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Evaluating Growth, Loin Muscle Area, and Backfat Accretion During Summer and Winter for Finishing Pigs in Bedded Hoop and Confinement Buildings

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Summary and Implications

Growth and development of finishing pigs in bedded hoop and confinement buildings during summer and winter was evaluated using serial ultrasound measurements of backfat (BF) thickness, loin muscle (LM) area, and serial weighing. A summer trial (April through August 2000) and a winter trial (October 2000 through February 2001) were conducted. Forty-eight pigs from the hoop building and eight pigs from each of the six pens in the confinement building were randomly selected and weighed; ultrasound images were recorded every 14 d during the last 56 d of the finishing phase. Backfat accretion rates were greater for summer hoop pigs (SH) than summer confinement pigs (SC) at 80 kg to 90 ($P < 0.05$), but did not differ at 95 to 115 kg. In winter, BF accretion rates did not differ from 80 to 105 kg, but winter hoop pigs (WH) had less BF accretion than winter confinement pigs (WC) at 110 kg and 115 kg ($P < 0.05$). Loin muscle accretion rates did not differ at 80 and 85 kg or from 100 to 115 kg, but were less for SH than SC at 90 kg and at 95 kg ($P < 0.001$). WH had greater LM accretion rates than WC at 80 kg to 115 ($P < 0.05$). Bodyweight gain (BWG) did not differ between SH and SC from 80 to 95 kg and was greater for SH at 100 kg to 115 kg ($P < 0.05$). Bodyweight gain did not differ for WH and WC pigs from 100 to 115 kg, but was less for WH than WC at 80 kg to 95 kg ($P < 0.05$). These results indicate that performance of finishing pigs is dependent on the thermal environment, and that hoop-reared pigs (particularly in winter) may compensate for a lag in performance early in the finishing period with greater accretion rates of LM and BW and lower accretion rates of BF later in the finishing period.

Although overall pig performance in hoop and confinement buildings is similar, some differences in accretion rates for bodyweight, backfat, and loin muscle area occurred during the finishing period. These differences are probably due to seasonal variation in the thermal environment. Performance of pigs reared in hoop buildings may be compromised early in the finishing period by their inability to overcome the difference between temperature and thermoneutrality. However, it appears that hoop-reared pigs compensated for earlier lags in performance by increased BW gain and LM accretion, along with less BF deposition compared to pigs in confinement at the same BW. This study provides some evidence to justify feeding pigs in hoops to heavier weights. Research studying accretion rates of pigs at a wider range of bodyweights will be needed to better understand the effects of environment and building type on pig performance.

Introduction

Due to high fixed costs and increased pressure from environmental, community, and animal welfare interests, alternatives to confinement pig finishing systems have received interest in the last decade. One alternative being adopted is hoop buildings. Hoop buildings are quonset shaped, with a tarp pulled tightly over trusses and attached to sidewalls. Pigs are kept inside the structure and the majority of the floor is covered with bedding, usually cornstalks or straw.

Real-time ultrasound has been an accurate technology to predict carcass composition since the early 1990s. Serial ultrasound imaging (repeated measurements of the same animal over a period of time) has been used to better understand swine growth and development, particularly backfat (BF) and loin muscle (LM) accretion rates. Rearing environment influences the ability of pigs to maximize protein accretion.

The objective of this study is to evaluate the effects of season and building type on growth and development of finishing pigs. By obtaining serial weight and ultrasound measurements, comparisons of weight gain, as well as BF and LM accretion can be made between hoop- and confinement-reared pigs in summer and winter.

Materials and Methods

In this study, pigs reared in a hoop building or conventional finisher building were weighed, and backfat and loin muscle area measurements were taken using real-time ultrasound five times during the finishing phase. These data were used to evaluate environmental effects on growth and on the deposition of loin muscle and backfat of pigs reared in the two housing systems.

All pigs for the experiment were from terminal Duroc boars crossed with predominantly white sows. The groups consisted of approximately half barrows and half gilts. Pigs entered the two buildings types weighing 16 kg and were marketed at 124 kg. In the summer (April through August 2000), 152 pigs were placed in the hoop building and 22 pigs were placed in each of the six confinement pens. In the winter (October 2000 through February 2001), 154 pigs were placed in the hoop building and 22 pigs were placed in each of the six confinement pens.

Forty-eight pigs were randomly selected from the hoop building pen for serial scanning in each season. Eight pigs from each of the six confinement pens were randomly selected for serial scanning in each season. All pigs were finished at the Hoop Research Complex at the Rhodes Research Farm near Rhodes, IA.

Pigs were harvested at a commercial packing plant (Excel Corp., Ottumwa). Marketing began when the pigs in a building attained an average weight of 109 kg. There were two marketings for each building. On the first marketing, all pigs weighing 109 kg or more were marketed. All pigs less than 109 kg remained in the building until the average weight in the building was 107 kg; all pigs were then marketed out of the building. Only marketed pigs were included in the analysis.

All pigs in the hoop and confinement buildings were weighed in the morning after feed had been removed for approximately 12 h at approximately 28 d intervals. Pigs selected for serial scanning were weighed and scanned every 14 d for the last 56 d of the finishing period. All pigs were scanned and images were analyzed by a National Swine Improvement Federation certified ultrasound technician. The ultrasound machine used was an Aloka 500 V SSD ultrasound machine fitted with a 3.5-MHz, 12.5-cm linear array transducer. The experiment was designed so that each pig selected at the beginning of the trial for the serial scan portion of the experiment could be weighed and scanned five times at approximately 14 day intervals the last 56 days of finishing. However, some pigs were not weighed and/or scanned all five times. Weigh/scan period 2 for winter confinement pigs and weigh/scan period 3 for winter hoop pigs were unavailable for recording due to inclement weather. Raw means and standard deviation at each weigh period can be found in Table 2.

Off-test measures. Pig weights and ultrasound measurements were used at the off-test weigh period to calculate average daily gain (ADG), lean gain on test (LGOT), tenth-rib backfat (BF), and loin muscle area (LMA). Least squares means and corresponding standard errors were calculated using the Proc Mixed procedure from SAS (SAS Inst. Inc., Cary, NC). The model for ADG and LGOT contained fixed effects of building, season, and gender, and it also included a linear covariance for on-test weight. The model for BF and LMA included fixed effects of building, season, gender, and a linear covariance for off-test weight. All two-way interactions were included in the full model and all interactions of nonsignificance were eliminated.

Serially measured traits. Traits measured serially were BF, LMA, and BW. A random regression model was fit to the serial data using SAS to model covariances between repeated records. The model used to evaluate growth patterns of serially measured traits included similar effects for the model described previously of the building, and season, along with the addition of fixed and random curves. Interactions of second-order polynomial terms with the building were also fit for the evaluations of BF, LMA, and BW. A first-order polynomial was fit for the random curves of BF, LMA, and BW. An unstructured covariance structure was fit for the random terms and an auto-regressive covariance structure was fit for the residuals. All two-way interactions were evaluated but were not significant and were dropped from the model. Repeated records from scanning and weighing were used for the SAS random regression model.

Results and Discussion

Growth Performance

Off-test average daily gain. Average daily gain (ADG) did not differ between building type averaged over both seasons ($P > 0.05$) (Table 1). Differences ($P < 0.001$) were detected for ADG between summer (802 g/d ± 6) and winter (844 g/d ± 6) for the confinement building. This difference may be explained by heat stress caused by warm temperatures in the summer season, which may reduce feed intake and increase the maintenance requirements of the pigs. Pigs in confinement buildings in the winter are more likely to be at a thermally neutral temperature. No difference ($P > 0.05$) between seasons was found for ADG in the hoop building. There was a difference ($P < 0.05$) for ADG between the hoop building (819 g/d ± 6) and the confinement building (802 g/d ± 6) during the summer season (Table 1). These results may indicate that hoop pigs have less heat stress than confinement pigs due to the open-air ventilation and their ability to find a cooler microenvironment. There was no difference in ADG between building types for the winter season ($P > 0.05$) (Table 2). In hoop buildings, pigs have the ability to find a suitable microclimate by burrowing into the bedding pack thereby reducing heat loss by conduction and reducing draft exposure; thus, the effective temperature for the pigs is much closer to thermoneutrality than the ambient temperature. The composting bedding pack in a hoop building generates temperatures of 40ºC at 15- to 30-cm depths and 30ºC over half of the bedding pack area. This decomposition can result in an increase in temperature inside the hoop building of 3.3 to 4.4ºC on the coldest days in winter, and perhaps even warmer temperatures for the effective zone that the pigs occupy due a reduction in heat loss from conduction and convection.

Off-test lean gain on test. On-test kilograms of lean and off-test kilograms of lean were calculated using the following formula from the National Pork Producers Council.

Off-test lean (kg) = 0.3782 × sex (barrow and boar = 1; gilt = 2) – 2.9488 × (BF10, cm) + 0.3817 × (LMA, cm^2) + 0.291 × (off-test weight, kg) – 0.2424

On-test lean (kg) = 0.188 × (on-test weight, kg) – 1.644

Lean gain on test (LGOT) was calculated by subtracting on-test lean from off-test lean and dividing by the number of days on test.

Lean gain on test was 6 g/d more in the confinement building over the entire test period ($P < 0.05$) (Table 1). In summer, LGOT was more for confinement-reared pigs (346 g/d ± 55 vs. 338 ± 55 g/d) than hoop-reared pigs ($P < 0.05$). In winter, confinement pigs had LGOT was 14.5 g/d more than pigs in hoop buildings ($P < 0.001$). Average daily gain was not depressed in pigs reared in hoops in the winter, probably because of an increase in feed intake. Small differences in carcass composition, particularly LMA, can affect LGOT. In winter, hoop-reared pigs were leaner, i.e. had less backfat, ($P < 0.05$) but also had smaller LM ($P < 0.001$) than confinement pigs, which may explain why they also had a poorer LGOT (Table 2).

Ultrasonically Measured Carcass Composition

Off-test loin muscle area. Loin muscle area (LMA) difference between building type was 1.87 cm^2 more over the entire trial period for confinement-reared pigs ($P < 0.001$) (Table 1). Loin muscle area did not differ between seasons for the confinement building; however, hoop-reared pigs in the summer had 3.23 cm^2 larger LMA area than hoop-reared pigs in the winter ($P < 0.001$). Comparisons between buildings by season did not differ in the summer but in the winter, hoop-reared pigs had 3.1 cm^2 smaller LMA than confinement-reared pigs ($P < 0.001$) (Table 2). Pigs with the same genotype may have different upper limits of protein deposition (PDmax), depending on environment. The type of housing system may influence the PDmax of pigs housed in it, and the influence may vary, depending on the season.

Off-test backfat. Overall, backfat (BF) was 6 mm more for confinement-reared pigs than hoop-reared pigs ($P < 0.05$) (Table 1). Also BF between buildings in the winter was 8.7 mm less for hoop-reared pigs compared to confinement-reared pigs ($P < 0.05$). However the difference in BF between buildings did not differ in the summer. Thickness of BF between seasons for each building (hoop and confinement) did not differ (Table 2).

Serially Measured Traits

Accretion rates for LMA, BF and BW for pigs from 80 to 115 kg are shown in Table 3. The analysis of the serially measured traits showed that growth, loin muscle, and backfat accretion may be dependent on building type and thermal environment.

Backfat. There was no difference between hoop- and confinement-reared pigs for cumulative BF thickness measurements from 80 to 115 kg BW when seasons were combined, or in summer or winter. When winter and summer seasons were combined, hoop-reared pigs had 0.04 mm/d greater BF accretion rates at 80 and 85 kg BW ($P < 0.05$). There was no difference in BF accretion rates from 90 to 110 kg BW. At 115 kg, hoop-reared pigs had 0.09 mm/d less accretion than confinement-reared pigs ($P < 0.05$).

Comparison of pigs reared in hoop and confinement buildings during summer illustrates that daily accretion rates are greater for hoop-reared pigs by 0.04, 0.05, and 0.05 mm at 80, 85, and 90 kg BW, respectively ($P < 0.05$) (Table 3). There were no differences detected from 95 to 115 kg. At 105 kg, the accretion curves for the two building types cross and confinement-reared pigs began depositing BF at a greater rate than at lighter weights. Although accretion rates do not differ at 115 kg between building type, if the trend continued, at heavier weights some differences would occur and the confinement-reared pigs would accrete BF at a greater rate than the hoop-reared pigs.

Comparison of BF accretion rates in winter for hoop and confinement buildings showed no difference from 80 to 105 kg BW (Table 3). At 110 and 115 kg BW, accretion rates for confinement-reared pigs were 0.082 and 0.119 mm greater than hoop-reared pigs, respectively ($P < 0.05$). The hoop-reared pigs deposited BF at a more constant rate from 80 to 115 kg than the confinement-reared pigs. Confinement pigs tended to deposit less fat at lighter weights and increased the rate of BF deposition as their weight increased. Because the diets in both buildings were the same and hoop pigs generally had a greater average daily feed intake, the hoop-reared pigs in the summer received more metabolizable energy (ME) than the confinement pigs at the same weight. This increase in ME resulted in hoop-reared pigs depositing more BF/d than confinement pigs at 80 to 90 kg BW in summer when their energy need for maintenance was similar to the pigs reared in confinement.

Loin muscle area. When summer and winter seasons are combined, in summer there was no difference in cumulative LMA measurements from 80 to 115 kg. However, in winter cumulative LMA measurements are greater for confinement-reared pigs from 80 to 90 kg ($P < 0.001$) and from 95 to 115 kg BW ($P < 0.05$).

In summer, LM accretion rates for hoop- and confinement-reared pigs differed at 85 and 105 kg BW ($P < 0.05$) (Table 3). From 90 to 100 kg BW, accretion rates also differed ($P < 0.001$). From 85 to 110 kg BW, confinement-pigs have greater LM accretion rates than hoop-reared pigs. At 80 kg and 115 kg BW, LM accretion rates are similar. Between those weights, the confinement-reared pig accretion rates increase slightly, and hoop-reared pig accretion rates decrease slightly creating the difference in rates. The difference in accretion rates is probably due to the difference in rearing environment.

In winter, LM accretion rates were greater for hoop-reared pigs than confinement-reared pigs from 80 to 105 kg ($P < 0.05$) and at 110 and 115 kg BW ($P < 0.001$) (Table 3). Greater LM accretion rates for hoop-reared pigs from 80 to 115 kg BW may suggest that they are still in the linear phase of their growth curve.

When studying BF and LM accretion curves for summer and winter, some generalities can be made. In both seasons, hoop-reared pigs had more constant rates of accretion from 80 to 115 kg for BF and LM. Confinement pigs increased BF deposition and decreased LM accretion rates beginning at 100 kg. These differences between building types may be due to the lag in performance hoop pigs experience because of environmental variation when placed in the hoop building. Thus, hoop-reared pigs from 80 to 115 kg may not have reached the inflection point of their growth curve, which may explain why the increase in BF accretion and decrease in LM accretion had not occurred by 115 kg BW.

Additionally, bodyweight gain (BW gain) is more constant in confinement buildings during both seasons, which may also be a reflection of fewer environmental stressors in the earlier stages of finishing. The more neutral environment may cause confinement-reared pigs to reach the point of inflection on their growth curve at a lighter weight. As a result, BF accretion rates in confinement were increasing while LM accretion rates were decreasing after 100 kg BW. Accordingly, the LM accretion rates for hoop-reared pigs from 80 to 115 kg are greater than in the other building/season subgroups. Pigs reared in an open-air structure in the winter should have the most difficulty adapting from the heated nursery to the cold hoop finishing building and a more severe lag in performance would likely occur. Hoop-reared pigs in winter may be in the linear phase of their growth curve as evidenced by the greater LM accretion rates and lower BF accretion rates in relation to the other building/season subgroups.

Daily bodyweight gain. When combining summer and winter seasons, the daily BW gain of hoop-reared pigs was 86 g/d less at 80 kg and 68 g/d less at 85 kg BW than confinement-reared pigs, and there was no difference from 90 to 115 kg BW. In summer, hoop- and confinement-reared pigs have similar BW gains from 80 to 90 kg and then there was a sharp increase in BW gain from 90 to 115 kg for the hoop-reared pigs (Table 3). The BW gain of hoop-reared pigs was 91 g/d greater at 100 kg, 132 g/d greater at 105 kg, 179 g/d greater at 110 kg, and 231 g/d greater at 115 kg BW ($P < 0.05$). In winter, the daily BW gain for hoop-reared pigs was 188 g/d less at 80kg, 170 g/d less at 85 kg, and 145 g/d less at 90 kg BW than for confinement-reared pigs ($P < 0.001$) (Table 3). At 95 kg, BW gain was 114 g/d less ($P < 0.05$). At 100 to 115 kg BW, BW gain was similar between both building types.

The difference in daily BW gain is probably due to environment. The hoop-reared pigs may have experienced some compensatory gain once they reached a weight where they could overcome the effects of temperature on their maintenance needs. As their maintenance needs were reduced in relation to their BW and average daily feed intake, an increase in growth rate may occur due to the increase in available nutrients

Table 1. Least squares means ± (SE) for ultrasonic and growth performance measures of pigs reared in hoop and confinement buildings (summer and winter combined).

Item[1]	Hoop	Confinement
Ultrasonically Measured		
BF, mm	20 ± (2)	21 ± (2)
LMA, cm^2	42.7 ± (0.3)[a]	44.6 ± (0.3)[b]
Growth performance		
ADG, g/day	827 ± (4)	824 ± (4)
LGOT, g/day	336 ± (2)[a]	342 ± (2)[b]

[1]BF = Tenth-rib backfat; LMA = Loin muscle area; ADG = Average daily gain; LGOT = Lean gain on test
[ab]LS means with different superscripts in the same row differ (*P* < .05)

Table 2. Least squares means ± (SE) for ultrasonic and growth performance measures of pigs reared in hoop and confinement buildings in summer and winter.

	Summer		Winter	
Item[1]	Hoop	Confinement	Hoop	Confinement
Ultrasonically measured				
BF, mm	19.9 ± (0.3)[a,b]	20.3 ± (0.3)[a,b]	19.8 ± (0.3)[b]	20.8 ± (0.3)[a]
LMA, cm^2	44.3 ± (0.4)[a]	45.0 ± (0.4)[a]	41.1 ± (0.4)[b]	44.1 ± (0.4)[a]
Growth performance				
ADG, g/day	819 ± (6)[b]	802 ± (6)[c]	832 ± (6)[a,b]	844 ± (6)[a]
LGOT g/day	350 ± (2)[a]	345 ± (2)[a]	323 ± (2)[c]	338 ± (3)[b]

[1]BF = Tenth-rib backfat; LMA = Loin muscle area; ADG = Average daily gain; LGOT = Lean gain on test
[abc]LS means with different superscripts in the same row differ (*P* < 0.05)

Table 3. Least squares means (± SE) for daily accretion rates of backfat, loin muscle, and bodyweight, in relation to body weight for hoop- and confinement-reared pigs in summer and winter.

	Summer		Winter	
Item[1]	Hoop	Confinement	Hoop	Confinement
80kg				
BF, mm/d	0.17 ± (0.01)[a]	0.13 ± (0.01)[b]	0.09 ± (0.03)[b]	0.11 ± (0.03)[b]
LM, mm^2/d	28 ± (1.5)[b]	31 ± (1.4)[b]	53 ± (4.3)[a]	34 ± (2.9)[b]
BW, g/d	818 ± (2)[a]	838 ± (2)[a]	681 ± (2)[b]	869 ± (2)[a]
85kg				
BF, mm/d	0.17 ± (0.01)[a]	0.13 ± (0.01)[b]	0.10 ± (0.03)[b]	0.11 ± (0.02)[b]
LM, mm^2/d	26 ± (1.6)[b]	34 ± (1.5)[b]	51 ± (4.2)[a]	36 ± (2.8)[b]
BW, g/d	829 ± (2)[a]	829 ± (2)[a]	691 ± (2)[b]	861 ± (2)[a]
90kg				
BF, mm/d	0.18 ± (0.02)[a]	0.13 ± (0.02)[b]	0.10 ± (0.03)[b]	0.11 ± (0.02)[b]
LM, mm^2/d	24 ± (1.7)[c]	35 ± (1.6)[b]	49 ± (4.1)[a]	37 ± (2.6)[b]
BW, g/d	850 ± (2)[a]	826 ± (2)[a]	713 ± (2)[b]	858 ± (2)[a]
95kg				
BF, mm/d	0.18 ± (0.02)[a]	0.14 ± (0.02)[a,b]	0.10 ± (0.03)[b]	0.12 ± (0.02)[b]
LM, mm^2/d	22 ± (1.7)[c]	34 ± (1.7)[b]	48 ± (3.9)[a]	37 ± (2.3)[b]
BW, g/d	883 ± (2)[a]	829 ± (2)[a]	746 ± (2)[b]	860 ± (2)[a]
100kg				
BF, mm/d	0.18 ± (0.02)[a]	0.15 ± (0.02)[a,b]	0.10 ± (0.03)[b]	0.14 ± (0.02)[a,b]
LM, mm^2/d	21 ± (1.8)[c]	32 ± (1.9)[b]	47 ± (3.7)[a]	35 ± (2.1)[b]
BW, g/d	928 ± (2)[a]	837 ± (2)[b]	790 ± (3)[b]	869 ± (2)[a,b]
105kg				
BF, mm/d	0.18 ± (0.02)[a]	0.18 ± (0.02)[a]	0.10 ± (0.03)[b]	0.16 ± (0.02)[a,b]
LM, mm^2/d	21± (2.1)[c]	29± (2.2)[b]	46± (3.7)[a]	32± (2.0)[b]
BW, g/d	984 ± (3)[a]	852 ± (3)[b]	846 ± (3)[b]	883 ± (3)[b]
110kg				
BF, mm/d	0.17 ± (0.03)[a]	0.20 ± (0.03)[a]	0.10 ± (0.03)[b]	0.18 ± (0.02)[a]
LM, mm^2/d	20 ± (3.0)[b]	25 ± (2.8)[b]	46 ± (3.9)[a]	27 ± (2.3)[b]
BW, g/d	1051 ± (4)[a]	872 ± (4)[b]	913 ± (4)[b]	904 ± (4)[b]
115kg				
BF, mm/d	0.17 ± (0.04)[a]	0.23 ± (0.03)[a]	0.09 ± (0.04)[b]	0.21 ± (0.03)[a]
LM, mm^2/d	20 ± (4.2)[b]	19 ± (3.8)[b]	46 ± (4.7)[a]	21 ± (3.1)[b]
BW, g/d	1130 ± (6)[a]	899 ± (6)[b]	992 ± (6)[b]	929 ± (5)[b]

[1]BF = Tenth-rib backfat; LM = Loin muscle; BW= Bodyweight

[a,b]LS means with different superscripts within a row differ ($P < 0.05$)