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Relationship between gilt behavior and meat quality using principal component analysis

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ABSTRACT

Pig on-farm behavior has important repercussions on pig welfare and performance, but generally its relationship with meat quality is not well understood. We used principal component analysis to determine the relationship between meat quality traits, feeding patterns, scale activity, and number of conflict–avoidance interactions. The first principal component indicated that gilts with greater daily feed intake stayed longer in the feeder and their meat had increased intramuscular fat (IMF), was lighter in color, and, in the second principal component, had better juiciness, tenderness, chewiness, and flavor. Meat from gilts with lower scale activity scores appeared to have more IMF but greater drip losses (DL). The third principal component suggested that dominant gilts could gain priority access to the feeder, eating more and growing fatter. In conclusion, except for the slight associations with IMF and DL, gilt scale activity and conflict-avoidance behaviors were not good indicators of final meat quality attributes.

1. Introduction

Pig behavior is the aggregate of pig actions and reactions in response to internal and external stimuli. Understanding and selecting for beneficial behaviors is very important for successful management, performance, economical return, and overall pig welfare. Individual genetic variance exists in behavioral traits and so, these traits can be used in selection programs (Holl, Rohrer, & Brown-Brandl, 2010; Turner et al., 2006; van Erp-van der Kooij, Kuijpers, van Eerdenburg, & Tielen, 2003). For example, a beneficial selection trait for pigs would be the ability to cope with pre-slaughter stress during the marketing process, or a reduction in aggression when group housed (Lawrence, Terlouw, & Illius, 1991; Turner et al., 2006). At the same time, selection with a singular focus on performance traits may induce changes in behavior that are detrimental to the individual or group of pigs. For example, negative impacts in their feeding patterns (Young, Cai, & Dekkers, 2011) or increases in aggression (van Erp-van der Kooij et al., 2003) may result from such selection.

At Iowa State University, a line of purebred Yorkshire pigs has been selected for decreased residual feed intake (RFI), alongside a randomly bred control line. After 4 generations of selection, the Low RFI line required 6% less feed for the same amount of growth and backfat (Cai, Casey, & Dekkers, 2008). Sadler, Johnson, Lonergan, Nettleton, and Dekkers (2011) reported behavioral differences between the two genetic lines, with Low RFI gilts becoming less active. However, the relationship between feeding patterns and conflict–avoidance behaviors (within the pen and around resources) of Low RFI pigs on their final meat quality is not well understood. Therefore, the objective of this investigation was to determine the extent to which on-farm feeding and social behaviors affect fresh pork loin composition and quality using principal component analysis.

2. Materials and methods

2.1. Animals

All procedures involving live animals were approved by the Iowa State University Animal Care and Use Committee (approval number 12-07-6482-S). Data from 192 purebred Yorkshire gilts were used. These gilts belonged to a selection experiment for decreased RFI, conducted from April 15 to August 14, 2008. One-half of the gilts were from a line that had been selectively bred for decreased RFI over 5 generations (Low RFI) and the other one-half from a randomly selected control line. Development of these lines was described in Cai et al. (2008). The experimental design was a randomized complete block design, with pen as block and individual pig as the experimental unit. Gilts were placed on test in 2 groups and housed in 12 finishing pens with 8 pigs from each line in each pen at an average of 98.9 (SD 8.2) d of age and 40.3 (SD 5.8) kg. They were fed ad libitum a diet formulated to meet or exceed nutrient requirements. Gilts were

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slaughtered in a commercial facility at an average of 214.2 (SD 16.0) d of age and with an average body weight of 111.7 (SD 6.6) kg.

2.2. Feeding patterns

Gilt feeding patterns of 173 gilts were collected using an electronic single-space feeder (FIRE, Osborne Industries Inc., Osborne, KS). Feed intake was recorded one week after placement and until the first gilts reached the targeted market weight of 110 kg. Average daily feed intake was derived by summing feed intake of each pig per day and averaging across days. Average number of visits to the feeder per day was calculated by averaging the number of visits per day by pig. Average feed intake per visit to the feeder was calculated by averaging feed consumption by visits across days. Average occupation time per day and average occupation time per visit were calculated in a similar manner as daily feed intake and feed intake per visit. Average feed intake rate was obtained by dividing the amount of feed consumed by the time spent in the feeder and then averaging the individual visit feeding rates.

2.3. Scale activity scores

Gilts were evaluated for scale activity when they were weighed. Scale activity scores were collected for individual gilts once the weigh scale back gate was closed. Scale activity was on a 1 through 5 scale (1 = calm, minimal movement; 2 = calm movement, including the gilt walking forward and backward at a slow pace; 3 = continuous fast movement, including quickly walking forward and backward; 4 = continuous rapid movement and vocalizing; 5 = continuous rapid movement and an escape attempt). This scale activity score was modified from Rempel, Rohrer, and Brown-Brandl (2009). Two trained researchers assigned two scale activity scores to gilts, and the mean value was used. The successive evaluations took place at the same established measurement/evaluation periods for all animals (called rounds). They started one week after placement (round 1) and subsequent evaluation periods (rounds 2 to 10) took place every two weeks until gilts reached their targeted market weight. Most gilts underwent a minimum of 7 evaluation rounds (n = 188).

2.4. Conflict and avoidance interactions in the home pen

Video was collected on the day of placement and then every four weeks until the end of the study, for a total of 4 recordings. Video was collected from 0800 h to 2000 h (12 h), and then the four most active hours of the day were used. The four pre-determined active hours were 0700 to 0900 and 1600 to 1800 h. This resulted in 16 h of video/gilt. Gilts were individually marked with an animal-safe paint stick (Prima Tech Retractable Marking Sticks, Prima Tech, Kenansville, NC) on their backs the day before recording. Twelve color cameras (Panasonic, model WV-CP484, Matsushita Co. Ltd., Kadoma, Japan) were placed over the pens and video was collected onto a DVR (Reco, Darim Vision, Pleasanton, CA) at 10 frames/s (Sadler et al., 2011). Seven mutually exclusive conflict–avoidance behavioral events were scored that occurred in the home pen (Table 1). The number of conflict–avoidance events that occurred within one gilt body length around the feeder or drinker was recorded. Gilt behaviors were collected by two experienced observers using the Observer software (The Observer, version 5.0.31 Noldus Information Technology, Wageningen, the Netherlands). Training was conducted to ensure reliability and a final agreement of 98% was reached.

2.5. Meat quality

Meat quality traits were measured in loin chops from 169 gilts (Smith et al., 2011). Ultimate pH was measured at 48 h postmortem using a Hanna 9025 pH/ORP meter (Hanna Instruments, Woonsocket, RI) with a penetration probe. Boneless chops were trimmed free of subcutaneous adipose tissue and were homogenized and prepared to measure intramuscular fat content (IMF) (AOAC, 1990). Hunter L, a, and b values were determined on two chops in triplicate at 1 d postmortem using a calibrated Hunter LabScan colorimeter (Hunter Association Laboratories Inc., Reston, VA). The colorimeter utilized a C10 illuminant to obtain color scores using a 10° observer and 1.27-cm aperture. The 6 color readings were used to calculate the average value for each chop. Drip loss (DL) was determined at 3 d postmortem on two chops per loin. Chops were trimmed of external fat, weighed, and stored in a sealed plastic bag at 4 °C. After 24 h of storage, the liquid lost was removed from each bag, the chops were blotted of excess moisture and reweighed, and DL was calculated as the percentage of liquid lost with respect to the original weight of the chops. Water-holding capacity (WHC) was assessed using a centrifugation method, also at 3 d postmosterm. Duplicate 10-g minced samples were placed into centrifuge tubes and centrifuged for 10 min at 40,000 g at 4 °C. After centrifugation, the liquid was removed, and WHC was recorded as percentage of the final weight of the samples with respect to the original weight. A trained sensory panel (n = 4) scored cooked chops for sensory quality traits at 7 to 10 d postmortem. The chops were cooked on clamshell grills to an internal temperature of 70 °C. The temperature of each chop was monitored individually using thermocouples (Omega Engineering Inc., Stamford, CT). The chops were cooled to room temperature before analysis. Four cubes were cut from the center of the chop and each panelist evaluated the samples for the cooked chops juiciness (1 = not juicy; 15 = very juicy), tenderness (1 = not tender; 15 = very tender), chewiness (1 = not chewy; 15 = very chewy), and flavor (1 = little pork flavor, bland; 15 = extremely flavorful, abundant pork flavor). Sensory data were recorded using a computerized sensory software system (Compusense five 4.6, Compusense, Inc., Guelph, Ontario, Canada).

Table 1
Gilt behaviors (adapted from Bornett, Morgan, Lawrence, & Mann, 2000).

Behavior	Definition
Fight	Gilts were in continuous contact with one another, pushing and circling. At intervals, bouts of vigorous biting and head-knocking occur. Both gilts engage with the other, each apparently trying to injure the other.
Push	Similar to fighting, but without bouts of biting or head-knocking. Gilts engage with one another, leaning their bodies together and shoving one another.
Bully	The actor engages in close social contact with the recipient, including bouts of biting and head-knocking. The recipient moves away without retaliation (similar to fight, but there is no attempt to fight back by the recipient).
Head-knock	Actor makes a rapid sideways or upwards movement of its head delivering a blow to recipient pig. Occurring outside of fight or bully.
Chase	Actor runs after the recipient, who runs away.
Threat	Moving the head and/or body quickly towards another pig with the mouth open, but with no physical contact.
Avoidance	Actor moves away from the recipient without having come into social contact. Avoidance does not appear to be initiated by a deliberate act on behalf of the recipient (unlike chase).
At feeder	Occurring within 1/2 body length from feeder or within the plane of the feeder related to an attempt at placement/displacement in the race of the feeder.
At drinker	Occurring within 1 body length from water resource related to the water resource.

2.6. Principal component analysis

A principal component analysis (PCA) was performed using the statistic package JMP 8 (SAS Institute Inc., Cary, NC) with the data of both lines together. The correlation matrix between scale activity scores was examined to reduce the high number of variables in the analysis. Moderate correlations were observed among the scale activity scores in the initial rounds (e.g., mean correlation through rounds 1 to 4 was