

# Meat Science and Muscle Biology: Measuring and Manipulating Pork Quality

**290 Oxidation results in formation of an intramolecular disulfide bond in  $\mu$ -calpain.** R. Lametsch<sup>2</sup>, E. Huff-Lonerger<sup>1</sup>, and S. M. Lonergan<sup>\*1</sup>, <sup>1</sup>Iowa State University, Ames, <sup>2</sup>University of Copenhagen, Copenhagen, Denmark.

Examination of mechanisms that regulate calcium dependent protein degradation in muscle continues to be a significant area of inquiry in muscle biology. The active site cysteine of calpain not only facilitates effective catalysis, it also makes the enzyme sensitive to oxidation as characterized by its decreased activity in the presence of an oxidant. It is hypothesized that oxidation of the active site cysteine residue of  $\mu$ -calpain is responsible for the reversible inactivation of calpain that has been observed. Oxidation of cysteine is very complex and more than 10 different sulfur oxidation states are found *in vivo*. Porcine  $\mu$ -calpain contains 11 cysteines, which are all likely to be subject to oxidation. This makes it clear that sulfur oxidation state may contribute to regulation of calpain proteolytic activity. These experiments utilized LC-MS/MS analysis to determine the specific consequence of the oxidation of porcine  $\mu$ -calpain by hydrogen peroxide ( $H_2O_2$ ). The effect of different oxidative and reducing conditions on  $\mu$ -calpain activity was examined by incubating  $\mu$ -calpain with either with 200  $\mu$ M  $H_2O_2$ , 0.03%, 0.1%, or 0.2% 2-mercaptoethanol (MCE) or without  $H_2O_2$  and MCE. Activity was determined in the presence (0.2%) or absence (0%) of MCE. Pre-incubation with  $H_2O_2$  resulted in an inhibition of autolysis, activation and activity. However, when activity was evaluated under reducing conditions, the effects of incubation with  $H_2O_2$  were reversed. The LC-MS/MS analysis of the oxidized  $\mu$ -calpain revealed a peak at m/z 1032.5 that was not present in the control. The MS/MS data revealed that the peptide 105-133 likely contains a disulfide bond between Cys(108) and Cys(115). The disulfide bond was confirmed by reduction of the peptide. The finding that the active site cysteine in  $\mu$ -calpain is able to form a disulfide bond has to our knowledge not been reported before. It is hypothesized that this is part of a unique mechanism for regulation of  $\mu$ -calpain.

**Key Words:** Calpain, LC-MS/MS, Oxidation

**291 Developmental changes in tissue skatole levels and hepatic activity of cytochrome P4502E1 and P4502A6 in local and exotic pigs.** C. Y. Li\*, C. Wu, T. Z. Shan, J. X. Liu, Y. Z. Wang, and J. K. Wang, Ministry of Education Key Laboratory of Molecular Animal Nutrition, Zhejiang University, Hangzhou, P.R. China.

The objective of this study was to evaluate the developmental changes in tissue skatole levels and hepatic activity of cytochrome P4502E1 (CYP2E1) and P4502A6 (CYP2A6) in local Jinhua and exotic Landrace pigs. Eighteen intact male pigs (nine for each breed) were slaughtered at 30, 90 and 150 days of age, when samples were taken from blood, backfat, abdomen fat and liver and analyzed for skatole levels. CYP2E1 and CYP2A6 activities were evaluated for liver samples. For both breeds, tissue skatole contents elevated with the increasing age ( $P < 0.01$ ), but the two breeds showed different developmental changes with age. Compared with Jinhua pigs, plasma skatole levels were significantly lower in Landrace, at all ages ( $P < 0.05$ ). Skatole levels in liver and abdomen fat were lower in Landrace only at d 90 ( $P < 0.05$ ) and d 150 ( $P < 0.05$ ), respectively. No significant difference was found in backfat skatole levels between the two breeds ( $P > 0.05$ ). There were significant breed  $\times$  age interactions ( $P < 0.05$ ) in plasma and abdomen skatole levels, but not

in liver and backfat skatole content. The CYP2E1 activity was not different among d 30, 90 and 150 in Landrace, but decreased ( $P < 0.05$ ) from d 90 to 150 in Jinhua pigs. At d 30, CYP2E1 activity in Landrace was significantly higher than that in Jinhua pigs ( $P < 0.05$ ), while CYP2A6 activity was not different between the two breeds. For pigs at d 90, no significant difference existed in both CYP2E1 and CYP2A6. For pigs at d 150, CYP2E1 activity was not different between the two breeds, but CYP2A6 activity were significantly higher ( $P < 0.05$ ) in Landrace than that in Jinhua pig. The lower tissue skatole levels in Landrace pigs appear to be associated with higher CYP2E1 or CYP2A6 activities. However, CYP2E1 or CYP2A6 was not involved in the mechanism of age-related increase in skatole levels of Landrace pigs. Factors other than CYP2E1 or CYP2A6 may play a role.

**Key Words:** Skatole, Pig, Breed

**292 Objective and sensory measures of meat quality and fatty acid profile of longissimus intramuscular lipid from pigs fed crude glycerol.** P. Lammers<sup>\*1</sup>, B. Kerr<sup>2</sup>, T. Weber<sup>2</sup>, K. Bregendahl<sup>1</sup>, S. Lonergan<sup>1</sup>, K. Prusa<sup>1</sup>, D. Ahn<sup>1</sup>, W. Stoffegen<sup>3</sup>, W. Dozier, III<sup>4</sup>, and M. Honeyman<sup>1</sup>, <sup>1</sup>Iowa State University, Ames, <sup>2</sup>Swine Odor and Manure Management Research Unit, USDA-ARS, Ames, IA, <sup>3</sup>Bacterial Diseases of Livestock Research Unit, USDA-ARS, Ames, IA, <sup>4</sup>Poultry Research Unit, USDA-ARS, Mississippi State, Mississippi.

The effect of inclusion of crude glycerol on pork loin quality and composition was examined. Barrows (48) and gilts (48) were fed corn-soybean meal based diets containing 0, 5, or 10% crude glycerol for 138-d. Crude glycerol was obtained from AG Processing Inc., Sergeant Bluff, IA and contained 84.51% glycerol, 11.95% water, 2.91% sodium chloride, and 0.32% methanol. Diets were fed in 5-phases with each diet within a phase formulated to be equal in ME, NaCl, and Lys with other AA balanced on an ideal AA basis. On d-138, all pigs were weighed ( $133 \pm 6$  kg BW) and on the morning of d-139, pigs were transported to a commercial abattoir. Loins from the left side of each carcass (87) was removed, vacuum packaged, placed on ice, transported to Iowa State University, and stored at 0°C until subsequent analysis. Loin marbling scores, color scores, purge loss, and drip loss were determined following 12 d of storage. Lipid was extracted and quantified from a sample of each loin (87), with fatty acid profile being determined using authentic standards. Two 2.54 cm thick loin chops were removed from the center of 48 loins (24 barrows, 24 gilts) for sensory and instrumental texture analysis. Data were analyzed using a regression model to test for effect of dietary treatment, pig gender, and diet  $\times$  gender interaction. Neither diet nor gender affected any meat quality or sensory evaluation measure of loin chops ( $P \geq 0.10$ ). There was no diet  $\times$  gender interaction for any measure examined. There was a trend ( $P = 0.06$ ) for loins from pigs fed 5 or 10% crude glycerol to have a greater ultimate pH than loins from control animals. Eicosapentaenoic acid increased with increasing crude glycerol supplementation ( $P = 0.02$ ) and pigs fed 10% crude glycerol had lower levels of linoleic acid than the other dietary treatments ( $P = 0.01$ ). The results of this study demonstrate that up to 10% crude glycerol can be fed to pigs with little to no effect on meat quality. The noted differences in fatty acid profile and trend in ultimate pH may warrant further examination.

**Key Words:** Crude Glycerol, Fatty Acid Profile, Pork Quality

**293 Correlation of pork texture characteristics determined using different instrumental texture analysis methods.** M. J. Anderson\*, R. M. Smith, E. Huff-Lonergan, and S. M. Lonergan, *Iowa State University, Ames.*

Warner-Bratzler shear (WBS) force and star probe (SP) are two regularly used methods of instrumental texture analysis. Previously, little research has focused on the relationship of measurements made with these two methods. The objective of this study was to determine consistency of correlations between these instrumental texture methods and specific quality attributes. Forty pork loins aged 10-12 days postmortem were cut into chops from the blade end, center, and sirloin end. Quality attributes were measured on the longissimus dorsi at each location. Hunter L\*, a\*, and b\* values as well as drip loss were measured in duplicate. Intact desmin and pH were also measured in each location. Correlations were run between instrumental methods and quality attributes. Linear regression between SP and WBS was also calculated. SP and WBS were positively correlated at  $r = 0.67$  ( $P < 0.01$ ). Drip loss tended to be positively correlated to SP ( $r = 0.16$ ,  $P = 0.08$ ) and WBS ( $r = 0.17$ ,  $P = 0.07$ ). L\* values were negatively correlated to SP ( $r = -0.47$ ,  $P < 0.01$ ) and WBS ( $r = -0.34$ ,  $P < 0.01$ ). a\* values were negatively correlated to SP ( $r = -0.38$ ,  $P < 0.01$ ) and WBS ( $r = -0.22$ ,  $P = 0.014$ ). b\* values were negatively correlated to SP ( $r = -0.47$ ,  $P < 0.01$ ) and WBS ( $r = -0.31$ ,  $P < 0.01$ ). WBS tended to be positively correlated to the intensity of the intact desmin band ( $P = 0.076$ ). SP was positively correlated with intact desmin ( $r = 0.26$ ;  $P = 0.02$ ). Linear regression between SP (kg) and WBS (kg) was used to calculate the model:  $SP = 1.5 + 1.47(WBS)$ . The data show that there was a very strong correlation between the two instrumental measures of texture. While not significant, there was a high consistency between the correlations of both SP and WBS to drip loss. For all color measurements, SP had a stronger correlation than WBS, and also had a correlation to the intensity of the intact desmin band whereas WBS did not. The linear regression between SP and WBS is the beginning of a prediction model of the two instrumental texture methods that will allow us to better interpret data from either source.

**Key Words:** Pork Quality, Star Probe, Warner-Bratzler

**294 Effect of different dietary levels of natural-source vitamin E in grow-finish pigs on pork quality and shelf life.** D. D. Boler\*<sup>1</sup>, S. R. Gabriel<sup>1</sup>, H. Yang<sup>2</sup>, R. Balsbaugh<sup>2</sup>, D. C. Mahan<sup>3</sup>, M. S. Brewer<sup>1</sup>, F. K. McKeith<sup>1</sup>, and J. Killefer<sup>1</sup>, <sup>1</sup>*University of Illinois, Urbana*, <sup>2</sup>*ADM Alliance Nutrition, Inc., Quincy, IL*, <sup>3</sup>*The Ohio State University, Columbus.*

Feeding high levels of DDGS in the diet will result in increased levels of poly-unsaturated fatty acids in adipose tissue which increases lipid oxidation. This project evaluated the effects of natural source vitamin E (NSVE; Nova-E) compared with synthetic vitamin E on pork quality, shelf life, and color stability. One hundred forty-three pigs were used in the experiment. Six diets were fed for 95 d prior to harvest at 120 kg BW in a complete randomized block design. Six pens per treatment with 4 pigs per pen were assigned to the following treatments: 10 mg/kg NSVE, 40 mg/kg NSVE, 70 mg/kg NSVE, 100 mg/kg NSVE, 200 mg/kg NSVE, and 200 mg/kg synthetic vitamin E. Carcass evaluations, objective color, and NPPC color, marbling, and firmness were recorded for all loins. One pig per pen was randomly selected for estimations of shelf life, color stability, and lipid oxidation. Thiobarbituric acid reactive substances (TBARS) was used to estimate amounts of lipid oxidation of fresh loin chops and ground pork packaged in high oxygen modified

atmosphere packages. Serial loin chops were taken posterior to the 10th rib and displayed for 1, 8, and 15 d post-fabrication. A sample of longissimus muscle anterior to the 10th rib was collected from each pig; samples were pooled by pen forming 36 homogenous samples. Samples were ground, packaged, and displayed for 0, 6, and 12 d post-fabrication. NSVE had no effect on carcass characteristics or meat quality when compared to synthetic E. Increasing dietary NSVE decreased TBARS ( $P < 0.01$ ) for loin chops and for ground pork. High levels of vitamin E did not appear to prevent discoloration of loin chops. Lower levels of NSVE might be used in pig diets with the same benefit of higher doses of synthetic vitamin E.

**295 Comparison of dose and durations of ractopamine on late finishing pig carcass characteristics and meat quality.** L. W. Kutzler\*<sup>1</sup>, S. F. Holmer<sup>1</sup>, D. D. Boler<sup>1</sup>, S. N. Carr<sup>2</sup>, M. J. Ritter<sup>2</sup>, C. W. Parks<sup>2</sup>, F. K. McKeith<sup>1</sup>, and J. Killefer<sup>1</sup>, <sup>1</sup>*University of Illinois, Urbana*, <sup>2</sup>*Elanco Animal Health, Greenfield, IN.*

The study objective was to compare various doses and durations of ractopamine hydrochloride (RAC; Paylean®, ELANCO Animal Health, Greenfield, IN) on pig carcass weight, cutability, and meat quality. Late finishing pigs with an average starting weight of 93 kg were allotted to 12 treatments, 35 d prior to market. Treatments consisted of two control diets: negative control diet (NEG; 13.1 % CP, 0.64 TID Lys), positive control diet (POS; 17.8 % CP, 0.94 TID Lys); two RAC diets 5 ppm (4.5 g/ton) or 7.4 ppm (6.75 g/ton) with pigs on RAC for 7, 14, 21, 28, or 35 d prior to market. Durations intended for RAC were fed at NEG until incorporation of RAC when CP was increased to 17.77 % to comply with label requirements. At harvest, five pigs closest to pen average (240 pigs total) were selected for carcass, cutability and meat quality measurements. Eleven orthogonal contrasts were used to compare treatments with significance at  $P \leq 0.05$ . Overall, carcass trait contrasts between 5 ppm and 7.4 ppm were not significant. Carcass weight for RAC was 5.56 kg greater than NEG,  $P = 0.0002$ . Increasing linear duration effects on carcass weight were significant for 5 ppm and 7.4 ppm,  $P = 0.0002$  and  $P = 0.003$  respectively. Percent lean for RAC was 1.00 greater than NEG,  $P = 0.004$ . An increasing linear duration effect on percent lean was significant for 5 ppm,  $P = 0.02$ . Carcass cut yield for RAC was 1.24 % greater than NEG,  $P = 0.001$ . An increasing linear duration effect on carcass cut yield was significant for 5 ppm,  $P = 0.03$ . Subjective marbling score for RAC was 0.49 less than NEG,  $P = 0.001$ . Linear duration effects on marbling score were not significant for 5 ppm or 7.4 ppm. Subjective color values were not significantly different, nor were shear force aging curves significantly different from NEG. Overall, RAC at both levels of 5 ppm and 7.4 ppm had greater responses in carcass weight and cutability than NEG, and had minimal affect on meat quality.

**Key Words:** Ractopamine, Cutability, Meat Quality

**296 Comparison of growth performance, carcass characteristics, and meat quality of barrows, immunocastrated pigs and entire males.** C. Pauly<sup>2</sup> and G. Bee\*<sup>1</sup>, <sup>1</sup>*Agroscope Liebefeld-Posieux Research Station ALP, Posieux, Switzerland*, <sup>2</sup>*Swiss College of Agriculture, Zollikofen, Switzerland.*

In Switzerland, castration of piglets without anesthesia will be banned in 2009. Two alternatives, which allow avoiding surgical castration

under anesthesia are immunocastration or entire male production. Thus, the study's objective was to compare the growth performance, carcass characteristics, and meat quality as well as to evaluate by a trained sensory panel the incidence of boar taint in the LM of barrows (B), immunocastrated pigs (IP), and entire males (EM). At weaning 36 Swiss Large White pigs were blocked by BW into 12 blocks and assigned to B, IP, and EM. All pigs were group-penned from weaning to 107 kg BW and had ad libitum access to standard diets. The 2 IMPROVAC® injections were applied to the IP at an average BW of 22.2 and 74.3 kg, respectively. Because ADG did not differ among the experimental groups (IP: 0.92; EM: 0.88; B: 0.93 kg/d;  $P > 0.05$ ) but EM and IP consumed less feed than B (IP: 191; EM: 185; B: 202 kg;  $P < 0.05$ ), IP and EM were more efficient than B (G:F: IP: 0.42; EM: 0.43; B: 0.39 g/g;  $P < 0.01$ ). However, carcass leanness was greatest ( $P < 0.05$ ) in EM (57.5%) followed by IP (56.3%) and B (54.5%). As expected the level (expressed per g lipid of the backfat) of androstenone was higher ( $P < 0.01$ ) in EM (1.2 µg) than IP and B (0.2 µg) whereas skatole level was higher ( $P < 0.05$ ) in both the EM (0.31 µg) and IP (0.08 µg) than the B (0.05 µg). On a scale from 1 (weak) to 9 (strong), sensory scores for boar odor and flavor were lower ( $P < 0.01$ ) in the LM of B and IP than EM, whereas juiciness and tenderness scores did not ( $P > 0.05$ ) differ. Initial and ultimate pH, color, percentage drip, thaw and cooking loss did not differ among the experimental groups ( $P > 0.05$ ), whereas shear force values were higher ( $P < 0.01$ ) in the LM of B and EM compared to IP (3.7, 3.8, and 3.5 kg, respectively). Although carcasses of EM were leaner, the similar feed efficiency and especially the lower sensory scores for boar odor and flavor in the LM of IP, confirm that immunocastration might be the best alternative to avoid castration under anesthesia.

**Key Words:** Boar Production, Immunocastration, Sensory Quality

**297 Effect of gender and slaughter weight on meat quality and weight loss of hams during ripening in Iberian pigs reared under intensive production systems.** M. P. Serrano<sup>1</sup>, D. G. Valencia<sup>1</sup>, R. Lázaro<sup>1</sup>, D. Menoyo<sup>1</sup>, A. Fuentetaja<sup>2</sup>, and G. G. Mateos<sup>\*1</sup>, <sup>1</sup>Universidad Politécnica de Madrid, Spain, <sup>2</sup>Copese, Segovia, Spain.

Iberian (IB) pigs, a native breed of Spain, have been traditionally reared under free range conditions, fed on grass and acorns, and slaughtered at heavy weights (160 to 180 kg body weight, BW). Currently, to meet the increasing demand for IB products, 80% of IB pigs are reared indoors, fed on concentrates, and slaughtered at 140–150 kg BW. Originally, males (CM) and females (CF) were castrated, but intact females (IF) might also be used. An increase in slaughter weight (SW) increases intramuscular fat which benefits the production of high quality cured products. However, excessive BW results in overly fat pigs which penalizes the acceptability of the end products. A total of 96 IB dam × Duroc sire pigs were used to study the influence of gender (coded CM, CF, IF) and SW (145 and 156 kg BW) on meat quality, fatty acid (FA) profile of backfat (BF), and ham weight losses during ripening. There were four pens of four pigs each per treatment. Meat samples were taken from the Longissimus dorsi at the level of the last rib and BF samples were taken at the tail insertion. Ripening of hams lasted for 719 d (19 d for salting, 63 d for postsalting, 28 d for drying, and 609 d for cellar phase). Meat quality (except chroma value), FA profile of BF, and ham weight losses during ripening were not affected by gender or by SW. Chroma (c\*) was higher in meat from CF than in meat from CM with meat from IF being intermediate (15.5 vs. 14.9 vs. 13.6;  $P \leq 0.05$ ). We conclude that based on meat quality and weight losses during the drying process, intact females are a good alternative to castrated females to produce high quality Iberian cured products. Also, Iberian pigs can be slaughtered at either 145 or 156 kg body weight without any loss in meat quality or in ham weight losses during ripening.

**Key Words:** Iberian Pigs, Gender, Slaughter Weight