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Impact of spontaneous exercise on performance, meat quality, and muscle fiber characteristics of growing/finishing pigs[1]

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ABSTRACT: The objective of this experiment was to determine if increased space and exercise for finisher pigs (0.90 vs 9.45 m^2/pig) affects performance, meat quality, or muscle fiber characteristics. Newsham barrows (n = 32, 4 pens/treatment) were placed in one of two space allocations: control space allowance (CONT) or in a long pen with increased space allowance (10×). Pigs were weighed every 28 d and feed intake/pen was calculated. Pigs were filmed for behavioral analysis on d 70 and 100 using video recorders to determine walking distances over a 24-h period. After a 5-h transport and 2-h rest period, pigs (approximately 115 kg) were slaughtered on the same day at a commercial facility. Muscle samples were obtained from the longissimus lumborum (LL) and semimembranosus (SM) muscles within 1 h postmortem for muscle fiber typing. Backfat thickness and pH decline were measured on the left side of each carcass. After 24-h chilling, a boneless loin was collected from each pig and stored at 2°C until analyzed. On d 14 postmortem, loins were cut at the 10th rib for color evaluations, and chops were cut for Warner-Bratzler shear (WBS) force and sensory analysis. Histochemical staining methods were used for the detection of type I, IIA, and IIB/X muscle fiber types. There were no significant differences ($P > 0.10$) in live weight, ADG, ADFI, or G:F ratio of the two experimental groups evaluated. Pigs finished in 10× pens walked a greater ($P < 0.01$) distance over a 24-h period than pigs finished in the CONT pens. Pigs finished in the 10× pens were fatter ($P < 0.05$) at the last lumbar vertebra than pigs finished in the CONT pens, but no significant differences were found in loineye area, loin color, marbling scores, WBS, sensory panel scores, retail display measures, or muscle fiber type percentages. Expanded space allowance to increase exercise resulted in no improvements in pig performance, pork loin measures, or muscle characteristics.

Key Words: Exercise, Meat Quality, Pigs, Spacing

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Introduction

Pigs are commonly finished on concrete, slatted-flooring in the United States and other parts of the world. Pigs often are allowed 0.56 up to 1.1 m^2/pig of space during the growing and finishing periods (Fritschen and Muehling, 1986; McGlone and Newby, 1994). Researchers have determined that pig performance in pens of mixed sex and grown to 113 kg live weight was maximized at 0.93 m^2/pig space allocation (NCR-89 Committee on Confinement Management of Swine, 1993). Lewis et al. (1989) determined that exercise did not affect performance measures or muscle quality of the loin. Enfält et al. (1993) determined that exercised pigs had a paler meat color with a higher drip loss, but no differences were found in ADG or backfat measurements. In our previous research, we determined that finishing pigs outdoors on alfalfa pasture resulted in improvements in pork color and tenderness (Gentry et al., 2002). We wish to distinguish the space allowance and exercise effects from the presence of a substrate in an outdoor finishing system on pork color and tenderness by conducting this experiment in an indoor finishing barn, where pigs are housed on concrete, slatted floors. We designed this experiment to determine which component of the outdoor finishing

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system (expanded space allowance and exercise or the presence of a substrate) resulted in the advantage in pork quality.

The relationship between muscle fiber types and meat quality is not fully understood in pigs (Essén-Gustavsson and Jensen-Waern, 1993; Swatland, 1994). Because the use of alternative finishing systems is increasing, research to determine the effects of pen size, exercise levels, distance to the feed and(or) water, and their interactions on pig performance parameters and meat quality is needed. The objective of this experiment was to determine if greatly increasing exercise for finisher pigs (0.90 vs 9.45 m^2/pig space allowance) affects performance, meat quality, or muscle fiber characteristics.

Materials and Methods

Animal Selection and Processing. Crossbred barrows (n = 32; Newsham Hybrids, Colorado Springs, CO) were randomly selected from a group of pigs that were born indoors in a farrowing crate. Sows were housed in stalls during gestation and farrowed in crates. Pigs were weaned at 21 d and placed in a nursery for 5 wk. This indoor system was described by Johnson et al. (2001). Pigs were obtained from a PRRS-negative herd that had a high health status. All pigs were from genetic lines that had been tested halothane negative. Animals were housed in accordance with the *Guide for the Care and Use of Agriculture Animals in Agricultural Research and Teaching* (FASS, 1999), and the Texas Tech University Animal Care and Use Committee approved the project. The air temperature in the finishing barn during the trial averaged 27°C (range: 20 to 34°C) and the relative humidity was 40%.

Pigs were selected at the end of the 5-wk nursery period and placed in their respective treatments for growing and finishing. Littermates were placed in each of the two treatments. Four pigs were placed in each pen (four pens/treatment), and pigs were randomly assigned to the treatments. Pigs were allotted so that each pen consisted of animals with similar average weights. Pigs were placed in one of two space allocations: control (CONT) that was an industry recommended space allowance (NCR-89 Committee on Confinement Management of Swine, 1993; 1.0 × 3.6 m, 0.90 m^2/pig) or in a long pen with increased (10×) space allowance (1.8 × 21.0 m, 9.45 m^2/pig) designed to increase exercise levels of the pigs. In the long pens, the feeder was located at one end of the pen and the nipple waterer was located at the opposite end. All pens had one three-hole feeder (Smidley feeders, Marting Manufacturers, Yazoo City, MS) and one nipple waterer. Pigs were housed in confinement on concrete, fully slatted flooring during the experiment.

Subjects were placed on trial on March 23, 2001, and slaughtered on July 31, 2001. Pigs were weighed on d 0, 28, 56, 112, and 129 of the experimental period on a common scale (Toledo Honest Weight 169371, Mettler Toledo, Inc., Columbus, OH). Animals were given ad libitum access to a milo-soybean meal diet that met nutrient requirements (NRC, 1998). Pigs were slaughtered using commercial practices in Guymon, OK, on the same day. Pigs were transported for 5 h to the packing plant and allowed to rest for 2 h prior to slaughter.

Behavior Data Collection. Barrows were individually marked in each pen with numbers on their back, and each animal was observed for activity levels. Pigs were observed continuously for a 24-h period. In the long pens (21 m), four cameras were connected to a quad-unit (Panasonic WJ-410) to view all areas of the pen simultaneously. In the small pens, one camera was used to record two side-by-side pens. Pens were video-recorded for two 24-h periods using black and white video cameras (Panasonic CCTV Camera, model WV-BP70, Matsushita, Laguna, Philippines) attached to time-lapse video recorders (Panasonic AG-TL500, Matsushita, Japan) set to record in 72-h mode (0.8 frame/s). Animals were video-recorded on d 70 and 100 of the experiment. The long pens were marked for distance by a white line placed every 3 m. In the small pens, a white line was placed at the halfway mark (1.8 m) of the pen. The white lines were visible on the videotape and used for tracking the distance traveled by each pig. Distance traveled was determined by counting the number of lines that the pig crossed each hour. Total distance traveled by each pig was determined by a summation of the lines crossed for the 24-h period. An animal was counted as crossing the line when the hind legs passed the white line.

Sample Collection and Color Evaluation. Temperature and pH declines of the carcasses were measured at 1, 6, and 24 h postmortem at the 10th and 11th rib interface. Temperature was measured using Sapac temperature recorders (Monitor Company, Modesto, CA) that were placed in the loin. The pH decline was monitored using an IQ Scientific 150 pH meter (IQ Scientific Instruments, Inc., San Diego, CA) with a stainless steel pH probe that housed a silicon chip sensor.

After 24 h chilling, the carcasses were fabricated into wholesale cuts. Loins were cut into boneless loins (Institutional Meat Purchasing Specification No. 413), vacuum packaged, and transported under refrigeration to the Texas Tech University Meat Laboratory for further analyses. Loins were stored at 2°C until d 14 postmortem and chops (2.5 cm thick) then were cut for Warner-Bratzler shear (WBS) force and sensory analysis (AMSA, 1995). Chops were vacuum packed and frozen at –40°C for 1 mo until analyzed. Loin color was evaluated at 14 d postmortem at the 10th rib interface for Commission Internationale de l'Eclairage (CIE) L* (muscle lightness), a* (muscle redness), and b* (muscle yellowness) values using a Minolta Spectrophotometer Meter model CM-2002 with a D_{65} illuminant with a 1-cm-diameter aperture (Minolta Camera Co., Ltd., Osaka, Japan). Three readings per loin chop were taken and averaged. The instrument was calibrated following manufacturer's instructions. Visual color, marbling, and firmness scores were assigned to each loin by two trained personnel that were blind to the treatment groups (NPPC, 1999). Color was scored on a 6-point scale with 6 = dark purplish-red, 3 = reddish-pink, and 1 = pale pinkish-gray to white. Marbling scores were assigned on a 10-point scale where 10 = moderately abundant or greater and 1 = devoid. Firmness was scored on a 5-point scale, where 5 = very firm and very dry, 3 = slightly firm and moist, and 1 = very soft and very watery. A loin drip loss core sample (2.5 × 2.5 cm) was obtained. Samples were weighed, placed in a drip loss tube (meat juice containers, C. Christensen Laboratory, Denmark) and held at 2°C for 24 h. Samples were reweighed at 24 h to determine percentage drip loss. Loin purge was determined by weighing the vacuum packaged loin. The loin then was removed from the package and allowed to air dry for 20 min. Any excess moisture was removed with a paper towel. Loins then were reweighed to determine purge loss. A loin sample was ground and analyzed for the percentage moisture and fat using AOAC (1990) approved methods.

Sensory and Shear Force Analyses. Chops (n = 4) from each loin were used for sensory and WBS evaluations. All chops were thawed overnight in a refrigerator to an internal temperature of 2°C and then cooked on a belt grill (Model TBG-60 Magigrill, MagiKitch'n, Inc., Quakertown, PA) to an internal temperature of 71°C (AMSA, 1995). Warner-Bratzler shear values were collected in accordance with AMSA (1995) procedures. Internal temperature was recorded with a needle thermocouple meat thermometer (Model #91100, Cole-Parmer, Vernon Hills, IL). Each core (three 1.3-cm-diameter cores per chop) was sheared once through the center with a Salter Warner-Bratzler Shearing Device (Model #9406482, G-R Electric Mfg. Co., Manhattan, KS) with a crosshead speed setting of 20 cm/min (AMSA, 1995; Wheeler et al., 1997). The other two cooked chops were cut into 1.3 × 1.3 × 2.5-cm pieces for sensory evaluation. Samples were served warm to a six- to eight-member panel selected and trained according to Cross et al. (1978). Panelists evaluated the samples on an 8-point scale for initial and sustained juiciness, initial and sustained tenderness, flavor intensity, pork flavor, and overall mouthfeel (8 = extremely juicy, tender, intense, and characteristic pork mouthfeel; 1 = extremely dry, tough, bland, unsavory, and uncharacteristic mouthfeel, respectively). The samples were served under red lights to mask color differences. The panelists were served water and apple juice to rinse their palates between samples. The sensory panelists' scores were averaged to obtain sample mean values for each sensory trait for statistical analyses.

Retail Display. One loin chop from each animal was placed on a tray and overwrapped with polyvinyl chloride film for display in a retail case for 4 d at 4°C. Two lamps, each containing two bulbs of 30 SPX and providing 1,000 lumens each, were placed over the retail case. The chops were placed randomly in the display case (Model DGC6, Tyler Refrigeration Co., Niles, MI) and continually illuminated during the 4-d display period. CIE L*, a*, and b* values were taken initially and at 24-h intervals. A trained, six-member panel evaluated the chops each day for color (8 = extremely bright grayish-pink and 1 = extremely dark grayish-pink), color uniformity (5 = extreme two-toning and 1 = uniform), surface discoloration (7 = 100% discolored and 1 = 0% discolored), and browning (6 = dark brown and 1 = none) according to AMSA (1991).

Muscle Fiber Typing. Muscle samples were removed from the longissimus lumborum (LL) and semimembranosus (SM) muscles at 1 h postmortem. Samples were immediately cut into 1.3- × 1-cm pieces parallel to the muscle fibers, frozen in cooled isopentane, and stored in liquid nitrogen. Samples were transported to the Texas Tech University Meat Laboratory in a liquid nitrogen tank and then transferred to an ultracold freezer (–80°C; Revco Ultima II, GS Laboratory Equipment, Asheville, NC). Muscle samples were cut (12 μm thick) on a cryostat (Leica CM 1800-3, Leica Instruments Gmbh, Nussloch, Germany) at –20°C and placed on silane-treated (3-aminopropyl triethoxy-silane) microscope slides. Samples were stained histochemically using acid preincubation at pH 4.3, 4.35, and 4.4 followed by an alkaline treatment at pH 7.8 to identify type I, IIA, and IIB/X muscle fiber types (Brooke and Kaiser, 1970; Solomon and Dunn, 1988). Samples were viewed using a Leitz (Wetzlar, Germany) Diavert Inverted Phase Contrast-Fluorescence Microscope with a magnification of 160×. Images were taken using a Spot 2 Slider (Model 1.4.0, Diagnostic Instruments Inc., Sterling Heights, MI) camera. At least 500 myofibers on four viewing frames per sample were counted for the determination of fiber type percentages.

Statistical Analyses. Data were analyzed using SAS (SAS Inst. Inc., Cary, NC). Performance and carcass data were analyzed as a completely randomized design using GLM procedures of SAS. The pen was the experimental unit. For muscle fiber type percentages, all data were expressed as percentages and were subjected to a square-root arcsine transformation process to achieve a normalized distribution. Transformed data were analyzed as a completely randomized design to obtain appropriate P-values. Retail display data were analyzed as repeated measures over time. Behavior data were analyzed using a split-plot design over treatment and time. Treatment by time was tested using the residual error term. Least squares means were separated by a protected predicted difference test within SAS GLM procedures.

Results

Growth Characteristics and Feed Intake. No differences were found in ADG, ADFI, or G:F ratio of pigs finished in either CONT or 10× pens. Body weight, ADG, ADFI, and G:F ratio for pigs finished in CONT or 10× pens

Table 1. Effects of experimental treatments on performance traits

Measure	CONTROL[a]	10×[b]	SEM	*P*-value
0 to d wt, kg	17.7	17.7	0.12	1.00
129-d wt, kg[c]	115.6	120.5	4.22	0.12
ADG, kg/d	0.76	0.80	0.03	0.12
ADFI, kg	2.60	2.33	0.37	0.29
G:F ratio	0.29	0.34	0.30	0.25

[a]CONTROL = 0.90m^2/pig space allowance.
[b]10× = 9.45 m^2 /pig space allowance.
[c]Final weight, feeding period was 129 d.

were similar (Table 1). There were no differences ($P > 0.10$) in performance measures of the two experimental treatments evaluated.

Behavior. Pigs in the 10× pens walked greater distances ($P < 0.05$) over a 24-h period than pigs in the CONT pens (Figure 1). Pigs in CONT pens walked an average of 13.9 ± 1.59 m/d compared to 32.8 ± 1.59 m/d for pigs in the 10× pens ($P = 0.0002$). This difference was the result of the design of the pens; the feeder and waterer were located at opposite ends of the pen, forcing the pigs to walk the length (21 m) of the pen to drink or eat in sequence. The activity levels of the pigs in CONT pens followed the same general trend as the activity levels of the pigs in the 10× pens. Pigs were most active during the morning between 0800 and 1200.

Carcass Measurements and Muscle Quality. Pigs finished in 10× pens had a higher initial pH measurement and were fatter at the last lumbar vertebra than pigs finished in the control pens, however, no differences were detected in other carcass measures, including muscling, color, or water-holding capacity of the loin. Loin pH values at 45 min postmortem were higher ($P < 0.05$) for loins from pigs finished in 10× pens compared to those in the CONT pens (Table 2), but no differences were detected in 3- or 24-h pH measurements. Loin purge and drip loss values also were similar between the pigs finished in either CONT or 10× pens, indicating no differences in water-holding capacity of the muscle. Pigs finished in 10× pens had greater fat depth at the last lumbar vertebra than pigs finished in the CONT, but no differences were found in first rib or last rib measurements. Carcass length, ham muscle score, marbling score, firmness score, and visual or instrumental color scores of loins were not significantly different between CONT and 10× groups. Loins from both treatments were acceptable in water holding capacity, moisture, and fat content. Carcass and loin quality measures were not affected by the two space allowances evaluated.

Sensory and WBS. Sensory traits evaluated on loin chops were not significantly different except for sustained juiciness between pigs finished in CONT or 10× pens. Loin chops from pigs finished in CONT pens had 0.2 point higher ($P < 0.05$) sustained juiciness score than loin chops from pigs finished in 10× pens (Table 3). No visual or chemical differences were found for the percentage of intramuscular fat; therefore, it is difficult to determine why loin chops from pigs finished in small pens were scored higher in juiciness by the sensory panel. The WBS values were not significantly different between the two groups.

Retail Display. Retail display measures for the treatment by day interaction were not significant ($P > 0.05$; Table 4). Differences in visual and instrumental scores in the retail display case were minimal, and no significant differences were detected for any of the retail display measures.

Muscle Fiber Typing. Muscle fiber type distribution was not significantly different between samples from pigs finished in the two treatments (Table 5). As expected, type IIB/X fibers were the most prevalent fiber type in both the LL and SM muscles. For the LL muscle, the predominant fiber type was IIB/X (63.9%), followed by I (19.7%), and IIA (16.4%). For the SM, the most prevalent fiber type was also IIB/X (57.1%).

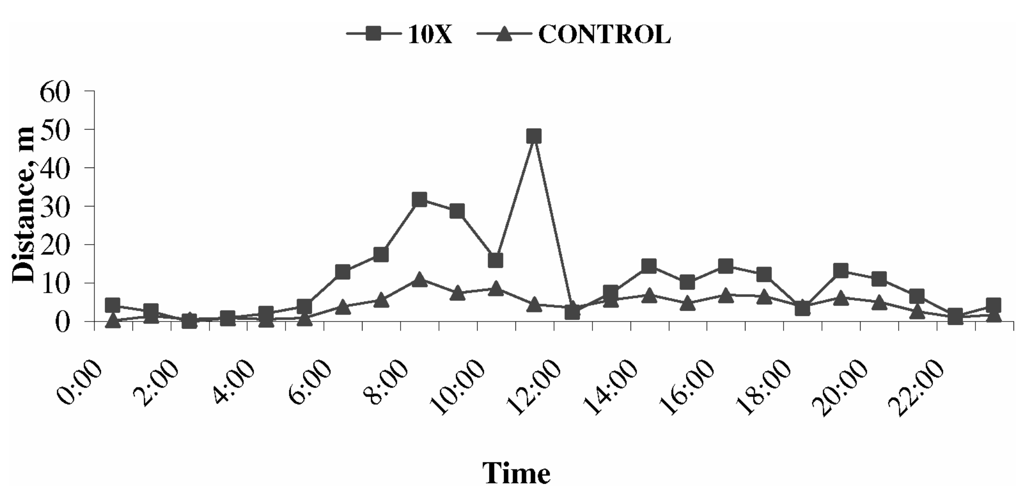

Figure 1. Activity levels as measured by distance traveled of pigs finished in 10× and CONTROL pens over a 24-h sampling period averaged on d 70 and 100 of the experiment.

Table 2. Effects of experimental treatments on carcass and loin measurements

Measure	CONTROL	10×	SEM	*P*-value
45-min pH[a]	6.0	6.2	0.04	0.05
3-h pH[a]	6.0	6.1	0.06	0.40
24-h pH[a]	5.7	5.8	0.02	0.13
First rib backfat, cm	4.4	4.6	0.07	0.51
Last rib backfat, cm	2.8	2.8	0.05	0.87
Last lumbar backfat, cm	2.0	2.3	0.04	0.04
Loineye area, cm^2	44.2	43.7	0.24	0.84
Carcass length, cm	81.3	82.3	0.33	0.43
Ham muscle score[b]	1.9	2.0	0.03	0.33
Color score[c]	3.2	3.1	0.10	0.48
Marbling score[d]	2.1	2.2	0.25	0.76
Firmness score[e]	2.9	3.1	0.10	0.16
Minolta L*[f]	52.1	51.6	0.62	0.62
Minolta a*[g]	3.9	3.7	0.40	0.72
Minolta b*[h]	12.4	12.1	0.29	0.53
Purge, %	2.0	2.3	0.26	0.41
24-h drip loss, %	0.2	0.4	0.09	0.16
Moisture, %	72.3	72.0	0.33	0.61
Fat, %	3.9	3.8	0.33	0.95

[a]pH was measured at the 9th and 10th rib interface of the longissimus muscle.
[b]Ham muscle scores are 1 = thin, 2 = average, and 3 = thick.
[c]Color scores range from 1 to 6, 1 = pale, pinkish-gray and 6 = dark, purplish-red.
[d]Marbling scores range from 1 to 10, 1 = devoid and 10 = moderately abundant or greater.
[e]Firmness scores range from 1 to 5, with 1 = very soft and watery and 5 = very firm and dry.
[f]Minolta L* values range from 1 to 100 with 1 = pure black and 100 = pure white.
[g]Minolta a* values represent the amount of red to green colors and a higher value indicates a redder color.
[h]Minolta b* values represent the amount of blue to yellow color in the meat and a higher b* value indicates a more yellow color.

Discussion

Previous researchers have examined the effects of exercise levels and expanded space allowance on pig performance and meat quality. Lewis et al. (1989) determined that induced exercise did not affect ADG or feed efficiency of pigs. Enfält et al. (1993) also found no differences in ADG, backfat, or individual muscle weights of exercised pigs compared to the control group. These results agree with our findings as we did not detect any large differences in ADG or feed efficiency of the pigs finished in either small pens with minimal exercise or larger pens with increased exercise. The Committee on Confinement Management of Swine (NCR-89) (1993) found a linear improvement in ADG and G:F ratio for 0.56, 0.74, and 0.93 m^2/space allowances and concluded that pig performance was maximized at 0.93m^2/pig space allowance. Pigs from the two treatments in our experiment had similar weights during the growing and finishing periods. Beattie et al. (1996) suggested that increasing space allowance beyond 1.1 m^2/pig did not provide any additional advantages in pig behavior or performance.

Table 3. Effects of experimental treatments on sensory traits of loins

Measure	CONTROL	10×	SEM	*P*-value
Initial juiciness[a]	5.8	5.7	0.06	0.19
Sustained juiciness[a]	5.8	5.6	0.06	0.03
Initial tenderness[a]	6.1	6.0	0.16	0.77
Sustained tenderness[a]	6.1	6.0	0.19	0.77
Pork flavor intensity[a]	5.8	5.6	0.09	0.26
Pork flavor[a]	5.5	5.4	0.07	0.11
Overall mouthfeel[a]	5.8	5.5	0.12	0.18
Off flavor[b]	1.2	1.3	0.05	0.39
WBS, kg	2.5	2.4	0.20	0.86

[a]Sensory panel scores for initial and sustained juiciness, initial and sustained tenderness, flavor intensity, pork flavor, and overall mouthfeel range from 1 to 8 with 1 = extremely dry, tough, bland, unsavory, and uncharacteristic mouthfeel and 8 = extremely juicy, tender, intense, and characteristic pork mouthfeel.
[b]Scores for off flavor are 1 = no off flavor, 5 = extreme off flavor.

Table 4. Retail display characteristics of loin chops from pigs finished in CONTROL or 10× treatments

Attribute	CONTROL	10×	SEM	*P*-value
Color[a]	4.7	4.6	0.09	0.66
Uniformity[b]	1.2	1.5	0.10	0.13
Discoloration[c]	1.1	1.2	0.06	0.19
Browning[d]	1.1	1.2	0.05	0.33
Minolta L*	56.1	57.8	1.01	0.28
Minolta a*	6.0	6.4	0.17	0.18
Minolta b*	6.3	7.0	0.64	0.48

[a]Color scores range from 1 to 8 (1= extremely dark grayish-pink; 8 = extremely bright grayish-pink).
[b]Uniformity scores range from 1 to 5 (1 = uniform, 5 = extreme two-toning).
[c]Discoloration scores range from 1 to 7 (1 = 0% discoloration, 7 = 100% discoloration).
[d]Scores for browning range from 1 to 6 (1 = none, 6 = dark brown).

Table 5. Percentage of muscle fiber types from pigs finished in CONTROL or 10× treatments

Muscle and type	CONTROL, %	10×, %	SEM	*P*-value
Longissimus				
Type I	19.7	18.4	4.74	0.82
Type IIA	16.4	16.6	3.97	0.93
Type IIB/X	63.9	65.0	0.77	0.49
Semimembranosus				
Type I	24.3	21.6	6.08	0.79
Type IIA	18.6	18.4	2.52	0.98
Type IIB/X	57.1	60.0	3.56	0.67

Treatment differences for carcass measurements and loin muscle quality were minimal. We found significant differences in 45-min pH and last lumbar backfat measurements. Pigs finished in 10× pens had a higher 45-min loin pH measurement and had more backfat at the last lumbar vertebra than pigs finished in the CONT. Previous researchers have suggested that exercise did not affect muscle pH but exercise decreased backfat thickness and sensory panel tenderness scores (Lewis et al., 1989). In our recent work, we determined that pigs finished outdoors on alfalfa pasture with a much larger space allowance (212 vs 1.2 m^2/pig) had loins that were darker and redder in color and had improved shear force values than loins from pigs finished indoors on concrete slats (Gentry et al., 2002). In contrast, Enfält et al. (1993) found that pork from exercised pigs had higher loin drip loss values. In our experiment, the pH difference at 45 min postmortem was significant, but no differences were found in the 3- or 24-h measurements, indicating that pork from pigs finished in either CONT or 10× pens was similar in color and water-holding capacity. Loineye area and ham muscle scores were not different between the pigs finished either in CONT or 10× pens, indicating that pigs from the two finishing systems had carcasses with similar muscle mass. Although pigs in the 10× pens were fatter at the last lumbar vertebra than pigs in the CONT pens, no differences were found in first rib or last rib backfat measurements. Overall, measures of carcass muscling, fattness, and water-holding capacity were similar between pigs finished in the CONT or 10× space allowance treatments. The degree of exercise evaluated in this experiment is not the explanation for differences in quality that have been previously noted by the authors.

Many researchers agree that the chemical composition of muscle is not affected by moderately intense exercise or spontaneous physical activity (Lewis et al., 1989; Enfält et al., 1997; Petersen et al., 1997a). We also found no differences in the chemical composition (moisture or fat) of loin muscle from pigs finished in the CONT or 10× treatments.

Enfält et al. (1993) found that exercised pigs had paler-colored meat than control pigs. These results disagree with our findings (Table 4) as we found no difference in loin color of pigs in the CONT and 10× treatments. However, the degree of exercise and the genetic composition of the pigs varied between the two experiments. Research on the effects of pen space and exercise levels on pork retail display characteristics has not been published. Visual scores for color, discoloration, and browning were similar between the two groups. Water-holding capacity measures (drip loss, purge) and Minolta color measurements were not significantly different between pigs finished in the CONT or 10× pens indicating that loins from the two groups evaluated were similar in quality. The shelf life period of chops from pigs finished in either the CONT or 10× pens also was similar.

Spontaneous physical activity or induced exercise levels of pigs may affect muscle fiber characteristics and meat quality. Petersen et al. (1998) determined that spontaneous activity significantly increased the ratio of type IIA to IIB/X fibers in the longissimus muscle, while others have determined that the chemical composition of the longissimus is not altered with increased exercise (Lewis et al., 1989; Enfält et al., 1997; Petersen et al., 1997b). Pigs finished in the 10× pens had increased activity levels compared to pigs in the CONT pens. This increase in exercise did not result in any differences in muscle composition or fiber type distribution. Research investigating pen size or exercise levels on pig meat quality and muscle characteristics has produced variable results. Lewis et al. (1989) determined that induced exercise did not affect sarcomere length or muscle fiber diameter of the longissimus muscle. Petersen et al. (1998) reported that spontaneous activity of pigs reared in large pens significantly increased the ratio of type IIA to IIB/X fibers on the longissimus muscle. Our results were similar to Lewis et al. (1989). Pigs in this study were not subjected to an induced exercise treatment; however, the pigs reared in the large pens were required to walk a distance of 21 m to reach the waterer and 21 m back to the opposite end of the pen for feed. Pigs reared in the 10× pens walked significantly more than pigs reared in the CONT pens; however this level of added exercise did not result in any change in muscle fiber types or pork quality. Muscle fiber type percentages for pigs finished in the CONT or 10× pens were not significantly different, indicating that the exercise levels and expanded space allowance evaluated in this experiment did not alter the distribution of muscle fibers within the loin or ham.

Implications

Expanded space allowance for finisher pigs did not result in any significant improvements in pig performance or loin muscle quality. The increased exercise defined in this experiment did not affect meat quality or muscle fiber types. Large floor spaces did not explain improvements in pork quality observed from past studies in which pigs were finished outdoors.

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