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The effects of pre-slaughter pig management from the farm to the processing plant on pork quality

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ABSTRACT

Two experiments (Exp.1, n = 80; Exp.2, n = 144) were conducted to determine the effects of pre-slaughter pig management on pork quality by monitoring blood lactate concentration ([LAC]) during marketing. [LAC] was measured at: (1) baseline at farm, (2) post-loading on truck, (3) pre-unloading after transport, (4) post-unloading at plant, (5) post-lairage, (6) post-movement to stun, and (7) exsanguination. Pearson correlations were used to determine relationships between [LAC] and meat quality. Higher [LAC] post-loading or a greater change in [LAC] during loading resulted in increased 24 h pH ($P = 0.002$, $P = 0.0006$, Exp.1; $P = 0.0001$, $P = 0.01$, Exp.2, respectively), decreased L^* ($P = 0.03$, $P = 0.04$; $P = 0.001$, $P = 0.01$) and decreased drip loss ($P = 0.02$, $P = 0.12$; $P = 0.002$, $P = 0.01$). Even though improved handling during loading is important to animal well-being, it will not necessarily translate into improved pork quality.

1. Introduction

Physiological changes associated with immediate pre-slaughter stressors such as handling and physical exertion have been shown to have detrimental effects on pork quality (Edwards et al., 2010; Hambrecht et al., 2005a; Hambrecht et al., 2005b; Hambrecht et al., 2004; Warriss et al., 1998). Hill and Schultz-Kaster (2006) reported immediate improvements in meat quality with improved pre-stun animal handling. One physiological change in swine associated with animal handling stress is an increase in blood lactate concentration ([LAC])(Anderson et al., 2002; Benjamin et al., 2001). Hambrecht and coworkers (2004, 2005a) have explored the relationship between high exsanguination [LAC] and pork quality and determined that swine with higher [LAC] at slaughter resulted in pork with higher drip loss. This effect was enhanced by high muscle glycolytic potential indicating the complexity of determining ultimate pork quality. Warriss (1994) has demonstrated that pork from animals stressed during immediate pre-slaughter handling, with higher exsanguination [LAC], had less acceptable eating quality than from animals handled carefully, despite there being no difference in the predictors of quality that were measured. Warriss et al. (1994) were able to demonstrate a correlation between the subjective assessment of stress level and the objective measures of stress and meat quality in a survey study of swine slaughter plants. High stress was associated with high exsanguination [LAC] and lower meat quality, i.e. decreased water holding capacity and lighter color.

Although several studies have been conducted exploring the effects of pre-slaughter stresses on pork quality (Hambrecht et al., 2005a; Hambrecht et al., 2004; Warriss, Brown, Adams & Corlett, 1994), these studies have specifically focused on animal management immediately before slaughter. Therefore, the objective of this study was to determine if a relationship existed between pre-slaughter animal management, from the farm to the meat processing plant, and meat quality.

2. Materials and methods

Two studies were conducted in which blood lactate concentration was measured on each individual pig at seven different sampling points throughout the marketing process. Experiment 1 and 2 were conducted in July 2007 and January 2008, respectively. Study replications were analyzed as separate experiments due to difference in season, processing plant facility design and experimental protocol. Prior to the initiation of these experiments, all animal use, handling, and sampling techniques were approved by the Colorado State University Animal Care and Use Committee.

2.1. Animals, housing and transportation

Crossbred swine, from the mating of Fast 536 sows to either a Duroc boar line (40 barrows/40 gilts in Exp. 1) or a PIC 337 boar line (120 barrows/24 gilts in Exp. 2) were used. Animals were housed in

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commercial finisher facilities (approximately 1000 animals/barn) in pens of approximately 22 animals/pen. Approximately 12 h prior to transportation to a commercial pork processing plant, experimental animals were selected from 4 pens (5–6 animals/pen) based on structural soundness and health and were identified with a unique tattoo and ear tag number. The 20 (Exp. 1) or 24 (Exp. 2) experimental animals were loaded on a commercial swine pot-belly transportation trailer. Animals were transported in four truckloads (2/day) in Exp. 1 and six truckloads (2/day) in Exp. 2. At loading, animals were moved either 15 or 46 m to the loading chute, dependent upon pen location, by farm personnel and researchers. The portable loading chute was approximately 0.76 m wide and the ramp was at a 14º and 11º incline for Exp. 1 and Exp. 2, respectively. Electric prods were used during loading, primarily as animals were entering and moving up the loading chute; there was minimal prod use in the barn. Experimental animals were loaded into the two top middle compartments of the trailer with an approximate stocking density of 0.42 m^2/pig. The remainder of the trailer compartments were filled with non-experimental commercial finished swine (total load size of approximately 170–175 pigs). Due to a miscommunication between plant and farm personnel during Exp. 1, some test animals transported on the first experimental day were transported on the bottom deck of the trailer in the nose compartment (Truck 1 = 11 animals; Truck 2 = 9 animals).

Animals were transported approximately 2.5 h to the processing plant, unloaded, moved to lairage pens and rested for either a 30 min (lairage density = average of 2.6 m^2 per animal) or 4.5 h (lairage density = average of 5 m^2 per animal) lairage. After lairage, test animals were either moved 20 m or 280 m to the pre-slaughter handling area, i.e. a circular crowd pen and a single-file chute. Electric prods were not used in the plant or on the truck during unloading except for during immediate pre-slaughter handling in the crowd pen and single-file chute. The voltage of the electric prods used were 13 and 17.5 V in Exp. 1 and Exp. 2, respectively. Following handling, test animals were electrically stunned with a head-to-chest constant amperage, variable voltage stunning system and subsequently exsanguinated. At this point, all test animals entered normal post-mortem processing of the pork processing facility. The pork processing facility had an average line speed of 630 animals/h. Live weights (125 ± 9 and 128 ± 3 kg in Exp. 1 and 2, respectively) were estimated by dividing the hot carcass weights by an average dressing percentage of 75%.

2.2. Sampling points

Each of the experimental animals were sampled at seven different points throughout the marketing process: (1) baseline, (2) post-load, (3) pre-unload, (4) post-unload, (5) post-lairage, (6) post-movement and (7) exsanguination. The baseline blood sample (1) was collected in the barn pen approximately 12 h prior to transport. The post-loading sample (2) was obtained on the truck after the experimental animals had been loaded and before the remainder of the trailer was loaded with non-experimental commercial finished swine. The pre-unloading sample (3) was obtained on the truck upon arrival at the packing plant prior to unloading of the experimental animals. Trucker/plant personnel unloaded all animals on the trailer except the test animals prior to the third sampling; the test animals were in a separate compartment so unloading the rest of the truck did not directly impact the test animals. The post-unload sample (4) was collected from the test animals after they had been unloaded and moved to lairage pens. The post-lairage sample (5) was collected in the lairage pen approximately 20 min prior to the end of the predetermined lairage time. The post-movement sample (6) was obtained immediately after the test animals had been moved to the pre-slaughter handling area — circle coral. The exsanguination sample (7) was obtained after animals had moved through the pre-slaughter handling area and been electrically stunned and exsanguinated within approximately 10 s following stunning.

2.3. Sampling protocol

At each sampling, animals were restrained to obtain a blood sample for [LAC]. The technique used was a low-stress restraint method that did not require use of a snare or excessive restraint. Researchers restrained each pig using sorting boards. Another researcher pricked one of the animal's distal ear veins with a retractable 20 gauge needle. A sample strip was inserted into a hand-held lactate analyzer (Lactate Scout, EKF Diagnostic GmbH, Magdeburg, Germany) and a drop of blood from the animal's ear was immediately administered to the sample strip. The analyzer provided [LAC] in approximately 15 s and the information was recorded. After the blood sample was obtained, pressure was applied to the ear vein for several seconds to induce clotting.

2.4. Equipment standardization

Prior to data collection on each slaughter day, the hand-held lactate analyzers were tested for reproducibility. Lactate analyzers were tested daily with a standard solution to ensure accuracy (C.V. 2.8%). Furthermore, the hand-held lactate analyzer was compared to a laboratory procedure involving blood collection in potassium oxalate sodium fluoride tubes (obtained post slaughter) and subsequent analysis of the plasma using immobilized enzyme technology with lactate oxidase on a YSI 2700 Select Biochemistry Analyzer (YSI Inc., Yellow Springs, OH, USA). Blood samples (n = 39) were tested to assess agreement between methods and, although the methods were highly correlated ($r = 0.97$, $P = 0.0001$), the mean [LAC] using the hand-held analyzer was lower compared to the enzymatic procedure (7.4 ± 3.2 and 9.5 ± 4.1 mM, respectively; $P < 0.05$).

2.5. Meat quality analyses

The left side of the carcass was used for all meat quality measurements. Forty-five minute pH was obtained at the 10th rib of the *longissimus dorsi* using a pH meter (Version 1.5, Meat Probes, Inc., Topeka, KS) with a glass tip probe. At approximately 24 h post-mortem, pH was measured again from the same location on the carcass using the same pH meter. An approximately 2.5 cm thick loin chop was removed from the *longissimus dorsi* at the 10th rib and used for all of the subsequent measurements and analyses. All chops were placed on ice prior to analysis for color measurements and drip loss determination. Subjective color of the chop was determined using the 1–6 color score system (NPPC, 2000). Drip loss was determined using the method of Rasmussen and Stouffer (1996). A 2.54 cm coring device was used to remove two meat samples from each loin chop. The remainder of the chop was placed in a sealed plastic bag and frozen at −80 °C for future analyses. Each of the meat cores was assessed for L*, a* and b* color using a CR 400 Chroma meter (Konica Minolta Holdings, Inc., Tokyo, Japan) with D65 illuminant and a 2 degree observer. Each sample was then weighed and placed in a 3 cm × 3 cm plastic drip loss tube with an exudate collection funnel. Drip loss containers were stored at 4 °C. After 24 h, the meat samples were taken out of storage and reweighed. The percentage drip loss was calculated. Color score and drip loss were analyzed in duplicate.

2.6. Glycolytic potential

Glycolytic potential was determined on loin chop samples that were frozen and stored as previously described. Glycolytic potential was calculated based on Monin and Sellier (1985): Lactate + [2 × (Glucose + Glucose-6-Phosphate + Glycogen)]. Loin chops were moved from −80 °C storage to 8 °C storage 12 h prior to analysis. A