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THE EFFECT OF SPACE ALLOCATION ON SWINE PERFORMANCE, PORK QUALITY AND ADIPOSE TISSUE COMPOSITION

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Introduction

Alternatively-managed pigs differ from intensive systems in that pigs have a chance to pursue their natural instincts and have more space to move freely (Honeyman, 1996). This is brought about by variations in housing style, stocking rate, flooring, and bedding type. Variations in stocking rates influence behavior (Schmolke et al., 2004) and swine performance (Hyun, Ellis, Riskowski & Johnson, 1998). Reducing space has been shown to increase observations of abnormal behaviors and levels of aggression (Randolph et al., 1981). Higher incidence of these behaviors could increase stress, thereby impacting peri-mortem metabolism. Variations in perimortem metabolism will induce changes in the conversion of muscle to meat, leading to differences in ultimate pork quality (Klont et al., 2001). Several studies have reported increased acceptability of pork from pigs finished in systems which allocate more space (Millet et al., 2004; Gentry, McGlone, Miller & Blanton, Jr., 2002a; Beattie et al., 2000). The standard stocking density commonly implemented in confinement systems is 0.72 - 0.90 m^2/pig from 70 to 113 kg. (NCR-89, 1993). The optimum space allocation for several alternative environments has yet to be defined.

Objectives

The space requirement of pigs housed in large groups in deep-bedded, semi-outdoor structures has not been adequately evaluated. The following experiment was designed and implemented to determine the degree to which space allocation in a deep bedded system influences swine performance, pork quality and adipose tissue attributes in deep-bedded, semi-outdoor structures.

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 low ($0.70 m^2$/pig, n = 50) and high ($1.13 m^2$/pig, n = 50) space allocation. Gilts assigned were transported 126 miles to the ISU Western Research Farm, Castana, IA. The alternative method employed in the current study was the use of hoop structures. Hoops are large, tent-like shelters with cornstalks or straw for bedding (Honeyman et al., 2001). 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 and measurements.

Growth and Performance: Beginning weight, 21-day weight and live weight prior to slaughter were obtained for each pig. Average daily gain (ADG, g/day), feed conversion (g:f) and shrink (%) during transport and lairage were calculated for each pig.

Slaughter and Sampling: Pigs were slaughtered and placed in a 0°C cooler and chilled for 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. Percent fat free lean (% FFL) was calculated using the NPB percent fat free lean calculation (National Pork Board, 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 2.54cm thick chops using a calibrated 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 calculated as: percentage total crude lipids = lipid weight * lipid layer volume (ml) / 10 (ml) / sample weight (g) * 100. Fatty acids were methylated and separated using the method of Morrison and Smith (1964). Methylated fatty acids were used for gas chromatographic analysis according to the method of 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 positions on the square, and were averaged by sample for statistical analysis.

Results & Discussion

Allocating greater area of space did not influence performance (Table 1). Space differences in previous reports may be due to seasonal variation (Honeyman & Harmon, 2003). Greater space allocation had minimal influence on fresh pork quality attributes (Table 2). Temperature and pH decline did not differ between the two treatment groups ($P>0.05$). Space allocation did not affect lean marbling, firmness or wetness. ($P>0.05$). High treatment pigs had significantly lower ($P<0.05$) degree of muscling in the loin ($44.71cm^2$ v $42.19cm^2$), and produced pork appearing significantly darker ($P<0.05$) than low pigs. There were no measurable differences between L*, a* or b* between the two groups of pigs. Although our subjective color measurements were not congruent with objective color measurements our results are similar to Gentry et al. (2002a), who reported pigs finished with larger space allowance had pork obtaining higher color scores than highly stocked pigs. Drip and purge loss were not affected by space allocation. Space allocation variation altered the fatty acid composition of inner layer adipose tissues (Table 3). Greater space allocation resulted in higher ($P<0.05$) amounts of C14:0 and significantly lower ($P<0.01$) amounts of C18:2 in adipose. These differences in concentration led to significant differences in total saturation (SAT) and polyunsaturation (PUFA) overall. These results are interesting in that there were no differences in feed intake or g:f between treatments. Factors affecting fatty acid composition are diet, fatness, age/body weight, gender, breed, environmental temperature, depot site and maintenance (Wood & Enser, 1997). Replications spanned the months of August to November, with temperatures ranging from -2° - 32°C within the hoop. Lebret et al. (2002) reported decreasing outdoor environmental temperature from 24°C to 17°C during finishing affected the fatty acid composition of the back fat of pigs leading to higher MUFA and lower SAT and PUFA contents ($P<0.001$). SAT, MUFA and PUFA varied by replication group in the current experiment. As environmental temperature declined, adipose tissue decreased in SAT and PUFA. In agreement with Lebret et al. (2002), an increase in MUFA occurred as temperature decreased. Therefore, replication responses might have been dictated by temperature, leading to differences in fatty acid profile. Fat firmness and height did not vary between treatments. Pigs with greater space allocation had significantly higher total lipid. Paralleling these differences was an increase in PUFA incorporation in low space pigs. Bee et al. (2004) noted a similar response between indoor and outdoor finished pigs, where outdoor pigs displayed increased PUFA with a lower total lipid in the outer layer of backfat. It is has been established that when lipid content is reduced, the proportion of unsaturated phospholipids is higher, driving an increase in overall PUFA content (Bee, 2002). Therefore, changes in fatty acid composition in this study were predominately due to depositional changes within the adipose tissue.

Conclusions

The results showed that allocating larger space during finishing in hoop structures did not affect swine growth, performance or pork quality. Variations in fatty acid composition and lipid percentage of adipose tissue were observed when space allocation was changed within hoop structures. These results were related to depositional changes in adipose tissue, and may also be dependant on ambient temperature fluctuations. These results indicate the influence of ambient temperature in alternative production scenarios and its resulting effect on items such as backfat deposition and consistency, intramuscular and subcutaneous adipose fatty acid composition need to be further investigated.

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Table 1 The effect of space allocation within hoops on swine growth and carcass performance

	L [1]	H [1]	L v H [2]	SE [3]	Group [4]	INT [5]
BW (kg)	73.82	73.98	NS	3.58	***	NS
LW (kg)	106.09	106.66	NS	5.19	**	***
CW (kg)	79.15	78.60	NS	3.92	***	***
FFL (%)	56.86	56.18	NS	0.53	***	***
ADG (kg/day)	0.80	0.82	NS	0.09	NS	NS
G:F	0.42	0.43	NS	0.03	NS	NS
DP (%)	74.20	74.04	NS	0.62	NS	NS
10th rib BF (mm)	13.72	12.70	NS	0.02	**	NS
LRBF (mm)	17.02	15.49	NS	0.05	***	NS

1 Low = 0.70m^2/pig, High = 1.13 m^2/pig
2 ** P<0.05 *** P<0.01
3 Standard Error of Treatment
4 Group 1-5
5 Interaction of treatment and repetitive group

Table 2. The effect of space allocation within hoops on fresh pork quality attributes

	L [1]	H [1]	L v H [2]	SE [3]	Group [4]	INT [5]
Temp – 1 °C)	36.48	36.36	NS	0.43	NS	**NS**
Temp – 6 °C)	9.05	8.64	NS	0.42	NS	NS
Temp – 24 °C)	1.39	1.46	NS	0.43	NS	NS
pH – 1	6.21	6.16	NS	0.56	NS	NS
pH – 6	5.61	5.52	NS	0.53	NS	NS
pH – 24	5.32	5.37	NS	0.52	NS	NS
LEA (cm)	44.71	42.19	**	0.20	***	**
Color	1.91	2.12	**	0.10	**	NS
Marbling	1.41	1.47	NS	0.14	***	NS
Firmness	1.90	1.91	NS	0.06	NS	NS
Wetness	1.84	1.83	NS	0.08	NS	NS
L*	54.58	54.74	NS	0.68	**	NS
a*	8.05	8.34	NS	0.26	NS	NS
b*	14.16	14.53	NS	0.33	NS	NS
DL (%)	3.67	3.59	NS	0.35	NS	NS
Purge (%)	2.74	2.64	NS	0.33	NS	NS

1 Low = 0.70m^2/pig, High = 1.13 m^2/pig
2 ** P<0.05 *** P<0.01
3 Standard Error of Treatment
4 Group 1-5
5 Interaction of treatment and repetitive group

Table 3. The effect of space allocation within hoops on fatty acid composition and total lipid of adipose tissue

FA	L[1]	H[1]	L v H[2]	SE[3]	Group[4]	INT[5]
C14:0	1.88	3.09	**	0.55	***	**
C16:0	15.23	15.06	NS	0.59	**	**
C16:1, n7	9.41	10.22	NS	0.39	**	**
C17:0	0.93	0.83	NS	0.11	NS	NS
C17:1, n10	0.73	1.14	NS	0.32	NS	NS
C18:0	11.16	11.59	NS	0.81	NS	NS
C18:1, n9	40.03	39.33	NS	1.59	NS	NS
C18:1, n7	0.74	1.49	NS	0.46	NS	NS
C18:2, n6	16.76	12.74	***	0.82	***	***
C18:3, n3	0.84	0.96	NS	0.14	NS	NS
C20:0	0.67	1.74	NS	0.19	NS	NS
C20:4, n6	0.64	0.73	NS	0.11	**	**
C20:5, n3	0.44	0.51	NS	0.15	**	**
C22:0	0.30	0.32	NS	0.10	NS	NS
C22:5, n3	0.18	0.19	NS	0.08	**	**
C22:6, n3	0.06	.11	NS	0.04	**	**
SAT	30.17	32.48	**	0.82	**	**
MUFA	50.77	51.57	NS	1.44	NS	NS
PUFA	17.63	15.24	***	0.88	**	***
% Lipid	81.55	85.52	**	1.89	NS	NS

1 Low = 0.70m^2/pig, High = 1.13 m^2/pig

2 ** P<0.05 *** P<0.01

3 Standard Error of Treatment

4 Group 1-5

5 Interaction of treatment and repetitive group