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Effects of lairage time on welfare indicators, energy metabolism and meat quality of pigs in Beijing

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ABSTRACT

A total of forty Duroc–Landrace–Large White female pigs (90 ± 5 kg) were used to study the effects of different lairage times (0 h, 3 h, 8 h, 24 h) on welfare, energy metabolism and meat quality. The results showed that lairage time of 3 h led to a lower blood cortisol, a decreased drip loss and a delayed degradation of glycogen in muscles compared with pigs without rest, while lairage times of 8 h and 24 h resulted in a significant increase in pork toughness. It was concluded that three hours of lairage was appropriate to reduce pre-slaughter stress and obtain better meat quality for pigs transported for 4 h in winter, under the most frequent commercial conditions in Beijing, China. No lairage, or excessively long lairage time, might compromise animal welfare and meat quality.

1. Introduction

Pre-slaughter handling includes mixing of unfamiliar animals, loading, unloading, transportation and abattoir lairage. All these handling practices can induce stress, either psychologically or physically (Rosenvold & Andersen, 2003). Pre-slaughter stress is both an animal welfare issue and a quality issue, as it has long been recognized that pre-slaughter stress can adversely affect the quality of pork (Fernandes, Smith, Ellis, Clark, & Armstrong, 1979; O'Neill, Lynchb, Troy, Buckley, & Kerrya, 2003; Van de Perre, Permentier, De Bie, Verbeke, & Geers, 2010).

A period of rest in lairage is generally recommended to allow the pigs to recover from transport and associated handling. Shorter lairage is associated with more pale, soft, exudative (PSE) meat, because of insufficient time to relieve stress. Longer lairage can increase the amount of dark, firm, dry (DFD) meat, reduce carcass yield and increase the risk of carcass cross-contamination (Faucitano, 2010; Warriss, 2003). Therefore, proper resting time is very important to relieve stress and improve meat quality. The effects of different lairage times on both animal welfare and meat quality have been reported by many research groups, but the results are not well defined. Geverink, Engel, Lambooij, and Wiegant (1996) suggested that pigs should be slaughtered immediately upon arrival. Young, Bertram, and Oksbjerg (2009) observed that one hour rest could improve meat quality. Warriss, Brown, Edwards, and Knowles (1998) found that overnight lairage reduced the amount of stress exhibited by pigs, although increased the prevalence of DFD meat. Moreover, differences in pig breeds, growth environment, raising conditions and preslaughter handling may lead to different optimal lairage times.

In Beijing (China), most commercial pigs are Duroc–Landrace–Large White crossbreed. Before slaughter, most pigs are transported for 3–5 h by trucks with separate pens without mixing, and no water is provided during transporting. Feed is withdrawn approximately 4 h before loading and pigs are usually mixed in lairage pens and rarely fed during lairage in the abattoir. In addition, lairage conditions and human handling are similar in different abattoirs, but lairage time may vary from 0 h to 24 h in practice. Several studies on the effects of lairage time on meat quality have been reported in China but did not mention welfare and energy metabolism (Wang, Yue, & Wang, 2007; Zhu et al., 2008).

Therefore, the aim of this study was to investigate the effects of lairage time on blood constituents as an indicator of welfare and the meat quality traits of color, drip loss and toughness, under the most frequent environmental and commercial conditions in Beijing. Furthermore, we aimed to study the effect of lairage time on post-mortem energy metabolism in pig muscles. This research was conducted in Pengcheng Meat Factory which was the largest meat producing enterprise in Beijing. A single nonreplicated experiment had been developed as a pilot-study which could set the stage for further studies.

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2. Materials and methods

2.1. Animal treatment

The study was carried out in Beijing, China, in December 2010 (winter). Forty females from Chinese Duroc boars and Chinese Landrace × Large White sows were used. All the animals came from five rearing pens (eight pigs with an average live weight of 90 ± 5 kg were chosen from every pen) at the same farm (Beijing Taiping Pig Farm, China) and were fed ad libitum the same commercial diet. On the experiment day, the animals were deprived of food and water for 4 h before loading. A tailgate lift was used for loading and a ramp (15° slope) for unloading. The pigs from five rearing pens were loaded into five vehicle pens (2.0 × 1.6 × 1.2 m, length × width × height) without mixing during transport. Pigs were transported on a truck with a single deck, and transportation time was 4 h, at a mean speed of 60 km/h. The ambient temperatures during transport varied from −6 to 1 °C. On arrival, two pigs were chosen randomly from each vehicle pen, and four groups were reformed with ten pigs per group, then the pigs were held in four identical lairage pen (8.0 × 4.0 × 2.5 m, width × length × height) respectively. After two-minute showering, the first group was slaughtered immediately, while the other three groups were held in lairage for 3 h, 8 h and 24 h, respectively, before slaughtering. The temperature inside and outside the lairage pen was 10 and −1 °C respectively. During the period of the lairage, water was provided but no food. These different lairage times were chosen from the most common lairage times used under Chinese commercial conditions in a standard industrial abattoir. All pigs were driven gently with a wooden goad and slaughtered with general operating procedure (GB/T17236-2008, China) in Pengcheng Meat Factory (Beijing, China). All the pigs were electrically stunned (85 V for 3 s) and exsanguinated in the horizontal position. After evisceration, carcasses were kept in the cooler at 4 °C for 24 h. In order to compare the effect of lairage time, all the other conditions associated with handling and transport were the kept the same for all the pigs.

2.2. Welfare indicators

Blood measurements were carried out in order to assess preslaughter stress. Blood samples were collected at exsanguination and were kept refrigerated until arrival at the laboratory for immediate processing. Hematological parameters were: white blood cells (WBC), red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC) and platelet count (PLT). Blood was analyzed immediately with an automatic counter (Sysmex F800, TOA Medical Electronics Co., Ltd., Japan).

EDTA plasma and serum were quickly obtained by centrifugation, and aliquots were frozen (−30 °C) for subsequent analysis of lactate, glucose, creatine kinase (CK), alanine amino transferase (ALT), lactate dehydrogenase (LDH) and cortisol. Plasma cortisol (EDTA K3) level was measured by radioimmunoassay (CT-RIA-I125, Biolink 2000 S.L., Pii Molist 133, Barcelona, Spain). Plasma lactate (EDTA KF) concentration was measured using a Sigma Diagnostics kit and a spectrophotometer (Perkin Elmer Lambda 5, PerkinElmer & Co GmbH, 7770 Überlinger, Germany). Serum enzyme activity levels and glucose concentration were analyzed by a multianalyzer spectrophotometer (Technicon RA-500, Swords Co., Ltd., Dublin, Ireland) using Bayer reagents.

Hot carcass weight was recorded at 45 min post-mortem. The extent of skin blemish on the carcass was estimated visually with a scale of 1 to 4 (four-point scale: 1 = none, 2 = slight, 3 = moderate, 4 = severe) (Barton Gade, Warriss, Brown, & Lambooij, 1996).

2.3. Meat quality measurements

The temperatures in the left *M. longissimus dorsi* (LD), at 2 cm from the last rib in the cranial direction, and in *M. biceps femoris* (BF), 20 cm from the knee joint in the caudal direction toward the tail base, were recorded at 5 min (T_0) and 24 h (T_{24}) after slaughter. Muscle pH was measured with a portable pH meter (HI99163, Hanna Instruments Inc., Italy) attached to an insertion glass electrode (FC232D, Hanna Instruments Inc., Italy) and automatic temperature compensating probe at 45 min (pH_{45}) and 24 h (pH_{24}) post-mortem in LD and BF.

For estimation of drip loss, meat samples were cut from carcasses at 24 h postmortem. Samples were placed in netting and suspended in an inflated bag for 24 h at 4 °C. Drip loss was expressed as percentage of the initial sample weight (Honikel, 1998).

Color of both LD and BF were measured with a reflectance colorimeter (WSC-S, Shanghai Precision & Scientific Instrument Co., Ltd., China), based on the CIE $L^*A^*B^*$ system.

Samples of the right LD from the last rib in the cranial direction and the middle 7 cm of BF were dissected 24 h postmortem for texture analysis. Samples were cut into blocks of 5 × 8 × 4 cm, vacuum packed and heated in a water bath (80 °C) until the samples obtained a core temperature of 75 °C. Then the samples were cut into six 3-cm long 1 × 1 cm strips parallel to the longitudinal orientation of the muscle fibers. Strips were sheared at room temperature using the Warner-Bratzler shear device (Model Warner-Bratzler, G-R Manufacturing Co., USA).

2.4. Glycogen and lactate content

Glycogen and lactate analyses were performed on biopsies taken from the left LD at 4 cm from the last rib in the cranial direction. Biopsies were frozen in liquid nitrogen and stored at −80 °C until analysis. The muscle glycogen content was measured via the method described by Dreiling, Brown, Casale, and Kelly (1987). Glycogen change values were calculated by the difference between glycogen contents at 1 min, 5 min, 45 min, 12 h and 24 h postmortem.

For lactate determination, approximately 500 mg of muscle was homogenized for 30 s in 2 ml of 1 M PCA. 2 M KOH was added to neutralize the solution, and the final volume was made to 10 ml with distilled water. Following 20 min of refrigeration and centrifugation, lactic acid concentrations were determined using a commercially available lactate analysis kit (Nanjing Jiancheng Bioengineering Institute, China). Lactate change values were obtained by the difference between lactate contents at 1 min, 5 min, 45 min, 12 h and 24 h postmortem.

2.5. Statistical analysis

Data were analyzed as a completely randomized design using SPSS13.0. A multiple analysis of variance (general linear model) was used to compare the significant differences among the mean values, and differences at $P<0.05$ were considered to be statistically significant. Data were reported as the means ± standard errors.

3. Results

3.1. Hematological parameters

Mean values of hematological variables investigated in relation to lairage time are shown in Table 1. These results showed that differential RBC count and HGB concentration were significantly influenced by lairage time. Compared with the group without rest, the number of red cells and HGB concentration decreased in the lairage groups ($P<0.05$). However, no differences were found among different lairage groups. The HCT values were similarly reduced as lairage time increased. The HCT values in the 24 h lairage group decreased nearly 13% compared with 0 h group.

3.2. Biochemical measurement

The results of biochemical measurements, as affected by lairage time, are shown in Table 2. With the exception of ALT levels, lairage