

## General Poster Session

### Oxymyoglobin and lipid oxidation in $\alpha$ -tocopherol supplemented pork liver microsomes

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

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

### Effect of high oil corn and vitamin E supplementation on beef steak case-life properties

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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 ( $P < 0.05$ ) 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 ( $P < 0.01$ ) 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

## Evaluation of growth rate, carcass composition and meat quality of Berkshire- and Yorkshire-sired progeny

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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

## Mechanisms of vitamin D3 on tenderness of lamb

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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 (S0); 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

## Lean lamb production: Bioelectrical impedance as a lean tissue evaluation method

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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  $R^2$  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  $R^2 = 0.93$  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:  $LNI = 0.973 + 0.3118 \cdot \text{live wt} + (0.017 \cdot Rs) + (0.1739 \cdot Xc) + (0.0102 \cdot L)$  The  $R^2$  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.  $R^2$  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

## Impact of HACCP implementation on the Kansas meat and poultry processing industry

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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

## Development and Evaluation of an Advanced HACCP Workshop for Meat Processors

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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

## Development of a Beef Myology and Muscle Profiling Cd-rom

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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

## Microbial condition of aged lamb meat treated with 1% acetic acid

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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

## Comparison of recovery methods for freeze-injured *Listeria monocytogenes*, *Salmonella Typhimurium* and *Campylobacter coli* associated with cell suspensions and pork surfaces

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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 nonselective 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

## Incorporation of nisin into a collagen film retains antimicrobial activity against *Listeria monocytogenes* and *Brochothrix thermosphacta* associated with a ready-to-eat meat product

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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<sub>10</sub> 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<sub>10</sub> CFU/g; whereas LM was not reduced greater than 0.60 log<sub>10</sub> CFU/g. Following temperature abuse and 14 days of refrigerated storage, BT and LM were reduced by approximately 1 log<sub>10</sub> 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

## Survival of *Listeria* spp. following bacon processing

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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<sub>10</sub> 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<sub>10</sub> 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<sub>10</sub> 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<sub>10</sub> 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

### Effects of Electrolyzed Oxidizing Water on Microbial Growth, Lipid Oxidation and Color of Displayed Beef during Refrigerated Storage

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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 × 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

### Thermal conductivity model for predicting heat penetration in non-stirred raw rendered products

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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

## Analyzing Plant Sanitation Processes using Statistical Process Control Techniques

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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

## Recombinant production of chicken egg-yolk antibodies against Enterotoxigenic *Escherichia coli* by use of a DNA vaccine

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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*

## Decreasing cost in processed meat products with the addition of pork collagen

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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

### Evaluation of wet salting in the “Charqui” processing

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“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 (CI%), 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  $CI\% = 5.6581 - 1.4062 * PBM + 0.4237 * TT + 0.2462 * PBM * TT$  and  $W\% = 70.2327 - 1.2337 * TB + 1,6687 * PBM$ . The analysis of variance (ANOVA) for CI% indicated that the model was significant at  $p < 0.05$ , and had a  $R^2$  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 CI%, was inversely proportional. The CI% in the meat increased varying from 3.5% to 7.0%, as the PBM decreased. There was a positive influence of TT in CI%, but it was negligible in the range of the experiment. W% had 63.5% ( $R^2 = 0.635$ ) 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 signifi-

cant. 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

### Effect of freezing rate and storage on the functional properties of manufacturing beef

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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

## High temperature conditioning prior to rigor onset does not affect the functional properties of beef subsequently chilled rapidly

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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

## Influence of beef cuts and cooking time on color properties of a beef sausage model system

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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  $h = \arctan(b \cdot / a \cdot)$  results expressed in degrees, and  $C \cdot = (a \cdot ^2 + b \cdot ^2)^{1/2}$ .

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

## Antioxidant effect of dried milk mineral in fresh and cooked ground pork

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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 2°C. 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 2°C 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

## Effect of rosemary extract, sodium lactate and film permeability on the shelf-life of vacuum packaged ground ostrich meat

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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 (ΔE) were calculated and reflectance differences (ΔR<sub>630-580</sub>) 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=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

## Functionality of prerigor meat on the chemical, physical, and textural properties of beef patties

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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 semi-membranosus (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

### Postharvest interventions to overcome the tenderness problems in meat from older animals

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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

### Improving tenderness of beef round and sirloin muscles through pre-rigor skeletal separations

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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

### Relationship of Pork Quality Traits to Consumer Acceptability

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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

### Repeatability of Warner-Bratzler shear values in beef steaks using three different cooking methods

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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 ante-

rior 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  $71^{\circ}\text{C}$ . Steaks cooked with the BROIL method were turned at  $40^{\circ}\text{C}$ . After cooling to less than  $10^{\circ}\text{C}$ , 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

### Sample location within muscle affects pork quality measurements

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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

### Heat Penetration Patterns Of Biceps Femoris, Longissimus Lumborum And Semitendinosus Muscles Cooked By Electric Broiler, Electric Belt Grill, Or Forced-Air Convection Oven

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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 1°C for 14 days and then frozen (-37°C). Each frozen muscle was sawed into 2.54-cm thick steaks, vacuum packaged, and stored until cooking. Steaks were thawed and held at 4°C for 24 h before cooking and were assigned to one of three cooking treatments: an electric belt grill at 163°C, a forced-air convection oven at 163°C, or an electric broiler (no temperature control). All steaks were cooked to 70°C 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 40°C, heat penetration rate was relatively slow for all muscles. However, heat penetration rate

into all muscles decreased above 40°C ( $p<0.05$ ), which likely was because of denaturation of contractile proteins starting at about 40°C. The slowest heating rates occurred in the 60-70°C interval and can be attributed to collagen shrinkage and protein denaturation. Heat penetration rate between 10 and 20°C 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 70°C. 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

### Instruments differ in estimating lightness of fresh meat

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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<sub>65</sub> with a 2° observer), the Hunter Mini-scan spectrophotometer (H; illuminant D<sub>65</sub> with a 10° observer) and the ColorTec (C; illuminant D<sub>65</sub>). 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,  $L^*$

## Effect of supplemental fat on growth, quality, palatability, and fatty acid composition of beef from steers fed barley-potato product finishing diets

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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 ( $318 \pm 2.8$  kg) were allotted within weight block (3) to a randomized complete block design with a  $2 \times 3 + 1$  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  $1.6 \pm 0.16$  kg/d and decreased ( $P < 0.05$ ) feed-to-gain from 5.9 to  $5.5 \pm 0.16$ . 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  $7.4 \pm 0.1$ , and decreased ( $P < 0.10$ ) with alfalfa level. Diet did not affect total fatty acid (FA) content (DM basis) of LM ( $143 \pm 4.5$  mg/g) or fat ( $958 \pm 9.3$  mg/g). Level of yellow grease increased CLA quadratically ( $P < 0.01$ ) in LM from 0.45 to 0.64 to  $0.62 \pm 0.02$  g/100g FA and fat from 0.61 to 0.835 to  $0.825 \pm 0.02$  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 \key Yellow Grease, CLA

## Sensory evaluation of pork longissimus muscle from swine fed soybean meal from Roundup Ready® or conventional soybeans

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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® [RR]) or near-isogenic conventional (C) soy-

beans 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®, 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 postmortem 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

## Reducing airborne bacteria and molds using a germicidal air cleaning system

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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

## Effect of potato-processing waste in finishing diets on meat quality from yearling heifers

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Inclusion of potato-processing waste (PW) was evaluated in high-grain finishing diets fed to one hundred twenty-five crossbred yearling heifers ( $365.5 \pm 0.3$  kg initial weight). Heifers were fed for 84 and 105 d. Heifers were blocked by weight and allotted randomly to one of five dietary treatments (5 pens/treatment). PW replaced 0, 10, 20, 30, and 40% of corn and concentrated separator by-product in the diet. As the beginning of the trial, heifers were implanted with estradiol/trenbolone acetate. At harvest, a portion of the shortloin was removed from carcasses in the heaviest four blocks ( $n=20$ ) and aged for 16 d. After aging, 3 steaks (2.54 cm) were cut from the shortloin, vacuum packaged and frozen. Color meter readings were taken on the longissimus muscle and subcutaneous fat when the steaks were processed. One steak per heifer was broiled at  $185^{\circ}\text{C}$  to an internal temperature of  $70^{\circ}\text{C}$  and cooled to room temperature. Warner-Bratzler shear force was measured on six cores (1.27 cm). No effect ( $P > 0.4$ ) was observed on fat and muscle color characteristics ( $L^*$ ,  $a^*$ , and  $b^*$ ) with inclusion of PW. Inclusion of PW did not affect thawing and cooking losses ( $P > 0.2$ ). No difference ( $P > 0.2$ ) was observed for shear force for 0, 10, 20, and 30% levels (3.10, 3.02, 3.11,  $3.27 \pm 0.15$  kg, respectively); however, 40% PW ( $2.75 \pm 0.15$  kg) replacement reduced ( $P = 0.5$ ) shear force compared with other levels of PW. Inclusion of PW in a finishing diet does not affect muscle or fat color, cooking characteristics or tenderness; however, inclusion of 40% PW may improve tenderness.

**Key Words:** Potato-processing waste, beef, meat quality