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DEEP BEDDED FINISHING OF PIGS: EFFECTS ON SWINE PERFORMANCE, PORK QUALITY AND ADIPOSE TISSUE COMPOSITION

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Introduction

An alternative system for finishing pigs utilizes deep-bedded hoop structures. Hoops are large, tent-like shelters with cornstalks or straw for bedding (Honeyman et al., 2001). Items differing between hoops and confinement systems are the use of straw bedding and exposure to the environment. Deep-bedded systems are enrichment strategies that have been shown to stimulate foraging and explorative behavior (O'Connell et al., 2004, De Jong et al., 1998). Finishing in deep-bedded environments has also supported increased spontaneous exercise (Morrison et al., 2003a; Gentry et al., 2002; Beattie et al., 1996). Increased exercise and exploratory behavior may lead to changes in stress susceptibility, influencing performance and ultimate pork quality (Morrison et al., 2003b; Klont et al., 2001). Stress during finishing and before slaughter is known to influence the physiological and biochemical processes in pigs, which will affect the perimortem muscle metabolism and thereby meat quality (Cassens, 1975).

Objectives

Few studies have compared growth characteristics from confinement systems to deep-bedded systems. No research has been conducted comparing pork quality and adipose tissue composition between these two systems. This study was undertaken to compare pigs finished in standard confinement systems to pigs finished in hoop structures and the effects of swine performance, pork quality and adipose tissue composition.

Methodology

Animal Selection: Five groups of 600 pigs were farrowed and reared in intensive confinement conditions at the Iowa State University Swine Nutrition Farm, Ames, IA. At four months of age, gilts were separated from barrows, weighed and allocated into groups stratified by weight. From those weight allocation groups, 100 gilts ranging in weight from 59 – 71 kg were randomly assigned to treatments of hoop (n = 50) and CON (n = 18). Stocking density in each treatment group was 0.70m^2/pig. Gilts were fed a two-phase diet ad libitum for a standard period of 45 days. At 45 days, gilts were weighed and

allocated into pre-slaughter groups stratified by weight. One gilt was randomly chosen to represent each weight group to total six pigs per treatment for observations.

Growth and Performance: Beginning weight, 21-day weight and final slaughter weight were obtained for each pig. Average daily gain (ADG, g/day), feed conversion (g:f) were calculated for each pig.

Slaughter and Sampling: After standard slaughter, carcasses were placed in a 0°C cooler and chilled for 24 hours. After 24 hours, two 20 g samples of adipose tissue from the blade end of the loin were obtained for fatty acid analysis and fat firmness measurement. Four 2.54 cm chops were obtained for star probe analysis; the first two chops were assigned an aging period of 24 hours and the second two were assigned an aging period of 120 hours. Three 2.54 cm chops were obtained for objective color and drip loss analysis. Sirloin ends of pork loin were obtained for purge analysis. All samples were vacuum packaged and held until analysis was conducted.

Pork Quality: pH and temperature measurements were taken at 1, 6 and 24 hours postmortem on right side loins by a penetration probe. Carcasses were ribbed between the 10^{th} and 11^{th} ribs and were subjectively analyzed for color and appraised for firmness, wetness and marbling. Objective measurements of tenth and last rib backfat and loin eye area were taken. Fat free lean % (FFL%) was calculated using the NPB percent fat free lean calculation (NPB, 2005). Four 2.54 cm chops from right side loins were stored in a vacuum bag at 4°C for 24 or 120 hours postmortem. After aging, chops were frozen in a -20°C blast freezer until needed for star probe analysis. All procedures were done in accordance to Lonergan and Prusa (2002). Hunter L*, a* and b* values were determined at 1-d postmortem on 2.54 cm thick chops using a Hunter Labscan colorimeter (Hunter Association Laboratories Inc.; Reston, VA). Drip loss was determined using 2.54 cm-thick boneless chops by similar method to Lonergan et al. (2001). Purge Loss was measured on the sirloin and of the loin after 120 hours of storage at 4°C.

Fatty Acid Compositon and Total Lipid: Approximately 3 g samples from inner layer only were weighed into a 50 mL test tube for total lipid analysis by the method of Folch et al. (1957). Crude lipid analysis was conducted from the method of 10 ml of folch extract from lipid extraction. Total lipid percentage was determined on a wet weight basis. Fatty acids were methylated using the method of Morrison and Smith (1964) and separated (Jo and Ahn, 2000).

Firmness: Adipose samples were cut into 5 x 3 cm squares and analyzed for firmness using a method modified from Nishioka and Irie (2005). Samples were evaluated using TA-XT2 Texture Analyzer (Texture Technologies, Scarsdale, NY) with a ¼" diameter ball shaped probe. Sample height was noted by the testing machine, and the probe was driven downward at 2mm/sec to a depth of 20% of the sample height. Peak force exerted (kg) and sample height (cm) were recorded for three separate positions on the square.

Results & Discussion

Hoop pigs gained significantly ($P<0.01$) less per day and required more feed for lean growth than CON pigs (Table 1). These results are congruent with Larson et al. (1999). Carcass weights and dressing % did not differ between the two groups. Confinement pigs had lower lean percentages than hoop pigs (55.50 vs 56.87). Significant ($P<0.05$) replication effects were noted in beginning weight, live weight, carcass weight, fat free

lean, and backfat at the 10th rib as well as the last rib. Several other studies have noted lower levels of backfat in pigs finished outdoors or semi-outdoor compared to indoor finished pigs (Gentry et al., 2002; Warriss et al., 1983; Enfält et al., 1997). Group effects and main effect interactions were noted for live weight, carcass weight, backfat (10th & last rib), and % fat free lean (FFL). With no change in feed intake, it is probable that the effect of temperature may play a role in fat deposition and lean gain. Environment did not affect temperature or pH decline (Table 2). There were no differences in loin eye area, color, firmness or wetness of the loin. Confinement pigs had higher levels of marbling in the loin compared to hoop pigs. Environment had no affect on fat firmness. Hoop pigs had lower proportions of C16:0, and higher deposition of C18:1 and C18:2 in the inner layer of adipose tissue (Table 3). These differences led to overall differences in proportions of total saturated (SAT), total monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) in the adipose tissue. Total SAT was lower (34.06 v 49.80), and total MUFA and PUFA were higher in hoop pigs compared to confinement pigs (48.04 v 35.05 and 17.54 v 15.17 respectively). There was a significant replication effect noted for several individual fatty acids as well as fat firmness. The interactive effect of environment and replication gave insight that individual fatty acids were being deposited at different levels from rep to rep, and also were differing between treatments. The main characteristic differing by replication, irrespective of treatment, was ambient temperature. Temperatures within the confinement ranged from 31° – 9°C, where in hoops temperature ranged from 33° – -2.9°C. Fluctuations in ambient temperature due to alternative production systems have been shown to influence fatty acid composition in pigs (Bee et al., 2004;Lebret et al., 2002). Outdoor pigs have been shown to deposit more unsaturated fats than their confinement counterparts (Hogberg et al., 2004; Bee et al., 2004). Specifically, decreasing temperature affects the fatty acid composition of the back fat leading to higher MUFA and lower SAT and PUFA contents of adipose tissue in pigs finished at cooler temperatures. Pearson correlation coefficients were analyzed for each individual fatty acid against average and low temperatures (Table 4). Individual fatty acids were correlated to temperature, where saturated fatty acids were positively correlated and unsaturated fatty acids were negatively correlated. These differences drove strong correlations between SAT and MUFA with temperature. These data verify that fluctuations in ambient temperature below the thermonuetral zone for pigs accompanied an increased in MUFA and PUFA in the adipose tissue of pigs.

Conclusions

Hoop pigs varied from CON finished pigs, being less fat at the 10th rib with lower amounts of intramuscular fat in the loin. Hoop-finished pigs had significantly higher amounts of MUFA and PUFA and significantly lower amounts of SAT comprising the adipose tissue. Replication effects and treatment by replication interactions caused variations within growth, subsequently affecting fatty acid composition and adipose tissue firmness. The specific role of ambient temperature fluctuation on these attributes needs to be further evaluated.

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Table 1. The effect of finishing environment on swine performance and carcass composition

Variable	Hoop	CON	ENV[1]	SE[2]	Rep[3]	ENV*Rep[4]
BW (kg)	73.82	71.40	NS	5.25	**	**
LW (kg)	106.92	110.41	NS	5.64	***	**
CW (kg)	79.15	82.75	**	4.34	***	**
Dressing (%)	74.65	74.90	NS	0.37	NS	NS
10^{th} rib BF (mm)	13.72	15.24	**	0.03	**	**
LRBF (mm)	19.02	20.32	NS	0.09	**	***
FFL (%)	56.87	55.50	***	0.52	***	***
ADG (kg/day)	0.81	1.07	***	0.09	NS	NS
G:F	0.52	0.42	***	0.09	NS	NS

1 ** P<0.05 *** P<0.01
2 Standard Error of Treatment
3 Group 1 - 5
4 Interaction of replication and treatment

Table 2. The effect of finishing environment on fresh pork quality attributes

Variable	Hoop	CON	ENV[1]	SE[2]	Rep[3]	ENV*Rep[4]
Temp – 1 (°C)	36.49	36.82	NS	0.50	NS	NS
Temp – 6 (°C)	9.05	9.77	NS	0.22	NS	NS
Temp – 24 (°C)	1.39	1.32	NS	0.62	NS	NS
pH – 1	6.21	6.18	NS	0.52	NS	NS
pH – 6	5.61	5.62	NS	0.42	NS	NS
pH – 24	5.32	5.40	NS	0.53	NS	NS
LEA (in^2)	6.93	6.96	NS	0.21	**	NS
Color	1.92	2.07	NS	0.12	NS	NS
Marbling	1.42	1.78	***	0.12	NS	NS
Firmness	1.90	1.88	NS	0.06	NS	NS
Wetness	1.83	1.89	NS	0.07	NS	NS
L*	54.48	54.40	NS	0.64	**	NS
a*	8.06	8.26	NS	0.24	**	NS
b*	14.19	14.27	NS	0.35	***	NS
Drip (%)	3.68	4.64	NS	0.92	NS	NS
Purge (%)	2.74	2.28	NS	0.30	NS	NS

1 ** P<0.05 *** P<0.01
2 Standard Error of Treatment
3 Group 1 - 5
4 Interaction of replication and treatment

Table 3. The effects of finishing environment on fatty acid composition and total lipid concentration of adipose tissue[1]

	Environment			Significance[4]		
Formula	Hoop[2]	CON[2]	SE[3]	ENV[5]	Rep[6]	ENV*Rep[7]
C14:0	1.88	2.94	0.55	NS	NS	NS
C16:0	19.16	32	0.50	***	**	**
C16:1, n7	5.5	6	0.51	NS	***	**
C17:0	0.93	0.84	0.11	NS	NS	NS
C17:1, n10	0.73	1.01	0.32	NS	NS	NS
C18:0	11.11	12.28	0.81	NS	***	**
C18:1, n9	39.96	26.52	1.32	***	***	***
C18:1, n7	2.21	1.5	0.42	NS	***	**
C18:2, n6	15.38	13.14	0.81	***	***	**
C18:3, n3	0.84	0.8	0.18	NS	***	**
C20:0	0.67	1.52	0.46	NS	***	**
C20:4, n6	0.63	0.58	0.12	NS	**	**
C20:5, n3	0.46	0.34	0.16	NS	***	**
C22:0	0.31	0.22	0.10	NS	***	**
C22:5, n3	0.18	0.21	0.07	NS	***	**
C22:6, n3	0.05	0.1	0.04	NS	NS	***
Total SAT	34.06	49.8	1.28	***	***	**
Total MUFA	48.4	35.03	1.22	***	***	**
Total PUFA	17.54	15.17	0.85	***	***	***
% Lipid	81.55	83.6	1.68	NS	***	NS

[1] Analysis done on inner layer of backfat tissue. Presented as least squared means.
[2] Hoop = hoop finished pigs, CON = confinement finished pigs.
[3] Standard Error of the treatment mean.
[4] Significance: **, P<0.05; ***, P<0.01; NS, P>0.05.
[5] Environmental significance, hoop versus confinement.
[6] Replication group
[7] Treatment by replication
[8] Monounsaturated
[9] Polyunsaturated

Table 4. Pearson Correlation Coefficients of FA to Average and low temperatures

	C16:0	**C16:1**	**C18:0**	**C18:1, n9**	**C18:1, n7**	**C18:2**	**Sat**	**MUFA**	**PUFA**
AVG	0.70 (0.001)	-0.79 (0.001)	0.44 (0.001)	-0.21 (0.01)	-0.28 (0.001)	0.22 (0.01)	0.65 (0.001)	-0.66 (0.001)	-0.18 (0.02)
LOW	0.56 (0.001)	-0.58 (0.001)	0.34 (0.001)	-0.18 (0.02)	-0.27 (0.001)	0.11 0.15	0.50 (0.001)	-0.48 (0.001)	-0.07 0.35