirates University.*

Milk is an important food for children. Although camel is the dominant animal in the U.A.E., camel milk is not available commercially. The objectives of the study were to investigate: 1) consumption of milk and dairy products among elementary school students, 2) hedonic rating for sensory characteristics and overall acceptance of camel milk, and 3) acceptability of flavored camel milk. A questionnaire was designed to provide information on milk and dairy products consumption, milk flavor preference and willingness to participate on a milk tasting test. The questionnaire was distributed to 470 students (boys and girls, grades 4, 5 and 6) at elementary schools (public and private) in Al Ain. A panel of 173 students was selected to evaluate the milk samples (fresh cow milk, dried cow milk, fresh camel milk and chocolate-flavored camel milk). Seven-point hedonic scale (smiling faces) was used for rating the

color, aroma, taste, texture, and overall acceptance of the milk. Most of the students (93.2%) drink milk and only few (9.6%) drink camel milk. Most of the participants drink chocolate (43%) and strawberry-flavored (38.3%) milk. Beside the milk most of the participants consume other dairy products (yogurt, liquid yogurt, chesses and ice-cream). Camel milk had the lowest ratings for taste (3.2), aroma (4.1), and overall acceptance (3.8) compared to the fresh and dried cow milk (5.3 - 5.9). However, flavoring camel milk with chocolate enhanced the attributes of camel milk specially the taste (6.4), aroma (6.3) and overall acceptance (6.2).

**Key Words:** camel milk, acceptance, elementary school, UAE

**1568 Effect of formulation and processing on emulsion stability of recombined sterilized milk.** G. Prez-Hernandez, S. Bhatia, and R. L. Richter, *Texas A&M University, College Station, TX.*

The objectives were to determine the effect of product formulation and processing conditions on the composition of the milk fat globule membrane in recombined sterilized milk and to determine the effect of these changes on the emulsion stability. Samples contained casein to whey protein ratios of 80:20, 60:40, 40:60 and 0:100, and 0.5% monoglycerides, 0.5% lecithin, or a mixture of lecithin with monoglycerides. The protein and fat concentrations of the milk were 3%. Samples were homogenized at 20 and 90 MPa and sterilized at  $121^\circ\text{C}$  for 15 min. Emulsions were characterized by stability index, protein load, particle size distribution, and rheological parameters. Inclusion of monoglycerides in the samples caused the mean pH for all samples to decrease from 6.58 to 6.56 ( $p \leq 0.0152$ ). Maximum viscosity occurred in samples with a casein to whey protein ratio of 0:100. This was caused by denaturation of whey protein during sterilization. There was a four fold increase in volume surface average diameter as the ratio of whey protein in the samples was increased from 80:20 ( $0.4425\mu\text{m}$ ) to 0:100 ( $1.7175\mu\text{m}$ ). The surface area of particles in all treatment increased as the homogenization pressure increased. Particle surface area increased when samples that had a casein to whey protein ratio of 0:100 were formulated with emulsifier. Emulsifiers did not affect the particle surface area in any other sample. The protein load increased as the ratio of whey protein in the samples increased. Inclusion of emulsifiers in the samples caused the protein load to decrease. Stability index increased as viscosity, particle surface area and relative distribution width increased and pH and protein load decreased.

**Key Words:** emulsion stability, recombined milk, sterilization