

# Meat Science and Muscle Biology

**747 Impact of stunning and carcass chilling on pork quality and post-mortem proteolysis.** G. Petca and G. Bee,\* *Agroscope Liebefeld Posieux, Research Station ALP, Posieux, Switzerland.*

The aim of the study was to evaluate the effects of stunning procedures (electrical (ES) vs. CO<sub>2</sub> (CS) stunning) and carcass chilling regimens (conventional [CC; 4°C for 23.5 h] vs. rapid chilling [RC; -30°C for 2.5 h; 4°C for 21 h]) on pork quality traits and post-mortem (pm) proteolysis in the LM. Twenty Swiss Large White × Piétrain crosses were randomly assigned to either ES or CS. Carcasses were then scalded (7 min; 65°C), eviscerated and split. At 45 min pm, the left and right carcasses were subjected to CC and RC, respectively. Compared with ES, the pH of the LM (10th rib) was greater ( $P < 0.01$ ) at 45 min (6.5 vs. 6.0), 3 h (6.3 vs. 5.6) and 24 h (5.5 vs. 5.4) in CS. Stunning procedure affected muscle temperature being lower in CS at 45 min (38.3 vs. 38.8°C) but greater at 3 (18.8 vs. 16.2°C) and 24 h (1.8 vs. 1.5°C) pm. Regardless of the stunning procedure, pH of the LM was slightly greater ( $P \leq 0.03$ ) in RC than CC at both 3 (6.1 vs. 5.9) and 24 h (5.5 vs. 5.4) pm. As expected, RC resulted in lower ( $P < 0.01$ ) LM temperature at 3 h pm (13.7 vs. 21.4°C). Percentage drip loss (48 h) was lower ( $P < 0.01$ ) in loin chops from CS pigs (3.5 vs. 4.5%). Considering the cooling regimen, RC resulted in greater ( $P = 0.04$ ) drip loss than CC (4.3 vs. 3.7%). Maximal shear force was influenced both by stunning procedure ( $P < 0.01$ ) and chilling regimen ( $P < 0.01$ ), with greater values for CS (6.3 vs. 5.3 kg) and RC (6.4 vs. 5.3 kg). Intact desmin abundance determined at both 24 and 72 h pm was not affected by the stunning procedure ( $P \geq 0.46$ ) or by the chilling regimen ( $P \geq 0.07$ ). When CS is followed by CC and when ES is followed by RC, abundance of intact talin in the LM is lower at 24 but not ( $P \geq 0.39$ ) at 72 h (stunning procedure × chilling regimen interaction;  $P < 0.01$ ). Relative abundance of the unautolyzed 80 kDa  $\mu$ -calpain unit at 24 h pm was influenced by stunning procedure ( $P < 0.01$ ) and cooling regimen ( $P < 0.05$ ), with greater abundance in the LM of CS and RC. By contrast, the relative abundance of the 78 kDa  $\mu$ -calpain subunit was lower ( $P \leq 0.06$ ) for the CS and RC. The results reveal an overall positive effect of CS, except for shear force values, and CC on LM quality traits.

**Key Words:** stunning procedure, chilling rate, proteolysis

**748 Effects of cannabinoid receptor 1 on muscle fiber types and muscle oxidative metabolism.** E. Xu\*<sup>1,2</sup>, L. N. Zhu<sup>1</sup>, T. Wu<sup>1</sup>, Y. N. Huang<sup>1</sup>, and Y. Z. Wang<sup>1</sup>, <sup>1</sup>*Institute of Feed Science, Zhejiang University, The Key Laboratory of Molecular Animal Nutrition, Ministry of Education, Zhejiang Provincial Laboratory of Feed and Animal Nutrition, Hangzhou, Zhejiang, China,* <sup>2</sup>*College of Animal Science, Guiyang, Guizhou, China.*

The cannabinoid receptor type 1 (*CNR1*) is a key component of the endocannabinoid system, which has been reported to play a pivotal role in modulating feeding behavior and energy balance. *CNR1* is expressed in skeletal muscle and has effects on skeletal muscle metabolism. However, how this gene regulates muscle fiber types and muscle oxidative metabolism remains un-elucidated. In this study, 2 different strategies have been carried out: siRNA suppression and overexpression of *CNR1*. Results showed that the *CNR1*-overexpressed L6 cells exhibit higher expression levels of oxidative type muscle gene myosin heavy chain type II $\alpha$  (MyHCII $\alpha$ ,  $P < 0.01$ ) and oxidative enzyme succinic dehydrogenase (SDH,  $P < 0.05$ ) compared with the control group. While knockdown the *CNR1* in L6 cells, MyHCII $\alpha$  expression ( $P < 0.01$ ) was

decreased and the expression of glycolytic enzyme lactate dehydrogenase (LDH) was significantly increased ( $P < 0.01$ ). Overexpression of *CNR1* in rat soleus muscle significantly increased MyHCII $\alpha$  ( $P < 0.01$ ), SDH ( $P < 0.01$ ) and malate dehydrogenase (MDH,  $P < 0.05$ ) mRNA expression. In addition, *CNR1* overexpression in vivo induced SDH ( $P < 0.01$ ) and MDH ( $P < 0.05$ ) enzyme activities and downregulated LDH ( $P < 0.05$ ) enzyme activity. Furthermore, gene expression of extracellular-regulated kinase 1 (ERK1) and proliferator-activated receptor- $\gamma$  coactivator-1 $\alpha$  (PGC-1 $\alpha$ ) were remarkably increased in both overexpression L6 cells and rat soleus muscle. In contrast, we observed that PGC-1 $\alpha$  gene expression was significantly decreased, but extracellular-regulated kinase2 (ERK2) gene expression significantly increased in siRNA cell lines. Based on these results, we conclude that *CNR1* enhance the MyHCII $\alpha$  and oxidative enzyme MDH and SDH gene expression and activities, inferring that the gene may play an important role in muscle oxidative metabolism. Moreover, *CNR1* may affect muscle fiber types and muscle oxidative metabolism via ERK1/2 and PGC-1 $\alpha$ . These results contribute to further understanding the role of *CNR1* in skeletal muscle energy metabolism, and also help to explore the key genes to improve meat quality.

**Key Words:** cannabinoid receptor type 1, muscle fiber types, oxidative metabolism

**749 Fatty acid profile of meat from young bulls fed different levels of crude glycerin.** M. M. Ladeira,\* J. R. R. Carvalho, M. L. Chizzotti, E. M. Ramos, P. D. Teixeira, M. C. L. Alves, P. E. P. Barros, and O. R. Machado Neto, *Federal University of Lavras, Lavras, MG, Brazil.*

The fatty acid profile in beef has an extreme importance, because many of these fatty acids have beneficial and malefic actions to human health. The objective was to determine the fatty acid (FA) profile of muscle and subcutaneous fat of feedlot young bulls fed different levels of crude glycerin in the diet. The experiment was conducted in a completely randomized design, with 4 treatments and 11 repetitions. Forty-four Red Norte animals were slaughtered at average live weight of 519 ± 15 kg, and the levels of crude glycerin (83% glycerol) in the diet were: 0, 6, 12 and 18% DM. The basal diet consisted of 30% corn silage, 12% soybean meal, 56% corn grain and 2% mineral mixture. Corn was partially replaced by glycerin, and to achieve an isonitrogenous diet, corn gluten meal (21% CP) was used. After slaughter, samples were taken from the *Longissimus dorsi* muscle of the left half carcass, and fatty acids were quantified using gas chromatography (GC-MS Finnigan Focus Gas Chromatograph; Column CP-Sil 88). When there was significant effects ( $P < 0.05$ ), regressions analysis using PROC REG of SAS 9.1.3 were done. There was a linear increase of oleic acid (C18:1 cis-9) content in subcutaneous fat ( $P < 0.05$ ) and muscle ( $P < 0.05$ ), which could be due to an inhibition effect of glycerol on rumen lipolysis and, consequently, on the biohydrogenation, resulting on greater flow of unsaturated fatty acids to small intestine. The octadecenoic acid (C18:1 trans-10, trans-11 and trans-12) content in muscle decreased ( $P < 0.05$ ), and there was a tendency ( $P < 0.10$ ) of reduction on palmitic acid (C16:0) content in the muscle and subcutaneous fat with the increase of crude glycerin in the diet. However, the linoleic acid (C18:2  $\omega$ -6),  $\alpha$ -linolenic acid (C18:3  $\omega$ -3) and CLA (C18:2 cis-9, trans-11) contents were not affected ( $P > 0.05$ ) by the levels of crude glycerin. In the muscle tissue, there was an increase ( $P < 0.05$ ) in concentration of monounsaturated fatty acids, and unsaturated:saturated fatty acids ratio ( $P < 0.01$ ). As a conclusion,

the use of crude glycerin in the beef cattle diet improved the fatty acids profile of meat. Funded by Fapemig, CNPq, Capes and INCT-CA.

**Key Words:** biohydrogenation, CLA, glycerol

**750 Effect of vitamin E inclusion on *trans*-18:1 isomers in subcutaneous fat of steers fed a high-barley grain diet.** C. Mapiye\*<sup>1</sup>, M. E. R. Dugan<sup>1</sup>, M. Juárez<sup>1</sup>, J. A. Basarab<sup>2</sup>, V. S. Baron<sup>1</sup>, T. Turner<sup>1</sup>, X. Yang<sup>1</sup>, N. Aldai<sup>3</sup>, and J. L. Aalhus<sup>1</sup>, <sup>1</sup>*Agriculture and Agri-Food Canada, Lacombe Research Centre, Lacombe, Alberta, Canada*, <sup>2</sup>*Alberta Agriculture and Rural Development, Lacombe Research Centre, Lacombe, Alberta, Canada*, <sup>3</sup>*University of Basque Country, Vitoria-Gasteiz, Spain*.

Beef from animals fed high-concentrate diets can contain more *trans* (t)10–18:1 than vaccenic acid (t11–18:1) and consumption of t10–18:1 is associated with unhealthy blood lipoprotein profiles in animal models. Vitamin E has been reported to alter the levels of biohydrogenation intermediates in the rumen and consequently the fatty acid composition of tissues. The objective of the current study was to determine the effect of different dietary vitamin E levels on t18:1 isomers in subcutaneous fat from steers fed a high-barley grain diet. Steers were fed 1 of 4 levels of supplementary DL- $\alpha$ -tocopheryl acetate (340, 690, 1040 or 1740 IU/steer/day) in a barley-based finishing diet for 120 d. Two pens of 7 animals were fed per diet. At slaughter, subcutaneous fat was collected from the grade site (12th rib), methylated with sodium methoxide, and analyzed by a combination of GC and Ag<sup>+</sup>-HPLC. Polynomial contrasts were used to test for linear and quadratic effects of increasing dietary levels of vitamin E on subcutaneous fatty acid composition. Addition of vitamin E led to linear reductions ( $P < 0.05$ ) in t6-/t7-/t8–18:1 and t10–18:1, and linear increases ( $P < 0.05$ ) in t11–18:1 and t11-/t10–18:1 ratio in subcutaneous fat. Although vitamin E led to improvements in the t18:1 profile of beef subcutaneous fat, t10–18:1 remained the predominant t18:1 isomer. Additional testing is, therefore, warranted where a greater range of vitamin E is fed combined with testing for interactions with other biohydrogenation modifiers.

**Key Words:** subcutaneous fat, *trans* fatty acids, vaccenic acid

**751 Influence of gender on meat quality and skatole in the fat of lambs.** N. M. Schreurs,\* *Institute of Food, Nutrition and Human Health, Massey University, Palmerston North, New Zealand*.

Boar taint is a negative attribute of pork that occurs due to hindgut skatole production. The sheep rumen also produces skatole but there is no scientific evidence of ram taint. The objective was to investigate the influence of gender on lamb meat quality and fat skatole concentration. Five-month-old entire ( $n = 19$ ) and castrated ram-lambs ( $n = 19$ ) were grazed on autumn ryegrass pasture for 70 d. Live weight was measured at the start and before slaughter. Hot carcass weight was measured and the carcass chilled at 4°C for 24 h. After chilling the left loin was removed, vacuum-packed, chilled for a further 24 h at 4°C then stored at –20°C. Intermuscular fat was collected from the hind legs of the carcass and stored at –20°C. After thawing, muscle lightness and redness was assessed on a fresh slice of the loin after 30 min exposure to air (Minolta CR-200 chromameter calibrated to a white standard). Tenderness was assessed by the peak force required to shear 13 mm-square cores from loin steaks cooked in a water bath at 70°C for 90 min (Warner-Bratzler device, square blade and 30 kg load cell). Skatole concentration in the

intermuscular fat was measured by GC-MS. Skatole concentration and peak shear force data required a log-transformation to achieve a normal distribution. Data were analyzed by *t*-test. The ram lambs had a greater pre-slaughter live weight (51.5 vs. 46.6 kg;  $P < 0.001$ ) and carcass weight (22.0 vs. 20.5 kg;  $P < 0.01$ ) due to a greater live weight at the start (40.3 vs. 37.7 kg;  $P < 0.05$ ) and a greater growth rate (160 vs. 127 g/day;  $P < 0.01$ ). Gender did not influence the lightness, redness or peak shear force. The skatole concentration was greater in the fat of the entire ram lambs (0.079 vs. 0.052  $\mu\text{g/g}$ ;  $P < 0.05$ ). In production systems, rams are preferred over castrated male lambs due to their greater growth rates and ability to produce a heavier carcass, as observed in this study. The ram lamb was not associated with poorer meat quality in terms of tenderness and color compared with the castrated male. The greater skatole concentration indicates potential flavor issues for meat from ram lambs but the concentration was well below the 0.25  $\mu\text{g/g}$  threshold at which boar taint is detected.

**Key Words:** lamb, skatole, gender

**752 Comparison of skinning versus scalding and singeing: Effect on temperature, pH and meat quality in goats.** A. B. Omojola\*<sup>1</sup>, E. S. Apata<sup>2</sup>, O. O. Olusola<sup>1</sup>, and A. B. Omotoso<sup>1</sup>, <sup>1</sup>*University of Ibadan, Ibadan, Oyo State, Nigeria*, <sup>2</sup>*Olabisi Onabanjo University, Ago-Iwoye, Ogun, Nigeria*.

The aim of this work was to investigate the effect of temperature and pH changes taking place at the slaughter line due to different post slaughter processing methods (PSPM) on meat of red Sokoto buck goats. A total of 27 good grade red Sokoto buck goats were slaughtered in batches of 3 and assigned randomly to the 3 PSPM of skinning, scalding, and singeing in a completely randomized design. Samples for pH analysis were taken from the Longissimus dorsi while the semi-membranosus muscles were used for evaluating shear force values (Kg/cm<sup>3</sup>) of the meat. Eating quality was estimated on aged semi-membranosus muscles using a trained taste panel on a 9-point hedonic scale. The internal temperature and pH values were taken at a depth of 2 cm at the Longissimus dorsi immediately after dressing and subsequently at 30 min intervals over a period of 3 h post-mortem. The rib-eye area was measured at the interface of the 12th and 13th rib while meat color was evaluated after freezing and thawing. Water Holding Capacity (WHC), drip loss and cooking loss were also evaluated. The ultimate pH was measured 24 h post-mortem. All data obtained were subjected to ANOVA. At the slaughter line, the skinned carcasses had a lower temperature ( $P < 0.05$ ) compared with scalded and singed carcasses. The rate of pH fall was lowest ( $P < 0.05$ ) in skinned carcasses from exsanguination until 3 h post-mortem while the ultimate pH was lowest ( $P < 0.05$ ) in skinned (5.54) carcasses and highest ( $P < 0.05$ ) in singed carcasses (5.70). Skinned carcasses showed a darker ( $P < 0.05$ ) meat color compared with meat from scalded and singed carcasses. Scalding and singeing led to increased toughness by 26.21 and 50% respectively over meat from skinned carcasses. Drip and cooking losses were higher ( $P < 0.05$ ) in meat from scalded and singed carcasses. WHC increased by 9.67% in meat from scalded carcasses while a decrease of 14.20% was obtained in meat from singed carcasses compared with those from skinned carcasses. The rib-eye area was not affected ( $P > 0.05$ ) by the 3 PSPM. The trained panelist preferred ( $P < 0.05$ ) meat from singed carcasses in terms of color, flavor, and overall acceptability.

**Key Words:** temperature, pH, postmortem processing

**753 Organoleptic and shelf life of displayed Red Sokoto buck meat as influenced by post-slaughter processing methods.** A. B. Omojola\*<sup>1</sup>, E. S. Apata<sup>2</sup>, O. O. Olusola<sup>1</sup>, and A. B. Omotosho<sup>1</sup>, <sup>1</sup>*University of Ibadan, Ibadan, Oyo State, Nigeria*, <sup>2</sup>*Olabisi Onabanjo University, Ago-Iwoye, Ogun, Nigeria*.

While post-slaughter processing methods have the potential to add value, enhance shelf life and eating qualities of animal products, their effects on meat displayed for marketing as practiced in most developing nations needs to be evaluated. An experiment was carried out to investigate the effects of 3 post-slaughter processing methods (PSPM) of scalding, skinning, and singeing on eating and shelf life of displayed Red Sokoto buck meat. Twenty-seven (27) matured Red Sokoto buck goats weighing between 18 and 20 kg were slaughtered in batches of 3 and assigned to the 3 PSPMs. A completely randomized design in a 3 × 4 factorial arrangement was employed. After evisceration, the carcasses were split into symmetric halves and were fabricated into wholesale cuts. Meat from the leg cut (semi-membranosus) of each carcass from each treatment were displayed on a clean and sanitized table to simulate open market retail situations at an ambient temperature of 27°C. Meat samples

were removed from the open displayed meat at intervals of 0, 3, 6 and 9 h for measurement of peroxide value, microbial load and organoleptic characteristics. The organoleptic score as measured on a 9-point hedonic scale was highest ( $P < 0.05$ ) at 0 h of display for all parameters while the value reduced as time of open display increased. Irrespective of the time of display, meat from singed carcasses were scored highest ( $P < 0.05$ ) for color (6.24), aroma (6.60), flavor (6.76) and overall acceptability (6.63). Tenderness and juiciness score were rated highest ( $P < 0.05$ ) in meat from scalded carcasses. The peroxide value was least ( $P < 0.05$ ) at 0 h of open display (0.43mEq) and increased as the display time increased. Displayed meat from skinned carcasses elicited the highest ( $P < 0.05$ ) peroxide value (0.52 mEq) followed by meat from scalded carcasses (0.45 mEq). The microbial load of displayed meat from singed carcasses were least ( $P < 0.05$ ) at various time of display while displayed meat from skinned carcasses had the highest microbial load at 0,3 6 and 9 h. Microbial load of all the displayed meat increased as time of display increased. Singeing enhanced shelf life and eating qualities of chevon displayed in open market situation.

**Key Words:** scalding, skinning, singeing